MODULE 1.0: HEALTH PHYSICS FUNDAMENTALS

Introduction

Welcome to Module 1.0 of the General Health Physics Practices for Fuel Cycle Facilities Directed Self-Study Course! This is the first of seven modules in this self-study course. The purpose of this module is to provide basic fundamentals of radiation and terms that are common to the health physics and nuclear industries. This self-study module is designed to assist you in accomplishing the learning objectives listed at the beginning of the module. There are nine learning objectives in this module. The module has self-check questions and an activity to help you assess your understanding of the concepts presented in the module.

Before You Begin

It is recommended that you have access to the following materials:

- Trainee Guide

Complete the following prerequisites:

- There are no prerequisites to this module.

How to Complete this Module

1. Review the learning objectives.
2. Read each section within the module in sequential order.
3. Complete the self-check questions and activities within this module.
4. Check off the tracking form as you complete the self-check questions and/or activity within the module.
5. Contact your administrator as prompted for a progress review meeting.
6. Contact your administrator as prompted for any additional materials and/or specific assignments.
7. Complete all assignments related to this module. If no other materials or assignments are given to you by your administrator, you have completed this module.
8. Ensure that you and your administrator have dated and initialed your progress on the tracking form.
9. Go to the next assigned module.

This page intentionally left blank.

MODULE 1.0: HEALTH PHYSICS FUNDAMENTALS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

MODULE 1.0: HEALTH PHYSICS FUNDAMENTALS

LEARNING OBJECTIVES

1.1 Upon completion of this module, you will be able to recognize basic fundamentals of radiation and terms that are common to the health physics and nuclear industries.

1.1.1 Identify the three basic particles that make up an atom.

1.1.2 Define the following terms commonly used by health physics professionals:

- Radiation
- Ionization
- Ionizing Radiation
- Non-ionizing Radiation
- Stable and Unstable Atoms
- Radioactivity
- Radioactive Material
- Radioactive Contamination
- Radioactive Decay
- Half-life

1.1.3 Identify the five basic types of ionizing radiation.

1.1.4 Identify the units most commonly used to measure radiation, contamination, and radioactivity.

1.1.5 Identify the possible effects of radiation on cells.

1.1.6 Distinguish between acute and chronic radiation exposure.

1.1.7 Identify contributions to the U.S. population dose from various radiation sources.

1.1.8 Identify the ALARA concept, basic exposure reduction concepts, and the purpose of radiological postings.

This page intentionally left blank.

MODULE 1.0: HEALTH PHYSICS FUNDAMENTALS

Learning Objective

When you finish this section, you will be able to:

1.1.1 Identify the three basic particles that make up an atom.

ATOMIC STRUCTURE

The basic unit of matter is the atom. The central portion of the atom is the nucleus, which consists of protons and neutrons. Electrons orbit the nucleus similar to the way planets orbit our sun.

The three basic particles of the atom are protons, neutrons, and electrons. See Figure 1-1, Basic Particles of the Atom. For a description of the basic particles of the atom, see Table 1-1.

Figure 1-1. Basic Particles of the Atom

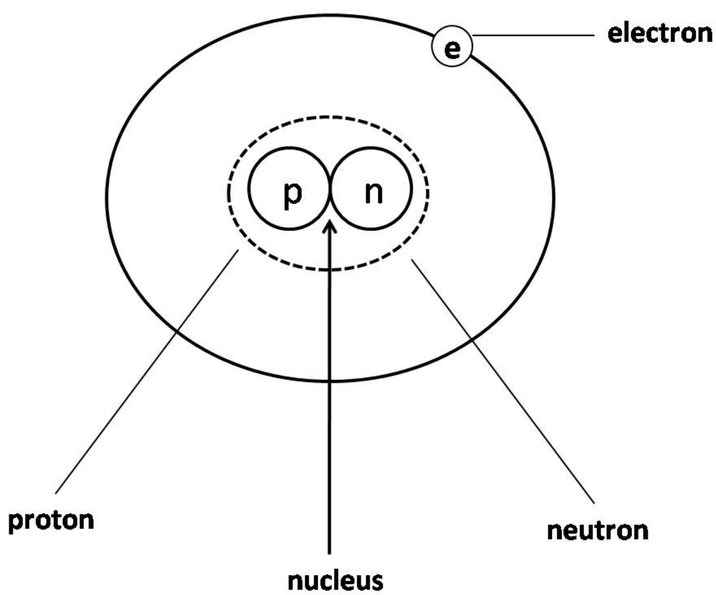


Table 1-1. Description of Basic Particles of the Atom

	Proton	Neutron	Electron
Location	In the nucleus of an atom	In the nucleus of the atom	In orbit around the nucleus of an atom
Charge	Positive (+)	No charge	Negative (-)
Facts	◙ The number of protons in the nucleus determines the element and atomic number ◙ If the number of protons in an atom changes, the element changes	◙ Have about the same mass as a proton	◙ Are very small (about 1/1800 the mass of a proton)

Self-Check Questions 1-1

INSTRUCTIONS: Complete the following questions. Answers are located in the answer key section of the Trainee Guide.

1. What are the three basic particles that make up an atom?

2. Match the particles listed in column A to the characteristics listed in column B.

Column A **Particles**	**Column B** **Characteristics**
A. Proton	1._____ No charge and located in the nucleus of the atom.
B. Neutron	2._____ Negative charge and orbits around the nucleus of an atom.
C. Electron	3._____ Positive charge and located in the nucleus of the atom.

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

This page intentionally left blank.

Learning Objective

When you finish this section, you will be able to:

1.1.2 Define the following terms commonly used by health physics professionals:

- Radiation
- Ionization
- Ionizing Radiation
- Non-ionizing Radiation
- Stable and Unstable Atoms
- Radioactivity
- Radioactive Material
- Radioactive Contamination
- Radioactive Decay
- Half-life

DEFINITIONS

The following terms and definitions are commonly used by health physics professionals involved in fuel cycle facility operations.

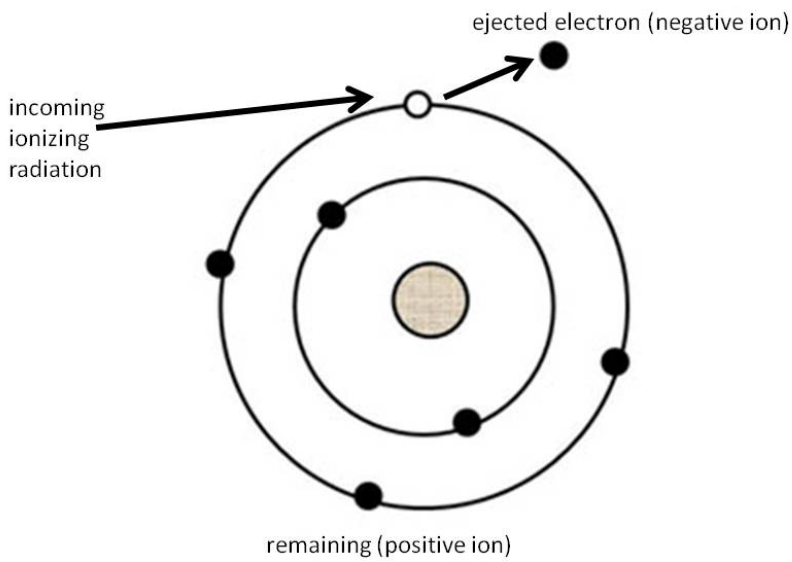
Radiation

Energy in the form of particles or waves that can travel through space.

Ionization

The process of removing electrons from atoms. Do not confuse ionization with radiation. Radiation is simply energy in motion. As a result of this energy, ionization may or may not occur. If enough energy is supplied to remove electron(s) from the atom, the remaining atom has a positive (+) charge. The positively charged atom and the negatively charged electron are called an <u>ion pair</u>. Ions (or ion pairs) produced as a result of radiation exposure allow the detection of radiation. See Figure 1-2, Ionization.

Figure 1-2. Ionization



Ionizing Radiation

Energy (particles or rays) emitted from atoms that can cause ionization. The basic types of ionizing radiation are alpha particles, beta particles, gamma rays, x-rays, and neutrons.

Non-ionizing Radiation

Radiation that does not have the amount of energy needed to ionize an atom with which it interacts. Examples are radar waves, microwaves, and visible light. Although the word "radiation" can be used to mean ionizing or non-ionizing radiation, it is most often used to mean ionizing radiation.

Stable and Unstable Atoms

Only certain combinations of neutrons and protons result in stable atoms.

If there are too many or too few neutrons for a given number of protons, the resulting nucleus will contain too much energy and will not be stable.

The unstable atom will try to become stable by giving off excess energy in the form of particles or electromagnetic waves (radiation). These unstable atoms are also known as radioactive atoms.

Radioactivity

Unstable (or radioactive) atoms trying to become stable by emitting radiation in the form of particles or energy.

Radioactive Material

Any material containing unstable radioactive atoms that emit radiation.

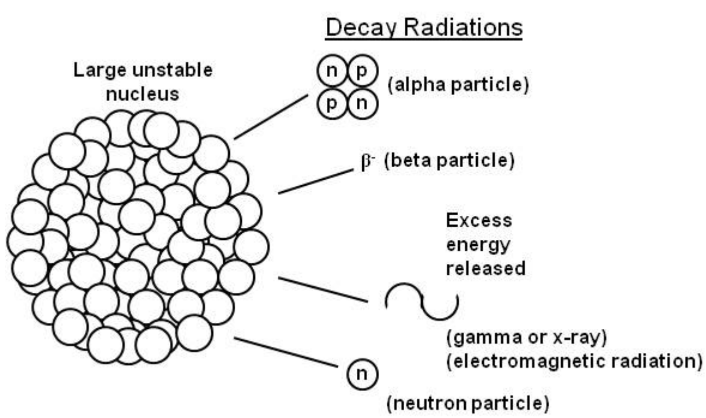
Radioactive Contamination

Radioactive material in an unwanted place. (There are certain places where radioactive material is beneficial). It is important to note here that exposure to radiation does not result in contamination of the worker. Radiation is a type of energy and contamination is a material.

Radioactive Decay

Radioactive decay is the process of radioactive atoms releasing radiation over a period of time to try to become stable (non-radioactive). (Also known as disintegration.) See Figure 1-3, Radioactive Decay.

Figure 1-3. Radioactive Decay



Radioactive Half-life

The time it takes for one half the radioactive atoms present in a radioactive sample to decay. After seven half-lives the activity of an average radioactive sample will be less than 1% of the original activity.

- Radioactive half-life of U-239 is 23.5 minutes
- Radioactive half-life of U-238 is 4,510,000,000 years

The amount of activity remaining after some number of half-lives can be calculated by multiplying the original amount of activity by the factor where n is the number of half-lives that have elapsed.

$$\left(\frac{1}{2}\right)n$$

Self-Check Questions 1-2

INSTRUCTIONS: Fill in the missing words in each statement. Answers are located in the answer key section of the Trainee Guide.

Choose from the following words:

decay	electromagnetic waves	energy	ionization
material	neutrons	non-ionizing	protons
radioactive	radioactivity	stable	half-lives

1. Radiation is energy in the form of particles or _____________ that can travel through space.

2. The process of removing electrons from atoms is known as _______________.

3. The basic types of ionizing radiation are alpha particles, beta particles, gamma rays, x-rays, and ______________.

4. Radar waves, microwaves, and visible light are examples of____________ radiation.

5. Only certain combinations of neutrons and _______________ result in stable atoms.

6. Unstable atoms are also known as ____________ atoms.

7. _____________ is defined as unstable atoms trying to become stable by emitting radiation in the form of particles or energy.

8. Radiation is a type of _____________ and contamination is a ______________.

9. Radioactive _____________ is the process of radioactive atoms releasing radiation over a period of time to try to become ________________.

10. After seven _____________ the activity of an average radioactive sample will be less than 1% of the original activity.

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

This page intentionally left blank.

Learning Objective

When you finish this section, you will be able to:

1.1.3 Identify the five basic types of ionizing radiation.

THE BASIC TYPES OF IONIZING RADIATION

The basic types of ionizing radiation are alpha particles, beta particles, gamma rays, x-rays, and neutrons.

Alpha Particles

- <u>Physical Characteristics</u>

  A large mass positively charged. Consists of two protons, two neutrons, and no electrons.

- <u>Penetrating Power (Range)</u>

  Deposit large amounts of energy in a short distance of travel. Travel through air only one to two inches.

- <u>Shielding</u>

  Most particles are stopped by a few centimeters of air, a sheet of paper, or the dead layer (outer layer) of skin.

- <u>Biological Hazard</u>

  An internal radiation hazard when alpha-emitting materials inhaled or ingested due to deposition of large amounts of energy.

- <u>Sources</u>

  Uranium, plutonium and most radioisotopes with atomic number >82.

Beta Particles

- Physical Characteristics

  A small mass negatively charged.

- Penetrating Power (Range)

  Beta particles are emitted with energies that vary over a wide range; all deposit their energy in a relatively short distance of travel. Travel through air for high-energy beta particles is ten to twelve feet.

- Shielding

  Most particles are shielded by plastic, glass, metal foil, or safety glasses.

- Biological Hazard

  Can be an internal hazard if beta-emitting materials are ingested or inhaled. Externally, higher-energy beta particles are potentially hazardous to the skin and eyes, but low-energy beta particles present less of a hazard. Some beta sources can produce measurable Bremsstrahlung.

- Sources

  Uranium decay products, tritium, carbon-14, Tc-99.

Gamma Rays/X-Rays

- Physical Characteristics

  A wave that has neither mass nor electrical charge. Gamma rays originate within the nucleus of an atom. X-rays originate from the orbital electrons.

- Penetrating Power (Range)

  Because gamma/x-ray radiation has no charge and no mass, it has a very high penetrating power.

  Travel several hundred feet in air.

- Shielding

  Best shielded by dense materials, such as concrete, lead, or steel.

- Biological Hazard

  Can result in radiation exposure to the whole body.

- Sources

  Decay products of natural uranium, x-ray machines.

Neutrons

- Physical Characteristics

  No electrical charge; mass about the same as a proton.

- Penetrating Power (Range)

  Because of the lack of a charge, neutrons have a relatively high penetrating ability and are difficult to stop.

  A direct interaction occurs as the result of a collision between a neutron and a nucleus. A charged particle or other ionizing radiation may be emitted during these interactions.

  Able to travel several hundred feet in air.

- Shielding

  Best shielded by materials with a high hydrogen content, such as water.

- Biological Hazard

  Whole body hazard due to high penetrating ability.

- Sources

  Those used to calibrate instruments, such as americium–beryllium (Am-Be) and plutonium–beryllium (Pu-Be).

  Uranium hexafluoride (UF_6) cylinders.

  There are several ways to produce neutrons. The ones that are most likely to be seen in fuel cycle facilities are fissions and alpha–neutron (α,n) reactions. Fissions are not normally seen in fuel cycle facilities because criticality accidents are strongly avoided. That leaves α,n reactions as the most common source of neutron radiation in fuel cycle facilities. These reactions can occur when an alpha emitter is intimately mixed with a light element. The high-energy alpha particles can interact with the nucleus of the light element and cause a neutron to be released. Examples are those sources used to calibrate instruments, such as Am-Be and Pu-Be.

Table 1-2 summarizes the characteristics of basic types of ionizing radiation.

Table 1-2. Characteristics of Basic Types of Ionizing Radiation

TYPE	ALPHA	BETA	GAMMA/X-RAYS	NEUTRON
Physical Characteristics	Particle (+2 charge)	Particle (-1 charge)*	Ray, Wave (no charge)	Particle (no charge)
Penetrating Power (Range)	Very Low (1 to 2 inches in air)	Limited (10 to 12 feet in air, few millimeters in skin)	High (several hundred feet in air)	High (several hundred feet in air)
Shielding	◙ <1 inch of air ◙ Outer layer of dead skin ◙ Clothing	◙ Glass ◙ Metal foil ◙ Plastic ◙ Safety glasses	◙ Concrete ◙ Lead ◙ Steel	◙ Hydrogenous materials: □ Water □ Concrete □ Polyethylene
Biological Hazard	Internal	Internal/External skin, eyes	Internal/External (whole body)	External (whole body)
Sources	Uranium and plutonium and most radioisotopes with atomic number >82	◙ Uranium decay products ◙ Tritium ◙ Carbon-14 ◙ Sulfur-35 ◙ Tc-99**	◙ Decay products of natural uranium ◙ X-ray machines ◙ Most radioactive isotopes emit secondary photons	◙ Those used to calibrate instruments such as: □ americium-beryllium □ plutonium-beryllium ◙ Uranium hexafluoride (UF_6) cylinders***

* sometimes +1 charge, called beta-plus or positron

** Tc-99 is often times a non-U containment in gaseous diffusion facilities.

*** These neutron sources are referred to as (α,n) sources. An alpha particle is captured by a low-Z nucleus, which in turn decays by neutron emission.

Self-Check Questions 1-3

INSTRUCTIONS: Complete the following questions. Answers are located in the answer key section of the Trainee Guide.

1. In the blank, identify the biological hazard of each type of ionizing radiation. Place an "I" for internal, an "E" for external or an "I/E" for both internal/external.

   _____ A. Alpha particles

   _____ B. Beta particles

   _____ C. Gamma rays/X-rays

   _____ D. Neutrons

Circle the best multiple choice response.

2. These are potentially hazardous to the skin and eyes.

   A. Alpha particles
   B. Beta particles
   C. Gamma rays/x-rays
   D. Neutrons

3. Best shielded by dense materials, such as concrete, lead, or steel.

   A. Alpha particles
   B. Beta particles
   C. Gamma rays/x-rays
   D. Neutrons

4. Best shielded by hydrogenous materials such as water.

   A. Alpha particles
   B. Beta particles
   C. Gamma rays/x-rays
   D. Neutrons

5. Deposits a large amount of energy in a short distance of travel.

   A. Alpha particles
   B. Beta particles
   C. Gamma rays/x-rays
   D. Neutrons

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

This page intentionally left blank.

Learning Objective

When you finish this section, you will be able to:

1.1.4 Identify the units most commonly used to measure radiation, contamination, and radioactivity.

RADIOLOGICAL UNITS

Radiation

Per 10 CFR Part 20.1004, the following are units of radiation dose:

- **Absorbed dose** is the amount of radiation energy absorbed per unit mass.
- **Quality factor** is a weighting factor applied to account for the amount of biological damage caused by different radiations.
- **Dose equivalent** mathematically is equal to absorbed dose multiplied by the quality factor. This relates the absorbed dose in human tissue to the effective biological damage of the radiation.
- **Gray (Gy)** is the Systeme International (SI) unit of absorbed dose. One Gray is equal to an absorbed dose of 1 joule kilogram (100 rad).
- **Rad** is the common unit of absorbed dose, used in the US. One Rad is equal to $1/100^{th}$ of a Gray (1 rad = 0.01 Gray). One rad is equal to an absorbed dose of 100 ergs/gram.
- **Sievert** (Sv) is the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in Gray multiplied by the quality factor (1 Sv=100 rem).
- **Rem** is the common unit of dose equivalent, used in the U.S. One Rem is equal to $1/100^{th}$ of a Seivert (1 rem=0.01 Sievert). The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor.

Radioactivity Units

- Other units commonly used to measure radioactivity are disintegrations per minute, disintegrations per second, and counts per minute.
- **Disintegrations per second (dps)** describes the number of atoms disintegrating each second in a radioactive source.

- **Disintegrations per minute (dpm)** describes the number of atoms disintegrating (decaying) each minute in a radioactive source.
- **Counts per minute (cpm)** represents the number of radiations detected per minute by a radiation detection instrument. Cpm can be converted to dpm by using a conversion factor for the radiation instrument you are using.

Per 10 CFR Part 20.1005, units of radioactivity are:

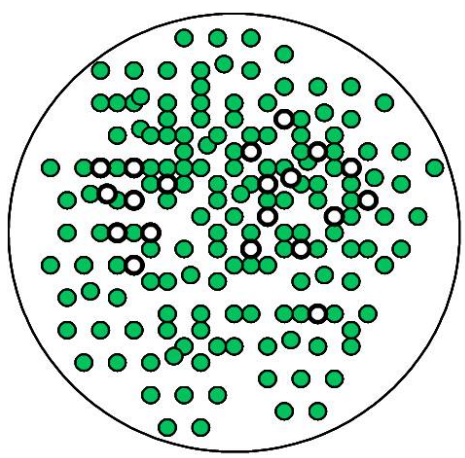
- Becquerel (Bq) is the SI unit for measuring radioactivity. One becquerel = one disintegration per second (s^{-1}).
- Curie (Ci) is the common unit used in the U.S for measuring radioactivity. One curie = 3.7×10^{10} disintegrations per second or Becquerels.

= 3.7×10^{10} becquerels
= 2.22×10^{12} disintegrations per minute.

Activity is expressed in the unit of curies (Ci) or in the SI unit of becquerels (Bq), or their multiples, or disintegrations (transformations) per unit of time.

Contamination Units

Contamination is activity per unit area or per unit volume, i.e., dpm/cm^2 or dpm/cm^3. Contamination is also frequently expressed as activity per detector surface area, e.g. dpm/100cm^2 or dpm/63cm^2.



Consider a disk contaminated with 100 atoms that are radioactive. Suppose 20 atoms disintegrate in one minute and the surface area is 20cm^2. The level of contamination is 20 dpm/20cm^2 = dpm/cm^2.

Self-Check Questions 1-4

INSTRUCTIONS: Complete the following questions. Answers are located in the answer key section of the Trainee Guide.

1. Match the following units of radiation listed in column A with their equivalent in column B.

Column A **Radiation Units**	**Column B** **Equivalent**	
A. Gray	1._____	Absorbed dose in rads multiplied by the quality factor (1 rem= 0.01 sievert)
B. Rad	2._____	Absorbed dose in grays multiplied by the quality factor (1 sievert=100 rem)
C. Rem	3._____	Absorbed dose of 1 joule/kilogram (100 rad)
D. Sievert	4._____	Absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray)

2. Provide a brief description of each of the following units most commonly used to measure radioactivity.

dpm –

dps –

cpm –

3. Fill in the missing word or formula to identify units of radioactivity.

One __________ = one disintegration per second (s^{-1})

One curie = __________ disintegrations per second

Activity is expressed in the special unit of __________ or in the SI unit of __________, or their multiples, or disintegrations (transformations) per unit of time.

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

Learning Objective

When you finish this section, you will be able to:

1.1.5 Identify the possible effects of radiation on cells.

EFFECTS OF RADIATION ON CELLS

Ionizing radiation can potentially affect the normal operation of cells.

The method by which radiation causes damage to any material is by ionization of atoms in the material. Some radiation damage is repaired by the cell. Some effects of radiation may not be observed immediately following exposure. Examples of possible effects of radiation on cells may include cell killing, reproductive failure, or transformation to cancer cells.

Self-Check Questions 1-5

INSTRUCTIONS: Answer True or False to the following statements. Answers are located in the answer key section of the Trainee Guide.

1.___ Ionizing radiation does not affect the normal operation of cells.

2.___ The method by which radiation causes damage to any material is by ionization of atoms in the material.

3.___ Radiation damage cannot be repaired by the cell.

4.___ Some effects of radiation may not be observed immediately following exposure.

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

Learning Objective

When you finish this section, you will be able to:

1.1.6 Distinguish between acute and chronic radiation exposure.

ACUTE AND CHRONIC RADIATION EXPOSURE

Potential biological effects depend on the magnitude and rate in which a radiation exposure is received. Radiation doses can be grouped into two categories: acute dose and chronic dose.

Acute Radiation Exposure

Doses of radiation received in a short period of time are called acute doses. Acute exposures are generally associated with radiological incidents described by a large radiation dose received in a short period of time. An acute effect is a physical reaction due to cell damage.

Chronic Radiation Exposure

A chronic radiation dose is typically associated with a small amount of radiation received over a long period of time. A typical example of a chronic dose is the dose a person would receive from occupational exposure; for example, 500 mrem/yr for 30 years.

Self-Check Questions 1-6

INSTRUCTIONS: Write "A" for acute or "C" for chronic by each of the following statements that reflect that type of exposure. Answers are located in the answer key section of the Trainee Guide.

1. ___ Large doses of radiation received in a short period of time.

2.___ A small amount of radiation received over a long period of time.

3. ___ Generally associated with radiological incidents.

4.___ A typical example of dose a person would receive from occupational exposure.

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

Learning Objective

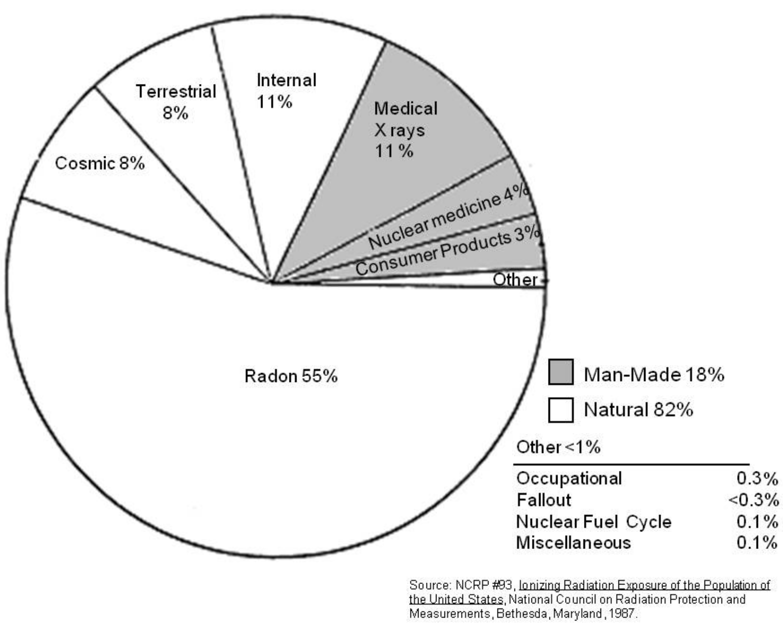
When you finish this section, you will be able to:

1.1.7 Identify contributions to the U.S. population dose from various radiation sources.

CONTRIBUTIONS TO U.S. POPULATION DOSE FROM VARIOUS RADIATION SOURCES

To identify contributions to the U.S. population dose from various radiation sources see Figure 1-4.

Figure 1-4. Contributions to U.S. Population Dose From Various Radiation Sources



Self-Check Questions 1-7

INSTRUCTIONS: Circle the best multiple choice response. Answers are located in the answer key section of the Trainee Guide.

1. Which of the following natural radiation sources contributes the highest percentage of radiation to the U.S. population dose?

   A. Cosmic
   B. Internal
   C. Radon
   D. Terrestrial

2. The Nuclear Fuel Cycle contributes what percentage of man-made radiation to the U.S. population dose?

   A. 0.1%
   B. 3.0%
   C. 4.0%
   D. 11.0%

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

Learning Objective

When you finish this section, you will be able to:

1.1.8 Identify the ALARA concept, basic exposure radiative concepts, and the purpose of radiological postings.

ALARA PROGRAM

ALARA stands for As Low As Reasonably Achievable.

ALARA is an approach to radiological control whereby exposures (individual and collective) to the workforce and to the general public are managed and controlled to be at levels as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit but a philosophy that has the objective of attaining doses as far below the applicable controlling limits as is reasonably achievable, while being able to complete work in a radiological environment, for the worker, the general public, and the environment.

This concept includes reducing both internal and external exposure to ionizing radiation in a practical way. The ALARA concept is an integral part of all site activities that involve the use of radioactive materials.

The implementation of the ALARA concept is the responsibility of all employees and begins with management to set the standard.

The main goal of the ALARA program is to reduce exposure when reasonable by minimizing the time spent within a field of radiation, maximizing the distance from a source of radiation, using shielding whenever possible, and/or using proper personal protective equipment (PPE).

Basic Exposure Reduction Concepts

Time

Reducing the amount of time spent within a field of radiation will lower the dose received.

- Pre-plan and discuss the task thoroughly prior to entering the area. Use only the number of workers actually required to do the job.
- Pre-staging - Have all necessary tools before entering the area.

- Use mock-ups and practice runs that duplicate work conditions to determine where efficiencies may be gained.

Distance

Methods for maintaining distance from sources of radiation include the following:

- Stay as far away as possible from the source of radiation.
- During work delays, move to lower dose rate areas.
- Use remote handling devices when required.

Shielding

Shielding reduces the amount of radiation dose to the worker. Different materials are used to shield a worker from different types of radiation. Many materials, such as a vehicle, a mound of dirt, or a piece of heavy equipment between the worker and the source of radiation, can reduce the exposure level during field activities.

Radiological Postings

Radiological postings are used to alert personnel to the presence of radiation and radioactive materials. See Figure 1-5, Example of a Radiological Posting.

Areas controlled for radiological purposes will be designated with a magenta (or black) standard three-bladed (tri-foil) radiological warning symbol on a yellow background. Additionally, yellow and magenta ropes, tapes, chains, or other barriers will be used to denote the boundaries.

- The barriers will be clearly visible from every side. Entrance points to those areas will have signs (or equivalent) stating the entry requirements, such as "Personnel Dosimeters, Radiation Work Permit (RWP) and Respirator Required." Additionally, the radiation dose rate, contamination level, and/or airborne radioactivity concentration will be included on or near each posting, as applicable.
- Before entering an area controlled for radiological purposes, read all of the signs. Since radiological conditions may change, the signs are also changed to reflect the new conditions. So, a sign or posting that you saw yesterday may be replaced with a new one tomorrow.
- In some cases, more than one radiological hazard may be present in the area and will be posted as such (e.g., Radiation Area, Contamination Area, Airborne Radioactivity Area.)

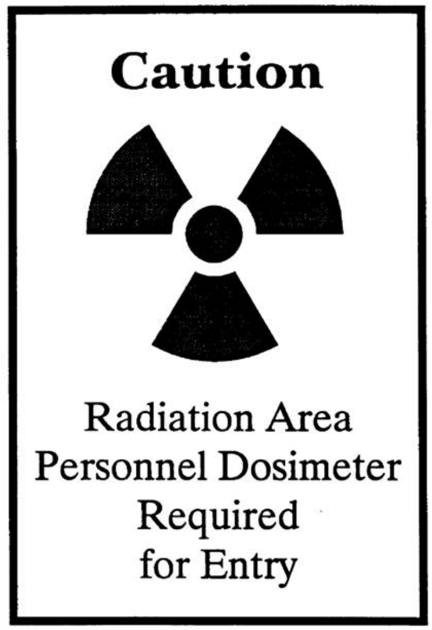


Figure 1-5. Example of a Radiological Posting

Self-Check Questions 1-8

INSTRUCTIONS: Answer the following questions. Answers are located in the answer key section of the Trainee Guide.

1. ALARA is an acronym for what?

Answer True or False to the following statements.

2. _______ ALARA is a dose limit below the applicable controlling limits.

3. _______ ALARA includes reducing both internal and external exposure to ionizing radiation.

4. _______ The implementation of the ALARA concept is the responsibility of all employees.

5. ______ The main goal of the ALARA program is to reduce exposure when reasonable by minimizing the time spent within a field of radiation, maximizing the distance from a source of radiation, using shielding whenever possible, and/or using proper personal protective equipment (PPE).

Place a "T" for Time, "D" for distance, or an "S" for shielding next to each statement that reflects one of these three exposure reduction concepts.

6. _____ Use remote handling devices when required.

7. _____ Have all necessary tools before entering the area.

8. _____ During work delays, move to lower dose rate areas.

9. _____ Use mock-ups and practice runs that duplicate work conditions.

10. ____ A vehicle, a mound of dirt, or a piece of heavy equipment between the worker and the source of radiation.

Fill in the missing words.

11. Radiological postings are used to alert personnel to the presence of radiation and ________________________ materials.

12. Areas controlled for radiological purposes will be designated with a __________________standard three-blade radiological warning symbol on a yellow background.

13. Before entering an area controlled for radiological purposes, ________________all of the signs. Why should you do this?

14. In some cases, more than one radiological ___________________ may be present in the area and will be posted as such.

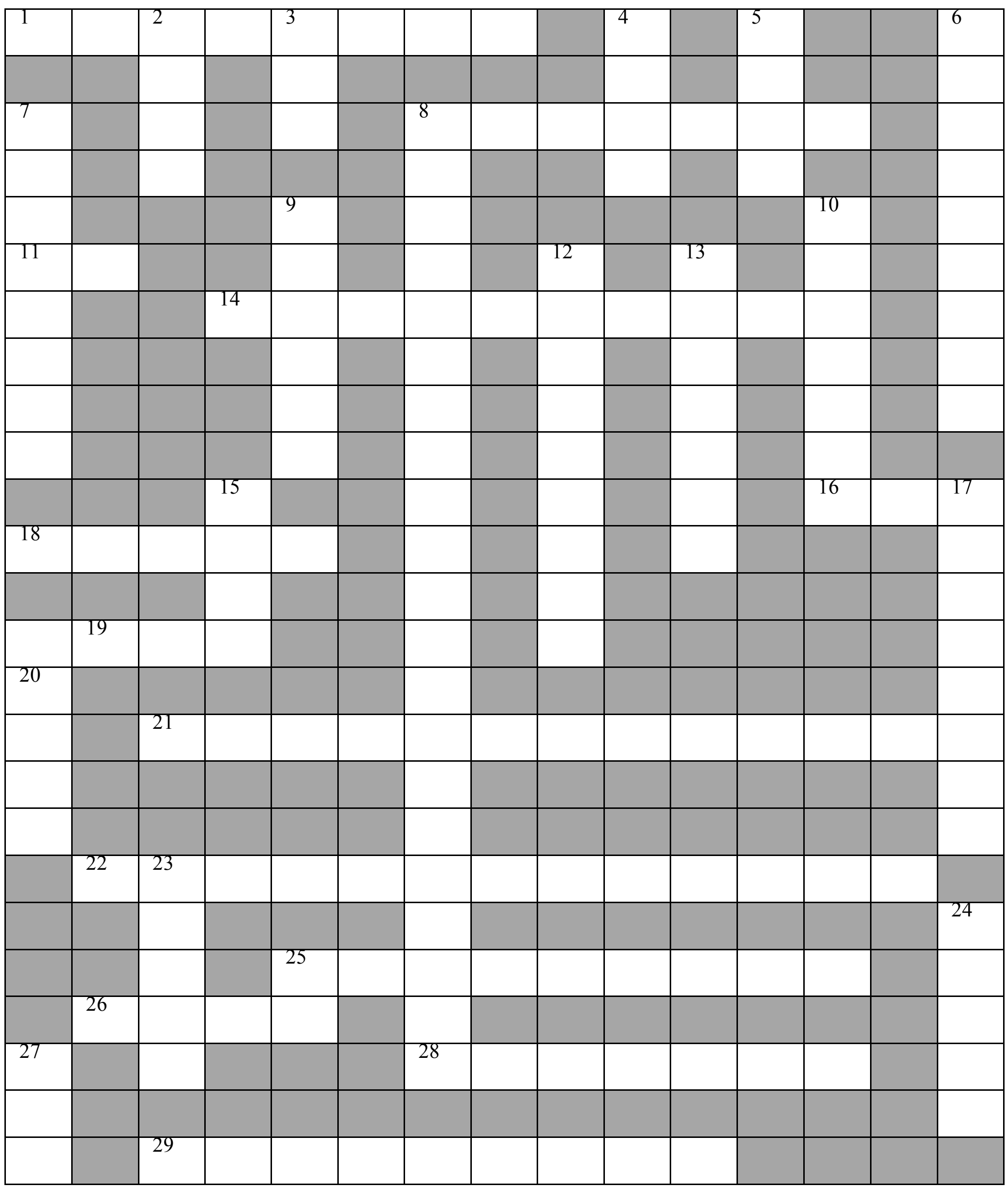
You have completed this section.
Please check off your progress on the tracking form.
Go to Activity 1.

Activity 1 – Health Physics Fundamentals

PURPOSE: The purpose of this activity is to review basic health physics terminology and concepts.

INSTRUCTIONS: Complete the following activity using terminology used throughout the module. Answers are located in the answer key section of the Trainee Guide.

Health Physics Fundamentals



Across

1. Radioactive ____________ contains unstable radioactive atoms that emit radiation.
8. One of two particles that could be in a nucleus.
11. A radioactivity unit equal to 3.7 x 10^{10} disintegrations per second.
14. The process of removing electrons from atoms.
16. Equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray)
18. Process of radioactive atoms releasing radiation over a period of time to try to become stable.
19. A unit to measure radioactivity.
21. Radioactive material in an unwanted place.
22. Unstable atoms trying to become stable by emitting radiation in the form of particles or energy.
25. Reduces the amount of radiation dose to the worker.
26. Equal to an absorbed dose of 1 joule/kilogram (100 rad).
28. The central portion of the atom.
29. A radioactivity unit equal to one disintegration per second (s^{-1}).

Down

2. Reducing this within a field of radiation will lower the dose received by workers.
3. A radiological unit that equals 0.01 sievert.
4. A type of ionizing radiation.
5. A basic unit of matter.
6. The time it takes for one half the radioactive atoms present in a radioactive sample to decay.
7. This orbits the nucleus of an atom.
8. Examples of this are radar waves, microwaves, and visible light.
9. One of two things that could be in a nucleus.
10. The positively charged atom and the negatively charged electron.
12. Energy in the form of particles or waves that can travel through space.
13. The dose equivalent of this is equal to the absorbed dose in grays multiplied by the quality factor. Equal to 100 rem.
15. These gamma _____ are best shielded by dense materials, such as concrete, lead, or steel.
17. Using remote handling devices is an example of this basic exposure reduction concept.
20. These ____ings are used to alert personnel to the presence of radiation and radioactive materials.

23. An approach to radiological control whereby exposures to the workforce and to the general public are managed and controlled to be at levels as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations.

24. These particles can be an internal radiation hazard when materials that emit them are inhaled or ingested.

27. The number of atoms decaying each minute in a radioactive source.

It's time to schedule a progress meeting with your administrator. Review the progress meeting form on the next page. In Part III, as a Regulator, write your specific questions to discuss with the administrator.

PROGRESS REVIEW MEETING FORM

Date Scheduled: ________________________________**Location:**______________________

I. The following suggested items should be discussed with the administrator as to how they pertain to your current position:

- Radiation versus ionization
- Ionizing radiation versus non-ionizing radiation
- Radiation versus contamination
- Radioactive decay
- Half-life

II. Use the space below to take notes during your meeting.

III. As a Regulator:

- Which ionizing radiation will I come in contact with in my work?
- What should I know about radiological units in my work? What documentation will I review that uses the radiological units mentioned in this module?

Use the space below to write your specific questions.

IV. Further assignments? If yes, please note and complete. If no, initial completion of progress meeting on tracking form.

Ensure that you and your administrator have dated and initialed your progress on your tracking form for this module.
Go to the module summary.

MODULE SUMMARY

A familiarity with basic health physics terminology and concepts is necessary for communicating with health physics professionals involved in fuel cycle facility operations.

Congratulations! You are ready to go to the next assigned module.