UCSC Radiation Awareness Training

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1. Objectives

Upon completion of Radiation Awareness Training (RAT), you will be able to discuss your responsibilities for maintaining exposures to radiation and radioactive material as low as reasonably achievable (ALARA).

You will be able to select the correct response from a group of responses to verify your ability to:

- Identify natural background and human-made sources of radiation.
- State the whole body radiation dose limit for non-radiological workers.
- State the potential biological effects from chronic radiation exposure.
- Identify the ALARA principle and practices for implementing this principle.
- State methods used to control radiation and radioactive material.
- State different types of radiation and the types encountered at UCSC.
- Identify radiological postings and identification used at UCSC.
- Describe actions for alarms, accidents, and emergencies at UCSC.

2. Introduction

2.1 Lesson Introduction

Radiation Awareness Training is required training for:

- All UCSC employees who frequently enter radiation use areas.

***Note**: Radiological Worker Training (RWT) is required for personnel identified as radiological workers.*

For the purposes of this document, the word personnel is used to refer to anyone at UCSC including UCSC employees, visitors, users, and subcontractors.

Personnel responsibilities for observing and obeying radiological postings and procedures are emphasized throughout this training. All personnel, both non-radiological workers and radiological workers, play an active part in maintaining exposure to radiation and radioactive material as low as reasonably achievable.

Although most personnel will probably not be exposed to radiation and radioactive material, all personnel must have an understanding of and respect for the procedures designed to keep radiation exposure at UCSC as low as reasonably achievable.

The risk of radiation exposure at UCSC is low. In Section 5, the radiation exposure risk associated with working at a University of California (UC) campus is compared with other risks encountered in everyday life.

2.2 Qualification

When you complete RAT you will:

- Be trained as a non-radiological worker.
- Be permitted to enter Radioactive Material Use Areas only if doing so could not result in an annual radiation dose that is greater than 100 mrem.

***Note**: A millirem, abbreviated mrem, is a unit of radiation dose equivalent. Dose equivalent will be referred to as dose in this document.*

Completion of RAT does not permit you to:

- Enter High Radiation areas and Radiological Control Areas.
- Enter Radioactive Material Use Areas if doing so could result in an annual radiation dose that is greater than 100 mrem.
- Handle radioactive material if doing so could result in an annual radiation dose that is greater than 100 mrem.

3. Sources of Radiation

Humans are constantly exposed to radiation from naturally occurring sources. Radiation, simply defined, is energy transferred through space and matter. Many sources of radiation exist in the environment, even inside the human body.

The average annual radiation dose equivalent to a given member of the general population is about 360 millirem. This amount is a combination of both natural background and human-made sources of radiation. The amount of radiation dose received from natural background and human-made sources of radiation varies from location to location.

3.1 Natural Background Sources of Radiation

Natural background radiation is the largest contributor (about 300 mrem/yr) to an individual's total radiation dose. The main sources of natural background radiation are:

- Radon, a naturally occurring gas.
- Cosmic radiation, that is, radiation from the sun and outer space.
- Radioactive elements, such as thorium and uranium, present in the earth s crust (terrestrial radiation).
- Radioactive elements, such as potassium-40, present in the human body.

3.2 Human-made Sources of Radiation

Human-made sources of radiation contribute to the remainder of the annual average radiation dose (about 60 mrem).

Examples of human-made sources of radiation include:

- Medical x-rays and nuclear medicine.
- Consumer products such as smoke detectors, lantern mantles, and tobacco.
- Fallout from nuclear weapons testing.
- Nuclear reactors for power generation.

The annual radiation dose due to human-made sources of radiation is not the same for everyone. For example, individuals who smoke or undergo medical x-ray procedures may receive higher annual radiation doses than those who do not.

3.3 Comparison of Radiation Doses

As stated earlier, the dose from natural background radiation is approximately 300 mrem/yr and is by far the largest contributor to an individual's total radiation dose. To illustrate this, the radiation doses received from some of the main natural background and human-made sources of radiation are compared in Table 1.

Note: *Smoking is not included in the comparison of radiation doses. The average radiation dose from smoking is estimated to be approximately 1,300 mrem/yr.*

Table 1 Comparison of Radiation Doses

Natural Background Sources	mrem/yr
Radon	200
Cosmic	30
Terrestrial	30

Human-made Sources	mrem/yr
Medical	53
Round-trip US by air	5
Building material	3.6
Natural-gas range	0.2
World-wide nuclear fallout	<1
Smoke detector	0.001

4. Ionizing and Non-ionizing Radiation

As stated earlier, radiation is energy transferred through space and matter. Radiation is emitted as waves or particles from unstable atoms.

4.1 Atoms

All matter is composed of atoms. Atoms are made up of three basic particles: protons, neutrons, and electrons.

- Stable atoms do not contain excess energy.
- Unstable atoms contain excess energy. They release this excess energy in the form of radiation until they reach a stable form called the ground state.

4.2 Ionizing Radiation

Radiation that has enough energy to eject electrons from electrically neutral atoms, leaving behind charged atoms or ions, is known as *ionizing radiation*. From the standpoint of human health and safety, ionizing radiation is of most concern since it can damage atoms. Damaged atoms in living cells engage in chemical reactions that interfere with the normal processes of cells.

There are four basic types of ionizing radiation:

- Alpha particles
- Beta particles
- Neutron particles
- Gamma rays (X-rays)

Note: *Gamma rays are identical to x-rays except in their place of origin. X-rays are generated in collisions between electrons and atoms, whereas gamma rays are emitted spontaneously from the nuclei of unstable atoms.*

Alpha, beta, and gamma, and X-rays are all generated at UCSC.

4.3 Non-ionizing Radiation

Non-ionizing radiation does not have enough energy to eject electrons from electrically neutral atoms. Even though non-ionizing radiation is capable of causing biological damage, it is not a radiological concern since it does not damage atoms.

Types of non-ionizing radiation include:

- Ultraviolet (could ionize)
- Visible light
- Infrared
- Microwaves
- Radio waves
- Heat

4.4 Radiation and Radioactive Contamination

A common misconception is that individuals exposed to radiation will become contaminated. Exposure to radiation (a type of energy) does not result in contamination. Radioactive contamination occurs only if individuals come in contact with radioactive material, such as radioactive dust, and particles from the radioactive material adhere to them.

RAT-qualified personnel (non-radiological workers) at UCSC are not permitted to handle radioactive material if doing so could result in an annual radiation dose that is greater than 100 mrem. Only trained and qualified Radiation Users (radiological workers) may handle radioactive material if doing so could result in an annual radiation dose that is greater than 100 mrem.

5. Risks in Perspective

5.1 Dose Limit

The UCSC and federal dose limit for non-radiological workers and visitors is 100 mrem/yr.

For occupational radiation exposure to radiological workers the federal dose limit is 5,000 mrem/yr. The UCSC administrative dose limit for occupational radiation exposure to radiological workers is 500 mrem/yr.

5.2 Occupational Radiation Exposure

The risks associated with occupational radiation exposures at UC campuses, such as UCSC, are very small when compared to the risks associated with radiation exposures for other occupations.

The average annual radiation doses associated with various occupations, including working at UCSC, are compared in Table 2.

Table 2 Average Annual Radiation Dose for Various Occupations

Occupation	Dose (mrem/yr)
Airline flight crew member	About 1,000
Nuclear power plant worker	700
Grand Central Station worker	120
Medical personnel	70
UCSC radiation worker	<10

5.3 Chronic Radiation Dose

A chronic radiation dose refers to small amounts of ionizing radiation received over a long period of time. Examples of chronic radiation doses are those received from natural background, medical, and occupational sources of radiation.

5.4 Potential Effects From Chronic Radiation Doses

Adverse health effects from chronic radiation doses may occur in the exposed individual or in the future children of the exposed individual.

5.4.1 Exposed Individual

There is a slight risk that cancer may be caused by chronic radiation doses. This risk is small when compared to the total cancer risk.

5.4.2 Future Children of the Exposed Individual

Genetic effects caused by radiation exposure have been studied extensively in plants and animals including humans, but there have been no genetic effects clearly caused by radiation observed in human populations.

5.5 Comparison of Occupational Radiation Exposure Risk and Other Risks

In Table 3 and Table 4, the risk of working with or around sources of ionizing radiation is compared with other risks encountered in everyday life.

Table 3 Loss of Life Expectancy Due to Various Causes

Occupation	Days of Life Lost)
Being an unmarried male	3,500
Smoking (1 pack/day)	2,250
Being an unmarried female	1,600
Being a coal miner	1,100
Being 25% overweight	777
Drinking alcohol (US average)	365
Being a construction worker	227
Driving a motor vehicle	207
All industry	60
Being exposed to 100 mrem/yr of radiation for 70 years	10
Drinking coffee	6

Table 4 Activities with One-in-a-Million Chance of Causing Death

Receiving 10 mrem of radiation (cancer)
Smoking 1.4 cigarettes (lung cancer)
Eating 40 tablespoons of peanut butter (liver cancer)
Eating 100 charcoal broiled steaks (cancer)
Spending 2 days in New York City (air pollution)
Driving 40 miles in a car (accident)
Flying 2,500 miles in a jet (accident)
Canoeing for 6 minutes (accident)

5.6 Benefit Versus Risk

Accepting the potential risks of working with ionizing radiation is a personal matter. Each individual must weigh the benefits against the potential risks. Upon accepting the risks, each individual must respect radiation, and work safely with and around it.

6. ALARA Principle – As low as reasonably achievable

UCSC is firmly committed to having a Radiation Safety Program of the highest quality. Therefore, maintaining occupational exposures to radiation and radioactive material as low as reasonably achievable is an integral part of all UCSC activities.

There are three basic practices for maintaining exposures to radiation and radioactive material as low as reasonably achievable:

- **Time -** Reduce the amount of time spent near a source of radiation.

- **Distance** -Stay as far away from the source as possible. Radiation exposure decreases rapidly as you move away from the source.
- **Shielding** -Surround the source with shielding. Appropriate shielding reduces radiation exposure.

7. Radiological Controls

In support of the ALARA principle, radiological controls are in place to protect personnel from exposure to radiation and radioactive material. These controls include a radiological identification system used to designate radiological areas and radioactive materials. The UCSC Radiation Safety Manual contains complete descriptions of the rules and requirements for radiological controls at UCSC.

The EH&S Department measures radioactivity, designates radiological areas, and ensures that UCSC complies with rules and requirements for radiological controls.

7.1 Radiological Identification System

All radiological areas are identified by one or more of the following types of postings:

- Yellow signs with the standard radiation symbol in magenta or black.
- Yellow and magenta rope, tape, chains, or other barriers.

Examples of some of the types of radiological signs at UCSC are shown in Appendix A.

All radioactive material is identified by one or more of the following types of postings:

- Yellow tags and labels with the standard radiation symbol in magenta or black.
- Yellow plastic wrapping or labeled containers.

The EH&S Department designates those individuals who may handle radioactive sealed sources.

In the unlikely event that you discover radioactive material that appears to be unattended (such as radioactive material that has been discarded in a trash receptacle, or is uncontained outside or in a building corridor), you should:

1. Not touch or handle the material.
2. Warn others to stay away from the area.
3. Guard the area and have someone immediately notify Radiation Safety personnel in the EH&S Department at x9-2553. Off hours, notify Dispatch at 911.
4. Await the arrival of Radiation Safety personnel.

7.2 Radiological Areas

Radiological areas contain a potential or known radiological hazard. Radiological areas are designated by postings to alert personnel of potential or known radiological conditions and to help minimize radiation exposures.

7.2.1 Radiation Controlled Areas

Controlled Areas have been established to protect personnel from exposure to radiation and radioactive contamination. Other types of radiological areas can exist within Controlled Areas.

Controlled areas include:

-
-
-
-
-

7.2.2 Radioactive Material Use Areas

Radioactive material use areas are areas in which the potential exists for radioactive contamination due to the presence of unencapsulated or unconfirmed radioactive material. All of the laboratories at UCSC that use radioactive materials are labeled “Caution Radioactive Materials” on the entry doors.

8. Emergency Procedures

All personnel must be familiar with the emergency procedures for their building or area. In particular, personnel must know the evacuation route and where to assemble after an emergency evacuation from the building or area. All occupied areas at UCSC are equipped with evacuation alarms or signals, and posted evacuation routes.

Report accidents, such as a hazardous material spill or a radiation release, to the Dispatch at 911 and to the appropriate department or group.

In case of emergency call 911 from any UCSC phone.

9. Personnel Responsibilities for the ALARA Program

All personnel, not just radiological workers, are responsible for maintaining exposures to radiation and radioactive material as low as reasonably achievable.

Personnel at UCSC facilities must:

- Obey all radiological postings.
- Comply with all radiological and safety rules.
- Stay out of radiological controlled areas unless escorted or specially trained.

- Report unusual radiological situations.

  Unusual radiological situations may include, for example, finding a compromised radiological barrier or radioactive material outside a radiation use area.

- Know how to contact Radiation Safety personnel in the EH&S Department.
- Comply with all emergency procedures.
- Keep exposures to radiation and radioactive material as low as reasonably achievable.

10. Summary

You must be aware of potential radiological risks and take appropriate protective measures to minimize them. Through an enhanced awareness of radiological risks and a sense of personal responsibility for minimizing those risks, you can contribute to maintaining exposures to radiation and radioactive material as low as reasonably achievable.

11. Evaluation

You will be asked to complete an exam which consists of 10 multiple-choice questions on the material covered in RAT. The exam is included at the end of this document is open book.

A Radiological Signs

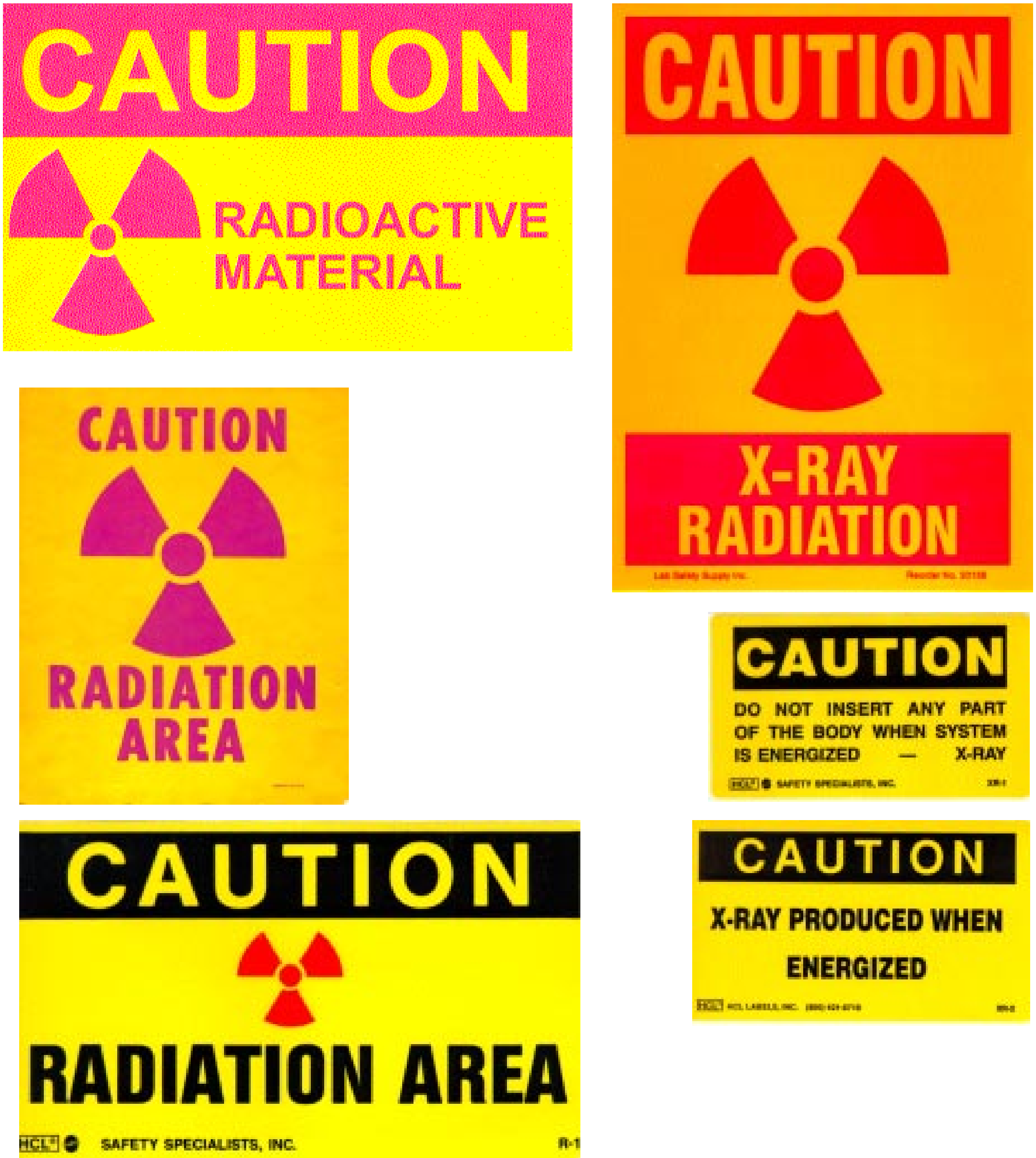

Figure A-1 Examples of some of the types of radiological signs at UCSC

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B Radiation Awareness Exam

1. Circle three main natural background sources of radiation in the list below.

    A. Cosmic radiation
    B. Nuclear reactors
    C. Radon
    D. Medical x-rays
    E. Earth's crust (terrestrial radiation)
    F. Fission
    G. Accelerators

2. Circle the best answer for the following question. What is one of the main biological effects caused by chronic radiation dose?

    A. An increased risk of developing cancer
    B. Temporary hair loss
    C. Accelerated aging
    D. High blood pressure

3. Circle the symbol that is used to identify radiological hazards and material.

    A. ∑ B. ☯ C. ☢ D. ☣

4. The department at UCSC that measures radioactivity, designates radiological areas and ensures that UCSC complies with rules and requirements for radiological controls is:

    A. The Chancellor's Office
    B. Environmental Health and Safety (EH&S)
    C. Division of Natural Sciences
    D. Human Resources

5. In the unlikely event that you discover radioactive material that appears to be unattended (such as radioactive material that has been discarded in a trash receptacle, or is uncontained outside or in a building corridor), what should you do?

    A. Pick up the material and examine it more closely, then contact EH&S with a complete description.
    B. Ask a bystander to help you to transport the material to the EH&S office
    C. Do not touch the material, warn others to stay away, guard the area and send someone to contact EH&S.
    D. Leave the material where you found it and go to call EH&S.

6. The whole body radiation dose limit for non-radiological workers and public visitors to the campus is

   A. 100 mrem/yr
   B. 500 mrem/yr
   C. 1,000 mrem/yr
   D. 5,000 mrem/yr

7. Three type of ionizing radiation found at UCSC are

   A. Karma fields, auroras and transcendental vibes
   B. Gamma rays, photon torpedoes and quasar particles
   C. Microwaves, radio waves and ultra sound
   D. Alpha particles, beta particles and gamma rays

8. Three methods you can use to protect yourself from radiation are (circle three)

   A. Wearing dosimetry
   B. Time
   C. Remain electrically grounded
   D. Distance
   E. Sheilding
   F. Using lock-out tag-out procedures

9. Fill in the blank in the following statement: Radiation is ________ transferred through space and matter.

   A. Energy
   B. Force
   D. Atoms
   E. Sound waves

10. Radiation has both benefits and risks.

   A. True
   B. False