(Part 3 of 3)

General Employee Radiological Training

Student's Guide

Coordinated and Conducted
for the
Office of Health, Safety and Security
U.S. Department of Energy

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TERMINAL GOAL:

Upon completion of this training, the participant will be able to DISCUSS (1) the hazards associated with radiological areas and radioactive material, (2) his/her limitations as a trained general employee during access to or work in the controlled areas, and (3) his/her responsibilities for complying with radiological requirements, including his/her expected response to abnormal radiological events or emergencies.

ENABLING OBJECTIVES:

The participant will be able to:

EO1 IDENTIFY basic radiological fundamentals and radiation protection concepts.

EO2 IDENTIFY the relative risks of exposure to radiation and radioactive materials, including prenatal radiation exposure.

EO3 IDENTIFY engineered and administrative controls, limits, policies, procedures, alarms, and other measures implemented at the facility to control doses.

EO4 IDENTIFY individual rights and responsibilities as related to implementation of the radiation protection program (including the ALARA Program).

EO5 IDENTIFY actions implemented to control doses under emergency conditions.

EO6 IDENTIFY exposure reports or other exposure data which may be provided and how to request these reports.

Prerequisites:

None

I. LESSON INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Course Overview

General Employee Radiological Training (GERT) is provided to all site employees who receive occupational exposure during access to controlled areas at a DOE site or facility or who are permitted unescorted access to controlled areas. These individuals may routinely enter the controlled area and encounter radiological barriers, postings, radiation producing devices or radioactive materials. Employee responsibilities for observing and obeying radiological postings and procedures are emphasized throughout this training.

- Additional training beyond GERT is required for the employees who are identified as radiological workers. Every employee, both radiological worker and non-radiological worker, must play an active part in maintaining exposures to radiation and radioactive materials within DOE limits and As Low As Reasonably Achievable (ALARA).

- GERT qualified individuals should be able to place the risks associated with working at a nuclear facility in perspective with other risks that we take in our everyday life.

C. Introduce Objectives

1. Terminal Goal
2. Enabling Objectives

II. LESSON

A. Non-ionizing and Ionizing Radiation (EO1)

Radiation is energy emitted through space and matter. This energy release is in the form of rays or particles and is emitted from unstable atoms or various radiation-producing devices, such as televisions and X-ray machines.

1. Atoms

   The elements that make up all matter are composed of atoms. Atoms have three basic particles: protons, neutrons and electrons.

   a. Stable atoms

      Most atoms are stable and do not emit excess energy

   b. Unstable atoms

      Unstable atoms emit excess energy. This energy is called radiation.

2. Ionizing radiation

   Ionizing radiation has enough energy to remove electrons from electrically neutral atoms.

- There are four basic types of ionizing radiation; alpha particles, beta particles, neutrons and gamma rays.

3. Non-ionizing radiation

   Non-ionizing radiation does not have enough energy to remove an electron from an atom.

   - Types of non-ionizing radiation include: Microwaves, radio waves, visible light, heat, and infrared radiation.

   Non-ionizing radiation is not addressed further in this training.

4. Radioactive Contamination

   Contamination is uncontained radioactive material in an unwanted location.

5. Comparison of radiation and radioactive contamination

   Exposure to radiation does NOT result in contamination of the worker. Only in the case of an individual coming in contact with radioactive contamination would there be a potential for the individual's skin or clothing to become contaminated.

B. Sources of Radiation (EO1)

People have always been exposed to radiation. Radiation, simply defined, is energy emitted through space and matter. We are exposed to radiation from naturally-occurring sources in our environment, man-made sources, and even from materials inside our bodies.

- The average annual radiation dose to a member of the general population is about 620 millirem/year. This amount is a combination of both natural background and man-made sources of radiation.

1. Natural background sources of radiation

   Natural background radiation is by far the largest contributor (about 310 millirem/year) to radiation doses. The main sources of natural background radiation are listed below:

   a. Cosmic radiation - radiation from the sun and outer space, varies with altitude, (e.g., Denver would be higher than Miami).

   b. Radon - (the principal source of background radiation exposure.) A gas from naturally-occurring uranium in the soil.

   c. Terrestrial radiation from naturally-occurring radioactive material found in the earth's crust, such as uranium found in rocks and soil.

   d. Materials present in our bodies. These come from naturally-occurring radioactive material present in our food, such as Potassium-40.

2. Man-made sources of radiation

   Man-made sources of radiation, where the radiation is either produced or enhanced by human activities, contribute to the remainder of the annual average radiation dose (approximately 310 millirem). Man-made sources include the following:

   a. Medical uses such as X-rays and nuclear medicine tests or treatments

   b. Tobacco products

   c. Building materials

3. Comparison of annual radiation doses from selected sources

Examples of the annual radiation dose from selected sources of radiation exposure are as follows:

• Cigarette smoking (1 pack a day)	1300
• Radon	200
• Medical exposures (average)	300
• Terrestrial radiation (rocks and soil)	28
• Cosmic radiation (sun and space)	28
• Round trip US by air	5
• Building materials	7
• World wide fallout	<1
• Domestic water supply	5
• Natural gas range	0.2
• Smoke detectors	0.001

C. Risks in Perspective (EO2)

Radiation comes from background and man-made sources. We receive approximately 620 millirem/year. This is separate from, and in addition to, occupational exposure received on the job. The potential risks from occupational exposure can be compared to other risks we accept everyday.

1. Occupational dose

The risks associated with occupational doses are very small and considered acceptable when compared to that of other occupational health risks (i.e., being a coal miner or construction worker).

a. Radiation dose limit (EO3)

The DOE whole body radiation dose limit for general employees is 5000 millirem/year.

b. Administrative Control Levels

Sites typically have administrative control levels below the DOE limit. (Insert facility-specific limits). Individuals who complete only this GERT training are not expected to receive more than 100 millirem/yr occupational dose.

c. Average annual radiation dose for various occupations

DOE radiological workers who received measurable radiological doses had an average dose of 63 millirem in 2006. This amount is compared to other occupations.

Occupation	millirem/year
• Airline flight crew member	400-600
• Nuclear power plant worker	300
• Medical personnel	70

2. Potential health effects from exposure to radiation. (EO2)

Biological effects from exposure to radiation may occur in the exposed individual or in the future children of the exposed individual.

a. Exposed individual

There is scientific evidence for health effects (primarily cancer) from radiation doses well above the annual limit for occupational exposure (greater than 10,000 millirem) received under a short duration. The risks associated with occupational doses are very small and considered acceptable when compared to other occupational and non-occupational risks.

For very large doses received over a short period of time (referred to as an acute exposure), prompt effects (i.e., effects that appear shortly after the exposure) may result. These doses are received typically under accident conditions such as the firefighters responding to the Chernobyl accident. These effects may include reddening of the skin, vomiting, hair loss, or even death.

Table 1
Prompt Biological Effects

Dose (rad)	Effect
0-25	None detectable through symptoms or routine blood tests.
25-100	Changes in blood.
100-300	Nausea, anorexia.
300-600	Diarrhea, hemorrhage, and possible death

For small doses received over a long period of time (referred to as a chronic exposure), delayed effects (i.e., effects that appear long after the exposure) may result. These effects include an increased risk of cancer. Although there is no scientific evidence for health effects (such as cancer) from radiation doses well below the annual limit for occupational exposure, we assume that any exposure, no matter how low, has an associated risk of health effects (such as cancer).

b. Future children of the exposed individual

Heritable effects (i.e., genetic changes to the parents sperm and/or eggs that results in an observed effect in their offspring) from ionizing radiation have been found in plants and animals, but have not been observed in human populations. The risk of heritable effects from ionizing radiation is considered to be very small when compared to other naturally-occurring heritable effects and difficult to detect over the natural background rate of birth defects.

3. Prenatal effects (EO2)

A developing embryo/fetus is especially sensitive to ionizing radiation because of its rapidly dividing cells . Radiation is one of many agents that may cause harm to the embryo/fetus (i.e., chemicals, heat, etc.). Significant radiation doses (>10,000 millirem) to the embryo/fetus may increase the chances that the child will develop conditions such as a small head size, lower birth weight, and/or slower mental growth.

a. Possible effects

Radiation dose to the embryo/fetus may increase the chances that the child will develop conditions such as slower growth or mental development or childhood cancer. These effects can also be caused by many other hazards in our environment.

b. **DOE Limits** (EO2)

The risk of these effects occurring is minimized by having special protective measures for the embryo/fetus of a declared pregnant woman. This is a worker who voluntarily notifies her employer, in writing, that she is pregnant and wishes to invoke the limit for the embryo/fetus of 500 millirem for the period from conception to birth.

It is the recommendation of DOE's Radiological Control Standard that the employer provide the option for a reassignment of work tasks to a declared pregnant worker, without loss of pay or promotional opportunity, such that further occupational radiation exposure is unlikely.

4. Comparison of risks of occupational radiation doses with other health risks (EO2)

The risk of working with or around sources of ionizing radiation can be compared to the risks we accept as part of everyday life.

These data address the expected effect on the average life span of a large population of individuals subjected to the risk factor/behavior in question.

a. Loss of life expectancy due to various causes (Expressed in days)

Health Risk	Estimated Days of Life Expectancy Lost, Average
• Being unmarried male	3500
• Smoking (1 pack/day)	2250
• Being unmarried female	1600
• Being a coal miner	1100
• 15% overweight	777
• Alcohol (US average)	365
• Being a construction worker	227
• Driving a motor vehicle	205
• All industry	60
• Radiation 100 mrem/yr (70 yr)	10
• Coffee (US Average)	6

b. The following activities create a risk of 1 in a million chances of dying
   - Smoking 1.4 cigarettes (lung cancer)
   - Eating 40 tablespoons of peanut butter
   - Eating 100 charcoal broiled steaks
   - Spending 2 days in New York City (air pollution)
   - Driving 40 miles in a car (accident)
   - Flying 2500 miles in a jet (accident)
   - Canoeing for 6 minutes
   - Receiving 2.5 mrem of radiation (cancer)

5. Benefit versus risk (EO2)

   In summary, the estimated risk associated with occupational radiation dose, when compared to other occupational and non-occupational risks , is considered to be within the normal range of risk tolerance by national and international scientific groups who have studied these issues. Clearly though, the acceptance of risk is a personal matter that each individual must make for themselves and is best made with accurate information.

D. Radiological Controls (EO3)

Radiological controls are established to protect individuals from unplanned or uncontrolled exposure to radiation and from ingestion, inhalation, or absorption of radioactive material. These controls include, but are not limited to, a unique system of identifying radioactive materials using certain colors and/or symbols and radiological postings, implementation of controls to maintain radiation exposures As Low As Reasonably Achievable (ALARA), and training of workers on radiation safety and emergency response.

1. Radiological identification system(s)

   Only specially trained/qualified workers are permitted to enter areas controlled for radiological purposes or handle radioactive material. All areas or material controlled for radiological purposes are identified by one or more of the following.

   a. Signs that have the standard radiation symbol colored magenta or black on a yellow background are used.

b. Yellow and magenta rope, tape, chains or other barriers are used to designate the boundaries of posted areas.

c. Tags and labels with a yellow background and either a magenta or black standard radiation symbol are used to identify radioactive material.

"CAUTION-RADIOACTIVE MATERIAL"

d. Yellow plastic wrapping, yellow plastic bags and labeled containers are used to package radioactive material.

e. Designated areas are used to store radioactive material.

f. Protective clothing used to prevent personnel contamination is yellow and/or distinctively marked.

g. Potentially contaminated tools, and portable equipment used for radiological work are marked.

2. Postings (EO3)

Postings are used to alert personnel of a potential or known radiological condition and to aid them in controlling exposures and preventing the spread of contamination.

a. Controlled Area

1) Controlled areas are areas established around radiological areas to manage personnel access to the radiological areas and to provide warning of the existence of radiological hazards in the area.

2) This training will permit you unescorted entry into the controlled area.

b. Radioactive Material Area

1) This is an area within a controlled area where radioactive material in excess of specified quantities is located.

2) This training alone typically will not permit you unescorted access to these areas.

c. Radiological Areas

1) There are radiological areas established within the controlled area.

"Radiation Area, High Radiation Area, and Very High Radiation Area," identify areas where the hazard is exposure to ionizing radiation and the different areas designate increasing levels of hazard (increasing levels of dose rates).

"Contamination Area" and "High Contamination Area" identify areas where the hazard is from accessible loose radioactive

contamination. Protective clothing is used to prevent contamination of personnel.

"Airborne Radioactivity Area" indicates the potential for radioactive contamination in the air. Protective clothing and respiratory protection may be used to protect personnel from getting contamination on their skin or inhaling the contamination."

2) This training typically will NOT permit you to enter these areas. Personnel trained at the GERT level are typically not permitted to enter these areas unless escorted and/or trained.

d. Radiological Buffer Area

1) A radiological buffer area may be established within the controlled area to provide a secondary boundary for minimizing exposures to radiation or contamination.

2) This training typically does NOT qualify you to enter the radiological buffer area unless you are continuously escorted. (Insert facility-specific requirements.)

E. ALARA Program (EO4)

1. ALARA Concept

The DOE and this Site are firmly committed to having a Radiological Control Program of the highest quality. Therefore, maintaining

occupational dose from radiation and radioactive materials As Low As Reasonably Achievable (ALARA) is an integral part of all site activities. The purpose of the ALARA program is to control radiation doses in consideration of the overall benefit of the activity causing the dose.

There are a few basic practices used to maintain exposure to radiation ALARA.

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

b. Distance-Stay as far away from the source as possible.

c. Shielding-Shielding is placed between workers and the source.

d. Source elimination or reduction: Eliminate the source, if possible (e.g., flushing the pipeline) or substitute with non-radioactive substance.

e. Radioactive contamination is controlled using engineered ventilation, containments, decontamination, and lastly, personnel protective equipment to minimize the potential for inhalation, ingestion, or absorption of radioactive material.

F. Emergency Procedures (EO5)

In the unlikely event that a radiological incident occurs, it is important for each employee to know the emergency procedures.

1. Abnormal Conditions

If you discover radioactive material that is not where it belongs, (e.g., discarded in a clean trash receptacle, outside of radiological areas, or loose outside or in a building corridor), you should take the following actions:

1) Do not touch or handle the material.

2) Warn other personnel not to approach the area.

3) Guard the area, moving a safe distance, (see following ALARA Section) and have someone immediately notify Radiological Control personnel.

4) Await Radiological Control personnel.

These actions are taken to minimize exposure to radiation and potential contamination of yourself and others.

2. Facility Alarms

(Insert facility specific information)

3. Facility Evacuation Procedures

(Insert facility specific information)

G. Employee Responsibilities (EO4)

All employees have an impact on maintaining exposures to radiation and radioactive material ALARA. Work planning is a key component of the ALARA program to ensure each of the controls listed below is applied as appropriate to the work being performed. Some of the employee responsibilities are listed.

1. Obey all signs/postings.

2. Comply with all radiological and safety rules.

3. Do not enter any radiological area unless escorted. If visiting a radiological area with an escort:

    a. obey the instructions of your escort.

    b. obtain and properly wear dosimeters as instructed by procedure, Radiological Control personnel, or your escort.

    c. utilize ALARA techniques to control your exposure.

4. Be alert for and report unusual radiological situations.

    Unusual situations may include finding radioactive material outside a designated area or finding a compromised radiological barrier.

5. Know where and/or how to contact Radiological Control personnel in your work area.

6. Comply with emergency procedures for your work area.

7. Keep exposures to radiation and radioactive materials ALARA and know the Administrative Control Levels and Dose Limits.

8. Know your cumulative and annual dose.

H. Monitoring (Dosimetry)

Since radiation cannot be detected with the human senses, special detection devices must be used. Workers should become familiar with the equipment and devices used to measure and detect radiation and radioactive material, as applicable to their job functions. Monitoring is only required if you are likely to receive a dose in excess of 100 millirem in a year. Therefore, it is possible based on your job function and location that you will not be provided a dosimeter.

(Insert facility-specific information)

Some workers are monitored for intakes of radioactive material (e.g., inhaling or ingesting radioactive material). This is typically done by either using an apparatus (e.g., whole body counter) to detect the material in the body or by analyzing a sample the individual provides (e.g., urinalysis).

I. Exposure Reports (EO6)

Although DOE and DOE contractor employees who are only trained at the GERT level are not expected to receive occupational dose above the monitoring threshold, they may be monitored for exposure in any case. This could occur during escorted entries into radiologically controlled areas or in other circumstances. Individuals who are monitored for exposure at DOE facilities have the right to request reports of that exposure as follows:

- Upon the request from an individual terminating employment, records of radiation exposure dose shall be provided by the DOE facility within 90 days. If requested, a written estimate of radiation exposure received by the terminating employee shall be provided at the time of termination.

- Each individual who is required to be monitored for radiation exposure at a DOE facility shall receive a report of that exposure on an annual basis.

Note: As previously discussed, individuals may be monitored with a dosimeter even though they are not required to be monitored. In this case an annual report is not required to be sent.

- Detailed information concerning any individual's exposure shall be made available to the individual upon request of that individual.

- When a DOE contractor is required to report to the Department, pursuant to Departmental requirements for occurrence reporting and processing, any exposure of an individual to radiation and/or radioactive material, or planned special exposure, the contractor shall also provide that individual with a report on his/her exposure data included therein.

Such a report shall be transmitted at a time not later than the transmittal to the Department.

III. SUMMARY

It is important to understand what radiation and radioactive materials are and to recognize the postings associated with radiological work. All employees are responsible to comply with the safety rules and to access only areas they are authorized to enter. Through an enhanced awareness of this topic, each employee may contribute to safe practices in the workplace.

References :

1. DOE Radiological Control Standard, [DOE-STD 1098-99, Ch. 1]
2. "Guide to Good Practice in Radiation Protection Training," ORAU 88/H-99
3. US NRC Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure" June 1999
4. US NRC Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure," February 1996
5. DOE Occupational Radiation Exposure 2005 Report
6. DOE 10 CFR 835, "Occupational Radiation Protection."

DOE-HDBK-1131-2007

CONCLUDING MATERIAL

Review Activities:

DOE	Ops Offices
NA	AL
HS	CH
EM	ID
SC	NV
NE	OR
LM	RL
	SR

Preparing Activity:

DOE HS-11

Project Number:

TRNG-0057

Area/Site Offices	National Laboratories
Amarillo	BNL
Ashtabula	LANL
Carlsbad	LLNL
Columbus	PNNL
Fernald	Sandia
Kansas City	FNL
Kirtland	SRNL
Los Alamos	
Miamisburg	
Pinellas	
West Valley	
Y-12	