



ENVIRONMENT, SAFETY & HEALTH DIVISION

General Employee Radiological Training Study Guide

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Acronyms and Abbreviations

ACR	Accelerator Control Room
ALARA	as low as reasonably achievable
BCS	beam containment system
BSOIC	beam shut-off ion chamber
BSY	Beam Switchyard
CA	controlled area
DOE	Department of Energy
DREP	Dosimetry and Radiological Environmental Protection
EOIC	engineering operator-in-charge
ESA	End Station A
ESB	End Station B
ESH	environment, safety, and health
GERT	General Employee Radiological Training
LCLS	Linac Coherent Light Source
linac	linear accelerator
MeV	mega-electron volt: 1 million eV
mR	milliroentgen
NCRP	National Council on Radiation Protection and Measurements
OHC	Occupational Health Center
POC	point of contact
PPS	personnel protection system
R	roentgen
RAM	radioactive material
RCA	radiologically controlled area
rem	roentgen equivalent man
RMA	radioactive material area
RMMA	radioactive material management area
RP	Radiation Protection
RPFO	Radiation Protection, Field Operations
RWP	radiological work permit

RWT	radiological worker training
SI	International System of Units
SLAC	SLAC National Accelerator Laboratory
SPEAR	Stanford Positron Electron Accelerating Ring
SSRL	Stanford Synchrotron Radiation Lightsource
Sv	sievert
VUE	Visitor User Employee (Center)

1 Introduction

Welcome to SLAC National Accelerator Laboratory's General Employee Radiological Training (GERT) (GERT).

The GERT course ([ESH Course 115](#)) was developed by the Radiation Protection (RP) Department to introduce you to the radiation safety controls and requirements in place at SLAC.

Understanding the requirements you will be learning about will help meet the Department of Energy (DOE) and SLAC's workplace safety goal: occupational radiation doses that are as low as reasonably achievable (ALARA).

SLAC is committed to keeping radiation doses to the public, workers, and the environment ALARA and far below occupational exposure limits.

1.1 Who Must Become GERT-qualified

You must complete GERT if you need unescorted access to areas that are posted as a

- **Controlled area (CA).** An area where access is managed to protect individuals from exposure to radiation and/or radioactive materials
- **Radiologically controlled area (RCA).** A controlled area where a dosimeter is required for entry



Figure 1-1 GERT Is Required to Enter These Areas

GERT training will help you identify these areas as well as areas that you must not enter unless you have completed the required level of additional radiological worker training (RWT).

1.2 GERT Qualification Requirements

1.2.1 Prerequisites

The prerequisite for GERT is the appropriate safety orientation:

- ESH Course 219, Environmental Safety and Health Orientation ([ESH Course 219](#)). For SLAC employees, users, and service subcontractors
- ESH Course 375, Construction Safety Orientation ([ESH Course 375](#)). For construction subcontractors

1.2.2 Initial Qualification

If you are new to SLAC, you must complete all sections of the [web-based GERT training](#) and score at least 80 percent on the multiple choice exam. In addition, you must demonstrate that you know how to wear a dosimeter properly if you request one.

Note Instruction in another language may be arranged for groups under certain circumstances.

Upon successful completion, your SLAC identification badge will indicate your GERT qualification in the lower left corner. Note the expiration date is also indicated (month, day, and year). You must carry your badge to enter controlled areas and radiologically controlled areas.



Figure 1-2 SLAC ID Badge with GERT Qualification

1.2.3 Requalification

When your GERT qualification expires at the end of two years you may repeat the web-based course or take a multiple choice challenge exam. To help prepare to pass the exam, use the most current version of this [study guide](#).

You may take the exam by computer. As with the initial training, the minimum score to pass is 80 percent.

1.3 GERT Objectives

Upon completion of GERT you will

- Understand basic radiological fundamentals, hazards, and radiation protection concepts
- Have reviewed occupational exposure limits, SLAC's ALARA goals, and the relative risks of exposure to radiation and radioactive materials
- Be able to recognize radiological postings of areas you may enter and areas that require further training for entry

- Know when a dosimeter is required and how to obtain one
- Be aware of physical safety features that control exposures
- Know how to respond to a medical emergency in a controlled area, radiologically controlled area, and in radiological areas
- Know how to respond to an unusual radiological condition
- Understand your responsibilities with regard to complying with SLAC's radiological safety policy

1.4 Radiation Protection Department Contacts

The two Radiation Protection Department groups that GERT-qualified personnel will have the most contact with are

- Radiation Protection Field Operations (RPFO), ext. 4299
- Dosimetry and Radiological Environmental Protection (DREP), ext. 3793

For additional information on how to contact RP or to find out how we can help you meet requirements, be sure to visit the RP [web page](#). Also, you may find it helpful to explore the many links to RP resources as you work through each section of this guide.

2 Radiological Fundamentals

2.1 Learning Objectives

After completing this section you should have a basic understanding of

- Terms and concepts
- Non-ionizing and ionizing radiation types
- Naturally occurring and human-made radiation sources

2.2 Terms and Concepts

2.2.1 Atoms

The basic unit of matter is the *atom*. The atom is the smallest unit into which elements can be divided and still retain their unique chemical and physical properties.

The center of the atom is called the *nucleus*. It is composed of

- *Protons*, which are located within the nucleus and have a positive electrical charge
- *Neutrons*, which are located within the nucleus and have no electrical charge
- *Electrons*, which are located outside the nucleus and have negative electrical charge

2.2.2 Radioactivity

Most atoms are stable and do not emit radiation. Unstable atoms emit *radiation*, which, simply defined, is energy transferred through space and matter. Radiation can be classified as *non-ionizing* and *ionizing*.

Any material that emits ionizing radiation is called *radioactive material*.

2.2.2.1 Non-ionizing Radiation

Non-ionizing radiation does not have enough energy to eject electrons from atoms. It is, however, a safety concern, and additional safety training may be required if you work around certain non-ionizing radiation generating devices. Types of non-ionizing radiation include

- Visible light
- Infrared rays
- Microwaves
- Radio waves
- Heat

- Lasers

2.2.2.2 Ionizing Radiation

Radiation that has enough energy to eject electrons from atoms, leaving behind charged atoms or *ions*, is known as ionizing radiation. Common types of ionizing radiation include

- Alpha particles
- Beta particles
- Neutrons
- Photons (gamma rays, x-rays, and synchrotron radiation)

The operation of high energy machines such as accelerators and klystrons can produce prompt radiation and/or residual radiation.

- *Prompt radiation* is the type of radiation that occurs only when the machine is on and ceases as soon as the machine is shut off.
- *Residual radiation* will be created if a machine operates near or above 10 mega electron volts (MeV), as this is the energy threshold that generally *activates* material – that is, causes it to be radioactive.

An accelerator that operates at above 10 MeV is an example of a machine that produces both prompt and residual radiation. A klystron in the klystron gallery is an example of a machine that produces only prompt radiation because there is no residual radiation when the machine is turned off.

Ionizing radiation is of concern to human health and safety since it may damage living cells and may increase an individual's risk of developing cancer.

2.2.2.3 Effective Dose

The *effective dose* (also referred to in this document as *radiation dose* or simply *dose*) is a measurement of the radiation dose to the body.

In the US, the standard unit for radiation effective dose is the *rem*, which is the acronym for **roentgen equivalent man**. Because rem is a fairly large unit, dose received is normally expressed in thousandths of a rem, or millirem (mrem):

$$1 \text{ rem} = 1000 \text{ mrem}$$

The corresponding unit in the International System of Units (SI) is the *sievert (Sv)*. $1 \text{ Sv} = 100 \text{ rem}$.

2.2.2.4 Radioactive Contamination

Radioactive contamination is uncontained radioactive material in an unwanted location.

Radiation exposure results in a radiation dose but does not result in contamination unless one comes in contact with radioactive material (such as radioactive debris) and the particles adhere to the person.

2.3 Radiation Sources

Everyone is exposed to some amount of natural background radiation and radiation from human-made sources.

The average annual radiation dose for any person in the US from the combination of both naturally occurring and human made sources is about 620 mrem. Naturally occurring radiation contributes about 50 percent of the average annual dose, and the amount depends largely on geographic location. The average annual radiation dose has increased over the past decade due to an increase in exposure from medical procedures.

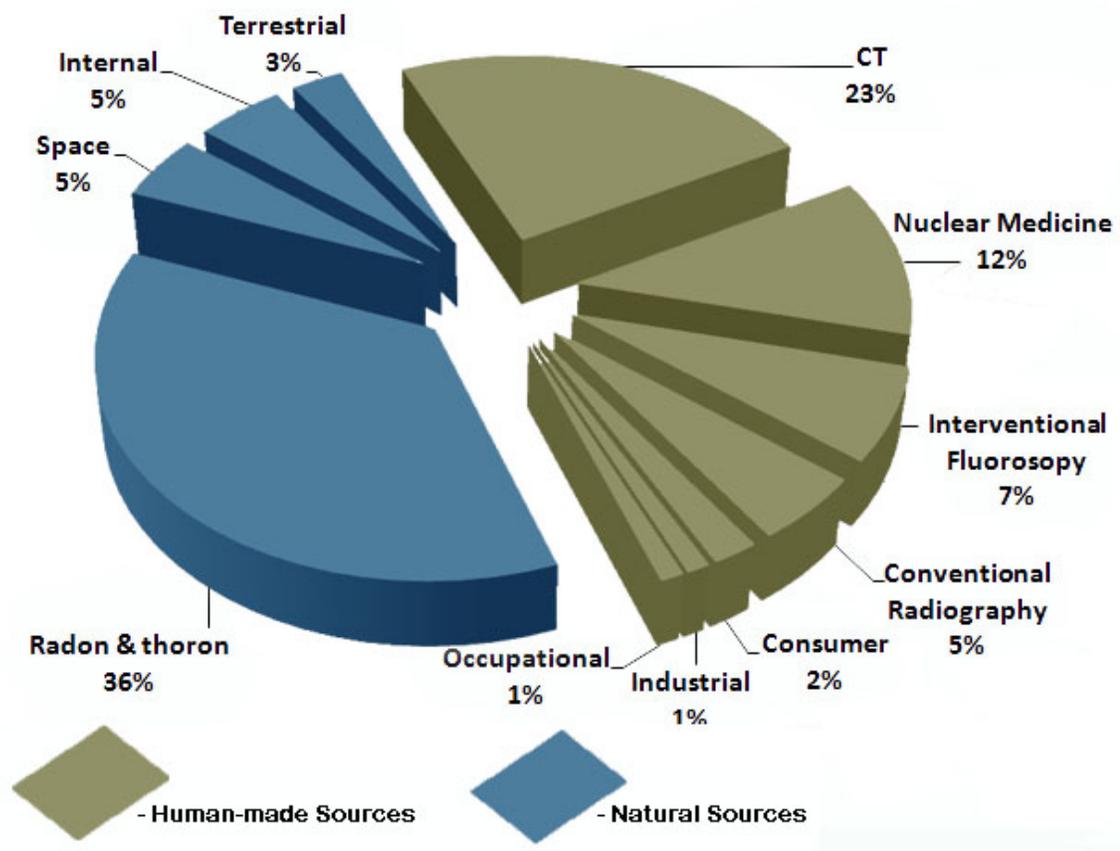


Figure 2-1 Contribution of Natural and Human-made Sources to the Average Annual Dose¹

The actual radiation dose received by any one person varies according to many factors, including where the person lives and if any medical and occupational doses are received.

¹ *Ionizing Radiation Exposure of the Population of the United States*, National Council on Radiation Protection and Measurements (NCRP), Report No. 160 (2009)

2.3.1 Natural Radiation Sources

The average annual radiation dose to the general population from natural sources is about 311 mrem.² Natural sources of ionizing radiation are all around; the main ones include

- Radon, a naturally occurring gas (the largest contributor)
- Cosmic radiation (radiation from the sun and outer space)
- Terrestrial radiation (radiation due to radioactive elements, such as thorium and uranium, present in the earth's crust)
- Radioactive elements that are naturally present in the human body (such as potassium-40)

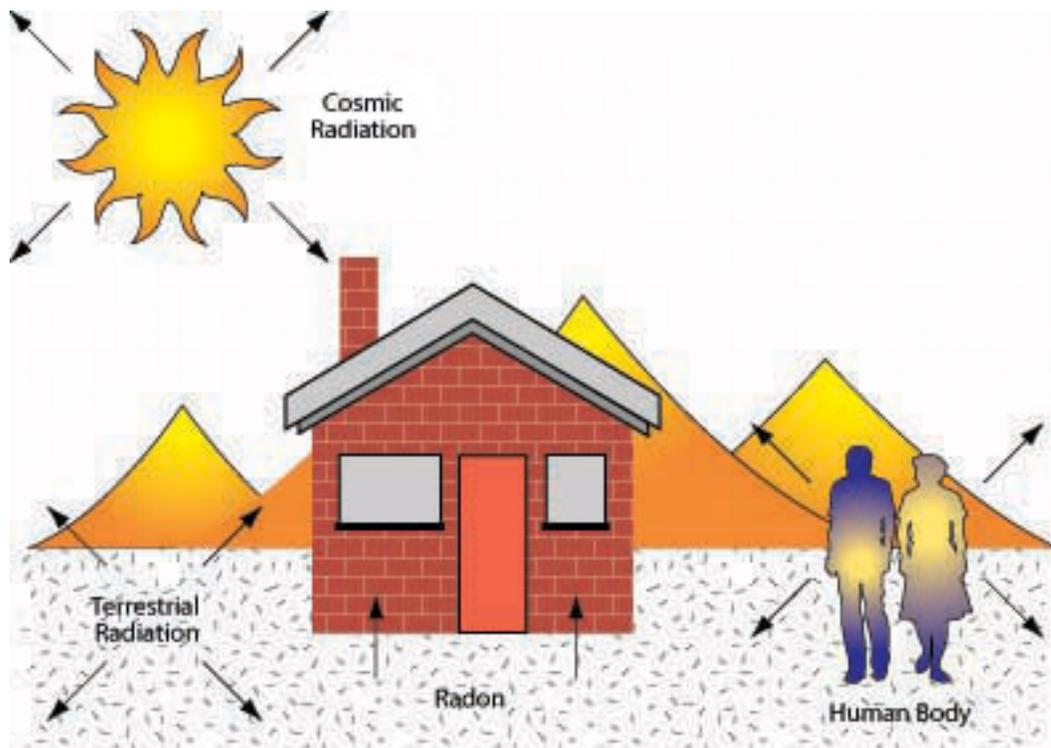


Figure 2-2 Radiation from Natural Sources

2.3.2 Human-made Radiation Sources

Human-made sources of ionizing radiation contribute the remaining 50 percent of the annual average radiation dose.

- Medical x-rays (223 mrem) and nuclear medicine (77 mrem) contribute the largest annual dose.
- Consumer products such as smoke detectors and lantern mantles contribute on average 13 mrem.

2 See footnote 1.

- Other sources include nuclear weapons testing fallout and nuclear power plant emissions (about 5 mrem).

2.3.3 Occupational Radiation Sources at SLAC

Sources of ionizing radiation at SLAC include

- Radioactive materials such as sealed sources and materials that have become radioactive due to accelerator operation
- Radiation generating devices such as klystrons and accelerators, which produce radiation while they are operating

3 Health Effects and Risks

3.1 Learning Objectives

After completing this section, you will know about

- The potential health effects of radiation
- Risks associated with occupational radiation doses
- SLAC's prenatal radiation exposure policy

3.2 Risks Associated with Radiation Exposure

Our knowledge of radiation health effects is mainly from cases where high doses of radiation were received over short periods of time. However, workers who receive any radiation tend to receive small doses over long periods of time. These are called chronic radiation doses. Persons who receive radiation doses may increase their risk of cancer.

The increased risk of cancer from occupational radiation exposure is small when compared to the overall cancer rate in the United States: the current lifetime risk of dying from any type of cancer is approximately 20 percent. If a person were to receive, over a lifetime, a cumulative radiation dose of 10,000 mrem to the entire body (above background), his or her estimated risk of dying from cancer would increase by about 0.5 percent. Factors that affect the level of risk include the radiation dose level and the area of the body that is exposed.

Radiation-induced genetic disorders that are passed on to future generations are called heritable effects. Such effects have been found in plants and animals but not in humans. The risk of heritable effects from ionizing radiation is considered to be very small when compared to the normal rate of genetic disorder.

3.3 Prenatal Radiation Exposure

The embryo-fetus is known to be more sensitive to radiation than adults due to the rapid division rate of developing cells. Radiation doses can increase the chances that the child will experience slower growth or mental development, or develop childhood cancer. These effects can also be caused by many hazards other than radiation.

Women who are or may be pregnant, or who are planning a pregnancy, have these options:

1. File a [Declaration of Pregnancy Form](#) with the Occupational Health Center (OHC). Once an official declaration has been made, you may request a mutually agreeable assignment of work tasks that make occupational radiation exposure unlikely during the gestation period. A reassignment will not result in loss of pay or promotional opportunity.

2. Withdraw a declaration by submitting a [Withdrawal of Declaration of Pregnancy Form](#). Upon submitting this form, you agree to lifting all additional dosage and work restrictions, and to removing all additional dosimeters.
3. Not formally declare your pregnancy (or your intention to become pregnant), and continue to work without the dose or work restrictions or additional dosimeters that apply to a declared pregnancy.

Your benefits, seniority, or potential for promotion will not be affected by the choice you make regarding a declaration. To obtain forms or more information about these options, contact the [OHC](#).

For more information, see [Radiological Safety: Personnel Dosimeter Requirements](#).

4 Dose Limits and Dosimeters

4.1 Learning Objectives

After completing this section, you will know about

- SLAC radiation dose limits
- Radiation doses at SLAC compared to other occupational doses
- Dosimeter requirements

4.2 SLAC Radiation Dose Limits

In the course of their work at SLAC, some people may receive occupational radiation above background levels.

The DOE sets dose limits for occupational radiation exposure to protect individuals at all of its facilities. In turn, SLAC sets an *administrative limit* for workers and visitors within these limits. Both sets of limits are shown in Table 4-1. Note that the SLAC dose limit for GERT-qualified workers is the same as for visitors: 100 mrem per year.

Table 4-1 Occupational Total Effective Dose* Limits for GERT-qualified Workers

Dose Limit	Visitor	GERT-qualified Worker
SLAC Administrative Limit	100	100
DOE Dose Limit	100	5000

*Dose to the whole body

4.3 Expected Dose at SLAC

The radiation doses associated with occupational radiation exposure at SLAC from radiation generating devices and radioactive materials are very small when compared to those for other occupations. In 2007, for example, of over 2,400 GERT-trained persons monitored at SLAC, 99.5 percent received no detectable occupational dose. Only 12 persons received a dose, and of these, the average annual dose was 33 mrem. In comparison, airline flight crew members receive an annual dose of 307 mrem per year, and medical personnel receive an average annual dose of 75 mrem.³

3 See footnote 1.

4.4 Personnel Dosimeter

A personnel dosimeter measures radiation dose; it does not protect the wearer from radiation exposure.



Figure 4-1 Personnel Dosimeter

4.4.1 Obtaining a Dosimeter

The need for a dosimeter is based on the type of area you will be working in.

- **Controlled areas:** No dosimeter is required to enter this type of area.
- **RCAs:**
 - Only GERT-qualified personnel who need to enter an RCA will be issued a dosimeter. The need for a dosimeter is reviewed and approved by your supervisor. If approved, complete [SLAC Dosimeter / ID Request Form A](#).
 - Individuals who are escorted into an RCA, such as visitors without ESH training, are required to wear dosimetry and must be accompanied by a GERT-qualified escort with a dosimeter. Obtain the appropriate dosimeter request form from SLAC Site Security.

Submit your completed form to the appropriate person or issuing office:

- [SLAC Site Security](#) (issues dosimeters to employees, users, subcontractors and visitors)
- [Dosimetry points of contact representatives](#)
- [Visitor User Employee \(VUE\) Center](#) (issues dosimeters to users)

4.4.2 Using a Dosimeter

In order to accurately measure whole body dose, the dosimeter

- Must be worn on the front upper torso between the neck and waist
- Must be worn on the outside of your clothing and any personal protective clothing
- Must remain uncovered so that the dosimeter window is unobstructed and facing outward
- Should always be worn with a break-away lanyard

In addition to wearing a dosimeter correctly, please pay attention to the following:

- Do not take your dosimeter off-site at the end of the working day; you should store it in your office, on an assigned dosimeter board (where applicable), when not in use.
- Never open, deface, intentionally expose, or otherwise tamper with the dosimeter.
- Never have more than one dosimeter at any given time.
- Never loan the dosimeter to someone else or borrow someone else's dosimeter.
- Do not clip your dosimeter to a pants pocket, a belt, or shirtsleeve.
- Do not keep your dosimeter in a purse, wallet, or vehicle.

For additional information, see the [Radiological Safety: Personnel Dosimeter Use Requirements](#).

4.4.3 Exchanging Your Dosimeter

4.4.3.1 Routine

Non-SLAC employees must return the dosimeter to their point-of-contact when their SLAC work ends.

All SLAC employees must return a GERT dosimeter at the end of each wear period, which is generally January 1 unless otherwise specified. When you are ready to exchange the dosimeter, remove it from the holder and return it to your point-of-contact or to RP, Mail Stop 48. When you receive your new dosimeter, place it into your holder.

If the dosimeter is not returned at the end of the wear period, both the person to whom the dosimeter was issued and using the dosimeter and his/her supervisor will be notified via e-mail that the return is overdue.

4.4.3.2 Non-routine

Your SLAC-issued dosimeter is intended to only measure any dose you receive at SLAC. If you will be receiving any medical treatment that involves nuclear medicine, contact [RP](#) at ext. 4299 before undergoing any treatment.

Your dosimeter should always stay at SLAC. If, however, your dosimeter is exposed to non-SLAC sources of radiation, immediately report the circumstances to DREP. The first step is to fill out the [SLAC Lost / Damaged Dosimeter Form](#).

Reportable circumstances or conditions include

- If the dosimeter is lost or damaged
- If the dosimeter is exposed to radiation from any source other than occupational exposure at SLAC

4.4.4 Requesting a Dose Report

Anyone who has worn a dosimeter at SLAC may obtain a copy of his/her dose report or have his radiation dose record transferred to another institution. To make a request, complete an [Authorization to Release Occupational Exposure Information](#) form and follow the instructions on the form. A copy of your [dose report](#) is also available online.

For additional information, see the Dosimetry and Radiological Environmental Protection (DREP) [group web page](#).

4.4.5 Assignment to a Non-DOE facility

Your SLAC-issued dosimeter is intended to measure only any dose you receive at SLAC. Each individual who is acting in an official capacity at a non-DOE facility and is monitored for occupational radiation exposure must provide the monitoring results to their employer within 30 days of receipt. If you are assigned to work at a non-DOE facility please contact Radiation Protection .

5 ALARA

5.1 Learning Objectives

After completing this section, you will

- Be familiar with the ALARA principle
- Know basic ALARA practices

5.2 ALARA Principle

ALARA (as low as reasonably achievable) is the underlying principle for the radiation protection program for DOE and SLAC. ALARA is not a dose limit but a process that has the objective of attaining doses as far below the applicable limits as is reasonably achievable, taking into account social, technical, economic, practical, and public policy considerations.

5.3 ALARA Practices

The ALARA principle translates into three basic practices to reduce dose:

1. Reducing the amount of time spent in radiation fields
2. Increasing the distance from the radiation source
3. If possible, staying behind shielding or placing shielding between yourself and the radiation source

To reduce time:

- Stay only as long as absolutely necessary to complete the task when working in a controlled area.
- Plan ahead: gain proficiency before entering a controlled area and perform preparatory work and parts assembly outside the area.
- Work safely, efficiently, and quickly and do the job right the first time.

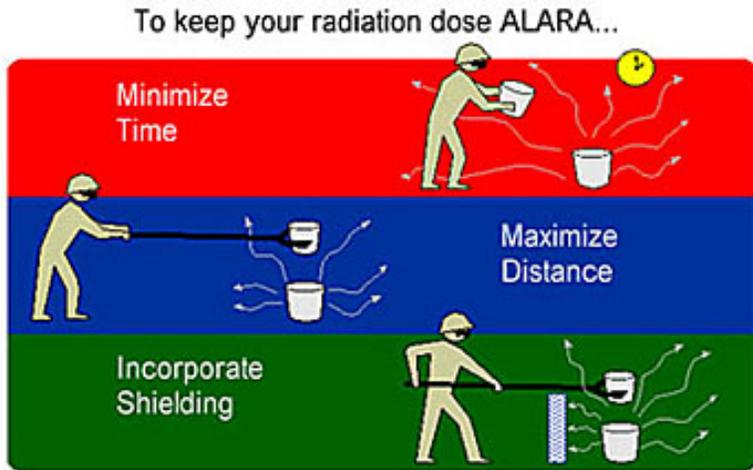


Figure 5-1 Basic ALARA Practices: "Time, Distance, Shielding"

6 Radiological Controls

This section presents the radiological controls that are in place to protect you from unnecessary radiation exposure.

6.1 Learning Objectives

After completing this section, you will know

- How to recognize controlled areas and radiologically controlled areas and understand requirements for entry
- How to recognize radioactive material and how to find out which materials you may handle
- How to recognize areas that you may not enter until you have completed additional radiological safety training
- Entry procedures for two types of personnel protection systems (PPS)

6.2 Radiological Identification Requirements

All areas or materials controlled for radiological purposes are identified by the international radiation symbol, which is a magenta or black trefoil (or three-bladed propeller) on a yellow background.



Figure 6-1 Radiological Controls

Radiological identification applies to areas and materials.

- **Areas.** Postings are used to alert personnel of a potential or known radiological condition and to indicate requirements for entry (the most common types are shown in Figure 6-2). Yellow and magenta rope, tape, chains, or other barriers are used to designate the boundary of posted areas.
- **Materials.** Radioactive materials are identified by tags and labels with the radiation symbol on a yellow background.

Do not remove any radiological postings or labels. Contact RP immediately at ext. 4299 if you

- Discover postings or labels that have been compromised (torn or fallen)
- Discover radioactive material outside a controlled area

6.3 Areas GERT-qualified Persons May Enter

Once you have completed GERT you may enter a controlled area, even if no dosimeter has been issued to you. To enter an RCA, however, you must wear a dosimeter. The requirements are on the sign:



Figure 6-2 Areas GERT-qualified Persons May Enter

6.3.1 Area Requirements

To enter a controlled area or an RCA you must have a valid ID showing the GERT qualification. In addition, to enter an RCA, you must be wearing your personnel dosimeter.

For an illustration of areas generally posted as a controlled area or RCA, see the [Controlled Areas and Radiologically Controlled Areas \(RCAs\)](#) map.

Important Read all signs before entering any posted area because radiological conditions may change and signs are updated to reflect current conditions.

6.3.2 Escort Requirement

A GERT-qualified person may escort others who have not completed GERT into a controlled area, and into an RCA if the persons under escort have personnel dosimeters.

Escort duties include

- Entering only areas you are qualified to enter
- Maintaining visual contact with the escorted person at all times
- Providing a safety briefing to escorted personnel
- Making sure the escorted person obeys all postings, follows all requirements, and avoids hazards
- Directing the escorted person in case of emergency
- Acquiring a dosimeter for the visitor if he/she will be in an RCA

- Returning the escorted person's dosimeter at the end of the visit to SLAC Site Security or the DREP Group in the Radiation Protection Department

6.4 Areas GERT-qualified Persons May Not Enter

The GERT qualification does **not** authorize you to enter any area posted as a

- Radiation area
- High radiation area
- Radiological buffer area
- Contamination area
- High contamination area



Figure 6-3 Postings for Areas GERT-qualified Persons May Not Enter

As each sign indicates there are additional requirements for entering these areas, which may include one or more of the following:

- Additional radiological training (RWT I and/or RWT II)
- Supplemental dosimeter
- Additional authorization, and/ or a radiological work permit (RWP)

Note You may enter any area to render first aid in a medical emergency.

Appendix A, “Radiological Work and Area Entry Requirements,” itemizes all types of radiological areas potentially found at SLAC and includes an example for each type of posting as well as requirements for entry.

6.5 Radioactive Materials

You may encounter *radioactive materials* (also referred to as *RAM*) in a controlled area or RCA. Requirements for labeling, storing, and handling these materials are described in this section.

6.5.1 Labeling

Radioactive materials are identified by tags or labels with a yellow background and the radiation symbol, such as the one shown below. Any radioactive material with this label must always be located within an area that is controlled for radiological purposes.



Figure 6-4 A Yellow and Magenta Tag Indicates the Item Is Radioactive

Radioactive material types at SLAC include

- Material that was in an accelerator housing during beam operation
- Radioactive sources (sealed or in instruments or devices)
- Radioactive samples used in user experiments
- Radioactive waste

6.5.2 Radioactive Material Areas

An area where radioactive materials are stored is a *radioactive material area (RMA)*. Each access point to an RMA must be posted.

The materials and installed components inside all accelerator housings are considered radioactive material until surveyed and cleared by RP.

The four postings associated with an RMA are the following (also shown in Figure 6-5):

1. RADIOACTIVE MATERIALS
2. RADIOACTIVE MATERIAL / CONTROLLED AREA
3. RADIOACTIVE MATERIAL / RADIOLOGICALLY CONTROLLED AREA (dosimeter required to enter)
4. RMMA / RADIOACTIVE MATERIAL MANAGEMENT AREA (RP survey required, call ext. 4299)

These signs are generally located in an area controlled for radiological purposes, but you may encounter one in a controlled area. Note the specific requirements on each posting may vary with where the posting occurs.



Figure 6-5 Radioactive Material Area Posting Types

6.5.2.1 Radioactive Material Management Area

A *radioactive material management area (RMMA)* is an area that has been exposed to a beam capable of causing activation. At SLAC, the RMMA designation applies to all beam housings and tunnels. As such, the potential exists in these areas for radioactive contamination due to the presence of unencapsulated or unconfined radioactive material.

As indicated on the RMMA posting, any material in an RMMA may not be removed before RPFO personnel have conducted a radiological survey. The material must be placed in the designated storage area or left behind the personnel protection system (PPS) gate until it is surveyed.

Any item found to be radioactive will be tagged and controlled as radioactive material. If it is not radioactive it will be tagged with a white tag that indicates that it has been surveyed and released without any restrictions.

6.5.2.2 Radioactive Material Survey Requirement

In some areas, everything is assumed to be radioactive until it is surveyed. An accelerator housing is an example of such an area: any beamline component or material present during beam operation may have become radioactive. Such areas are posted as an RMMA.

Do not handle, work, or remove any item from an area posted with these signs unless the item is first surveyed.

To request a survey, call RP at ext. 4299.



Figure 6-6 RPFO Technician Surveying Material for Radioactivity

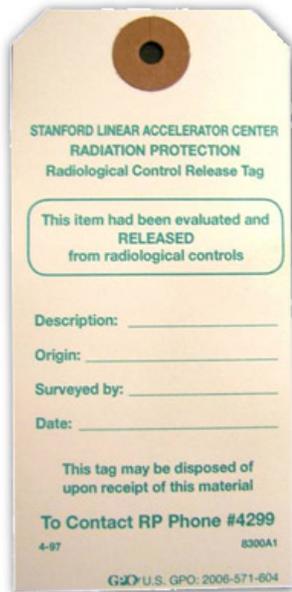


Figure 6-7 Released Material is indicated by a Green and White Tag

Important Material, tools, and other implements that were not in an accelerator housing while the beam was on can be removed without contacting RPFO unless the material was in a contamination area. Avoid creating radioactive waste by always taking out any tools or equipment you bring into the accelerator housing because exposure to the beam may activate the item.

6.5.3 Radioactive Material Handling Restrictions

Completing GERT permits you to

- Enter an RMA to conduct observations, inspections, and tours. The RMA posting must be within a controlled area or RCA for you to enter.
- Enter accelerator housings to conduct observations, inspections, and tours.
- Handle or work with low level radioactive sealed sources (additional training is required)
- Operate very low risk (Class 1) radiation generating devices such as electron microscopes

Completion of GERT does **not** permit you to

- Handle radioactive material. Handling includes the use of hands or tools to move/manipulate any radioactive material, including activated beamline components.
- Work with radioactive materials. Work includes the use of tools to perform actions such as cutting, machining, welding, grinding, filing, drilling on any radioactive materials, including activated beamline components.

7 Personnel Protection System

Very high levels of radiation exist inside accelerator housings during beam operations. At SLAC, the interlock access control system that keeps persons from entering during beam operations is called the *personnel protection system (PPS)*. It includes interlocked doors, key banks, and beam and access status displays and other controls.

The PPS both prevents entry to the accelerator housing during beam operations and shuts off the beam in case of an access violation. Certain areas that present hazards not controlled by the PPS are posted as personnel exclusion areas.



Figure 7-1 Three Examples of Personnel Protection Systems at SLAC

7.1 Access Control Systems

This section covers basic information on SLAC's access control systems.

Note The web-based GERT training includes videos that cover much of the following information.

Important Do not enter an area under a PPS until you become familiar with the entry and exit procedures specific to the facility; additional training may be required.

7.1.1 Major PPS Zones

Table 7-1 lists SLAC's major PPS zones and the control center you would contact to gain entry.

Table 7-1 Major PPS Facilities

Control Center	Facility
Accelerator Control Room (ACR)	Linear accelerator (linac) Beam Switchyard (BSY) LCLS Positron Vault End Station A (ESA)
NLCTA Control Room	NLCTA
Stanford Positron Electron Accelerating Ring (SPEAR) Control Room	SSRL Booster SSRL Linac SPEAR Ring

7.1.2 PPS Access States

The *access state* of a facility determines the conditions for entry of an area controlled by a PPS. The access state is indicated by an annunciator sign (NO ACCESS, CONTROLLED ACCESS, or PERMITTED ACCESS). The sign is generally located adjacent to or above the housing entry door.

Table 7-2 PPS Access States

PPS Access State	Restrictions	Beam Status	Hazardous Electrical Equipment Status
No access	Personnel may not enter	On	On
Controlled access	Enter only by following entry procedure; contact the responsible control center (ACR, , NLCTA, SSRL / SPEAR)	Off	Off
Permitted access	No key or log in required	Off	Off

A PPS access control system consists of locked and interlocked doors, key banks, and gates. These controls prevent anyone from entering the beam housing areas when the beam is on or when electrical hazards are present.

7.1.3 Warning Lights

Table 7-3 lists the warning light types located at accelerator entrances and the system status each indicates.

Table 7-3 Beam Status as Indicated by Warning Lights

Warning Light Status	System Status
Yellow light on	Beam is off but residual radiation may be present
Magenta light on	Beam is off but could be turned on momentarily
Magenta light flashing	Beam is on

7.1.4 PPS Entry Module Equipment

7.1.4.1 Typical Equipment

Most PPS entry modules are equipped with

- PPS annunciator sign and/or the yellow and magenta machine operation lights and sign
- Interlocked and locked outer door with emergency entry and exit mechanism
- Interlocked and unlocked inner gate (or a movable concrete shielding block)
- Telephone or intercom
- Keybank
- Door release box and push button
- Radiological information controls, including radiological posting, a radiological work permit (RWP), and a radiation survey map
- TV camera (for control operators at the ACR and SPEAR to monitor entry and exit)

7.1.4.2 Linac Entry

With the exception of Sectors 21–23 and Sectors 24–25 there is no controlled access provision for the linac. Operators can release keys and operate the hatch, which serves as the inner gate, but they cannot control the door release remotely or monitor the door. The area must be searched by operators before resuming beam operation.

7.1.5 Access States

Access to beam housing zones is allowed only after a controlled access or permitted access state has been attained. To achieve this, the beam stoppers (either a mechanical device that can absorb the beam power or a de-energized magnet that prevents the beam from entering protected zones) must be IN (or OFF) and uncovered electrical hazards must be OFF.

Beam stoppers and electrical hazards are listed for each PPS zone in the [Entry and Exit Procedures](#).

7.1.6 Residual Radiation

Once the beam is turned off, residual radiation may persist in such zones as the positron target and dump enclosures. Each person entering a PPS zone must heed the radiation warning signs and follow radiation safety guidelines.

Note The PPS does not prevent exposure to residual radiation once access to the zone is allowed.

7.1.7 PPS Entry / Exit Procedures

Before entering any PPS entry module

- Check the PPS annunciator sign for the access state
- Check the yellow and magenta machine operation lights
- Review any posted radiation signs or survey data
- Make sure you are wearing your personnel dosimeter properly

7.1.7.1 Controlled-access Entry Procedure

- Call the control operator or push the button on the intercom.
- Tell the operator your location and the name of each person who will be entering the housing. The operator will log each person's name and release one key to each person, which they must take from the key bank. Each person must keep possession of their key at all times while in the PPS zone.
- One person must insert their key in the key switch on the "door release" box next to the entrance door. As this key is turned the operator will release the door. After the door is open, remove the key and retain it while in the PPS zone.
- All persons with keys may now enter. The door must be closed behind the last person entering, and the door must be mechanically latched. (The inner gate, or door, should be left open.)

7.1.7.2 Controlled-access Exit Procedure

Persons must exit using the same entrance and following the same procedure.

- Call the control operator or push the button on the intercom.
- Tell the operator your location and the name of each person who will be exiting the housing.
- Turn the key in the key switch on the door release box as the operator releases the door latch.
- Close the entry door when all have exited, making sure the door is mechanically latched.
- Return all keys to the key bank.

7.1.7.3 Permitted-Access Entry and Exit Procedures

For entry during permitted access, it is not necessary to contact the control room or to use keys. In most cases a push button on the door release box next to the entrance door will release the door latch.

Note Do not use the emergency entry and exit mechanisms (such as the crash bars or pull rings) except in an emergency.

7.1.7.4 Linac Entry Procedure

To check the access state of the linac area, you must check the lights next to the doors. (There is no controlled-access state for the linac.)

- A yellow light indicates entry allowed
- A magenta light indicates no entry

Procedure to enter the linac housing:

1. In even-numbered sectors, call the ACR to release a key from the key bank to unlock the manway door. The operator may ask that the door be tied open.
2. In odd-numbered sectors, call the ACR to request that the manway door be opened. An operator will bring an odd sector key.
3. Return the key to the key bank if the sector has a local key bank.
4. The engineering operator-in-charge (EOIC) must verify that the panic circuit has been interrupted and the information logged.
5. Open the hatch and tie it back using the cord behind the hatch.
6. Call down the ladder and shaft to ensure an all clear condition below before entering.

Note Sectors 21-23 and Sectors 24-25 are configured for permitted and controlled access states. In order to access these sector pairs follow the entry and exit instructions in 7.1.7, 7.1.7.1, 7.1.7.2 and 7.1.7.3. If you are not accessing Sectors 21-23 or 24-25 then follow the entry procedure instructions listed in this section.

7.2 Radiation Safety Systems

7.2.1 Work Control

Written approval is required before any manipulation of equipment associated with the PPS, beam containment, or access control. In addition, a [radiation safety work control form](#) must be completed.

This requirement applies to the main beam radiation protection devices at SLAC, including

- Radiation shielding
- Access control system, which includes gates, doors, flashing lights, audio warnings, and the beam stoppers
- Beam containment system (BCS)
- Beam shut-off ion chambers (BSOICs)
- Any devices associated with the access control system, including gates, door micro-switches, flashing lights, audio warning, emergency push-buttons, and voltage substations

Important Never tamper with any radiation protection equipment. These elements work together to limit beam radiation in occupied zones to very low levels.

7.2.2 Unique Hazards

Accelerator housings present unique work hazards that include limited egress, radiation hazards, radioactive material, electrical hazards, flammable gases, and cryogenic material. Motorized vehicles, forklifts, cranes, and rigging fixtures must only be used in accordance with laboratory and departmental policies and procedures. For additional information, refer to the [SLAC Guidelines for Operations](#).

8 Emergencies and Unusual Conditions

8.1.1 Medical Emergency

A medical emergency that occurs in any type of posted radiological area should be handled in the same manner as any other medical emergency:

1. Assess the scene for safety (such as a chemical spill, electrical hazard).
2. If the scene is safe, assess the extent of the injury and call 911 if needed.
3. Administer first aid to the best of your ability and training.



Figure 8-1 First Aid Takes Precedence over Radiological Controls

8.1.2 Unusual Conditions

An unusual radiological condition should be handled by immediately calling ext. 5555, notifying your supervisor, and calling RP at ext. 4299. Unusual conditions may include

- Discovery of a radioactive material outside a controlled area
- Spill from a labeled radioactive container

8.1.3 Beam Alert System

If you are in a beam line tunnel and the lights begin to flash and/or you hear “warning, the beam is about to come on,” immediately push the nearest EMERGENCY OFF button, leave the tunnel through the closest exit, and call the control operators to report the occurrence.



Figure 8-2 EMERGENCY OFF Button

9 Your Rights and Responsibilities

You are responsible for doing your job safely. It is very important that you know whom to contact and where to find the information you need to thoroughly understand all hazards and controls associated with your work.

If you have safety concerns, discuss them with the responsible individual, your supervisor, your safety coordinator, or RP personnel before beginning the work.

Your responsibilities and rights:

- You must observe all SLAC rules, regulations, and policies related to safety.
- You must observe all postings and signs.
- You must comply with all radiological requirements.
- You must stay alert for and respond to any unusual or unsafe conditions.
- You have the right not to work in unsafe condition.

10 Related Documents

The following are related documents and forms. Always locate and use the latest version, either online from the addresses below or from the originating unit.

Table 10-1 Related Documents

Title	Document Number	Originating Unit	URL
Radiological Safety Program			
Radiological Safety: Work and Area Entry Requirements	SLAC-I-760-0A05S-002	RP	http://www-group.slac.stanford.edu/esh/eshmanual/references/radReqWorkEntry.pdf
Radiological Safety: Personnel Dosimeter Requirements	SLAC-I-760-0A07S-001	RP	http://www-group.slac.stanford.edu/esh/eshmanual/references/radReqDosimeterPersonnel.pdf
SLAC Dosimeter / ID Request Form A	SLAC-I-760-0A07J-006	RP	http://www-group.slac.stanford.edu/esh/eshmanual/references/radFormDosimeterRequestA.pdf
SLAC Dosimeter / ID Request Form B	SLAC-I-760-0A07J-007	RP	http://www-group.slac.stanford.edu/esh/eshmanual/references/radFormDosimeterRequestB.pdf
SLAC Dosimeter / ID Request Form C	SLAC-I-SLAC-I-760-0A07J-008	RP	http://www-group.slac.stanford.edu/esh/eshmanual/references/radFormDosimeterRequestC.pdf
SLAC Lost / Damaged Dosimeter Form	SLAC-I-760-0A07J	RP	http://www-group.slac.stanford.edu/esh/eshmanual/references/radFormDosimeterLost.pdf
My SLAC Dose Report		RP	https://oraweb2.slac.stanford.edu/apex/e/pnprod/?p=100
Radiological Safety: Declaration of Pregnancy Form	SLAC-I-760-0A02J-001	RP	http://www-group.slac.stanford.edu/esh/eshmanual/references/radFormPregnancyDeclare.pdf
Radiological Safety: Withdrawal of Declaration of Pregnancy Form	SLAC-I-760-0A02J-002	RP	http://www-group.slac.stanford.edu/esh/eshmanual/references/radFormPregnancyWithdrawal.pdf

Title	Document Number	Originating Unit	URL
Authorization to Release Occupational Exposure Information	SLAC-I-760-0A07J-005	RP	http://www-group.slac.stanford.edu/esh/eshmanual/references/radFormExpRelease.pdf
Radiation Protection Department		RP	http://www-group.slac.stanford.edu/esh/rp/
Radiation Protection – DREP		RP	http://www-group.slac.stanford.edu/esh/rp/drep.htm
Radiation Protection – DREP: Points of Contact (POC)		RP	https://slac.sharepoint.com/sites/ESH/rp/drep/Lists/dospoc/AllItems.aspx
Controlled Areas and Radiologically Controlled Areas (RCAs)	8473A9	RP	http://www-group.slac.stanford.edu/esh/rp/rca_sitemap.pdf
ESH Other			
SLAC Training - Web Based Courses		Training	http://training.slac.stanford.edu/web-training.asp
ESH Course 219, Environmental Safety and Health Orientation	ESH Course 219	ESH	https://www-internal.slac.stanford.edu/esh-db/training/slaonly/bin/catalog_item.asp?course=219
ESH Course 375, Construction Safety Orientation	ESH Course 375	TIM	https://www-internal.slac.stanford.edu/esh-db/training/slaonly/bin/catalog_item.asp?course=375
SLAC Site Security		SEM	http://www-group.slac.stanford.edu/esh/security/
SLAC Occupational Health Center		ESH	http://www-group.slac.stanford.edu/esh/medical/
SLAC Other			
Visitor User Employee (VUE) Center			https://vue.slac.stanford.edu/vue-center
SLAC Guidelines for Operations	SLAC-I-010-00100-000	ADSO	https://docs.slac.stanford.edu/sites/pub/Publications/SLAC%20Guidelines%20for%20Operations%20Index.pdf
Radiation Safety Work Control Form	SLAC-I-040-305-001-01	ADSO	https://docs.slac.stanford.edu/sites/pub/Publications/%5b040-305-011-02_Safety%5dRSWCForm.pdf
AOSD Entry and Exit Procedures		Accelerator Operations and Safety Division	https://docs.slac.stanford.edu/sites/pub/Publications/Forms/AOSD%20Entry%20and%20Exit%20Procedures.aspx

Title	Document Number	Originating Unit	URL
Other			
Ionizing Radiation Exposure of the Population of the United States	Report No. 160 (2009)	National Council on Radiation Protection and Measurements (NCRP)	

A Radiological Work and Area Entry Requirements

Chapter 9: [Radiological Safety](#)

Radiological Work and Area Entry Requirements

Product ID: [237](#) | Revision ID: 2100 | Date published: 19 July 2019 | Date effective: 19 July 2019

URL: <https://www-group.slac.stanford.edu/esh/eshmanual/references/radReqWorkEntry.pdf>

1 Purpose

The purpose of these requirements is maintain personnel radiation doses below regulatory limits and as low as reasonably achievable (ALARA) and to prevent unplanned or accidental exposure to ionizing radiation. They cover authorizing radiological work and posting of and access to areas. They apply to workers, supervisors, points of contact, and project managers, Radiation Protection and any other group involved in these activities.

2 Requirements

2.1 Radiological Work

Radiological work is any work involving the use of tools on beam lines, beam line components, beam line safety items, radiation hot spots; or *radioactive low conductivity water (LCW)* systems. All radiological work at SLAC must be authorized by line management and approved by cognizant Radiation Protection (RP) Department personnel. Radiological work must be conducted by trained personnel who are following written procedures and/or a radiological work permit (RWP). (See the [Radiological Work Permits Procedure](#) and the [Radiological Work Permit](#) site for further information.)

2.2 Area Entry

2.2.1 Area and Worker Classification

Workers at SLAC are classified according to the level of their training, which determines the areas they can enter without an escort (see [Chapter 55, "Site Access Control"](#)).

- General Employee Radiological Training (GERT)-qualified personnel can enter controlled areas (no dosimeter is required) and RCAs (a dosimeter is required). (See [Controlled Areas and Radiologically Controlled Areas \(RCAs\)](#) for a map of these areas.) The dose for GERT-qualified personnel is limited to 100 mrem total effective dose (TED) in a year. If a worker is likely to receive a dose higher than 100 mrem TED in a year, he or she must first complete RWT I training or higher.
- Radiological Worker Training (RWT) I or higher training and a dosimeter are required to enter any radiological area or a radiological buffer area.

2.2.2 Posting

All areas containing radiation hazards or having the potential to contain radiation hazards will be posted with the appropriate signs. [10 CFR 835](#) defines the radiological posting requirements. Any posting must

- Be clear, legible, conspicuously posted, and may include radiological protection instructions
- Contain the standard radiation symbol colored magenta or black on a yellow background, with black or magenta lettering
- Be used to alert personnel to the presence of radiation and radioactive materials, and to aid them in minimizing exposures and preventing the spread of contamination
- Be kept up to date by RP

Postings and signs inform personnel of potential or actual radiation hazards and to indicate requirements to enter, such as level of training, dosimeter types, and controls such as a radiological work permit (RWP) or specialized equipment.

Note Postings and signs indicate radiological area types, which are associated with particular occupational radiation dose limits, expressed in units of mrem. The indicated level of training is required so that visitors and workers are prepared to recognize hazards, use specialized equipment, and abide by specified controls.

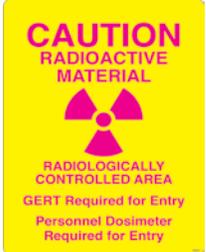
The postings and signs are organized by the required level of training that a person (or qualified escort) must complete before entering. The tables below list every radiological area type and the associated requirements in terms of signage, dosimetry, training, and controls.

Note Certain types of areas are included for completeness but may not be encountered at SLAC.

Table 1 Training Courses

Table	Minimum Required Training	Abbreviation	Notes
Table 2	General Employee Radiological Training (ESH Course 115)	GERT	A GERT-qualified worker or escort must be present, and special permission may be required as listed in Table 2.
Table 3	Radiological Worker I Training (ESH Course 116)	RWT I	
Table 4	Radiological Worker II Training (ESH Course 250)	RWT II	
Table 5	Varies		Signs that may be encountered in any type of area

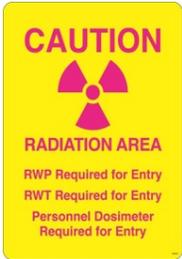
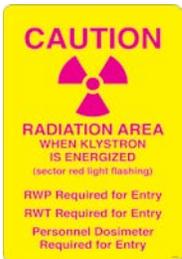
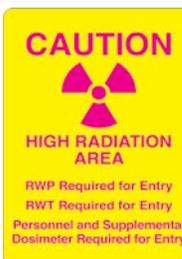
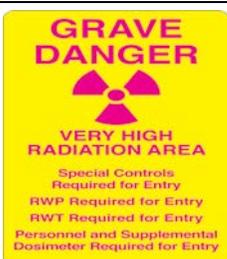
Table 2 Areas Requiring GERT Training

Representative Signage	Posted Area	Description	Dosimetry	Minimum Training ^a
	Controlled area	Area where access is managed by or for the DOE to protect individuals from exposure to radiation and/or radioactive material. A controlled area at SLAC is one where an individual is not expected to receive more than 100 mrem per year.	None	GERT ^b
	Radiologically controlled area (RCA)	A controlled area that requires dosimetry for entry due to the radiation levels in localized areas. The radiation level in certain localized areas within an RCA may vary, requiring limited occupancy. Individuals who enter only RCAs without entering radiological areas are not expected to receive a TED of more than 100 mrem in a year.	Personnel dosimeter	GERT ^b
	Controlled Area and Radioactive material area (Controlled Area + RMA)	A controlled area where items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in Appendix E of 10 CFR 835.	None	GERT ^b
	Radioactive material area (RMA)	Any area within a controlled area accessible to individuals in which items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in Appendix E of 10 CFR 835.	Personnel dosimeter required if the area is also posted as an RCA	GERT ^b
	Radiologically Controlled Area and Radioactive Material Area (RCA+ RMA)	A radiologically controlled area where items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in Appendix E of 10 CFR 835	Personnel dosimeter	GERT ^b

^a Indicates the minimum training required for unescorted access. If training is not complete, the person seeking access must be accompanied by a GERT-qualified escort at all times.

^b GERT-qualified personnel are permitted to enter these areas if it will not result in an annual radiation dose greater than 100 mrem.

Table 3 Areas Requiring an RWT I Qualification (no untrained individuals allowed in these areas)

Representative Signage	Posted Area	Description	Dosimetry	Permit, Control, or Approval	Minimum Training
	Radiation area (RA)	Area where radiation dose rates are greater than 5 mrem per hour @ 30 cm and less than or equal to 100 mrem per hour @ 30 cm	Personnel dosimeter	Sign routine area radiological work permit (RWP) upon entry and exit Job type or routine task RWP for any radiological work to be performed	RWT I
	Radiation area (RA) intermittent condition	A radiation area only when the klystron is energized (prompt radiation)	Personnel dosimeter	Sign routine area radiological work permit (RWP) upon entry and exit Job type or routine task RWP for any radiological work to be performed	RWT I
	High radiation area (HRA)	Area where radiation dose rates are greater than 100 mrem per hour at 30 cm and less than 500rad/hr at 100 cm	Personnel and supplemental dosimeter	Sign routine area radiological work permit (RWP) upon entry and exit. Job type RWP for any work to be performed	RWT I
	Very high radiation area	Area where radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads in one hour at 100 cm from a radiation source	Personnel and supplemental dosimeter	Sign routine area radiological work permit (RWP) upon entry and exit. Job type RWP for any work to be performed Special controls	RWT I
	Personnel exclusion area	Area secured during beam operations due to the potential for abnormal ionizing radiation dose rates, that are not controlled by engineered personnel protection systems (PPS)	Personnel and supplemental dosimeter as directed by RP	For approval contact Accelerator Directorate Safety Officer (ADSO)	RWT I

Representative Signage	Posted Area	Description	Dosimetry	Permit, Control, or Approval	Minimum Training
	Radiological buffer area	Intermediate area established outside a contamination area to prevent the spread of radioactive contamination	Personnel dosimeter		RWT I

Table 4 Areas Requiring an RWT II Qualification (no untrained individuals allowed in these areas)

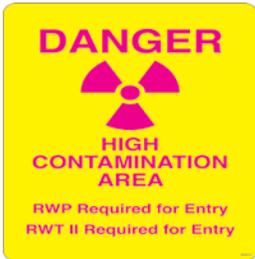
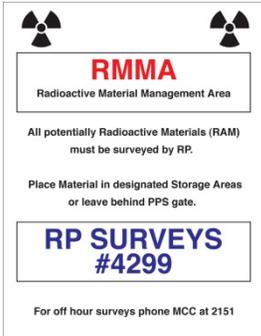
Representative Signage	Posted Area	Description	Dosimetry	Permit, Control, or Approval	Minimum Training
	Contamination area	Area accessible to individuals where the removable contamination levels exceed or are likely to exceed the removable surface contamination values specified in Appendix D of 10 CFR 835, but do not exceed 100 times those values	Personnel dosimeter	RWP upon entry, exit and to conduct work	RWT II
	High contamination area	Area accessible to individuals where the removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in Appendix D of 10 CFR 835	Personnel dosimeter	RWP upon entry, exit and to conduct work	RWT II
	Airborne radioactivity area	Any area accessible to individuals where 1) the concentration of airborne radioactivity above natural background, exceeds or is likely to exceed the DAC values listed in Appendix A or C of 10 CFR 835; or 2) an individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hrs in a week	Personnel dosimeter	RWP upon entry, exit and to conduct work	RWT II
	Potential internal contamination	An LCW system where the low conductivity water or the resin bottle may be radioactive		Contact RP prior to opening the system. Depending on the activity/concentration additional radiological controls may be needed.	RWT II

Table 5 Additional Signage

Representative Signage	Posted Area	Description	Dosimetry	Permit, Control, or Approval	Minimum Training
	Radioactive material management area (RMMA)	Placed at the exits of accelerator housings. Indicates that materials that were in the RMMA while the beam was on could be radioactive. All potentially radioactive items must be surveyed by RPFO prior to removal.	Personnel dosimeter	All potentially radioactive items must be surveyed by RPFO prior to removal	GERT
	Hot spot	A localized area where the dose rate is > 100 mrem per hour on contact	Hot spots are posted within RCAs and radiological areas. Follow all dosimetry requirements during entry.	Hot spots are posted within RCAs and radiological areas. Follow all radiological controls during entry.	GERT

3 Forms

The following are forms required by these requirements:

- [Radiological Work Permit](#)

4 Recordkeeping

- The Radiation Protection Department maintains radiological work permits following the requirements of 10 CFR 835.

5 References

[SLAC Environment, Safety, and Health Manual](#) (SLAC-I-720-0A29Z-001)

- [Chapter 9, “Radiological Safety”](#)
 - [Radiological Safety: Personnel Dosimeter Requirements](#) (SLAC-I-760-0A05S-001)
 - [Radiological Safety: Safety Briefing](#) (SLAC-I-760-0A05S-004)
- [Chapter 55, “Site Access Control”](#)

Other SLAC Documents

- [Controlled Areas and Radiologically Controlled Areas \(RCAs\)](#)

- [Radiological Control Manual](#) (SLAC-I-720-0A05Z-001)
- [Radiological Work Permits Procedure](#) (SLAC-I-760-0A05B-002, FO 005)
- [Radiation Protection Department](#)
- [Radiation Protection \(SharePoint\)](#)
- ESH Course 115, General Employee Radiological Training ([ESH Course 115](#))
- ESH Course 116, Radiological Worker I Training ([ESH Course 116](#))
- ESH Course 250, Radiological Worker II Training ([ESH Course 250](#))

Other Documents

- Title 10, *Code of Federal Regulations*, “Energy”, Chapter 3, “Department of Energy”, Part 835, “Occupational Radiation Protection” ([10 CFR 835](#))