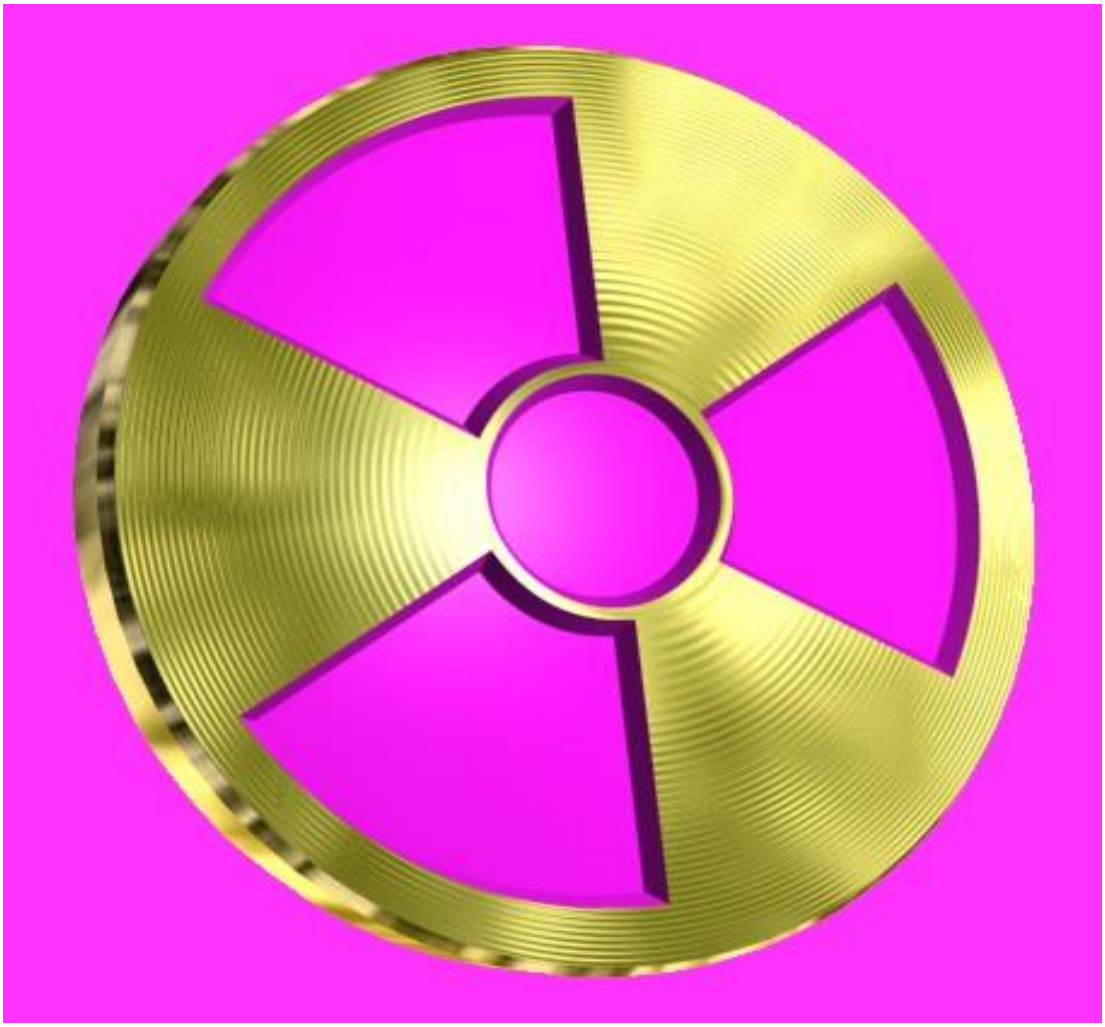
Radiation Safety at LLNL
General Employee Radiological Training

GERT

HS6001-W



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The LLNL Radiation Protection Program: The Regulatory Environment

Federal Law

The federal government requires Lawrence Livermore National Security (LLNS) and other Department of Energy (DOE) contractors to comply with the requirements of nuclear safety rules. DOE, through the Office of Enforcement and Oversight located within the Office of Health, Safety and Security, self-regulates contractor compliance with these requirements. Regulatory compliance is assured when LLNS employees understand and follow Laboratory policy and procedures designed to implement nuclear safety requirements.

Failure to follow Laboratory nuclear safety policy and procedures, including those described in the LLNL Radiation Protection Program, constitutes a noncompliance with DOE nuclear safety requirements. DOE requires LLNL to report these noncompliances and to take corrective action to prevent recurrence of the reported noncompliant condition. Noncompliances that DOE considers significant enough to warrant independent investigation may result in DOE determining that violations have occurred, not only subjecting LLNL to possible federal enforcement action including civil penalties (i.e., fines) and contract fee reductions, but also potentially and seriously damaging the Laboratory's reputation.

Nuclear Safety Rules

The following sections of Title 10 of the Code of Federal Regulations comprise the nuclear safety rules currently enforced by the Department of Energy:

1. 10 CFR 835, "Occupational Radiation Protection," protects LLNL workers like you from the potentially harmful effects of radiation.
2. 10 CFR 830, "Nuclear Safety Management," Subpart A, "Quality Assurance," describes Quality Assurance requirements applicable to all LLNL facilities and operations that create a potential to cause radiological harm.
3. 10 CFR 830, Subpart B, "Safety Basis Requirements," describes requirements specific to nuclear facilities and operations that utilize high---hazard radioactive materials such as plutonium.
4. 10 CFR 820, "Procedural Rules for DOE Nuclear Activities," describes general requirements for managing nuclear activities, including reporting of noncompliances with nuclear safety rules.
5. 10 CFR 708, "DOE Contractor Employee Protection Program," protects your right to express concerns about nuclear safety without fear of reprisal from your employer.

The LLNL *ES&H Manual* contains LLNL's and DOE's radiation safety program requirements and is available at https://esh-int.llnl.gov/esh-manual/volume2.html#s20.

General Employee Radiological Training

A variety of radioactive materials and radiation-generating devices (RGDs) (e.g., x-ray machines, electron beam devices, and accelerators) are used at LLNL to accomplish its research and development mission. To ensure that individuals are aware of the potential radiological hazards associated with such activities, General Employee Radiological Training (GERT) is required as part of the general training requirements for all new LLNS employees and supplemental labor workers and must be completed before individuals are allowed unescorted access into areas posted with the radiation symbol (Figure 1). In addition, GERT is required before individuals are allowed to receive an occupational radiation dose in posted areas, whether or not they are escorted.

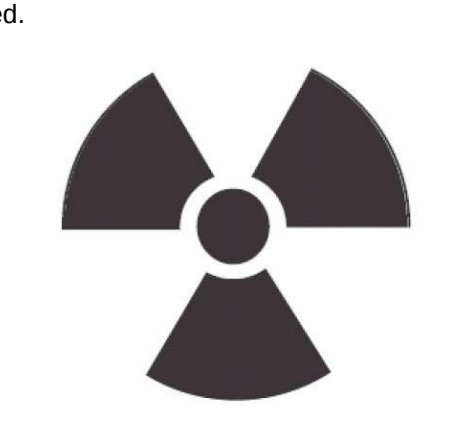

Figure 1. Radiation Symbol

Table 1 describes additional Radiological Worker training courses required prior to unescorted access to Radiation Areas, Contamination Areas, and Airborne Radioactivity Areas, and before performing independent assignments as a Radiological Worker.

Table 1. Courses Required for UNESCORTED ACCESS to Radiologically-Controlled Areas

Course	Area Posting
HS6001-W, General Employee Radiological Training (GERT)	• Radioactive Materials Area (RMA) • Radiation-Generating Device (RGD) Area • Radiological Buffer Area (RBA)
HS6901-W, Radiological Worker Core Training OR HS6010-W, Radiological Worker	• Radiation Area (RA)
HS63xx, Contamination Control ("Rad-Worker II" training)	• Contamination Area (CA) • High Contamination Area (HCA) • Airborne Radioactivity Area (ARA)

For course information on lecture, practical, and web-based training contact your training coordinator or the Safety Education and Training Section (SETS) (ext. 2-0587), or access the SETS Website at: https://hcd-int.llnl.gov/.

GERT retraining is:

- Required every two years.
- Satisfied by reading the information presented in this document.
- Automatically documented in the Livermore Training Records and Information Network (LTRAIN) when the employee uses the link presented in the web course and acknowledges that they have read this material.

Other individuals (e.g., visitors and contractors who are not enrolled in LTRAIN) may receive this information by completing the web-based course or as a booklet when they are issued their dosimeter and security badge. Individuals may document their GERT training by signing the card on the back of the GERT booklet. The signed GERT card documents the individual's date of training.

An individual who has completed GERT may escort untrained workers into areas requiring GERT training (e.g., a Radioactive Material Area or an RGD Area). The escort is responsible for ensuring that the untrained worker complies with the posted radiation safety requirements.

This document provides general information about radiation and the controls that LLNL implements to ensure the safety of workers, visitors, and the environment. For specific information about your work area, consult your area supervisor or ES&H Team health and safety technician.

What Is Radiation and Where Does It Come From?

All material is made up of atoms. Most atoms are stable, but some are inherently unstable and release energy in the form of ionizing radiation, that is radiation with enough energy to remove electrons from neighboring atoms. (Non-ionizing radiation, such as laser light and microwaves, usually does not have enough energy to remove electrons from neighboring atoms.) The common types of ionizing radiation are alpha, beta, neutron, x-ray, and gamma. Some atoms (e.g., uranium, thorium, and tritium) are naturally radioactive, whereas others (e.g., most medical radioisotopes) are made radioactive in reactors or accelerators. Devices such as x-ray machines and accelerators can generate radiation, and are collectively referred to as 'radiation-generating devices', or RGDs.

When radiation deposits energy in a person, he or she receives a 'radiation dose.' Radiation doses are measured in units of rem or millirem (mrem). One thousand millirem is equal to one rem (1000 mrem = 1 rem).

Background radiation is naturally found in the environment. It comes primarily from cosmic rays, radioactive material in the earth, naturally occurring radionuclides (such as potassium-40) in food, and radon gas in the air we breathe. In the United States, the average background radiation dose is about 310 mrem/year. Figure 2 shows typical annual radiation doses in the United States.

Manufactured sources of radiation contribute an additional dose of approximately 310 mrem/year, of which approximately 300 mrem/year is from medical procedures (e.g., CT scans, x-rays, and certain diagnostic tests). Consumer products and activities (e.g., cigarette smoking, building materials, and commercial air travel) contribute roughly 10 mrem/year.

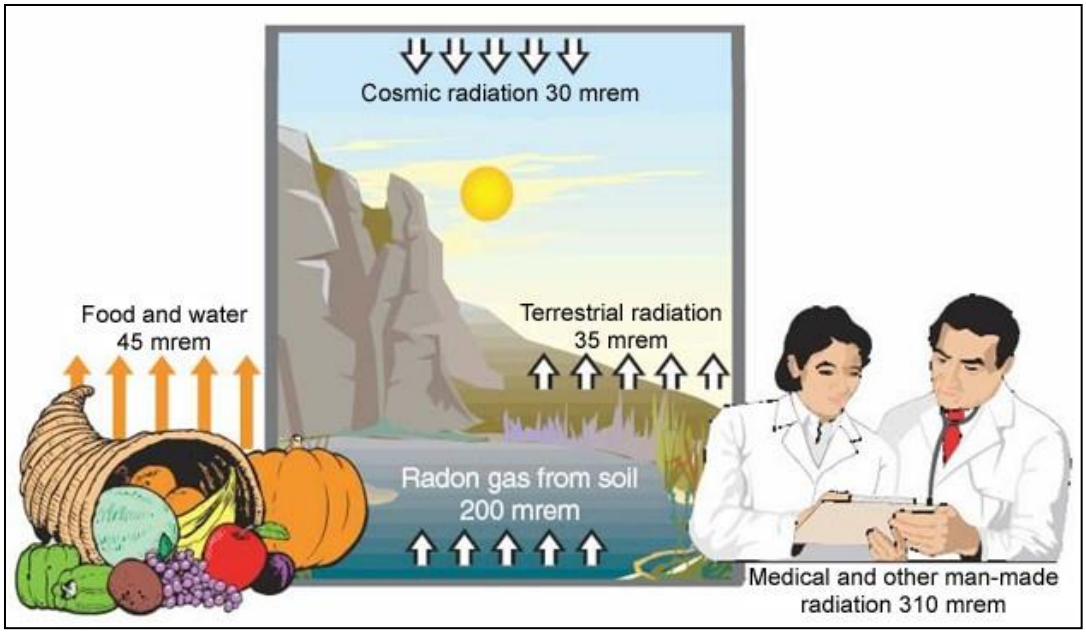

Figure 2. Average annual background radiation dose in the United Sates from natural and manufactured radiation sources.

Occupational Dose Limits

The DOE and LLNL occupational radiation dose limits are shown in Table 2.

Table 2. Occupational Radiation Dose Limits

Group	Dose Limit
General employees (any LLNS or subcontractor employee)	5,000 mrem/year
Embryo/fetus of a declared pregnant worker	500 mrem/gestation
Minors and members of the public entering areas posted with the radiation symbol	100 mrem/year

LLNL has been very successful in keeping occupational doses as low as reasonably achievable (ALARA) below the legal dose limits. In fact, in 2012 (a typical year as far as radiation dose is concerned) more than 99% of LLNL workers did not receive any occupational radiation dose. For comparison, Table 3 shows the average annual dose received by workers in other occupations. The radiological risks to the individual at doses below the dose limits are small, particularly when compared to the risks of other occupations..

Table 3. Annual Radiation Dose by Occupation

Occupation	Average dose (Mrem/year)
Airline flight crew member	310
Nuclear power plant worker	190
Medical personnel	80
Industry and commerce	80
DOE employee or contractor	60

Risks Associated with Radiation Exposure

The primary risk associated with whole body occupational radiation dose is an increased risk of cancer. The degree of risk depends on the amount of radiation dose received, the time period over which it is received, and the body parts that receive the dose. Although scientists assume that low-level radiation doses increase one's risk of cancer, studies have not demonstrated any adverse health effects in individuals who are chronically exposed to small radiation doses over a period of many years (e.g., a total of up to 10,000 mrem above the average background dose).

The increased risk of cancer from occupational radiation exposure is small when compared to the normal cancer rate in today's society. For example, the current risk of dying from all types of cancer in the United States is approximately 25 percent, and a person who receives a whole-body radiation dose of 25,000 mrem over his or her lifetime has a 26 percent risk of dying from cancer — a one percentage point increase.

Figure 3 shows the natural incidence of cancer fatalities and genetic (i.e., heritable) birth defects, as well as the estimated risk of a cancer fatality or genetic effect from receiving a 25,000 mrem radiation dose. (A "genetic effect" is one that occurs in an exposed individual's eggs or sperm and appears in the individual's offspring.) The data on heritable effects are based on animal studies, because heritable effects from radiation have not been observed in humans.

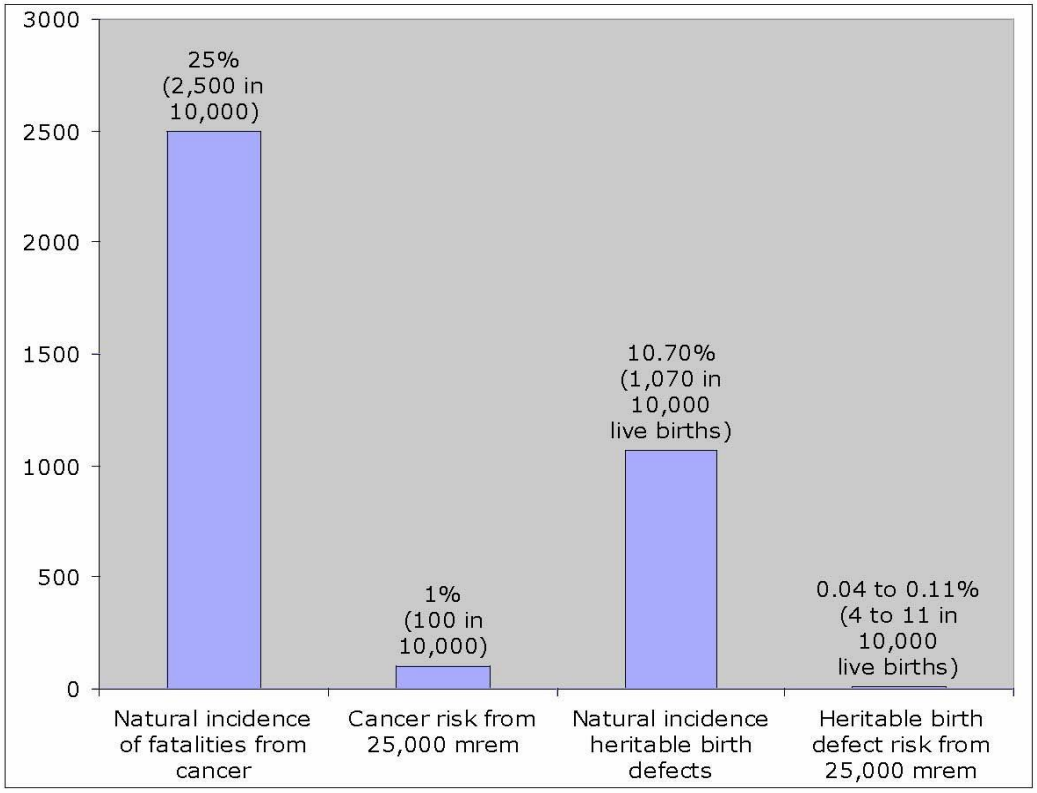

Figure 3. Estimated Risks

Protecting the Embryo/Fetus

Although heritable effects from radiation exposure have not been observed in humans, the embryo/fetus is known to be more sensitive to radiation than an adult. Therefore, LLNS employees who are planning a pregnancy, as well as those who suspect (or know) that they are pregnant, are strongly encouraged to notify the Health Services Department (ext. 2-7459) as soon as possible. Health Services will provide a 'Declaration of Pregnancy' form and information and, with the individual's concurrence, will arrange to have the workplace evaluated (confidentially, if desired) for potential hazards that could affect the fetus. Based on the interview with the individual and/or the workplace evaluation, Health Services will recommend whether or not a medical restriction is warranted and, again with the individual's concurrence, will issue a medical restriction that limits exposure to pregnancy-related hazards. (**Note:** A medical restriction that limits exposure to radiation is issued only if the employee signs the "Declaration of Pregnancy" form.) Contractors must declare their pregnancy with their employers, who are then responsible for informing LLNL of the work restriction.

For additional information on the reproductive effects of radiation and other toxic agents, see the pamphlet "Reproductive Health: Effects of Chemicals and Radiation on Fertility and the Unborn Child" (LLL-TB-89), which is available from the Health Services Department.

Monitoring Radiation Exposures

A radiation dosimeter measures the dose a person receives from external sources of radiation. Employees and supplemental labor workers must wear any LLNL-issued radiation dosimeter while onsite unless otherwise authorized by the Radiological Control Manager (or designee). Visitors and temporary contractors are required to wear an LLNL dosimeter only if conducting radiological work or if entering a posted Radiation Area. If you need a dosimeter, call “2-GET1” (ext. 2-4381).

The type of dosimeter routinely used at LLNL is a thermoluminescent dosimeter (TLD). Crystals inside a TLD absorb energy when exposed to ionizing radiation and release that energy in the form of light when heated. The amount of light released from the dosimeter is proportional to the radiation dose received. Figure 4 shows an exploded view of an LLNL dosimeter packet.

In addition to being monitored with a TLD, workers who routinely handle dispersible radioactive material may be required to participate in LLNL’s internal dose monitoring program. This program assesses internal dose by measuring either radioactivity in urine or radiation emitted from the body.

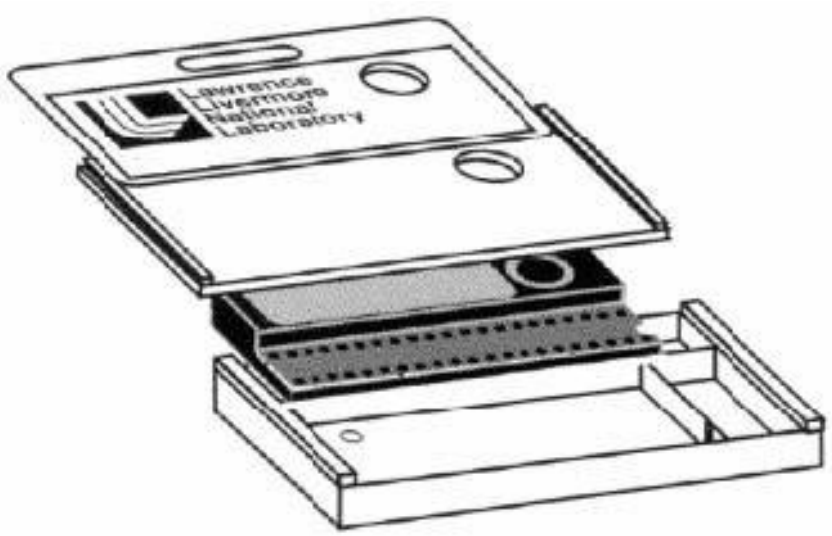

Figure 4. Exploded view of an LLNL dosimeter packet.

Radiation Dose Reports

For routine situations, individuals (or their employers) who are monitored in the dosimetry program are notified of positive doses approximately 30 days after the dose is assigned to the individual’s record. The dose report includes both internal and external radiation dose.

An annual summary dose report (Figure 5) is provided to all monitored LLNL workers, regardless of whether they received a dose in the preceding calendar year. The report is delivered via e-mail for workers with a current e-mail address and via U.S. mail for those without a current e-mail address.

A similar dose report is also provided to any visitor who indicates (when obtaining a dosimeter) that he or she is to work with radioactive materials or RGDs and to a few specific non-LLNL work groups (e.g., DOE and Defense Nuclear Facilities Safety Board staff).

Termination dose reports are provided upon request. Anyone who has worn a dosimeter at LLNL may obtain a copy of his/her dose report from the Radiation Protection Functional Area (RPFA) External Dosimetry Team.

Lawrence Livermore National Laboratory
2012 Annual Dose Statement

For: IMA GOODWORKER
Employee #: 456789

Dose to the whole body
(in mrem)

0	Effective Dose (ED) from external radiation
NM	Committed Effective Dose (CED) from internal radiation
0	Total Effective Dose (TED)
NM	Total Effective Dose (TED) to the fetus
63	Total Effective Dose (Lifetime)

Dose to the skin, hands, and eye
(in mrem)

0	Skin of the whole body
NM	Right hand
NM	Left hand
NM	Lens of the eye

Notes:
1. NM = Not Monitored
2. Whole body annual dose limit is 5,000 mrem
3. Fetal dose limit is 500 mrem/gestation
4. Skin and hands annual dose limit is 50,000 mrem
5. Eye annual dose limit is 15,000 mrem

Figure 5. LLNL Annual Dose Report

The Total Effective Dose (TED) is the sum of the effective dose (for external exposures) and the Committed Effective Dose (CED) (for internal exposures). Organ-specific information is provided if an internal does is received.

The Total Effective Dose (Lifetime) is the sum of all the doses LLNL has in its database, including previous year's internal and external doses, doses received at other sites, and doses received from previous employment, as provided by you or your previous employer.

Regarding Your Dosimeter

Do:

1. Wear your dosimeter facing outward on the upper part of your body.
2. Ensure that the plastic flap bearing the LLNL logo covers the dosimeter. If the plastic flap with the LLNL logo is missing, call ext. 3-7902 or stop by the Dosimetry Office (B253) to obtain another one.
3. Notify your ES&H Team if you have received (or will be receiving) a radiopharmaceutical (i.e., a radioactive drug) as part of medical diagnosis or treatment. Some radiopharmaceuticals result in a positive dosimeter reading, which needs to be subtracted from your occupational dose record. If you are not sure whether the treatment or diagnosis you are receiving involves radiopharmaceuticals, ask your physician.
4. Promptly notify your ES&H Team health physicist or the External Dosimetry Team if your dosimeter is exposed to excessive heat or moisture or becomes lost or damaged.

Do NOT:

1. Wear your dosimeter at other sites. If a dosimeter is required at another site, that site will issue you one.
2. Expose your dosimeter to radiation outside your work environment (e.g., dental x-rays, medical procedures).
3. Carry your dosimeter in airline-checked baggage.
4. Wear another person's dosimeter.
5. Allow other objects (e.g., plastic cards) to cover the dosimeter.

Privacy Act

Your occupational radiation dose records are protected in accordance with the Privacy Act of 1974 (Public Law 93-579). LLNL's External Dosimetry Team does not release your records to any company, organization (other than DOE or as directed by DOE), or individual outside of LLNL without your written permission. DOE requires LLNL to use your Social Security Number for identification purposes. LLNL handles your Social Security Number and records in accordance with both Privacy Act and California Information Practices Act requirements. Social Security Numbers are not printed on the routinely-generated dose reports.

LLNL Dosimetry and the Nation's Homeland Security Effort

Radiation-generating devices (RGDs) are being used extensively in the U.S. Homeland Security effort. Most people are familiar with the x-ray machines used to screen hand-carried items at airports. Recently, much higher dose RGDs have been installed to screen checked luggage. RGDs are also being used to sanitize mail at some post offices (notably, Washington, DC). These RGDs deliver enormous doses of radiation. Table 4 shows the effects on a radiation dosimeter that is exposed to Homeland Security RGDs. To avoid these effects, observe the following guidelines.

Airports/U.S. Ports of Entry

1. When traveling, do not take your dosimeter with you. The site you are visiting is required to supply you with any necessary dosimetry. If you need to take your Lab security photo ID, detach it from the dosimeter.
2. If, for some reason, you need to take your dosimeter to another (non-LLNL) site (or, you find yourself at the airport with dosimeter), be sure to keep your dosimeter in your hand-carried luggage. Do NOT put it in your checked luggage.

U.S. Mail

1. Do not mail your dosimeter through the U.S. mail.
    a. Employees on extended assignments should make arrangements with the External Dosimetry Team to retain their dosimeters past the normal exchange date and exchange the dosimeters upon their return.

Table 4: Effects of Homeland Security RGDs on Your Radiation Dosimeter

Exposure pathway	Dose to dosimeter	Effect on the LLNL dosimetry program
Hand-carry baggage	0.01 mrem	None
Checked baggage	50-100 mrem	Dose is automatically assigned to employee's record as an occupational dose unless a dosimeter investigation is completed.
Sanitized mail	100,000,000 mrem	May destroy a $10,000 phototube in the dosimeter reader; destroys the individual dosimeter.

Basic Radiation Safety Controls

Engineered controls (such as shielding, ventilation, alarms, warning signals, and material containment) are the primary means of controlling radiation doses at LLNL. Administrative controls (e.g., signs, procedures, dosimetry, and training) supplement these engineered controls.

External Radiation Protection

An external radiation dose is a dose received from a radiation source outside of the body. You may encounter low-level radiation fields (i.e., fields less than 5 mrem in an hour) in Radioactive Material Areas, Radiation Generating Device Areas, and Radiological Buffer Areas. While in such areas, you can reduce your external radiation dose by:

1. Minimizing the time you are exposed to sources of radiation.
2. Maximizing your distance from radiation sources (radiation level decreases significantly with increased distance from the source).

Radiation Signs

Signs with the radiation symbol are used to identify radiologically controlled areas and to inform workers of access requirements. (Controls for work are contained in the applicable work control document.) Individuals who have completed GERT, or who are escorted by a GERT-trained worker, may enter areas posted with the signs shown in Figure 6. To enter areas posted with the signs shown in Figure 7; workers must have additional radiological training, or have completed GERT and be escorted by a trained Radiation Worker.

Individuals entering an area posted with the radiation symbol must adhere to the posted requirements.

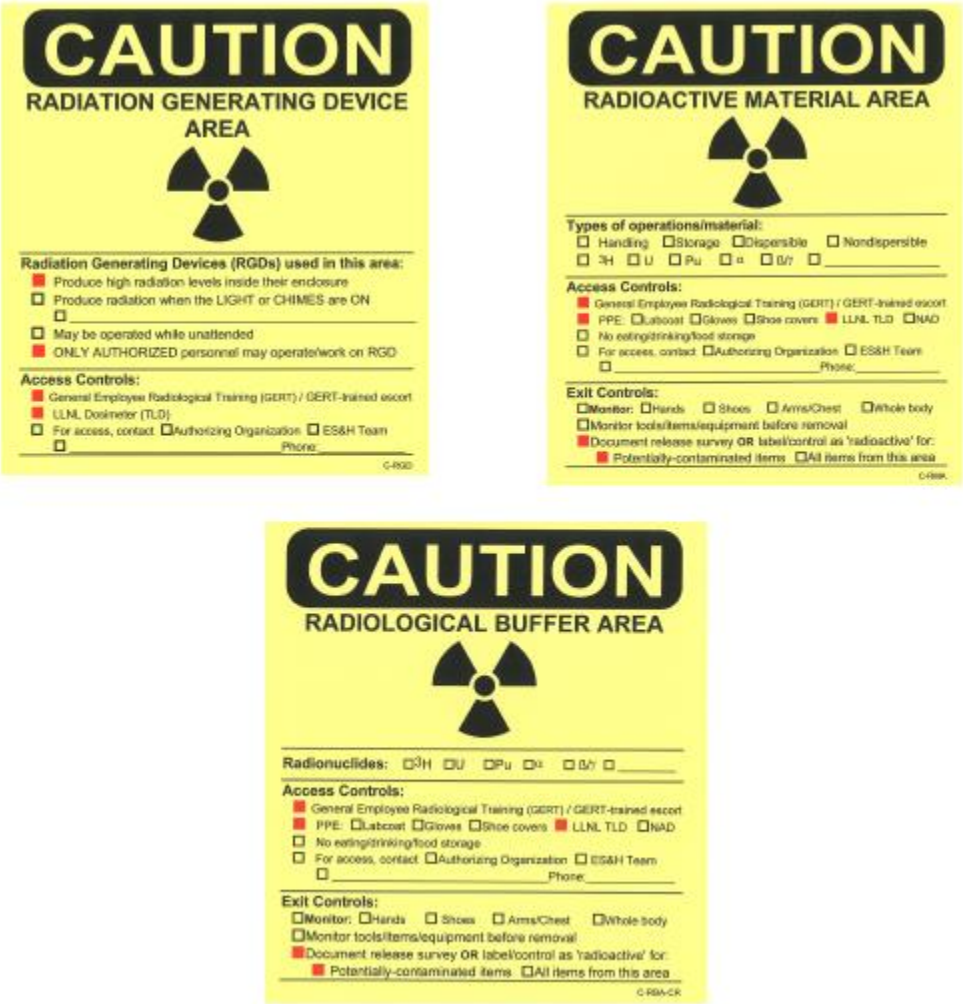

Figure 6. GERT is required for unescorted access to areas posted with these signs. Visitors are exempt from the "LLNL TLD" required markings on these signs.

Figure 7. Radiological Worker training is required for unescorted access to areas posted with these signs, or variations of these signs. Read such signs carefully, because access requirements may change (as noted by marked boxes) depending on whether or not radiation is being produced in the area. Note: EVERYONE (including Visitors) must wear a TLD if entering areas posted with these signs, unless otherwise authorized by the Radiological Control Manager.

Internal Radiation Protection

An internal radiation dose is a dose received from radioactive material taken into the body. Intake of radioactive material can result from inhalation, ingestion, injury, or, in some cases, absorption through the skin. All persons receive some internal dose of radiation from their diet, but LLNL strives to prevent internal occupational exposures by controlling releases of airborne radioactive material and prohibiting eating or drinking in areas where dispersible radioactive material is handled. In addition, radiation workers are required to use personal protective equipment (e.g., lab coats and gloves) to keep dispersible radioactive material off their clothing and body.

Acquiring and Transporting Radioactive Material

The Radiation Protection Functional Area must approve the acquisition of radioactive material – whether purchased, borrowed, or provided by others (e.g., other DOE contractors, universities, or companies). Radioactive material that is received onsite must be processed by Materials Management (which administers the B231 Vault) and must be properly labeled and controlled.

The transfer of radioactive materials (including contaminated items) from an LLNL facility requires a coordinated effort between the Authorizing Organization, the ES&H Team, and (depending on the amount of material involved) either Materials Management or Radioactive and Hazardous Waste Management (RHWM) personnel. This coordinated effort ensures that radioactive materials are properly labeled, packaged, monitored, and controlled. Controls for transferring radioactive materials are described in *ES&H Manual*, Document 20.2, “LLNL Radiological Safety Program for Radioactive Materials.”

The Sealed Radioactive Source Program

The Sealed Radioactive Source Program (SRS) custodians and users are reminded that:

1. SRSs may be very fragile and may be easily breached. Care must be used when handling SRSs.
2. Breaching even a “low activity” Class I SRS can produce contamination levels that are reportable to DOE.
3. Use of Class III and IV SRSs requires an IWS (or equivalent work control document).
4. SRS are only to be used in the manner for which they were designed and intended.
5. SRS Custodians are responsible for assuring the safe use, labeling, and storage of sources, as well as for ensuring that the source can be located promptly.
6. Materials Management maintains the official inventory of all Class II, III, and IV SRSs.
7. SRS Custodians must complete the “Sealed Radioactive Source Change Form” to make physical or administrative changes associated with Class II, III, and IV SRSs.
8. *ES&H Manual*, Document 20.2, has additional SRS controls and links to the site-wide procedure containing the “Sealed Radioactive Source Change Form.”

Responsibilities

Anyone entering a radiologically-controlled area (i.e., any area posted with the radiation symbol) is responsible for:

1. Wearing a dosimeter unless otherwise authorized by the Radiological Control Manager or his/her designee.
2. Obeying posted signs and instructions given by their escorts. (Visitors are exempt from 'TLD' required' indication on RGD Area, Buffer Area, and RMA signs.)
3. Not handling radioactive material or operating RGDs unless specifically trained to do so.
4. Reporting any unsafe conditions to the Responsible Individual, the ES&H Team health and safety technologist, or in the case of visitors, to their LLNL host.

Visitors monitored under the LLNL dosimetry program are responsible for returning their dosimeter at the end of their visit (or every 6 months for long visits).

1. Dosimeters can be returned to the Dosimetry office or at any security portal.
2. New dosimeters can be obtained from the Dosimetry Office (B253/R1312) or by calling "2-GET1" (ext. 2-4381).

The ES&H Team health and safety technologist assigned to your facility can answer questions or refer you to a health physicist. You can also find ES&H Team contact information online at: https://esh-dir.lln.gov/about.html.

References

1. National Council on Radiation Protection (NCRP) Report No. 160 "Ionizing Radiation Exposure of the Population of the United States" (2009)
2. U.S. Department of Energy, 10 CFR 835, Occupational Radiation Protection
3. The National Research Council Committee on the Biological Effects of Ionizing Radiation, "Health Effects of Exposure to Low Levels of Ionizing Radiation" (known as BEIR III) (1980)
4. The National Research Council Committee on the Biological Effects of Ionizing Radiation, "Health Effects of Exposure to Low Levels of Ionizing Radiation" (known as BEIR V) (1990)
5. American Cancer Society, "Cancer Facts and Figures 2007" (2007)
6. International Council on Radiation Protection (ICRP), "Recommendations of the International Commission on Radiological Protection," Publication 60 (1990)

Test Your Knowledge

Test your knowledge about GERT with these true or false questions:

1. LLNL workers require a dosimeter for access into areas posted with the radiation symbol?
2. Visitors require a dosimeter for access into posted Radiation Areas, unless otherwise authorized by the Radiological Control Manager?
3. LLNL workers should not take their dosimeter on travel unless special arrangements have been made with the ES&H Team health physicist?
4. LLNL TLDs should not be mailed via the U.S. Postal Service?
5. GERT is required prior to receiving occupational exposure in an area posted with a radiation symbol?
6. GERT is required for unescorted access into areas posted with the radiation symbol?
7. Radiation Worker Core Training (HS6901) or an alternate, higher level course is required for unescorted access into radiation areas?
8. Additional Radiation Worker training is required before handling radioactive material or working with RGDs, and before unescorted access is allowed into contamination areas and airborne radioactivity areas?
9. Visitors can obtain a dosimeter by going to the Dosimetry Office (B253/R1312) or by calling “2-GET1” (ext. 2-4381)?
10. Anyone entering an area posted with the radiation symbol must adhere to the posted requirements?
11. Safety-related questions should be directed to the area supervisor, Responsible Individual or the ES&H Team?
12. The *ES&H Manual* radiation-related documents are Documents 20.1, 20.2, 20.3, and 22.6?
13. Visitors who are issued a dosimeter must return it to the Dosimetry Office or a Security kiosk at the end of their visit (or 6 months after it was issued), whichever comes first?

Answers: All answers are TRUE!