Fermi National Accelerator Laboratory

GENERAL EMPLOYEE RADIATION TRAINING

Operated by Fermi Research Alliance, LLC under contract with the United States Department of Energy

January, 2013

INTRODUCTION

Every employee and user at Fermilab who encounters radiation and radioactivity, must play an active part in maintaining exposures to radiation and radioactive materials As Low As Reasonably Achievable (ALARA). In order to do this, we need to develop a sense of pride and ownership toward our daily activities.

OBJECTIVES

Upon completion of this class, the participant will be able to DISCUSS the Fermilab Radiological Control Program in regards to radiological terminology, sources of radiation, biological effects of radiation, dose limits, ALARA, radiological controls, postings, employee responsibilities, and emergency situations.

- DEFINE the basic terminology used in radiological control.
- IDENTIFY natural background and manmade sources of radiation as well as sources of radiation at Fermilab.
- DIFFERENTIATE between non-ionizing and ionizing radiation.
- STATE the potential biological effects from ionizing radiation.
- STATE the whole body radiation exposure limit for non-radiological workers.
- STATE the ALARA concept and principles.
- STATE the methods used to control radioactive material.
- STATE general employee responsibilities for the Radiological Control program.
- EXPLAIN what to do in case of a radiation emergency.

DEFINITIONS

There are certain terms that are unique to work with radiation. Some of these are defined below.

GENERAL EMPLOYEE **-** an individual who may routinely encounter radiological barriers, postings, and/or radioactive materials in the course of his/her assignment. Same as an OCCUPATIONAL WORKER.

RADIOLOGICAL WORKER - an individual whose job assignment requires work on, with, or in the proximity of radiation producing machines or radioactive material and has the potential of being exposed to greater than 100 mrem each year. Same as a RADIATION WORKER.

CONTROLLED AREA - an area where access is controlled due to the chance of higher than background radiation levels being present.

RADIATION - energy emitted in the form of rays or particles from unstable atoms or accelerator beams.

RADIOACTIVE MATERIAL - any material, equipment, or system component that contains or has on its surface unstable nuclei.

RADIOACTIVITY - the natural and spontaneous process by which unstable nuclei emit or radiate excess energy.

RADIOACTIVE CONTAMINATION - radioactive material that is removable, loose, transferable, or in an unwanted place.

rad - a unit which quantifies the amount of energy deposited in matter by radiation.

rem - a unit used to quantify the amount of biological damage done to our bodies by ionizing radiation. However, because most doses are so small, they are usually reported in thousandths of a rem, or millirem (mrem).

SOURCES OF RADIATION

People have always been exposed to radiation. We are exposed to it from sources in our environment and even from sources inside our bodies.

The average annual radiation dose from both natural background and manmade sources of radiation to a member of the general population is about 620 mrem/year.

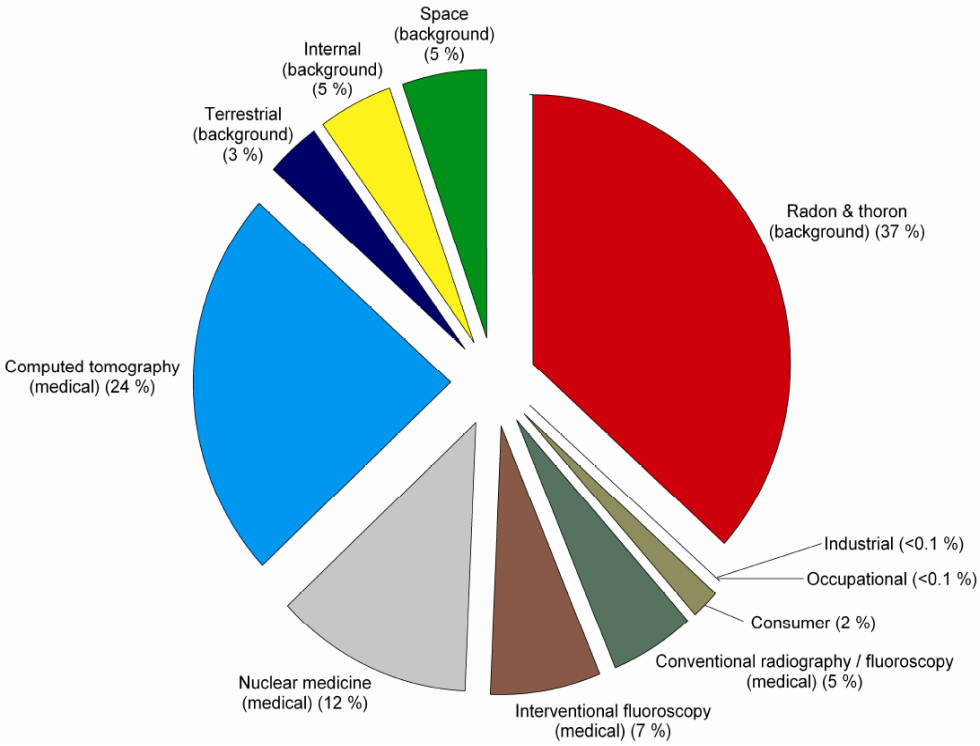
Natural background radiation comprises half of public radiation doses. The main sources are:

- cosmic radiation or the radiation from the sun and outer space;
- radon inside buildings;
- terrestrial radiation or the radiation from the material in the earth's crust such as rocks and soil; and
- internal radiation from material present in our bodies such as potassium-40.

Manmade sources of radiation contribute the remainder of the annual average dose and include:

- medical uses such as diagnostic x-rays and nuclear medicine;
- consumer products such as smoke detectors, lantern mantles, and tobacco products; and
- fallout from nuclear weapons testing

Total Average Annual Background Radiation Dose from All Sources



Because of the type of work that is done here, individuals who work at Fermilab may be exposed to additional sources of radiation.

The largest radiation dose would come from an accidental exposure to an operating beam inside the accelerator tunnel or other beamline enclosures. The chance of this happening is remote due to the safety hardware and procedures that are in use.

It is far more likely that the radiation dose you could receive is from low level sources, such as magnets and other materials which have been exposed to the accelerator beam or specially manufactured sources.

IONIZING AND NON-IONIZING RADIATION

Ionizing radiation has enough energy to remove electrons from an electrically neutral atom. This is the type of radiation of most concern and what is usually referred to when one speaks of radiation.

Generally speaking, there are four basic types of ionizing radiation: alpha particles, beta particles, gamma/x-rays, and neutrons. Because of the unique nature of the work done at Fermilab, there may be other types of ionizing radiation present, such as that due to muons.

Non-ionizing radiation does not have enough energy to remove an electron from an electrically neutral atom. Even though it is capable of causing biological damage, it is not a major radiological concern.

Types of non-ionizing radiation include microwaves, radio waves, ultraviolet and visible light.

BIOLOGICAL EFFECTS

Effects of radiation on biological systems depend on the total dose and the rate at which the dose is delivered.

Acute radiation dose refers to a large dose that is received over a short period of time such as radiation therapy for cancer treatment**,** whereas a chronic dose is a small amount of radiation received over long periods of time. Examples of chronic exposures are those from natural background, routine medical exposures, and work-related or occupational exposures.

Biological effects from chronic exposure may be observed in the exposed individual or in the future children of the exposed individual.

Genetic effects may appear in an exposed individual's children as a result of a dose to that person's reproductive cells prior to conception. Mutations in the chromosomes of the reproductive cells can be passed on to future generations.

A developing embryo/fetus is considered to be in the most radiosensitive stage of human development as the cells are rapidly dividing. Exposure of the embryo/fetus to radiation may increase the child's chances of impaired physical growth, slower mental development or childhood cancer. These risks are virtually eliminated by special protective measures for pregnant radiation workers.

Occupational exposures may slightly increase the risk for the development of cancer and/or cataracts.

DOSE LIMITS

The DOE and FERMILAB radiation dose limit for the general employee or non-radiological worker is 100 mrem/year. DOE has established a limit of 5000 mrem/year for all radiation workers. At Fermilab, a goal for limiting radiation worker doses is set at 1500 mrem/year. A pregnant radiation worker may only receive 500 mrem during gestation.

ALARA

ALARA, As Low As Reasonably Achievable, is the concept at the base of any radiological control program. The ALARA concept can be defined as minimizing exposures, both on site and off site, to radiation and radioactive materials. There are three basic principles of radiation protection used to maintain exposures ALARA: time, distance, and shielding.

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

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

Shielding - Place some type of shielding between you and the source.

Besides our ALARA policy and program, the Laboratory has other radiation safety related policies:

1. Particle beams will not be accelerated without good reason.

2. No person will be exposed to radiation unnecessarily.

3. Beam losses will be limited so that the residual dose rate inside the beamline enclosures will safely permit maintenance.

RADIOLOGICAL CONTROLS

All areas or materials 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 posted at the entrance.

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

c. Labels are used to identify radioactive material.

RADIATION SYMBOI

d. Yellow plastic wrapping is used to package radioactive material.

e. Only designated areas are used to store radioactive material.

f. Protective clothing and equipment are used to protect personnel from contamination.

POSTINGS

AREA	DEFINITION
Controlled Area	An area to which access is controlled to protect personnel from exposure to radiation and/or radioactive material above natural background levels.
Radioactive Materials Area	An area where radioactive materials are used, stored, or handled.
Radiation Area	An area with dose rates between 5 mrem/hr and 100 mrem/hr.
High Radiation Area	An area with dose rates >100 mrem/hr, but $\leq$ 500 rad/hr.
Other	Can designate areas with higher dose rates or contamination.

Fermilab also has a label classification system for radioactive materials. In general, the greater the number on the label, the greater the level of radiation being emitted.

Note that an individual with GERT can enter a Controlled Area without an escort. In addition, the individual may enter an area solely posted as Radioactive Materials provided that he/she does not handle any radioactive materials.

EMPLOYEE RESPONSIBILITIES

All employees have an impact on maintaining exposures to radiation and radioactive material ALARA.

Some of the general employee responsibilities are listed.

1. Obey all signs/postings.

2. Comply with all radiological and safety rules.

3. Do not enter radiological areas for which you have not had the appropriate training without an escort.

   If being escorted:

   - obey the instructions of your escort;

   - obtain and properly wear any dosimetry; and

4. Be alert for and report unusual radiological situations.

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.

EMERGENCY SITUATIONS

A radiation emergency is any situation involving radiation which places or may place in jeopardy human life, health, or safety or valuable property.

Examples are:

a. fires in radiation areas.

b. a leaking container in a radiation area.

c. a transportation accident involving radioactive material.

Responsibility for reporting the emergency initially rests with the person who discovers it.

If you discover what you think may be an emergency of any kind:

- Call X3131.
- Remain on the scene.
- Keep others from entering the hazardous area.

SUMMARY

As an employee, it is important to be informed of the radiological hazards at the site. Workers need to be able to identify the hazards and take appropriate protective measures. Through an enhanced awareness and a sense of personal responsibility and ownership, each employee can contribute to safe ALARA practices.

Should you have any questions regarding the material in this handout, please ask your supervisor or contact your Area Radiation Safety Officer (RSO) or the ES&H Radiation Physics Team.