TRAINING & QUALIFICATIONS PROGRAM OFFICE

BROOKHAVEN NATIONAL LABORATORY

RADIOLOGICAL WORKER 1 TRAINING

STUDY GUIDE

Revised: October 6, 2016

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Learning Objectives

To receive credit for completion of this training course, each participant will be required to attain a grade of 80% or greater on a 50-question multiple-choice examination covering the following objectives.

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2	Identify the unit used to measure radioactivity.
3	Explain the difference between non-ionizing and ionizing radiation.
4	Identify the four types of ionizing radiation.
5	State the meaning of the radiation unit rem.
6	Explain the difference between occupational and non-occupational radiation dose.
7	Identify the average annual radiation dose from non-occupational sources.
	MODULE 2
1	Explain the difference between acute and chronic effects.
2	State the potential effects associated with prenatal radiation dose.
3	Identify the primary risk associated with occupational radiation dose.
4	Compare occupational risk from radiation to health risks in industry and daily life.
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6	Apply the concepts of using Time, Distance and Shielding to reduce radiation dose.
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2	State the requirements for marking and/or labeling radioactive materials.

3	Identify the requirements for moving radioactive materials at BNL.
4	Explain the difference between fixed, removable, soil, and airborne radioactive contamination.
5	Identify sources and radiological concerns associated with radioactive hot particles.
6	Identify the purpose of internal radiation monitoring programs.
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	MODULE 8
1	State the purpose of a Radiological Work Permit.
2	Explain the difference between a General and Job-Specific RWP
3	Identify activities requiring the use of Radiological Work Permits.
4	Using a completed Radiological Work Permit, correctly obtain information from its contents.
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6	Identify the requirements for signing a General and Job-Specific RWP Access Record.
	MODULE 9
1	Identify the radiological and administrative consequences for disregarding radiological alarms.

Introduction

The Department of Energy, in conjunction with each laboratory, is firmly committed to having a radiological control program of the highest quality. This program, as outlined in the BNL Radiological Control Manual, requires managers and supervisors at all levels to be involved in the planning, scheduling, and conduct of radiological work, and that radiological safety shall not be compromised to achieve production or research objectives.

To accomplish this goal, all personnel who may encounter radiation or radioactive materials while performing their job must be informed of the potential effects and the policies and procedures in place to minimize their risk.

Radiological Worker 1 Training is considered the minimum training required for the worker who needs unescorted entry into **Radiation Areas** and **High Radiation Areas**.

General Employee Radiological Training (GERT) is the minimum training required for the worker who needs unescorted entry into **Controlled Areas**, **Fixed Contamination Areas**, and **Radioactive Materials Areas** (RMAs) containing only sealed sources, activated material or properly packaged and labeled radioactive material.

Refer to Module 7 for complete requirements for entry and/or exit from all radiologically controlled areas

Overview

All employees[1] need to develop a sense of pride and ownership toward our daily activities and have a healthy respect for the type of work performed at BNL. We should be able to place the risks associated with working at a research facility that uses radiation and radioactive materials in perspective with other risks that we take in our everyday life. To that end, every employee, both radiological worker and non-radiological worker, must play an active part in maintaining exposures to radiation and radioactive materials As Low As Reasonably Achievable (known as "ALARA" and discussed on page 24).

Brookhaven National Laboratory's Radiological Worker 1 training course is intended to inform all radiological workers of the Lab's Radiological Protection Program requirements. The course is divided into nine sections that provide workers with the information needed to work safely around potential radiological hazards. These sections are:

1. Radiation Fundamentals
2. Biological Effects of Radiation
3. Federal Regulations, Policies and Procedures
4. Dose Limits and Administrative Control Levels
5. Radiological Posting and Access Controls
6. Personnel Monitoring
7. Radioactive Materials Control
8. Radiological Work Permits
9. Emergency Alarms and Responses

Successful completion of the Radiological Worker 1 training course can be attained by:

1. Taking the two-part web and classroom combination Radiological Worker 1 course. The first part of the course is available on the web at http://training.bnl.gov. Once the web-based portion is successfully completed, you may register for the second part of the course, which is a classroom course offered every Tuesday morning. You must complete Part One before attending Part Two.

2. Attending the full-day classroom Radiological Worker 1 course, which is offered once a month. Classroom course attendance requires preregistration.

3. Passing a comprehensive 50-question challenge exam. This option is available to anyone who has previously completed BNL's Radiological Worker 1, has prior experience, or a similar qualification at another facility. You should study reference materials (such as this study guide) at your own pace before taking the

[1] Within the context of this study guide, the term "employee" is used to include BNL/BSA employees, contractors, guests, and visitors.

exam. The challenge exam is available from the BNL web course list at http://training.bnl.gov.

Once you have successfully completed the course and passed the exam with a grade of 80% or higher, you will be classified as Radiological Worker 1 certified for a period of two years.

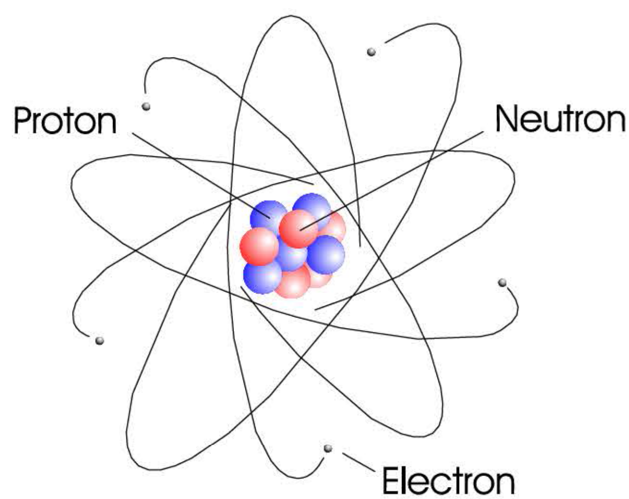
Module 1 - Radiation Fundamentals

- Explain the difference between radioactivity, radioactive material, and radiation-generating devices.
- Identify the unit used to measure radioactivity.
- Explain the difference between non-ionizing and ionizing radiation.
- Identify the four (4) types of ionizing radiation.
- State the meaning of the radiation unit "rem."
- Explain the difference between occupational and non-occupational radiation dose.
- Identify the average annual radiation dose from non-occupational sources.

Explain the difference between radioactivity, radioactive material, and radiation-generating devices

Atomic Structure

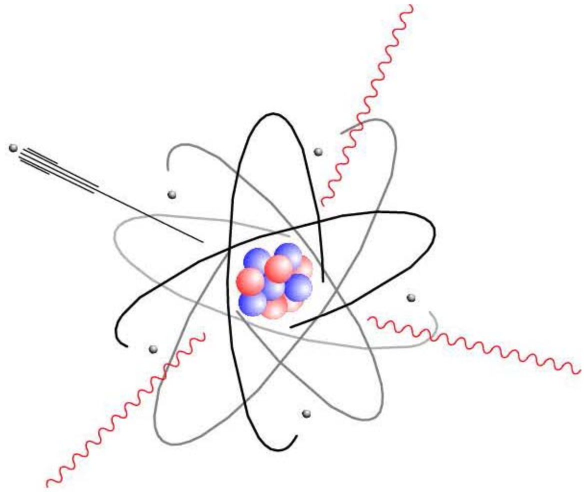
All common, everyday materials, whether they are gas, liquid, or solid, are composed of atoms. Atoms are the smallest units of matter that retain the properties of an element (such as carbon, lead, and helium). Atoms are made of two parts: the nucleus and orbiting electrons. Further, the atom can be described as having three basic particles.



The central core of the atom, called the nucleus, is made up of protons (positively charged) and neutrons (zero charge). The third part of the atom is the electron (negatively charged), which orbits the nucleus. In general, each atom has an equal number of protons and electrons so the atom is an electrically neutral unit.

An element is a substance made up of atoms bearing an identical number of protons in each nucleus. Most of the atoms of an element also have the same number of neutrons in each nucleus, but not always. If atoms have the same number of protons, but a different number of neutrons, they are called isotopes of the element. They retain the same chemical properties of the element, but may exhibit different nuclear properties, such as nuclear decay.

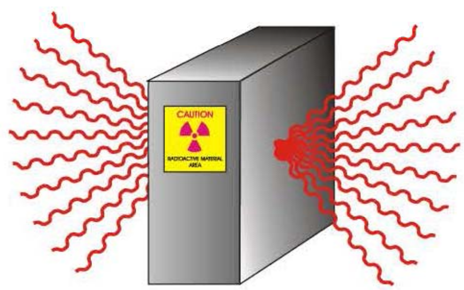
Radioactivity



Radioactivity is the property of certain atoms to emit particles, electromagnetic-wave energy, or both, spontaneously. The nuclei of some atoms are unstable, and eventually adjust to a more stable form by the emission of radiation. These unstable atoms are called radioactive atoms or radioactive isotopes. Radiation is the energy emitted from the radioactive atoms, either as electromagnetic waves or as particles. When radioactive (or unstable) atoms adjust, it is called radioactive decay or disintegration.

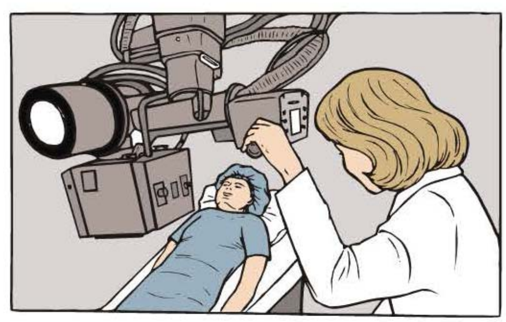
Radioactive Material

Any material containing radioactive atoms is called either radioactive material or a radioactive source. These sources can be identified because of the characteristic radiation energy being emitted. Sources of radioactive materials are not confined to nuclear power plants and research facilities such as BNL. As we will find out later in this training course, you routinely encounter radioactive materials in everyday life.



Radiation-generating Devices

Radiation-generating devices are machines that typically do not contain radioactive materials or sources, but create radiation fields when operated. Except in the case of BNL's high-energy accelerators such as the Alternating Gradient Synchrotron (AGS), the Relativistic Heavy Ion Collider (RHIC), or the National Synchrotron Light Source (NSLS), when radiation-generating devices are not operating, external radiation hazards do not exist. In addition, radiation exposure can be controlled as part of the device's operating procedure. This is accomplished by ensuring that all personnel are removed from the vicinity of the machine before it is operated and by using locked doors, alarms, and other engineered systems, commonly referred to as interlocks, that automatically restrict access to the hazard during operation.



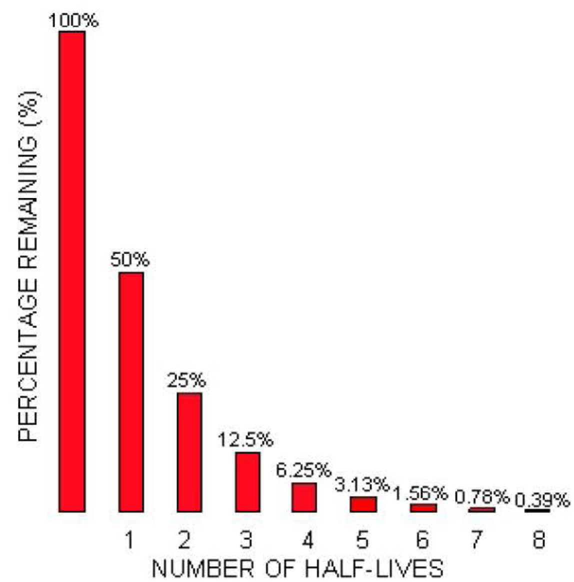
Types of radiation-generating devices at BNL include:

- High-energy accelerators such as AGS or RHIC
- Tandem Van de Graaff RHIC injector
- Free-electron lasers at the NSLS and ATF
- Diagnostic x ray machines used at the Occupational Medicine Clinic
- Therapeutic x ray machines used at the Radiation Therapy Facility
- Analytic x ray machines used to research atomic structure
- DT Generator (deuterium to tritium) used to produce high-energy neutrons for research.

Personnel who are assigned to operate any of these devices must receive training in their safe operation prior to use.

Identify the unit used to measure radioactivity

Measuring Radioactivity



Radioactivity is a natural phenomenon. All radioactive materials undergo this process in an attempt to become non-radioactive or more stable. Radioactive half-life is a measurement used to express the amount of time it takes for a particular radioactive material to decay to one half of its original value. Thus, after one half-life only 50% of the original radioactivity remains, after two half-lives 25%, after three, 12.5% and so on until eventually none of the original radioactive material remains. Every isotope has its own unique half-life, ranging from fractions of a second to millions of years.

Radioactivity is measured in units that are equivalent to the number of radioactive decays occurring each second, commonly referred to as disintegrations per second (dps).

The unit of measure is the Curie (Ci) where one curie equals thirty seven billion disintegrations per second.

$$1\text{ Ci} = 37{,}000{,}000{,}000\text{ dps } (3.7 \times 10^{10}\text{ dps})$$
$$1\text{ Ci} = 2{,}200{,}000{,}000{,}000\text{ dpm } (2.2 \times 10^{12}\text{ dpm})$$

The metric System International (SI) uses the unit Becquerel (Bq) to measure radioactivity. A Becquerel is equal to one disintegration per second.

$$1\ Bq = 1\ dps$$

This system is not widely used for routine operations at BNL, but will often be encountered in scientific journals, research papers, and reference documents.

Explain the difference between non-ionizing and ionizing radiation

Radiation

As previously stated, radiation is energy emitted as either electromagnetic waves or as particles. Radiation is emitted from radioactive atoms and is generated during the interaction of radiation with matter or from a radiation-generating device such as microwave generators, radio-frequency generators such as television and radio transmitters, x-ray machines and lasers.

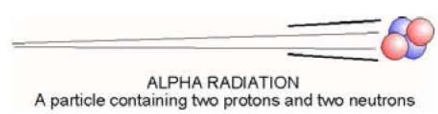
Radiation that has insufficient energy to remove electrons from atoms within material is classified as **non-ionizing radiation.** Examples of non-ionizing radiation include most visible light, infrared light, microwaves, and radio waves.

Radiation that has sufficient energy to remove electrons from atoms through a process known as ionization is classified as **ionizing radiation**. Examples of ionizing radiation include alpha and beta particles, gamma rays and x rays, and neutrons.

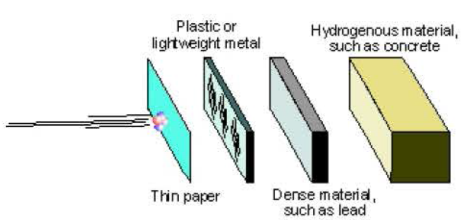
For the purposes of this training we will focus our attention on the hazards and risks of exposure to ionizing radiation only. Thus for the remainder of this study guide, the term "radiation" refers only to ionizing radiation.

Identify the four types of ionizing radiation

Alpha particles

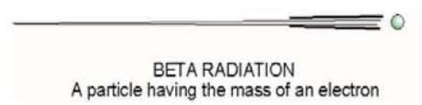


Alpha particles are charged particles containing two protons and two neutrons that are emitted from the nuclei of certain heavy atoms, such as uranium, when they decay. Because of its size and charge, an alpha particle only travels a few centimeters in air. It can be stopped or shielded using a sheet of paper.



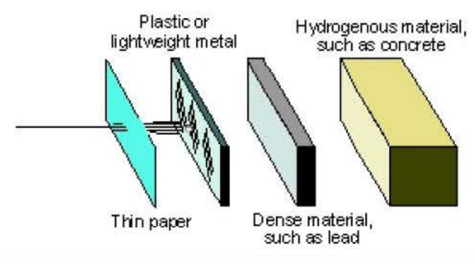
Although the alpha particle cannot penetrate the dead layer of human skin, it represents an internal hazard. Alpha radiation can be very damaging if its source is inside the body. There are only a few sources of alpha radiation at BNL. These are primarily in laboratories in the form of uranium and thorium salts.

Beta particles



Beta radiation is a stream of high-energy electrons (called beta particles) emitted from certain radioactive materials. If the beta particles have a positive charge, they are called positrons.

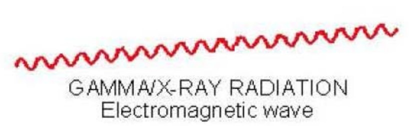
Both are likely to interact and deposit their energy as they pass through surrounding matter. Their range in air can be as far as several feet.



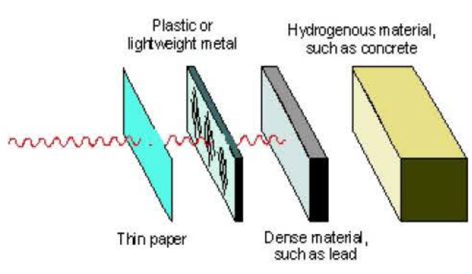
Beta particles can penetrate the dead layer of skin and affect the live skin tissue, and therefore represent both an internal and external hazard. Large doses of beta radiation can cause serious injury to the skin and also to the eyes. Some sources of beta radiation at BNL include tritium (^{3}H), phosphorous (^{32}P), and carbon (^{14}C). Beta particles can easily be shielded by using 3/8" plastic or Lexan, or thin, lightweight metals, such as aluminum.

Beams of high-energy electrons are also generated in our accelerators, but these are not usually termed beta particles. These electrons can penetrate deep into the body and as a result, require more sophisticated shielding. Shielding materials used for high-energy electrons must be correctly engineered to minimize the phenomenon known as bremsstrahlung radiation. Bremsstrahlung radiation is produced when a high-energy particle penetrates into a dense material producing electromagnetic (x-ray) radiation. Personnel are protected from the accelerator beams by the use of appropriate shielding and interlocks to prevent access.

Gamma and X rays



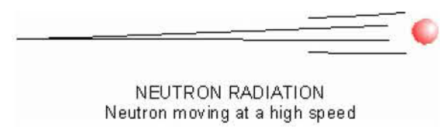
Gamma and x rays are electromagnetic radiation with no mass or charge. Gamma rays are generally emitted from the nucleus during radioactive decay, while x rays are emitted from orbital electrons. Electromagnetic radiation may also be given off by a charged particle accelerating in an electric field, which occurs in accelerators. Accelerating a multitude of electrons causes a phenomenon known as synchrotron radiation, which is the major source of radiation at facilities such as the National Synchrotron Light Source (NSLS).



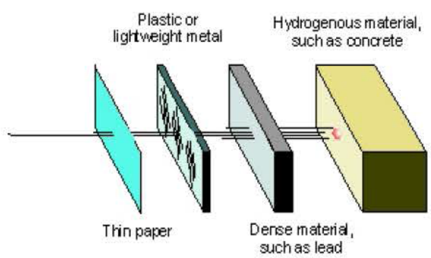
Because they have no mass and no charge, gamma rays and x rays are very penetrating forms of radiation. In air, high-energy gamma rays or x rays may travel several hundred feet. Dense materials such as lead are used for shielding. From a biological perspective, x rays and gamma rays are considered external hazards, meaning that even with the source of radiation outside your body, the radiation can penetrate and affect internal organs.

Gamma radiation is the major contributor to the total dose at the Brookhaven National Laboratory. Some of the major sources of gamma radiation at BNL include the particle accelerators and some of the radionuclides used in the various labs.

Neutrons



Neutron radiation is energy released from an atom in the form of neutral particles called neutrons. Neutrons are emitted from the nucleus of an atom during the fission process (splitting of an atom), as well as the decay process of californium and other transuranic radionuclides. Neutron radiation is also given off as secondary radiation from interaction of other high-energy radiations with matter.



Because they have no charge, neutrons can be a very penetrating form of radiation and can travel several hundred feet through air. At high energies, they transfer energy by collision with light atoms, especially hydrogen. At lower energies, neutrons can be absorbed and the absorbing material can become radioactive. Neutrons, like x rays and gamma rays, are considered an external hazard. Shielding that is most effective for neutrons includes water, paraffin, boron, cadmium, and concrete.

With the High Flux Beam Reactor (HFBR) and the Brookhaven Medical Research Reactor (BMRR) both shut down, the remaining neutron sources at BNL are primarily accelerators such as the Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), and isotopic neutron sources maintained on site.

Sources of Radiation from Accelerators

Beams of protons, electrons, or heavy ions are accelerated and aimed at targets for various experiments. Workers are protected from the beam lines by specially designed shielding and interlock systems. Radiation doses to personnel during operations are primarily the result of secondary radiation caused by the beam striking a target, hardware, or shielding that surrounds the beam line. This radiation dose to personnel is mostly from gamma rays and neutrons. The beam pipes and other parts of the machine may become activated during operations. This residual activity is a major source of exposure during maintenance.

State the meaning of the radiation unit rem

Exposure is a quantity, originally defined to determine the output of x-ray machines, and the unit of measure is the Roentgen (R). The number of ions created when x-ray or gamma radiation passes through a specific volume of air defines the Roentgen.

Absorbed dose is the term used for quantifying all types of radiation, and relates the amount of energy deposited in any material by the radiation. The unit of measure for absorbed dose is the rad, which is equal to 100 ergs/gram deposited by any ionizing radiation in any type of material. The SI unit for absorbed dose is the gray (Gy), where 1 Gy = 100 rad.

When evaluating the risks associated with exposure to radiation in people, equal absorbed doses (rads) may not result in equal risks. This is partially due to the ability of some types of radiation to cause more biological damage while depositing the same amount of energy. In other words, for equal absorbed doses of different types of radiation, the biological effects may be different. For the purposes of radiation protection and control, the unit rem is used when we are concerned about the biological damage or risk to people, rather than merely the absorbed dose.

The unit rem is used to relate the biological risk on a common scale for all kinds of ionizing radiation. The unit rem is the product of the absorbed dose, in rads, and a Radiation Weighting Factor. The Radiation Weighting Factor is a multiplier used to account for the differences in the biological effects of the different types of radiation.

Dose Equivalent (rem) = Absorbed Dose (rad) x Radiation Weighting Factor

Dose Equivalent (Sv) = Absorbed Dose (Gy) x Radiation Weighting Factor

Examples of Radiation Weighting Factor for various radiations are:

Gamma and x rays	1
Beta	1
Neutrons	5 - 20
Alpha (internal)	20

Neutrons have a range of Radiation Weighting Factors because the amount of biological damage varies depending on their energy.

Dose and Dose Rate

Dose is a general term denoting the quantity of radiation or energy absorbed. In general, the term dose without any qualifiers refers to absorbed dose and is measured in rads. For the purposes of this course, dose refers to dose equivalent and is measured in rem, unless otherwise identified.

The dose rate is the rate at which the energy from radiation is absorbed. Because dose refers to the dose equivalent in this course, dose rate is generally measured in mrem/hour, unless otherwise identified.

When evaluating the risk of receiving radiation at a specific dose rate, one must consider the duration of the exposure. The total dose can be determined by multiplying the existing dose rate (mrem/hr) by the duration of the exposure (hr).

TOTAL DOSE (mrem) = DOSE RATE (mrem/hr) X DURATION OF EXPOSURE (hr)

If an individual is planning to enter an area where the dose rate is 60 mrem/hr for a period of 30 minutes, that person's total dose could be calculated as follows:

TOTAL DOSE (mrem) = 60 mrem/hr X 0.5 hr.

TOTAL DOSE = 30 mrem

Explain the difference between non-occupational and occupational radiation dose

Exposure to radiation is generally discussed in two broad categories, radiation doses to the general public (non-occupational) and radiation dose received while performing work at your place of employment (occupational).

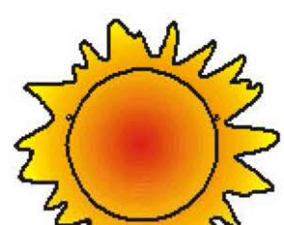
Sources of non-occupational radiation dose

Within the category of non-occupational radiation dose, sources of radiation can be further divided into natural background or artificial.

Humans have been exposed to natural background sources of radiation throughout history. The major natural background sources include the following:

Radon gas comes from the radioactive decay of uranium, which is naturally present in the soil. The radon gas can migrate through the soil and into the air. The decay products of radon may be inhaled, which will then deliver a dose to the tissue of the lungs. On Long Island, the dose from radon is much lower than the national average because there is very little uranium/thorium in the soil. The average effective dose equivalent from radon in the United States is about **230 mrem/year**.

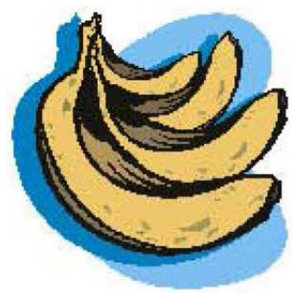
Cosmic radiation comes from outer space and our own sun. The earth's atmosphere and magnetic field affects the levels of cosmic radiation, which reaches the surface, so your dose from cosmic



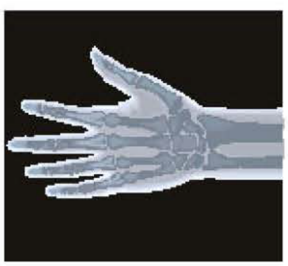
radiation is determined by where you live. For example, the dose rate on Long Island (at sea level) is about 25 mrem/ year, while the dose rate in Denver, Colorado is 50 mrem/year. The average dose from cosmic radiation in the U.S. is about **30 mrem/year**.

Terrestrial sources exist because a number of materials have remained radioactive since the formation of the earth. These natural radioactive materials are found in the ground, rocks and building materials. Some of the contributors to terrestrial sources are the natural radioactive elements radium, uranium, and thorium. In fact, there are some areas in Brazil and India where the natural background radiation levels reach 3,000 mrem/year. The average dose from terrestrial sources in the United States is about **20 mrem/year**.

Internal sources. Our bodies contain various, naturally occurring radioactive elements. Potassium (^{40}K) is one of the major contributors to your internal dose. The average dose from internal sources in the United States is about **30 mrem/year**.



The major artificial sources that contribute to the radiation dose to the general public include:



Medical/dental sources include diagnostic (such as chest or dental x ray) and therapeutic uses of radiation (such as radiation therapy for tumors). Because medical and dental doses are so individualized, your dose may vary from a few millirem to several thousand mrem. The average dose from medical and dental sources in the United States is about **300 mrem/year**.

Consumer products. Some consumer products contain small amounts of radioactive material. Examples include certain ceramic dishes (usually with an orange glaze), some luminous dial watches, and some smoke detectors. These consumer products account for a very minor contribution to the background dose. The average dose from consumer products in the United States is about **10 mrem/year**.

Other. This category includes radiation doses from fallout caused by bomb testing and accidents such as Chernobyl. The average dose from other sources in the United States is less than 1 **mrem/year**.

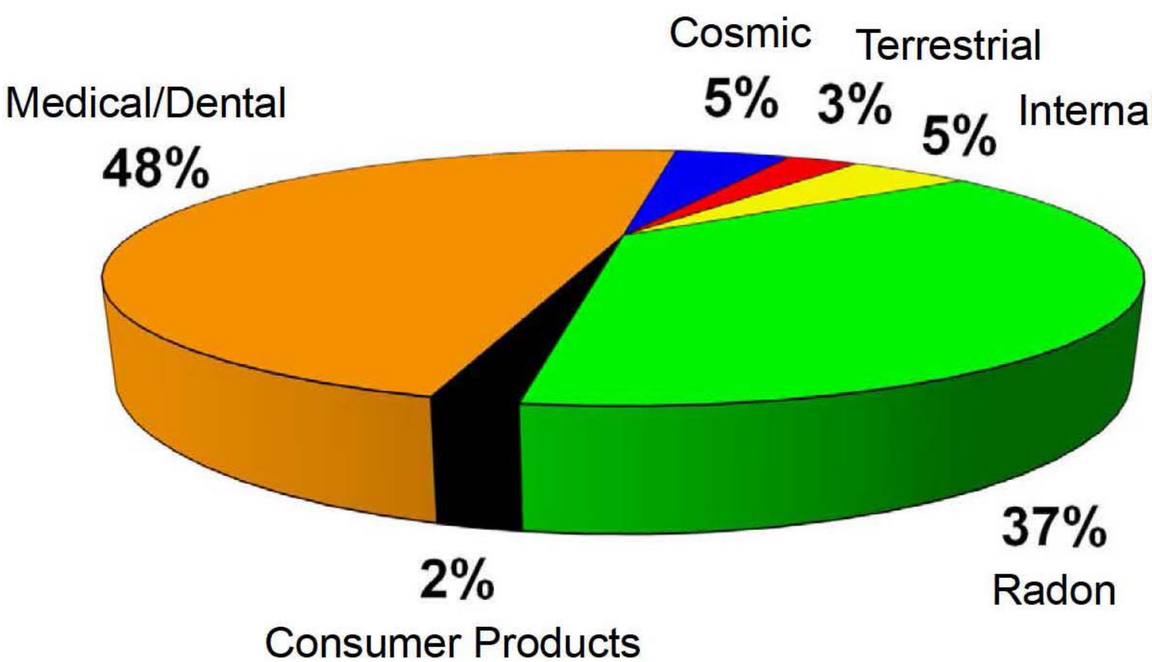
Sources of occupational radiation dose

The other broad category of radiation sources is occupational. Occupational dose is that which is received while working at your job. This includes any dose from previous employers or the military. Occupational dose does not include doses received from background radiation, medical treatment, or therapy.

Identify the total average annual radiation dose from non-occupational sources

Overall, the average radiation dose to a member of the general population in the United States, from natural background and artificial sources, is about **620 mrem/year**. On Long Island, this average dose is significantly lower because of the low levels of radon.

U.S. AVERAGE ANNUAL BACKGROUND RADIATION SOURCES



Module 2 - Biological Effects of Radiation Exposure

- Explain the difference between acute and chronic effects.
- State the potential effects associated with prenatal radiation dose.
- Identify the primary risk associated with occupational radiation dose.
- Compare occupational risk from radiation to health risks in industry and daily life.
- State the BNL management policy for the ALARA program.
- Apply the concepts of using Time, Distance, Shielding, and Interlocks to reduce radiation dose.

Explain the difference between acute and chronic effects

A. Effects from Radiation Exposure

1. Two ways in which radiation affects cells
   a. Direct effect
      a) Radiation ionizes structural or DNA molecules
      b) Having a direct effect on the function of the cell
   b. In-direct effect
      a) Radiation ionizes water (H_2O) within cell
      b) Ionization creates "Free Radicals"
      c) Radicals chemically interact to form toxins (H_2O_2, hydrogen peroxide)
      d) Toxins indirectly affect the function of the cell

2. Various potential overall effect on cells
   a. Ionization occurs but molecules immediately recombine with no effect
   b. Cell sustains some damage from ionization, but totally repairs itself
   c. Cell sustains damage, repairs itself somewhat but functions abnormally
   d. Cell sustains sufficient damage to cause death to the cell

3. Ultimate effect dependent on several factors
   a. Magnitude of the dose
      a) How much dose is received
   b. Duration of the exposure
      a) What was the time period of the exposure
   c. Types of cells exposed to radiation
      a) Cells reproducing at a rapid rate are most sensitive
         (1) Blood cells
         (2) Lining of intestinal walls
         (3) Developing embryo/fetus
      b) Cells reproducing at a slower rate are less sensitive
         (1) Muscle tissue
         (2) Structural bone
         (3) Nerve tissue

Acute Radiation Effects

Observable, short-term effects, often referred to as **acute effects**, are associated with large doses of radiation received in relatively short periods of time. Acute radiation effects typically will not occur at doses less than 10 rad. Below this level, the effect of radiation is too small to detect with today's routine medical technology. The first detectable effect is a minor change in the concentration of white and red blood cells. As the cumulative dose increases in magnitude, the effects become more observable. Examples of expected effects versus radiation dose include:

25 rad	Onset of observable blood changes
100 rad	Onset of radiation sickness symptoms (nausea, diarrhea)
300 -450 rad	Established lethal dose (LD50/60), i.e., with no medical attention, expected 50% mortality within 60 days

Chronic Radiation Effects

In this course, a chronic dose is one received over a long period of time, usually repeatedly, in small increments. Examples of chronic doses include the dose received as a Radiological Worker at BNL (occupational dose) and the dose from background sources. Chronic doses may present an increased risk of a radiation-induced cancer developing later in life. ***There are no observable short-term effects associated with a chronic radiation dose***. Within the allowed dose limits, this increased risk of a radiation-induced cancer is considered small, especially when compared to risks people accept in their everyday lives.

Prediction of long-term effects occurring are based on studies of people exposed to large doses, and include sample populations such as survivors of Hiroshima/Nagasaki, radium dial painters, radiotherapy patients, and uranium miners. The effects observed from these high doses are extrapolated to lower doses by assuming a direct, linear correlation. There has been some discussion about the appropriateness of these extrapolations from high dose to low dose. Scientific opinion generally concurs that these estimates are conservative.

State the potential effects associated with prenatal radiation dose

As with many other physical factors that are known to have an adverse effect on a developing embryo or fetus, such as smoking and consuming alcohol or caffeine, radiation exposure may pose harmful effects to the unborn child. The rapidly developing and immature cells of the developing embryo or fetus are more sensitive to damage, and the effects from exposure to radiation are no exception. The actual effects are a function of the time during gestation that the dose is received as well as the dose received. Studies have linked excessive radiation exposure to low birth weight, retarded growth, and a potential increased risk of developing childhood cancer. Any harmful effect to the embryo or fetus (*in utero*) is called a teratogenic effect. The prediction of these effects occurring is based on studies from Hiroshima/Nagasaki and pregnant women receiving radiotherapy. When compared to the normal risks associated with a pregnancy, risk of teratogenic effects from exposure to radiation up to the DOE limits (500 mrem/gestation period) is considered negligible. Current knowledge indicates that only when radiation doses exceed 15,000 mrem is there a significant increase in the risk.

Because the embryo/fetus is more susceptible to injury from radiation (compared to mature developed cells), DOE and BNL have a policy restricting the dose allowed to a pregnant Radiological Worker. If you are pregnant or intend to become pregnant, and work in areas where you could be exposed to radiation or radioactive materials, you have the option of voluntarily notifying your supervisor in writing that you desire to reduce your radiation dose to protect the embryo/fetus. Upon receipt of the written notification, you will be classified as a "**declared pregnant worker**." Because of each individual's right to privacy, no action can be taken until the formal notification is received.

The policy of BNL is to offer the declared pregnant worker two options:

- The first option is to identify a mutually agreeable assignment without loss of pay or promotional opportunity, such that further occupational radiation exposure is unlikely. This is frequently referred to as the **zero-dose option**.

- The second option, referred to as the **low-dose option**, allows the declared pregnant worker to continue working in radiologically controlled areas with the DOE dose limit to the developing embryo or fetus of **500** mrem throughout the gestation period. For this class of declared pregnant worker, Brookhaven National Laboratory has established an administrative control level of **350** mrem throughout the gestation period. This dose ***shall be divided over the gestation period as evenly and consistently as possible without substantial monthly variation***.

Whatever option you choose, all benefits of work (pay, promotions, etc.) will not be affected. Furthermore, a declared pregnant worker may revoke her declaration at any time during the pregnancy. At such time the normal radiation dose limits and Administrative Control Levels apply.

At the termination of pregnancy, you must submit the signed and dated Withdrawal of Pregnancy Declaration form to your supervisor indicating that you are withdrawing your formal Declaration of Pregnancy. No additional explanation or justification shall be requested. After such notification has been made, line management shall remove any imposed radiological work or area restrictions. Contact your supervisor or Facilities Support Representative for further details.

Identify the primary risk associated with occupational radiation dose

Based primarily on human studies, the National Academy of Sciences, National Council on Radiation Protection and Measurement, and the International Commission on Radiation Protection estimate the risk value (to an adult) for an occupational radiation dose (above natural background) of 1 rem (1,000 mrem) represents a risk of 0.0004 or 4 in 10,000 of developing a fatal cancer.

To illustrate this, in a population of 10,000 people, current statistics indicate that approximately 3,000 will contract cancer in their lifetime. Of the 3,000 that develop cancer, approximately 2,000 will die from their cancer. If all 10,000 people were to receive occupational exposures of 1 rem in addition to the radiation dose from natural background and artificial sources, an additional 4 deaths may occur due to radiation induced cancers. This increases the total fatality from approximately 2,000 to 2,004. This small effect cannot be "seen" in the normal variation of the death rates, and therefore must be calculated.

Another way of stating this is that every member of the general population in the United States has roughly a 20% chance of dying from cancer (natural cancer mortality rate). If a person were to receive a cumulative occupational dose of 1 rem during their life, their risk of developing a fatal cancer would increase from 20% to 20.04%.

Still, we assume that there is some probability for effects occurring even at very low doses. Simply stated, there is no threshold or starting point for an effect. This requires us to justify the need to receive these doses and ensure the benefit outweighs the risk. This "no threshold" concept is the basis for our ALARA (As Low As Reasonably Achievable) policy.

Compare occupational risk from radiation to health risks in industry and daily life

The following tables may be used to gain perspective of the risk associated with exposure to radiation.

COMPARISON OF MORTALITY RATES

CAUSE	DEATHS/YR-MILLION PERSONS
Cardiovascular disease	4780
Cancer	1700
Motor accidents	220
Home accidents	150
Homicides	100
Fire	30
Drowning	30
Poisoning	13
Radiation effects (per rem)	9
Aircraft crashes	8
Electrocution	6
Lightning	1
Animal and insect bites	1

The above table indicates for the average United States citizens, there would be nine deaths out of a population of 1,000,000 people each exposed to one rem where the death occurs in the same year as the exposure. This is much lower than the 150 deaths each year attributed to accidents in the home among an equivalent population of 1,000,000 United States citizens.

COMPARISON OF OCCUPATIONAL RISK

INDUSTRY	AVE. DAYS OF LIFE LOST/PERSON
Mining and Quarrying	328
Construction	302
Agriculture	277
Transportation/Utilities	164
All industry	74
Government	55
Radiation dose of 1 rem/year for 50 years	50
Service	47
Manufacturing	43
Trade	30

Note: On the average, a construction worker in the United States will live about 302 days less than the average United States citizen. Similarly, a radiation worker who receives 1 rem per year for 50 years, (50 rem cumulative), will live about 50 days less than the average United States citizen.

The average BNL Rad Worker who receives measurable dose averages about 50 mrem per year.

<u>COMPARISON OF DAILY LIFE RISK</u>

ACTIVITY	AVE. EST OF DAYS OF LIFE LOST/PERSON
Smoking	2,190
Overweight by 15%	730
Consuming alcohol (average US consumption rate)	365
Motor vehicle accident	207
Home accident	74
Drowning	24
Natural disaster	7
Radiation dose from medical applications	6
Receiving 100 mrem/year from age 18 to 65	5

As can be seen from these tables, the risk of death from radiation exposure is quite low compared to many other causes of death in our society.

Benefits of Radiation

Although the risks are low, some individuals are concerned about exposure to radiation even at very low levels. These are personal value judgments that all individuals must make for themselves. Keep in mind that many uses of radiation are very important in health care or in other applications by society. The potential benefits of such use should be carefully weighed in consideration of the small risks produced by them. Some beneficial uses of radiation include:

1. Medical/dental x-rays
2. Nuclear medicine scans (heart stress test, liver, bone, kidney, brain, etc.)
3. Cancer therapy
4. Biomedical research, such as DNA, cancer and immune system diseases
5. Airport security
6. Radiography for structural integrity
7. Food preservation

State the BNL management policy for the ALARA program

Because there is a possibility, however small, of an adverse health effect occurring from any exposure to radiation, the main goal of the BNL Radiation Protection program is to reduce radiation doses to a level that is As Low As Reasonably Achievable (ALARA).

Under the ALARA concept, DOE and BNL management policy includes:

1. Controlling radiation doses to workers and the public at levels that are well below the regulatory limits.

2. Ensuring that no radiation exposure occurs without a corresponding benefit from the task, and that the benefit outweighs the risks associated with that dose.

3. Preventing unnecessary exposures to workers and the public.

4. Protecting the environment from unnecessary radiation exposures.

Individual Responsibilities

Your individual responsibilities as a Rad Worker at BNL include:

1. Assuming the ***primary responsibility*** for maintaining your radiation dose ALARA, and below the dose limits and assigned administrative control levels.

2. Using time, distance, and shielding to maintain your radiation doses low.

3. Report observed inoperability of radiation interlocking systems.

4. Reading and complying with all radiation barriers, signs, labels, and postings.

5. Never crossing over barrier fences or defeating any radiological protection systems.

6. Stopping work, terminating your exposure to radiation, and reporting the situation to your supervisor and Facility Support Representative if you suspect that you are approaching or exceeding a dose limit or administrative control level.

7. Complying with all regulations and orders establishing radiation dose limits and administrative control levels.

Apply the concepts of using Time, Distance and Shielding to reduce radiation dose

Minimize Time of Exposure to Radiation

Reducing the amount of time in a radiation area or field lowers the dose you receive. One of the keys in minimizing your time in a radiation area is to pre-plan the job or experiment. This may include:

1. Job-planning through the SBMS Subject Area Work Planning and Control for Experiments and Operations.

2. Using mock-ups to train on new equipment or procedures, or to gain proficiency at the task to be done.

3. Taking the best route to the job site; the shortest route may not be the best - know where the higher and lower radiation level areas are.

4. Preparing the necessary tools and equipment prior to entering the area; verify any special calibration or tool preparation is done before entering the radiation area.

5. Never loitering in an area controlled for radiological purposes.

6. Working efficiently and quickly.

7. Eliminating rework by doing the job right the first time.

8. Performing preparatory work and parts assembly outside the area.

Increasing Distance from the Radiation Source

Use the protection offered by distance from the source of radiation whenever possible. For many sources, radiation levels decrease rapidly as distance increases. For example, if the distance from a point source is doubled, the radiation level is only one-quarter as strong. Therefore, if a point source measures 360 mrem from a distance of one foot, it will measure only 90 mrem from two feet away. From three feet away, the radiation level would drop to only 40 mrem.

Some methods to increase the distance from the radiation source include:

1. During work delays, moving to lower dose rate areas. Radiological surveys will have areas designated as Low Dose Rate Areas (LDRA) clearly identified.

2. Using long-handled tools, mechanical arms, and robotics to increase the distance from the source.

3. Knowing the radiological conditions of the area you are entering. If possible, move the item being worked on away from the source of radiation, or move the source of radiation away from the work area.

4. Use of mirrors or closed-circuit TV to monitor the job site.

Use Shielding to Lower the Dose Rate

Shielding reduces the amount of radiation dose to the worker.

1. Select the proper materials to shield a worker from the different types of radiation.

2. Take advantage of permanent shielding such as equipment or existing structures.

3. Position yourself or the shielding so that shielding is between you and the source.

4. Wear safety glasses/goggles to protect the eyes from beta radiation, when applicable.

5. Install temporary shielding when required by procedure or the Radiological Work Permit (RWP). Temporary shielding is required to be marked or labeled with the statement: "Temporary Shielding - Do Not Remove without Permission."

Interlocks and Shielding Design

In addition to individual workers using time, distance and shielding, Brookhaven National Laboratory embraces the ALARA concept with its design and use of engineering solutions, such as shielding and interlock systems. Some of the basic interlock systems include:

1. Interlocks that prevent access.

2. Interlocks that turn off the source of radiation.

3. Interlocks that shield the source of radiation.

Because there are so many different interlock systems in use, specific operating instructions and concerns will be discussed when you receive facility-specific training. In addition to the interlocks, alarm systems are also used to warn people of a potentially hazardous condition or situation.

CONTAINMENT and CONFINEMENT

1. Cubicals, tanks, vessels, glovebags, designed to TOTALLY CONTAIN leakage of particulates, liquids and gases

2. Drip trays, catch basins, cofferdams designed to collect and contain liquid leakage

SOURCE REDUCTION or ELIMINATION

1. Fragment the source, (REDUCTION)

ADMINISTRATIVE CONTROLS, (good work practices)

Optimizing Manpower:

Using only essential manpower, not excessive
Training on mock-ups to increase efficiency and speed
Quality work the first time
Skill versus unskilled toward completion of the task
Fix the problem so that the task is eliminated and manpower does not have to be utilized.

BNL's commitment to the ALARA Program

- Absolute commitment to ALARA at all levels of Management / Staff
- Ensure no radiation dose occurs without a corresponding benefit from the task
- Applies to collective and individual dose at BNL

Module 3--Federal Regulations, Policies, and Procedures

- Identify the purpose and scope of the Price-Anderson Amendments Act (PAAA) and 10CFR835 with regards to radiological protection at BNL.
- Identify the purpose and scope of the BNL policy regarding your responsibility and authority for stopping non-compliant radiological work.
- State the purpose of the BNL Radiological Awareness Report (RAR) Program.

Identify the purpose and scope of the Price-Anderson Amendments Act (PAAA) and 10CFR835 with regards to radiological protection at BNL

What is the *Price-Anderson Amendments Act*?

The *Price-Anderson Amendments Act* is a law designed to protect the health and safety of workers and the general public. The Act specifies that the Department of Energy (DOE) will insure its primary contractors (Brookhaven Science Associates) against liability arising from nuclear or radiological accidents or incidents resulting from activities performed within the scope of the BSA contract.

DOE has put nuclear and radiological safety requirements into federal regulations. These regulations are contained within the Code of Federal Regulations (CFR). The Occupational Radiation Protection rule, 10 CFR 835, applies to all DOE personnel.

The Code of Federal Regulations applies to several categories of work at BNL:

- 10 CFR 830 Nuclear Safety Management, Subpart A (Quality Assurance) and 10 CFR 835 (Occupational Radiation Protection) apply to radiological activities at BNL
- 10 CFR 820, Procedural Rules and Enforcement Policy
- 10 CFR 708, DOE Contractor Employee Protection Program

To Whom Does This Apply?

PAAA applies to all DOE contractors, such as Brookhaven Science Associates (BSA), as well as sub-contractors and suppliers to Brookhaven National Laboratory. This means that all employees, guests, contractors, and outside suppliers are responsible for adhering to these regulations. It is each individual's obligation and responsibility to identify and report any known non-compliance issue.

If the CFR requirements are not met, the primary contractor (BSA), sub-contractor, supplier, and/or responsible individual may be liable to civil and/or criminal penalties and/or fines up to $150,000 per day.

What Must You Do If You Find a Requirement Has Not Been Met?

Upon discovering that a requirement has not been met, it is your responsibility to report the deficiency to your immediate supervisor. It is very important not to overlook this requirement; ignorance is not an acceptable excuse. If you knowingly allow a non-conforming activity to continue or make fraudulent statements during an investigation concerning the activity, you may be held liable for willful negligence.

Once reported, a preliminary review will take place to determine the applicability of the non-conforming activity. Results of the review will identify the root cause of the problem and describe comprehensive corrective actions to ensure the non-conforming activity does not recur.

What Can You Do to Ensure That the Requirements are Met?

BNL management is responsible for providing each employee with adequate direction to ensure that all work can be performed safely and within the regulatory requirements. Brookhaven National Laboratory uses an Integrated Safety Management (ISM) system to empower each and every person, at all levels, with the authority and responsibility to control and perform work safely.

BNL Senior Management

As the prime contractor, Brookhaven Science Associates (BSA) is responsible for the operation of Brookhaven National Laboratory under contract with the Department of Energy. As written, the contract is BSA's commitment to operate this facility in a safe and reliable manner and, for purposes of radiological protection, in compliance with all of the requirements specified within 10 CFR 835.

Radiological Control Manual

The BNL Radiological Control Manual specifies programmatic and implementation methods that BNL has adopted to satisfy 10CFR835 and the requirements of the contract. The requirements within the BNL Radiological Control Manual apply to all BNL activities involving radiation or radioactivity that pose a potential hazard to workers, the public, or the environment.

Standards Based Management System (SBMS)

Site-wide programs, policies, and procedures are published and available on the Web through the Standards Based Management System (SBMS). These documents clearly define the requirements that must be followed and directions for implementing them adequately into your work at BNL.

Radiological Control Division

The Radiological Control Division, part of the Environment, Safety, Health Directorate, is responsible for providing BNL organizations with the necessary support and services to implement the requirements of the BNL Radiological Control Manual. Your Facility Support Representative and Facility Support Technicians belong to the Radiological Control Division. These people are the experts assigned to your BNL organization to provide day-to-day radiological safety services, such as:

1. Radiological safety reviews and job coverage for work and research projects
2. Response to abnormal conditions and emergencies
3. Radiological surveys
4. Job coverage for industrial hygiene and safety concerns

Occurrence Reporting and Processing System

There is also an Occurrence Reporting and Processing System (ORPS) in the SBMS that states that all staff is required to report, as appropriate, abnormal events or conditions that they perceive may:

a. Endanger the health and safety of staff or the public,

b. Have an adverse effect on the environment,

c. Seriously impact the operations and intended purpose of BNL facilities,

d. Result in loss or damage of property, or

e. Adversely affect national security or the security interest of DOE or BNL

The event or condition must be categorized within two (2) hours of discovery. Therefore, it is very important that you notify your supervisor as soon as practicable if you feel that a situation may require an ORPS report.

Employees, Guests, and Sub-Contractors

As a RadWorker and a part of the BNL Team, it is each individual's responsibility to adhere to all BNL policies and procedures to ensure all work at the Laboratory is performed safely and within the regulatory requirements.

Direction and guidance are provided to you in a variety of ways:

- Standards Based Management System (SBMS)

  The Standards Based Management System makes available over the Web all BNL programs, policies, and procedures necessary to ensure requirements are incorporated into your work. All work performed at BNL must be evaluated using the

Work Planning and Control for Experiments and Operations Subject Area within SBMS. These pre-work evaluations will ensure that all the applicable requirements are addressed before beginning your work.

- Written Procedures

  When written procedures exist for your work, always follow the instructions. If you have questions, make sure they are answered BEFORE you start or continue with your job.

- Radiological Training

  Make sure you are aware of what training is necessary for your job and always ensure your training qualification is current BEFORE you start work. You can check your training status using the BNL Training and Qualification Web Page at

  http://training.bnl.gov

- Radiological Work Permits

  Always obey all of the requirements contained within Radiological Work Permit (RWP). Read the permit carefully BEFORE starting the job. If you have questions concerning the radiological conditions or protective measures, ASK questions. Don't assume anything without concurrence from a qualified Facility Support Technician.

- Radiological Postings

  Always READ and comply with area radiological signs and posting. In the event you find a radiological sign or posting misplaced or illegible, contact a Facility Support Technician for assistance. DO NOT alter or remove any radiological signs, postings, or barricades.

Identify the purpose and scope of the BNL policy regarding your responsibility and authority for stopping non-compliant radiological work

Stop Work for Radiological Activities

The Code of Federal Regulations (10 CFR 835) applies to ALL radiological activities that we conduct at BNL. Management expectations for performing radiological work safely and fully compliant with regulations have been clearly stated by the Laboratory Director. The Director has empowered each and every individual who has received radiological safety training with the authority and responsibility to stop non-compliant or unsafe radiological work immediately. This policy is commonly known as the "Radiological Stop Work Policy."

Who Can Issue a Radiological Stop Work Order?

Any employee, guest, or visitor that has received formal training in the contents of the stop-work procedure through the successful completion of the GERT or RadWorker 1 training can issue a Radiological Stop Work Order.

If, while working, a Radiological Stop Work Order is issued, you MUST:

- Stop working on the affected activity as soon as safely possible
- Place the workspace in safe condition
- Report to your supervisor and explain why the Radiological Stop Work Order was issued at your job

Work is not to resume until safety reviews are performed and your department chairperson or equivalent line manager authorizes you to restart work.

It is essential that all BNL radiological control policies and procedures are respected. Our objective is to ensure excellence in radiological performance by utilizing the safety awareness and involvement of all personnel.

State the purpose of the BNL Radiological Awareness Report (RAR) Program

Excellence in Radiological Controls is not merely having a good program; it also involves a continued desire to seek improvements throughout all levels of the program. To aid in continuing program improvement, Brookhaven National Laboratory has implemented the Radiological Awareness Program.

Radiological Awareness Reports (RARs) are used to notify Laboratory management of good work practices, as well as radiological deficiencies and incidents, and for addressing concerns relating to radiological hazards. You, as a Radworker, play a vital role in the success of this program. The RAR Program depends on information gathered from radiological control practices in the field. It is the role of the Radworker to provide this information. This program is your avenue of communication between daily work activities and management concerning good practices or deficiencies in the administration of our Radiological Controls Program. In turn, with this information, management will be able to better identify program strengths, weaknesses, and shortcomings; specify corrective actions; and develop action plans for improvement.

For further information on generating RARs, contact your Facility Support Representative and/or the BNL RAR Coordinator. These contacts can be linked through SBMS.

Module 4 - Dose Limits and Administrative Control Levels

- Identify the DOE radiation dose limits and Administrative Control Levels (ACLs)
- Identify the purpose of ACLs
- Identify the BNL ACL
- Identify your responsibility concerning adherence to a dose limit or an ACL.

The Brookhaven National Laboratory Standards Based Management System (SBMS) contains detailed information and instructions concerning this subject matter. Please refer to SBMS at the following URL address for specific instructions:

https://sbms.bnl.gov

Radiation Dose Limits and ACLs

Identify the DOE radiation dose limits and ACL

The United States Government has established legal limits of occupational exposure in order to minimize the potential risk of biological effects associated with radiation exposure. Limits are set by regulatory agencies and cannot be exceeded intentionally, except for approved emergency actions. The established limits for occupational workers are based on guidance from the National Council on Radiation Protection (NCRP) and the International Commission on Radiological Protection (ICRP). DOE uses these limits, which are also consistent with those of other agencies (such as the Nuclear Regulatory Commission) and other countries.

DOE has established an Administrative Control Level (ACL) well below the legal limit to ensure employees at the various DOE facilities do not exceed the established limits. Under special circumstances and with pre-approval by DOE, the ACL may be exceeded, but additional precautions will be implemented to ensure limits are not attained.

The annual effective whole body dose limits and ACL for radiological workers have been established for ***routine conditions***. (Limits for emergency situations also exist.) The whole body limit applies to the major part of the body not including the forearms, hands, lower legs, and feet. The regulatory whole-body **limit** and **ACL** for Radiological Workers are:

	LIMIT	ADMINISTRATIVE CONTROL LEVEL
WHOLE BODY	5,000 mrem/year	2,000 mrem/year

In addition to the occupational radiation dose limit for the whole body, DOE has established several other limits, including:

	LIMIT
SKIN and **EXTREMITIES** (hands, feet, forearms, and lower legs)	50,000 mrem/year
INTERNAL ORGANS (individual organs)	50,000 mrem/year
LENS of the EYE	15,000 mrem/year
DECLARED PREGNANT WORKER	500 mrem/gestation
UNTRAINED PERSON (visitors, guests, and minors)	100 mrem/year

Identify the purpose of Administrative Control Levels (ACLs)

With legal limits in mind, Brookhaven National Laboratory has established additional Administrative Control Levels (ACLs) below the DOE limits and ACLs to control worker doses even further. The purpose of the BNL ACLs is to reduce individual and total worker radiation dose (collective dose) and to ensure the DOE limits and ACLs are not exceeded.

Identify the BNL ACLs

Brookhaven National Laboratory has established Administrative Control Levels (ACLs) for the following:

	BNL Administrative Control Level (ACL)
WHOLE BODY (site-wide)	1,250 mrem/year
WHOLE BODY (Org.-specific)	Less than Site-Wide
DECLARED PREGNANT WORKER	350 mrem/gestation
DECLARED PREGNANT WORKER	No substantial monthly variation
UNTRAINED PERSON (visitors, guests, and minors)	25 mrem/year

As illustrated in the table above, BNL Administrative Control Levels are established for the Whole Body, Declared Pregnant Worker, and for people who have not received radiological protection training. In addition, each BNL organization may establish additional Administrative Control Levels at or below that set for BNL site-wide. As with the DOE Administrative Control Levels, under certain circumstances, the ACL may be exceeded so long as the appropriate approval is obtained first.

To exceed any of the ACLs, you must have written permission from the originating organization in advance of the exposure. For example, to go above a BNL organizational ACL, you must justify the additional dose and obtain written permission from the Department Chairperson or Division Manager. To go above the BNL site-wide ACL, you must justify the additional dose and obtain written permission from the Laboratory Director and the Radiological Control Division Manager. To obtain your BNL organization's ACL, speak with your Facility Support (FS) Representative or Environmental Safety and Health (ES & H) Coordinator.

The intent of this "tiered" system is to ensure that management is involved in any decision to exceed an ACL, and that there is a justification for the dose. The end result is that ACLs aid in maintaining doses as low as reasonably achievable (ALARA).

Identify your responsibility concerning adherence to a dose limit or an ACL

If you are approaching an ACL and foresee the need to exceed the control level, immediately notify your supervisor and seek assistance from the Facility Support Representative. Do not exceed an ACL without authorization.

For additional information concerning Administrative Control Levels and the process for obtaining permission to exceed them, you should refer to the Radiological Control Division or the Standards Based Management System (SBMS) web site to ensure you obtain the most recent information.

Module 5 - Personnel Monitoring

- State the purpose and identify the correct use of a Thermoluminescent Dosimeter.
- State the purpose and identify the correct use of an alarming dosimeter.
- State the method for obtaining your dose records at BNL.
- Identify your responsibility for reporting dose received from other facilities.
- Identify your responsibility for reporting medical treatment/therapy involving the use of radioisotopes.

This module addresses materials contained within the Standard Operating Procedure:

HP-SOP-017, Selection, Use and Termination of Personal Monitoring

It is recommended that you review the most recent revision of the procedure(s) prior to performing activities governed within them. You may view or print a copy of the procedure(s) through the Radiological Control Division web site at:

https://sbms.bnl.gov

Dosimeters

There are several devices used to monitor **occupational** dose at BNL, including the whole body thermoluminescent dosimeter (TLD), alarming dosimeter (Electronic Personal Dosimeter, EPD), and finger ring (extremity TLD).

State the purpose and identify the correct use of a Thermoluminescent Dosimeter

Whole Body Thermoluminescent Dosimeter (TLD)

For purposes of Whole Body radiation dose tracking, Brookhaven National Laboratory uses the thermoluminescent dosimeter, commonly referred to as the TLD. The TLD offers no protection from radiation, but monitors your exposure to beta, gamma, x-ray, and neutron radiation. TLDs are exchanged on a monthly basis and processed on-site. This processing usually takes a few weeks, unless there is a need for a quicker turn around in an individual case. TLDs are more resistant to physical and environmental shock than old style film badges and can be reused after processing.

Because the ***TLD is the basis for the legal record of your occupational dose,*** there are many rules and requirements regarding their use. These requirements include:

1. TLDs are worn when required by signs or postings, Radiological Work Permits, and when directed by Facility Support Representatives or Facility Support Technicians.

2. TLDs must be worn on the front of the torso, between the waist and the neck, or where required by a Radiological Work Permit (RWP) unless otherwise directed by FS personnel. The best location is the center of the chest with the color bar facing away from the body.

3. When other types of dosimeters are required, they shall be worn adjacent to the TLD unless otherwise directed by a Facility Support Technician or Facility Support Representative.

4. All TLDs shall be stored in low background areas and protected from adverse environments (excessive heat, moisture, etc.) when not in use. The TLD should be placed on the designated badge board at the close of business. If the TLD is taken home by mistake, return it the next working day.

5. TLDs at BNL are usually exchanged the last weekend of each month.

    a. If you leave BNL (employment is terminated or your guest appointment has expired), turn in your TLD to the Facility Support Representative and request that they cancel your TLD service. It is also permissible to return your TLD directly to the Personnel Monitoring Group.

    b. If you will not be here for the monthly exchange (e.g., business trip or vacation), leave your TLD on the badge board and it will be exchanged with the others.

    c. If you are wearing your TLD during the monthly exchange, see your Facility Support Representative the next working day to exchange the TLD.

    d. Personnel who fail to return a TLD **may** be restricted from continued radiological work.

    e. You must also surrender your TLD to Facility Support upon request.

6. TLDs issued at BNL should not be worn at another facility, and dosimetry issued from another facility should not be worn at BNL. The concern is that your dose should be recorded only once for any time period

monitored. If you have any questions or concerns, contact your Facility Support Representative.

7. Radiological Workers should **never** wear another worker's TLD, nor should they allow another to wear theirs. Because the TLD is issued to monitor an individual's monthly dose, either of these practices would invalidate the dose recorded on the TLD.

8. Visitor TLDs are identified by a red color band on the front. Individuals wearing them require escorts in radiologically controlled areas. Fully trained Radiological Workers receive a TLD with a blue or yellow color band on the front. When TLDs are collected for monthly processing, the used TLD is exchanged with a new one. To aid in determining whether all TLDs have been exchanged, the new TLD will have a different colored band. If you should notice that your TLD has a different colored band than most others, contact your Facility Support Representative and have your TLD exchanged.

9. If you suspect the TLD has been misused or damaged in any way (such as a trip through the laundry cycle, worn during a medical x-ray or a procedure using radioisotopes, or exposed to excessive heat), you should notify your Facility Support Representative and a new TLD will be issued. **Wearers should never open or tamper with the TLD**.

10. Individuals working in areas controlled for radiological purposes should take specific actions if their TLD is lost, damaged, or contaminated. These actions include placing your work activities in a safe condition, immediately exiting the area and notifying your Facility Support Representative or Facility Support Technician and your supervisor of the situation.

11. The TLD label is not to be written on or defaced in any way. The internal TLD filters must not be shielded in any manner. TLD users may affix a small label to the backside of the case with their name written on it.

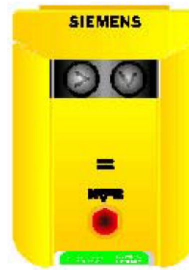
12. TLD results are your legal records of dose. Report any lost TLD immediately, and if you find a TLD, turn it in to your Facility Support Representative. If you lose your TLD or fail to return it, an estimated dose is assigned to you based on your work activities and radiological conditions of your work sites. An investigation is required to determine your estimated dose, which costs BNL time and money and is less accurate than reading the actual TLD.

13. TLD service MUST be terminated for each individual when they no longer need the service. Upon termination, the TLDs will be recycled into the BNL

system and a final dose status “termination report” will be generated, saved on file, and submitted to the individual for their personal records.

State the purpose and identify the correct use of a Electronic Personal Dosimeter

Alarming Dosimeter (Electronic Personal Dosimeter, EPD)



The digital, alarming dosimeter is used primarily in High Radiation areas that require either a pre-set alarm or a dose rate-indicating device (areas above 1,000 mrem/hr). Digital, alarming dosimeters, which can be pre-set to alarm at a specific cumulative dose, are also becoming popular for use in lieu of the self-reading dosimeter.

It is the responsibility of the issuing BNL organization to provide facility-specific training on the operation and use of the digital alarming dosimeter prior to allowing access to areas requiring its use. If you have any unanswered questions regarding the operation and/or use of the digital, alarming dosimeter, speak with your Facility Support Technician or Facility Support Representative BEFORE using the device within a radiologically controlled area.

SIEMENS EPD MARK II

To power up the unit
Press and hold the button until the display changes.

To power down the unit
1. Press and hold the button until the word **ON** appears in the display.
2. Quickly double press the button. The word **OFF** should appear flashing on the display.
3. Quickly double press the button. The display should now show **OFF**.

Display
The default display is your H-10, or deep dose, shown in mrem. The Heart Beat flashing in the upper right corner indicates the unit is active. One short press of the button will display current dose rate, in mR/hr. After 10 seconds the display will return to default.

Confidence Test
1. Press and hold the button until the word ”tESt” is displayed.
2. Quickly double press the button
3. Upon completion of the test the display will revert back to the default display
4. If the Letter **F** is followed by a number, appears in the display, the unit has failed

Clearing Dose
1. Press and hold the button until the word CLr appears on the display.

2. Press the button once. The display should show CLr2.
3. Quickly double press the button, the display will start to flash.
4. Quickly double press the button. The display will change to 0000 and return to default display.

Alarms

1. If the unit should fail it will display “fff” and give a continuous alarm that is not acknowledgeable.
2. The unit has a programmable cumulative dose alarm (d Al). It is a single continuous tone which is not acknowledgeable. You must reset the unit to zero to stop it.
3. The unit has a programmable dose rate alarm (r on). It is a single continuous tone that cannot be acknowledged.
4. The unit has a programmable low dose rate threshold (r off) below which a dose rate alarm will be silenced.
5. The unit has a low battery alarm. It is a low-frequency intermittent tone.

Replacing the EPD Battery

Caution: Take care when removing the EPD battery cap. The cap may spring free with unexpected force.

Always fit a new undamaged battery of the correct type**. A time interval of at least 10 seconds must elapse between removal and replacement of the EPD battery** (this allows the internal circuits of the EPD to power down).

The EPD is fitted with a coin release battery cap. The cap should be rotated using a small coin. The battery cap also provides the return path for the EPD power supply. During fitment of the battery cap the EPD will begin its start-up sequence. If the battery is not fitted cleanly and contact is temporarily broken, the software initialization process may not be successful**.** Under these circumstances, it is essential that the battery cap is removed and a time interval of at least 10 seconds elapses before any attempt is made to refit the battery cap.

Finger Ring TLD

The Finger Ring TLD is used to monitor the dose to your extremities under certain circumstances. If you are working with sources that will give your hands a much greater dose than that recorded by your Whole Body TLD, notify the Facility Support Representative. He or she will evaluate the situation and determine if the use of the Finger Ring TLD is warranted. Proper use of this dosimeter is explained prior to issue.

State the method for obtaining your dose records at BNL

Dose Records

You have a right to know your current accumulative dose. The records maintained by the Personal Monitoring Group are available to you and may be obtained through your Facility Support Representative or by written request directly to Personnel Monitoring.

A copy of your dose record is provided to you on an annual basis. If requested in writing, Personnel Monitoring will send you a copy of your dose records within 90 days after terminating your employment at BNL. Unless a special written request is submitted, visitors or guests monitored with TLDs will be mailed a dose report when the annual BNL employee dose report is issued.

Identify your responsibility for reporting dose received from other facilities

Occupational doses received from another facility (such as another DOE Laboratory or civilian nuclear power plant) or from employment (such as a part-time job as an x-ray technician at a local hospital) shall be reported to your Facility Support Representative and Personnel Monitoring. To ensure your dose records reflect your current year's occupational dose, and reduce the possibility that you might receive exposure in excess of the annual limit, this information is reported on the Dosimetry Request and Exposure History form. Speak with your Facility Support Representative for more information.

Identify your responsibility for reporting medical treatment/therapy involving the use of radioisotopes

The dose from nuclear medicine studies and tests is not included in occupational doses, but may affect the dose registered by your TLD.

Recently, there was a perfect example of the importance for reporting this concern. An individual who typically received no radiation dose on their monthly TLD report had a monthly TLD reading of 100 mrem. After a short investigation, it was identified that the individual had a thallium stress test and wore their TLD immediately after the test. The nonoccupational dose from the thallium still in their system was incorrectly recorded on the TLD as occupational dose.

If you, as a monitored employee, visitor, or guest, are scheduled to receive such a medical procedure, you must let the Personnel Monitoring Group or your Facility Support Representative know in advance.

Further, if you are in the presence of others receiving radiotherapy, you can bring contamination from home to the workplace. Any dose contribution from the patient should not be added to the occupational dose measured on the worker's TLD. You also need to alert the RadCon organization when a family member undergoes nuclear medicine therapy.

If you have any questions regarding this matter, please ask your Facility Support Representative or contact the Radiological Control Division.

Module 6 - Radioactive Material Control

- Identify the process for procuring radioactive materials at BNL
- State the requirements for marking and/or labeling radioactive materials
- Identify the requirements for moving radioactive materials at BNL
- Explain the difference between fixed, removable, soil and airborne radioactive contamination
- Identify sources and radiological concerns associated with radioactive hot particles
- Identify the purpose of internal radiation monitoring programs

This module addresses materials contained within the Standard Operating Procedure:

The Brookhaven National Laboratory Standards Based Management System (SBMS) contains detailed information and instructions concerning this subject matter. Please refer to SBMS at the following URL address for specific instructions:

https://sbms.bnl.gov

Procurement of and Approval to Use Radioactive Materials
Bioassay Requirements for Performing Radiological Work

FS-SOP-3010 - Labeling, Documentation and Handling Radioactive Materials

It is recommended that you review the most recent revision of the procedure(s) prior to performing activities governed within them.

Identify the process for procuring radioactive materials at BNL

It is extremely important that the Laboratory maintains control and accountability of radioactive materials on-site. For this reason, any work that involves transferring radioactive materials to BNL from an outside source or purchasing radioactive material for use at BNL requires the involvement of the Nuclear Materials Management (NMM) Group, which is part of the Radiological Control Division (RCD).

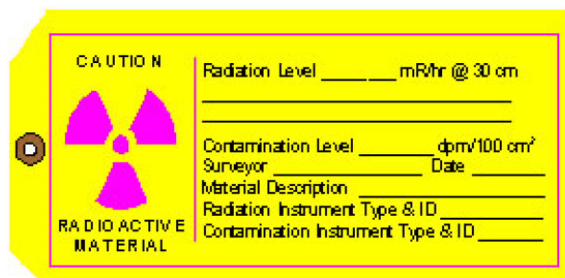
Accountability for radioactive sources begins with your BNL organization's work planning personnel. Each experiment or job must have either an Experimental Safety Review or a Work Planning Review completed prior to the start of the work. The review process will identify that radioactive materials will be brought on-site, triggering the need for NMM Group involvement.

Direct deliveries to specific laboratories or work location are not allowed, although on rare occasions exceptions are made for short-lived radionuclides. All radioactive materials are processed through Central Receiving. Before delivering the materials to their final destination, the Packaging and Transportation Group will ensure that the federally mandated radiological surveys, inspections, and documentation are performed correctly and ensure that recipients of the materials are adequately trained to maintain and use radioactive materials.

State the requirements for marking and/or labeling radioactive materials

All radioactive materials should be clearly marked, identifying them as being radioactive. The standard trefoil radiation symbol and yellow and magenta (or black) color combination are used to identify radioactive materials.

When radioactive materials are being moved outside of radiologically controlled areas they must be properly packaged and "tagged" as radioactive material. Tagging of radioactive materials involves a radiological evaluation performed by a qualified Facility Support Technician. Once packaged and tagged, the radioactive materials can be moved by individuals trained in RadWorker 1.



Identify the requirements for moving radioactive materials at BNL

Radworker 1 trained individuals are authorized to move radioactive materials that are properly packaged and tagged. Each Radioactive Material Area must have an individual, designated by the BNL organization, who is responsible for the radioactive materials stored or used within the area. Before bringing materials into or removing materials from a designated Radioactive Material Area, the responsible individual should be notified to ensure control and, if necessary, maintenance of radioactive material accountability.

A package of radioactive material MUST be re-evaluated by a qualified Facility Support Technician if:

- The material is exposed to a source of activation such as a beam line or reactor.

- The package is taken into an area with the potential for contamination, such as a Radiological Buffer Area, Contamination Area, or Airborne Radioactivity Area.
- The package is opened and contains dispersible radioactive material.

DOE Metals Moratorium

A Department of Energy moratorium on the unrestricted release* of metal waste from radiological areas remains in effect. Moratorium Metal Waste is defined as metal that has been determined to be contaminated in volume with radioactive material. This waste stream, if it cannot be reused on site or in the DOE complex, must be disposed of as radioactive waste.

Suspension Encumbered Metal is metal that has been declared as scrap while it was inside of a Radiological Area. This waste steam, if it cannot be reused on site or within the DOE complex but meets the preapproved authorized release limit of DOE 458.1, can be disposed of as industrial or sanitary waste.

Clean Scrap Metal is metal that has not been in a Radiological Area or was released from a radiological area prior to being designated as scrap. This waste stream can be released into the clean scrap metal recycling program.

*Unrestricted release means the item has no residual DOE-added radioactivity above background in it, i.e., indistinguishable from background when surveyed by FS.

Explain the difference between fixed, removable, soil, and airborne radioactive contamination

Fixed Contamination

Fixed contamination is contamination that cannot be easily removed from surfaces by casual contact, wiping, brushing, or washing. Fixed Radioactive Contamination does not pose a threat of being spread unless physically disturbed by buffing, grinding, or using volatile liquids for cleaning. Over time, fixed contamination may "weep," leach, or otherwise become loose or transferable. Although it is not easily spread, at high enough levels it can pose a beta or gamma external exposure hazard to the lens of the eye or skin.

Removable Contamination

Removable contamination is contamination that can be easily removed from surfaces. It may be transferred by casual contact, wiping, brushing, or washing. Air movement across removable/transferable contamination could cause airborne contamination. Loose contamination can be spread very easily. Once control is lost, an individual can unknowingly contaminate clean areas throughout the facility, as well as personal vehicles and private homes.

Soil Contamination

Soil contamination is radioactivity mixed within media (e.g., soil) at levels exceeding natural background. Soil contamination may exist at Brookhaven National Laboratory in areas that have been designated for clean-up or have underground radioactive material. Contamination levels in these areas exceed background levels. Access to these areas is determined by cognizant FS personnel.

Airborne Radioactivity

Airborne radioactivity is contamination in any chemical or physical form that is dissolved, mixed, vaporized, suspended, or otherwise entrained in air.

Identify sources and radiological concerns associated with radioactive hot particles

Hot particles are small, sometimes microscopic, pieces of radioactive material that are highly radioactive. They can cause a high, localized radiation dose in a short period of time if they remain in contact with skin or tissue. Hot particles may be present, or generated, when contaminated systems are opened, or when machining, cutting, or grinding is performed on highly radioactive materials. Abrasion or disturbing of fixed contamination, or leaks or tears in containers, such as barrels, plastic bags, or boxes that have radioactive contents can also create hot particles.

Because of their extremely small size, these particles are very difficult to detect with hand-held portable instruments. Therefore, special programs must be implemented when working in the vicinity of nuclear reactor fuel assemblies, storage areas, or near the reactor vessel.

Identify the purpose of internal radiation monitoring programs

An internal radiation dose can be received as a result of radioactive material being taken into the body through inhalation, ingestion, injection, absorption through the skin, or entry through a wound. For this reason, a “BASELINE” bioassay may be required prior to working in authorized areas depending on work assignment.

The methods of internal monitoring used to determine the amount of radioactive material taken into the body and to calculate a dose for the uptake are whole body counts (*in vivo*) and urinalysis (*in vitro*). If you are suspected of getting contamination inside your body, you may be asked to provide a urine sample and/or have a whole body count. The results of the internal monitoring (calculated dose) will be documented in your dose records.

In vivo Bioassay

The *in vivo* bioassay method is commonly referred to as the “Whole Body Count.” This method involves monitoring the radiation emitted from a person's body using a sophisticated detection system linked to a computer. Using the measurements obtained from the detector, the computer system identifies the type and amount of radioactive materials within the body, allowing the internal dosimetrist to calculate the radiation dose that will result from the deposits. This dose is then tracked as part of your BNL dose records.

In vitro Bioassay

If the radioactive materials within the body emit radiation that has insufficient energy to penetrate out of the body (tritium, Strontium-90, or alpha emitters), a “Whole Body Counter” cannot be used. In this case, a sample of body fluid or excretion, such as urine, must be obtained and analyzed. This method of internal dose monitoring is known as the *in vitro* bioassay.

As a Radworker 1 trained individual, you will not be allowed access to areas posing a threat for internal radioactivity without additional training in the safe handling and protective techniques and a “Baseline” bioassay.

Module 7 - Radiological Posting and Access Controls

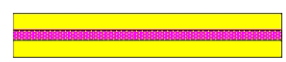
- Identify the distinguishing markings for radiological hazards
- Identify the posting and requirements for entry and/or exit from all radiologically controlled areas
- Identify the radiological and administrative consequences of unauthorized removal or disregarding of radiological postings, signs and labels
- Identify whether Radworker 1 satisfies the training requirements for entry to various radiologically controlled areas
- Identify the requirements for providing escort into radiologically controlled areas in lieu of training

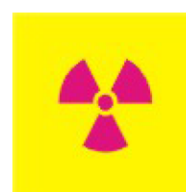
This module addresses materials contained within the Entry and Egress Requirements for Areas Controlled for Radiological Purposes SBMS Subject Area.

It is recommended that you review the most recent revision of the procedure(s) prior to performing activities governed within them. You may view or print a copy of the procedure(s) through the SBMS web site at:

https://sbms.bnl.gov

Identify the distinguishing marking for radiological hazards





Radiological postings are used to alert personnel to the presence of radiation and radioactive materials. All areas controlled for radiological purposes are posted with a sign containing a magenta (or black) three-bladed radiological warning symbol (trefoil) on a yellow background. Additionally, yellow and magenta ropes, tapes, chains, or other barriers may be used to denote the radiological boundaries. These barriers must be clearly visible to anyone approaching the area. Entrance points to those areas are posted with signs (or equivalent) listing the entry requirements.

Radiological boundaries are to be considered planes at the line that is demarcated. An individual and any part of their body may not cross the plane unless they have met all the conditions for access to that area. Placing or transferring items into an area (e.g. handing tools to another worker) may only be done in a manner that avoids breaking the plane by the individual. Additionally, if items are being placed or transferred into a CONTAMINATION AREA (defined below), an RCT should make a determination if contingency actions, such as wearing gloves or booties, are required to prevent inadvertent cross contamination.

Before entering an area controlled for radiological purposes, read and comply with all requirements on the signs. As radiological conditions change, the signs are updated to reflect the new conditions and requirements for entry. An area that was a Radiation Area yesterday may be reposted as a High Radiation Area today.

Identify the posting and requirements for entry and/or exit from all radiologically controlled areas

Controlled Area - Any area to which access is managed to protect individuals from exposure to radiation or radioactive materials.

Minimum Training Requirements:

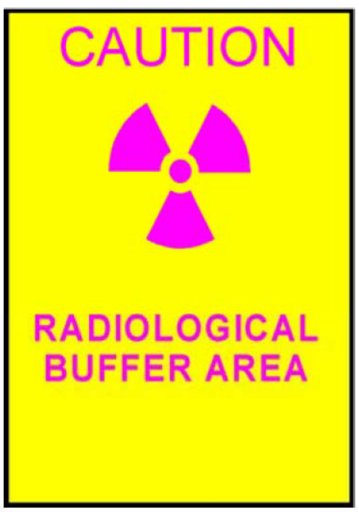
- GERT

Entry Controls:

- Read and abide radiological posting

Exit Controls:

- Read and comply with radiological posting



Radiological Buffer Area (RBA) – An intermediate area established to prevent the spread of radioactive contamination and to protect personnel from radiation exposure.

Minimum Training Requirements:

- Radworker 1 AND either:
- Radiological Buffer Area Access Training OR
- Contamination, High Contam & Airborne Training/Practical OR
- Benchtop/Dispersibles Training

Entry Controls:

- Read and comply with radiological posting

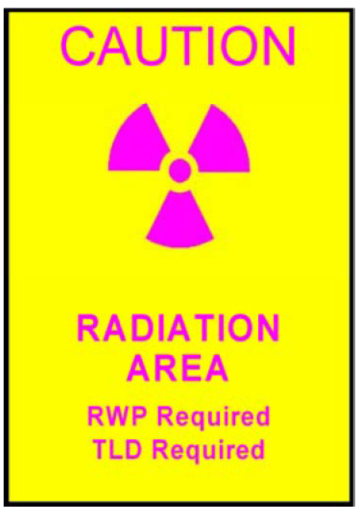
Exit Controls:

- Read and comply with radiological posting
- At a minimum, monitor hands and feet for contamination
- Items must be evaluated by FS Tech for release

Radioactive Material Area – Any area, within a Controlled Area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of the radioactive material exceeds the quantities specified within the BNL Radiological Control manual.

Minimum Training Requirements:

- GERT (if within Controlled Area ONLY)
- Radworker 1 (if the RMA is contained within a Radiation or High Radiaton Area or requires an RWP)
- Benchtop-Dispersibles (if the RMA contains Dispersibles In Use)



Radiation Area – An area, accessible to individuals, in which radiation levels could result in an individual receiving a whole body radiation dose in excess of 5 mrem in one hour. Dose rate measurements shall be obtained at 30 cm from the radiation source or from any surface that the radiation is penetrating.

Minimum Training Requirements:

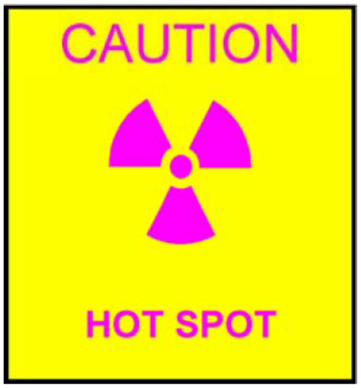
- Radworker 1

Entry Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit
- Practice good ALARA principles

Exit Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit



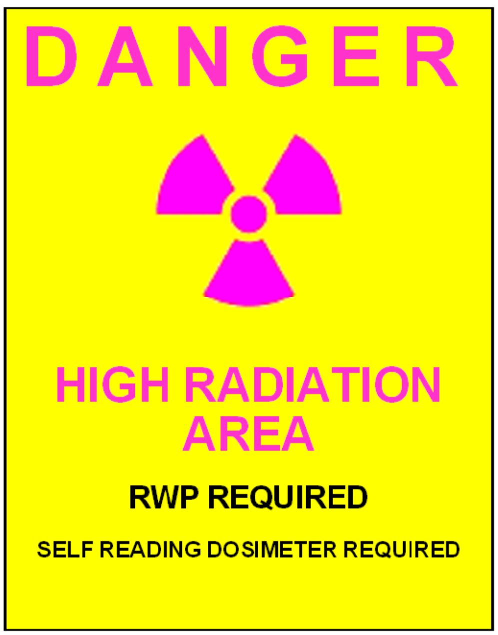
Radiation HOT SPOT – An area of localized radiation or radioactive materials that causes a dose rate to exceed the general area level by more than a factor of five (5) and exhibits a radiation dose rate in excess of 100 mrem/hr when measured on contact.

Minimum Training Requirements:

- Radworker 1

Controls:

- Read and comply with requirements on Radiological Work Permit
- If practical, do not touch or handle



High Radiation Area – An area, accessible to individuals, in which radiation levels could result in an individual receiving a whole body radiation dose in excess of 100 mrem in one hour. Dose rate measurements shall be obtained at 30 cm from the radiation source or from any surface that the radiation is penetrating.

Minimum Training Requirements:

- Radworker 1

Entry Controls:

- Read and comply with radiological posting
- Ensure associated interlocks are operational
- Read and comply with requirements on Radiological Work Permit
- Practice good ALARA principles
- When High Radiation Areas greater than 50 rem/hr exist, entry shall not be allowed except with the written approval of the Department Chairperson or Division Manager, and the Manager, Radiological Control Division

Exit Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit

Very High Radiation Area - An area, accessible to individuals, in which radiation levels could result in an individual receiving a whole body radiation dose in excess of 500 rads in one hour. Dose rate measurements shall be obtained at 1 meter from the radiation source or from any surface that the radiation is penetrating.

Minimum Training Requirements:

- Radworker 1

Entry Controls:

- Entry is PROHIBITED in most cases
- Special permission from Radiological Control Division Manager
- Special training (briefing) required

Exit Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit

Fixed Contamination Area – An area accessible to individuals, where contamination is present that cannot be easily removed from surfaces by casual contact, wiping, brushing, or washing. Fixed Radioactive Contamination does not pose a threat of being spread unless physically disturbed by buffing, grinding, or using volatile liquids for cleaning.

Minimum Training Requirements:

- GERT

Exit Controls:

- Read and comply with radiological posting

Contamination Area – Any area, accessible to individuals, where the removable surface contamination levels exceed or are likely to exceed the removable surface contamination limits established within the BNL Radiological Control Manual.

Minimum Training Requirements:

- Radworker 1 AND
- Contamination, High Contam & Airborne Training/ Practical

Internal Monitoring Requirements

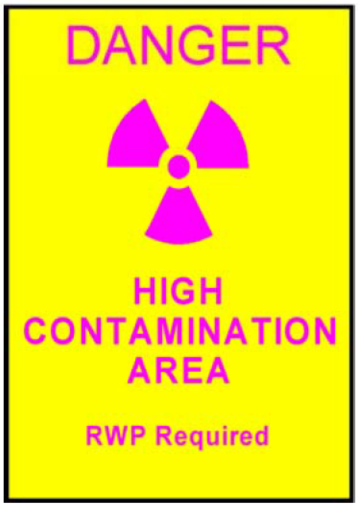
- RP-WBC1 – BASELINE and annual bioassay required

Entry Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit
- Personal Protective Clothing

Exit Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit
- Whole-body contamination monitoring required
- Items must be evaluated by FS Tech for release



High Contamination Area - Any area, accessible to individuals, where the removable surface contamination levels exceed or are likely to exceed a value 100 times that of the removable surface contamination limits established within the BNL Radiological Control Manual.

Minimum Training Requirements:

- Radworker 1 AND
- Contamination, High Contam & Airborne Training/Practical

Internal Monitoring Requirements

- RP-WBC1 – BASELINE and annual bioassay required

Entry Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit
- Personal Protective Clothing

Exit Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit
- Whole-body contamination monitoring required
- Items must be evaluated by FS Tech for release

Airborne Radioactivity Area – Any area accessible to individuals where either:

- Concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed derived air concentration (DAC) values listed in Appendix A or C of 10CFR835; or
- An individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week.

Minimum Training Requirements:

- Radworker 1 AND
- Contamination, High Contamination & Airborne Training/Practical

If respiratory protection is required:

- IND301/307 – APR/PAPR Respirator Training
- MED001 – Respiratory Protection Medical Evaluation
- IND317 – Respirator Fit Test for particular respirator in use

Internal Monitoring Requirements

- RP-WBC1 – BASELINE and annual bioassay required

Entry Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit
- Personal Protective Clothing

Exit Controls:

- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work Permit
- Whole-body contamination monitoring required
- Items must be evaluated by FS Tech for release

Identify the radiological and administrative consequences of unauthorized removal or disregarding of radiological postings, signs, and labels.

It is each worker's responsibility to read and comply with all the information identified on radiological postings, signs, and labels. Disregard or unauthorized removal and/or relocation of any radiological sign, posting, label, or barrier may result in administrative and/or radiological consequences, including loss of control of radioactive material (within BNL property general public/environment), violation of federal limits, stoppage or slowdown of work, disciplinary action, excessive radiation dose, and/or radiation induced injury.

Identify whether Radworker 1 satisfies the training requirements for entry to various radiologically controlled areas.

Radiological Worker I training is the minimum training required for unescorted access to areas posted as Radiation Areas and High Radiation Areas, as well as Radioactive Material Areas that are within Radiation and High Radiation Areas.

Thus, after successfully completing Radworker 1 training an individual is authorized unescorted access to all:

- Controlled Areas
- Radioactive Material Areas
- Radiation Areas
- High Radiation Areas
- Fixed Contamination Areas

Identify the requirements for providing escort into radiologically controlled areas in lieu of training

From time to time, there may be a need to allow short-term, escorted access to these areas without first satisfying the minimum training requirements. Escorts may be used in lieu of training for short-term access to all radiologically controlled areas with the exception of High Radiation Areas, Very High Radiation Areas, High Contamination Areas, and Airborne Radioactivity Areas. In order to provide escort in lieu of training, the following conditions must be met:

For Access ONLY (no work performed)

- A Request for Training Exemption Form, which may be obtained from the Training & Qualifications SBMS Subject Area, must be completed and submitted to the Radiological Control Division Manager for approval prior to providing escort.
- The individual providing escort MUST be qualified for UNESCORTED access to the area.

- The escort must perform a pre-entry briefing covering all of the hazards present in the area.
- The individual being escorted MAY NOT perform any activity that may degrade radiological conditions.
- The individual being escorted may not leave the direct line of sight of the individual providing escort.
- The escort and individual being escorted must be able to communicate in the same language.

For Access and Limited Work
- The responsible Facility Support Representative must pre-review the work plan and authorize the work to be performed under escort.
- A Request for Training Exemption Form, which may be obtained from the Training & Qualifications SBMS Subject Area, must be completed and submitted to the Radiological Control Division Manager for approval prior to providing escort.
- The Facility Support Representative must perform a pre-entry briefing covering all of the hazards present in the area.
- The work must be performed under a Radiological Work Permit.
- The work must be performed under continuous FS Technician coverage.

Module 8 - Radiological Work Permits

- State the purpose of a Radiological Work Permit
- Explain the difference between a General and Job-Specific RWP
- Identify activities requiring the use of Radiological Work Permits
- Using a completed Radiological Work Permit, correctly obtain information from its contents
- Using a completed Radiological Survey Record, correctly obtain radiological information from its contents
- Identify the requirements for signing a General and Job-Specific RWP Access Record

> The Brookhaven National Laboratory Standards Based Management System (SBMS) contains detailed information and instructions concerning this subject matter. Please refer to the SBMS at the following URL address for specific instructions:
>
> https://sbms.bnl.gov
>
> This module addresses materials contained within the SBMS Radiological Work Permit Subject Area.
>
> For more detailed information see the Standard Operating Procedure:
> **FS-SOP-4031 – Radiological Work Permit**

State the purpose of a Radiological Work Permit

All work performed at Brookhaven National Laboratory must undergo a preliminary review using the Work Planning and Control for Experiments and Operations SBMS Subject Area. If the work involves radiological hazards, a Radiological Work Permit review process must be included. Your organization's work planning group and supervisors, working with the Facility Support Technicians and Representatives, perform a thorough radiological hazard assessment and document the results on a Radiological Work Permit.

Once documented and approved for use, the Radiological Work Permit becomes the administrative mechanism that documents the work review process for jobs involving radiological hazards. The RWP outlines the minimum criteria for entry and work within the area and when desired, provides a mechanism to relate worker exposure to specific work activities.

As a Radworker trained individual, you will be required to use Radiological Work Permits when entering or performing work within:

- Radiation Areas
- High Radiation Areas
- Areas where hot particles are present
- Contamination Areas
- High Contamination Areas
- Airborne Radioactivity Areas

Explain the difference between a General and Job-Specific RWP

There are two types of Radiological Work Permits: the General RWP and the Job-Specific RWP.

General Radiological Work Permit

The General Radiological Work Permit is used to control minor work, and routine or repetitive activities in areas with historically stable or predictable radiological conditions. General RWPs may be valid for up to one calendar year.

Job-Specific Radiological Work Permit

The Job-Specific Radiological Work Permit is used to control non-routine operations, work in areas with changing radiological conditions, and jobs that require radiation dose tracking. These permits are generally valid for the expected duration of the specific job but may not exceed one calendar year.

Identify activities requiring the use of Radiological Work Permits

An RWP is required for the following:

- Any work requiring access to Radiation, High Radiation, Contamination, High Contamination, or Airborne Radioactivity Areas.
- Any work involving handling material with radioactive contamination exceeding the levels specified in Table 2-2 of the BNL Radiological Control Manual.
- Any work involving handling dispersible radioactive materials exceeding 1% of the material's Annual Limit on Intake (ALI).
- Performance of surveys by FS in support of work planning and surveillance.

A **Job-Specific RWP** is required for the following:

- Any non-routine or non-repetitive radiological operations in areas with changing radiological conditions.
- Any work requiring access to High Radiation, High Contamination, Airborne Radioactivity Areas, or to areas where hot particles are present.
- Any work with expected individual dose exceeding 20 mrem/job.

- Any job with an expected collective dose of 200 person-mrem.
- Any job with an expected extremity or organ dose exceeding 200 mrem/job.

Using a completed Radiological Work Permit, correctly obtain information from its contents

The Radiological Work Permit process begins after your organization's Work Planning Group or Experiment Review Committee determines that your work involves radiological hazards requiring a pre-work radiological review. The process begins with the originating organization completing the upper portion of the Radiological Work Permit.

Originator

To initiate the Radiological Work Permit, the originator must provide:

- Initiator's/Job Supervisor's names
- Life number
- Telephone number and pager number (if applicable)
- Building number
- Job location
- Brief description of the work (attach more detail if necessary)
- Any radiological concerns that have surfaced while previously performing this job or similar jobs.
- Signatures of the originator/job supervisor

The RWP is then routed to the Radiological Control Division for review and evaluation.

Facility Support/Work Planning Group

Upon receiving an initiated Radiological Work Permit, the Facility Support Representative reviews the job description to determine whether adequate information is available to perform a radiological assessment. If the description is inadequate, the Facility Support Representative will return the initiated RWP to the Originator for additional information. Since this will result in unnecessary delays, it is important that the Originator takes the time and expends the effort to provide the Facility Support Representative with adequate detail when originally initiating the RWP.

After accepting the initiated RWP, the Facility Support Representative assigns a Facility Support Technician to perform a radiological survey of the work area, if required based on the specific RWP. Results of this survey are used to assist the Facility Support Representative and the RWP Originator in determining adequate radiological controls throughout the job.

Radiological Controls

Using the job description and the radiological survey performed for the work, the Facility Support Representative and the RWP Originator work together to determine the appropriate radiological controls for the job. The RWP itemizes work-related radiological controls including:

- Level of pre-job and post-job reviews required for the job
- Estimated individual and collective dose for the job, which may include “per entry” and/or “per job” target levels
- Documentation required at the job site, such as radiological survey data or work package
- Required level of radiological training to work on the job
- Work controls, including Facility Support intermittent or continuous coverage, work hold points, special air samples, or shielding requirements
- Protective clothing necessary to control the spread of radioactive contamination
- Personal dosimetry requirements
- Check-out instructions for exiting or removing items from the work area and/or post-job radiological assessments to determine the radiological impact of the work
- Special instructions to all the workers entering the area covered by the Radiological Work Permit

Approval

Once completed, the Facility Support Representative issues an official RWP number, assigns a start and end date, and approves the Radiological Work Permit by signing where indicated. The BNL RWP form also provides an approval block for a organization-specific approval signature. This signature is not required, but may be used by organizations for controlling radiological work within their facilities.

Generic Example of a Radiological Work Permit

(For reference only. To view the latest RWP form, refer to the SBMS Radiological Work Permit Subject Area.)

Attachment 9.1

BROOKHAVEN NATIONAL LABORATORY

BNL RADIOLOGICAL WORK PERMIT (RWP)

RWP #____________________

RWP Type: ☐ Job Specific ☐ General **Start Date** ________ **End Date** ________ **Revised End Date** _______

1. Initiator:	2. Life #:	3. Phone #:	4. Bldg.:

5. Job Location:

6. Job Description:

7. Radiological Concerns: (e.g. Primary radionuclides, high dose rate, airborne)

8. Conditions that will void the use of this RWP:
☐ None N/A

9. Job Review:
- ☒ Pre-Job Review
- ☐ ALARA Review
- ☐ Post-Job Review
- ☐ Other

10. Estimated Dose: (mrem)
- Highest Individual __________
- ☐ Per Job
- ☐ Per entry
- Collective __________
- ☐ Per Job
- ☐ Per Entry
- ☐ Not Applicable

11. References:
- ☐ Radiological Survey Form
- ☐ Technical Work Document
- TWD# __________
- ☐ Other
- ☐ Not Applicable

12. Training Requirements:
- ☐ Radiation Worker (RWT 002)
- ☐ RBA Practical (RWT 002A)
- ☐ Contamination (RWT 300 /300A)
- ☐ Benchtop/dispersibles (RWT 500)
- ☐ Other __________
- ☐ Not Applicable

13. Work Controls:
- ☐ FS Coverage
  - ☐ Intermittent
  - ☐ Continuous
    - ☐ Continuous Presence
  - ☐ Pre-Job Briefing
- ☐ Limiting Conditions
- ☐ Hold Point
- ☐ Air Monitoring
- ☐ Shielding
- ☐ Other
- ☐ Not Applicable

14. Protective Equipment:
- ☐ Gloves
- ☐ Shoe Covers
- ☐ Booties
- ☐ Lab Coat
- ☐ Coveralls
- ☐ Respirator
- ☐ Head Cover
- ☐ Other
- ☐ Not Applicable

15. Dosimetry:
- ☐ TLD
- ☐ Self Reading Dosimeter
  - ☐ Alarming Dosimeter
- ☐ Finger Dosimetry
- ☐ Not Applicable

16. Check Out Instructions:
- ☐ Bioassay
  - ☐ Whole Body Count
    - ☐ Annual
    - ☐ Pre-Job
    - ☐ Post-Job
  - ☐ Urine
    - ☐ Annual
    - ☐ Pre-Job
    - ☐ Post-Job
  - ☐ Not Applicable
- ☐ Contamination Check
  - ☐ Personnel Frisk
  - ☐ PCM
  - ☐ Equipment Tools
- ☐ Post Job Survey
- ☐ Not Applicable

17. Expected Radiological Conditions

Radiation ☐ N/A
- General Area: __________
- On Contact: __________
- Gamma ☐ Neutron ☐
- Beta ☐ Check all that apply

Surface Contamination ☐ N/A
- Removable: _______ dpm/100cm^2 Alpha
- Removable: _______ dpm/100cm^2 Beta/Gamma
- Removable: _______ dpm/100cm^2 Tritium

Airborne Radioactivity ☐ N/A

Nuclide	Concentration

18. Special Instructions (Hold Points, Limiting Conditions, Special Dose Limits, etc.)

19.	Approvals	Signatures	Life Number	Date
	Initiator/Supervisor			
	Facility Support Representative			
	Department (As Required)			
20.	Close Out Signatures FS Rep.			

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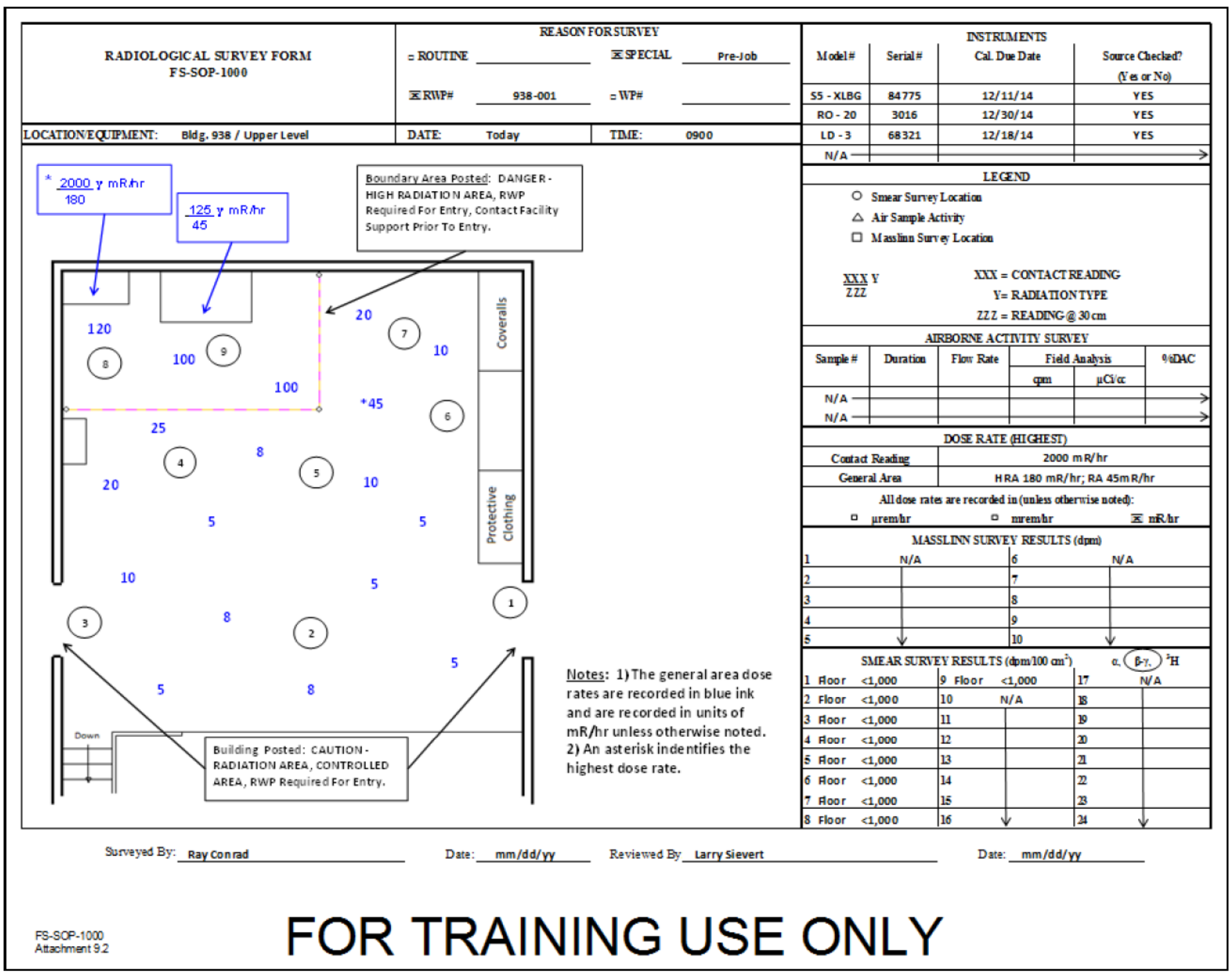
Using a completed Radiological Survey Record, correctly obtain radiological information from its contents.

The radiological survey performed to evaluate the radiological conditions of a work area contains an assortment of valuable information. The radiological survey record, also referred to as a survey form or survey map, is used not only to document completion of a survey, but also to provide data to the individuals entering the work area. For this reason, each person must have the ability to read and understand the information on the survey form.

Information contained on a Radiological Survey Record may include:

- General Area (whole body) radiation dose rates
- Contact (extremity) radiation dose rates
- Surface contamination survey (Masslinn and smear) data
- Airborne radioactivity data
- Low Dose Rate Areas (LDRAs)



RADIOLOGICAL SURVEY FORM
FS-SOP-1000

REASON FOR SURVEY
☐ ROUTINE ______ ☒ SPECIAL Pre-Job
☒ RWP# 938-001 ☐ WP# ______

LOCATION/EQUIPMENT: Bldg. 938 / Upper Level DATE: Today TIME: 0900

INSTRUMENTS			
Model#	Serial#	Cal. Due Date	Source Checked? (Yes or No)
S5 - XLBG	84775	12/11/14	YES
RO - 20	3016	12/30/14	YES
LD - 3	68321	12/18/14	YES
N/A →			

LEGEND
○ Smear Survey Location
△ Air Sample Activity
☐ Masslinn Survey Location

XXX Y / ZZZ
XXX = CONTACT READING
Y = RADIATION TYPE
ZZZ = READING @ 30 cm

AIRBORNE ACTIVITY SURVEY					
Sample #	Duration	Flow Rate	Field Analysis cpm	Field Analysis µCi/cc	%DAC
N/A →					
N/A →					

DOSE RATE (HIGHEST)	
Contact Reading	2000 mR/hr
General Area	HRA 180 mR/hr; RA 45mR/hr

All dose rates are recorded in (unless otherwise noted): ☐ µrem/hr ☐ mrem/hr ☒ mR/hr

MASSLINN SURVEY RESULTS (dpm)			
1	N/A	6	N/A
2	↓	7	↓
3		8	
4		9	
5		10	

SMEAR SURVEY RESULTS (dpm/100 cm²) α, (β-γ,) ³H

1 Floor	<1,000	9 Floor	<1,000	17	N/A
2 Floor	<1,000	10	N/A	18	↓
3 Floor	<1,000	11	↓	19	
4 Floor	<1,000	12		20	
5 Floor	<1,000	13		21	
6 Floor	<1,000	14		22	
7 Floor	<1,000	15		23	
8 Floor	<1,000	16		24	

Notes: 1) The general area dose rates are recorded in blue ink and are recorded in units of mR/hr unless otherwise noted.
2) An asterisk indentifies the highest dose rate.

Surveyed By: Ray Conrad Date: mm/dd/yy Reviewed By: Larry Sievert Date: mm/dd/yy

FS-SOP-1000
Attachment 9.2

FOR TRAINING USE ONLY

General Area (Whole Body) Radiation Dose Rates

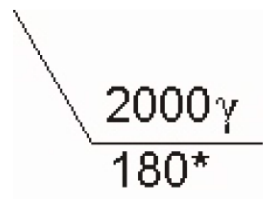
Radiation dose rates that affect the entire body are called "general area" radiation dose rates. These measurements are obtained throughout the work area to provide reliable data concerning where the radiation hazards exist. All general area radiation dose rates are indicated on the survey map by a numeric value representing the dose rate in mrem/hour, unless otherwise noted.

The highest general area radiation dose rate in the work area is listed in the table to the right of the survey map. For the sample survey map on the previous page, the highest whole body radiation dose rate in the posted Radiation Area is 45 mrem/hr. The highest whole body radiation dose rate in the posted High Radiation Area is 180 mrem/hr.

Contact (Extremity) Radiation Dose Rates

Situations can be encountered when the source of the radiation causes localized higher dose rates known as Hot Spots. Radioactive Hot Spots pose a hazard primarily to the extremities (hands, forearms, feet, and lower legs).

A contact measurement is indicated on a survey record with a line pointing to the localized source of the dose rate. Both the contact radiation dose rate and the general area dose rate are represented. The contact measurement is provided on the top and includes a Greek symbol for the type of radiation present (α: alpha, β: beta, γ: gamma). The bottom value is the measurement obtained at 30 centimeters (approximately 12 inches) from the localized source.



On the sample survey record on the previous page, the contact reading within the Posted High Radiation Area is 2,000 mrem/hr gamma and its associated general area dose rate is 180 mrem/hr. The highest contact reading in the work area is also listed in the table on the right of the survey map. On the survey map itself, the highest dose rate (contact and/or general area) in each work area is indicated by an asterisk (*).

Surface Contamination Survey Data

Surface contamination surveys are performed using quantitative surface "smears," covering an area of 100 cm^2, or qualitative large area wipes known as "Masslinns," covering up to 50 ft^2. Numbered circles represent smear survey locations, while Masslinn survey locations are identified by numbered squares. In both cases, the survey analysis results are entered in a table located at the bottom right side of the survey record.

On the sample survey form above, the survey lists nine smears all indicating less than 1,000 dpm/100 cm^2. No Masslinn surveys were obtained.

Airborne Radioactivity Survey Data

If an airborne radioactivity survey is performed as part of the radiological evaluation, the air sample location is represented by numbered triangles. In addition, the survey analysis results are entered in a table located on the right side of the survey record.

There are no airborne radioactivity samples indicated on the sample survey record provided within this handout.

Low Dose Rate Areas (LDRA)

When radiation dose rates warrant, the Facility Support Technician will identify areas of lowest dose rate that should be used when not actually performing work on the component. It is a good ALARA technique to use these Low Dose Rate Areas when reviewing procedures or waiting within the work area for a hold-point. Low dose rate areas are identified by the acronym “LDRA” on the survey record.

There is one LDRA identified within the posted Radiation Area on your sample survey record.

Identify the requirements for signing a General and Job-Specific RWP Access Record.

General and Job-Specific Radiological Work Permits that do not require dose tracking use a simple RWP Sign-In Log. After reviewing all of the requirements of the Radiological Work Permit and ensuring all of the requirements are understood and have been met, each individual signs into the Log with their name, life number, and date of entry. Log entries must be made using blue or black ink.

When using this log for a Job-Specific Radiological Work Permit, the individual must re-sign the Access Log once each day that they access the area.

When using this log for a General Radiological Work Permit the individual need only sign the log

Attachment 9.5

Sign-In Log for RWP No. ________________

Your signature on this form indicates that you have read, understood, and meet the requirements of the above numbered RWP unless properly escorted. ***ALL ENTRIES SHALL BE IN BLUE OR BLACK INK ONLY!***

Print Name	Signature	Life / Guest Number	Individual Under Escort Y/N	Date

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prior to the initial entry for that area. Signing the Log allows an individual access to the specified work area throughout the duration of the General Radiological Work Permit.

Although it is not required to re-sign the log each day you enter the area under a General Radiological Work Permit, you should check the sign-in log to ensure that your name is still on record. This will ensure you will not inadvertently enter the area after a change has been made to the RWP. If the RWP has changed since your last entry, your name will not be present on the new sign-in log. If your name is present, this is clear indication that conditions have not changed and you are still authorized to enter. Pulling the old sign-in sheets is a good practice, but not required. A notice may be placed in the RWP work area to notify worker of a change to the RWP.

Job-Specific Radiological Work Permits

Job-Specific Radiological Work Permits may use a more sophisticated RWP Access Control Log. This dose-tracking log provides space for each individual to track the amount of time and radiation dose for the specific job. Each individual signs into the Access Record with their name, life number, date, time, dosimeter serial number, and dosimeter reading upon entry. When leaving the job, the individual signs out of the Access Record by entering the time and dosimeter reading upon exit. The value entered in the far right column, dosimeter reading TOTAL, is the cumulative dose obtained while within the work area and is derived by subtracting the value of the dosimeter reading upon entry from the dosimeter reading upon exit.

Each time you enter and leave the area covered by the Radiological Work Permit, you must sign in and sign out of the Access Control Log. Exceptions are allowed when individuals are making multiple entries to the same area during the same day. In this case, it is only required that the individual sign-in upon initial entry and sign-out upon final exit each day.

|

RWP ACCESS SHEET RWP#_____________

PRINT NAME	SIGNATURE	Individual Under Escort Y/N	LIFE #	DATE	DOSIMETER #	TIME IN	SRD READING PRE	TIME OUT	SRD READING POST	NET-SRD READING
Please Do Not write in this section ---							PAGE TOTAL			

NOTE: ***Signing this access sheet indicates you have had any required pre-job briefing, and have read, understand and meet the requirements of this RWP unless properly escorted***. ***ALL ENTRIES SHALL BE IN BLUE OR BLACK INK ONLY!***

CAUTION: ***Changes in Job Scope or in Radiological Conditions will void this RWP. Consult the Radiological Control Division Facility Support Representative for direction.***

Module 9 - Emergency Alarms and Responses

Identify the radiological and administrative consequences for disregarding radiological alarms

Equipment that monitors for unusual radiation levels and airborne radioactivity are placed in strategic locations in some facilities. It is essential that each worker be able to identify the equipment and alarms, and respond appropriately to those alarms. Workers should also be familiar with locations of exits and fire extinguishers. Because of the variety of systems at the various facilities, more detailed information is covered during facility specific training.

Disregard for any radiological alarms or the site sirens may result in unwarranted exposure, spread of contamination or loss of privileges/access to radiologically controlled areas. Working in a radiological environment requires more precautionary measures than performing the same job in a non-radiological setting.

If you witness any unusual situations, take appropriate actions immediately. For radiological concerns, contact your Facility Support Technician and your supervisor. If you cannot reach the Facility Support Technician or need other assistance in an emergency, telephone 2222 or 911 (from cell phones and pay phones, call 631-344-2222). This is the BNL emergency phone number, which rings in both the Police Station and the Fire Department.