TRAINING & QUALIFICATIONS PROGRAM OFFICE

BROOKHAVEN NATIONAL LABORATORY

RADIOLOGICAL WORKER 1 TRAINING (RWT002)

STUDY GUIDE

Revised 16 May 2003

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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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1 Differentiate between radioactivity, radioactive material and radiation generating device.
2 Identify the unit used to measure radioactivity.
3 Differentiate between non-ionizing and ionizing radiation.
4 Identify the four (4) types of ionizing radiation
5 State the meaning of the radiation unit rem.
6 Differentiate between occupational and non-occupational radiation dose
7 Identify the average annual radiation dose from non-occupational sources

LESSON 2

1 Differentiate between acute and chronic dose
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.
5 State the BNL management policy for the ALARA program.
6 Apply the concepts of using Time, Distance and Shielding to reduce radiation dose.

LESSON 3

1 Identify the purpose and scope of the Price Anderson Amendment Act (PAAA) and 10CFR835 regarding matters involving radiological protection at BNL.
2 Identify the purpose and scope of the BNL policy regarding your responsibility and authority for stopping non-compliant radiological work.
3 State the purpose of the BNL Radiological Awareness Report (RAR) Program.

LESSON 4

1 Identify the DOE radiation dose limits and ACL
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1 Identify the process for procuring radioactive materials at BNL
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5 Identify sources and radiological concerns associated with radioactive hot particles.
6 Identify the purpose of internal radiation monitoring programs.

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1 Identify the distinguishing marking for radiological hazards
2 Identify the posting and requirements for entry and/or exit from all Radiological Areas.
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4 Identify whether Radworker 1 satisfies the training requirements for entry to various radiological areas.
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LESSON 8

1 State the purpose of a Radiation Work Permit.
2 Differentiate between a General and Job-Specific RWP
3 Identify activities requiring the use of Radiological Work Permits.
4 Using a completed Radiation Work Permit, correctly obtain information from its contents.
5 Using a completed Radiological Survey Record, correctly obtain radiological information from its contents.
6 Identify the requirements for signing a General and Job-Specific RWP Access Record.

LESSON 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 (RW002) is considered the minimum training required for the worker who needs unescorted entry into:

1. Controlled Areas
2. Radiation Areas
3. Radioactive Materials Areas (RMAs) containing only sealed sources, activated material or properly packaged and labeled radioactive material.
   (If the area contains any dispersible radioactive material, or if work is in progress that could create dispersible radioactive material, Benchtop/Dispersibles (RWT500) training is required for entry.)
4. High Radiation Areas

If an individual is trained only to the Radiological Worker 1 level and unescorted access is required to a Radiological Buffer Area the individual must also complete a graded practical exercise (RWT002A) on the proper use of a portable contamination monitoring instrument (frisker).

Overview

Within the context of this course, the term "employee" is used to include BNL/BSA employees, contractors, guests, and visitors.

Every employee, both radiological worker and non-radiological worker, must play an active part in maintaining exposures to radiation and radioactive materials to As Low As Reasonably Achievable (ALARA). In order to do this, we need to develop a sense of pride and ownership toward our daily activities and have a healthy respect, rather than a fear for the type of work performed at BNL.

In other words, 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.

Brookhaven National Laboratory's Radiological Worker 1 training course is divided into nine units that provide workers with the information needed to work safely around radiological hazards. These units are:

- Radiation Fundamentals
- Biological Effects of Radiation
- Federal Regulations, Policies and Procedures
- Dose Limits and Administrative Control Levels
- Personnel Monitoring
- Radioactive Materials Control
- Radiological Posting and Access Controls
- Radiological Work Permits
- Emergency Alarms and Responses

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

1) Attending a 6-hour classroom training session and obtaining an 80% or greater on a multiple choice examination immediately following the class.

2) Studying reference materials at your own pace and be exempted from attending the classroom training by obtaining an 80% or greater on a comprehensive multiple choice challenge examination. This alternative is designed for an individual with prior experience, similar qualification at another facility or formal training in radiological controls or health physics.

3) Radiological Buffer Area Access training (RWT002A) is administered On-the-Job and requires a graded practical exercise for successful completion.

Once an individual has successfully completed the course, they are classified as Radiological Worker 1 certified for a period of two years.

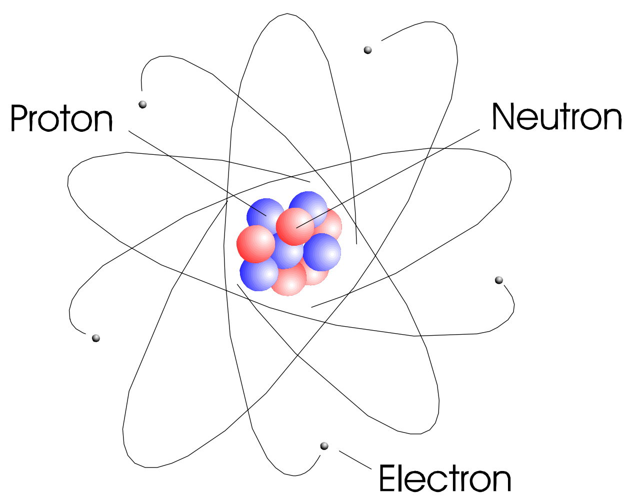
Module 1 - Radiation Fundamentals

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

Differentiate between radioactivity, radioactive material and radiation generating device

Atomic Structure

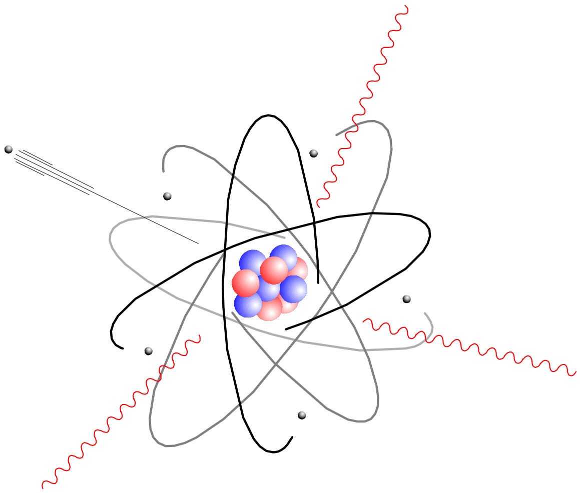
All of the materials we work with, whether they are gas, liquid, solid, plant, animal or mineral, are composed of atoms. Atoms are the smallest unit of matter that retain the properties of an element (such as carbon, lead, and helium). The atom can be described as having three basic particles.



The central core of the atom, called the nucleus, is made up of protons (positively charged) and neutrons (no 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 radioactivity.

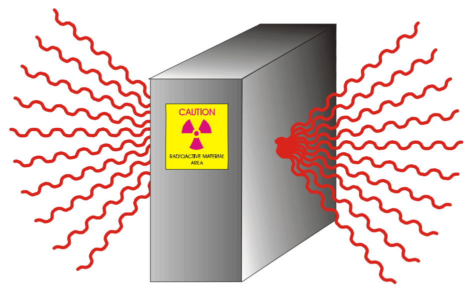
Radioactivity



Radioactivity is the property of certain atoms to spontaneously emit particle or electromagnetic wave energy. 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.

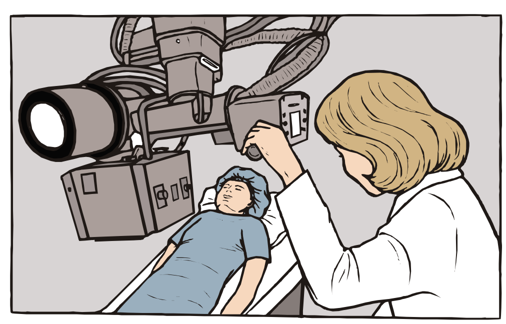
Radioactive Material

Any material containing radioactive atoms is called either radioactive material or a radioactive source. These sources can be readily 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 the 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 Radiation Treatment Facility (RTF) when radiation generating devices are not operating, external radiation hazards do not exist. In addition, radiation exposure can readily be



controlled as part of the devices operating procedure. This is accomplished by ensuring all personnel are removed from the vicinity of the machine before it is operated and by using locked doors and warning lights, commonly referred to as interlocks, to restrict access to the hazard during operation.

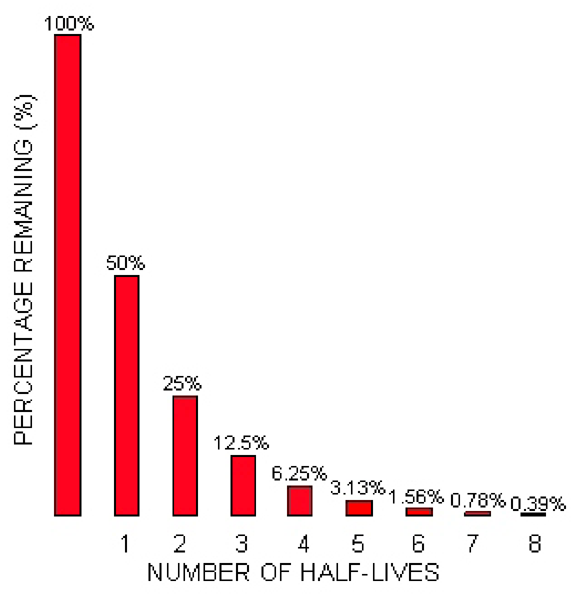
Types of radiation generating devices at BNL include:

- High energy accelerators such as AGS or RHIC
- Tandem Van de Graaff RHIC injector
- Free electron laser research 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 machine machines used for research of atomic structure
- DT Generator (deuterium to tritium) used to produce high-energy neutrons for research.

Personnel assigned to operate these devices must be trained in their safe use before allowing them to utilize the machine as part of their job.

Identify the unit used to measure radioactivity

Measuring Radioactivity



The process of radioactivity is a natural phenomenon. All radioactive materials undergo this process in an attempt to become non-radioactive. 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.

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 Ci = 37,000,000,000 dps or 3.7×10^{10} dps.
1 Ci = 2,200,000,000,000 dpm or 2.2×10^{12} dpm.

A measurement program called System International (SI) uses the unit Becquerel (Bq) to measure radioactivity. A Becquerel is equal to a single 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 or reference documents.

Differentiate between non-ionizing and ionizing radiation

Radiation

Radiation is merely energy in the form of electromagnetic waves or sub atomic 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.

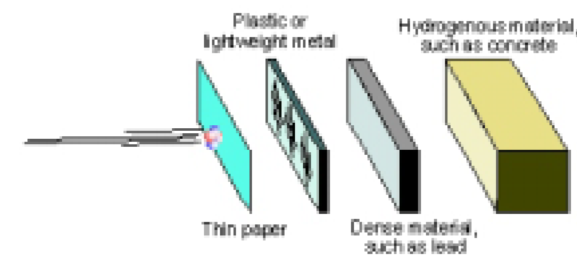
When radiation has sufficient energy to remove electrons from atoms, a process known as ionization, the radiation is classified as **ionizing radiation**. For the purposes of training course, examples of ionizing radiation include alpha, beta, gamma or x-ray, and neutron.

There should be no misunderstanding, ALL TYPES OF RADIATION either non-ionizing or ionizing may pose health risks. You may be aware of recent discussions regarding risks associated with exposure to microwave radiation or cellular phone transmission, which are both non-ionizing radiation sources. For the purposes of this training we will focus our attention to the hazards and risks of exposure to ionizing radiation only. Thus for the remainder of this course, 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 also be stopped or shielded using a sheet of paper.

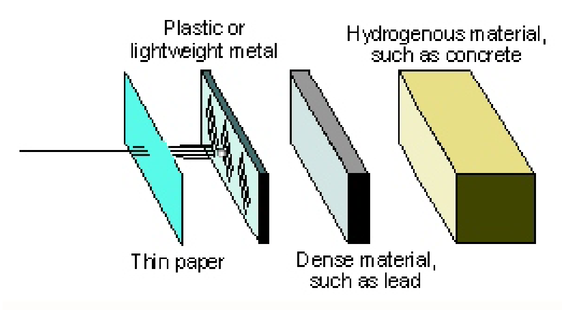


The alpha particle cannot penetrate the dead layer of human skin, but may be very damaging if the source of alpha radiation is inside the body. There are only a few sources of alpha radiation at BNL. These are primarily in laboratories in the form of uranium and thorium salts.

Beta particles

Beta radiation is a particle with the mass of an electron emitted, with energy, from many different radioactive atoms. Betas with a positive charge 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.

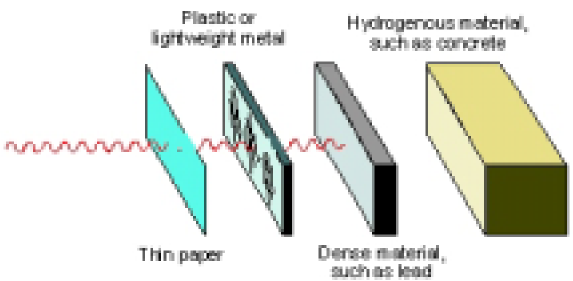


Beta particles can easily be shielded by using 3/8" of plastic, Lexan, or thin lightweight metals such as 1/8" of aluminum. Because beta particles can penetrate the dead layer of skin and affect the live skin tissue, large doses can cause serious injury to the skin and also to the eyes. Some sources of beta radiation at BNL include tritium (^{3}H), phosphorous (^{32}P) and carbon (^{14}C).

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 bundle of light causes a phenomenon known as synchrotron radiation, which is the major source of radiation at facilities such as the National Synchrotron Light Source (NSLS).

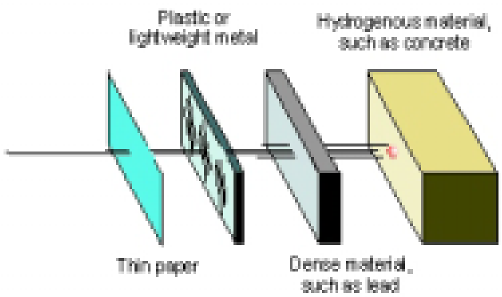


Because they have no mass and no charge, gamma and x-rays are very penetrating forms of radiation. In air, high energy gamma or x-rays may travel several hundred feet. Dense materials such as lead are used for shielding. From a biological perspective, x-rays and gammas are considered external hazards, 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

Neutrons are neutral particles emitted from the nucleus during fission (splitting of an atom), emitted as part of the radioactive decay of californium, and are 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 in 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 the x-rays and gammas, 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) or 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 quality factor. The quality factor is a multiplier used to account for the differences in the biological effectiveness of the different types of radiation.

Dose Equivalent (rem) = Absorbed Dose (rad) x Quality Factor

Dose Equivalent (Sv) = Absorbed Dose (Gy) x Quality Factor

Examples of quality factor for various radiations are:

Gamma and x-rays	1
Beta	1
Neutrons	3 - 10
Alpha	20

Neutrons have a range of Quality Factors to account for their ability to cause a varying amount of biological damage, depending on their energy. Low energy neutrons (less than .025 eV to 1.0 keV) have a Quality Factor of 3, while faster neutrons (100 keV to 1.0 Mev) have Quality Factors ranging from 7.5 to 10.

Dose and Dose Rate

The 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 for 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

Differentiate 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).

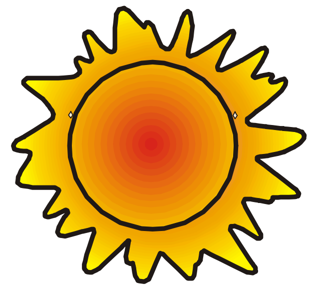
Sources of non-occupational radiation dose

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

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

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. The decay products of radon 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 **200 mrem/year**.

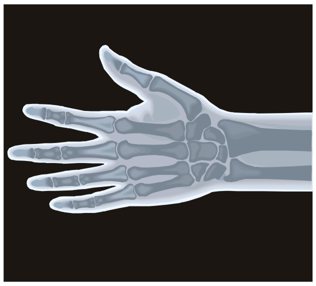
Cosmic radiation comes from outer space and our own sun. The earth's atmosphere and magnetic field affects the levels of cosmic radiation, which reaches the surface, so your dose from cosmic radiation is determined by where you live. For example, the dose rate on Long Island (at sea level) is about 24 mrem/year, while the dose rate in Denver, Colorado is 50 mrem/year. The average dose from cosmic radiation in the U.S. is **28 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 **28 mrem/year**.

Internal sources. Our bodies contain various, naturally occurring radioactive elements, and 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 **40 mrem/year**.

The major man-made 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 **51 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 about **3 mrem/year**.

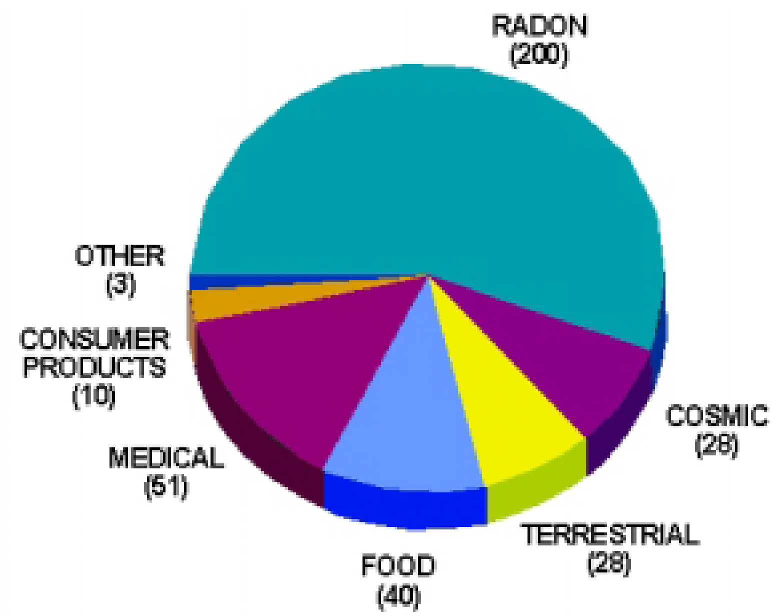
Sources of occupational radiation dose

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 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 background and man-made sources is about **360 mrem/year**, or about 25,000 mrem over the average lifetime. On Long Island, this average dose is significantly lower because of the low levels of radon.

U.S. AVERAGE ANNUAL BACKGROUND RADIATION DOSE



Module 2 - Biological Effects of Radiation Exposure

- Differentiate 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.

Differentiate between acute and chronic effects

Acute Radiation Effects

Observable, short-term effects, often referred to as **acute effects**, are associated with large doses of radiation received in a relatively short period 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 blood count. As the cumulative dose increases in magnitude, the effects become more observable. Examples of expected effects versus radiation dose include:

25 Rad	Onset of minor observable blood changes
100 Rad	May observe radiation sickness symptoms (nausea, diarrhea)
250 Rad	Possible hair loss
450 Rad	Established lethal dose LD50/60 (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, but 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, 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, and the amount of 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.

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 average risk (to an adult) of fatal cancer from radiation in his/her lifetime is **4 in 10,000 per rem**, using linear extrapolation.

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 1,000 mrem (in addition to the radiation dose from natural background and man-made 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 a member of the general population in the United States has roughly a 20% chance of dying from cancer (natural cancer mortality rate). If this person were to receive an occupational dose of 1 rem (cumulative during his/her 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

COMPARISON OF OCCUPATIONAL RISK

INDUSTRY	AVE. EST OF DAYS OF LIFE LOST/PERSON
Mining and Quarrying	328
Construction	302
Agriculture	277
Radiation dose of 5 rem/year for 50 years	250
Transportation/Utilities	164
All industry	74
Government	55
Service	47
Manufacturing	43
Trade	30
Radiation accidents (deaths from exposure)	less than 1

COMPARISON OF DAILY LIFE RISK

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. Everyone should 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

Every person working at Brookhaven National Laboratory has a responsibility to themselves and their co-workers to work safely and maintain a safe working environment. Because there is a possibility, however small, of an effect occurring from any exposure to radiation, all doses are maintained 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 well below the regulatory limits.

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

3. Preventing unnecessary exposures to workers and the public.

4. Protecting the environment.

Individual Responsibilities

Individual responsibilities as RadWorkers 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. Use time, distance, shielding to maintain your radiation doses low.

3. Ensure radiation interlock systems are operational.

4. Read and comply with all radiation barriers, signs, labels and postings.

5. Do not climb over barrier fences, or defeat any radiological protection systems.

6. If you suspect that you are approaching or exceeding a dose limit or administrative control level, stop work, terminate your exposure to radiation, and report the situation to your supervisor and Facility Support Representative.

7. Comply 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

The main goal of the ALARA program is to reduce the radiation doses to a level that is **A**s **L**ow **A**s **R**easonably **A**chievable. 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 SBMS Work Controls or Experimental Review Subject Areas

2. Use of 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 when possible. For many sources, radiation levels decrease exponentially with increased distance. If the distance from a source is doubled, the radiation level decreases by a factor of four. Some methods to increase the distance from the radiation source include:

1. During work delays, move 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 avoid higher dose rate areas.

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 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, alarms systems are also used to warn people of a hazardous condition or situation.

Module 3 - Federal Regulations, Policies and Procedures

- Identify the purpose and scope of the Price Anderson Amendment Act (PAAA) and 10CFR835 regarding matters involving 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 Amendment Act (PAAA) and 10CFR835 regarding matters involving radiological protection at BNL

What is the Price-Anderson Amendment Act?

The Price-Anderson Amendment Act is a Congressional Act, 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 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 a document called the Code of Federal Regulations (10 CFR 835).

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

- 10CFR830 Nuclear Safety Management, Subpart A (Quality Assurance) and 10CFR 835 (Occupational Radiation Protection) apply to radiological activities at BNL.
- 10CFR830 Nuclear Safety Management, Subpart B (Safety Basis Requirements) applies only to DOE facilities designated as Hazard Category 1, 2, or 3. This encompasses all activities supporting the Waste Management Facility.

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 to adhere to these regulations. It is each and everyone's obligation and responsibility to identify, report and correct any known non-compliance issue.

If these 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 $110,000 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 during an investigation make fraudulent statements 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 comprehensive corrective actions to ensure the non-conforming activity does not recur.

What Can You Do To Ensure the Requirements are Met?

BNL management is responsible to provide each employee with adequate direction to ensure all work can be performed safely and within the regulatory requirements. Brookhaven National Laboratory utilizes 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 that involve 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 adequately implementing them into your work at BNL.

Radiological Control Division

Within the Environment, Safety, Health & Quality Directorate is the Radiological Control Division responsible for providing BNL Departments/Divisions 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 Division/Department that 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

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 is 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 Experimental Review 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 it 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

Radiation Work Permits

Always obey all of the requirements contained within Radiation 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

When working in or near radiological areas 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 immediately stop non-compliant or unsafe radiological work. 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 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 the Radiological Awareness Program commonly referred to as the RAR Program.

You, as a Radworker play a vital role in the success of this program. The RAR program is dependent 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 or weaknesses and shortcomings, specify corrective actions and develop action plans for improvement.

If you have any questions regarding the RAR Program you may contact the RAR Coordinator or your facility representative.

Module 4 - Dose Limits and Administrative Control Levels

- Identify the DOE radiation dose limits and ACL
- Identify the purpose of Administrative Control Levels (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 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***. It applies to the "whole body," which is 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 is:

	LIMIT	ADMINISTRATIVE CONTROL LEVEL
WHOLE BODY	5000 mrem/year	2000 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 further control worker doses. The purpose of the BNL ACLs is to reduce individual and total worker radiation dose, (collective dose) and 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 (Dept./Div. Specific)	Less than Site-Wide
DECLARED PREGNANT WORKER	350 mrem/gestation
DECLARED PREGNANT WORKER	40 mrem/month
UNTRAINED PERSON (visitors, guests, and minors)	25 mrem/year

As illustrated, 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 Department or Division 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 the Department or Division 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.

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 the administrative control levels 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 before allowing yourself to 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 Controls 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 a self-reading 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:

PM-SOP-017
Guidelines for Initiating Dosimeter Service and Use of Dosimeters at BNL

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

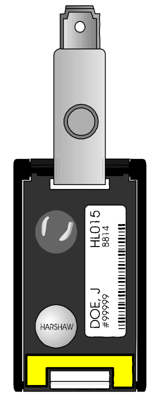
http://rcd.esh.bnl.gov

Dosimeters

There are several devices used to monitor **occupational** dose at BNL. They include the whole body thermoluminescent dosimeter (TLD), self-reading dosimeter (SRD), alarming dosimeter 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 utilizes the thermoluminescent dosimeter, commonly referred to as the TLD. This type of dosimeter is less sensitive to physical and environmental effects and unlike the old style film badge, can be reused after processing. 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 onsite. This processing usually takes a few weeks, unless there is a need for a quicker turn around in an individual case. There are many rules and requirements regarding the use of a TLD because the ***TLD is the basis for the legal record of your occupational dose***. These requirements include:

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

2. TLDs must be worn on the front of the torso, between the waist and the neck. 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 Facilities Support Technician or Facility Support Representative.

4. 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 first week of each month.

   a. If you leave BNL (employment is terminated or your guest appointment has expired), turn your TLD in to the Facility Support Representative and request he/she cancel your TLD service.

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 that fail to return a TLD **may** be restricted from continued radiological work.

6. TLD 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 or worn during a medical x-ray) 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

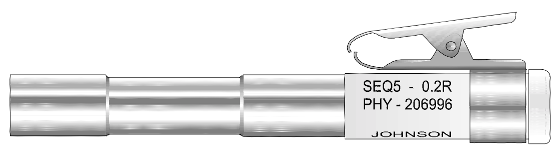
Representative or Facilities Support Technician and your supervisor of the situation.

11. 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.

12. 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.

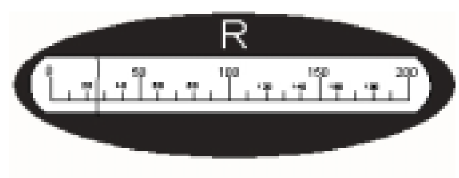
State the purpose and identify the correct use of a self-reading dosimeter

Self-Reading Dosimeters

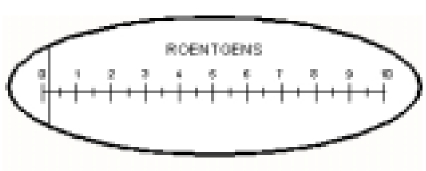


Self-reading Dosimeters (SRDs) can be used to monitor an individual's exposure to gamma or x-ray radiation. The main benefit of the SRD is that it provides an immediate read out, and can be viewed as often as you wish. At BNL, the SRD is usually used in High Radiation Areas or when an individual is expected to receive a relatively high monthly dose.

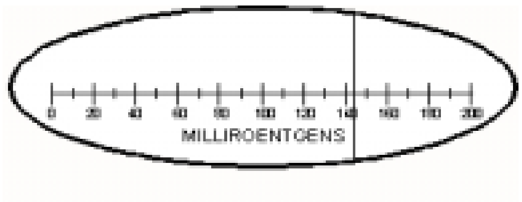
Several ranges of self-reading dosimeters are available at Brookhaven National Laboratory.



Emergency response personnel utilize a very high range dosimeter that has the capability of tracking dose up to 200 Roentgens.



Emergency Services personnel use a self-reading dosimeter that has the capability of tracking doses up to 10 Roentgens.



As a Radiological Worker at BNL, you will be utilizing a low range self-reading dosimeter that has the capability of tracking doses up to 200 milliRoentgen.

Operation of the Self-reading Dosimeter

The self-reading dosimeter consists of an air filled metal cylinder with an electrically insulated capacitor installed within it. With the capacitor charged, the force of similar electrical charges separates two small metal plates. One of these plates is stationary, while the other is left free to move based upon the amount of charge present within the capacitor.

When properly charged, the movable plate aligns with the zero dose reading on the meter face. As radiation creates ions within the air filled chamber, the electrical charge of the capacitor is diminished. As the electrical charge is reduced, the force separating the plates is less, thus allowing the loose plate to move closer to the stationary plate. The small fiber that you see when looking through the self-reading dosimeter is a shadow of the fiber that is attached to the loose plate. As the loose plate moves, the fiber moves across the scale representing the amount of radiation dose received.

Use of the Self-reading Dosimeter

Self-reading dosimeters are typically utilized when entering High Radiation areas or when dose tracking is required for a Radiological Work Permit. When using a self-reading dosimeter one should:

- Wear the dosimeter in close proximity to your whole body TLD
- Routinely check the dosimeter while working
- The dosimeter should be recharged (re-zeroed) prior to entry when the cumulative dose reaches 25% of the full scale
- The dosimeter should be recharged (re-zeroed) when the cumulative dose reaches 75% of the full scale
- If dropped or damaged, immediately leave the area and report it to the Facility Support Technician or Facility Support Representative

Alarming Dosimeter

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 1000 mrem/hr). Digital, alarming dosimeters are also becoming popular for use in lieu of the self-reading dosimeter. An alarming dosimeter is merely a dosimeter device that can be pre-set to alarm at a specific cumulative dose.

Because of its limited use, it is the responsibility of the issuing Department/Division 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 radiological area.

Finger Ring TLD

The Finger Ring TLD is used to monitor the dose to your hands 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

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

A copy of your dose record is provided to you on an annual basis. If requested in writing, a copy of your dose records will be sent to you 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) should be reported to your Facility Support Representative and Personnel Monitoring. This is 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.

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.

When a monitored employee, visitor or guest is scheduled to receive such a medical procedure, the individual must let the Personnel Monitoring Group or his or her Facility Support Representative know in advance

If you have any questions regarding this matter, please ask your Facility Support Representative or contact the Radiological Controls 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
- Differentiate 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 and Use of Radioactive Material
Bioassay Requirements for Radiological Work

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

http://rcd.esh.bnl.gov

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

Identify the process for procuring radioactive materials at BNL

It is extremely important that the laboratory maintain control and accountability of radioactive materials on site. For this reason, any work involving transferring radioactive materials to BNL from an outside source or purchasing radioactive material for use at BNL requires the involvement of the Isotopes & Special Materials (I&SM) Group.

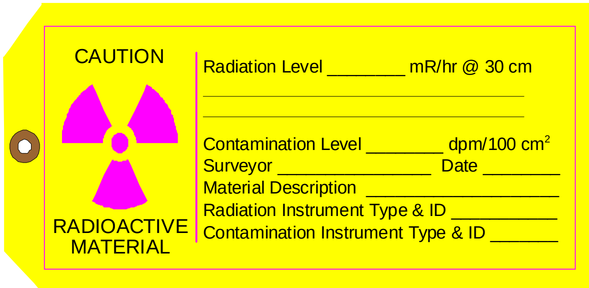
Accountability for radioactive sources begins with your Department/Division planning personnel. Each experiment or job must have either an Experimental Safety Review or a Work Planning Review completed prior to the start of the work. The review process will identify that radioactive materials will be brought on site and thus trigger the need for I&SM Group involvement.

Direct deliveries to specific laboratories or work location are not allowed. Instead, all radioactive materials will be processed through Central Receiving. Before delivering the materials to their final destination, the I&SM Group will ensure 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 color combination are used to readily 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 Department/Division, 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 radioactive material accountability is maintained.

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, Contamination or Airborne Radioactivity Area.
- The package is taken into a benchtop setting with dispersible radioactive materials in use.
- The package is opened and contains dispersible radioactive material.

Differentiate between fixed, removable, soil and airborne radioactive contamination

Fixed Contamination

Fixed contamination is contamination that cannot be readily removed from surfaces. Casual contact, wiping, brushing, or washing cannot remove it. Fixed Radioactive Contamination does not pose a threat of being spread unless buffing, grinding, or using volatile liquids for cleaning physically disturbs it. 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 to the lens of the eye or skin.

Removable Contamination

Removable contamination is contamination that can readily be 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, 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 in these areas may be well below the levels required for Contamination Area posting, but require marking to prevent events involving spreading contamination. In the event soil contamination exceeds the limits for Contamination Area, it will be posted as such and appropriate access control measures will apply.

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.

Currently, the only hot particle control program instituted at Brookhaven National Laboratory is in the High Flux Beam Reactor (HFBR).

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, absorption through the skin or entry through a wound. For this reason, each person completing the Contamination, High Contamination and Airborne Radioactivity training course (RWT300) must have a "BASELINE" bioassay before authority will be granted to enter any of these areas.

The methods used for internal monitoring are whole body counts (invivo) and urinalysis (invitro) to determine the amount of radioactive material taken into the body, and to calculate a dose for the uptake. 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.

Invivo Bioassay

The invivo bioassay method is commonly referred to as the "Whole Body Count." This method involves monitoring the radiation emitted from 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 and calculates the radiation dose that will result from the deposits. This dose is then tracked as part of your BNL dose records.

Invitro 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 invitro bioassay.

As a Radworker 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 Radiological 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 radiological areas.
- Identify the requirements for providing escort into radiological 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 display for review or obtain a printed copy of the procedure(s) through the Radiological Control Division web site at:

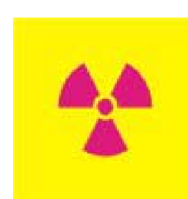
http://rcd.esh.bnl.gov

Standard Operating Procedure:

FS-SOP-3000 – Radiological Posting Requirements
FS-SOP-4027 – Entry and Egress Requirements for Areas Controlled for Radiological Purposes

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, and 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 which 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. If items are being placed or transferred into an area (e.g. handing tools to another worker) it 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 an RCT should make a determination if contingency actions are required to prevent inadvertent cross contamination such as wearing gloves or booties.

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. This is especially important at Brookhaven National Laboratory because an area that was a Radiation Area yesterday may be a High Radiation Area today.

Identify the posting and requirements for entry and/or exit from all Radiological Areas.

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

Minimum Training Requirements:
- RWT001 – GERT

Entry Controls:
- Read and abide radiological posting

Exit Controls:
- Read and comply with radiological posting

Radiological Buffer Area (RBA) – An intermediate zone established to prevent the spread of radioactive contamination to uncontaminated.

Minimum Training Requirements:
- RWT002 – Radworker 1 AND either:
- RWT002A – Radiological Buffer Area Access Training OR
- RWT300 – Contamination, High Contam & Airborne Training OR
- RWT500 – 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:
- RWT001 – GERT (if within Controlled Area ONLY)
- RWT002 – Radworker 1 (if the RMA is within an area for which are you are allowed unescorted access)
- RWT500 – Benchtop/Dispersibles (if using dispersible sources)

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:
- RWT002 – Radworker 1

Entry Controls:
- Read and comply with radiological posting
- Read and comply with requirements on Radiological Work

Permit
- Do not loiter in area

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 which causes a dose rate that exceeds 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:
- RWT002 – 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:
- RWT002 – Radworker 1

Entry Controls:
- Read and comply with radiological posting
- Ensure associated interlocks are operational
- Read and comply with requirements on Radiological Work Permit
- Do not loiter in area

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:
- RWT002 – Radworker 1

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

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

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:
- RWT002 – Radworker 1 AND
- RWT300 – Contamination, High Contam & Airborne Training with RWT300A 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:
- RWT002 – Radworker 1 AND
- RWT300 – Contamination, High Contam & Airborne Training with RWT300A 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 10-CFR-835; or

An individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week.

Minimum Training Requirements:
- RWT002 – Radworker 1 AND
- RWT300 – Contamination, High Contam & Airborne Training with RWT300A 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 have severe administrative and/or radiological consequences such as 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 radiological areas.

Radiological Worker I training is the minimum training required for unescorted access to areas posted as, Radiation and High Radiation and also 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 (when dispersible materials are not being used)
- Radiation Areas
- High Radiation Areas
- Fixed Contamination Areas

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

You may have noticed that the minimum requirements for access to each of the posted radiological areas specifically addressed the need for UNESCORTED access to the areas. It is understandable from time to time there may be a need to allow short term 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 radiological areas with the exception of 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 section 12 of the Entry and Egress Requirements for Areas Controlled for Radiological Purposes 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 Radiation Work Permit.
- Differentiate between a General and Job-Specific RWP
- Identify activities requiring the use of Radiological Work Permits.
- Using a completed Radiation 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.

> This module addresses materials contained within the SBMS Radiological Work Permit Subject Area.
>
> For more detailed information see the Standard Operating Procedure:
> **HP-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 Department work planning group and supervisors, working with the Facility Support Technicians and Representatives perform a thorough radiological hazard assessment and document the results on the 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
- Very High Radiation Areas

Differentiate 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, routine or repetitive activities in areas with historically stable or predicable 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 or jobs that requiring 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, Very High Radiation Contamination, High Contamination or Airborne Radioactivity Areas
- Any work involving handling material with radioactive contamination exceeding the levels specified within the Radiological Control Manual.
- Any work involving handling dispersible radioactive materials exceeding 1% of the material's Annual Limit on Intake (ALI).

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

- Any work requiring access to High Radiation, Very High Radiation, High Contamination or Airborne Radioactivity Areas
- 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 Radiation Work Permit, correctly obtain information from its contents

The Radiological Work Permit process begins after your Department 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 Department completing the upper portion (shaded area) of the Radiological Work Permit.

Originator

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

- Initiator's/Job Supervisor's name
- Life Number
- Telephone number and pager number (if applicable)
- Building Number
- Job Location
- Brief description of the work (attach more detail if necessary)
- Planned start date and time
- Planned end date and time
- Any radiological concerns that have surfaced while previously performing this job or similar jobs.
- Signature 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. This will result in unnecessary delays, therefore 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. 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 in determining the appropriate radiological controls for the job. Blocks 10 through 18 of the RWP contain the 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. This 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 block number 19. The BNL RWP form also provides an approval block for a Department Specific approval signature. This block is not required, but may be used by Departments for controlling radiological work within their facilities.

SAMPLE Radiological Work Permit

Brookhaven National Laboratory
RADIOLOGICAL WORK PERMIT

RWP#: 938-005
Start Date: Today
End Date: Today
Revised End Date: ____________

[X] Job Specific
[ ] General
Shaded area to be completed by requestor

1. Initiator: Job Supervisor	2. Life #: 99999	3. Phone: 9999	4. Bldg: 129-A

5. Job Locations: Upper Level, Building 938

6. Job Description (Attach sheets as needed):
Check the door of the red fire alarm panel located on the East wall to ensure it is securely locked.

6a. Work Begins: 08:00	6b. Work Ends: 18:30

7. Historical / Other Concerns: Previous activities of this nature have resulted in personnel contamination and cross contamination of the RBA.

8. Signature of Initiator: Job Supervisor

9. Conditions that will void the RWP: Changes in the scope of the activity, changes in radiological conditions requiring modification of the RWP.

10. Job Review:	11. Estimated Doses:	12. Attachments:	13. Training Requirements:
[ ] Pre-Job Review [X] Pre-Job Briefing [ ] ALARA Review [ ] Summary / Closeout [ ] Other: [ ] Not Applicable	[ ] Per Job [X] Per Entry Highest Individual : 10 mRem Collective: 100 mRem [ ] Not Applicable	[X] Radiological Survey Form [ ] Technical Work Document [ ] Other: ____________ [ ] Not Applicable	[X] RadWorker 1 (RWT002) [ ] Contamination (RWT300) [ ] Benchtop/Dispersibles (RWT500) [ ] Other: __________

14. Work Controls:	15. Protective Clothing:	16. Dosimetry:	17. Checkout Instructions:
[ ] Facility Support Coverage [ ] Intermittent [ ] Continuous [ ] Hold Points (See Section 18) [ ] Air Monitoring [ ] Shielding [ ] Other ____________ [X] Not Applicable	[ ] Gloves (Inner plastic, Outer rubber) [ ] Shoe Covers __________ [ ] Booties (Inner liner & rubber overshoes) [ ] Coveralls __________ [ ] Red Trim Lab Coat [ ] Respirator __________ [ ] Head Cover __________ [ ] Other: __________ [X] Not Applicable	[X] TLD [X] Self Reading Dosimeter [X] Pencil [ ] Digital [ ] Alarming Dosimeter [ ] Finger Dosimetry [ ] Not Applicable	[ ] Whole Body Count [ ] Urine Sample (Bioassay) [ ] Contamination Check [ ] Personnel [ ] Equipment [ ] Equipment Return [ ] PCM-1B [ ] Tools [ ] Post Job Survey [X] Not Applicable

18. Special Instructions: (Hold Points, special dose limits, etc.):
- Baseline Bioassay required to be on file prior to entry
- Use Low Dose Rate Areas (LDRA) as much as possible
- Tools and equipment must be surveyed by a qualified FS Technician
- Frisk hands and feet prior to leaving the RBA

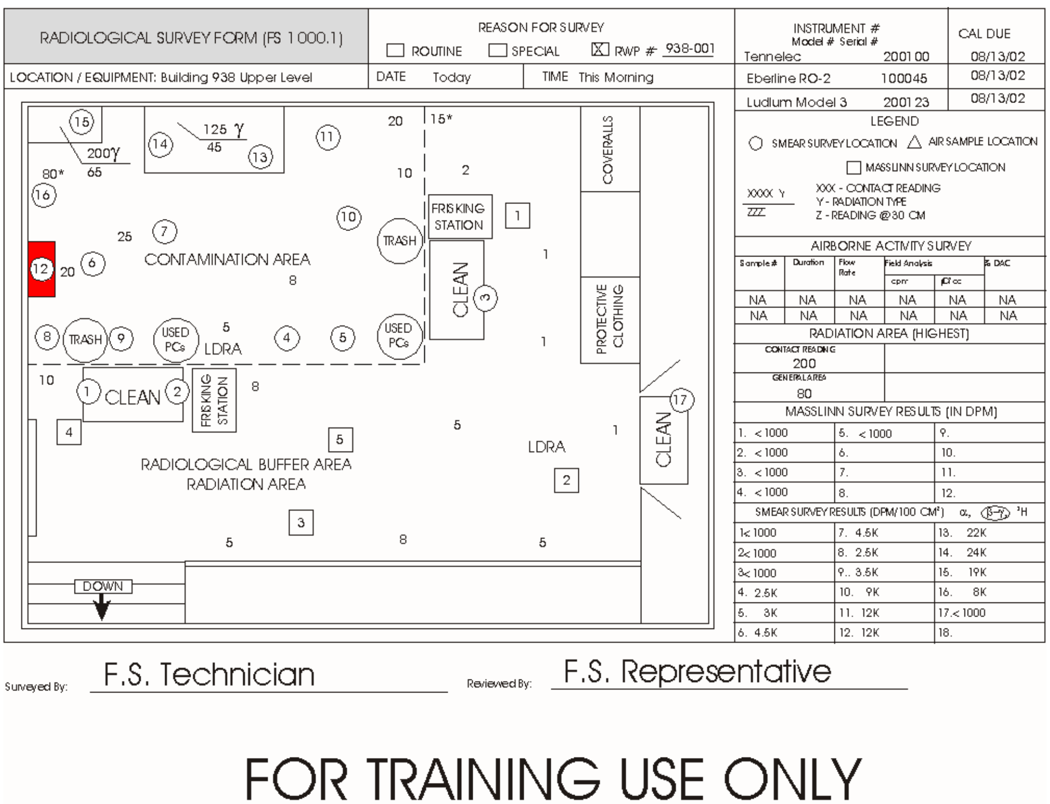
19. Signature Approvals: Signature	Department	Life Number	Date
FS Representative: F. S. Representative	Radiological Control	99998	Today
Other (Department Specific):			
20. Close-Out Signature: FS Representative:			

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 is used not only to document completion of a survey but also 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 (LDRA)



General Area (Whole Body) Radiation Dose Rates

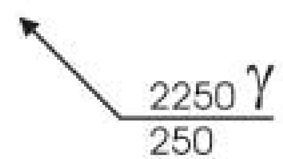
Radiation dose rates that affect the entire body are called “General Area” radiation dose rates. These measurements are obtained throughout the work area to provide reliable data concerning where the radiation hazards exist. All general area radiation dose rates are indicated on the Survey Record by a numeric value representing the dose rate in mrem/hour.

The highest General Area radiation dose rate in the work area is indicated by an asterisk (*). This value is also listed in the table on the right of the survey map for Radiation Area (Highest). On the sample survey record on the next page, the highest whole body radiation dose rate in the posted Radiation Area is 55 mrem/hr. The highest whole body radiation dose rate in the posted High Radiation Area is 250 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 (gamma – γ). The bottom value is the measurement obtained at 30 centimeters (approximately 12 inches) from the localized source.



On the sample survey record on the next page, the contact reading within the Posted High Radiation Area is 2,250 mrem/hr and its associated general area dose rate is 250 mrem/hr.

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 “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 record on the next page, the survey has 10 smears all indicating less than 1,000 dpm/100cm^2 and 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 utilize these Low Dose Rate Areas when reviewing procedures or waiting within the work area for a hold-point. Low dose rate waiting areas are identified by the acronym “LDRA” on the survey record.

There are two (2) low dose-rate waiting areas identified on your sample survey record, both being within the posted Radiation Area.

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 utilize 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.

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 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.

RWP Sign-In Log

RWP Number: ____________

Your signature on this form indicates that you have read, understand and will comply with the requirements of the above numbered RWP.

Name (Print)	Signature	Life/ Guest Number	Date

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 utilize 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 and 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 effected 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 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.

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 alarms. 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.