PROGRAM:	**GENERAL EMPLOYEE TRAINING**		
COURSE:	**RADIATION PROTECTION**	COURSE NO.:	
TOPIC:	**RADIATION WORKER**	TOPIC NO.:	**GRP400**
LESSON:	**GENERIC RADIATION WORKER**	LESSON NO.:	**GRPA400**
APPROXIMATE TIME FOR INSTRUCTION:	8 HR		

Instructor Materials

1. This is designed to be a web based training lesson with additional graphics and movies.

Student Materials

1. Computer connected to the DCPP intranet
2. Headphones
3. Student handout if desired

Lesson References

1. ACAD 00-007
2. 10CFR20
3. Basic Radiation Protection, Gollnick, Daniel
4. SOER 85-03

Remarks

1. CMD Training Commitments T00091, T01011, and T35831
2. This lesson is designed for the web-based training but may be taught in classroom in necessary.
3. The information in this lesson will be evaluated by the use of a computer based test (80% criteria)
4. Practice items for each objective are already programmed into the web-based training and shall not be repeated here.
5. This lesson revision documents the split of GRPA400I and GRPA650I as separate documents.

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Introduction

Lesson introduction

This lesson is the first part of the requirement of radiation worker training. This covers the generic portion which spans the knowledge base common to the entire nuclear industry.

- Training goal – to align DCPP with INPO standards for Generic Radiation Worker knowledge.
- Effectiveness measure – 80% on the computer test

Objectives

Terminal objective

Upon completion of this class the student will be able to safely work in radiological areas of nuclear power plants, understanding the risks, and procedures to decrease those risks associated with that work in general.

Enabling objectives

The following objectives apply to the lesson.

Number	Objective Text
A. Sources of Radiation	
A1	State the basic structure of an atom, including the three primary components
A2	Define ionizing radiation.
A3	Define contamination.
A4	Describe the four types of ionizing radiation found at nuclear power plants
A5	Define radioactive decay.
A6	Define fission and fission product.
A7	Define corrosion product.
A8	Define neutron activation.
A9	Define calibration source.
B. Biological Effects	
B1	Compare the relative penetrating ability of the four types of ionizing radiation.
B2	Define dose and doserate.
B3	Convert between rem and millirem.
B4	List the effects radiation can have on cells.
B5	Define "chronic radiation exposure" and the associated risks.
B6	Define "acute radiation exposure" and the associated risks.
B7	Define "genetic" and "somatic" effects. Compare somatic versus genetic effects of radiation exposure.
B8	Compare the radiosensitivity of different age groups.

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Objectives, Continued

Enabling objectives (continued)

Number	Objective Text
B9	Identify the possible effects of radiation on an unborn child due to prenatal exposure.
B10	Compare the safety record of nuclear power to other industries.
B11	State the purpose of an NRC form-4.
C. Exposure Limits	
C1	Define the classes of individuals for exposure limit purposes.
C2	State the consequences of exceeding federal exposure limits.
C3	State the federal exposure limits (including declared pregnant female).
C4	State the reason for having station limits, and the actions taken if they are being approached.
C7	State the rights of a declared pregnant worker.
C8	Recognize the definition of a planned special exposure.
D. ALARA	
D1	State the purpose of the ALARA concept, and describe DCPP's ALARA program.
D2	Explain the benefits of reducing exposure.
D3	Explain how time, distance, and shielding can be used to reduce radiation dose, and state some methods used to implement time, distance, and shielding concepts.
D4	State individual responsibilities concerning temporary shielding.
D5	List the rights and responsibilities of radiation workers concerning radiation exposure.
D6	Calculate stay time given a dose rate, current exposure, and an exposure limit.
E. DOSIMETRY	
E1	State the purpose of dosimetry
E5	Explain the actions to be taken if dosimetry is lost or damaged and the radiological consequences.
F. CONTAMINATION CONTROL	
F1	Identify and compare fixed, loose, discrete, and airborne contamination.
F2	Describe the methods used for measurement of contamination, including the units used and the limits for contamination.
F3	Explain why contamination is controlled, including techniques for controlling the spread of contamination (e.g., to personnel or other areas), and how contaminated areas are designated.

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Objectives, Continued

Enabling objectives (continued)

Number	Objective Text
F4	Describe sources and indications of contamination including: - spills and leaks - opening contaminated systems - maintenance activities
F6	State the methods used to monitor personnel for contamination, the actions necessary upon discovering contamination, and list decontamination techniques for personnel.
F7	Identify situations that require immediate exit from contaminated areas.
G. Internal Contamination	
G1	Explain how contamination enters the body.
G2	List the techniques used to measure contamination in the body.
G3	Describe the mechanisms by which contamination is removed from the body.
G4	Define Annual Limit of Intake (ALI), Derived Air Concentration (DAC), Committed Dose Equivalent (CDE), Committed Effective Dose Equivalent (CEDE), and the relationship between the terms.
G5	List activities that have the potential for increasing airborne contamination levels.
G6	List the methods used to limit internal contamination at DCPP in the order of preference.
H. Radiation Work Permit (RWP)	
H1	State the purpose of a radiation work permit (RWP).
H3	State the radworker's responsibilities concerning RWP instructions and the correct worker response to radiological or work conditions not described on the RWP.

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Objectives, Continued

Enabling objectives (continued)

Number	Objective Text
I. POSTINGS	
	None
J. Radioactive Waste	
J1	Define radioactive waste.
J2	Define mixed waste.
J3	Explain the importance of keeping separate the following: Contaminated and uncontaminated materials Wet and dry contaminated materials Contaminated materials and hazardous materials
J4	State the difference in disposal costs of radioactive materials versus non-radioactive materials.

A. Sources of Radiation

Atomic Structure

Objective A1 State the basic structure of an atom, including the three primary components.

Introduction Everything you see and touch is made out of atoms. An atom is a tiny particle of which all substances are made. The atom is the smallest particle that can exist on its own and still be recognized as a particular element.

Need to know Atoms are made of even smaller particles. The three primary particles of atoms are:

- protons
- neutrons
- and electrons.

Nice to know Protons are located in the center, or nucleus, of the atom. Protons have a positive electrical charge. Since protons all have a positive charge, they repel each other within the nucleus.

Neutrons are also in the nucleus of the atom and are electrically neutral. Neutrons help spread out the positive charges of the protons in the nucleus. You can think of this arrangement as helping to balance the attractive and repulsive forces in the nucleus in order to keep the atom stable.

Electrons are small negatively charged particles that orbit around the nucleus. Electrons have a negative charge and are continually in motion orbiting around the nucleus.

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Atomic Structure, Continued

Examples

Each element has a unique number of protons, that is, all Oxygen atoms have the same number of protons. An element can have different numbers of neutrons and still be the same element, but some of its other properties will be affected.

The numbers of electrons as well as their arrangement around the nucleus give the element its chemical properties. Electrons are in different configurations depending on their numbers. There will normally be as many electrons as protons in an atom, and the overall charge of an atom should be neutral. Atoms that are not neutral (do not have equal numbers of positive protons and negative electrons) are called ions.

Ionizing Radiation

Objective A2 Define ionizing radiation.

Introduction

Normally atoms combine to form molecules. Atoms and molecules usually have equal numbers of protons and electrons for a total (overall) net charge of zero. Ions are any particles that have an overall net charge, either positive or negative.

Ionize means to create charged particles by removing one or more electrons from the atom or molecule. Radiation passes through material, sometimes imparting energy to that material and ionizing the material by removing an electron. Ionization creates an ion pair (the nucleus and the ejected electron will both have a net charge).

Need to Know

Ionizing radiation is particles or waves of energy emitted from radioactive atoms which has sufficient energy to ionize surrounding material (this does not make the material radioactive.)

Ionizing radiation cannot be detected by human senses; it cannot be seen, heard, felt, smelled, or tasted.

Ionizing radiation is emitted by the sun, stars, soil, and concrete, as well as by nuclear reactors.

Nice to Know

Radiation does not get on people or equipment. Radiation cannot be carried from one place to another. You cannot carry radiation home with you. The energy from nuclear radiation only lasts for a small fraction of a second before it is absorbed by the surrounding material. Radiation is not a solid, liquid, or gas; it is energy.

Examples / Non-examples

Heat, light, sound, and microwaves are radiated energy. They are referred to as non-ionizing radiation. At DCPP we use the term radiation only to refer to radiation that results from the decay of radioactive material, which is ionizing radiation.
Radiation does not stick to you like grease, dirt, or paint. Radiation is like sunlight: When you walk around in the sun you do not accumulate sunlight on yourself. You do not carry sunlight inside and then shine on other people.

Contamination

Objective A3 Define radioactive contamination.

Introduction

When an atom doesn't have the correct balance of forces in the nucleus, it will give off energy, or particles, or both until it becomes stable again. Atoms that to do this are called **radioactive**, and the process is called **radioactivity**. At nuclear power plants the term radioactivity is often shortened and simply referred to as activity.

Radiation is energy that comes from radioactive material. It is important that the energy not be confused with the radioactive material that produces the energy.

Need to Know

Radioactive material contains some radioactive atoms that emit energy (radiation). Contamination is radioactive material in an undesirable location. Contamination can be a solid, liquid, or gaseous material.

Nice to Know

Material can be seen (except when it is in very small amounts). Contamination will look like (and actually is) dirt, rust, water, dust, etc.

The term contamination is generally used for undesirable material. A beach would be described as contaminated with oil, but an oil tank is not described as contaminated with oil because it is expected to have oil in it.

Radioactive material is also called contamination when it is in an undesired location. The uranium fuel in our reactors is radioactive, but it would only be called contamination if it were located outside the fuel bundles in some unwanted location.

Examples / Non-examples

Contamination is a material, just as mud is a material. If you walk in a muddy area you will get mud on your shoes. You will then spread that mud to clean areas such as a floor, your pants, your skin, or people unless you wash it off or change shoes.

Radiation, which is energy, must come from a source. Contamination is a source of radiation. This is analogous to a flashlight being a source of light. You can carry around a flashlight (the source) that is giving off light (the energy), but you cannot carry around just the light separately (i.e., without the flashlight).

Types of Ionizing Radiation

Objective A4 Describe the four types of ionizing radiation found at nuclear power plants.

Introduction Radiation is not all the same. There are four major types of radiation in power plants. The four types have different penetrating abilities, have varying energies, and have different types of interactions with matter. Recall that radiation is transient energy (i.e., energy moving from one place to another). Certain types of radiation are particles, which carry away energy from the unstable atoms, and quickly interact by depositing this energy into surrounding materials.

Need to Know Alpha radiation is the biggest particle of radiation.

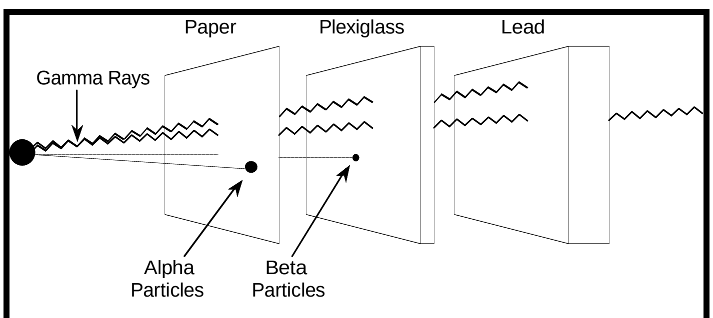
Beta particles are electrons unattached to a nucleus.

Gamma radiation is waves (like light) that can travel long distances through air. Gamma rays are best shielded by dense materials such as lead, concrete, or water. Photons and x-rays are other names for gamma radiation.

Neutrons, like gammas, have no charge so they too must collide with surrounding materials in order to deposit their energy (ionization). Neutrons are not a problem during outages when the reactor is shut down.

Most of the radiation given off from radioactive material in a power plant is beta or gamma. Most of the radioactive material is contained within the plant's systems. Therefore, most of the exposure in a power plant comes from gamma because beta radiation is easily shielded.

Diagram



Penetration Power of Radiation

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Types of Ionizing Radiation, Continued

Nice to Know

Radiation can be either particles or waves of energy. Gamma, x-ray, and photons are waves with no mass, like light, except you cannot see it.

Neutrons are particles. Neutrons are difficult to stop because they have no charge.

A beta particle is an electron that is not attached to an atom. The beta particle may be an electron that was separated from its orbit around a nucleus or it may have been ejected from the nucleus of an atom. Both are beta radiation. Beta particles normally have a negative charge, although they can also be positively charged.

Alpha particles are much larger than betas. An alpha particle is about 8000 times the size of a beta. Alpha particles are easier to stop because they are large, and carry a heavy +2 charge. Once an alpha is stopped, it acquires two electrons and becomes a complete and harmless helium atom. It is no longer radiation (i.e., capable of ionizing).

Examples / Non-examples

Radioactive material that is in a closed container (box, pipe, or tank) will not expose workers to any alpha or beta radiation because alpha and beta will be stopped by the container's wall. Radioactive material in containers will not expose workers to neutron radiation because neutrons are only present in and near the reactor when it is operating.

Alpha particles are large and they are only produced by larger atoms, such as uranium. Alpha radiation has rarely been a concern at DCPP. Contaminated areas and equipment will usually have only beta and gamma radiation present.

Radioactive Decay

Objective A5

Define radioactive decay.

Introduction

Most atoms do not give off radiation; these are called stable atoms. Other atoms are unstable (radioactive) and will give off radiation.

Need to Know

Radioactive decay is the process in which an unstable atom gives off radiation. Atoms vary in their stability; some decay after seconds or minutes, and others take years or even thousands of years to decay.

A characteristic of each type of radioactive material is the time it takes to decay. The term half-life is used to describe the amount of time that it will take for half of the radioactive atoms of a given radioactive sample to decay away. Half of the material left will decay after another half-life.

Nice to Know

The rate at which radioactive atoms decay can be measured by the instruments or meters that the RP Technicians use.

Examples / Non-examples

An atom with one proton in its nucleus is a hydrogen atom. Most hydrogen atoms have no neutrons and are stable. Another form of hydrogen atom has two neutrons and is unstable. The hydrogen with two neutrons is called tritium and is used for luminous wristwatches, lighted markers for the exit in commercial jets, and many other uses.

The atoms of non-metals can be radioactive also. They become radioactive in the same way as metals and radioactively decay by the same methods as metal.

Fission

Objective A6 Define fission and fission product.

Introduction Nuclear power plants produce electricity by boiling water to turn a turbine. The only difference between nuclear and non-nuclear plants is the way we produce the heat used to boil the water.

Need to Know Heat in a nuclear power plant is produced by fission in our uranium fuel. Fission is the splitting of a large atom into smaller atoms. These smaller atoms are called fission products.

Nice to Know Fission of uranium produces two smaller atoms (occasionally three), two or three free neutrons, gamma rays, and heat.

Uranium atoms are large and unstable (radioactive). They are so large that the addition of one more neutron makes them split (fission). When a uranium atom splits, its protons and most of its neutrons form two smaller nuclei and heat is produced. The free neutrons are not attached to a nucleus and travel away from the fission. If one of the free neutrons is absorbed by another uranium atom, it causes that atom to fission, releasing more free neutrons. When one fission produces neutrons, which cause another fission, it is called a chain reaction.

The two smaller atoms (fission products) are radioactive and will decay over time emitting more radiation. Fission products usually remain inside the fuel bundles. If fission products get into the reactor water they will increase the radiation levels (gamma) throughout the plant. If reactor water containing fission products leaks out of the pipes it will contaminate the floor or equipment it contacts. The contamination will emit mostly beta and gamma radiation. Fission products are a major source of radiation in plants where the fuel bundles leak.

Heat is the useful part of fission. The fission products are what is left after fission, like ashes are the left over part after a wood fire.

Examples / Non-examples Only a few elements will fission in a chain reaction. Uranium and plutonium are the two most common elements. Commercial nuclear reactors use uranium, which fissions primarily with slow (i.e., low energy) neutrons. The time that it takes for the neutrons to slow down after the fission that produces them is one reason that reactors cannot explode like an atom bomb. Atom bombs use mainly plutonium for fuel, which is capable of fissioning when struck by a fast neutron (i.e., plutonium will likely fission with any energy neutron).

Corrosion Product

Objective A7	Define corrosion product.
Introduction	There are sources of radiation in a nuclear power plant in addition to fission products. Corrosion products are the next source of radiation we will discuss.
Need to Know	Corrosion products result from the corrosion, or rusting, of plant materials.
Nice to Know	Corrosion products circulate through the reactor water until filters remove them or they plate out on plant pipes and valves. Radioactive iron will rust the same as non-radioactive iron. Rust is a result of corrosion, and can be called a corrosion product. Most of the metals used in the construction of a power plant can corrode, and any material produced by this corrosion is called a corrosion product.
Examples / Non-examples	Nearly all metals can oxidize (corrode), and produce corrosion products.

Neutron Activation

Objective A8 Define neutron activation.

Introduction Radioactive metals corrode in the same ways as non-radioactive metals. Iron can become radioactive and then rust or it can rust and then become radioactive. Metal atoms in plant materials or rust can absorb a neutron and become radioactive.

Need to Know Neutron activation occurs when a neutron is absorbed by an atom, changing it from stable to radioactive.
Neutrons are only produced in the reactor during fission so neutron activation is only possible in or near the reactor when it is operating.

Nice to Know Neutrons cause fission in uranium and are produced during the fission of uranium in the reactor core. Not all of the neutrons produced during fission interact with another uranium atom to cause additional fissions.

Some of the neutrons escape the fuel and travel through the reactor water and anything in the water such as corrosion products. Some of the neutrons pass through the reactor vessel and other material in the containment. All neutrons produced during fission will be quickly absorbed by the nucleus of some atom. When one of these neutrons causes an atom to become radioactive, we call it neutron activation.

Examples / Non-examples Nickel is used to make steel less likely to corrode. Nickel in the reactor vessel is exposed to neutrons when the reactor is operating and may become radioactive. The nickel may become radioactive and then corrode off of the vessel and travel through the plant piping.

Cobalt is used to harden valve parts so they will not wear away as fast. Cobalt that does wear away will be transported through the reactor during operation and can become activated by absorbing neutrons from the fission process.

Calibration Source

Objective A9

Define calibration source.

Introduction

Fission products are an undesirable result of the fission process and an undesirable source of radiation. Neutron activation of plant materials is an undesirable effect of material being near the reactor core. Not all radioactive material is undesirable, some is brought on site intentionally.

The uranium fuel represents the biggest quantity of radioactive material we bring on site, but there are others such as calibration sources.

Radiation instruments, like all other instruments must be calibrated to be accurate.

Need to Know

Radiation instruments are calibrated with precisely measured amounts of radioactive material that are called "calibration sources".

Nice to Know

Radioactive sources can emit alpha, beta, gamma, or neutron radiation, or a combination of these. The sources are used by technicians to calibrate and check accuracy of the instruments used to measure radiation in the plant.

Intentionally manufactured sources are also used at DCPP for examination of plant pipes and welds. Radiography is very similar to medical x-rays except that the radiation comes from a piece of radioactive material instead of an x-ray machine. Radiography sources are much more radioactive than calibration sources and must be transported and stored in heavily shielded containers.

Examples / Non-examples

Some household smoke detectors use radioactive material to help identify smoke. This material is intentionally radioactive material because it is the radioactivity that causes ionization that enables smoke to be detected.

Tungsten-inert gas (TIG) welding rods are radioactive. Thorium, which makes the tungsten more durable, is naturally radioactive. Radioactivity is neither necessary nor useful in the tungsten rods.

Thorium is also put in lantern mantles because it fluoresces and produces a very bright white light when heated. The radioactivity is unintentional in this case also.

B. Biological Effect

Penetrating Power

Objective B1 Compare the relative penetrating ability of the four types of ionizing radiation.

Introduction The four types of radiation found in nuclear power plants have different masses and different charges. The amount of damage done to cells, the range the radiation can travel, and the best type of shielding varies because of these differences.

Need to Know Alpha radiation travels only a few inches in air and will be stopped by any solid or liquid, even a thin layer of cloth or a piece of paper. Alpha will also be stopped by a single layer of skin cells.

The distance that beta travels depends on its energy. Beta will typically travel several feet through the air, but can be stopped by any metal or thin layers of water or plastic (e.g., plastic safety glasses or faceshields). Beta typically penetrates about 1/8" into the body.

The distance that neutrons travel depends on their energy. Neutrons typically can penetrate several inches of water or tissue, and even farther in heavier materials or air. Remember that the only significant source of neutrons is a reactor making power.

Gamma radiation can travel long distances in air and is best shielded by heavy metals, like lead. Concrete and water are less effective, but they are reasonably good shielding against gamma radiation if you have several feet of it (low cost and highly available).

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Penetrating Power, Continued

Nice to Know

Alpha particles cannot penetrate cloth or skin. Exposure to an external source of alpha does not damage live tissue because the radiation doesn't travel far enough to get to the live tissue.

Beta is only a concern when plant components are disassembled or are leaking (i.e., there is loose contamination present) because beta cannot penetrate through the metal walls of plant piping.

Neutrons interact differently than charged particles and are best shielded by water and concrete. Since neutrons are only present during reactor operation, no special attention is paid to neutron shielding for outages.

Gamma radiation is best shielded by heavy metals such as lead and uranium. Concrete and water are less effective, but reasonably good shielding against gamma radiation. Concrete is widely used because it is easy to build into the plant during construction.

Examples / Non-examples

Beta-emitting materials are in the reactor water, but beta cannot penetrate the piping. Beta radiation is a concern only when plant components are open or have leaked.

Gamma radiation is present in many areas of the plant. Gamma is not completely stopped by shielding like the alpha and beta particles. Gamma radiation is attenuated, or reduced in level, by steel, concrete, and water. Gamma can penetrate all the way through the body and can damage cells throughout (e.g., internal organs).

Neutrons are uncharged particles that are stopped by colliding with atoms. The energy loss is greatest when a neutron collides with a particle the same size, such as a hydrogen atom. When a neutron collides with an atom larger than itself it bounces off of the atom with little energy loss.

Dose & Dose Rate

Objective B2

Define dose and dose rate.

Introduction

A unit of measurement is necessary for any quantity that will be measured. Some of the units for time are seconds, hours, and years. Common units for weight are ounces, pounds, and tons.

Radiation also has units, and workers need to be familiar with them to be able to understand the warning signs and documents in the plant.

Need to Know

Dose is the amount of exposure to radiation and the standard unit of measure is the rem.
Dose rate is a measure of how quickly a worker will get dose. The unit is rem/hour.

Nice to Know

Rem is a biological risk-based unit. Radiation can be measured by the energy it contains, but different types of radiation do different amounts of damage to cells when the energy absorbed is the same. The unit rem takes into account the amount of cell damage and its risk, which is what we are interested in. A rem of alpha carries the same biological risk as a rem of beta, gamma, or neutron.

Dose rate is related to dose the way speed is related to distance. When you drive 30 mph for an hour you will travel 30 miles. In two hours at 30 mph you will travel 60 miles. If you spend 1 hour in a 1 rem/hour area you will get 1 rem. If you spend 2 hours you will get two rem. In a half hour you would get half a rem.

Examples / Non-examples

There are standardized units to measure almost everything. Gasoline is measured in gallons, potatoes are measured in pounds, and houses are measured in square feet. Using standard units helps everyone understand the amounts and exchange information more easily.

Rem & Millirem

Objective B3 Perform conversions between radiation units rem and millirem.

Introduction Distances are measured in inches, feet, and miles. Sometimes it is necessary to convert from feet to inches or feet to miles because the numbers become too large or too small. Radiation also has large units and small units and we can convert between them.

Need to Know

1 Rem=1000 millirem
1 millirem = 0.001 rem (1/1000th of a rem)
The conversion of rem to millirem is performed the same way for doserates.

Nice to Know

The prefix milli - means 1/1000th. This prefix is used in terms such as millimeter, millivolt, millisecond.
In the plant we use the unit millirem for most dose received and millirem/hour for most doserates because these units are more appropriate for the levels we usually encounter. Millirem is usually abbreviated mrem or mR.

Examples / Non-examples

Multiply by 1000 to convert from rem to millirem (e.g., 3.7 rem = 3,700 millirem).
Divide by 1000 to convert from millirem to rem (e.g., 1,800 millirem = 1.8 rem).

Effects on Cells

Objective B4

List the effects radiation can have on cells.

Introduction

The human body is composed of billions of cells that, through natural processes, are always dying and being replaced by new cells. Radiation exposure can create additional changes in cells beyond natural occurrences. The amount of cell damage caused by radiation is not always the same. There are factors that affect the amount of damage to the cells.

Need to Know: Effects

Cells are only damaged by radiation when the radiation interacts with the cell, depositing some of its energy into the cell's molecules, causing ionization to those molecules. Ionized molecules in the cell disrupt normal cellular chemistry, or damaged chromosomes in the cell's nucleus can impair the cell's reproductive process.

Cell damage caused by radiation, or any other cause, can have four possible effects:

Nothing (the damage is not important to the cell so the cell does not attempt to repair it)
Minor damage. Cells damaged from radiation or any other cause can usually be repaired by the cell (e.g., minor sunburn turns skin red for a few days and then returns to normal).
Cell death. Cells killed by radiation, or other causes, are eliminated by the body and replaced by a new cell (in most cases). Cells die and are replaced constantly in healthy plants, animals, and people. Skin that peels off after a sunburn are cells that were killed by excessive exposure to the ultraviolet sunlight.
Cell mutation. This means the cell is damaged and the damage is passed on to the new cells. Chemicals, pollution, and radiation can cause cell mutation. It also occurs naturally. Adults, no matter how well they have taken care of their skin, do not have skin as soft and smooth as babies. This is the result of natural skin cell mutations.

Like sunlight, chemicals, and other things that have potential risks, radiation risk depends on the amount of exposure. The federal government sets radiation exposure limits for workers. Radiation exposure below these limits can cause cell damage, but not to an extent that it will affect a person's overall health.

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Effects on Cells, Continued

Need to Know: Factors

Furthermore, there are four factors that affect the amount of cell damage caused by radiation:

Total exposure: Less exposure to radiation will cause less cell damage because a cell can only be damaged by radiation that interacts with the cell. With less exposure there is less chance of interaction with the cells.

Time frame: Less cell damage occurs when a given amount of radiation is received over a longer period of time. The cells will have time to repair the damage before being damaged again. One rem (the standard unit used for measuring radiation exposure) received over a period of a year will cause less damage than one rem received in a day.

Type of Cell: Some cells (i.e., in a given organ) are more sensitive to radiation. This is generally a function of cell specialization, with highly specialized cells being less sensitive to radiation-induced damage. Cells are most susceptible to damage when they are in the process of dividing. We have no indication when individual cells are dividing, but fast-growing (short-lived) cells are more likely to be dividing at any given time, and are therefore more susceptible to damage by radiation.

Type of radiation: Cell damage varies with the type of radiation because of the differences in penetrating ability, energy, and the way that energy is deposited in the cell.

Nice to Know: Effects

Damaged cells can be repaired without effect on the body unless the number of cells damaged is very large. A burn caused by a drop of hot grease will have only a minor effect on the body, but a burn of the same severity to the whole hand would place a burden on the body's resources to repair the damage. A burn of this same severity on a large portion of the body would overwhelm the body's resources and probably result in the person dying.

A cell that dies is replaced by a new cell. The new cell is formed by the division of another cell. The normal life span of a cell varies with the type of cell, ranging from one day for some blood cells to several decades for nerve and brain cells.

Radiation can pass through a cell without causing damage (common for gamma and neutron radiations), while some radiations passing through body cells can deposit some or all of their energy causing ionizing events (cell damage).

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Effects on Cells, Continued

Nice to Know: Factors

Concerning the four factors that determine the amount of cell damage:

Total exposure: Less exposure to any potentially damaging agent will produce less risk. This is true of tobacco, coffee, NutraSweet™, and radiation. Always strive to do your work at Diablo Canyon with as little radiation exposure as possible.

Time frame: A quart of boiling water would do a lot of damage if spilled on a person all at once. If the same amount of boiling water were spilled on the body one drop a day less damage would occur. The cells will have time to repair the damage before being damaged again. A whole bottle of aspirin taken in one day will kill a person, but a bottle taken over a period of a year will not kill the person.

Cell Susceptibility: There are many different types of cells in the body with different degrees of susceptibility to things. Hand lotion does not damage skin cells, but it will damage cells in the eye. Cell susceptibility to radiation is dependent on the cell division rate.

Type of radiation: Radiation can only damage cells that it can get to. The four different types of radiation get to different type of cells, and deposit different amounts of energy, because of the cells' location in the body. Alpha radiation is not damaging to skin because it cannot get to the living skin cells. It is stopped by clothing, or the outer layer of skin that is already dead. Gamma radiation does very little damage to skin because the probability of interacting with it is low. Skin is not thick enough to have many interactions with gammas of the normal energy range. External beta does cause damage to skin because it deposits most of its energy in the living skin cells. At high exposures (e.g., several hundred rems) beta causes damage that looks like sunburn.

Internal organs receive no damage from external alpha and beta radiation because it does not reach the internal organs. Internal organ cells are damaged by gamma radiation and neutrons, if present. Alphas and betas can only damage internal organs if a person were to somehow get radioactive alpha and beta emitting sources within the body (e.g., through ingestion or inhalation).

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Effects on Cells, Continued

Examples / Non-examples

There are many types of cell mutations, some insignificant, some minor, and some life threatening. Hair turning gray and baldness are examples of cell mutations. This is a result of natural mutations in the cells that produce hair. Excessive exposure to sunlight can increase the mutation in skin cells. Cancer is also a type of cell mutation, characterized by uncontrolled cell division.

Cells with low sensitivity to radiation damage due to low dividing rate include these:

- ◊ Nerve and brain cells.
- ◊ Connective tissues.
- ◊ Fatty tissue.
- ◊ Muscle tissue.

Cells with moderate sensitivity are:

- ◊ Blood vessels (veins and arteries).
- ◊ Mucous membranes.
- ◊ Skin.
- ◊ Internal organs (stomach, lungs, liver).

Cells with the highest sensitivity to radiation damage because they have the higher dividing rates include:

- ◊ Lens of the eye.
- ◊ Bone marrow (blood-forming cells).
- ◊ White blood cells.
- ◊ Gonads (male/female reproductive organs).

Chronic Radiation Exposure

Objective B5

Define "chronic radiation exposure" and the associated risks.

Introduction

The time frame in which an individual can receive a radiation exposure is not always the same. Most all radiation workers receive relatively small radiation exposures over long time frames.

Need to Know

A series of small exposures spread out over months or years is chronic exposure. Scientific studies show that chronic exposure to low levels of radiation **may** cause a slight increase in health problems such as cancer.

Nice to Know

Barring a significant accident, personnel working around radiation sources receive chronic exposures. Most studies that show a possible risk of radiation exposures are based on relatively large radiation exposures received over a shorter time frame (e.g., less than a day, see next objective).

Examples / Non-examples

A member of the general public receives about 360 mr per year of chronic radiation (average of about 1 millirem per day), depending on the area of the country and other factors. Likewise, outage workers picking up a few millirem per working day over the course of an outage is considered chronic exposure (even if it adds up to several hundred millirem total).

Acute Radiation Exposure

Objective B6

Define "acute radiation exposure" and the associated risks.

Introduction

Though rare, and despite some of the best controls to prevent accidental exposures, occasionally accidents happen and radiation workers (or radiographers) receive a relatively large dose (i.e., exceeding federal limits) in a short time frame.

Need to Know: Definition

An exposure received in a short time, usually less than 24 hours, is called an acute exposure..

Need to Know: Effects

The following chart shows the probable effects of an acute radiation exposure as determined by one authority. Realize that people have different sensitivity to radiation exposures (seen within 1 year after exposure)

Acute Dose (in Rem)	**Probable Clinical Effect**
0 - 25	No observable effects.
25 to 100	Slight blood changes. No other observable effects.
100 to 200	Vomiting may occur in 5 to 50 percent within three hours, with fatigue and loss of appetite. Moderate blood changes are likely. Except for the blood-forming system, recovery will occur in essentially all cases within a few weeks.
200 to 600	Vomiting, fatigue, and loss of appetite occur in 50 to 100 percent within three hours. Loss of hair after two weeks. Other effects include severe blood changes, hemorrhage, and infection. Death occurs in 0 to 80 percent within 2 months. For survivors, recovery period is a month to a year.
600 to 1000	Vomiting occurs within one hour. Severe blood changes, hemorrhage, infection, and loss of hair. Death occurs in 80 to 100 percent within two months. Survivors recover over a long time period.

The above effects are based on:

- exposure to the entire body
- exposures to the entire population
- no medical treatment

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Acute Radiation Exposure, Continued

Nice to Know	The above table was adapted from: S. Gladstone, Sourcebook on Atomic Energy.
Examples / Non-examples	During the Chernobyl nuclear accident, many of the emergency responders received acute exposures, many of them eventually dying within a year as a result. The accident at Three Mile Island resulted in relatively minor exposures, with no prompt effects to anyone involved.

Genetic & Somatic Effects

Objective B7

Define "genetic" and "somatic" effects. Compare somatic versus genetic effects of radiation exposure.

Introduction

Radiation exposures may be a risk to the individual exposed, and/or to the individual's future offspring.

Need to Know

Somatic effects are effects of radiation that take place in the exposed individual. There are two classes of somatic effects: prompt and delayed. Prompt effects may occur in a time range from immediately following the exposure up to several months or a year after the exposure. Prompt effects generally only result from large acute exposures.

Delayed effects do not occur until several months or years following an exposure. This delay in time creates a problem in linking the exposure with the delayed outcome, since the delayed effects may be caused by many influences other than the radiation exposure. Thus, there can be no positive assignment of the cause in most cases. Delayed effects may result from acute or chronic exposure. Some of the known delayed effects of radiation exposure are cancer and cataracts.

Genetic effects appear in future generations of an individual who received the dose. Genetic effects are caused by damage to genetic material (e.g., sperm cells or female eggs) and may appear as birth defects or other conditions in the future children of an exposed individual and succeeding generations.

Comparing somatic versus genetic effects:
Somatic effects are observable effects in the exposed individual, whereas genetic effects are observable effects to the exposed individual's future offspring.

Nice to Know

Genetic effects are NOT the same as pre-natal exposures (child already conceived). Prenatal exposures represent a relatively high risk. Most studies consider radiation induced genetic effects in humans as a very low risk.

Examples / Non-examples

Unlike the gross mutations most of us have seen in various movies, radiation studies on various animals and plants have shown genetic defects that are relatively common in nature (e.g., increases or decreases in size, growth rates, and longevity).

Age Groups

Objective B8

Compare the radio-sensitivity (i.e., sensitivity to radiation) of different age groups.

Introduction

Certain changes take place as a person ages that will lower the risks from a given exposure to radiation.

Need to Know

As previously discussed, the faster the cell-reproduction rate, the more sensitive the body or organ is to a given exposure of ionizing radiation. As a person ages, most cell-reproduction rates slow. Therefore, as an individual ages, he or she becomes less sensitive to radiation. In addition, cells become more specialized as a person ages, which also helps decrease radio-sensitivity.

Examples / Non-examples

When a person is first conceived, s/he is just one cell (i.e., the sperm imparts its chromosomes into the female egg). This cell is very unspecialized as it must divide many times before some of the newly divided cells form such things as organs, hands, and feet. Most all cells contain the entire set of genetic "blueprints" in order to form whatever cells the body needs. Any un-repaired damage to a newly conceived embryo's "blueprints" will eventually cause some mutation later on as cell division takes place and the various organs and body parts are formed (i.e., missing information in the chromosomes).

Once a cell is specialized (e.g., it becomes an eye cell), then any damage to that cell's chromosomes becomes unimportant unless it affects the particular specialty of the cell. In other words, an eye cell does not care if its chromosomes are damaged with information on how to become a blood cell. A specialized cell thus has a smaller effective target in which radiation can cause important damage.

Prenatal Exposure

Objective B9

Identify the possible effects of radiation on an unborn child due to prenatal exposure.

Introduction

For a given radiation exposure, risks to unborn children (those already conceived in the womb) are greater than risks to a fully grown adult.

Need to Know

Certain effects may be observed in children who were exposed to radiation during the fetal and embryonic stages of development. Radiation exposures may slightly increase the risks of death, structural abnormalities, abnormal growth, and mental retardation.

Nice to Know

Because of the slight increased risk from exposure to ionizing radiation, certain federal regulations (10CFR20.1208) are observed within the industry. These regulations restrict the amount of dose a “declared” pregnant female can receive (i.e., one who has notified management, in writing, of her pregnancy). These pre-natal limits will be covered later.

Safety Record

Objective B10

Compare the safety record of nuclear power to other industries.

Introduction

For many years the speed limit on California freeways was 70 mph. In 1974 it was lowered to 55 mph, then in 1996 the speed limit was raised to 65 mph. The speed limit now is 70 on some freeways. Much of the discussion on speed limits deals with safety. What is the safe speed to drive?

Safe is a relative term. There is no completely safe speed because any speed has some risk of injury. Transportation of any type will always involve some risk. The safe speed limit is zero if you use the literal definition of safe. Any speed above zero will involve some risk, normally the higher the speed the higher the risk.

As commonly used "safe" means safe enough, or as safe as reasonably possible considering what you have to do, or safer than the alternatives.

Need to Know

People usually feel safe with things that are familiar to them, like cars, and are concerned about things that are unknown, like radiation. The correct way to evaluate risks is to look at reliable information from past accidents and injuries. The real risks are often very different from the perceived risks.

The health risks of occupational radiation exposure below the federal limits are much lower than the risk of injury in an automobile accident and many other things that people encounter daily.

Nuclear power in the U.S. has a very good safety record. The public has never been injured by a catastrophic accident, and individual workers experience no higher rates of injury, illness, or death than workers in other industries.

Nice to Know

Radiation exposure is known to have some risk of producing cancer, but that does not prevent doctors from using x-ray machines to check for broken bones and it should not keep us from using reactors to make electricity because the actual risk to the individual is extremely low.

One of the oldest ways to produce electricity is to burn coal. Mining coal has always been a dangerous business. Mines collapse, catch on fire, and explode; and miners who escape these immediate hazards have a high incidence of respiratory disease. Burning of the coal causes air pollution and acid rain that affects the general public.

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Safety Record, Continued

Nice to Know (continued)

The risk to workers in nuclear plants is far less than the risk to miners producing coal for production of an equal amount of electricity. In fact the risk at nuclear power plants is less than other industries that use forklifts, cranes and heavy equipment according to the people who know - insurance companies.

As individual workers there are two factors to be considered: The real (actual or statistical) risk, and the perception of risk. Using transportation as an analogy again, consider cars and airplanes. All statistics show that commercial air travel is safer than automobile travel. Airplanes are safer than cars any way that you calculate it, yet there still some people who will not fly, and large numbers of people that fly reluctantly. The fear of flying is real even though the risk is less than the alternative of driving. This may be because someone else controls the plane, or because airplane crashes are rare enough that they get press coverage and car crashes are so common that they usually do not make the paper or TV news. All of the reasons are emotional issues, not supported by facts.

Any fear is difficult to overcome, and irrational fear is the most difficult. The numbers show that the real risk of occupational radiation exposure is small and less of a risk for workers than many other workplace hazards. The emotional side of the risk is a personal matter that must be evaluated individually, weighing the benefits against the perceived risks, and considering the options available.

Examples / Non-examples

Three Mile Island had an accident that destroyed several billion dollars worth of equipment, but the general public was not injured. Very little radioactive material was released during the accident. The radiation exposure for the workers inside the plant was less than federal limits for all but two workers, and the exposure to the public was hundreds of times lower than plant workers received.

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Safety Record, Continued

Examples / Non-examples (continued)

A lot of people die of cancer around Three Mile Island, but a lot of people die of cancer in every city. The most recent statistics show that 23.49% of all U.S. deaths are due to cancer (source: 1997 Information Please Almanac). Impartial studies of cancer around Three Mile Island show that the rate there is no higher than the U.S. average.

The accident at Chernobyl did cause a large increase in cancer and numerous deaths. The Chernobyl reactor was housed in a sheet metal building that could not contain the nuclear fuel during the accident. The Three Mile Island containment did hold the radioactive material from the accident, protecting the public. All U.S. reactors are in steel or concrete containment buildings that prevent the release of radioactive material in any plausible accident. The emergency planning and regulatory climate in Russia is much different than in the U.S. as well. These differences also help to reduce the risk to the public here.

Any action has risk attached to it. The appropriate way to consider risk is to compare it to the risk of alternatives. While many things can be made safer, and most things are safe enough, nothing can be made safe in the absolute sense of the word.

NRC Form-4

Objective B11 State the purpose of an NRC form-4.

Introduction Dose received at another nuclear facility must be recorded and included in the accumulated dose for each radiation worker, and applied toward his or her exposure limit. A required form, documenting all previous occupational exposures, must be completed. This form is NRC Form-4.

Need to Know Before you will be allowed to work as a radiation worker, you must have a completed and signed NRC Form-4 (or company equivalent) on record. It is your responsibility to ensure all exposure is reported to the company prior to starting work in the plant. This is also true if a company employee visits another nuclear facility. This form is also used to document all your dose.

C. Exposure Limits

Classes of Individuals

Objective C1 Define the classes of individuals for exposure limit purposes.

Introduction Exposure limits are not the same for everyone. The Nuclear Regulatory Commission (NRC) sets limits for radiation exposure that differ depending on the circumstances of the exposure.

Need to Know The NRC sets exposure limits because very high exposures can affect people's health. The NRC set limits low enough to prevent injury to workers and requires utilities to measure each radworker's exposure.

- Occupationally exposed individuals: Workers at DCPP are in this class because they receive radiation exposure in the course of their work. X-ray technicians at hospitals are also in this class.
- General public: People who receive radiation exposure not as a result of their work.
- Pregnant workers: Occupationally exposed workers that have declared the pregnancy to the RP department in writing. The limits for pregnant workers is lower because cells that are in the process of dividing have a higher risk of damage from radiation. The cells in a fetus are dividing faster than other cells, and they are highly unspecialized, and are therefore more susceptible to damage by radiation.
- Medical exposure is another class of exposure. The NRC has no limits for exposure to the patient. The physician determines the allowable exposure.
- Radiation workers have higher exposure limits than the general public because they have had training on proper techniques of working around radiation, and they have specifically accepted the small risk of radiation exposure.

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Classes of Individuals, Continued

Nice to Know

People who receive job specific training in order to receive radiation exposure while at work are subject to the occupational exposure limits.

People who receive exposure as a result of OTHER people's activities fall under the general public limits.

A declared pregnancy of an occupationally exposed female will result in a modified exposure limit, much lower than the regular occupational limit.

Regulatory agencies often allow trained individuals more exposure to potentially damaging agents than the public: linemen climb utility poles, electricians work on energized electrical equipment, carpenters climb incomplete scaffolds, and ironworkers walk on beams high in the air. All of these are considered unacceptable risks for the public, but acceptable for properly trained workers. The NRC sets radiation limits higher for occupational workers for the same reason.

A fetus grows very fast and is therefore more susceptible to radiation and other forms of damage than other cells. A worker can declare that she is pregnant and will then have much lower radiation exposure limits than a non-pregnant worker. This is due to the increased susceptibility to radiation damage in the fetus.

Radiation exposure limits for the general public are lower than for radiation workers because the public includes people who are more sensitive to radiation (pregnant women and children) than the people who work here.

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Classes of Individuals, Continued

Examples / Non-examples

The general public could receive some small amount of radiation exposure as a result of the operation of Diablo Canyon. The amount is small compared to the amount they would receive as a result of radon, cosmic radiation, and naturally occurring elements, but it could be enough to be measurable. The plant must monitor exposure and ensure that it is below the NRC limits.

Coal has always had some radioactive material in it. This radioactive material goes up the stack when the coal is burned. The amount of radiation exposure that coal power plant workers get is not measured because the radioactivity is the same as it has always been in coal, because the radioactivity is not concentrated or increased by any process at the plant. On average, the average annual occupational radiation exposure to a coal plant worker is about the same as it is for nuclear plant workers. Average annual occupational exposures to coal miners (not plant workers) are usually much higher than for nuclear plant workers.

Classes of people for radiation exposure are:

- General Public
- Radiation workers
- Pregnant women
- Medical patients

Exceeding Federal Limits

Objective C2

State the consequences of exceeding federal exposure limits.

Introduction

There are two possible consequences of exceeding the federal exposure limits established by the Nuclear Regulatory Commission (NRC). One is physical and the other legal.

Need to Know

Federal exposure limits are set so low that immediate health effects of radiation overexposure are not detectable unless a worker greatly exceeds the annual limit (e.g., receives at least 20 times the federal whole body limit). But recalling that the basic assumption of dose is: "The more dose the more risk", so exceeding any limit means the individual may be at a higher risk for some future health problem such as cancer.

Responsibility for radiation exposure is split between the RP department and individual workers. The RP department is responsible for measuring radiation levels, and informing workers of the levels through postings and briefings. Individual workers are responsible for following RP instructions, monitoring their exposure, and notifying RP of unexpected situations that arise during their work in radiological areas.

The legal consequences of overexposure occur for any exposure in excess of the limits. The organization that holds the license for the nuclear material can be fined tens or hundreds of thousands of dollars by the NRC for any overexposure, no matter how small. The licensee is normally fined for overexposure, not the individual worker. The NRC can take legal actions against workers who willfully violate RP policies or procedures (in addition to any disciplinary actions the company may take).

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Exceeding Federal Limits, Continued

Nice to Know

The physical consequences of a few millirem overexposure are undetectable and virtually non-existent, but the NRC has established limits and rigidly enforces them.

The risk of driving a car at 66 mph is indistinguishable from the same car traveling at 65, but the speed limit is 65 and you can be fined for driving faster. Unlike the CHP who normally do not stop people unless they are driving well above the speed limit, the NRC almost always levies fines for even small overexposures.

Each person's radiation exposure used to be reported on a Nuclear Regulatory Commission form 4. This form provided the individual with a record of occupational radiation exposure that could be taken to subsequent jobs and used to ensure annual and lifetime exposure limits were not exceeded. Computerized exposure records at nearly all U.S. nuclear plants have replaced the form.

Examples / Non-examples

In 1991, a radiographer violated procedures and received an overexposure of 15 rem from his own radiography source (while at DCPP). An intensive medical examination found no evidence of injury to the worker.

Federal Exposure Limits

Objective C3

State the federal exposure limits (including declared pregnant female).

Introduction

In 1994 the NRC changed the exposure limits for occupational workers. The new limits are in some cases higher and other cases lower than the old limits. In general the new limits are simpler than the old ones.

Need to Know

TEDE (Total Effective Dose Equivalent) 5 rem/year*
Previously called whole body dose
Eye 15 rem/year*
Skin 50 rem/year*
Extremities 50 rem/year*
(Elbows & beyond, knees & beyond)
Internal Organ 50 rem/year*
Pregnancy 0.5 rem/term
* calendar year (on January 1st your exposure starts over)

Nice to Know

The limits for different parts of the body are different because different types of cells have different sensitivity to radiation. Each of the above has about the same health risk as the others.

Examples / Non-examples

A worker is allowed to receive the TEDE limit, AND the extremity limit AND the skin limit AND the internal organ limit, not just one of them. Though allowed by regulation to get all of these, in practice a worker would reach one limit and then be prevented from getting any additional exposure of any type. The policy and practice at DCPP is that workers are not allowed to reach any limit.

Why Station Limits?

Objective C4

State the reason for having station limits, and the actions taken if they are being approached.

Introduction

The federal limits apply to all U.S. radiation workers. Nuclear power plants usually have station limits that are less than the federal limits.

Need to Know

Station exposure limits provide a margin to minimize the possibility that workers will exceed the federal exposure limits. If these limits are being approached, you must inform your supervisor and/or RP to ensure actions are taken to prevent exceeding these limits. Occasionally, a small handful of workers get approval to have station limits increased.

Nice to Know

By having station limits below the federal limits power plants can reduce the risk of a worker exceeding the federal limits. Radiation exposure above the station limit requires permission from supervisors and managers, and will trigger extra care by the RP department to ensure that the worker's exposure does not exceed any federal limit.

Examples / Non-examples

Exceeding a federal exposure limit is a very serious matter for utilities. The utility incurs liability, NRC scrutiny, and bad publicity when a worker is overexposed even when the worker is at fault. Utilities put a buffer or safety margin between the federal limit and the station limit because of the severe consequences.

At DCPP the RP Manager's approval is required to exceed the administrative guideline, the first exposure limit. Even with this approval the worker will always have a station limit that is below the federal limit.

Pregnant Worker

Objective C7 State the rights of a pregnant worker.

Introduction During pregnancy the cells of the fetus divide rapidly, making them more susceptible to damage by radiation. Federal regulations recognize this increased susceptibility and give the pregnant worker the right to declare the pregnancy so that lower radiation exposure limits will apply for the term of the pregnancy.

Need to Know A worker who is pregnant or expects to be soon can:

1. Voluntarily declare the pregnancy in writing to the RP department, maintaining the right to undeclare the pregnancy, in writing, at any time.
2. Ask her employer for reassignment to areas involving less exposure to radiation. PG&E policy is to maintain the total dose as close to zero as possible for declared pregnant workers.
3. Decide not to declare the pregnancy and continue working in all areas of the plant with the knowledge that there is increased risk for the unborn child.
4. Reduce exposure by decreasing the time spent in radiation areas and staying away from posted hot spots.

A worker will not be considered pregnant by PG&E unless she declares her pregnancy to the RP department in writing.

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Pregnant Worker, Continued

Nice to Know

When a worker declares her pregnancy a dose evaluation will be performed to determine the amount of exposure received to date and access to radiation areas will be controlled to limit the total exposure during the pregnancy to 450 mrem. If the exposure exceeds 450 mrem at the time the pregnancy is declared the limit will be an additional 50 mrem during the pregnancy.

Workers can also delay having children until they are no longer working in an area where radiation to the unborn baby could exceed 0.5 Rem, or plan the pregnancy for a time when radiation exposure is lower (i.e., exposure during plant operation is lower than exposure during outages).

RP engineers are available to discuss radiation exposure considerations of pregnancy. Call the RP Director’s secretary at 4325 to schedule an appointment.

Examples / Non-examples

The DCPP embryo/fetus protection program is contained in procedure RP1.ID10. This procedure, RP engineers, and your physician can provide additional information on radiation exposure during pregnancy.

Planned Special Exposure

Objective C8 Recognize the definition of a planned special exposure.

Introduction In addition to normal federal dose limits, the NRC regulations also define a "Planned Special Exposure" in which a radiation worker could legally receive 5 rem additional radiation exposure in addition to the occupational exposure under special circumstances (e.g., extended refueling outage with major maintenance such as replacing steam generators in a pressurized water reactor).

Need to Know A planned special exposure is an infrequent exposure to radiation separate from, and in addition to, the federal dose limits. This type of exposure has several requirements associated with it and can be used only in an exceptional situation where alternatives that might avoid the higher exposure are unavailable or impractical.

Nice to Know DCPP has never used a planned special exposure and does not intend to in the future.

ALARA

Reducing Exposure Benefits

Objective D2

Explain the benefits of reducing exposure.

Introduction

Although no credible study shows radiation exposure carries a risk at occupational levels, we assume all doses carry some risk and we want to reduce the risk as much as possible.

Need to Know

Most scientists believe that radiation exposure below the federal limits has little or no health risk, but to be safe, we should assume that less exposure equates to less health risk.

Diablo Canyon expects all workers to keep their exposure as low as possible and sets exposure goals for radiation exposure. Outage bonuses (when approved) are based in part on the total exposure of workers.

INPO and NRC evaluations of plant performance are based in part on total exposure and will be more favorable when exposure is lower.

Nice to Know

There are benefits of reduced radiation exposure to workers, such as reduced health risk and increased outage bonuses; and to the company, such as better industry and regulatory evaluations.

Reduction of exposure requires the efforts of everyone at DCPP: The RP technicians have to provide workers with good surveys and good job coverage, and workers must be aware of their exposure and the dose rates where they work.

Examples / Non-examples

If every radiation worker reduced his exposure by just 1 mrem per day for an outage the total saving would be 45 rem (1500 workers for 30 days). Every millirem you can save does really matter.

Time, Distance & Shielding

Objective D3

Explain how time, distance, and shielding can be used to reduce radiation dose, and state some methods used to implement time, distance, and shielding concepts.

Introduction

Workers are expected to keep their exposure as low as possible. To accomplish this, workers must know the methods of reducing exposure.

Need to Know

Exposure can be reduced in three ways:

1. Time – spend less time in the radiation area. Methods to decrease time near radiation sources include reading the work package ahead of time and being familiar with it, using ratchets or powered tools instead of manual ones, working efficiently, etc.
2. Distance – stay farther from the radioactive source. Methods to increase distance include waiting for a tool, inspection, or further instructions near a cold area sign away from the radiation source.
3. Shielding – put radiation-absorbing material between the source and the worker. Workers have some control over their time and distance near a source, but only RP personnel can put up, take down, modify, or move shielding. **Never move shielding**! A worker can occasionally position himself such that there is a wall or other large object between him and the radiation source.

Nice to Know

A worker that spends half as much time in a radiation area will receive half as much exposure.

A worker who is able to stay twice as far from a radioactive source could receive as little as one-fourth (1/4) the radiation exposure.
Shielding will reduce the exposure rate by varying amounts depending on the shielding material and thickness. Workers can request shielding for a job, then RP will determine if the dose required to install and take down the shielding is less than the dose savings with the shielding installed for the job (most temporary shielding is removed after the work is completed and before start-up, because its weight would stress the pipes too much during an earthquake).

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Time, Distance & Shielding, Continued

Examples / Non-examples

Staging tools and parts will enable the worker to perform the job in less time and the workers exposure will be reduced.

Moving to a lower dose area during inspections and waiting periods can reduce exposure substantially. Sometimes major work on equipment (e.g., a pump) can benefit from removing the pump from the system, repairing it in a low dose shop area, then re-installing it into its system after it is repaired and tested.

Jobs of long duration or that are in high exposure areas can benefit from the installation of shielding. For example, if having shielding installed saves workers 300 millirem total exposure, and it only takes 100 millirem to install and remove the shielding, then shielding is a good idea because the savings amount to 200 less total millirem.

Temporary Shielding

Objective D4 State individual responsibilities concerning temporary shielding.

Introduction Because shielding has the capability to decrease radiation dose rates significantly, if moved or mishandled in any way, the reverse could happen (i.e., dose rates could increase significantly). Installing and removing temporary shielding is a tightly controlled function of various RP personnel.

Need to Know Temporary shielding may not be installed, removed, or moved without the permission of the RP department. If shielding is ever in your way do NOT move it, contact RP for assistance and advice.

Examples / Non-examples Most temporary shielding is in the form of blankets containing lead (very heavy)

Radiation Exposure - Rights & Responsibilities

Objective D5

List the rights and responsibilities of radiation workers concerning radiation exposure.

Introduction

Minimizing your radiation exposure requires the effort of RP technicians, foremen, and individual workers. All workers at DCPP are expected to keep their exposure as low as possible (i.e., ALARA).

Need to Know

Each worker is responsible for keeping his exposure ALARA and is expected to be aware of his exposure. The computer at RCA access Control will display your exposure information each time you enter the radiological controls area (RCA).

Workers are expected to notify RP and their supervisor if they are approaching an exposure limit or guideline, or suspect that they may have exceeded any limit.

Workers have the right to review their exposure records at any time, and will be given a report of the exposure received here when they leave.

Nice to Know

The responsibilities for keeping exposure low is split between the RP department, which provides the radiological information, and the individual workers who must keep track of their exposure and report any potential overexposure or radiological problems.

Examples / Non-examples

The administrative guideline for all workers is 2000 millirem. A worker that has 1820 millirem for the year should not enter the RCA on an RWP that has a maximum dose per entry limit of 200 mrem. This situation should be reported to the RP technician at RCA access Control.

Calculate Stay Time

Objective D6 Calculate stay time given a dose rate, current exposure, and an exposure limit.

Introduction The more a worker knows about keeping track of his/her dose, the less likely s/he will exceed any limits. Even though we have computers and electronic devices (covered next section) to track dose, workers should also keep a close watch on their own exposure.

Need to Know Stay times are calculated by taking the allowed dose per entry (expressed in millirem), and dividing that amount by the radiation dose rate (expressed in millirem/hour) in the area where you will be working.

Nice to Know Radiation work permits (written authorization for working in the RCA) provide the allowed dose per entry. RP provides various survey maps indicating the radiation dose rates (and contamination levels) of the work areas.

Normally electronic devices are provided which also help prevent a worker from exceeding any dose limit specified (i.e., by alarming at some preset dose amount).

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Calculate Stay Time, Continued

Examples / Non-examples

Example A: A worker's permit specifies that the dose limit per entry is 200 millirem. The radiation survey map indicates that the dose rate in the work area is 50 millirem/hour. How long can the worker stay in the area without exceeding his allowed limit?
Answer: 200 millirem divided by 50 millirem/hour = 4 hours maximum.

Example B: A worker has 1700 millirem for the year and is allowed 2000 millirem per year. S/he is sent into an area where the radiation survey map indicates that the dose rate is 30 millirem/hour. How long can the worker stay in the area without exceeding his allowed limit of 2000 millirem for the year?

Answer: First, determine how much dose margin is left by taking the 2000 millirem allowed and subtracting the 1700 millirem already received.

2000 millirem – 1700 millirem = 300 millirem remaining

Next, take the remaining dose allowed and divide by the dose rate:

300 millirem divided by 30 millirem/hour = 10 hours maximum.

Note: At DCPP, we do not normally calculate stay times for most jobs. We depend more on the electronic devices to warn personnel if they are approaching any limit

E. Dosimetry

Dosimetry Purpose

Objective E1	State the purpose of dosimetry
Introduction	We need to accurately measure the amount of radiation exposure all radiation workers are exposed to in order to ensure nobody exceeds any limit.
Need to Know	Dosimetry measures the amount of **external** dose received by the worker.
Nice to Know	There are several companies that make dosimeters (i.e., dosimetry) for use in nuclear power.

Lost or Damaged Dosimetry

Objective E5

Explain the actions to be taken if dosimetry is lost or damaged and the radiological consequences of lost or damaged dosimetry.

Introduction

Dosimetry should be secured to your clothing, protective clothing (PCs), or lanyard, to prevent being lost.

Need to Know

Dosimetry that has damaged clips or fasteners should be reported to RP personnel and replaced to prevent loss.

SRDs that have been dropped should be inspected by RP personnel to determine if they are in working condition before further use. TLDs are usually not damaged by falling short distances, but you need to contact RP if the case opens or there is other indication of damage.

Any dosimetry that is dropped into water should not be retrieved because of the potential contamination. Contact an RP technician and let him get it.

Dosimetry that is damaged must be replaced. Go to RCA access immediately if you damage your dosimetry while in the RCA.

Report to an RP tech or go to RCA access immediately if you discover your dosimetry is missing while in the RCA, even if you know where it is.

Dosimetry that is lost or damaged does not record the worker’s dose properly. RP must be notified of this so they can calculate the worker’s exposure some other way.

Continued on next page

Lost or Damaged Dosimetry, Continued

Nice to Know

When dosimetry is lost or damaged the workers dose must be estimated from PED, PIC, or time and doserate data by RP personnel.
The RP technicians will determine if corrections need to be made to your exposure because of the dosimetry being in a different radiation field than the worker.

Dosimetry that is dropped or lost can result in inaccurate exposure being recorded. The actual exposure can be more or less than the dosimetry indicates.

When the dosimetry problem is reported to RP promptly, doserate and time information can be used to correct exposure records.

Dropped dosimetry could land in a sump or other highly contaminated area that the worker is not properly dressed to enter and has not been briefed to enter. Retrieving the dosimetry can result in spreading contamination on personnel or in the plant.

Dosimetry that is dropped might be damaged and fail to record exposure received later by the worker.

A dropped TLD can land in a low dose area and record less exposure than the worker is actually receiving.

A dropped TLD can land on a component that has a much higher doserate than the worker is receiving making the reading inaccurate, and making it dangerous for the worker to retrieve the dosimetry.

Examples / Non-examples

Lanyards can snag on equipment and break.

Dosimetry is sometimes dropped when it is being read.

Dosimetry is sometimes left in the PC pocket when getting undressed.

Dosimetry is occasionally lost or damaged while workers lean on equipment or climb around. To prevent this accidental loss or damage, place the TLD inside an outer pocket or tape it to your outer clothing.

In Containment dosimetry can fall several levels and land in an area with radiological conditions very different from the conditions where the person is working.

Contamination Control

Fixed, Loose, Discrete & Airborne

Objective F1 Identify and compare fixed, loose, discrete, and airborne contamination.

Introduction Contamination is defined as radioactive material in a place we do not want it. It is normally in the form of dust and dirt (i.e., mixed in with dust and dirt). You cannot look at dust and dirt and tell if it contains contamination, special monitoring devices (e.g., friskers covered in next objective) are used to see if contamination is present. Contamination is classified according to its form and mobility.

Need to Know There are four types of contamination; loose, fixed, airborne, and discrete (hot) particle.

Fixed contamination is bound to the surface of equipment, floors, walls, or systems. It is not easily removed and it generally does not get on you when you touch it.

Loose contamination is easily transferred to another surface, so it does get on you (or your clothes) when you touch it with your gloves, shoes, clothes, or skin.

Airborne contamination is radioactive material that is suspended in the air. Airborne contamination is a respiratory hazard because it can be breathed into the lungs.

Discrete contamination, also called hot particles, is very small particles that are very radioactive. The particles have the potential of causing radiation exposures in excess of federal limits if they come into contact with the skin or are inhaled. Personnel working in known or suspected hot particle areas wear additional protective clothing (PCs), have additional RP technician coverage, and are surveyed frequently to detect the discrete contamination.

Continued on next page

Fixed, Loose, Discrete & Airborne, Continued

Nice to Know

Touching or picking up items with fixed contamination will not usually result in transfer of contamination to your gloves. The contamination adheres to the item well enough that protective clothing is not required to keep the contamination from spreading.

Fixed contamination can become loose or airborne during operations such as grinding, sanding, or welding.

Loose contamination can be spread to skin or clothing and then can be spread to other areas or equipment. Protective clothing is worn to keep the loose contamination off of the skin and personal clothing.

Discrete (hot particle) contamination has not been a significant problem at Diablo Canyon. These particles are capable of delivering a very high localized dose (e.g., to a small area of skin) if they come into contact with the skin for a long enough period of time.

Airborne contamination is particles (dust) of radioactive material floating in the air. The contamination results from radioactive liquid evaporating, or from radioactive dust being stirred up by ventilation or the use of air tools.

Examples / Non-examples

Contamination can become fixed inadvertently, as when tools get contamination ground into them, or intentionally as when paint is applied over contamination to keep it from being spread around.
Loose contamination is easily spread to areas, equipment, and personnel. It may or may not be visible. Contamination looks just like non-contaminated dirt or dust. You cannot tell whether something is contaminated by looking at it.

Airborne contamination is most likely to be present in contaminated areas where workers are welding, grinding, or using power tools.

Contamination Measurement

Objective F2

Describe the methods used for measurement of contamination, including the units used and the limits for contamination.

Introduction

Contamination is measured by the RP technicians to determine the protective clothing (PC) and other precautions needed for workers. Any quantity that is measured has to have standardized units so that everyone who reads the results can understand them.

Need to Know: Fixed, Loose & Discrete

Fixed contamination is measured with a "frisker" which counts the number of decays or disintegrations of radioactive atoms that are occurring under the probe.

Loose contamination is measured by rubbing a small cotton or paper disk on the surface where the contamination is to be measured, in order to pick up a representative sample. The disk, or smear, is rubbed over a standard-sized area of 100 cm2 (about a 4 inch by 4 inch area) and then counted on a frisker or similar instrument to determine the amount of contamination that was on the smeared area of the material.

Discrete contamination can be measured by direct frisking, or by taking a smear of a large area of the surface. Discrete particles, being highly radioactive, normally cause a frisker to jump up in counts rapidly. They usually cause friskers to alarm on several scales (if the frisker probe is held close enough to the particle).

Frisker

Need to Know: Airborne Measurement

Airborne contamination is determined by using an air sampler to draw a known amount of air through a paper filter. The amount of radioactive material on the filter is counted with a frisker, or similar instrument, and the concentration of radioactive material in the air can then be calculated.

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Contamination Measurement, Continued

Need to Know: Units

Fixed and loose contamination results are reported in the standard units of disintegrations or decays per minute (dpm) per 100 cm^2 surface area. The number of disintegrations is usually a large number and so it is written with the last three digits replaced by a K, the abbreviation for the metric kilo - meaning thousand. Contamination of 5000 dpm would be written and discussed as 5K, and 12,000 dpm would be written as 12K.

Contamination in clean areas (not posted CA) is limited to less than (<) 1000 decays per minute per 100 cm^2, or normally recorded as <1K dpm/100 cm^2. Any area containing loose contamination >1K dpm/100 cm^2 would be posted as a contamination area.

Need to Know: Indications

When frisking equipment, or your skin, an increase in the countrate of 100 counts or more **above** background indicates that the equipment or skin is contaminated. Friskers have multiplier scales marked x1, x10, x100, and x1000. The frisker must be on the x1 scale to determine if an item is contaminated. Always verify the frisker is on the x1 scale before using it. A frisker will always show at least some small amount of background radiation (hear occasional clicking) if it is working properly.

Need to Know: Airborne Units

Airborne contamination is reported in units of DAC, or Derived Air Concentration. Different materials have different allowable concentrations in the air. Since many different materials can be present in the air and each can have a different maximum concentration, the air sample results are calculated to be more understandable. Working, for a given amount of time, in one area with air concentration of 1 DAC gives workers the same amount of radiation exposure as another area with 1 DAC, even when the air samples contain different materials.

The limit for airborne contamination is 1 DAC. Signs are put up at 0.3 DAC when the airborne condition is expected to last more than one shift.

Continued on next page

Contamination Measurement, Continued

Nice to Know

The RP technicians must measure contamination levels in a consistent way because the results obtained are dependent on the technique used for sampling. Only trained personnel can take surveys to determine contamination levels.

The frisker is only about 10% efficient; it counts only one out of every ten actual disintegrations. To correct for the 10% efficiency, the meter reading (the number of counts **above** background) is multiplied by 10 to give the true number of disintegrations.

Smears are taken over an area of 100 cm^2 so the number of disintegrations per minute when they are counted is the number of disintegrations per standard surface area of 100 cm^2. This size area was chosen for many reasons besides being a nice round number, most importantly it is because it is about the same area as your palm print, heal and ball sizes of your foot print, about the same size as your knee, elbow, or shoulder print. In other words, if the contamination level where you are working is 10K/100 cm^2, then you can expect to pick up about 10K/100 cm^2 on your protective clothing (PC) whenever you walk, handle, kneel, or brush up against the contaminated surface.

Examples / Non-examples

Areas are checked for airborne contamination when there is cause to suspect that it may be present, such as when there is grinding or welding on pipes in the RCA, or when piping containing radioactive water is opened.

When RP technicians count smears, the reading on the frisker (above background), which is counts per minute (cpm), is multiplied by 10 to determine the number of disintegrations per minute (dpm) of the smear. 100 counts above background on a frisker is equal to 1000 dpm actual (100cpm x 10 = 1000dpm), which is the limit for loose contamination (i.e., 1000dpm/100 cm^2.

Contamination Control Methods

Objective F3

Explain why contamination is controlled, including techniques for controlling the spread of contamination (e.g., to personnel or other areas), and how contaminated areas are designated.

Introduction

It is important to control contamination even inside the RCA. When contaminated areas are found, it is important to designate it as a contaminated area so only authorized radiation workers taking the proper precautions enter these areas. Radiation workers should know work practices that help minimize the spread of contamination.

Need to Know

Contamination is controlled to ensure that it stays inside the RCA where only trained radworkers will encounter it. Eating, drinking, and smoking are prohibited in the RCA so there is little chance of it being ingested. If contamination were not controlled, it could eventually be spread to eating areas, cars, and homes. This could result in unmonitored radiation dose (including internal exposures), more radioactive waste, decreased productivity, and exposure to the public.

An area designated as a contamination or high contamination area will be posted. The area is typically roped off with yellow and magenta rope with signs hanging from the rope with the area designation. Think of the ropes as walls. Do not enter the area or reach over the ropes unless authorized by RP. There is an entrance and exit to the area with a step-off pad. These are the only authorized ways in and out of the area. Normally yellow and magenta tape is along the floor to designate the actual boundary from the contaminated area to the step-off pad (step off pads should be maintained clean).

Need to Know: Contamination Monitoring

Workers are checked for contamination with a frisker or personnel contamination monitor (the ARGOS) before leaving the RCA to ensure that they are not taking any contamination out of the RCA, especially to a place where people eat, drink, and smoke. The ARGOS PCM may not detect contamination when clothing is damp. When in doubt, always talk to an RP technician at RCA access Control. They can frisk you with other instruments (i.e., when your clothing is damp).

Even inside the RCA we want to limit the spread of contamination. You are required to frisk at least your hands, face, and shoes after exiting an CA to prevent spreading contamination.

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Contamination Control Methods, Continued

Need to Know: Additional Controls

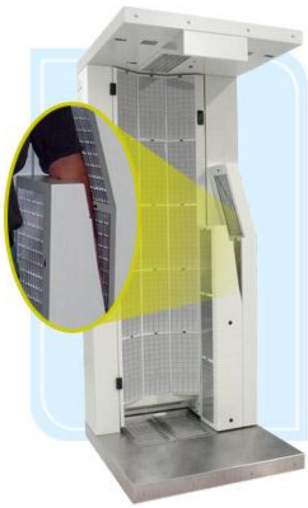
Other methods that control the spread of contamination are:

- planning a job and conducting prejob briefings
- using protective clothing (PC) when working in a contamination area
- avoiding water that is around or under a contaminated system
- avoiding skin contact with a contaminated area
- using step-off pads and warning signs
- restricting entry to contamination areas and restricting entry to areas that are not routinely monitored for contamination (e.g., climbing in overheads)
- using engineering controls such as temporary ventilation with filters and special enclosures

Contamination in clean areas should be cleaned up as soon as possible (e.g., an unplanned spill of radioactive liquid). Workers in the area should be alerted so they will not contaminate their clothing or spread the contamination. Small spills can be cleaned up by any radworker; larger spills will require the assistance of RP and Decontamination Specialists. If possible, start your work on the least contaminated component and proceed to the more contaminated components. When the more contaminated components must be handled first, outer gloves should be changed before handling less contaminated parts.

Graphic: ARGOS

ARGOS – Personal Contamination Monitor



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Contamination Control Methods, Continued

Nice to Know

No special clothing is required when floors and equipment can be maintained below the contamination limit (1000 dpm/100cm^2). Most areas of the Diablo Canyon plant are not contaminated. Work in contaminated areas takes longer because workers must dress in protective clothing each time they enter the area.

Contamination levels in CAs should be kept down to reduce the possibility of airborne contamination and personnel contamination. The amount of the plant that is contaminated is taken as an indication of plant performance. Regulators, industry associations, and visitors from other plants will have a better impression of a plant with few contaminated areas than a plant with a large amount of contaminated areas.

The PCM is also called a half-body frisker, as it frisks one side at a time.

Examples / Non-examples

Small radioactive spills occur occasionally. When we have a leak from a bag or a valve we could post the area as contaminated and make workers wear protective clothing, or we could stop the leak and clean the area. Stopping the leak and cleaning the area is normally the better option.

Various grated floor drains are installed throughout the RCA; they are normally surrounded by a yellow and magenta ring that surrounds the drain indicating potential contamination present. All workers should avoid stepping inside or on this ring.

Graphic: PCs

Protective Clothing without required hardhat and safety glasses

Contamination Sources

Objective F4

Describe sources and indications of contamination including:
- spills and leaks
- opening contaminated systems
- maintenance activities

Introduction

Being able to identify potential sources and indications of contamination may save you from becoming contaminated.

Need to Know

Potential sources of contamination include:
- spills and leaks from a system carrying radioactive water, or opening these systems for maintenance
- grinding, welding, or sanding on components with fixed or loose contamination
- disassembly of a plant component with internal contamination

The source for discrete particles is the reactor. All discrete particles must come from the reactor either as a possible fuel defect, or, more likely, as a neutron activated wear particle (more radioactive than activated rust).

The following are examples of potential indications of contamination:
- Radioactive water is leaking from a pump or valve.
- Components (e.g., pipe or valve) being removed from contaminated systems.
- Maintenance is being performed on a potentially contaminated component.
- Water or white crystals on the floor near or under a contaminated system.
- There is a rise in frisker counts or a frisker alarm (i.e., hear increased clicking)

Surveys for discrete contamination are performed when reactor components are opened or work is being done in the spent fuel pool, because these are the most likely place for them to be found.

Continued on next page

Contamination Sources, Continued

Nice to Know

The Reactor Coolant System (RCS) and its auxiliary systems (e.g., Residual Heat Removal or RHR) contain highly radioactive liquids and boric acid. Any time the RCS is open (or leaking), you can expect to find high levels of contamination. When leaks from any system containing reactor coolant occur, the boric acid that is in the RCS normally appears as white crystals once the water has evaporated away. Avoid these white crystals if possible.

If you find white or rust colored crystal deposits on plant equipment, write a Notification. A specialist team will evaluate the condition and arrange for corrective action.

Examples / Non-examples

Areas that have the potential for hot particles include the RCS when open, spent fuel pool area, refueling pool and canal. In the past, discrete particles have been found on vendor's equipment brought from other plants.

Small Article Monitors

Use care when operating Small Article Monitors (SAMs): their doors are extremely heavy. Do not slam the doors or get your fingers pinched in them.

Monitoring for Personnel Contamination

Objective F6

State the methods used to monitor personnel for contamination, the actions necessary upon discovering contamination, and list decontamination techniques for personnel.

Introduction

Personnel cannot be smeared, so they must always go to an area of low background radiation to be monitored by direct frisk. If contamination is found, taking prompt actions to decontaminate the area will help reduce the dose to the area of the skin where the contamination was found.

Contamination is radioactive dirt, grease, or other undesirable material. The main difference in removing radioactive dirt from personnel compared to removing non-radioactive dirt is that contamination must be contained when it is removed.

Need to Know: Frisker

Personnel are monitored for radioactive contamination by direct frisks only. This includes using a hand-held frisker, half-body frisker, and the portal monitor. When doing a proper manual frisk with a hand-held frisker, use the following techniques:

- Ensure the frisker is on the x1 (times 1) scale, and the audible clicking is loud enough.
- Check and note the background radiation level, if over 300 counts per minute (cpm), go to another frisker or call RP for assistance.
- Frisk your hand first, then pick up the hand-held probe with that hand.
- Hold the probe within ½” of what you are frisking, and move the probe no more than 1” to 2” per second over the areas being frisked. The probe should be held with the screen side facing the area being frisked.
- You should be paying close attention to the areas being frisked, ensuring you stay close and move the probe slowly while listening for an audible increase in the clicking rate. If an increase is heard, stop and hold the probe over that area for several seconds, even backtrack a little to try to pinpoint the area that caused the increase.
- If the count rate (i.e., meter reading) increases to 100 cpm over background (i.e., 100 cpm more than the amount you started with), or the alarm goes off, then contact RP.

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Monitoring for Personnel Contamination, Continued

Need to Know: PCM

Using the PCM half-body frisker involves following the LED instructions on its top screen. You insert either your right or left arm down its slot (as directed) and you'll hear an electronic beep to denote that it started frisking you. You need to hold still, after about 10-15 seconds you'll hear another beep indicating it is time to do the other side. When that side is done, it will indicate that you are clean and can proceed or that you are contaminated. If the screen states you are contaminated, you should try another PCM and repeat the process. If you also alarm a PCM on the second try, ask RP for assistance.

Need to Know: Personnel Decon

When personnel contamination is found, it needs to be reported to RP as soon as possible to start decontamination efforts. If you are in a remote area and find contamination with nobody around to assist you, try to contain the contamination as you go to the nearest phone. This can be done by placing a bag over the contaminated area, removing the contaminated item of clothing, etc. This will help prevent the unnecessary spread of contamination.

Personnel are usually decontaminated by washing the contaminated area with soap and warm water. In cases where a large part of the body is contaminated, a shower is the most effective means of decontamination.

Hand cleaning lotions can be used to remove contamination, and in some cases sweating can flush out contamination that is difficult to remove. Other methods are available for extreme cases, but are rarely needed.

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Monitoring for Personnel Contamination, Continued

Nice to Know

Personnel decontamination is a simple matter of washing off the contamination without spreading the contamination to some other area or material where it would be a problem. The contamination removed must be controlled and remain in the RCA. The process is rarely difficult and will never involve damaging or painful techniques. Because contamination is dirt that happens to be radioactive, normal soaps are used. Water close to body temperature is used to prevent opening or closing pores further. Hair that becomes contaminated will occasionally stay (slightly less) contaminated, as hair is hollow and it is difficult to wash all the contamination from all the hair all the time.

Decontamination of personnel will always be supervised by an RP technician to ensure effectiveness and safety of the procedures used, and by medical personnel if the contamination is in the vicinity of an injury.

Contamination is radioactive dirt. Contamination will look and act like dust, dirt, water, oil, or grease. It is spread in the same way as these materials.

An important concept of decontamination is that when something gets clean, something else gets dirty. Contamination cannot be destroyed, just moved. It is very important that it be moved to a place where it is less of a problem than where it was.

Removing contamination from tools or equipment is different from decontaminating personnel. Loose contamination is normally removed from tools by wiping with cloth towels wetted with a solvent such as EPA 2000. This will remove contamination from the tool and put it on the cloth. The contamination is later removed from the cloth by a washing machine or dry-cleaning machine that moves the contamination to the liquid. The contamination is removed from the liquid by special filters that are then buried as radioactive waste.

Contamination that is not removed by simple wiping could be removed by more aggressive means if it was essential. Pressure washing, grinding, and electro-polishing will remove contamination but damage the tools. These methods can be used when damage is not a concern, such as for broken tools or worn out equipment.

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Monitoring for Personnel Contamination, Continued

Nice to Know (continued)

Fixed contamination, or contamination that is not easily removed, is normally left in place on tools and equipment. The dose rate from the radioactive material is usually insignificant. As long as the tools are in the RCA the fixed contamination poses no hazard.

Examples / Non-examples

Painters are likely to get a little paint on their skin or clothes from time to time, and landscapers are likely to step in mud from time to time. In nuclear power plants we would like to avoid all personnel contaminations, but it is likely that occasionally a worker will get contaminated.

Skin contamination poses no real health hazard. The skin is not very sensitive and the radioactive material is not present long enough to add up to much dose to the skin. It should be removed as soon as possible to prevent spreading the contamination, but it poses little to no health hazard.

Immediate Exit from Contaminated Areas

Objective F7

Identify situations that require immediate exit from contaminated areas.

Introduction

Sometimes certain events occur that put a worker at a greater risk for becoming contaminated. When these events occur, the prudent thing to do is to leave the area immediately (and seek assistance from RP as needed)

Need to Know

If any of the following occur, leave the area immediately:

- cut or torn PCs
- cuts, abrasion, or any other type of open wound
- PCs that are wet from a leak or spill
- a self-reading dosimeter (e.g., your PED) showing some unexpected or unusual condition such as having a abnormally high or low reading, or no reading
- when directed to leave by RP
- lost or damaged dosimetry

Nice to Know

Whenever in doubt about whether it is safe to proceed with your work while in a contaminated area, it is better to ask for assistance rather than take chances. Decontamination efforts, while never painful, are rarely quick and easy by the time all the paperwork gets filled out.

Examples / Non-examples

You may also want to leave if due to excessive sweating, as PCs do not protect as well when they are wet (contamination can more easily soak through). You likely need a break anyway if you are sweating that much!

G. Internal Exposure

Entering the Body

Objective G1

Explain how contamination enters the body.

Introduction

There are several ways for a worker to get contamination in the body.

Need to Know

Contamination can enter the body in the same ways that other materials can enter the body: by inhalation, ingestion, absorption, or through open wounds. This is called internal contamination.

Wounds or open sores must be examined by RP before entry into the RCA. RP will have the wound bandaged by the medical department if they believe contamination could enter the wound.
Any injury received inside the RCA should be evaluated by an RP technician, as well as the medical department.

Nice to Know

The ways that contaminated materials can enter the body are:

- Liquids can be splashed into the eyes.
- Gases or particulates can be inhaled through the nose or mouth.
- Liquids or solids can be swallowed.
- Liquids and gases can be absorbed through the skin.
- Solids or liquids can enter an existing wound or they can enter at the time of injury.

Examples / Non-examples

Working on highly contaminated components, such as valve internals, can result in contamination becoming airborne where it can be breathed into the body.

Eating inside the RCA can result in contamination being swallowed since material inside the RCA is not necessarily clean enough to be released. This is the major reason why eating, drinking, and chewing are not permitted in the RCA.

Working with contaminated solvents can result in the contamination being absorbed through the skin.

A contaminated tool that slips and cuts the skin may leave contamination in the body.

Measuring Internal Contamination

Objective G2

List the techniques used to measure contamination in the body.

Introduction

We need to know how much internal contamination is present, and which radioactive materials (elements) are present to determine the half-life.

Need to Know

Internal contamination is normally measured by using large detectors or multiple detectors held adjacent to the body. These are called Whole Body Counters and they are similar to the PCM counter used each time a worker exits the RCA. The purpose of a whole body counter is to precisely measure the amount of radioactive material in the body.

Internal contamination can also be measured by collecting biological samples (e.g. urine), called bioassay samples, and counting them on more sensitive counters. This technique is normally only used for cases where the worker is suspected of a large intake of contaminated material.

Graphics: Whole Body Counters

Fast Scan (2 min)

Bed Counter (10 min)

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Measuring Internal Contamination, Continued

Nice to Know

The Whole Body Counter that is normally used at DCPP is a Fast Scan counter that the worker stands in for about two minutes. This count is performed prior to the first RCA entry to find out how much radioactive material is already in the body and is called an incoming whole body count (or baseline). Later, if internal contamination is suspected, another Whole Body Count is performed and the new quantity of radioactive material compared to the first, or incoming Whole Body Count, to see if there is an increase.

Everyone has some radioactive material in his or her body. Food, air, and other naturally radioactive materials are continuously ingested and expelled from the body. The amount present depends on the size of the person, their diet, the region where they live, medications they are taking, and any previous contamination they have ingested or inhaled.

Once a Whole Body Count is complete and the amount of radioactive material has been determined, an assigned internal dose can be added to the person’s exposure records. This dose is called a Committed Dose Equivalent (CDE).

A PCM can also detect some internal contamination, although it cannot determine which type of radioactive material is present. The whole body counter is a more sophisticated device that can determine which material is present, such as potassium (from bananas and diet salt) or manganese (from the power plant).

Examples / Non-examples

A person who is unable to pass a PCM without alarming it will usually be checked on a Whole Body Counter to determine if internal contamination is the cause of the alarm (after removing any external contamination).

Internal Contamination Removal

Objective G3

Describe the mechanisms by which contamination is removed from the body.

Introduction

Radioactive material that enters the body doesn't stay in the body forever. It is removed in two ways.

Need to Know

Radioactive material in the body decays away, becoming less radioactive over time. It also cycles through the body like non-radioactive material, a process called biological elimination.

Nice to Know

All radioactive material decays; this is the defining characteristic of radioactive material. The time frame for decay ranges from seconds to centuries, but for many of the contaminants in a power plant decay is a significant means of removal from the body.

The term half-life is used to describe the speed that radioactive material decays away. The more radioactive material you have, the more radiation it gives off. If you measure the amount of time it takes for half of the radioactive material to decay away, you have measured the half-life. The other half of the material WILL NOT decay away if you wait that same period of time again. Instead, half of the remaining half will decay (¼ of the original amount). Waiting a third half-life will reduce the amount left to 1/8. Less than 1% will be left after seven half lives, but it isn't practical to determine when it will all be gone.

Radioactive half-life is very similar to biological half-life. When you drink a glass of water, that water does not all leave your body at the same time. The water will be mixed thoroughly with all of the other water in your body. Your body loses water continuously through respiration and perspiration, but the water does not leave your body in the order it came in. It is all mixed together and leaves randomly.

Continued on next page

Internal Contamination Removal, Continued

Nice to Know (continued)

The only practical way to measure the removal of water (or alcohol or medication) is to determine the half-life. After seven half lives more than 99% of the material is gone. Generally speaking, 1% is too little to do any harm (or good) and the material is considered "gone", even though traces of it remain. This is called a biological half-life at DCPP to avoid confusion with the radioactive half-life.

Radioactive material in the body undergoes decay and biological elimination. One of these removal mechanisms may be predominant, or they may be equal, depending on the biological half-life and the radioactive half-life.

Examples / Non-examples

Radioactive material behaves chemically the same as non-radioactive material.

Tritium, a radioactive form of hydrogen, has a half-life of 12 years. It would take 84 years (7x12 years) for it to decay away. If tritium enters the body as water it will undergo all of the same processes as non-radioactive water: It will be dispersed throughout the body. The body cycles water through fairly quickly (biological half life of 12 days). In 12 days half of the water (tritium) will be gone. Essentially all of the tritium will be gone in 84 days.

This elimination of the tritium is primarily due to biological elimination rather than radioactive decay. In other chemicals the elimination may be primarily radioactive decay or equal amounts of both.

Other chemicals, radioactive or not, tend to travel to specific parts of the body instead of being equally dispersed like water. Calcium goes to the bones, iodine to the thyroid, and iron to the blood. Each of these has a biological half-life and a radioactive half-life and combine to reduce the amount of radioactive material in the body faster than either method would alone.

Internal Dose Terms

Objective G4

Define Annual Limit of Intake (ALI), Derived Air Concentration (DAC), Committed Dose Equivalent (CDE), Committed Effective Dose Equivalent (CEDE), and the relationship between the terms.

Introduction

10CFR20, which contains the federal regulations on radiation exposure, was changed extensively in 1994. With this revision came several new terms relating to internal exposure.

Need to Know

- Annual Limit on Intake (ALI) is the amount of radioactive material that will give an exposure of 5 rem CEDE when inhaled or ingested.
- Committed Dose Equivalent (CDE) is the dose equivalent to an organ from an intake (that will be received during a 50 year period after the intake).
- Committed Effective Dose Equivalent (CEDE) relates the actual single organ dose (CDE) to whole body dose equivalent risk by using a weighting factor provided by the NRC.
- An airborne concentration of 1 DAC would result in 1 ALI (5000 mrem) if a person breathed it for 40 hours per week for 50 weeks (2000 hours total). Each DAC-hour worth of exposure therefore equates to 2.5 mrem (5000 mrem/yr.÷2000 hours/yr.).
- Breathing air with a concentration of 1 DAC for an entire work year (2000 hours) would result in 1 ALI which would result in a CEDE of 5000 mrem.
- TEDE is CEDE plus external exposure (Deep Dose Equivalent) so the above would be in excess of the federal limit if the person had any external exposure.

Nice to Know

Being exposed to an airborne area is not quite the same as being exposed to a radiation area. In a radiation area you will receive the total dose immediately (e.g., standing in a 10 mrem/hour field for 2 hours means you picked up 20 mrem after the 2 hours). Breathing airborne (internal exposure) does not deliver the total dose immediately as the radioactive material now inside you continues to give you dose after you leave the area. You are credited with receiving the total dose after the exposure (i.e., a committed dose), but the total dose is actually delivered over time (e.g., a few days up to 50 years).

Continued on next page

Internal Dose Terms, Continued

Examples / Non-examples

Breathing airborne at a concentration of 2 DACs for 5 hours yields a total of 10 DAC-hours worth of exposure. Each DAC-hour of exposure yields 2.5 mrem eventually, so the 10 DAC-hours will eventually give you 25 mrem worth of CEDE (committed) dose.
(2 DACs x 5 hours = 10 DAC-hours) which is equal to a CEDE of 25 mrem (10 DAC-hours x 2.5 mrem / DAC-hour = 25 mrem). You will be credited with receiving the 25 mrem in the calendar year you receive the intake (and counted towards any DCPP or federal limit), even though it may take several years to actually receive it.

Increasing Airborne Contamination

Objective G5 List activities that have the potential for increasing airborne contamination levels.

Introduction Airborne activity can be affected by the work in progress being performed.

Need to Know

- Sweeping or brushing can raise airborne levels by stirring up dust. Cleaning is normally accomplished by mopping or using vacuum cleaners with special high efficiency filters, called HEPA filters. RP must be notified when a vacuum will be used because a vacuum cleaner can stir up dust and cause airborne contamination.
- Ventilation fans can increase activity in dusty areas.
- Leaks of radioactive systems can increase airborne levels.
- Spilled liquid can cause airborne contamination when it evaporates.
- Anything that stirs up dust can cause an airborne condition, such as use of pneumatic tools, cutting, grinding, sanding, and welding.
- Volatile solvents can cause contamination to become airborne and plant piping and valves may dry out and cause airborne contamination while open for repair.

Nice to Know Any activity that causes dust to be stirred up can cause contamination to become airborne.

Limiting Internal Contamination

Objective G6	List the methods used to limit internal contamination at DCPP in the order of preference.
Introduction	There are several ways to limit internal exposure, but some are better than others.
Need to Know	We limit the inhalation of radioactive material by using engineering controls or by using respirators if engineering controls are not practical. Respirators are the last resort because they are uncomfortable, they slow down work, and they add to worker stress.
Nice to Know	Engineering controls means ventilation, HEPA vacuums, decontamination, or containment devices such as glove bags or tents.
Examples / Non-examples	Engineering controls allow jobs that previously were performed in respirators to be accomplished without the inconvenience, discomfort, and physical stress. In other cases, the small amount of internal exposure saved by the respirator is more than offset by a large increase in external exposure, due to the increased time required to perform the job.

H. Radiation Work Permits (RWPs)

Prenatal Exposure

Objective H1	State the purpose of a radiation work permit (RWP).
Introduction	A Radiation Work Permit (RWP) is necessary for all entries to the RCA at Diablo Canyon.
Need to Know	The purpose of an RWP is to authorize entry into the RCA. Workers must read the RWP to learn protective clothing requirements, precautions, and job coverage requirements applicable to their work in the RCA.
Nice to Know	Active RWPs are kept at RCA access Control where workers can review them. Every worker must review and sign the RWP he will use prior to entering the RCA. The RP technician at RCA access Control can answer questions to clarify the requirements of the RWP.
Examples / Non-examples	When using an RWP for the first time a worker must get the RWP from the RCA access Control RP technician and determine the radiological requirements for entry into the RCA.

Radworker's Responsibilities

Objective H3

State the radworker's responsibilities concerning RWP instructions and the correct worker response to radiological or work conditions not described on the RWP.

Introduction

RWPs are based on current radiological conditions, previous work conditions, and RP experience. There may be times when the actual conditions are substantially different from the anticipated radiological and work conditions.

Need to Know

Radworkers are responsible for complying with the RWP instructions, limits, and limitations. The protective clothing and respiratory protection requirements are determined by RP based on current and anticipated conditions.

When a worker knows, or suspects, that radiological conditions or the work scope has changed from the conditions specified on the RWP, he must put the job in a safe condition and immediately contact RP for guidance on how to proceed.

Expectations are that workers will frequently monitor their PED and exit the area PRIOR to receiving an alarm. Remember, PEDs are set to alarm at the Exposure Guideline per entry as specified on the RWP.

You must read and understand your RWP before entering the RCA. Ask the RCA access Control RP questions if you do not understand. You must sign the RWP acknowledgment sheet to indicate that you have read, understand, and will comply with the RWP requirements.

Nice to Know

Radiation workers are not expected to be able to measure radiological conditions and determine radiological controls. They are expected to recognize changes in conditions and work scope that affect the radiological controls.

Workers are required to notify RP when job or radiological conditions change. RP will then assess the conditions and notify workers of the requirements.

Continued on next page

Radworker's Responsibilities, Continued

Examples / Non-examples

An RWP for a job inspecting valve internals may need to be changed if the inspection indicates the valve must be lapped. RP should be contacted for guidance.

An RWP for changing light bulbs may need to be modified if the socket has to be replaced.

An RWP for painting a floor may have to be changed if radioactive material is stored in the vicinity.

J. Radwaste

Definition

Objective J1

Define radioactive waste.

Introduction

Most waste produced at Diablo Canyon is not radioactive. Nearly all of the radioactive waste is only slightly radioactive.

Need to Know

Radwaste is unwanted solid or liquid material that is radioactively contaminated.

Radwaste is an unwanted byproduct of nuclear power. Examples are tape and worn out tools, equipment, and protective clothing. Personal items, such as a shoe, that cannot be decontaminated is also radwaste.

Putting clean items in the radwaste containers will cause them to become contaminated and will increase the amount of radwaste.

Nice to Know

Radioactive material can be in gaseous form as well as liquid and solid.

Gaseous radwaste is stored in holding tanks until it has decayed to a level safe for release.

Most radwaste at DCPP is categorized as Low Specific Activity (LSA) waste. This means it is not very radioactive.

Radioactive waste can be identified only by using RP instruments to determine if radioactivity is present.

Examples / Non-examples

Radioactive waste, commonly called radwaste, includes water or other liquids used for decontamination, used PCs, packing material, damaged tools and equipment, used cleaning supplies and other waste material from the RCA.

Mixed Waste

Objective J2	Define mixed waste.
Introduction	Hazardous material can be disposed of in hazardous waste facilities, and radioactive waste can be disposed of in low-level waste facilities when open. Disposal of both types of waste is very expensive.
Need to Know	Mixed waste is both chemically hazardous and radioactive. Some mixed waste must be stored on-site because many facilities will not normally accept mixed wastes. Facilities that do accept certain mixed wastes charge very large amounts of money.
Nice to Know	When grease or oil gets mixed with contaminated material, it is called “mixed waste”. When radioactive material gets hazardous material mixed with it, mixed waste is produced.
Examples / Non-examples	When paper towels are used to soak up hazardous chemicals in the RCA they usually have contamination and hazardous chemicals presents. Some mixed wastes must be stored on site because there is no place that will accept certain types of mixed wastes.

Keeping Waste Separate

Objective J3

Explain the importance of keeping separate the following:
- Contaminated and uncontaminated materials
- Wet and dry contaminated materials
- Contaminated materials and hazardous materials

Introduction

Certain materials need to be kept separate to help minimize the amount of radioactive waste generated, or the amount of processing needed prior to disposal.

Need to Know

Keep contaminated and uncontaminated materials separate, otherwise the contamination will likely spread to the uncontaminated material that will increase the total amount of radioactive material that needs to be processed or disposed of.

Keep wet and dry contaminated materials separate, mixing the two will likely increase the amount of processing needed.

Keep contaminated and hazardous materials separate, otherwise it creates mixed wastes in which many additional restrictions apply.

Nice to Know

Many radioactive materials must be dried before they can be processed. Wet materials do not compact very efficiently. We do not want to have any free standing water in our drums or boxes as they are more likely to leak out some time in the future.

Examples / Non-examples

We would not want to mix used mop heads with paper towels (from the RCA).

Disposal Costs

Objective J4	State the difference in disposal costs of radioactive materials versus non-radioactive materials.
Introduction	Due to the many restrictions and paper work required, radioactive wastes are much more expensive to dispose of.
Need to Know	Radioactive wastes are many hundreds or even thousands of times more expensive to dispose of when compared to non-radioactive wastes.
Nice to Know	The cost for us to process the waste before burial is not even included, which makes it that much more important to minimize the amount of radioactive wastes generated.
Examples / Non-examples	For a 55 gallon drum of non-radioactive waste, burial cost is only about $10. Compared to a 55 drum of low level radioactive waste (i.e., not very radioactive), it may cost upwards of $1000. For high activity radioactive wastes (i.e., highly radioactive) or mixed wastes, the costs go up even more (e.g., 2 - 4 times as much!)

GLOSSARY

ACTIVITY - Same as Radioactivity; a measure of the rate at which atoms (of a given radioactive substance) decay per unit time. Normally measured in decays per minute (dpm).

ACUTE - Radiation exposure (normally high doses) received in a short period of time.

ALARA - Concept of planning all work involving exposures to radiation so as to maintain radiation exposures to individuals and the worker population As Low As Reasonably Achievable.

ALI - Annual Limit on Intake: The maximum amount of radioactive material that can be taken into the body without exceeding either a 5 rem whole body exposure or 50 rem to any organ or tissue system.

ALPHA PARTICLE - A charged particle with mass and charge equal to that of a helium nucleus: two protons (+2 charge) and two neutrons (initially no electrons).

ATOM - The smallest particle of an element that can exist alone or in combination. It consists of a nucleus and a less dense outer area consisting of orbital electron(s).

BIO-ASSAY - Testing performed to determine the amount of internally deposited radioactive material (e.g., urinalysis).

BETA PARTICLE - Charged particle emitted from the nucleus of an atom, with mass and charge equal to that of an electron.

CDE - Committed Dose Equivalent: The dose to an organ following an uptake of radioactive material, calculated over the next 50 years (or however long the radioactive material remains in the body). The limit is 50 rem per calendar year.

CEDE - Committed Effective Dose Equivalent: the assigned internal dose that relates actual organ dose to whole body dose equivalent risk. The Committed Dose Equivalent for each organ is corrected by a weighting factor (based on the importance of the organ exposed).

CHRONIC - Radiation exposures (normally low doses) received over a long period of time.

CONTAMINATION - Radioactive material in undesirable locations.

CPM - Counts Per Minute: The rate at which a radiation detector (e.g., a frisker) is detecting ionizing radiations such as betas or gammas.

CRUD - Corrosion and wear products that become activated from neutron exposure while traveling through the reactor core at power (i.e., rust made radioactive).

DAC - Derived Air Concentration, a unit of airborne contamination. 1 DAC can be breathed 2000 hours per year before reaching the NRC limit of an ALI.

DOSE - Term used to describe the amount of radiation that a person receives, usually measured in millirem (corrects for biological damage).

DOSE RATE - The amount of dose delivered per unit time (millirem/hr.).

DPM - Decays Per Minute. A unit used in measuring the amount of radioactivity in a given sample.

GLOSSARY, continued

ELECTRON - A small negatively charged particle that forms part of the atom outside the nucleus. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.

EXTREMITIES - The outward portions of your body, from the elbows out to the hands, and from the knees down to the feet.

FISSION - The splitting of atoms in the reactor which results in a release of radiation and the generation of heat.

GAMMA WAVE - A penetrating wave type of ionizing radiation of nuclear origin.

GENETIC - An effect that is passed on to the next (or future) generations.

HALF-LIFE, BIOLOGICAL - Time required for the body to remove 1/2 of the (radioactive) substance through biological elimination (e.g., urination or sweat).

HALF-LIFE, RADIOACTIVE - Time required for 1/2 of the radioactive atoms (of a given substance) to decay to a stable (non-radioactive) state.

ION - Atom or atomic particle bearing a net electric charge, either positive or negative.

IONIZATION - The process by which a neutral atom or molecule acquires a positive or negative charge.

NEUTRON - A subatomic particle with a neutral net charge, located in the nucleus and whose mass is approximately equal to that of a proton.

NUCLEUS - The positively charged center of an atom that contains nearly all of the atom's mass (the protons and neutrons).

PERSONNEL ELECTRONIC DOSIMETER (PED) - A device that allows workers an easy way to keep track of their current dose for a job. PEDs can also be used as an alarming dosimeter if properly set up by an RCA Access Control RP technician.

POCKET ION CHAMBER (PIC) - A device that helps workers keep track of their current dose for a job (also called a pocket dosimeter, self reading dosimeter or SRD).

PROTON - A subatomic particle with a single positive charge and a mass approximately equal that of a neutron. Protons are part of the nucleus.

RADIOACTIVITY - The rate at which a radioactive material decays, normally measured in decays per minute or dpm.

RADIATION - Energy (in the form of waves or particles) emitted from a radioactive atom during the decay process.

RADIATION PROTECTION - Referred to as RP, (also H.P. and C&RP). A group of technicians qualified to assess radiological conditions, and to set up appropriate standards of protection based on their findings.

RADIOLOGICAL CONTROLS AREA (RCA) - Any area where access requires written authorization for entry for the purpose of radiation protection.

GLOSSARY, continued

RADIOGRAPHY - Process used for internally photographing pipes, valves, and other components using intense sources of ionizing radiation (either X-ray generator or large gamma emitting source).

REM - Roentgen Equivalent to Man, a Dose equivalent unit. Corrects absorbed dose from the various types of ionizing radiation and equates it to the potential biological effects or risks.

SRD – **S**elf **R**eading **D**osimeter- A dosimeter that the worker can read to determine exposure, such as the pencil type pocket ion chamber (**PIC)** or the personal electronic dosimeter (**PED**). TLDs are not SRDs because the worker cannot determine the exposure by looking at them.

SOMATIC - An effect that a worker can see in themselves (such as sunburns).

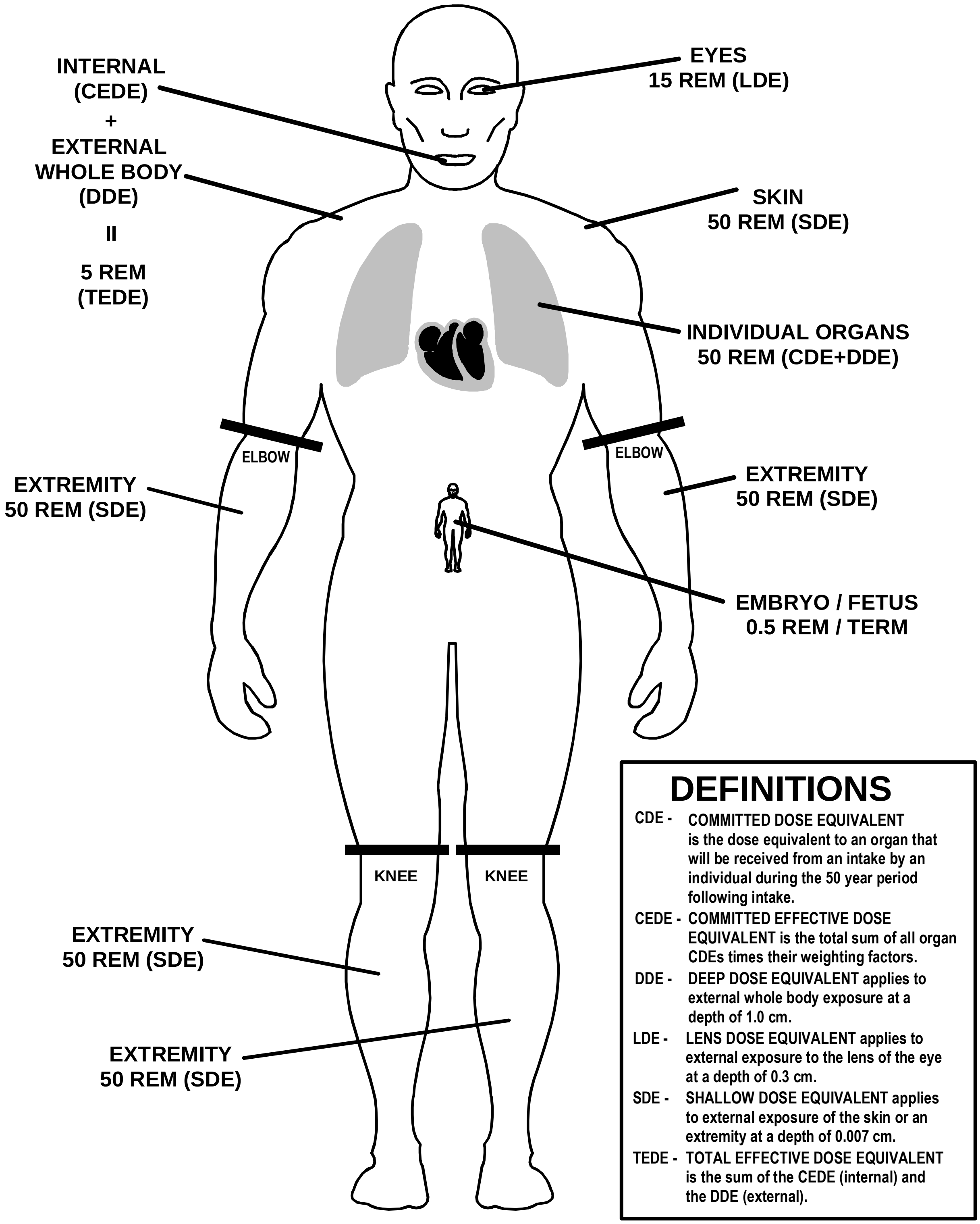
STEP-OFF PAD - A place for entry and exit into contamination areas, which includes instructions for proper use.

TEDE - Total Effective Dose Equivalent, the legal limit of 5 rem per calendar year from combining both Internal (CEDE) and External (TLD) exposures.

TEDE-ALARA - The concept of minimizing the total whole body dose from both sources, internal (CEDE) and external (TLD readings). Usually involves justifying the use of respirators (e.g., will wearing a respirator save enough internal dose without increasing the external dose delivered from possible increased time on the job).

TLD - Thermoluminescent Dosimeter, a device that fairly accurately measures dose, usually to the whole body. Sensitive to whole body gamma and neutron exposures, as well as beta exposures (skin and lens of the eyes).

WHOLE BODY - The major portion of the body including the head and trunk (above the knees and inward from the elbows).



NEW 10 CFR 20 ANNUAL DOSE LIMITS

ADULT OCCUPATIONAL WORKER

Review of the Lesson

Summary of the lesson

This lesson is generic (spans the common elements of nuclear power) radiation worker. The numbering system for the objectives corresponds with those objectives in the Vision system.

Terminal objective

Upon completion of this class the student will be able to safely work in radiological areas of nuclear power plants, understanding the risks, and procedures to decrease those risks associated with that work.

Enabling objectives

The following objectives apply to the lesson.

Number	Objective Text
A. Sources of Radiation	
A1	State the basic structure of an atom, including the three primary components
A2	Define ionizing radiation.
A3	Define contamination.
A4	Describe the four types of ionizing radiation found at nuclear power plants
A5	Define radioactive decay.
A6	Define fission and fission product.
A7	Define corrosion product.
A8	Define neutron activation.
A9	Define calibration source.
B. Biological Effects	
B1	Compare the relative penetrating ability of the four types of ionizing radiation.
B2	Define dose and doserate.
B3	Convert between rem and millirem.
B4	List the effects radiation can have on cells.
B5	Define "chronic radiation exposure" and the associated risks.
B6	Define "acute radiation exposure" and the associated risks.
B7	Define "genetic" and "somatic" effects. Compare somatic versus genetic effects of radiation exposure.
B8	Compare the radiosensitivity of different age groups.

Continued on next page

Review of the Lesson, Continued

Enabling objectives (continued)

Number	Objective Text
B9	Identify the possible effects of radiation on an unborn child due to prenatal exposure.
B10	Compare the safety record of nuclear power to other industries.
B11	State the purpose of an NRC form-4.
C. Exposure Limits	
C1	Define the classes of individuals for exposure limit purposes.
C2	State the consequences of exceeding federal exposure limits.
C3	State the federal exposure limits (including declared pregnant female).
C4	State the reason for having station limits, and the actions taken if they are being approached.
C7	State the rights of a declared pregnant worker.
C8	Recognize the definition of a planned special exposure.
D. ALARA	
D1	State the purpose of the ALARA concept, and describe DCPP's ALARA program.
D2	Explain the benefits of reducing exposure.
D3	Explain how time, distance, and shielding can be used to reduce radiation dose, and state some methods used to implement time, distance, and shielding concepts.
D4	State individual responsibilities concerning temporary shielding.
D5	List the rights and responsibilities of radiation workers concerning radiation exposure.
D6	Calculate stay time given a dose rate, current exposure, and an exposure limit.
E. DOSIMETRY	
E1	State the purpose of dosimetry
E5	Explain the actions to be taken if dosimetry is lost or damaged and the radiological consequences.
F. CONTAMINATION CONTROL	
F1	Identify and compare fixed, loose, discrete, and airborne contamination.
F2	Describe the methods used for measurement of contamination, including the units used and the limits for contamination.
F3	Explain why contamination is controlled, including techniques for controlling the spread of contamination (e.g., to personnel or other areas), and how contaminated areas are designated.

Continued on next page

Review of the Lesson, Continued

Enabling objectives (continued)

Number	Objective Text
F4	Describe sources and indications of contamination including: - spills and leaks - opening contaminated systems - maintenance activities
F6	State the methods used to monitor personnel for contamination, the actions necessary upon discovering contamination, and list decontamination techniques for personnel.
F7	Identify situations that require immediate exit from contaminated areas.
G. Internal Contamination	
G1	Explain how contamination enters the body.
G2	List the techniques used to measure contamination in the body.
G3	Describe the mechanisms by which contamination is removed from the body.
G4	Define Annual Limit of Intake (ALI), Derived Air Concentration (DAC), Committed Dose Equivalent (CDE), Committed Effective Dose Equivalent (CEDE), and the relationship between the terms.
G5	List activities that have the potential for increasing airborne contamination levels.
G6	List the methods used to limit internal contamination at DCPP in the order of preference.
H. Radiation Work Permit (RWP)	
H1	State the purpose of a radiation work permit (RWP).
H3	State the radworker's responsibilities concerning RWP instructions and the correct worker response to radiological or work conditions not described on the RWP.

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Review of the Lesson, Continued

Enabling objectives (continued)

Number	Objective Text
I. POSTINGS	
	None
J. Radioactive Waste	
J1	Define radioactive waste.
J2	Define mixed waste.
J3	Explain the importance of keeping separate the following: Contaminated and uncontaminated materials Wet and dry contaminated materials Contaminated materials and hazardous materials
J4	State the difference in disposal costs of radioactive materials versus non-radioactive materials.