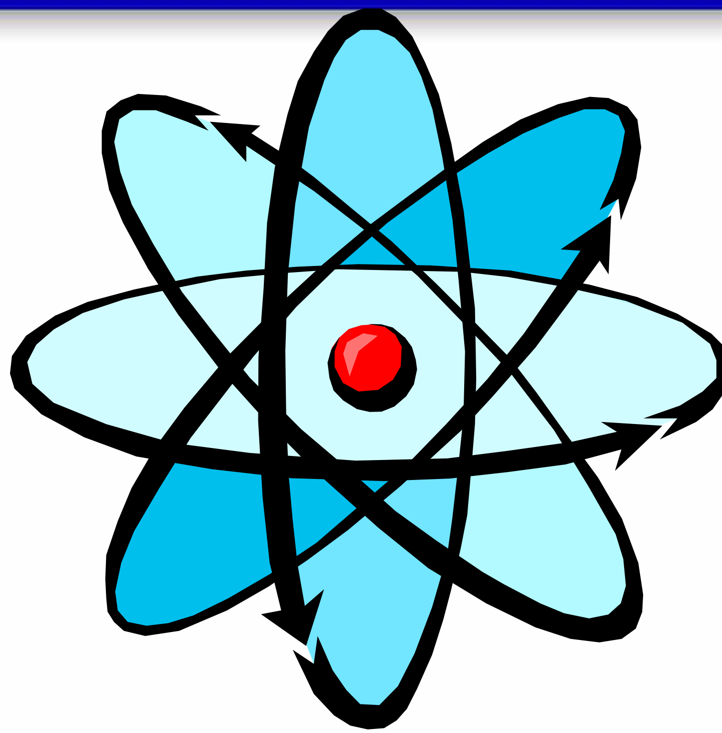
Radiation Protection Orientation



Department of Energy

Office of Environment, Safety and Health

Course Overview

- RADIATION FUNDAMENTALS
- BIOLOGICAL EFFECTS OF RADIATION
- RADIATION LIMITS AND ADMINISTRATION CONTROL LEVELS
- ALARA
- PERSONNEL MONITORING
- RADIOLOGICAL ACCESS CONTROLS AND POSTINGS
- CONTAMINATION CONTROL

Radiation Fundamentals

Objectives:

- Identify the three basic particles of an atom
- Define radioactive material, radioactivity, radioactive half-life, and radioactive contamination
- Identify the units used to measure radioactivity and contamination
- Define ionization and ionizing radiation
- Distinguish between ionizing radiation and non-ionizing radiation
- Identify the four basic types of ionizing radiation
  - Physical characteristics
  - Range
  - Shielding
  - Biological hazards
- Identify the units used to measure radiation.
- Convert rem to millirem and millirem to rem.

Atomic Structure

- The basic unit of matter is the atom.
- The three basic particles of the atom:
  - *protons,*
  - *neutrons, and*
  - *electrons.*
- The central portion of the atom is the nucleus
  - The nucleus consists of protons and neutrons.
- Electrons orbit the nucleus.

Radiation Fundamentals

- Atoms which have the same number of protons but different numbers of neutrons are called isotopes.

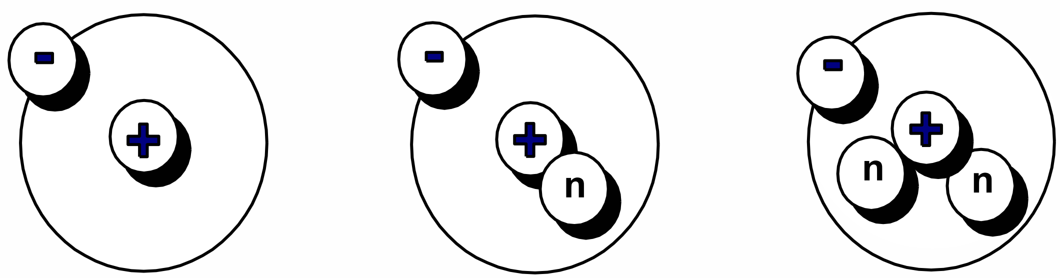
$^{12}_{6}C$ C-12

$^{14}_{6}C$ C-14

Radiation Fundamentals

ISOTOPES of hydrogen

Protium H	Deuterium D	Tritium T



No neutrons	1 neutron	2 neutrons
H	**D**	**T**

Radiation Fundamentals

Tritium is designated as:

T or H-3 or $^{3}_{1}H$

Uranium (238) is designated as:

U-238 or $^{238}_{92}U$

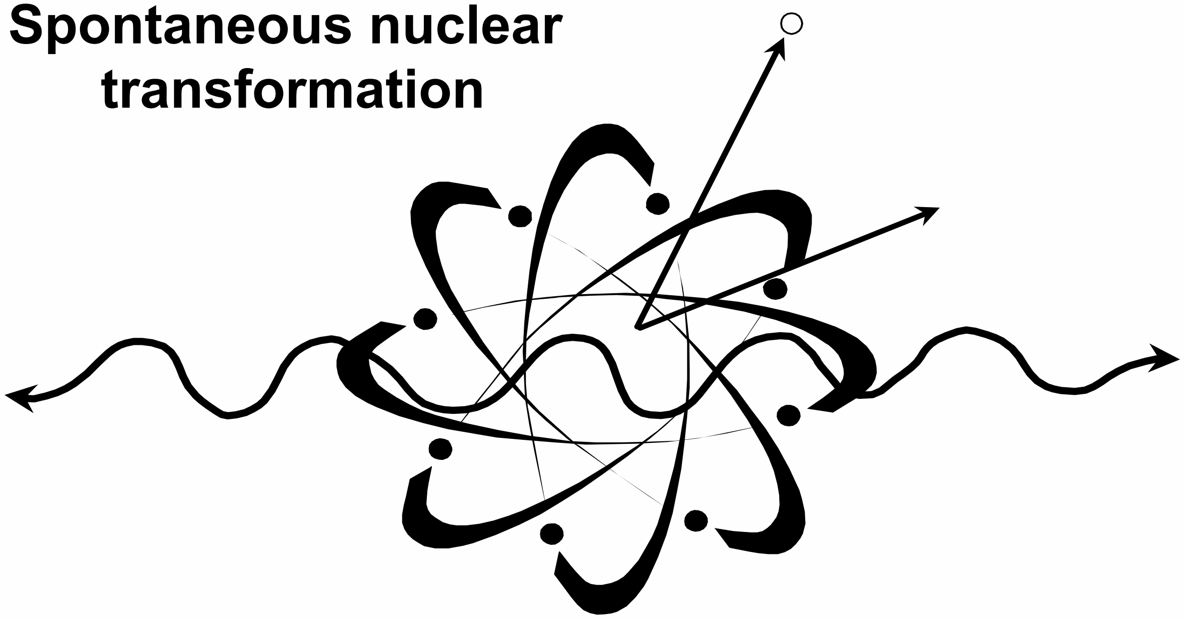
Radiation Fundamentals

- **If there are too many or too few neutrons for a given number of protons, the nucleus will not be stable.**
  - The unstable atom will try to become stable by giving off excess energy. This energy is in the form of particles or rays (radiation). These unstable atoms are known as radioactive atoms.

Radiation Fundamentals

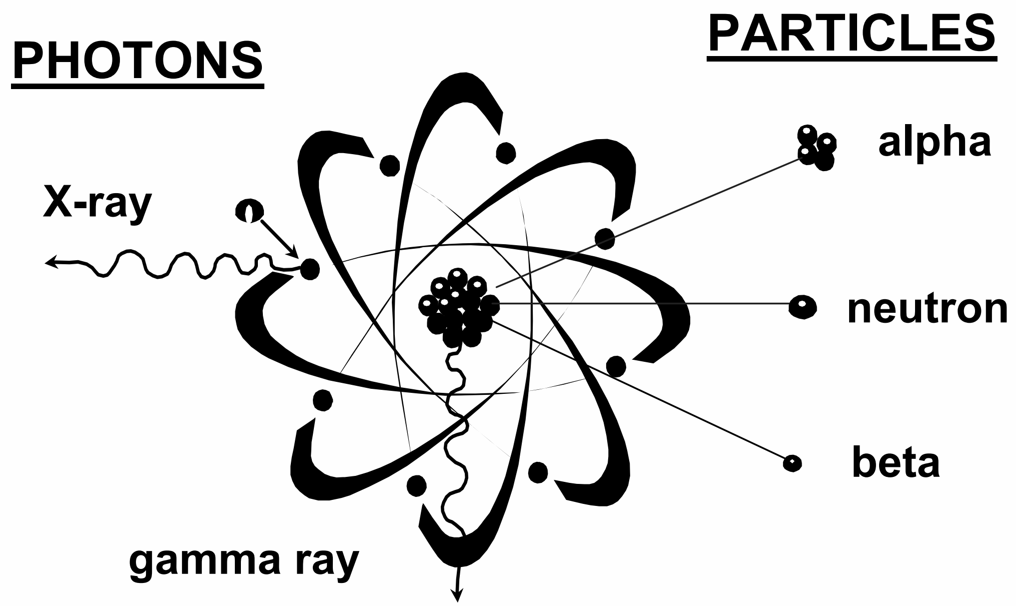
Radioactivity may be defined as:

Spontaneous nuclear transformation



Radiation Fundamentals

Two general categories of ionizing radiation:



Radiation Fundamentals

Radioactivity units

- Radioactivity is measured in the number of disintegrations radioactive material undergoes in a certain period of time.
  - dpm; dps (Becquerel)
  - Curie (Ci)
    - *One curie equals: 37 billion dps*
    - *3.7×10^{10} dps*
    - *Historically – 1 gram of Ra-226*

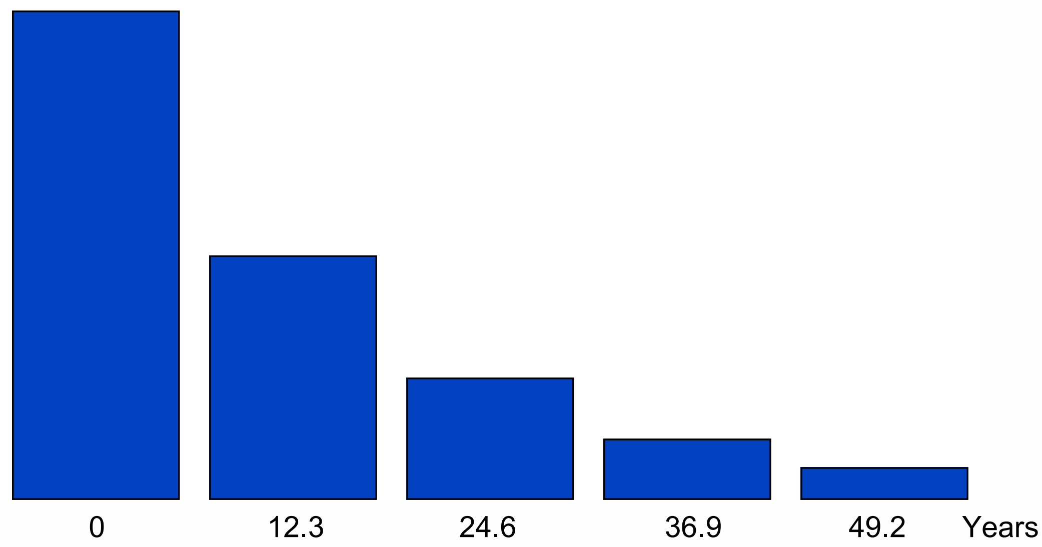
Radiation Fundamentals

Radioactive half-life

- Radioactive half-life is the time it takes for one half of the radioactive atoms present to decay.
  - U-238: 4.5 billion years
  - Pu-239: 24 thousand years
  - H-3: 12 years

Radiation Fundamentals

The radioactive half-life of tritium is 12.3 years

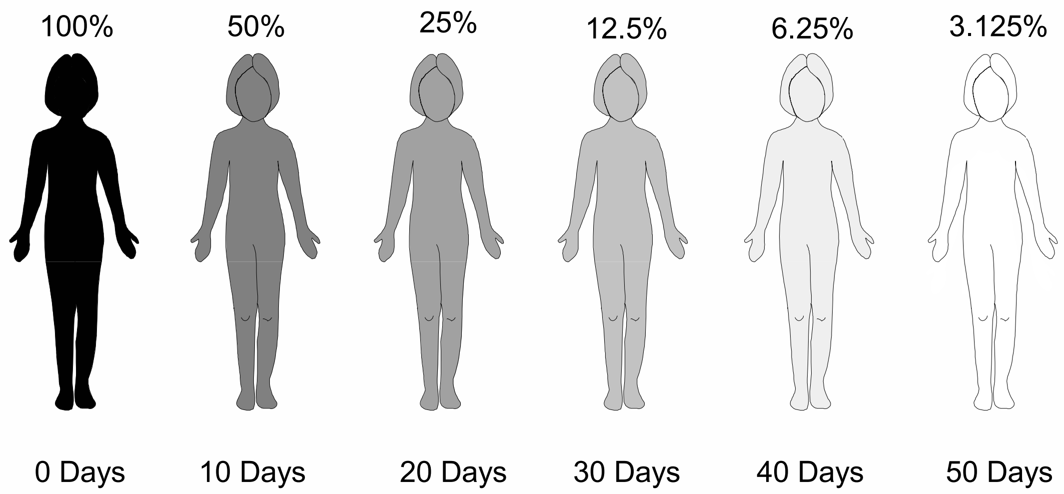


Radiation Fundamentals

Biological half-life

- Biological half-life is the time it takes for one half of the radioactive atoms present in the body to be biologically removed.
  - Pu - in liver: 40 years
  - Pu - in bone: 100 years
  - H-3: 10 days

The biological half-life of tritium is about 10 days.



Radiation Fundamentals

- **Radioactive contamination**
  - Radioactive contamination is radioactive material that is uncontained and in an unwanted place. (There are certain places where radioactive material is intended to be.)

Occupational	Environmental
dpm/100 cm^2	pCi/g
μCi/ml	pCi/L

Radiation Fundamentals

Ionization

- Ionization is the process of removing electrons from neutral atoms.
  - It is important to note that exposure to ionizing radiation, without exposure to radioactive material, will not result in contamination of the worker.

The Four Basic Types of Ionizing Radiation

- The four basic types of ionizing radiation of concern in the DOE complex are:
  - alpha particles,
  - beta particles,
  - gamma or X rays,
  - neutrons.

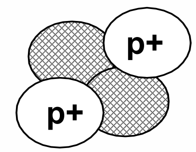
Radiation Fundamentals

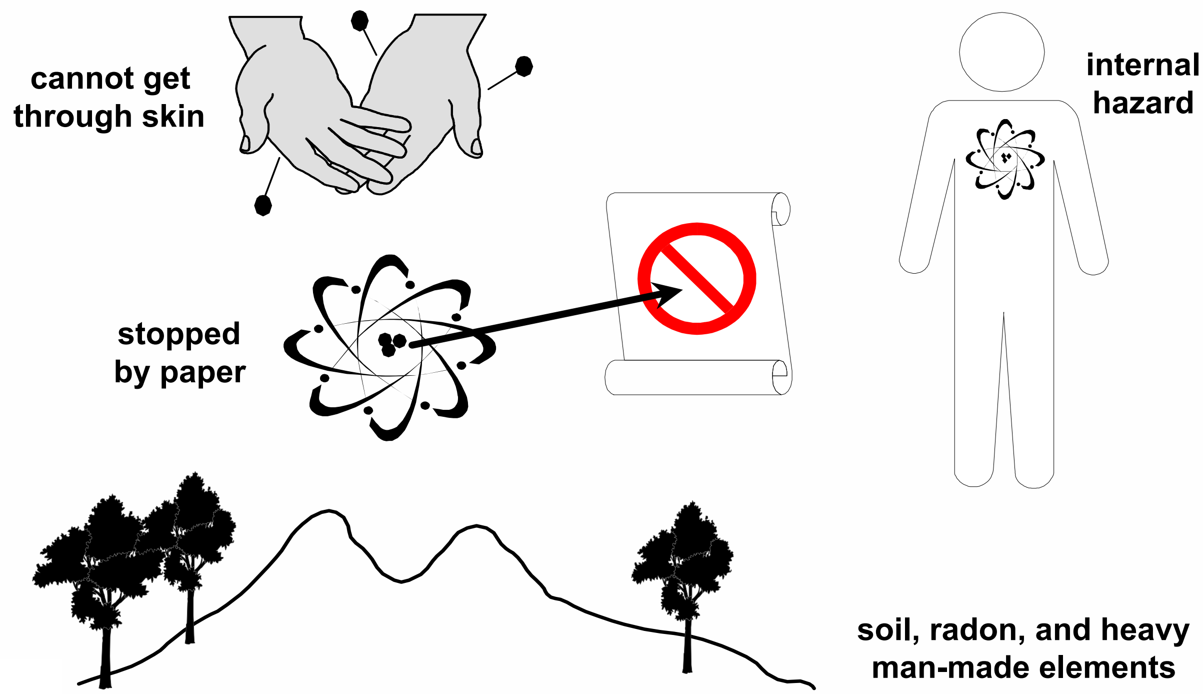
Alpha Particles

- **Physical Characteristics**· Large mass (2 protons, 2 neutrons)
- **Range**·1-2 inches in air
- **Shielding**·Dead layer of skin
- **Biological Hazards**·Internal, it can deposit large amounts of energy in a small amount of body tissue.

Radiation Fundamentals

Alpha particles are highly energetic helium nuclei





Radiation Fundamentals

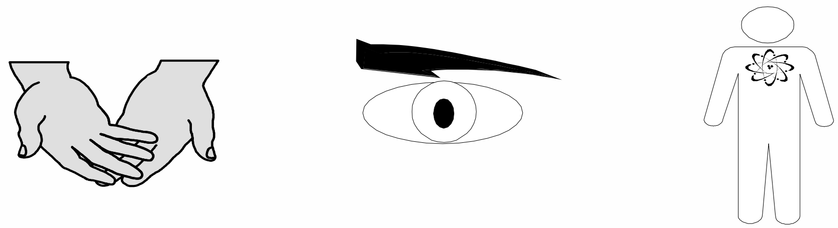
Beta Particles

- **Physical Characteristics**·Small mass, electron size
- **Range**· Short distance (one inch to 20 feet).
- **Shielding**·Plastic
- **Biological Hazard**· Internal hazard. Externally, may be hazardous to skin and eyes.

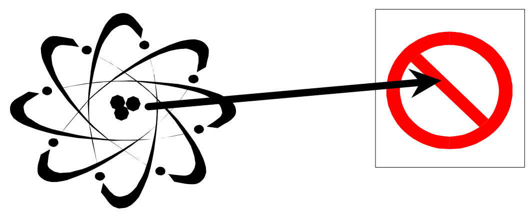
Radiation Fundamentals

Beta particle: an energetic electron from an unstable nucleus

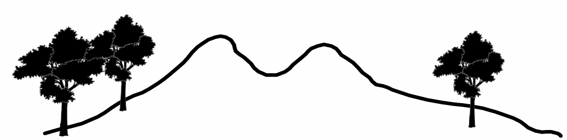
skin, eye, and internal hazard



stopped by plastic



natural food, water, air



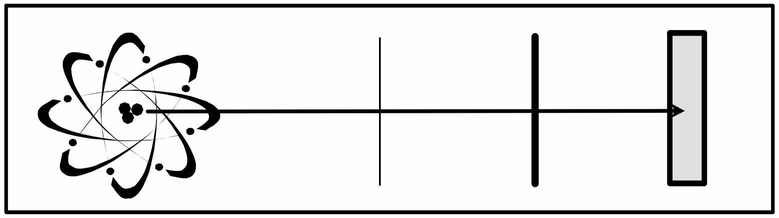
Radiation Fundamentals

- **Gamma Rays/X-Rays**
  - **Physical Characteristics** No mass. No charge. Electromagnetic wave or photon.
  - **Range**· Very far. It will easily go several hundred feet.Very high penetrating power.
  - **Shielding**· Concrete. Water. Lead.
  - **Biological Hazard**· Whole body exposure. The hazard may be external and/or internal. This depends on whether the source is inside or outside the body.

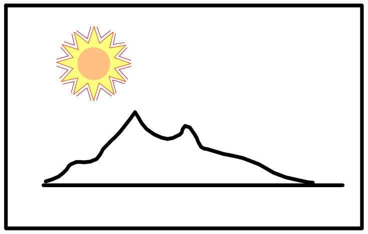
Radiation Fundamentals

Gamma and X-rays are photons (massless electromagnetic energy)

stopped by dense shielding



naturally present in soil and in cosmic radiation



medical, radioactive materials

Radiation Fundamentals

- **Neutrons**
  - **Physical Characteristics** Fairly large. No charge. Has mass.
  - **Range** Range in air is very far. Easily can go several hundred feet. High penetrating power due to lack of charge (difficult to stop).
  - **Shielding**· Water. Concrete. Plastic (high hydrogen content).
  - **Biological Hazard** External whole body exposure.

Radiation Fundamentals

Units of Measure for Radiation

- **Roentgen (R)**
  - Only photon in air,
  - instruments measure

- **Rad (Radiation absorbed dose)**
  - A unit for measuring absorbed dose in any material.
  - Gray – 100 Rad

Radiation Fundamentals

- **Rem (Roentgen equivalent man)**
  - Most commonly used unit – for person dose.
  - Pertains to the human body.
  - Takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation.
  - Sievert – 100 Rem
    - *1 rem = 1,000 millirem (mrem).*
    - *1 R = 1,000 milliRoentgen (mR).*

Radiation Fundamentals

- **Radiation Quality Factors:**

  accounts for relative hazard from various forms of radiation

  - alpha = 20
  - beta = 1
  - gamma/x-ray = 1
  - neutron = 10

- **rad x quality factor = rem**

Biological Effects of Radiation

Objectives:

- Identify sources of naturally occurring and manmade radiation
- Identify average annual dose to the general population
- Understand methods by which radiation causes damage to cells
- Define “acute” and “chronic” dose
- Define “somatic” and “heritable” effect
- Understand effects associated with prenatal radiation dose
- Compare risks from radiation exposure to risks from daily life

Biological Effects of Radiation

- Radiation is better understood than most environmental agents
- Health effects information available from:
  - Atomic bomb survivors;
  - Radiation accidents;
  - Patients who have undergone radiation therapy; and
  - Exposures to radiation workers

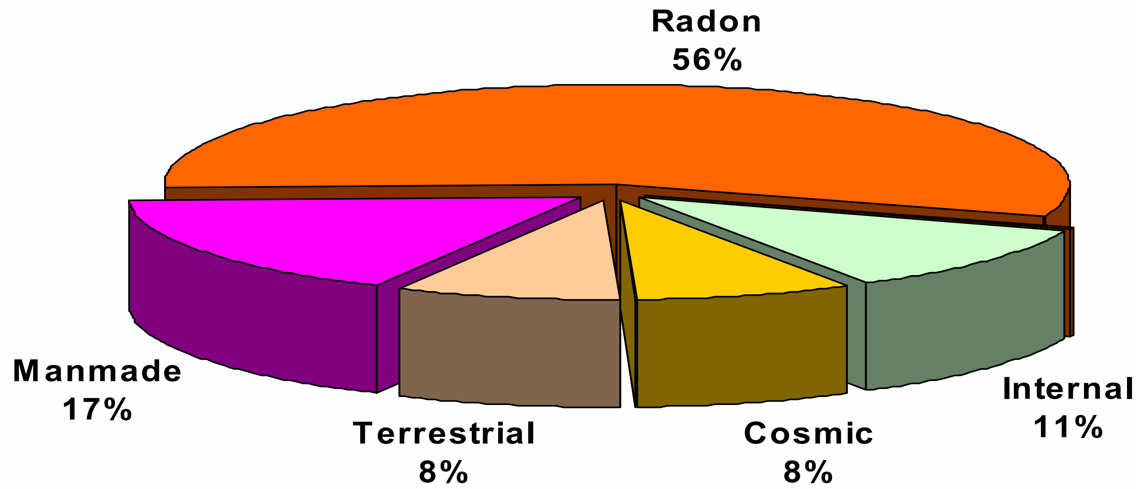
Biological Effects of Radiation

Sources of Radiation Exposures

- Occupational
  - DOE activities
- Non-occupational
  - Naturally occurring sources
    - *Radon*
    - *Sources in the human body*
    - *Sources in earth's crust (terrestrial)*
    - *Cosmic radiation*
  - Manmade sources
    - *Tobacco products*
    - *Building materials*
    - *Industrial sources*
    - *Medical radiation*
    - *Consumer products*
    - *Atmospheric testing of nuclear weapons.*

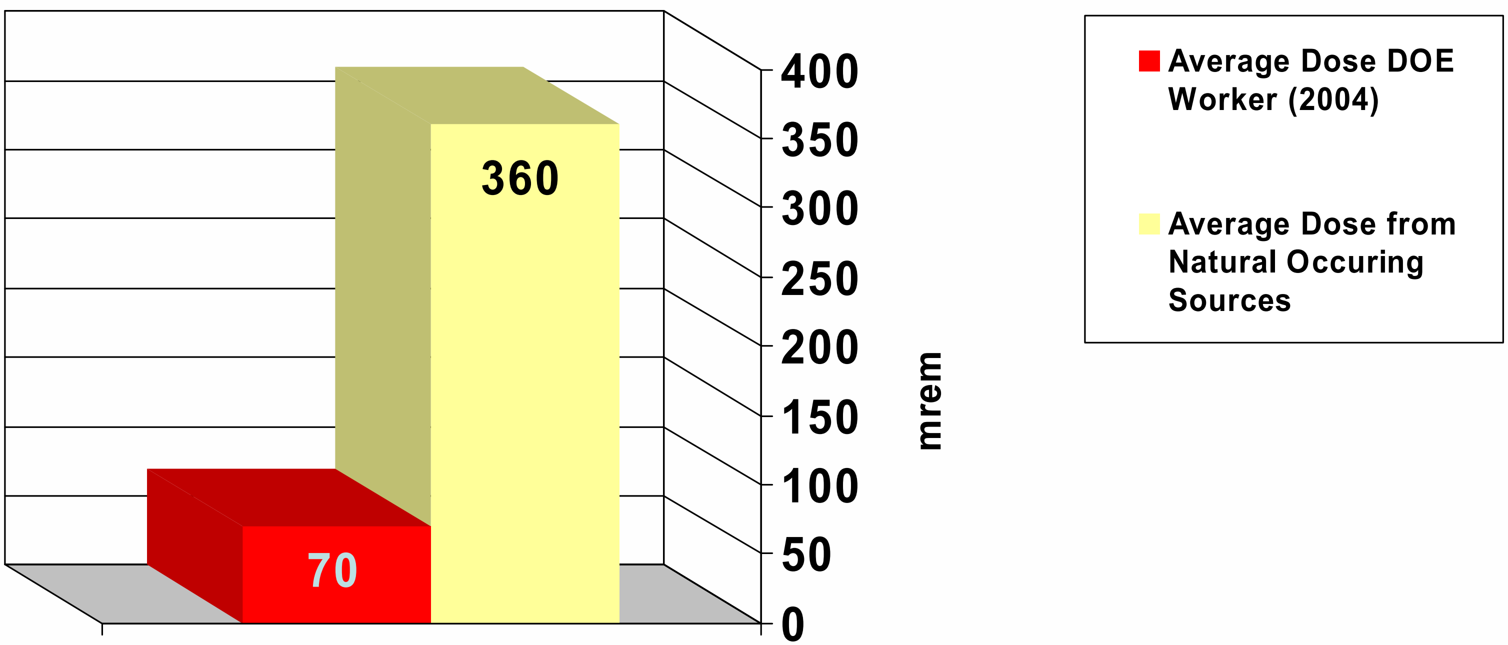
Biological Effects of Radiation

Non-Occupational Radiation Sources



Biological Effects of Radiation

Natural Background vs Occupational Exposures



Biological Effects of Radiation

Mechanisms of Cellular Damage and Repair

- The body is composed of cells the building blocks of organs and specialized tissues.
  - Two principal parts of cells
    - *The body - cytoplasm*
    - *The nucleus – genes (DNA)*
- Radiation interacts with cell
  - Water in cytoplasm is ionized producing free radicals
  - Genetic material in the nucleus is damaged (chromosome breaks)
- The cellular repair processes are activated

Biological Effects of Radiation

- **Results of Cell Damage:**
- **Cells function normally**
  - Radiation exposure is low
  - No vital structures damaged
  - Cells repair the damage
    - Note: the body repairs a large number of chromosome breaks every day
- **Cells function abnormally or die**
  - Cell incompletely repaired or not repaired at all.
  - Chromosome are not repaired correctly.

Biological Effects of Radiation

- **Actively dividing cells are more sensitive to ionizing radiation**
  - Blood-forming cells;
  - Lining of the intestinal tract;
  - Hair follicles; and
  - Sperm cells.

- **Slower dividing are not as sensitive**
  - Brain cells; and
  - Muscle cells

Biological Effects of Radiation

- **Biological effects depend on radiation dose**
  - How much
  - How fast

- **Acute vs. Chronic exposures**
  - Acute - High dose received in a short period of time.
  - Chronic – Low dose received over a long period of time.

Biological Effects of Radiation

Acute Doses

- The body's cell repair mechanisms are not as effective
  - Large acute dose required to see physical effects
  - Probability of large acute dose is small
  - In extreme cases i.e., Chernobyl firefighters (500 rem), the dose be so high recovery unlikely.
- Whole body
- Partial body
  - Focused dose
    - *Radiation therapy*

Biological Effects of Radiation

- **Chronic Doses**
  - Dose received from natural background every day or typical occupational exposures
  - Body has time to repair damage because a smaller percentage of the cells are damaged at any given time.

Biological Effects of Radiation

- **Somatic effects**
  - Effects which appear in the exposed worker
    - Prompt effects – appear shortly after exposure
      - *Hair loss after exposure to scalp*
    - Delayed effects – appear years after exposure
      - *Cancer, cataracts*

Biological Effects of Radiation

Prompt effects of acute exposures

(Effects dependent on medical intervention and health of individual)

Dose (Rad)	Effect
0 -25	No detectable symptoms or blood changes
25 -100	Changes in blood
100 - 300	Nausea, Anorexia
300 - 600	Diarrhea, hemorrhage, possible death

Biological Effects of Radiation

- **Delayed Effects**
  - Result from continuing low-level chronic exposures or from a single acute exposure
  - Some result are from damage to the cell's DNA
  - Examples include:
    - Cancer;
    - Cataracts; and
    - Life shortening

Biological Effects of Radiation

Heritable Effects

- Abnormalities that may occur in the future generations of exposed individuals
- Have been observed in plants and animals
- Have not been observed in humans but are considered possible

Biological Effects of Radiation

Factors Affecting Biological Damage

- Dose rate
- Total dose
- Type of radiation
- Cell sensitivity
- Individual sensitivity
- Area of the body exposed

Biological Effects of Radiation

- **Prenatal Radiation Exposure**
  - No effects observed in children of survivors conceived after atomic bomb dropped
  - Effects seen in children who were in the womb at the time the atomic bomb was dropped
    - Smaller head size and overall physical size
    - Lower average birth weight
    - Lower IQ scores
    - Increased behavioral problems

Biological Effects of Radiation

Factors Affecting Prenatal Radiation Exposure

- Sensitivity of the fetus.
  - Embryo/fetal cells are rapidly dividing,
  - The embryo/fetus most susceptible 8 - 15 weeks after conception.
- Many other chemical and physical (environmental) factors are suspected of causing or known to have caused damage to a fetus, especially early in the pregnancy.

Biological Effects of Radiation

Risks in Perspective

- Current assumptions
  - Any dose received carries a risk of health effects
  - The risk is proportional to the magnitude of the dose received
- This is referred to as the Linear Non-Threshold model
- These assumptions are conservative
  - Health effects have not been observed at doses less than 10 rem
- Possibility of cancer increase cannot be dismissed

Biological Effects of Radiation

Estimated Loss of Life Expectancy from Health Risks

Health risk	Estimated Loss of Life Expectancy
Smoking 20 cigarettes a day	6 years
Overweight by 15%	2 years
Alcohol consumption (U.S. Average)	1 years
Agricultural accidents	320 days
Construction accidents	227 days
Auto accidents	207 days
Home accidents	74 days
Occupational Radiation dose (1 rem/yr), from age 18 – 65 (47 rem total)	51 days
All natural hazards (hurricane, earthquake, flood)	7 days
Medical radiation	6 days

Biological Effects of Radiation

- Health risks from occupational radiation exposure are smaller than risks associated with day-to-day activities.

- Acceptance of a risk:
  - is a personal matter
  - requires a good deal of informed judgment.

- Some scientific groups claim that the risk is too high. DOE continues to fund and review worker health studies to resolve these concerns.

ALARA

Objectives:

- State the ALARA concept.
- State the DOE/Site management policy for the ALARA program.
- Identify the responsibilities of management, the Radiological Control Organization, and the radiological worker in the ALARA Program.
- Identify methods for reducing external and internal radiation dose.
- State the pathways by which radioactive material can enter the body.
- Identify methods a radiological worker can use to minimize radioactive waste

ALARA

ALARA concept

- ALARA stands for As Low As Reasonably Achievable.
- Because some risk, however small, exists from any radiation dose, all doses should be kept ALARA.
- Includes reducing both internal and external radiation dose.
- ALARA is the responsibility of all employees.

ALARA

- DOE Management Policy for the ALARA program
  - Radiation exposure to the work force and public shall be controlled such that:
    - Radiation doses are well below regulatory limits.
    - There is no radiation exposure without an overall benefit.

ALARA

Hierarchy of Controls:

used for External and Internal Radiation Dose Reduction

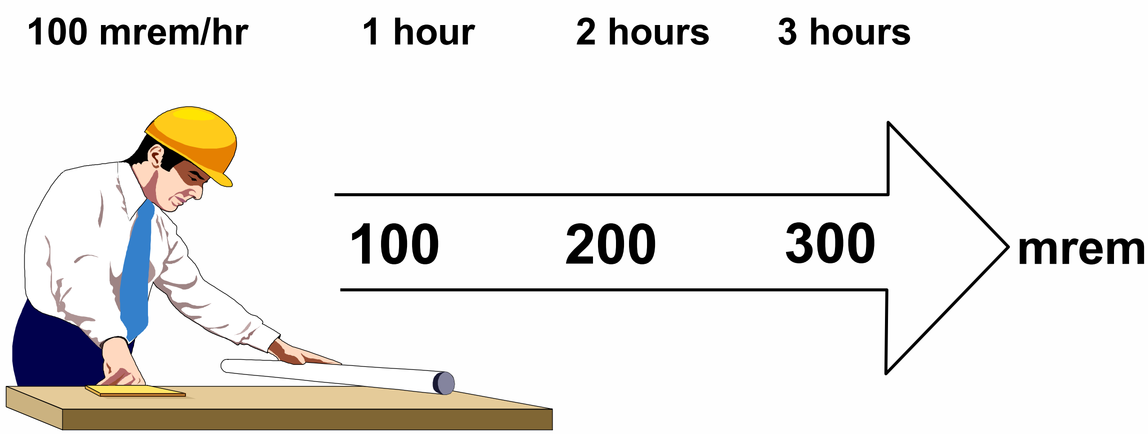
- **Engineering controls**- primary method to control exposure (e.g., enclosed hoods).
- **Administrative controls**- next method to control exposures (e.g., postings).
- **Personnel Protective Equipment**- last method (e.g., respirators).

ALARA

- **Basic protective measures used to minimize external dose include**
  - Minimizing time in radiation areas
  - Maximizing the distance from a source of radiation
  - Using shielding whenever possible
  - Reducing the amount of radioactive material (source reduction)

ALARA

An ALARA principle is to reduce the time in a radiation field



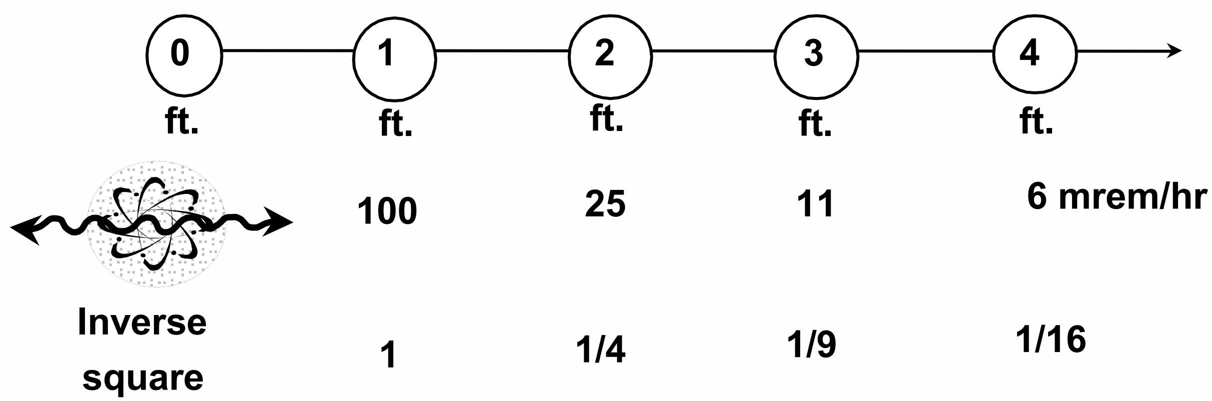
ALARA

Methods for minimizing time

- Plan and discuss the task thoroughly prior to entering the area.
- Use only the number of workers actually required to do the job.
- Have all necessary tools present before entering the area.
- Use mock-ups and practice runs.
- Take the most direct route.
- Don't loiter in area.
- Work efficiently and swiftly.
- Do the job right the first time.
- Perform as much work outside the area as possible.
- Do not exceed stay times.

ALARA

Another ALARA principle is to maximize the distance from source



ALARA

- **Methods for maximizing distance**
  - Stay as far away from radiation sources as practical given the task assignment.
    - For small area sources the dose rate follows inverse square law.
      - *Double the distance, the dose rate falls to ¼*
  - Be familiar with radiological conditions in the area.
  - During work delays, move to lower dose rate areas.
  - Use remote handling devices when possible.

ALARA

- **Proper uses of shielding**
  - Permanent shielding.
  - Use shielded containments.
  - Wear safety glasses/goggles to protect your eyes from beta radiation, when applicable.
  - Temporary shielding (e.g., lead blankets or concrete blocks)
    - Only installed when proper procedures are used.

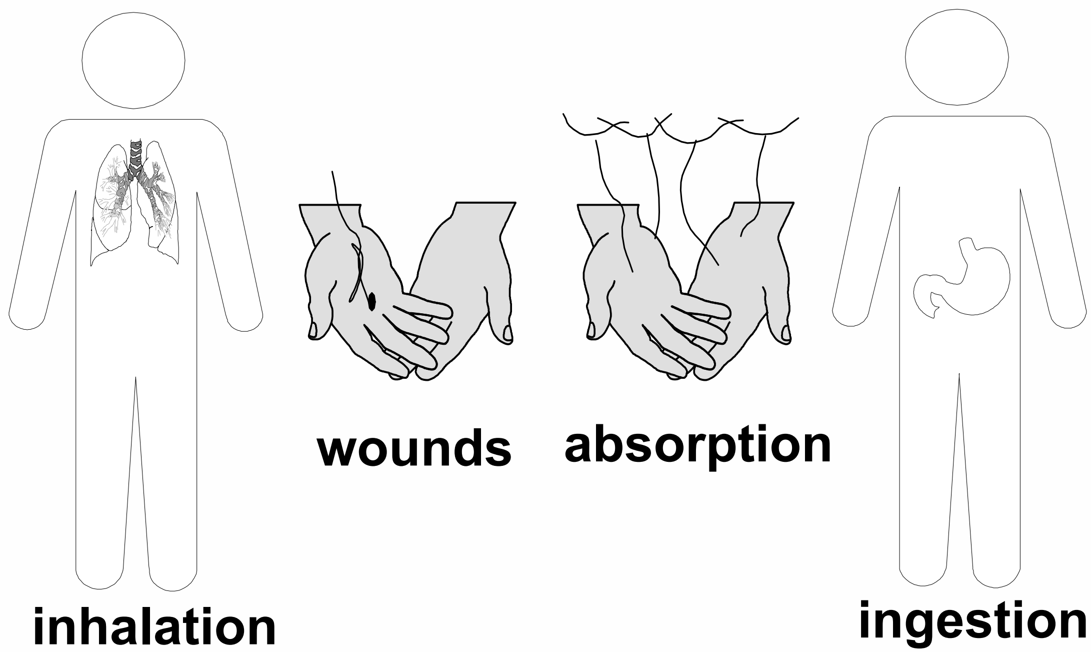
ALARA

Source Reduction

- Flushing radioactive systems.
- Decontamination, and removal of contaminated items.
- Use of materials low activation.
- Use of non radiological materials/procedures.

ALARA

Radionuclides can enter the body in four ways



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ALARA

- **Methods to reduce internal radiation dose**
  - Wear respirators properly.
  - Report all wounds or cuts.
  - Comply with the requirements of the controlling work documents.
  - Do not eat, drink, smoke, or chew in Radioactive Materials Areas, Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas.

ALARA

Methods to minimize radioactive waste

- Minimize the materials used for radiological work.
- Take only the tools and materials you need for the job into areas controlled for radiological purposes.
- Unpack equipment and tools in a clean area.
- Use tools and equipment that are identified for radiological work when possible.
- Use only the materials required to clean the area. An excessive amount of bags, rags, and solvent adds to radioactive waste.
- Sleeve, or otherwise protect with a covering such as plastic, clean materials brought into contaminated areas.

Personnel Monitoring

Objectives:

- State the purpose and worker responsibilities for each of the external dosimeter devices used at the site.
- State the purpose and worker responsibilities for each type of internal monitoring method used at the site.
- State the methods for obtaining radiation dose records.
- Identify worker responsibilities for reporting radiation dose received from other sites and from medical applications.

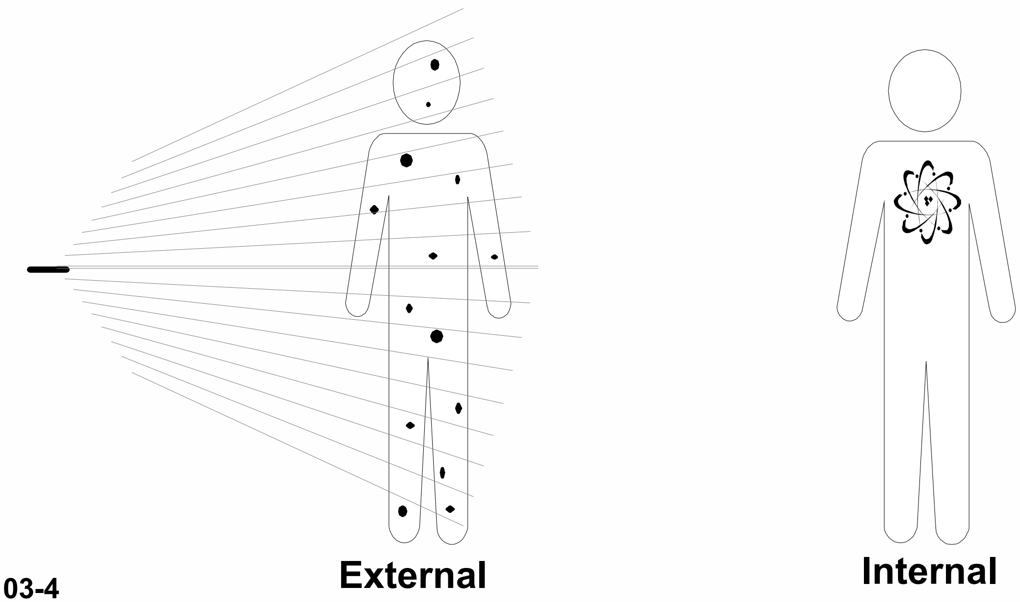
Personnel Monitoring

- External exposure results from radiation that comes from radioactive material outside of the body. A "personnel dosimeter" is a device used to measure external dose.

- Internal dose is radiation that comes from radioactive material within the body. The whole body counter, chest counter, and bioassay sampling are methods for measuring internal dose.

Personnel Monitoring

Dose can be delivered by external or internal sources



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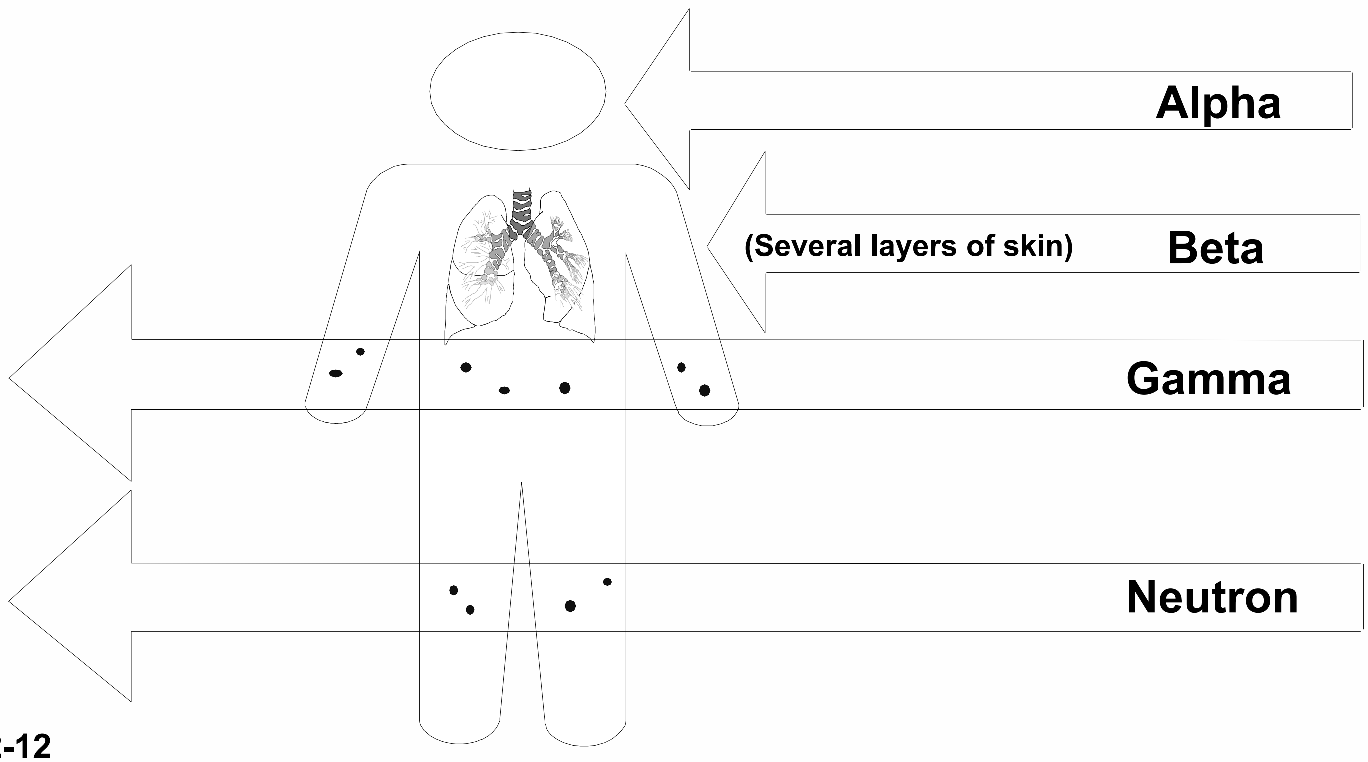
Personnel Monitoring

External Dosimetry

- A personnel dosimeter is a device used to measure radiation dose. Different types of external dosimeters may be used.
  - Radiological Control personnel determine which type(s) are needed.
  - Check signs and radiological work permits (RWPs) for the requirements.

Personnel Monitoring

Relative penetrating ability of ionizing radiation in tissue



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Personnel Monitoring

- Wearing dosimeters properly
  - Primary dosimeters normally are be worn on the chest area. This area is on or between the neck and the waist.
    - Radiological control procedures or work authorizations may identify other placement.
  - Supplemental dosimeters are worn in accordance with site policy.
    - This includes pocket, electronic dosimeters, extremity dosimetry, or multiple dosimeter sets.

Personnel Monitoring

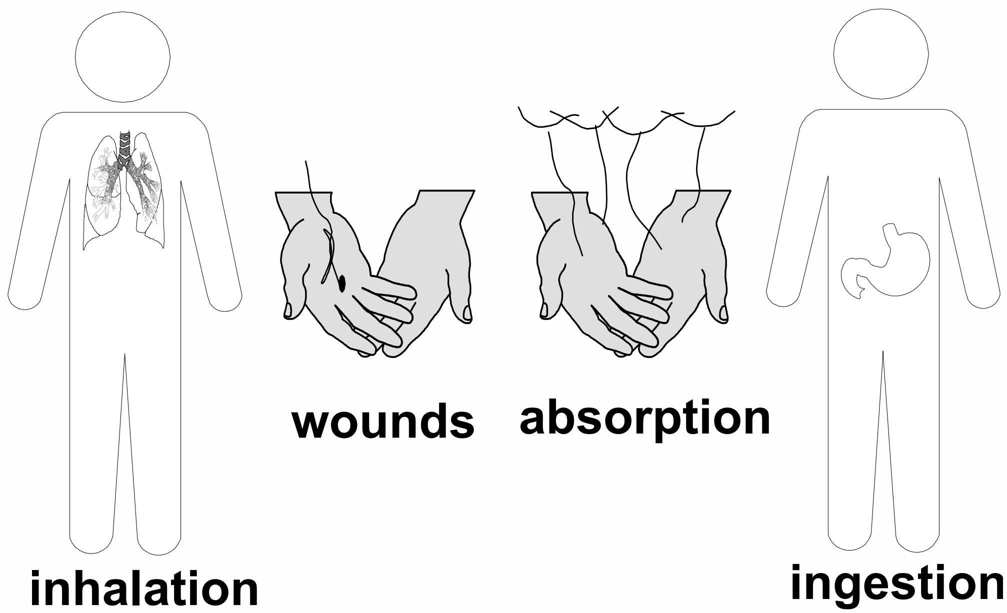
- Care of Dosimeters
  - **Take proper actions if dosimeter is lost, damaged, contaminated, or off-scale.**
  - **Return dosimeters for processing as directed. Personnel that fail to return dosimeters may be restricted from continued radiological work.**
  - **Dosimeters issued from the permanent work site cannot be worn at another site.**

Personnel Monitoring

- **Internal Monitoring**
  - Evaluate how much radioactive material has been taken into the body
    - Whole body counters, chest counters, measurements of airborne radioactivity, and/or bioassay samples (urine/fecal) may be used to evaluate radioactive material in the human body.
    - An internal dose estimate is performed based on these measurements.

Personnel Monitoring

Radionuclides can enter the body in four ways



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Personnel Monitoring

- Methods for Obtaining Radiation Dose Records
- Right to request reports of exposure
  - Terminating employment,
  - Annually
  - Upon request
- Contractor is required to report to DOE and the individual any significant unplanned exposure or exposure above the limit.

Personnel Monitoring

- **Report radiation dose received from other facilities and medical applications**
  - Notify Radiological Control personnel prior to and following any radiation dose received at another facility so that dose records can be updated.
  - Notify Radiological Control of medical radioactive applications.
    - This does not include routine medical and dental X rays.
    - This does include therapeutic and diagnostic radio-pharmaceuticals.

Postings and Access Control

Objectives:

- Understand purpose of and information found on Radiological Work Permits (RWPs).
- Understand worker's responsibilities for entering and working in controlled areas.
- Understand consequences of disregarding postings.
- Identify postings for radiological controlled areas.
- Identify types of radiological controlled areas.
- Understand requirements for entering, working in, and exiting posted areas.

Postings and Access Control

Radiological Work Permits (RWPs)

- RWPs establish controls for entry into radiological areas.
  - Inform workers of area radiological conditions.
  - Inform workers of entry requirements.

Postings and Access Control

- **General Radiological Work Permit**
  - Control routine or repetitive activities in well characterized stable radiological conditions
    - *tours*
    - *inspections*
    - *minor work activities*
  - Good for up to one year

- **Job-specific Radiological Work Permit**
  - Control non-routine operations or work in areas with changing radiological conditions.
  - Remains in effect for the duration of a particular job.

Postings and Access Control

Information found on the RWP

- Description of work
- Work area radiological conditions
- Dosimetry and protective clothing requirements
- Access requirements
- Exit requirements

Postings and Access Control

Pre-job briefing requirements

- Required level of training for entry.
- Protective clothing/equipment requirements.
- Radiological Control coverage requirements and stay time controls, as applicable.
- Limiting radiological condition that may void the permit.
- Special dose or contamination reduction.
- Special personnel frisking considerations.
- Authorizing signatures and unique identifying designation or number.

Postings and Access Control

Worker Responsibilities

- Read and comply with the RWP requirements.
- Workers must acknowledge they have read, understood, and agreed to comply with the RWP.
- Report to Radiological Control personnel if radiological controls are not adequate or are not being followed.

Postings and Access Control

- **Radiological postings**
  - Alert personnel to the presence of radiation and radioactive materials
  - Aid in minimizing personnel dose.
  - Prevent the spread of contamination.
- **Posting requirements**
  - Areas and materials controlled for radiological purposes will be designated with a magenta or black standard three-bladed radiological warning symbol (trefoil) on a yellow background.

Postings and Access Control

Worker's Responsibilities

- Read all signs
  - A sign or posting may be replaced day to day
- Obey posted, written or oral directions
- Report unusual conditions
  - Leaks, spills, or alarming area monitors.
- Be aware of changing radiological conditions
  - Others' activities may change the radiological conditions in your area

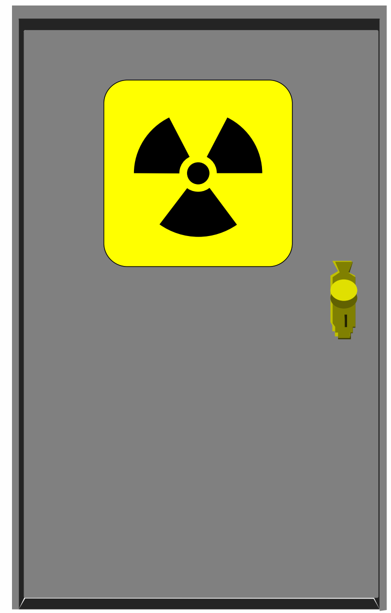
Postings and Access Control

- **Consequences of disregarding radiological postings, signs, and labels**
  - Unnecessary or excessive radiation dose.
  - Personnel contamination.
  - Disciplinary actions include:
    - Formal reprimand;
    - Suspension; or
    - Possible termination.

Postings and Access Control

Types of Posted Areas

- Radiation Areas
- High Radiation Areas
- Very High Radiation Areas
- Airborne Radioactivity Areas
- Contamination Areas
- High Contamination Areas
- Radioactive Materials Areas
- Others



Postings and Access Control

Radiation Area:
> 5 mrem/hr
but not more than
100 mrem/hr

30 cm from source

Postings and Access Control

- **Minimum requirements for unescorted entry:**
  - Appropriate training, such as Radiological Worker I Training.
  - Personnel dosimeter.
  - Worker's signature on the RWP, as applicable.

- **Minimum requirements for working in an RA**
  - Don't loiter in the area.
  - Follow proper emergency response to abnormal situations.
  - Avoid hot spots.
    - *Hot spots are localized sources of radiation or radioactive material normally within facility piping or equipment.*

Postings and Access Control

High Radiation Area:
> 0.1 rem/hr
But not more than
500 rad/hr

30 cm from source

NOTE: May use Caution or Danger on sign

Postings and Access Control

- **Minimum requirements for entering HRAs**
  - Appropriate training (e.g., Radiological Worker I Training plus High Radiation Area Training or Radiological Worker II Training)
  - Worker signature on the appropriate Radiological Work Permit (RWP)
  - Personnel and supplemental dosimeter
  - Survey meter(s) or dose rate indicating device available at the work area (may be required for certain jobs)
  - Access control
  - A radiation survey prior to first entry
  - Additional requirements where dose rates are greater than 1 rem in an hour

Postings and Access Control

Very High Radiation Area: >500 rad/hr

1 meter from source

Postings and Access Control

Very High Radiation Area

- Very few such areas
- Very rarely accessed
- Very prescriptive controls over any access

Postings and Access Control

Airborne Radioactivity Area:
> Derived Air Concentration values (DAC)
or
12 DAC-hrs in a week

NOTE: May use Caution or Danger on sign

Postings and Access Control

- **Unescorted entry into Airborne Radioactivity Areas (ARAs) requires**
  - appropriate training, such as RW II training

Postings and Access Control

Contamination Area: Removable contamination above values in 10 CFR 835 Appendix D

Postings and Access Control

- Unescorted entry into Contamination Areas requires
  - appropriate training, such as RW II training, and
  - PPE

Postings and Access Control

High Contamination Area:

Removable contamination 100 times above values in 10 CFR 835 Appendix D

NOTE: May use Caution or Danger on sign

Postings and Access Control

- Unescorted entry into High Contamination Areas (HCAs) requires
  - Appropriate training, such as RW II training, and
  - PPE.

Postings and Access Control

Area in which have containers of radioactive material

Total activity of material exceeds values in 10 CFR 835 Appendix E

Postings and Access Control

- **Minimum Radioactive Material Area unescorted entry requirements:**
  - Appropriate training, such as Radiological Worker I Training.
  - Radiation Area or Contamination Area entry requirements may also apply.

Postings and Access Control

Other Postings

- Buffer areas
- Fixed Contamination Area
- Soil Contamination Areas
- Underground Radioactive Materials Areas

Postings and Access Control

- **Requirements for exiting radiological areas**
  - Observe posted exit requirements
  - Sign-out on RWP or equivalent

Contamination Control

Objectives:

- Define fixed, removable, and airborne contamination
- State sources of radioactive contamination
- State the appropriate response to a spill of radioactive material
- Identify methods used to control radioactive contamination
- Identify the proper use of protective clothing
- Identify the purpose and use of personnel contamination monitors.
- Identify the normal methods used for decontamination.

Contamination Control

- Contamination control is an important aspect of radiological protection.
- Using proper contamination control practices helps to ensure a safe working environment.
- Important for all employees to recognize potential sources of contamination and to use appropriate contamination control methods.

Contamination Control

- **Ionizing Radiation vs. Radioactive Contamination**
  - Ionizing radiation
    - Energy (particles or rays) emitted from radioactive atoms or generated from machines such as X-ray machines
  - Radioactive contamination
    - Radioactive material which escapes its container
- **Radiation is energy**
- **Contamination is a material**

Contamination Control

- Radioactive contamination can be
  - Fixed
  - Removable
  - Airborne
- Fixed contamination
  - Contamination that cannot be easily removed from surfaces by casual contact
    - May be released by buffing, grinding, etc
    - May "weep" or leach

Contamination Control

Contamination Control

- **Removable contamination**
  - Contamination that can easily be removed from surfaces
    - Any object that comes in contact with it may become contaminated
    - It may be transferred by casual contact
    - Air movement across removable contamination could cause the contamination to become airborne

Contamination Control

Contamination Control

- **Airborne contamination**
  - Contamination suspended in air
    - It may be released by buffing, grinding, or otherwise disturbing radioactive items and/or items with fixed or removable contamination
    - Inhalation results in radiation exposures

Contamination Control

Contamination Control

Sources

- Leaks or breaks in radioactive fluid systems
- Leaks or breaks in air-handling systems for radioactive areas
- Airborne contamination depositing on surfaces
- Leaks or tears in radioactive material containers such as barrels, plastic bags or boxes

Contamination Control

- **Common cause of contamination is sloppy work practices**
  - Opening radioactive systems without proper controls
  - Poor housekeeping in contaminated areas
  - Excessive motion or movement in areas of higher contamination
  - Improper usage of step-off pads, monitoring equipment and change areas
  - Violation of contamination control ropes and boundaries

Contamination Control

- **Indicators of possible contamination:**
  - Leaks, spills, or standing water that is possibly from a radioactive fluid system
  - Damaged or leaking radioactive material containers
  - Open radioactive systems with no observable controls
  - Dust/dirt accumulations in radioactive contamination areas
  - Torn or damaged tents and glove bags or containments on radioactive systems

Contamination Control

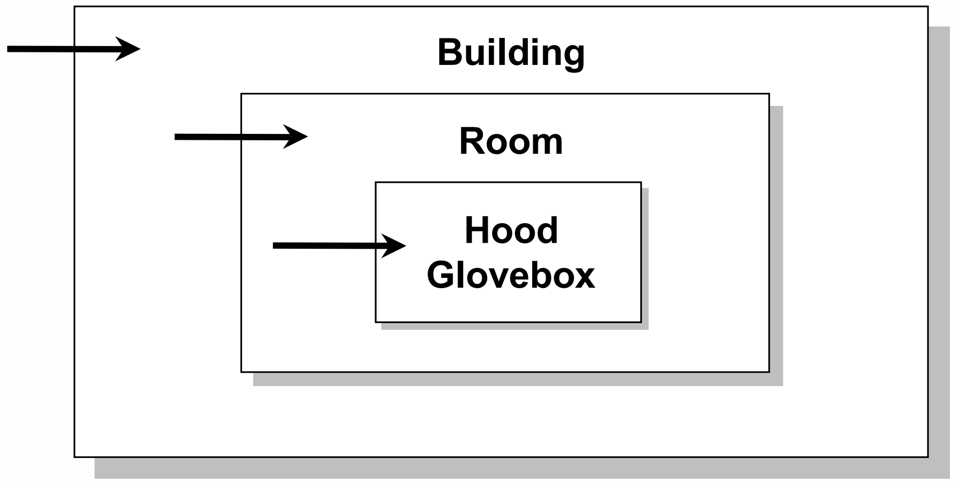
- **Radiological worker response to a spill of radioactive material**
  - Stop or secure the operation causing the spill, if qualified
  - Warn others in the area
  - Isolate the area
  - Minimize exposure to radiation and contamination
  - Secure unfiltered ventilation

Contamination Control

- **Contamination Control Methods**
  - Prevention
    - A sound maintenance program can prevent many radioactive material releases
    - Good work practices are essential
  - Engineering controls
    - Ventilation -negative pressure, proper airflow, HEPA filters
    - Containment -vessels, pipes, cells, glovebags, gloveboxes, tents, huts, and plastic coverings

Contamination Control

Airflow should be from areas of LEAST to MOST contamination in radiological facilities



Contamination Control

- **Contamination Control Methods**
- **Protective clothing**
  - Protective clothing is required for entering areas containing contamination and airborne radioactivity levels
  - The amount and type of protective clothing required is dependent on work area radiological conditions and nature of the job
  - Personal effects such as watches, rings, jewelry, etc., should not be worn

Contamination Control

- Full protective clothing generally consists of
  - Coveralls
  - Cotton liners
  - Rubber gloves
  - Shoe covers
  - Rubber overshoes
  - Hood

Contamination Control

- **Proper use of protective clothing**
  - Inspect protective clothing for rips, tears, or holes prior to use
  - Avoid getting coveralls wet
  - Contact Radiological Control personnel if clothing becomes ripped, wet, or otherwise compromised

Contamination Control

Contamination Monitoring Equipment

- Automatic Whole Body Monitors
- Hand Held Contamination Monitor:
  - Verify instrument is in service, set to proper scale, and has functioning audio equipment
  - Note background count rate at frisking station
  - Frisk hands before picking up the probe
  - Hold probe approximately ½ inch from surface being surveyed for beta/gamma and ¼ inch for alpha
  - Move probe slowly over surface, approximately 2 inches per second

Contamination Control

- Used to monitor individuals leaving contaminated areas
- Can detect alpha and beta radiation

Contamination Control

- **Perform frisk as follows:**
  - Head (pause at mouth and nose for approximately 5 seconds)
  - Neck and shoulders
  - Arms (pause at each elbow)
  - Chest and abdomen
  - Back, hips, and seat of pants
  - Legs (pause at each knee)
  - Shoe tops
  - Shoe bottoms (pause at sole and heel)
  - Personnel and supplemental dosimetry
- **The whole body survey should take at least 2-3 minutes**

Contamination Control

- Carefully return the probe to holder. The probe should be placed on the side or face up to allow the next person to monitor.
- If the count rate increases during frisking, pause for 5-10 seconds over the area.
- If contamination is indicated:
  - Remain in the area.
  - Notify Radiological Control personnel.
  - Minimize cross-contamination (e.g., put a glove on a contaminated hand

Contamination Control

- **Personnel decontamination**
  - Normally accomplished using mild soap and lukewarm water.
  - More aggressive decontamination techniques may be performed under the guidance of the Radiological Control Organization.

Contamination Control

- **Typical requirements for unescorted entry to Contamination, High Contamination, and Airborne Radioactivity Areas**
  - Appropriate training, such as Radiological Worker II training
  - Personnel dosimetry, as appropriate
  - Protective clothing and respiratory protection as specified in the RWP
  - Worker's signature on the RWP, as applicable
  - Pre-job briefings, as applicable

Contamination Control

- **Typical requirement for exiting Contamination, High Contamination, and Airborne Radioactivity Areas.**
  - Exit only at step-off pad
  - Remove protective clothing carefully. Follow posted instructions
  - Frisk or be frisked for contamination when exiting a contaminated area
  - Survey all tools and equipment prior to removal from the area
  - Use proper techniques to remove protective clothing
  - Do not smoke, eat, drink, or chew
  - Do not put anything in your mouth
  - When exiting, perform a whole-body frisk at the location provided by the Radiological Control Organization