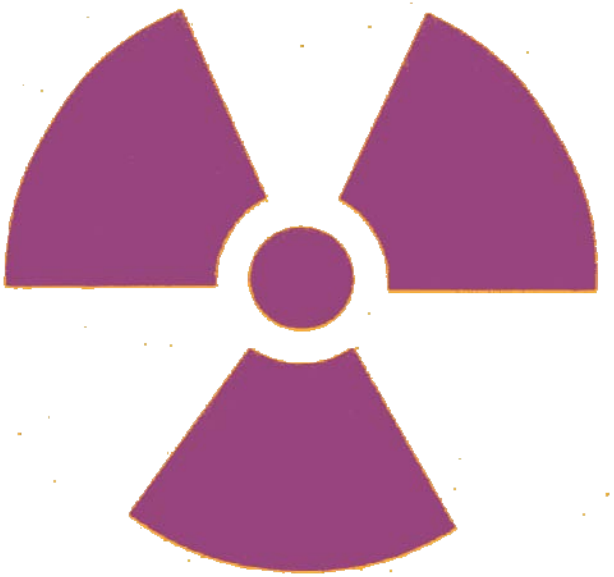
Radiation Safety Syllabus



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Revision History

Version Number	Revision Level	Principal Changes	Date of Publication
1.0	RSS-1	First Publication	Oct. 2005

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THE PLAIN FACTS ABOUT RADIATION

RADIATION -A FACT OF LIFE

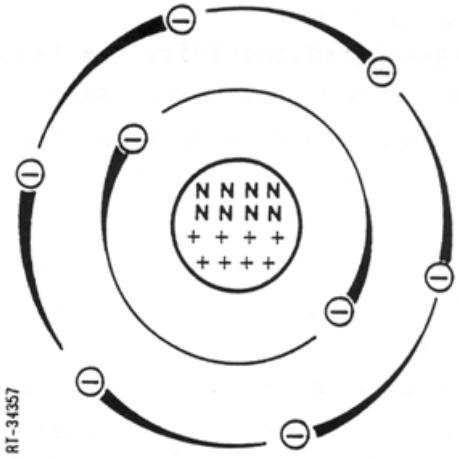
We live in a radioactive world. We are exposed to cosmic rays coming from the sun and from outer space; we are exposed to naturally occurring radioactive elements in the food we eat and the water we drink; our homes, off ices and factories are constructed of materials that contain radioactive elements that add to our -"Background" Radiation: travel by jet aircraft exposes us to higher levels of cosmic radiation; and, modern medical practices can expose us to high levels of radiation from diagnostic x-rays and radioisotopes.

The levels of natural radioactivity, called from one area of the world to another. People living in Denver receive two to four times as much radiation from cosmic rays as do tine people living in San Diego or Los Angeles, and people living in some parts of India and China receive 10 to 20 times as much background radiation as do the people in other parts of the world. The ill effects to those people who are exposed to these higher doses of radiation appear to be quite small. The only people who do display greater health problems due to high background doses are people who are exposed to radon gas or radon in their drinking water.

TYPES OF RADIATION

Radioactive materials consist of atoms that have more energy than they can retain and in order to get down to a stable state, they emit this energy as radiation. Radiation can actually take many forms, both particulate and electromagnetic. Particulate radiation is small Particles of matter that generally have an electric charge. Electromagnetic radiation is electric waves similar to light waves or radar waves.

Most of the particulate radiation comes from the center of the atom. The atom consists of a central core called the nucleus and a cloud of electrons orbiting the nucleus like a bunch of small moons. The nucleus contains two types of particles that are about the same size; protons which have a positive electric charge and neutrons that have no electric charge. The orbital electrons are tiny particles that have a negative electric charge. Electrons are 1800 times smaller than the proton or neutron.



Oxygen Atom

The protons, (+), and the neutrons, (N), are shown in the nucleus of the atom. The electrons, (-), are shown in orbit around the nucleus. The number of protons determines the atomic number of the atom and its chemical properties. The number of protons plus neutrons determines the atom's physical properties. The atom depicted above is oxygen 16 which is written $_{8}O^{16}$ where 8 is the atomic number, 16 is the atomic mass, and "O" is the element symbol.

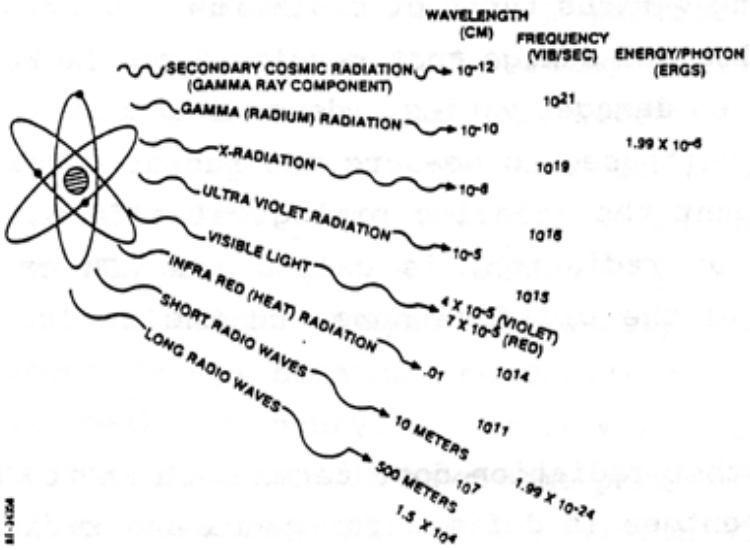
PARTICULATE RADIATION

The most common radiation particles are:

- The ALPHA PARTICLE with a plus 2 electric charge,
- The BETA PARTICLE with a Negative 1 electric charge,
- The POSITRON with a plus 1 electric charge,
- The PROTON with a plus 1 electric charge, and
- The NEUTRON with zero electric charge.

ELECTROMAGNETIC RADIATION

GAMMA RAYS AND X-RAYS are electromagnetic waves similar to radio waves, heat waves and microwaves. The difference between these waves is their, wavelengths; the gamma rays and x-ray have very short wavelengths compared to the other waves. In fact the gamma and x-ray wavelengths are so short, that they act like small particles and are called photons.



The Electromagnetic Spectrum

IONIZING RADIATION

Gamma rays and x-rays, and radiation particles, are frequently, called ionizing radiation; while infrared radiation, radio waves and microwaves are called non-ionizing radiation. The difference between the two types is that gamma rays, x-rays and radiation particles can dislodge an orbital electron from its position around the atom leaving behind a positively charge atom. This reaction is called ionization. The other waves, radar and infrared, cause ionization because the energy that they contain is too spread out to dislodge the electron.

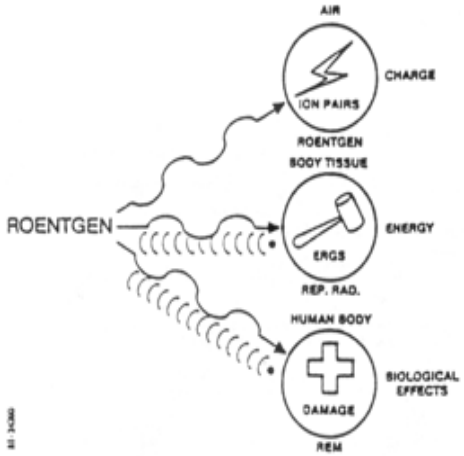
RADIATION DOSE

Soon after the discovery of x-rays, scientist and doctors started making use of them to take radiographs of people's broken bones. At about the same time, they became aware of the harmful effects of the x-rays and devised methods to measure the radiation and determine the amount of energy absorbed. Over the years a number of different instruments have been developed that can measure all of the various types of radiation. Of greatest concern to us is the biological damage that results from the body absorbing radiation. This damage varies, depending upon the type of radiation. The unit used to measure the radiation absorbed dose, taking into account the relative biological effectiveness of the different types of radiation, is called the REM or the The Sievert (Sv). The REM is the old dose name and the Sv is the new dose name.

There are other radiation dose terms such as the Roentgen and the RAD. The Roentgen is defined for gamma and x-ray absorbed in air and the RAD is defined for all types of radiation being absorbed in all types of matter.

The REM is determined by the following formula:

REM = RAD X RBE

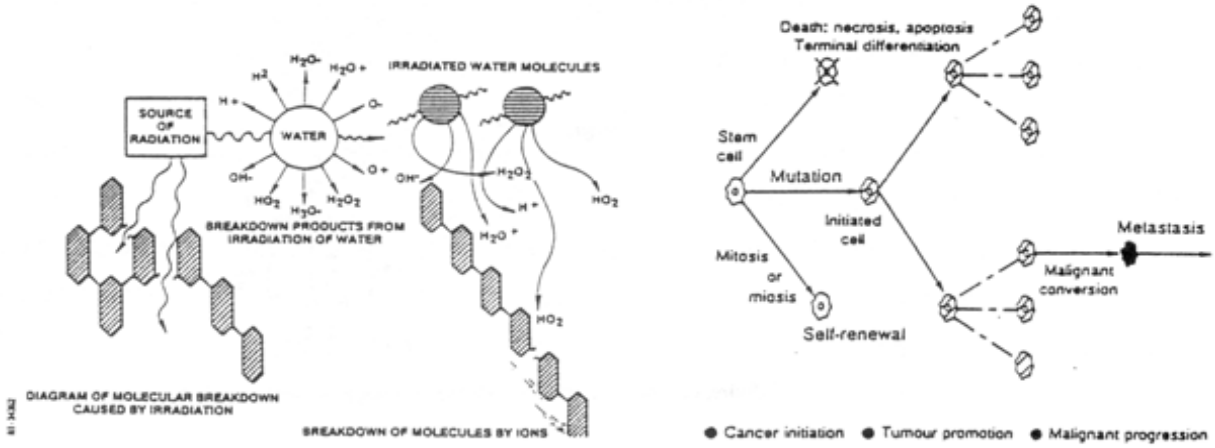


Defining the roentgen in terms of charge, energy and biological effects

Radiation Defined in Terms Of Charge, Energy, and Biological Effect

INTERACTION OF RADIATION WITH BIOLOGICAL SYSTEMS

Radioactive material emits energy which has the power to damage living tissue either directly or indirectly. All radiation damage starts as injury to the molecules in the cells; when enough cells in a particular organ have been impaired, the organ may stop working. This molecular damage is caused by the radiation directly altering the structure or the electrical charge of the molecule and indirectly by producing peroxides or other oxidizing agents in the liquid inside the cell which can damage the living cell. A single such event or even a small number of events, probably would not result in any permanent damage because the body's repair mechanisms would rapidly heal the injury. If there were a large number of these events, the person could have some permanent damage. Radiation can also cause abnormal cell division which possibly could result in the creation of some type of cancer or a tumor.



Molecular breakdown caused by radiation and water ions

BIOLOGICAL EFFECTS OF RADIATION

The two major types of biological effects due to radiation are genetic effects or birth defects, and somatic effects which are those effects experienced by the individual.

GENETIC EFFECTS

Genetic effects are the result of irradiation of the reproductive organs only. Radiation can alter genes and produce birth defects or mutations which may show up in future generations, This type of effect is very difficult to identify as being caused by radiation because we can' t determine the exact cause of any specific mutation. Most birth defects are the result of drugs (both legal and illegal), alcohol, and pollution. With radiation, it is known that high doses of radiation will cause birth defects, but it is not known exactly what effect small doses of radiation will have on biological organisms.

SOMATIC EFFECTS (THE EFFECTS OF RADIATION ON THE INDIVIDUAL)

Somatic effects can be either prompt or delayed. Prompt effects are generally caused by very high doses of radiation, 100 Rems or more, and can cause nausea, vomiting, massive loss of hair, fever, hemorrhaging, and blood changes. Whole body doses above 450 Rems can be fatal to about half the population. The delayed effects of radiation are an increase in the probability that an individual will develop leukemia or cancer and a shortening of the expected life span.

The biological damage from radiation is controlled by a number of factors:

- The body begins to repair itself as soon as damage occurs
- The type and energy of the radiation controls the amount of damage that occurs.
- Two other factors are total dose and exposure time.
- The final factor is the specific organ that is involved.

Some organs are more susceptible to radiation damage; such as the bone marrow which is very susceptible to damage from radiation; whereas, the bone itself is very resistant to damage from radiation.

RISK OF RADIATION DAMAGE

Several national and international scientific organizations have studied the question of an individual's risk of damage from radiation exposure. These groups include the International Committee on Radiation' Protection and the National Academy of Sciences. Working independently they have determined that a risk of getting cancer from a radiation exposure of 1 Rem is 1 chance in 3300. The American Cancer Society predicts that a normal chance of getting some form of cancer, due to his or her lifestyle, is 1 chance in 4 or 25%. If you add the radiation exposure to this 25%, it increases a person’s probability of getting cancer by only 0.03%, for a total of 25.03%.

It is important to realize that these risk numbers are only estimates. Many difficulties are involved in designing research studies that can accurately measure the small increases in cancer due to low exposures to radiation as compared to the normal incidence of cancer. The numbers used here result from studies involving high doses of radiation and they may not apply to doses at lower occupational levels of exposure. At low dose levels, it is known that the harmful effects of radiation are very small, but what is not known is how small these effects are.

RADIATION DETECTORS

A number of radiation detectors have been designed and they include Geiger counters, ion chambers, and proportional counters which are all different types of detectors that depend on the ionization of molecules in a gas to measure the passage of a radiation particle or photon. There are solid state detectors such as dosimeter, scintillation detectors, and other electronic detectors that will detect and measure radiation by various means. All of these detectors and monitors are used to identify the particles or photons or to measure the radiation dose rate.

FILM BADGES

Radiation can darken the film in the badge just as light can darken the film in a camera. Therefore, film can be used to determine a person's radiation exposure. After the film is developed, the exposure is determined by measuring the amount of light that can be transmitted through the film. The less light that is transmitted, the higher the person's dose. Film badges are used as personnel monitors and are the permanent legal record of radiation exposure.

RADIATION PROTECTION

How can you protect yourself from external radiation hazards?

- By: TIME, DISTANCE, and SHIELDING.
- Restrict the length of time you are exposed to a source of radiation, keep it as short as possible.
- Maintain the greatest possible distance between yourself and the source of radiation as is practical.
- Place as much shielding material between yourself and the source of radiation that will allow the job to proceed without hindering the operation. Proper shielding is especially useful for storage of radioactive materials.

RULES AND REGULATIONS

A number of different federal and state agencies control the use of radioactive materials and radiation-producing
machines.

Some of these agencies are:

The U.S. Nuclear Regulatory (NRC), The U.S. Department of Health and Human Services, Food and Drug Administration, Center for Devices and Radiological Health (CDRH). The U.S. Department of Transportation (DOT), and The State of California, Department of Health Services.

The NRC formulated the original regulations for use of radioactive materials and the standards for protection against radiation. The CDRH wrote the regulations for use of x-rays in medical practice and for x-ray cabinets. The DOT devised the regulations for transportation of Radioactive Materials. Agreement states, such as California must follow these federal regulations when they write their rules.

One of the major regulations concerns the exposure of people to radiation in the workplace. This is called Occupational Exposure. The limits apply to persons who are over 18 years of age and who are exposed to ionizing radiation as a result of their employment.

The allowable exposure to the whole body, gonads, blood-forming organs and the lenses of the eyes is 5 Rem per year averaged at 1.25 Rem per calendar quarter. Other organs, the skin, and the hands and feet can receive higher exposures because they are less susceptible to damage from radiation. This value, 5 Rem/yr, was based on the criterion that a person receiving this dose, year after year, beginning at age 18 and extending through his working life will suffer no observable ill effects --The general population and persons under 18 years of age may not be exposed to radiation in excess of 100 millirem per year from our use of radiation.
Consideration of the occupational exposure limit is an ongoing debate in the national and international radiation safety organizations. As more is learned about the effects of radiation and long time users, it is quite possible that the occupational exposure limits may be lowered in the future. Pregnant women shall not be occupationally exposed to more than 500 during the course of their pregnancy. This rule was established to protect the unborn child because the fetus is very sensitive to radiation.

Personnel monitoring equipment must be supplied to all personnel who actively work with radioactive materials or x-rays or who could be exposed to certain amounts of radiation as a part of their normal occupation.

RADIATION SAFETY OFFICER (RSO)

The Radiation Safety officer is responsible for assuring compliance with the state and federal regulations and with the license limitations. He provides personnel monitoring devices, conducts radiation surveys, inspections and monitors shipments and receipts of radioactive materials and inspects and monitors all operations involving radiation. The RSO also Conducts radiation safety training courses and approves all purchases of radioactive materials.

RULES FOR SAFETY

The primary objective of radiological safety is to keep all personnel exposures Reasonably Achievable, In order to achieve this objective, general rules have been established to guide the worker in handling radioactive materials, and while working around radiation-producing machines. These rules were written to protect the users and non-users. All users of radioactive material attend a radiation safety course where they are instructed in general radiation safety procedures and are informed of the Rules for Safety.

The rules for safety include:

Training in radiation safety and protection, proper use of film badges and dosimeters, the meaning of warning signs and proper posting thereof, proper storage of radioactive materials and areas of use, protection of personnel in adjoining areas, disposal of radioactive materials and the proper procedures for purchasing and shipping radioactive materials.

RADIATION SIGNS

- The radiation symbol must be included on all radiation warning signs. The symbol is the conventional three-bladed design, with the blades being colored magenta or purple on a yellow background.
- A Radioactive sign or label shall be posted in areas or on containers where certain amounts of radioactive materials are used or stored.
- A Radiation sign must be posted in each area in which an individual could receive in one hour body dose in excess of 5 mrem.
- A High Radiation sign must be posted in each area in which an individual could receive in any one hour a dose to the whole body in excess of 100

WARNING SIGNS

Radiation Warning Signs. Warning signs may be magenta and yellow, black and yellow, or black and white in color. Signs can be different sizes and can have different wording, but they must have the words “CAUTION” or DANGER” and some notification regarding radiation such as, “RADIATION AREA” or “RADIOACTIVE MATERIAL” and bear the familiar three bladed radiation symbol. Signs must be posted properly, not in a desk drawer, file cabinet, or on the back door of a camper. It is illegal to post any warning signs improperly.

RADIOACTIVE SOURCE HANDLING

Radioactive materials should be handled only by qualified personnel who have been instructed in radiation safety and are familiar with techniques for handling radioactive materials and are aware of proper procedures and the radiation hazards.

Before any operations begin the radiation dangers must be assessed and dose rates measured or estimated to assure minimal exposure to handlers and casual personnel. Operations should be planned to limit the time required for completion, to maximize the distance between the radioactive material and the operator, and to utilizing intervening shielding if feasible. Materials should not be handled with bare hands; or some other device should be used if possible.

When using devices and/or equipment containing radioactive materials and/or specific sources, it is imperative that the manufacturer's recommendations and handling procedures be followed. This includes the operational procedures and the maintenance procedures which normally include the source removal and replacement operations. In addition, it is absolutely necessary that there are no violations of the particular license conditions associated with the operation of the device.