Safety topic

Radiation protection

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Ionizing radiation

The use of ionizing radiation is common in health care settings, and is found in increasing frequency in manufacturing and industry. Radiation use in the occupational setting carries inherent health risks to workers and the public if efforts are not taken to minimize exposure. This document provides an overview of some of the control measures and rules for the safe use of ionizing radiation in the workplace.

Ionizing radiation use

There are many applications using ionizing radiation in industry. These uses include:

- Research, diagnostic testing, and treatment in health care
- Evaluation of materials and systems to ensure integrity of structures and welds in high hazard environments (for example, aerospace, power, and chemical industries)
- Identification of the presence of toxic metals (for example, lead in toys and dishes)
- Disinfection and sterilization of food and products

While having many benefits, radiation use can carry inherent health risks to workers and the public if efforts are not taken to minimize exposure. This document provides an overview of control measures and regulatory requirements for the use of ionizing radiation in the workplace.

Background

Radiation is energy transmitted through space. Radiation with enough energy to remove electrons from atoms and form ions is called ionizing radiation. The two types of ionizing radiation are particulate and electromagnetic radiation. Particulate radiation includes alpha, beta, and neutron radiation. Electromagnetic radiation includes x-ray and gamma ray radiation.

Ionizing radiation can come from two sources. The first source is from radioactive material. This is material that spontaneously decays, emitting radiation. The second source is from equipment that generates radiation, such as an x-ray machine. One of the key differences between radioactive material and radiation generating equipment is that the equipment only emits ionizing radiation when the equipment is on and has been activated. Radioactive material, though, continues to spontaneously emit radiation until it has decayed enough to no longer produce measurable radiation.

Health effects

Ionizing radiation can alter living cells and tissue by breaking chemical bonds. These changes to the chemical bonds can damage parts of cells, including DNA. Cells and living tissue try to repair damage, but sometimes the damage is too severe or widespread to be repaired. This results in cell, tissue, and, in severe cases, organ death. Sometimes cell repair can also alter cell function so that cells become cancerous.

Health effects caused by ionizing radiation can be acute or chronic. Acute effects are caused by high exposures to ionizing radiation over a short period of time. These effects usually appear quickly after excessive radiation exposure, and become more severe with higher exposures. Effects include burns and radiation sickness, and, if the dose is high enough, death. Symptoms of radiation sickness include nausea, vomiting, weakness, hair loss, and decreased organ function.

Chronic effects result from long-term exposure to low levels of radiation. Chronic health effects are usually delayed, sometimes taking 10 to 30 years to develop. Chronic effects include cancer, in which cell repair alters the cell growth and repair process, and changes to the cellular DNA, causing mutations. The greater the exposure, the more likely that these health effects will occur, but the amount of exposure does not affect the type or severity of the effect.

Organs of the body that contain cells that rapidly reproduce are more susceptible to ionizing radiation exposure. These include the blood-forming organs such as bone marrow and the spleen, reproductive organs, and skin. Organs that are less susceptible to radiation include the nervous system and muscles.

Because health effects increase with cell reproduction, a developing embryo/fetus is especially susceptible to damage from radiation; exposure should be carefully controlled. This susceptibility is particularly great during the first trimester of development. Health effects to a developing embryo/fetus from radiation exposure include low birth weight, mental retardation, and other neurological problems.

Radiation protection

Two key principles of radiation protection are "as low as reasonably achievable" (ALARA) and "time, distance, shielding."

ALARA
Since chronic (long-term. low-level) ionizing radiation exposure does not have a level where no health effects are thought to occur, a commonly used radiation principle is that of "as low as reasonably achievable" or ALARA. Use of the ALARA principle means that even if exposure is below the prescribed exposure limits, efforts should be made to further reduce exposure to as low a level as possible.

Time, distance, shielding
These three exposure-reducing principles can be used together or independently to reduce exposures.

- **Time—**limiting the amount of time of exposure to a fixed amount of radiation will result in decreased total exposure (dose).
    - An example of using time to limit exposure is when a worker enters a radiation area, performs the needed activity, and then exits immediately. This requires preplanning for the activity and knowing that this behavior reduces total exposure.
- **Distance—**The amount of radiation exposure varies inversely with the square of the distance. (For example, if the distance from a source of radiation is doubled, the dose is one quarter that of the original location).

  - Examples of using distance to reduce dose is to use tongs to hold a radioactive material instead of holding it directly in the hands, and to stand as far away as possible from a source of radiation.

- **Shielding—**The amount and type of required shielding can vary from the types of ionizing radiation. For x-ray and gamma ray radiation, lead, concrete, and barium sulfate are common shield materials.

  - An example of the use of shielding in a fixed setting is the use of lead shielding in the walls or wearing a lead apron. In a non-fixed location, using thick, dense materials (concrete, heavy equipment) between the radiation and the individual will reduce exposure levels.

Rules and statues in Oregon

Oregon Administrative Rules (OAR 333 -100 through 123) set the rules for x-ray generation machines and radioactive materials. Rules are specific to the type of ionizing source and the application. The information listed below includes general information and may not be applicable in all circumstances.

Radiation protection
Every license holder or registrant must develop, document, and implement a radiation protection program at a level that reflects the potential hazards associated with the applicable activities and radiation risk. The radiation protection program must include procedures and controls that will reduce both occupational and public radiation exposures to as low as reasonably achievable (ALARA).

The annual adult occupational exposure (dose) to ionizing radiation must be limited to the most restrictive of:

- Whole body dose of 5 rem
- The sum of deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rem
- Lens dose equivalent of 15 rem
- A shallow-dose equivalent of 50 rem to the skin of the whole body or to the skin of any extremity.

The annual occupational dose limits of ionizing radiation for minors is 10 percent of the annual dose limits for adults.

The occupational dose limit to an embryo/fetus during the entire pregnancy for someone who is a declared pregnant worker is 0.5 rem.

Monitoring ionizing radiation exposure is required in situations where it is likely that the occupational dose is in excess of 10 percent of the limited amount for both adults and minors, 20 percent of the dose limit for declared pregnant workers, and for any individual entering high or very high radiation areas or working with medical fluoroscopic equipment.

All individuals operating diagnostic X-ray equipment must be adequately trained in radiation safety. The amount and type of training is specific to the type of application (medical, dental, veterinary).

Radiation surveys of all analytical systems are performed upon installation of the equipment, at least every 12 months thereafter, whenever personnel monitoring devices show increased exposures, if inspections of equipment reveal abnormal conditions, and after intrusive maintenance activities.

Required postings for each licensee or registrant include:

- The license
- Copies of OAR 333-110 and OAR 333-120, or if not feasible, a summary of the documents and location where they can be accessed
- Operating procedures
- Notice of noncompliance involving radiological work conditions, if applicable
- "Notice to Employees", as required. Refer to: http://oregonstate.edu/ehs/sites/default/files/pdf/rso/notice_to_employees_2014.pdf

Or, search the internet under "Oregon Radiation Notice to Employees" to find and download the notice.

No individual shall be used routinely to hold film or patients, or work within the radiation area. Holding of patients shall be permitted only when it is otherwise impossible to obtain the necessary information.

X-ray machine registration
All operating x-ray machines must have a valid x-ray machine registration. This registration must be obtained from the state of Oregon Radiation Protection Services (RPS). Changes to the registration must be provided to Oregon RPS within 30 days. When required by the RPS, there must be an individual responsible for radiation protection of the machine. Prior to issuing an x-ray machine registration in a hospital, the x-ray machine must be inspected and approved. The x-ray inspector may be an employee of Oregon's RPS or may be an RPS accredited inspector.

Radioactive materials
Anyone who receives, produces, possesses, uses, transfers, owns, or acquires radioactive materials must be authorized with a specific or general license. A general license does not require an application with RPS; a specific license does.

General license
Within 30 days of taking possession of and prior to using general license radioactive materials, the owner must apply for registration. Changes to the registration information must be provided to Oregon Radiation Protection Services within 30 days.

Disposal
Whenever radiation producing machines or equipment, including general license containing radioactive material, are transferred or disposed of, RPS must be notified in writing by the registrant within 30 days of the date of such transfer or disposal.

Glossary

Radiation machine—Any device capable of producing radiation, except those that produce radiation only from radioactive material.

Radioactive material—Any solid, liquid, or gas that emits radiation spontaneously.

Radiation Equivalent Man (REM)—A measure of the absorbed dose and a weighting factor that accounts for the radiation's ability to cause biological harm.

Resources

Oregon OSHA topics page

https://osha.oregon.gov/Pages/topics/ionizing-radiation.aspx

Federal OSHA safety and health topics: ionizing radiation
https://www.osha.gov/SLTC/radiationionizing/

Oregon administrative rules: Oregon health authority public health division
http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_333/333_tofc.html#

More information on radiation can be found on: https://www.saif.com/safety-and-health/topics/chemical-and-other-health-hazards/biological-and-physical.html