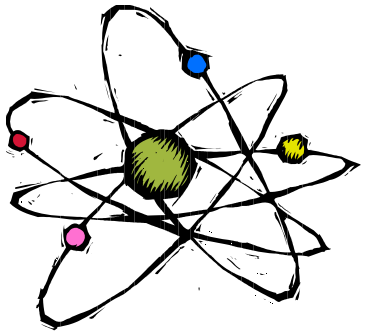
THE University of North Texas

Radiation Safety: Ionizing Radiation Equipment



Louie Tonry, CHP
Radiation Safety Officer

Overview

- Characteristics of Ionizing Radiation
- Radiation Units
- Biological Effects
- Occupational Dose Limits
- ALARA Philosophy
- Regulations, Rights & Responsibilities
- Dosimetry
- Summary & Questions

Characteristics

- Ionizing Radiation
  - Energy that is propagated through space and is of sufficient energy to be capable of producing ion pairs in matter.
  - Is of concern because it can transfer enough energy to damage or kill cells.

Types of Ionizing Radiation

- Ionizing radiation can be particulate or electromagnetic
- Particulate
  - α (alpha)
  - β (beta) or e^- (electrons)
  - η (neutron)
- Electromagnetic
  - γ (gamma) ray
  - x-ray

Units of Measure

- Activity – This is a unit which provide the number of atoms undergoing nuclear transformations (or decaying) per unit time. It tells the strength of a radioactive source.
  - Curie (Ci) (3.7×10^{10} disintegrations per second)
  - Becquerel (Bq) (37 GBq) (1 Bq = 1 disintegration per second)

Units of Measure

- Exposure is a measure of the strength of a radiation field.
- It is measured by counting the number of ion pairs created in a known volume of air by x or γ radiation at standard temperature and pressure (STP)
  - Roentgen (R)
  - Coulombs/kilogram (C/kg)

Units of Measure

- Dose – This is a measure of the amount of energy deposited in a unit mass of material. This can refer to energy deposited in a person or a block of granite.
  - Rad (100 ergs/gm)
  - Gray (Gy) (1 Gy = 100 R)

Units of Measure

- Dose Equivalent – This unit is important to us because it describes the relative biological damage caused by the deposition of a certain amount of energy or dose.
- These are the units used on our dosimetry records.
  - Rem = Rad x QF (1e, 5n, 20p/a)
  - Sievert (Sv) (1 Sv = 100 Rem)

Cell Sensitivity

- Tribondeau and Bergonie (1906), two French radiobiologists, generalized that a cells radiosensitivity is related to its reproduction rate and specificity
- The faster a cell divides and the less specific a cell's function is, the more sensitive the cell is to radiation damage.

Cell Sensitivity

- Two types of biological damage can occur in cells
  - Deterministic effects – these are also know an acute effects and occur from high doses of radiation
  - Stochastic effects – these are know as statistical effects because they are felt to increase the probability or “risk” of biological damage

Cell Sensitivity

- Deterministic effects occur within days or weeks after exposure
  - Examples include erythema, marked changes in blood cell count, cataracts, bloody stools
- Stochastic effects occur many years after exposure and may result from small chronic exposures.
  - Cancer induction is the primary stochastic risk from chronic exposures.
  - Stochastic risk from chronic exposures increase over time.

Fetal Exposure

- Fetal tissue is particularly sensitive to radiation exposure because fetal cells are rapidly dividing and non-specific
- During the first trimester fetal tissue is the most radiosensitive due to the rate at which they are dividing during that period
- Quite high exposures are required to cause fetal syndrome

Fetal Exposure

- Pregnant workers may declare their pregnancy with the Radiation Safety Officer and receive special exposure monitoring
- If you have any questions about fetal radiation exposures or special monitoring contact the Radiation Safety Officer
- For more information refer to USNRC Reg guide 8.29.

Biological Effects of Radiation

- It is thought that radiation effects vary with different exposure levels
- Two theories prevail regarding exposure vs. biological effects
- The theories are
  - Threshold Theory
  - Non-Threshold Theory

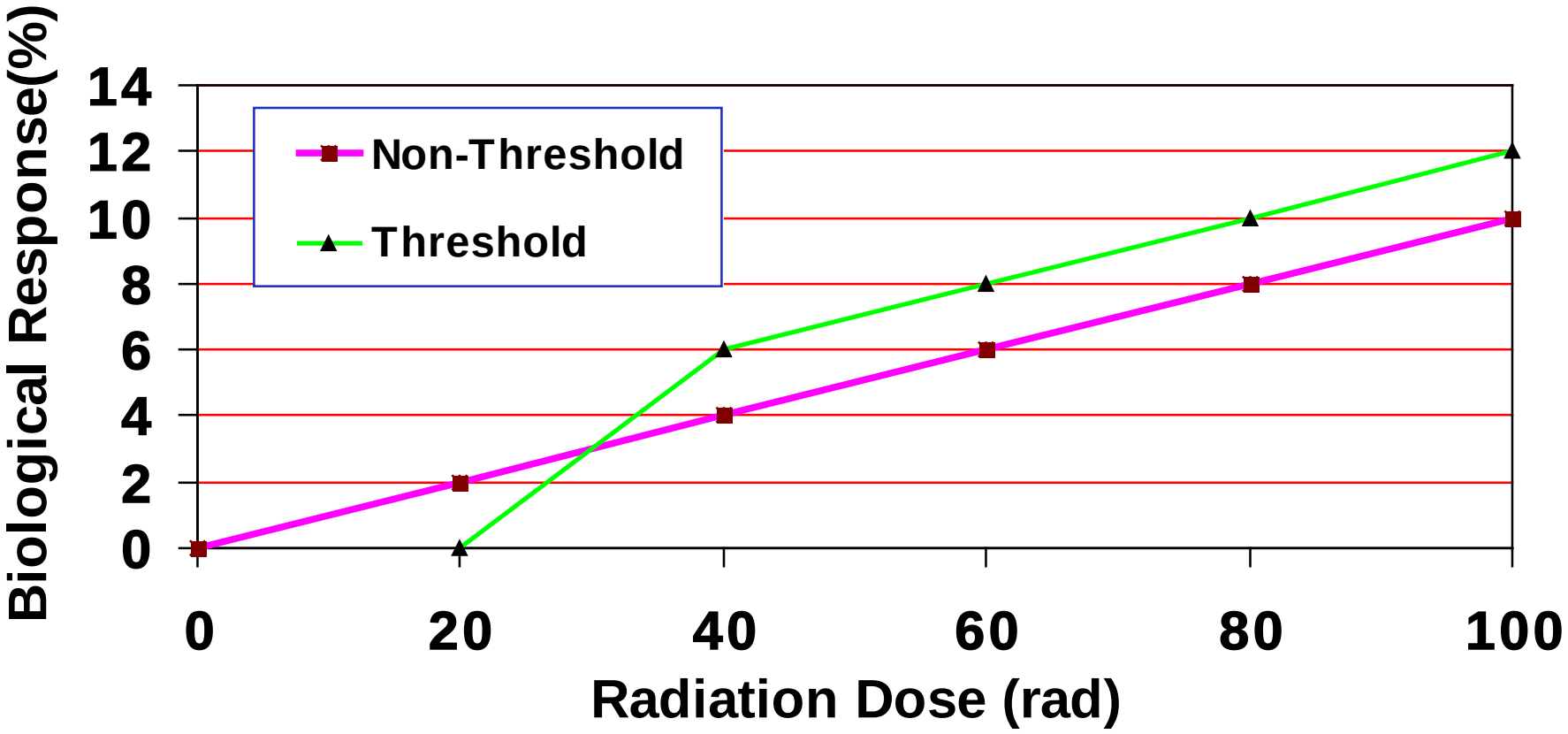
Biological Effects of Radiation

- Threshold Theory – the threshold theory states that below a certain exposure *no* biological effect will occur

Biological Effects of Radiation

- Non-Threshold Theory – the non-threshold theory states that even for the smallest exposure some risk of biological damage may occur
- This theory is the most conservative and is used for establishing Radiation Protection practices

Biological Effects of Radiation



Occupational Dose Limits

- For an occupational worker (a worker whose duties require exposure to radiation on a routine basis) there are limits established for radiation exposures
- These limits are considered safe based on many years of evaluations of radiation workers

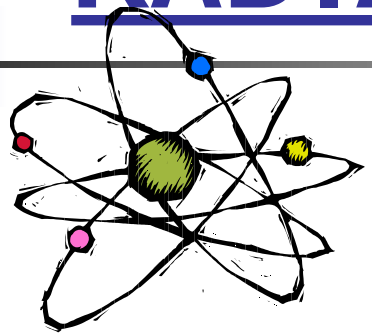
Occupational Dose Limits

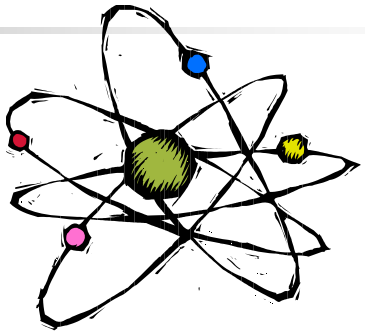
- *The State Occupational Exposure Limits are*
- Whole Body
  - 5 rem per year
- Lens of the Eye
  - 15 rem per year
- Extremity/Skin of the whole body
  - 50 rem per year

Occupational Dose Limits

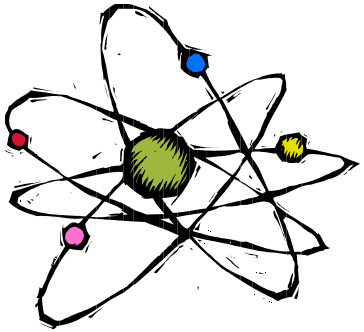
- Even though we have State limits on occupational exposures, the goal of Radiation Safety is to keep all exposures As Low As Reasonably Achievable (ALARA)
- Workers are encouraged to do every thing possible to keep their exposures low

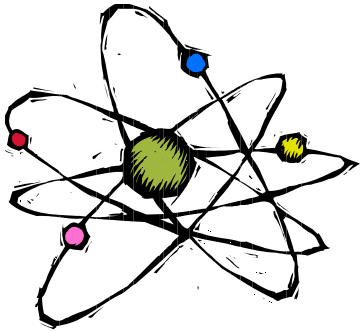
RADIATION PROTECTION





ALARA





The Three Protection Principles

- TIME - Exposure is directly proportional to amount of time spent in a radiation area.

- DISTANCE - Exposure intensity from a source will decrease exponentially per unit distance. Apply the inverse square law to determine Δ intensity.

- SHIELDING - Will protect you dramatically from potential exposure (if you use it).

The Three Protection Principles

- TIME – Minimize the time spent around radioactive material or radiation producing devices
- DISTANCE – Maximize the distance from radiation sources – doubling the distance decrease the exposure by four
- SHIELDING – Use lead aprons and lead shields when ever possible

Regulations Applicable to Radiation Safety

- State of Texas Radiation Safety Regulations
  - 289.226 - Registration of Radiation Machine Use and Services
  - 289.228 - Radiation Safety Requirements for Industrial Radiation Machines

Regulations

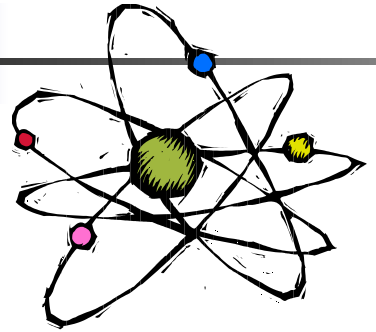
- The University operates under permits and licenses approved by the state.
- Observe the state regulations and operating procedures which apply to your work area, in order to protect yourself, your co-workers, members of the public and the environment.

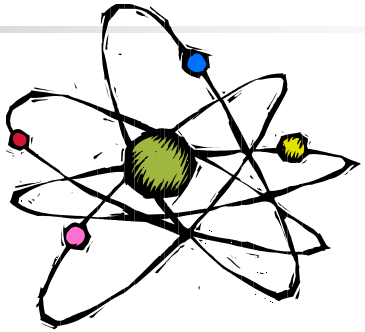
Rights and Responsibilities of Radiation Workers

- You have the right to request, at any time, a history of your occupational radiation exposure and bioassay results.
- You have the right to contact the state and request an inspection, if you believe your institution is operating in an unsafe manner.

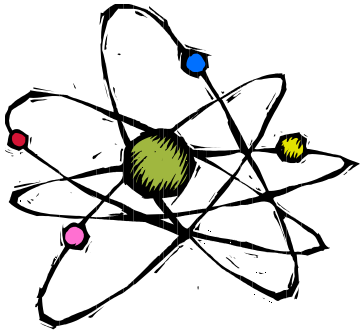
Rights and Responsibilities of Radiation Workers

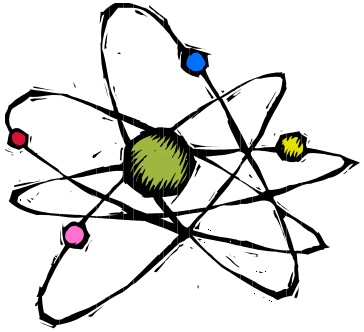
- If you notice unsafe work conditions, such as:
  - An unsafe act by a co-worker
  - Radiation producing equipment not working properly
- You are OBLIGATED to report the unsafe conditions to the Radiation Safety Officer.





Dosimetry





Dosimetry Program

- Dosimetry is the process of measuring radiation exposures
- It can be accomplished in many ways and by using different devices
- Monitoring may be active (instant readings) or passive (readings obtained at some later date)
- Mostly we use passive monitors

Dosimetry Program

- Personnel monitoring devices need to be stored in designated low-background locations in each work area.
- This is very important so we can monitor and account for background exposures when the badges are not being worn.
- When leaving a work for the day, ensure that dosimeters are left in the designated location.

Dosimetry Program

- Dosimetry is required while working in areas where exposures are expected to exceed 10% of the annual exposure limit.
- Most areas in the University have relatively low exposure rates.

Proper Wear of Dosimeters

- Whole body badges will be worn between the shoulders and the waist.
- Collar badges (head and neck) will be worn on the outside of protective garments.
- Ring badges will be worn on the dominant hand facing the source.

Exposure Investigations

- I screen exposure records when they are received to look for unusual exposures.
- The University has two action levels for radiation exposure
  - Level 1 – Exposures greater than 125 mrem/quarter but less than 375
  - Level 2 – Exposures greater than 375 mrem/quarter

Exposure Investigations

- For Level 1 exposure, you will be informed and reminded about time, distance, and shielding.
- For Level 2 exposures, you will be asked to provide an explanation of why your exposure was high.

Lost Dosimeters

- Lost dosimeters should be reported to the Radiation Safety Officer.
- The RSO will perform an investigation to determine the cause of the loss.
- The RSO will provide an replacement dosimeter as soon as a loss is reported.

Summary

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QUESTIONS?