Workplace Radiation Safety

Thunder Bay Regional research Institute
Radiation Safety Program

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Radiation Exposure

- We are all exposed to radiation:
  - Cosmic radiation
    - sun, space
  - Terrestrial radiation
    - soil, rocks
  - Internally
    - Food (potassium-40), air
  - Medical treatment

Source of Radiation	Dose (uSv)
1 day of background Radiation in Canada	5 - 10
Round Trip flight from Toronto to London	100
Average annual dose from medical sources	400 - 1000
Living in Canada for 1 year	2000 - 4000
Annual dose limit for member of public	1000
Annual dose limit for Nuclear Energy Worker (NEW)	50,000/yr 100,000/5yr

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Radiation Exposure

- We cannot avoid radiation exposure from sources of background radiation (cosmic and terrestrial radiation) or as a result of medical treatment
- However, by following safe work habits, we can minimize our radiation exposure from occupational sources of radiation

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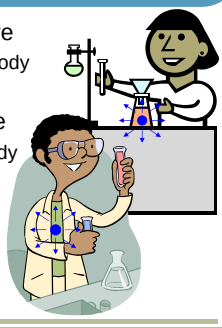
Radiation Exposure

- External radiation exposure
  - From sources outside the body
- Internal radiation exposure
  - From sources inside the body



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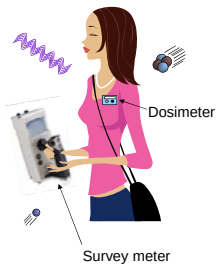
External Radiation Exposure

- Radiation from sources outside the body can be measured with a **survey instrument**
- Worker radiation doses can be measured using instruments called ***dosimeters***



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Radiation Protection Principles

- External radiation exposure can be minimized by considering the following:
  - **Time**
  - **Distance**
  - **Shielding**

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Time

- Limit the time spent near a source of radiation
- Wait for the source to decay before you start work
- The radiation field will drop by a factor of 2 for every half-life you wait
- This is a good approach when work is being done with short-lived radionuclides (half-lives of minutes or hours)

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Distance

- There will be a marked reduction in the radiation field if you increase the distance from a source

- For gamma-rays (or X-rays), the radiation at any point is inversely proportional to the square of the distance from the source

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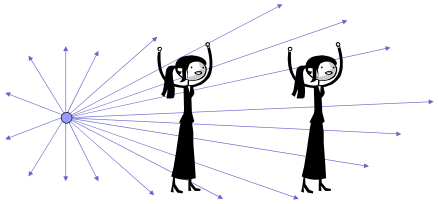
Distance

- The worker farther from the radiation source will receive less radiation exposure than the worker closer to the source



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Shielding

- The purpose of shielding is to block or attenuate the radiation field generated by a source
- The type of shielding employed depends on the type of radiation
- Many commercially available radiation sources and radiation devices are housed in shielded containers

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Shielding: Gamma Radiation

- No amount of shielding will stop gamma radiation entirely
- Gamma radiation can only be reduced to acceptable levels by:
  - Maintaining a safe distance from the source
  - Using appropriate shielding

Portable lead shielding

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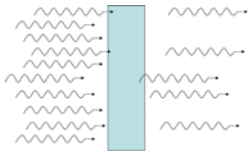
Shielding: Gamma Radiation

- The effectiveness of gamma shielding is frequently described in terms of the half-value layer (HVL)
- HVL is the thickness of absorber required to reduce the gamma ray radiation to half its initial value



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Shielding: Gamma Radiation

- Gamma photons interact with electrons when passing through matter
- Materials with many electrons per atom (i.e. large Z) and many atoms per unit volume are the most effective gamma shields
- Heavy metals like tungsten, lead, and gold are good examples
  - Concrete is also used, but must be much thicker

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Shielding: Beta Radiation

- Beta radiation can be completely stopped with appropriate shielding materials
- Many beta sources are also gamma emitters; this must be considered in the selection of shielding
  - ^{137}Cs (0.511 MeV beta and 0.622 MeV gamma)
  - ^{131}I (0.606 MeV beta and 0.365 MeV gamma)

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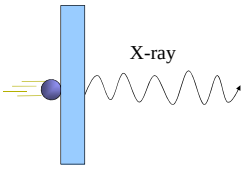
Shielding: Beta Radiation

- In addition, when beta radiation passes through matter, it can produce X-rays



- X-rays produced in this way are referred to as bremsstrahlung or “braking radiation”

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Shielding: Beta Radiation

- Typical shielding:
  - Plastic or glass (~1 cm is sufficient to stop beta)
  - Wood
  - Aluminum



- Intense beta radiation fields may require layered shields:
  - Shielding to stop beta radiation
  - Shielding to attenuate gamma and X-rays

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Shielding: Alpha Radiation

- Alpha particles have very little penetrating ability
- Even in air the most energetic alpha particle cannot travel more than 10 cm
- The dead layer on one’s skin will stop alpha particles completely

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Shielding: Alpha Radiation

- Alpha sources do not present an external hazard
- Shielding against alpha particles is not necessary
- Alpha particles are a very serious internal hazard and great care must be taken to ensure alpha sources are kept out of the body

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Radiation Contamination

- Contamination may occur as a result of routine work activities or accidents
- A spill will result in contamination of a work surface or floor
- Touching objects and surfaces can also cause contamination
- Follow proper work procedures to clean up contamination and contact the RSO

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Leak Testing

- Sealed Sources
  - Every 6 months for a source not in a device.
  - Every 12 months for a source in a device.
- Any package that comes in containing radioactive material
  - Inspect for damage
  - Wipe test exterior of package
  - Wipe test interior package

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Personal Contamination

- Contamination of skin or hair may occur if they come into direct contact with radioactive material
- A good wash with soap and warm water will generally remove contamination from the hands
- A soft bristle brush should be used with soap and warm water to remove contamination from under the fingernails

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Personal Contamination

- Do not scrub or rub the skin to the point where it reddens as there is a risk of absorbing the contamination through your skin
- If soap and water aren't effective, use a chemical hand cleanser

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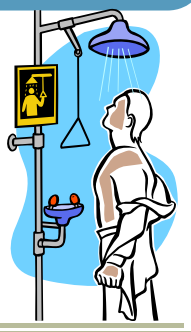
Personal Contamination

- For decontamination of the face and hair, showering once or twice is the most effective
- Keep your mouth and eyes shut while showering (keep an external exposure from becoming an internal exposure)



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Personal Contamination

- If you have minor cuts or scratches you should be very sure that:
  - They are covered with surgical dressings
  - You do not work in areas where you are likely to contaminate yourself

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Internal Sources

- Dealing with internal sources demands more elaborate precautions than for external sources of radiation
- If a source is taken into the body, all the radiation emitted is capable of interacting with the body

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Internal Sources

- Internal sources irradiate the body 24 hours a day, seven days a week, until they have been eliminated from the body by excretion and radioactive decay

- While some radionuclides are eliminated fairly rapidly, there are others that remain in the body for years

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Entry into the Body

- Radioactive materials may occur in many physical or chemical forms:
  - Solids
  - Powders
  - Dusts
  - Liquids or solutions
  - Gases, vapours

- Internal contamination can result from the careless handling of such radioactive materials

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Entry into the Body

- Radioactive materials may enter the body in three different ways:
  - Inhalation

  - Ingestion

  - Absorption through the unbroken skin or through wounds

Think about your methods so as to avoid hazards (e.g. use a pipette in place of a syringe)

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Effective Half-Life

- The effective half-life is the time required for one-half of a radionuclide to be removed from the body through biological processes and radioactive decay

Substance	T_r	T_b	T_e
H-3	12.3 years	10 days	10 days
S-35	87.4 days	90 days	44.3 days
I-131	8.04 days	80 days	7.3 days
P-32	14.28 days	1 155 days	14 days

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Internal Exposure Prevention

- Wear appropriate protective clothing
  - Lab coat
  - disposable gloves
  - safety glasses

- Protective clothing should not be worn outside the work area
- Do not eat, drink, smoke, or store food or personal items in the work area
- Avoid sharps if possible

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Internal Exposure Prevention

- Ensure that work areas are well ventilated
- Avoid working with radioactive materials if you have open cuts or abrasions
- Keep work areas neat and tidy
- Practice good hygiene
  - Wash hands often

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Radiation Safety Officer

- All CNSC licensees must have a Radiation Safety Officer (RSO) on staff
- The RSO is responsible for ensuring the safe use of all licensed radioactive materials and radiation devices in accordance with CNSC regulations and licence conditions

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Radiation Safety Officer

- The RSO should be the primary contact in regard to radiation safety matters including:
  - General questions or concerns
  - Safety issues
  - Compliance issues
  - Radiation safety training
- The RSO should also be one of the primary contacts in the event of an emergency involving radioactive materials or radiation devices

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Radiation Safety Officer

- Your RSO is:

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