Radiation Safety Training

This training is interned for users of radioactive unsealed/sealed sources and devices

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uOttawa

Bureau de la dirigeante principale de la gestion des risques

Office of the Chief Risk Officer

Sign-in Please

- For this online course via Teams Meeting, please sign-in by sending me the following information:
  - Your full name
  - Your Department
  - Your supervisor's (Permit Holder) name
  - Are you (going to be) a radioactive material user? Y/N

Training Requirements

- Complete this Radiation Safety Training course
  - 3 times per year at the beginning of each school session
  - To get your certificate: take an online quiz and achieve 75%

- Complete a New User Registration Form
  - Receive in-lab practical training from your PI/lab delegate
  - Submit to rad.safety@uottawa.ca

- Refresher training for existing users
  - Every 4 years by reviewing training material and taking a quiz

Course Outline

- Regulatory Framework
- uOttawa Radiation Safety Program
- Radiation 101
  - Characteristics, risks, units, dose limits
- Radiation Protection & Regulatory Control
  - ALARA, classes, EQ, transport, security
- Operational Practice
  - Acquisition, inventory, disposal, monitoring, exposure control, handling, safety precautions, etc.

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Module 1

REGULATORY FRAMEWORK

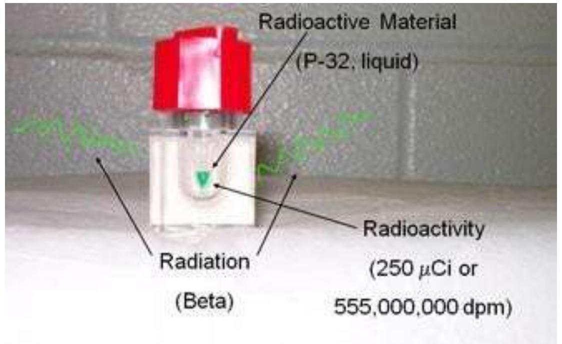
Regulators

- Canadian Nuclear Safety Commission (CNSC)
- International Atomic Energy Agency (IAEA)
- Transport Canada (TC)
- Health Canada (HC)
- Others: Ministry of Labor (MOL), Ministry of Environment (MOE), City of Ottawa

Types of Radioactive Materials

- Nuclear Substances and Radiation Device (NSRD)
  - Unsealed (open) source
  - Sealed source
  - Sealed source in device

- Naturally Occurring Radioactive Materials (NORM) and Environmental Samples



A vial of P-32 sample

A sealed check source Co-60

Sealed source in device

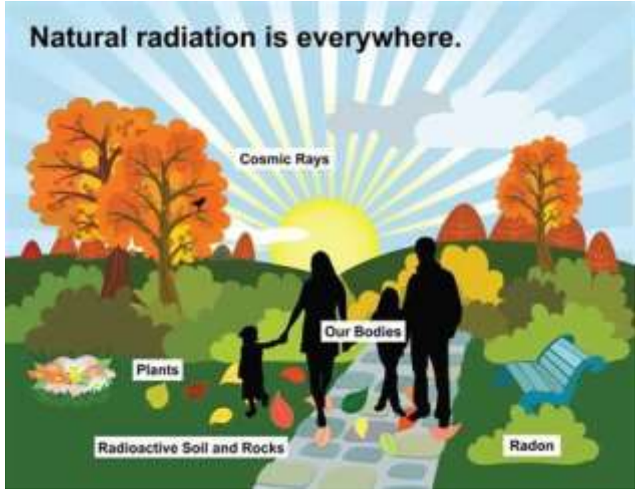

Natural occurring material

Naturally Occurring Radiation

Sources of naturally occurring radiation:

- Cosmogenic radionuclides: created when cosmic radiation interacts with the atmosphere, soils, rocks or water

- Primordial radionuclides: they have existed since the earth was formed due to their long half-life (U-238: $t_{1/2} = 4.5 \times 10^9$ years)



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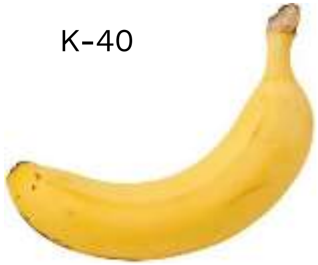


Why Regulate "natural occurring"?

- Homes
  - Radon gas (HC limit: 200 Bq/m3)
- Mining, oil and gas
  - Radioactive mineral on pipes, sludge & contaminated equipment
- Construction
  - Radioactivity in bricks, cement, granite counter tops, glazed tiles
- Consumer products
  - Radioactivity in phosphate fertilizer, tobacco

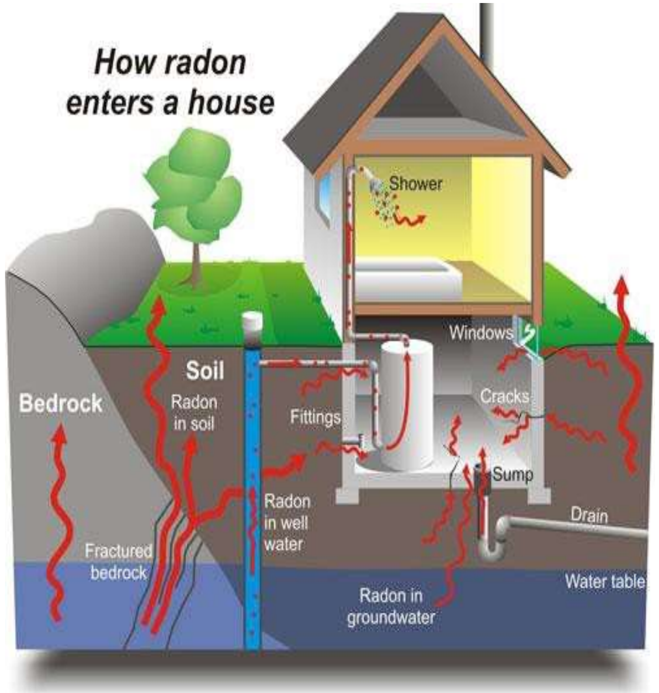


Image: Health Canada

Why Regulate “natural occurring”?

- NORM is material found in the environment that contains radioactive elements of natural origin.

- Long-lived radioactive elements of interest including uranium (U), thorium (Th), potassium (K), and any of their radioactive decay products, such as radium (Ra) and radon (Rn).
  - Natural uranium ore
  - Depleted Uranium
  - Uranyl Acetate, Uranyl Nitrate, Thorium Nitrate, etc.

Natural uranium ore samples

Uranium/thorium by-products

Regulation of NORM

- Regulated by provincial and territorial governments
- CNSC's Nuclear Safety Act regulates NORM only if it
  - Associated with the development, production or use of nuclear energy
  - Imported or exported
  - Transported when the specific activity is greater than the exempt material values (70 *Bq/g*)
- Health Canada - Federal Provincial Territorial Radiation
- Protection Committee (FPTRPC):
  - Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials

Nuclear Substances & Radiation Devices

- Unsealed source, or open source, is a source of ionizing radiation in the form of radioactive material which is not encapsulated or otherwise contained.

- Sealed source is radioactive nuclear substance in a sealed capsule or bonded and in a solid form.

- Radiation device is a device that contains more than exemption quantity (EQ) of a nuclear substance or a radium luminous compound

Open source

Sealed source

Sealed source in device

Class II Prescribed Equipment & Nuclear Facility

- Prescribed equipment are radioactive material, radiation devices, sealed source or equipment that are defined under different CNSC regulations

- Class II nuclear facility is a facility that includes Class II prescribed equipment

The AEL AMS Lab (located in ARC) is a Class II Nuclear Facility

CNSC Regulatory Framework

- Nuclear Safety & Control Act (NSCA, May 31, 2000)

- Key Regulations:
  - General Nuclear Safety & Control
  - Radiation Protection
  - Nuclear Substance and Radiation Devices (NSRD)
  - Packaging and Transportation
  - Nuclear Security
  - Non-proliferation Import and Export Control
  - Class I Nuclear Facility
  - Class II Nuclear Facility and Prescribed Equipment

CNSC Regulatory Vehicles

- uOttawa Licences:
  - Consolidated: NSRD Licence
  - Import Licence (H-3)
  - Class II Nuclear Facility & Prescribed Equipment Licence (AEL AMS lab)
- Licence renewal process (NSRD Licence: Mar. 2023 – Feb. 2028)
- Annual compliance report (ACR)
- Type I & II inspections (Type II: Feb. 2020, Sept. 2021)
- Reporting criteria

CNSC Safety Control Areas

1. Radiation Protection
2. Emergencies & Unplanned Events
3. Environmental Protection
4. Security
5. Training & Qualification
6. Operational Procedures
7. Transportation
8. Organization & Management
9. Quality of Management
10. Non-radiological Health & Safety
11. Public Information Programs
12. Fire Protection
13. International Obligations & Safeguards

The CNSC can impose monetary penalties for non-compliance by licensees

Module 2

UOTTAWA RADIATION SAFETY PROGRAM

uOttawa

Bureau de la dirigeante principale de la gestion des risques

Office of the Chief Risk Officer

uOttawa Radiation Safety Program

- Goal – Interpret the regulations, develop systems to allow for easy compliance and ensure reporting requirements are met
- “Cradle to Grave” management of radioactive materials

uOttawa RSP Oversees:

1. Internal permit
2. Authorized users, training, user comprehension
3. Inventory control
4. ALARA and safe work practices
5. Personal exposure monitoring
6. Monitoring activities
7. Waste management
8. Compliance monitoring
9. Security of radioactive material
10. Records retention

uOttawa RSP Accountabilities

- Radiation Safety Committee (RSC)
  - Reports to the board
  - Chaired by Vice-Dean, Research
  - Ensure compliance with CNSC regulations and licence conditions

- Office of the Chief Risk Officer (OCRO) – Radiation Safety Officer (RSO)
  - Manages the Radiation Safety Program
  - Monitors compliance
  - Tracks dose, inventory and waste
  - Delivers training

uOttawa RSP Accountabilities

- Permit Holders (PI)
  - Ensure all regulations, policies and requirements are met
  - Adhere to all permit limits and conditions
  - Ensure a safe work environment

- Radioactive Material Users (you)
  - Attend all required training
  - Comply with radiation safety program
  - Maintain safe practices (self, colleagues and environment)

Compliance Monitoring – Inspections

- Determine compliance and competency (Knowledge and Application)
- Conducted annually
- Mimics the CNSC inspections
- Being proactive by contacting rad.safety@uottawa.ca

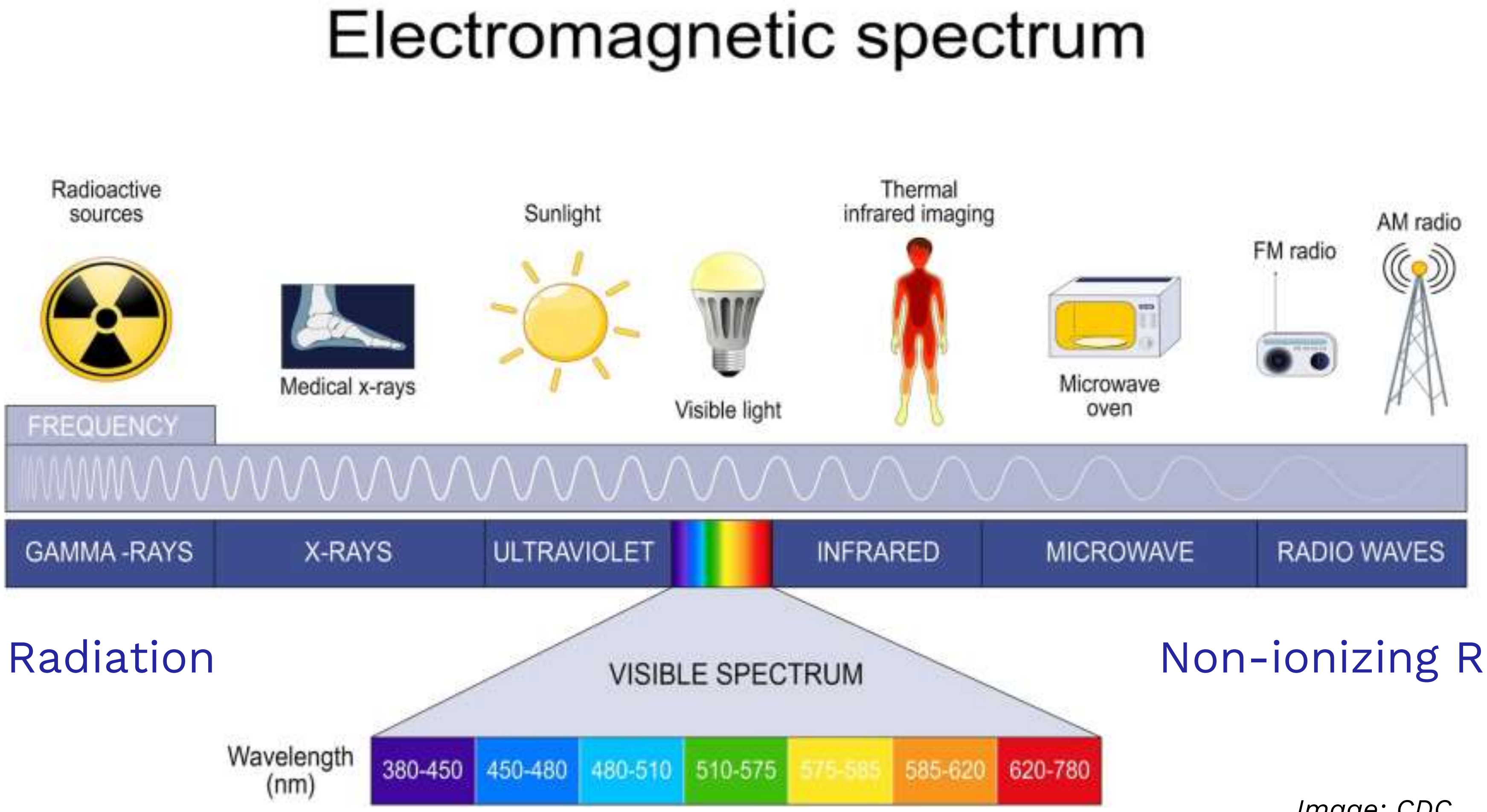
We are always available to help you achieve safety and continuous improvement in your lab.

Module 3

RADIATION 101

Ionizing Radiation

Radiation – the full spectrum



Ionizing Radiation

Non-ionizing Radiation

Image: CDC

Fundamental Building Blocks – Atoms

- Atoms
  - Protons
  - Neutrons
  - Electrons

- Mass (A) = Atomic (Z) + Neutron (N)

- Isotopes
  - Same atomic number (Z) but different neutron number (N)
  - Most nuclides in nature are stable isotopes

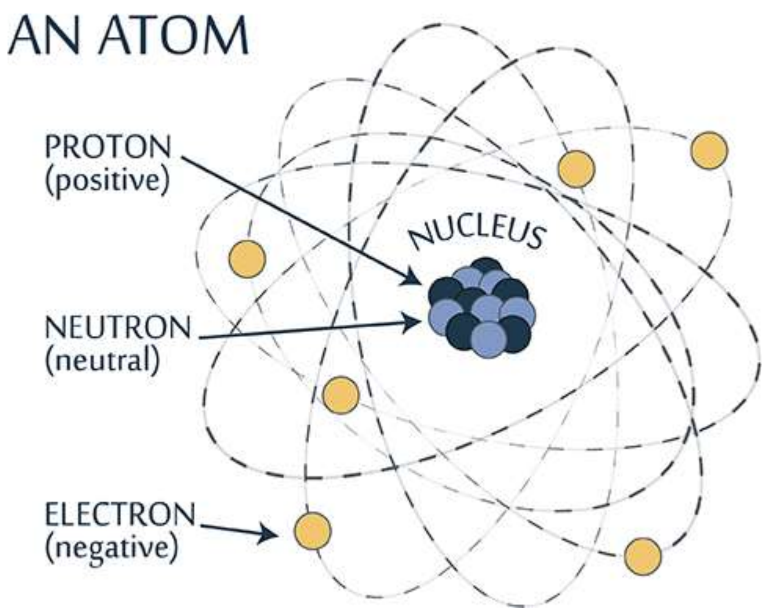
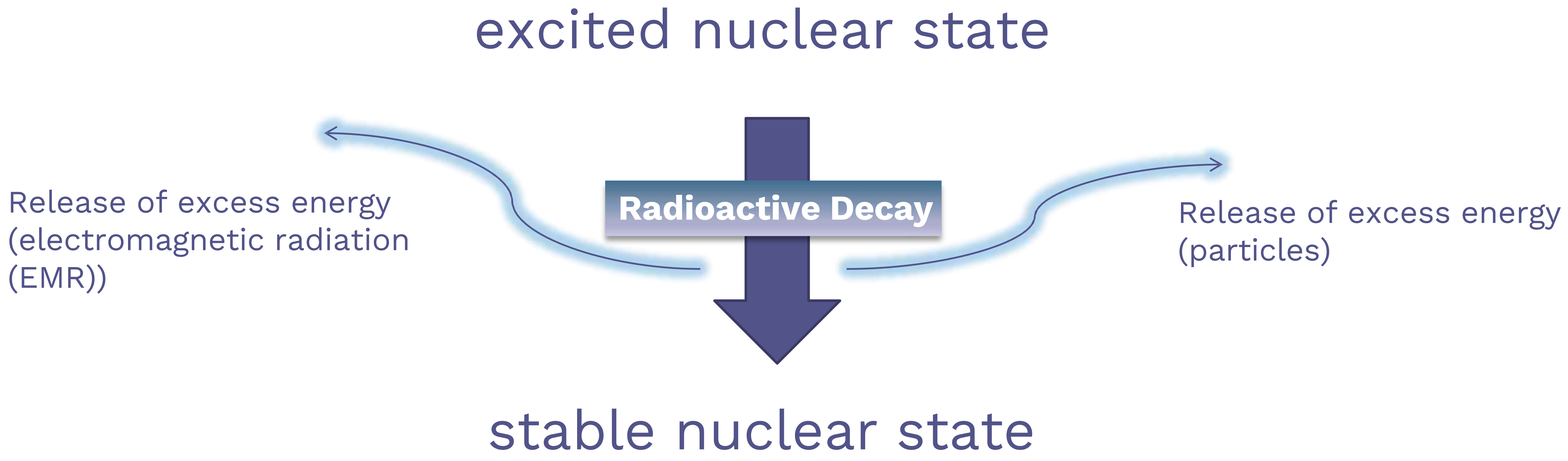


Image: CNSC

Atoms that are unstable are called <u>Radioactive</u>

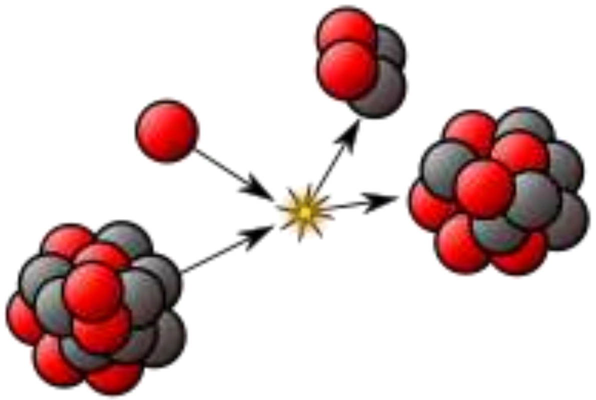
Regardless of the source of the nuclear radiation, its objective is always to achieve stability!



Ionizing Radiation & Radioisotope

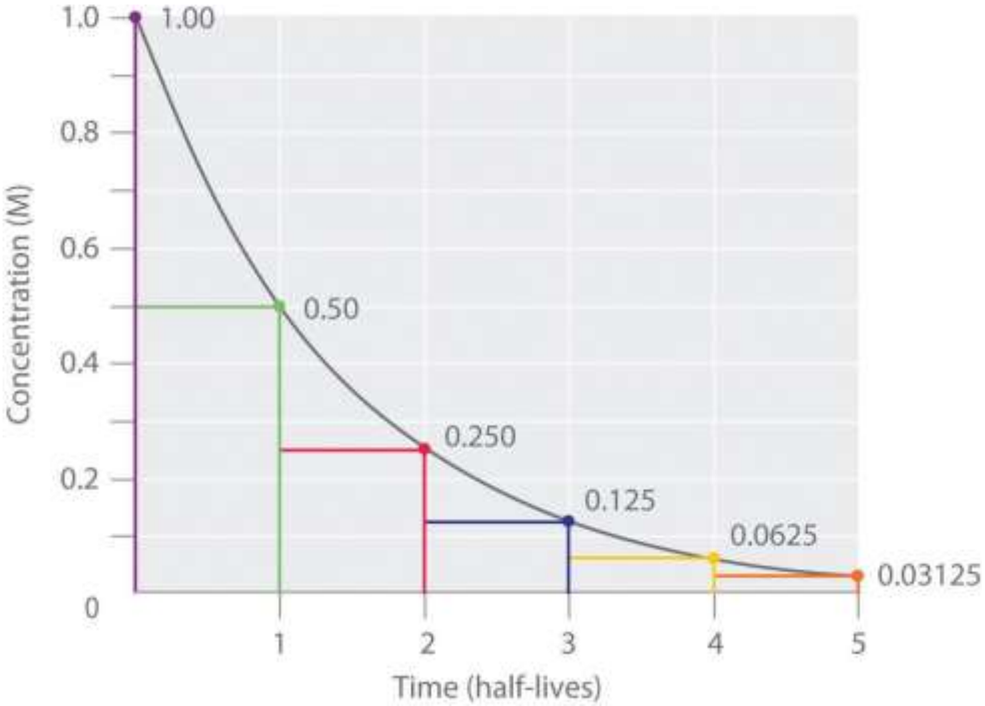
- Ionizing radiation is a spontaneous emission. It is a type of energy released by atoms that travels in the form of
  - Particles (alpha, beta or neutron), or
  - Electromagnetic waves (gamma or X-rays)

- Radioisotope = Radionuclide
  - Unstable isotope/nuclide
  - Emits excess energy/radiation to achieve stable



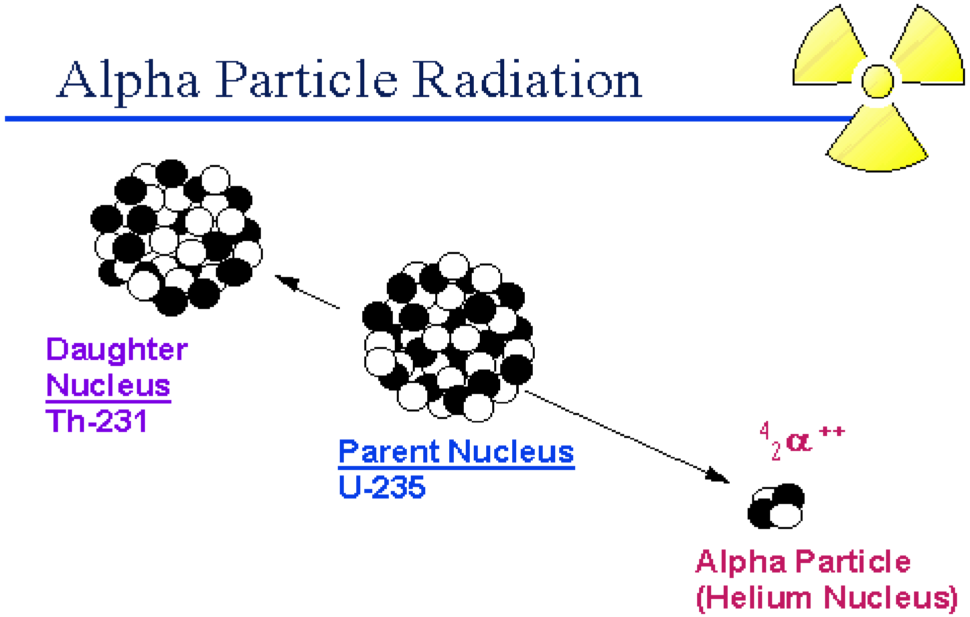
Radioactive Decay & Half-life

- Process of emitting radiation/energy is called radioactive decay
- Most common types: alpha, beta, gamma or X-rays
- Characteristic half-life is the time required for half of the radioactive nuclides to decay to a stable state
  - Short-lived: P-32, I-125
  - Long-lived: C-14, U-238



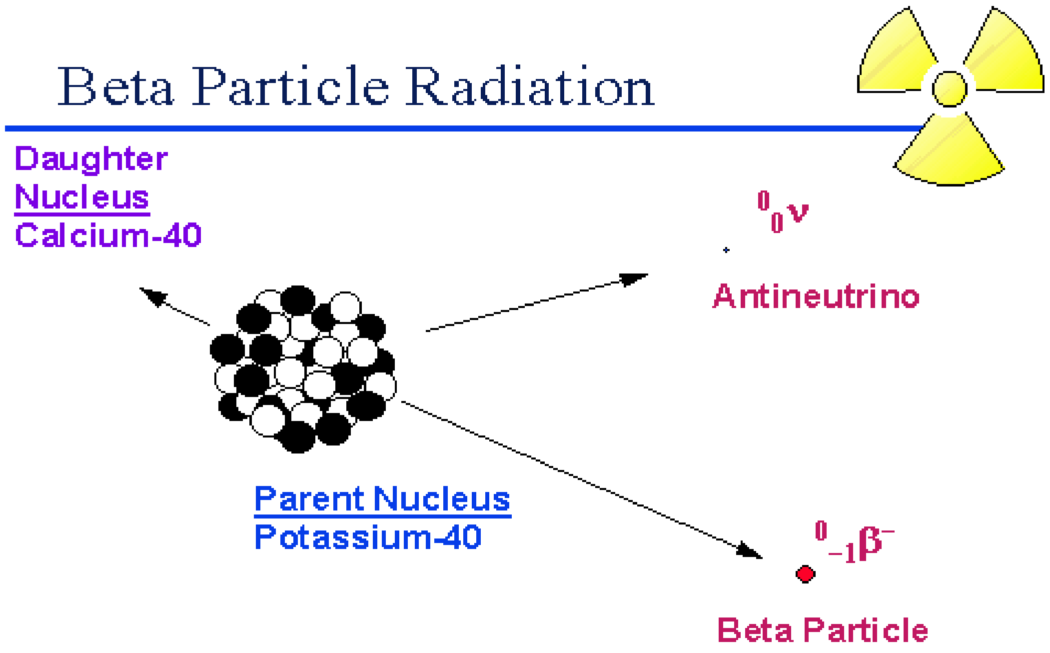
Alpha Radiation (α)

- Emits alpha particles
  - Helium atom (He2+): 2 protons and 2 neutrons
- Energy range: 4 – 8 MeV
- Travel range: 2 – 8 cm
- Characteristics:
  - Large mass, double charge
  - Limited external damage but great internal damage
  - Cannot penetrate skin
  - Heavy radionuclides – elements with Z greater than 82



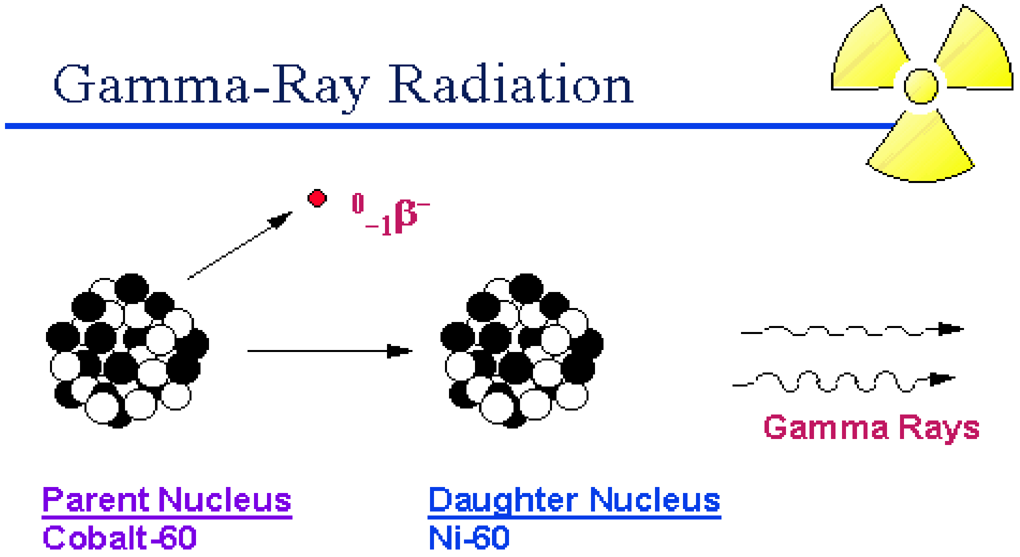
Beta Radiation (β)

- Emits beta particles
  - Electrons (-) and positrons (+)
- Energy range: 0.02 – 4.8 MeV
- Travel range: 0 – 10 m in air
- Characteristics:
  - Almost no mass
  - Can penetrate the skin ~0.2 cm in tissue
  - Travels almost the speed of light
  - Bremsstrahlung: x-ray can be produced when beta particles pass through matter

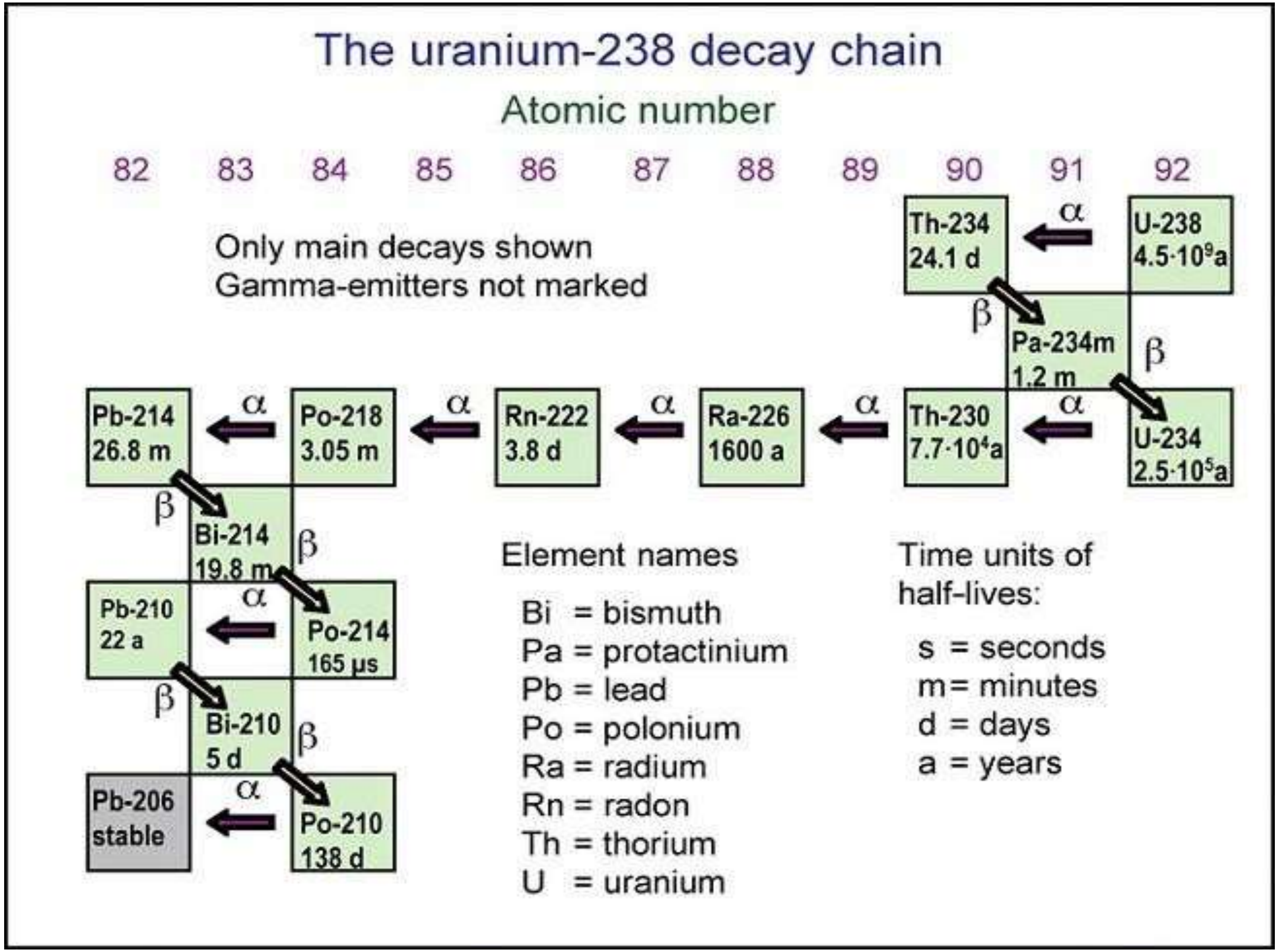


Gamma Radiation (γ)

- Made up of photons:
  - Packet of energy with no mass
- Energy range: 10 keV– 3 MeV
- Travel range: far
- Characteristics:
  - No mass
  - Electrically neutral
  - Always preceded by either a beta/alpha decay
  - Much more penetrating than alpha/beta particles

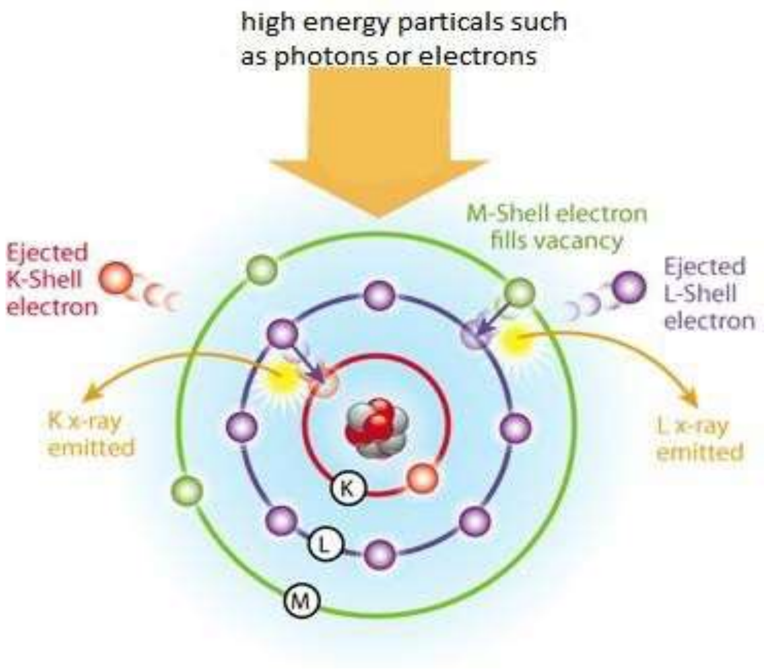


Radioactive Decay

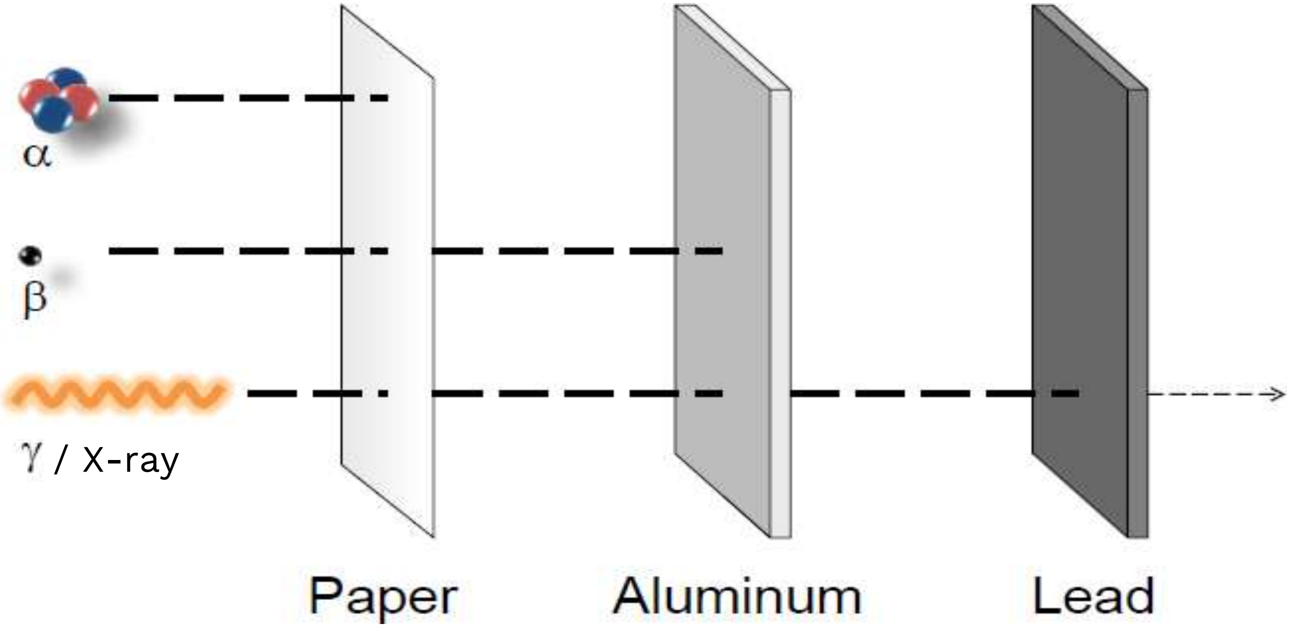


X-ray Emission

- Also made up of photons - emitted when high speed electrons are slowed down or change directions a target material
- Energy range: 10 eV– 120 keV
- Travel range: far
- Characteristics:
  - No mass
  - Electrically neutral
  - Similar to gamma ray but origin is different



Radiation Penetrating Power



Radiation Interaction & Biological Effects

Radiation Interaction

- Radiation can interact with atoms when passing through the matter

- Direct ionization
  - Charged particles (alpha, beta particles) with sufficient kinetic energy interact with atoms or molecules

- Gamma/X-ray: indirect ionization
  - Non-charged particles (photons: gamma, x-ray) interact with matter
  - Results in: photoelectric effect, Compton scattering, pair production

Radiation Interaction with Human Body

- In principle, radiation interaction with living material is the same as with non-living materials.
- Possible outcomes:
  - No damage: gamma and X-ray can pass through without interacting
  - Direct damage: breaks atoms or molecules in cells and DNA
  - Indirect damage: create ions react with atoms or molecules in cells or DNA
- Most severe internal damage is caused by alpha radiation

Damage in Human Body

- Direct damage
  - Cell damage and death
  - Chromosome damage: cell death, mutation

- Indirection damage
  - Ionizing radiation breaks apart water molecules and generate H_2O_2

- Level of radiation damage is dose-dependent
  - Higher dose, greater damage

Biological Effects on Human Body

- Genetic effects (hereditary effects)
  - Appears in future generations as a result of our exposure to radiation
- Somatic effects
  - Appears in irradiated individuals immediately or delayed
- Stochastic effects
  - A probability of biological effect
- Deterministic effects
  - A certain result from radiation exposure

Biological Effects on Human Body

- Some organs/tissues are more sensitive than others

- The most sensitive
  - Bone marrow: radiation causes decrease in the numbers of white blood cells, red blood cells and/or platelets
  - Reproducing cells: embryo/fetus

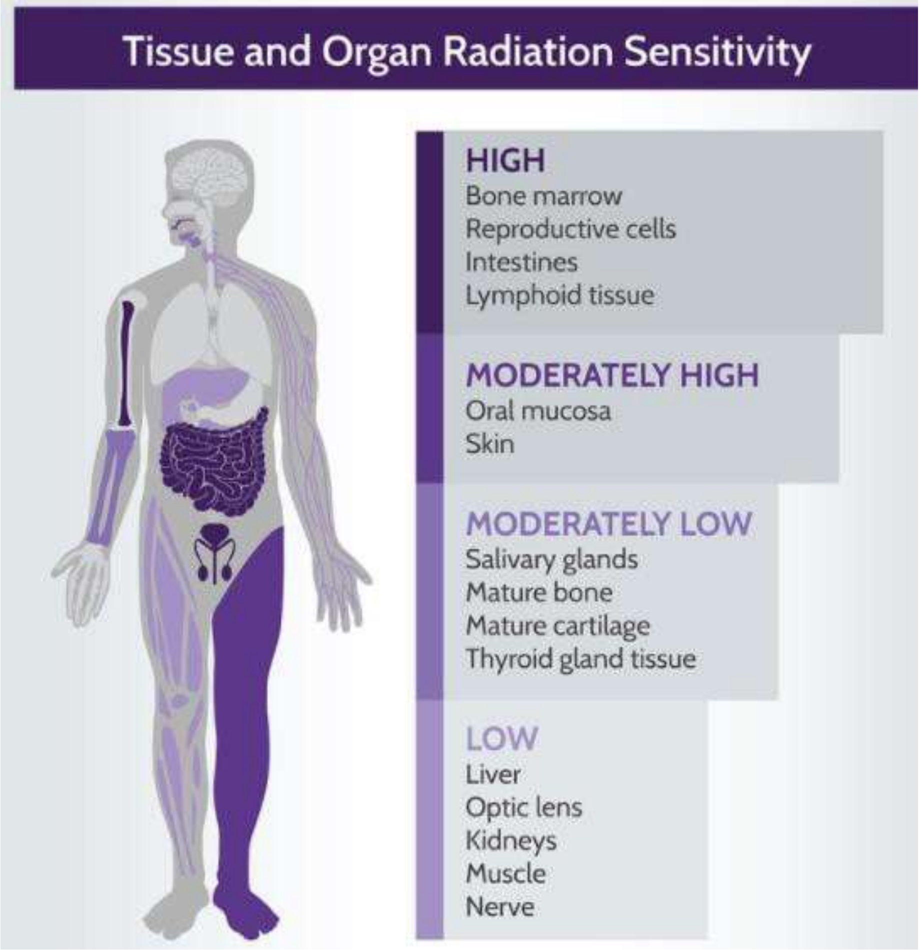
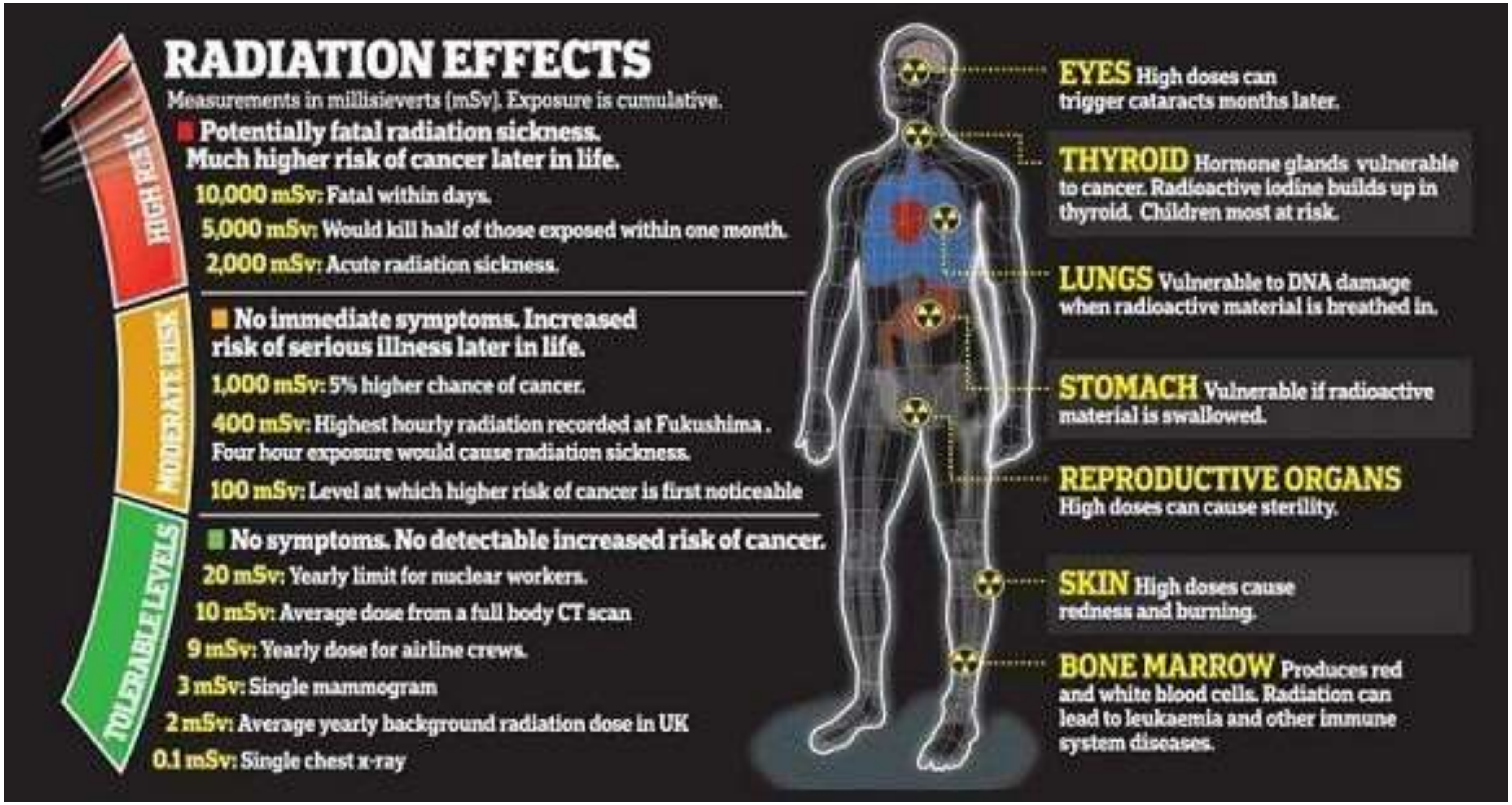


Image: hygienistprep.com

Higher doses cause severer damages



http://healthphysics.georgetown.edu

Radioactive Measurement

Radioactivity Measurement

- International System (IS) – used by the CNSC
  - The rate of decay of a nuclide: the number of disintegration per time (second or minute) and hence the units: *dps* or *dpm*
  - 1 *dps* = 1 *Becquerel* (*Bq*)

- Imperial System
  - *Curie (Ci)* named after Marie and Pierre Curie
  - Radioactivity emitted by 1 gram of Radium is 1 *Ci*
  - 1 *Ci* = 3.7×10^{10} *Bq* (37 billion *Bq*)

Pierre Curie and Marie Curie

Radiation Quantities

- Exposure vs. Dose

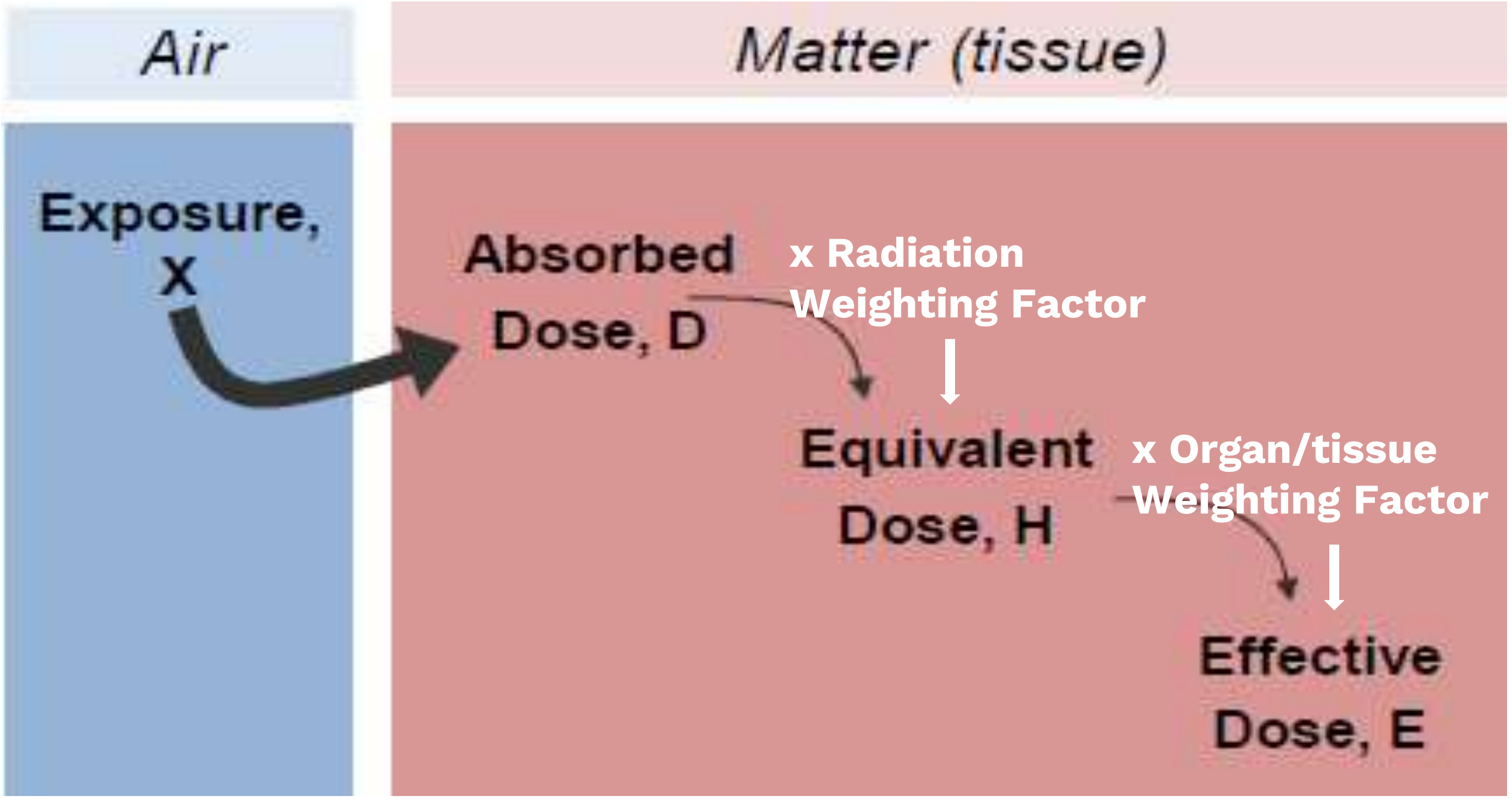


Image: Radiation Safety Institution of Canada

Equivalent Dose

- Measures the damage caused by different type of radiation

Equivalent Dose = Absorb Dose x Radiation Weighting Factor

Type of Radiation and Energy Range		Weighting Factor
Photons	all energies	1
Electrons	all energies	1
Neutrons	energy < 10 keV	5
Neutrons	energy 10 keV to 100 keV	10
Neutrons	energy > 100 keV to 2 MeV	20
Neutrons	energy > 2 MeV to 20 MeV	10
Neutrons	energy > 20 MeV	5
Protons, other than recoil protons	energy > 2 MeV	5
Alpha particles, fission fragments and heavy nuclei		20

Source: *CNSC Radiation Protection Regulations*

Effective Dose

- A single value representing the whole-body risk of stochastic effects resulting from exposure to radiation

Effective Dose = Equivalent Dose x Organ/Tissue Weighting Factor

Organ or Tissue	Weighting Factor
Gonads (testes or ovaries)	0.2
Red bone marrow, colon, lung, stomach	0.12
Bladder, breast, esophagus, thyroid gland	0.05
Skin, bone surfaces	0.01
All organs and tissues not listed such as the adrenal gland, brain, extra-thoracic airway, small intestine, kidney, muscles, pancreas, spleen, thymus and uterus	0.05
Whole body	1

Source: *CNSC Radiation Protection Regulations*

CNSC Dose Limits

- Nuclear energy workers (NEW)
  - A person who is required to be in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public.

- Non-nuclear energy workers (non-NEW) – general public

- The prescribed limit for the general public is 1 *mSv* per calendar year.

CNSC Dose Limits

Organ or tissue	Person	Period	Equivalent Dose Limit (*mSv*)
Lens of Eye	NEW	1 year dosimetry period	50
Lens of Eye	Non-NEW	1 calendar year	15
Skin	NEW	1 year dosimetry period	500
Skin	Non-NEW	1 calendar year	50
Hands and Feet	NEW	1 year dosimetry period	500
Hands and Feet	Non-NEW	1 calendar year	50

Source: *CNSC Radiation Protection Regulations*

CNSC Dose Limits

Person	Period	Effective Dose Limit (*mSv*)
NEW	1 year dosimetry period	50
NEW	1 year dosimetry period	100
Pregnant NEW	Balance of the pregnancy starting from the date on which the licensee has been informed of the pregnancy	4
Non-NEW	1 calendar year	1

Source: CNSC Radiation Protection Regulations

Radiation Measurement

Concept	Meaning	IS units	Old units
Radioactivity	Amount of ionizing radiation	*Becquerel (Bq)*	*Curie (Ci)*
Exposure	Amount of ionization in air by x-ray or gamma radiation	*Coulomb/kg*	*Roentgen*
Absorbed Dose	Amount of radiation absorbed	*Gray (Gy)*	*Rad*
Equivalent Dose	Express exposure in terms of the impact of the form and energy deposited	*Sievert (Sv)*	*Rem*
Effective Dose	Express exposure in terms of the organs and tissues impacted	*Sv*	*Rem*

Radiation Measurement – Personal Dose

- Amount of radiation dose received by a person during a dosimeter wearing period
- Unit: ***mSv***
- Measuring instrument/device: dosimeters
- Measurement in lab:
  - Monitoring personnel exposure
  - uOttawa action level: 0.3 *mSv* per dosimeter wearing period

Extremity dosimeter (left)
Whole-body dosimeter (right)

Radiation Measurement – Count Rate

- A rate of counts per unit time registered by a radiation counter
- Unit: count per minute (***cpm***), count per second (***cps***)
- Measuring instrument/device: Geiger counter, liquid scintillation counter, etc.
- Measurement in lab:
  - Measuring/monitoring radioactivity
  - For contamination monitoring, the unit must be converted to *Bq/cm²*

Geiger counters

Radiation Measurement – Dose Rate

- Quantity of radiation absorbed or delivered per unit time
- Unit: ***μSv/h***
- Measuring instrument/device: survey meters, does rate meters, ionization chambers, etc.
- Measurement in lab:
  - Monitoring/measuring radiation field in use/storage area
  - uOttawa action level: 2.5 *μSv/hr*

RadEye survey meter

Radiation Measurement – Conversions

- 1 *Coulomb/kg (C/kg)* = 3876 *Roentgen*
- 1 *Becquerel (Bq)* = 1 *decay per second (dps)*
- 1 *Bq* = 2.7 x 10^{-11} *Curie (Ci)* 1 *Ci* = 3.7 x 10^{10} *Bq*
- 1 *Gray (Gy)* = 100 *rad* 1 *rad* = 0.01 *Gy*
- 1 *Sievert (Sv)* = 100 *rem* 1 *rem* = 0.01 *Sv*
- *cpm/cps* to *Bq*: see details in “Contamination Monitoring”

RadPro calculator: http://www.radprocalculator.com/Conversion.aspx

Module 4

RADIATION PROTECTION & REGULATORY CONTROL

uOttawa

Bureau de la dirigeante principale de la gestion des risques

Office of the Chief Risk Officer

What is Radiation Protection?

- CNSC: Radiation protection is the science and practice of protecting people and the environment from the harmful effects of ionizing radiation.

- A radiation protection program is to ensure contamination levels and radiation doses to workers and members of the public are monitored, controlled and kept below regulatory limits and as low as reasonably achievable (ALARA).

CNSC criteria … that impact daily operations

- As low as reasonably achievable (ALARA) principle
- Exemption quantities (EQ)
- Annual limit on intake (ALI)
- Action levels
- Laboratory classification
- Radioisotope classes
- Transport of radioactive material
- Security & reporting

ALARA Principle

ALARA – As Low As Reasonably Achievable

- ALARA principle is a sound safety principle that is a mandatory requirement for all radiation safety programs.

- CNSC Regulatory Guide G-129:
  - Keeping Radiation Exposures and Doses “As Low as Reasonably Achievable (ALARA)”

- Economic and social factors should be considered.

ALARA – Three Ways to Reduce Radiation Exposure

Time

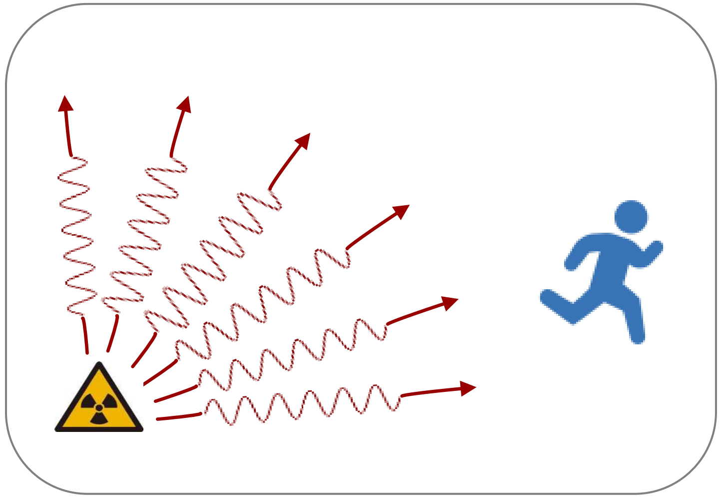
- Minimizing the time spent near the radiation source reduces the total dose received.

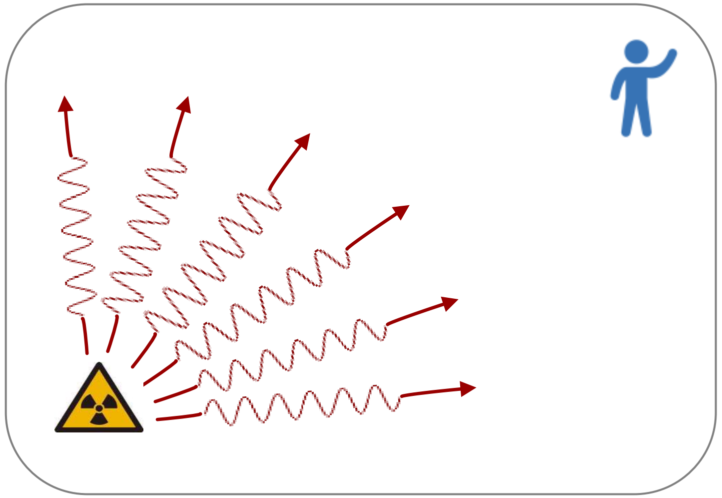
Distance

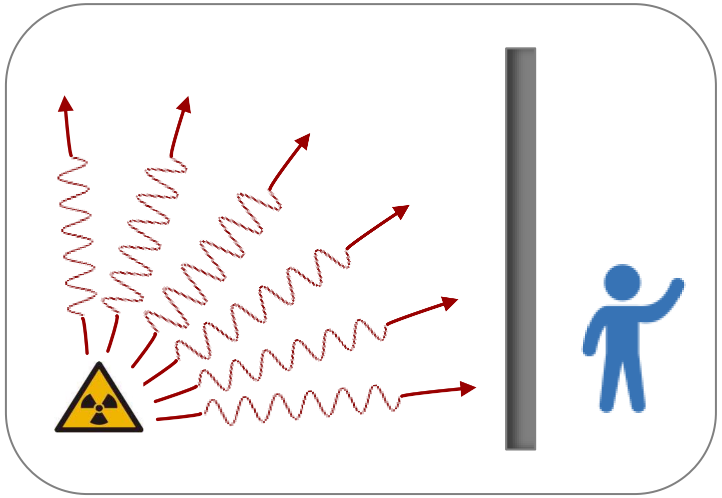
- Maximizing the distance from the radiation source lowers the exposure dose rate.

Shielding

- Use of shielding can effectively block or attenuate radiation.







ALARA – Reduce Time

- Minimizing the time of exposure directly reduces radiation dose:

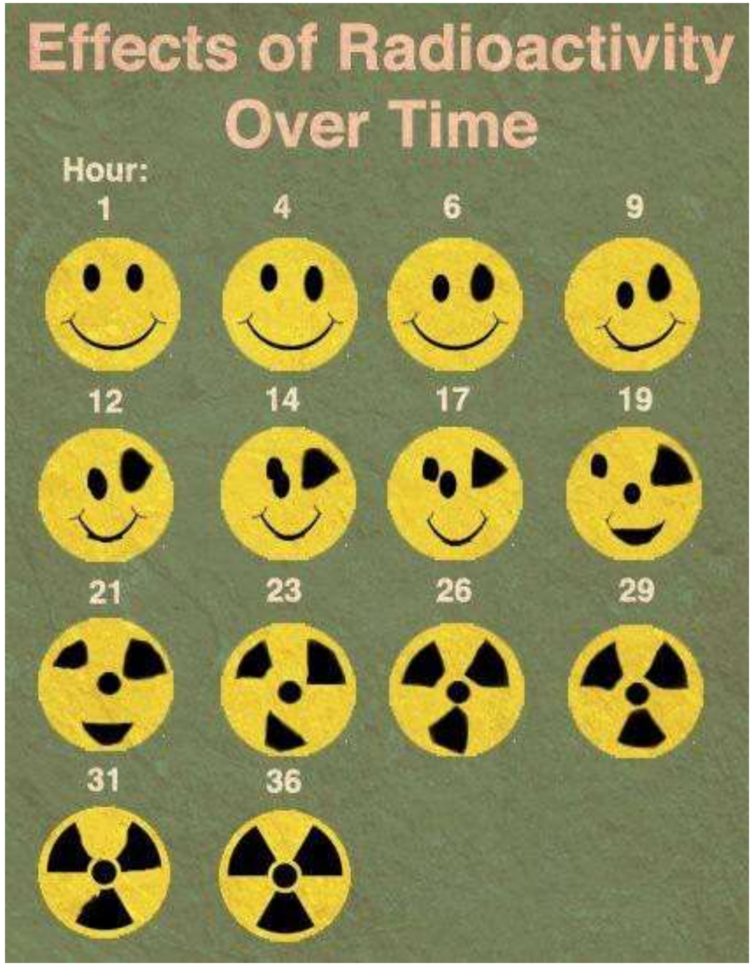
$$D = d \times t$$

Where:

D is the radiation dose received

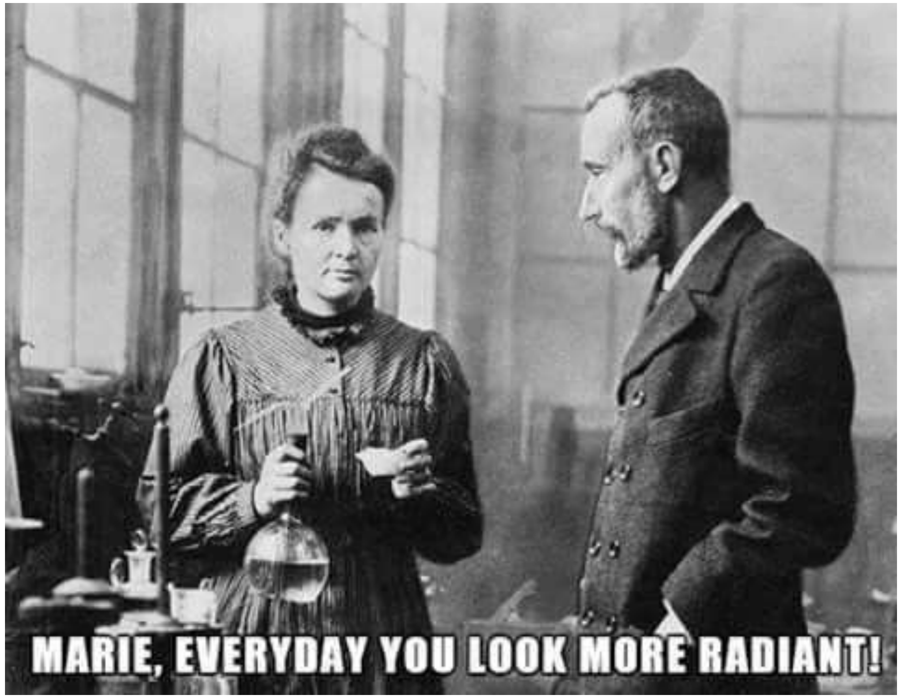
d is radiation dose rate

t is the time duration of exposure



ALARA – Reduce Time

- Reduce the amount of time you are exposed to the source by:
  - Planning your experiments with time reduction in mind
  - Returning the stock vial back to storage once you take aliquots
  - Knowing and avoiding areas of higher radiation



Example: Calculate Work Time

Given:

The gamma radiation in an area is 25 $\mu Sv/h$. To make sure you don't receive a dose greater than 200 μSv, how long can you work in this area?

Answer:

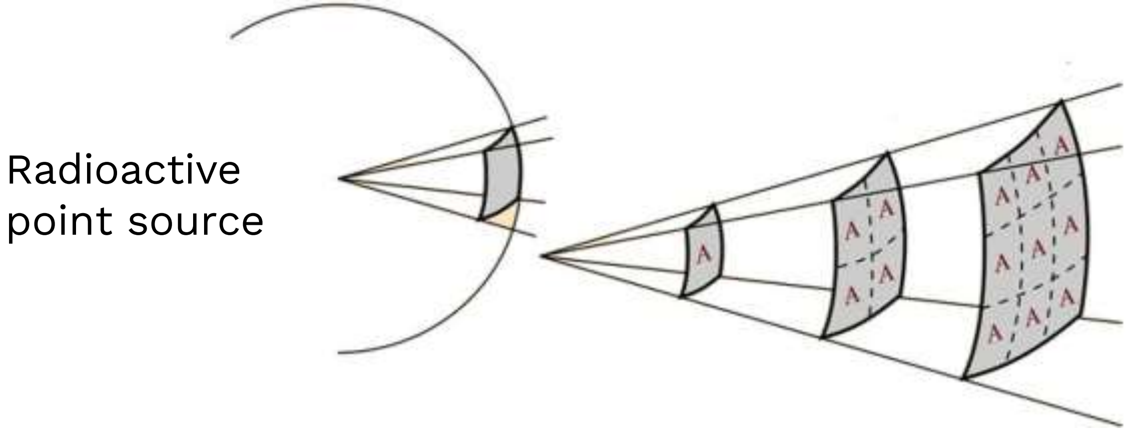
$$t = 200\ (\mu Sv)\ /\ 25\ (\mu Sv/h) = 8\ h$$

ALARA – Increase Distance

- Increasing the distance between you and the radiation source will reduce exposure by the square of the distance

- Gamma radiation follows the inverse square law

$$I = \frac{S}{4\pi r^2}$$



Where:

I is the intensity at surface of sphere
S is the point source strength
r is the distance from surface to source

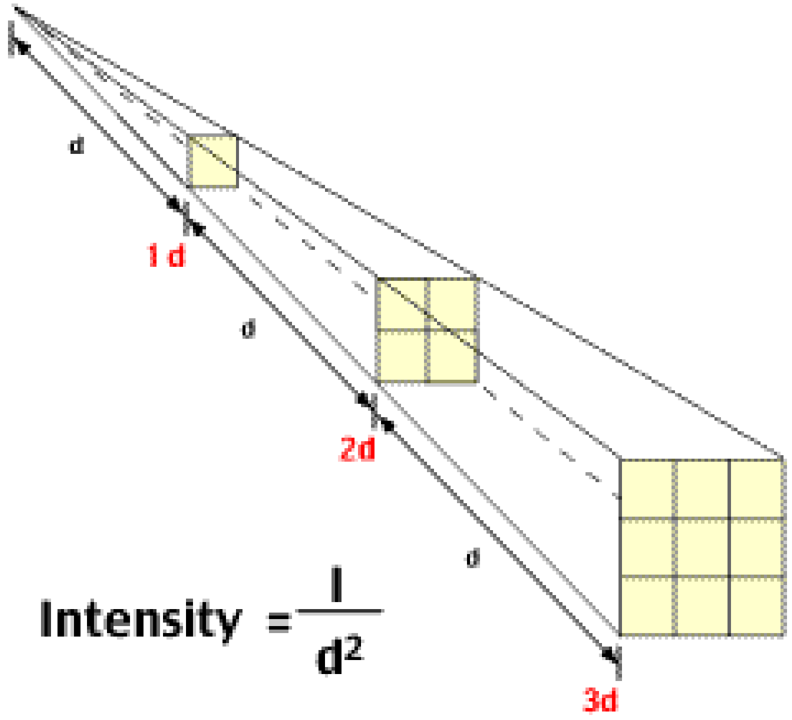
ALARA – Increase Distance

- Inverse square law:

$$\frac{I_1}{I_2} = \frac{D_2^{\,2}}{D_1^{\,2}}$$

Where:

I_1 is the intensity 1 at D_1
I_2 is the intensity 2 at D_2
D_1 is the distance 1 from source
D_2 is the distance 2 from source



http://www.ndt-ed.org

Example: Calculate Radiation at Further Distance

Given:

If the gamma dose rate at 1 m from a source is 160 *µSv/h*. What is the radiation field at 4 *m*?

Answer:

$$\frac{I_1}{I_2} = \frac{D_2^{\,2}}{D_1^{\,2}}$$

$D_1 = 1\ m$ | $D_2 = 4\ m$

$I_1 = 160\ \mu Sv/h$ | $I_2 = ?$

$$I_2 = (I_1 \times D_1^2) / D_2^2 = 160\ (\mu Sv/h) \times 1^2\ (m) / 4^2\ (m)$$

$$= 10\ \mu Sv/h$$

ALARA – Use Shielding

- Shielding can stop Alpha & Beta radiations but only attenuate Gamma radiation.

- The effectiveness of shielding depends on
  - The source of radiation,
  - The type of shielding material, and
  - The thickness of the shielding.

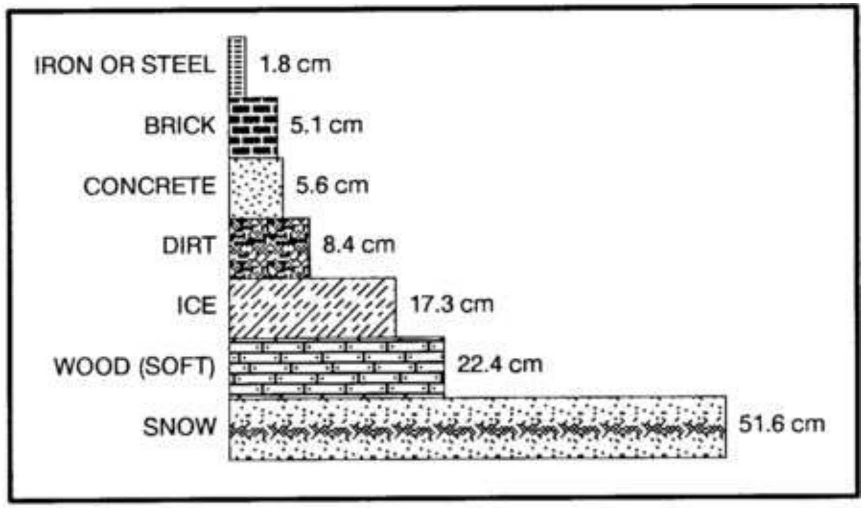
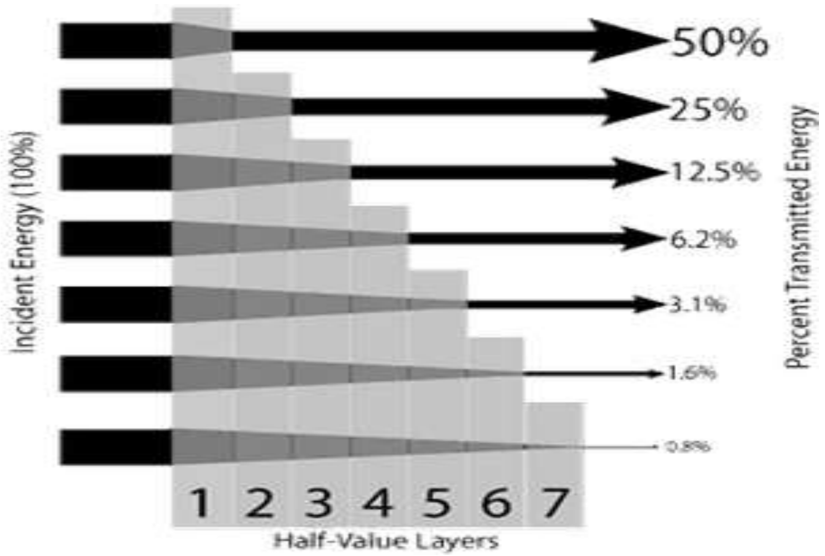


Figure 23-1. Thickness of materials to reduce gamma radiation.

ALARA – Use Shielding

- Half-value layer (HVL): the thickness of any given material reduce the gamma radiation to half of its initial intensity.

- After n HVLs, a gamma radiation field will be reduced by a factor of $1/2^n$
  - 7 HVLs: reduces to 1%
  - 10 HVLs: reduces to 0.1%



Examples: Use Radiation Shielding

Shielding on work bench

Shielding for during work

Shielding for radioactive waste

Shielding for sample storage

ALARA – Practices in Lab

- Knowing of radioisotope characteristics
- Conducting risk assessment: where/what would result in an exposure
- Coming up with exposure mitigation strategies
- Having a good lab design and experimental design, storage and waste management
- Conducting dry runs to test new experimental designs & equipment
- Monitoring exposures

EQ, ALI, Lab Classification, Action, Level, Radioisotope Classes

Exemption Quantities (EQ)

- Radioisotopes below their exemption quantities (EQ) are exempted from the CNSC licensing requirements, but if you have a licence, the licence conditions apply

- CNSC implications:
  - If >100 EQ, a radiation warning sign to be posted at entrance to the laboratory (or probability of an effective dose rate of > 25 *μSv/hr*)
  - If > 10,000 EQ of a radionuclide is used at a single time, CNSC approval is required

- Nuclear Substances and Radiation Device Regulations (NSRDR)
  - Schedule 1 – Exemption Quantities

Annual Limit on Intake (ALI)

- Defined by the CNSC:
  - The activity, in becquerel, of a radionuclide that will deliver an effective dose of 20 *mSv* during the 50-year period after the radionuclide is taken into the body of a person 18 years old or older, or during the period beginning at intake and ending at age 70 after it is taken into the body of a person less than 18 years old.

- ALI is specific to each radioisotope

Laboratory Classification

- For laboratories work with unsealed sources

- Determined by quantity of a source used at a single time
  - Basic level lab: does not exceed 5 ALI
  - Intermediate level lab: does not exceed 50 ALI
  - High level lab: does not exceed 500 ALI
  - Containment lab: exceeds 500 ALI

- Quantity of a source used at a single time = “Use Limit” on Permit

Action Levels

- Defined by the CNSC:
  - A specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program and triggers a requirement for specific action to be taken.

- Action Levels for radioactive material users at uOttawa:
  - A dose of **0.3 *mSv*** over a 3-month dosimetry wearing period
  - Atypical radiation fields (**2.5 *µSv/hr***), usually 5 times above background

Radioisotope Classes

- Radioisotope class is determined based upon common radiological properties and used to determines surface contamination criteria.

- Three Classes : A, B, C
  - Class A: Na-22, U-238
  - Class B: Sr-90
  - Class C: C-14, Co-57, H-3, I-125, P-32

- Reference: CNSC Classes of Nuclear Substances

Transport of Radioactive Material

Transport Regulations

- Transport Canada
  - Transportation of Dangerous Goods (TDG) Act and Regulations –Class 7

- CNSC
  - Packaging and Transport of Nuclear Substances Regulations

- IAEA – transport between countries
  - Regulations for the Safe Transport of Radioactive Materials

Excepted Packages

- Used for low radioactive materials
- Safety mark “RADIOACTIVE” must be visible upon opening the package
- Radiation level at any point on the external surface of the package must not exceed 5 *μSv/h*
- Label with UN code required, no need a radioactive signage

Excepted package label

Industrial Packages

- Industrial packages
  - Type A packages – low amounts
  - Type B (U) packages – large amounts; ≤ 700 kPa
  - Type B (M) package – large amounts; > 700 kPa
  - Type C packages – for air transport of high activity

- Specific labelling is required

Industrial package Type A

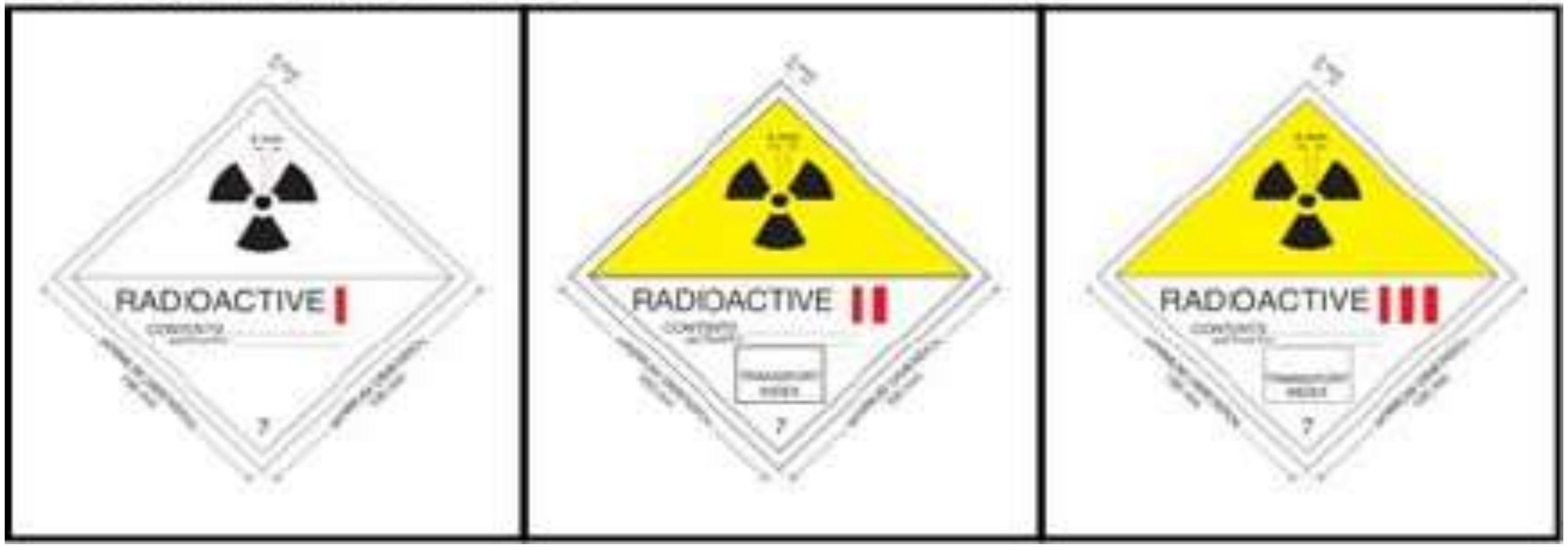
Labelling Requirement

- Labels determined by surface dose and transport index
  - Transport Index (TI): maximum radiation level in *μSv/h* at 1 meter from the external surface of the package, divided by 10
  - Example: 1 *μSv/h* at 1 m equals a TI = 0.1

- Three categories of labels vs. surface dose rate:
  - Category I-White: less than 5 *μSv/h*
  - Category II-Yellow: less than 500 *μSv/h*, TI less than 1
  - Category III-Yellow: less than 2 *mSv/h*, TI less than 10

Labelling Requirement

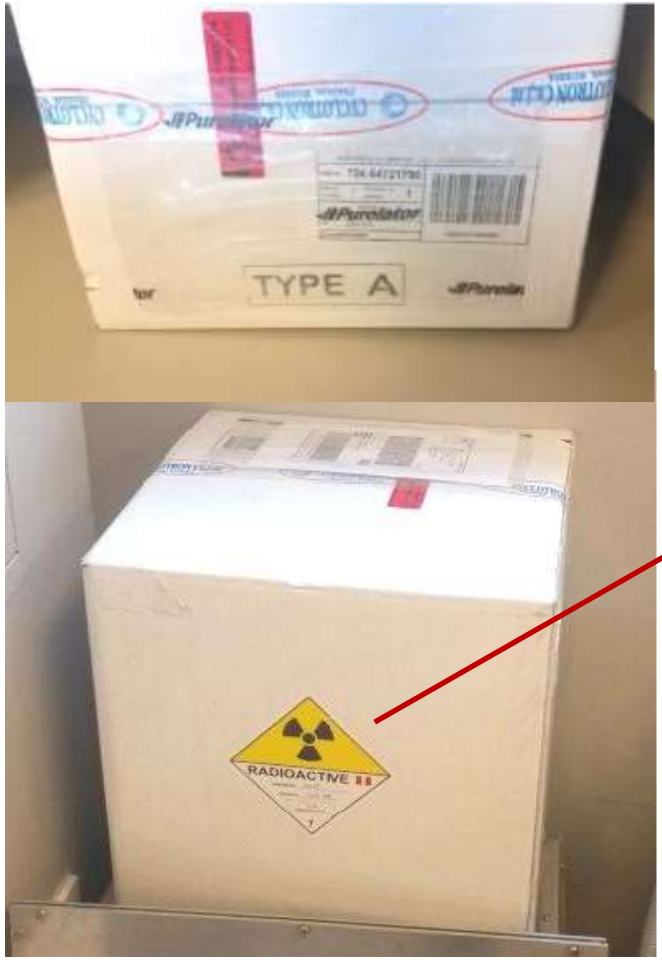
Transport Index	0	1	10
Dose rate at 1 m from surface	0	0.01	0.1
Dose rate at surface	0.005	0.5	2



Increasing dose rate (*mSv/h*)

Image: Radiation Safety Institution of Canada

Example: Packaging & Labelling



Type A package and labelling

Security & Reporting

Security

- Security can be achieved by
  - Physical barriers
  - Psychological barriers
  - Monitoring activities
  - Personnel clearance

- General Nuclear Safety and Control Regulations (GNSCR)
  - Obligations of licensee and workers

Security – Obligations

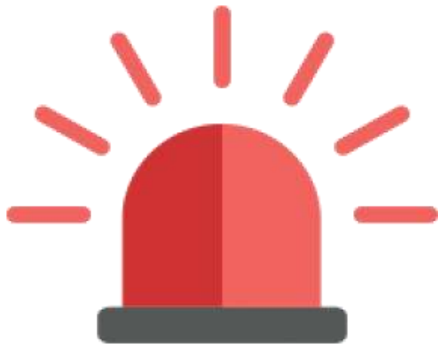
- Licensee (GNSCR Section 12)
  - Take all reasonable precautions
  - Implement alerting measures
  - Physical security program on site

- Workers (GNSCR Section 17)
  - Comply with the measures established by the licensee
  - Promptly inform the RSO or the worker's supervisor when there may be a security risk

Reporting Requirement

- GNSCR Section 29
  - Every licensee who becomes aware of a risk to security, environment or the health and safety of persons shall immediately make a report to the CNSC

- For users, report to RSO immediately
  - Ext. 5411
  - PI/lab delegate
  - OCRO: rad.safety@uottawa.ca
  - Online incident/accident report



Module 5

OPERATIONAL PRACTICES

Institutional Approval

Institutional Approval

- Permit Application
  - Lab to become authorized
- User Authorization
  - In-class training & quiz
  - User registration under permit
- Acquisition Approval
  - Purchase/transfer of radioactive material and nuclear substances
- Disposal
  - Waste assessment to determine disposal method

Internal Permit

- Types of internal permits
  - Open/unsealed sources: <EQ, basic, intermediate
  - Sealed sources
  - Sealed sources in a device
  - Others: environmental samples, etc.

- Conditions apply
  - Radioisotopes
  - Quantity: level of lab, use limit…
  - Disposal criteria
  - Contamination monitoring

Check uOttawa Radiation Safety Webpage for permit application and conditions

Unsealed Source Permit

PERMIS D'UTILISATION DES RADIOISOTOPES (SOURCE OUVERTE)

RADIOISOTOPE USE PERMIT (OPEN SOURCE)

N° DE PERMIS / PERMIT #

NOM / NAME	BUREAU / OFFICE — N° DE TÉL. / TEL. #
POSTE / POSITION: Professor	COURRIEL / E-MAIL
FACULTÉ / FACULTY	DÉPARTEMENT / DEPARTMENT
CONTACT DE LABO / LAB CONTACT	N° DE TÉL. LABO. / LAB TEL. #
COURRIEL DE CONTACT / CONTACT E-MAIL	N° DE TÉL. DE CONTACT / DELEGATE TEL. #
ENTRÉE EN VIGUEUR / EFFECTIVE DATE: February 22, 2016	DATE D'EXPIRATION / EXPIRY DATE: May 30, 2018

RADIO-ISOTOPES	QE EQ	LAI ALI	LIMITE D'UTILISATION USE LIMIT		LIEUX D'UTILISATION USE LOCATIONS	LIEUX D'ENTREPOSAGE STORAGE LOCATIONS
^{14}C	10 MBq	34 MBq	74 MBq	2 mCi	RGN 3110, RGN 3112	RGN 3110, RGN 3112
^{3}H	1 GBq	1 GBq	185 MBq	5 mCi	RGN 3110, RGN 3111, RGN 3112, RGN 3114A	RGN 3110, RGN 3111, RGN 3112
^{32}P	10 kBq	8.3 MBq	37 MBq	1 mCi	RGN 3110, RGN 3111, RGN 3112, RGN 3114A	RGN 3110, RGN 3111, RGN 3112
^{35}S	100 MBq	26 MBq	129.5 MBq	3.5 mCi	RGN 3110, RGN 3111, RGN 3112, RGN 3114A	RGN 3110, RGN 3111, RGN 3112

Abbréviations
LAI: Limite annuelle
QE: Quantités d'exe

uOttawa
BUREAU DE LA GESTION DU RISQUE
OFFICE OF RISK MANAGEMENT

Le sous-directrice, Radioprotection et Biosécurité
Assistant Director, Radiation and Biosafety
Date: Feb. 24, 2016

Spécialiste de la gestion du risque, Radiation
Risk Management Specialist, Radiation
(613) 562-5800 x3057 rad.safety@uottawa.ca

- Lab information
- Permitted Radioisotopes
- Use limit vs. EQ and LAI
- Use & storage locations

- Lab level

TECHNIQUES EXPÉRIMENTALES	☐ Vivo ☒ Vitro ☐ N/A			EXPERIMENTAL PROCEDURES
NIVEAU DE LABORATOIRE				**LABORATORY LEVEL**
ÉLÉMENTAIRE	LAI	0 - 5 X	ALI	BASIC
INTERMÉDIAIRE*	LAI	5 - 50 X	ALI	INTERMEDIATE*
*Approbation requise				*Preapproval Required

- Contamination criteria

Classe Class	Lieux d'utilisation et entreposage Use and Storage Locations	Lieux générales General Locations
A	3 Bq/cm²	0.3 Bq/cm²
B	30 Bq/cm²	3 Bq/cm²
C	300 Bq/cm²	30 Bq/cm²

- Disposal limits

RADIO-ISOTOPE	CLASSE CLASS	SOLIDE SOLID	LIQUIDE LIQUID	GAZ GAS
^{14}C	C	3.7 MBq/kg	10,000 MBq/yr	3.4 kBq/m³
^{3}H	C	37 MBq/kg	1,000 MBq/yr	37 kBq/m³
^{32}P	C	0.37 MBq/kg	4,000 MBq/yr	0 kBq/m³
^{35}S	C	0.37 MBq/kg	1,000 MBq/yr	0 kBq/m³

Institutional Approval

- Radiation Safety Training
  - 3 times/year at the beginning of each school session
  - A quiz must be completed after the class (>75%)

- New User Registration Form
  - User's obligations
  - Corporates in-lab practical training
  - Reviewed by Radiation Safety Specialist
  - Dosimeters may be required
  - User’s name to be added on the permit

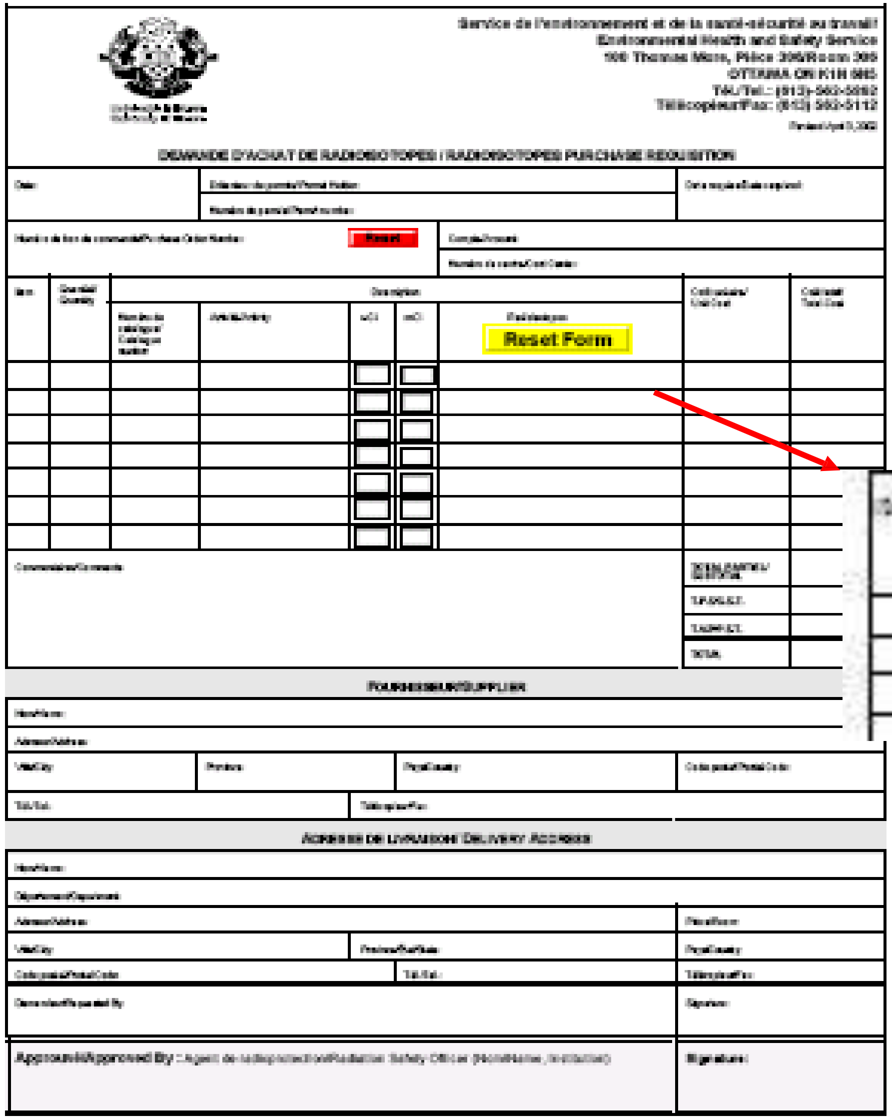
Link:
New User Registration Form

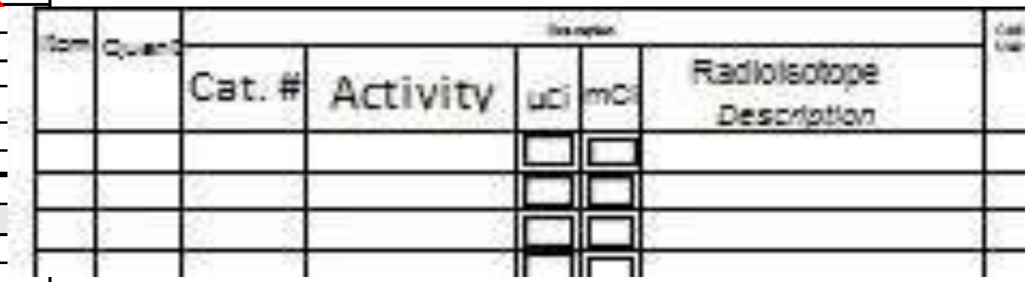
Acquisition Requirements

- Acquisition Must be approved by RSO
- CNSC Licence and Internal Permit conditions apply
- Documentation
- Radioisotopes Purchase Requisition Form
- Internal/External Transfer Form
- Records must be kept (approval, packaging slips, shipper's declaration)

Check uOttawa Radiation Safety Manual for Purchasing Procedure

Purchase Requisition Form





- Radioisotope & quantity
- PO# (sample ID)

Link:
[Purchase Requisition Form]

uOttawa
Bureau de la dirigeante principale de la gestion des risques
Office of the Chief Risk Officer

Receipt of Radioactive Material

- Review shipping label for possible exposure risk
- Inspect package both externally and internally for damage or leakage
- Perform contamination monitoring on the package
- Deface wording and labels prior to disposal of the package
- Start an Inventory of Use and Disposition Form for unsealed source
- Put a label on the radioactive material/device
- Report any anomalies to the supervisor and RSO

Contact rad.safety@uottawa.ca for Open Source - Use and Disposition Form

Inventory Management

Inventory Management

- Inventory is accurate and matches with OCRO records
- All samples and devices are properly labeled
- All samples and devices are storge at a secure location
- Each unsealed source must have a Use and Disposition Form
- Records are kept and available for inspection:
  - Purchase Order Form
  - Transfer From
  - Use and Disposition Form (UDF)
  - Waste Logs

Inventory Use and Disposition Form

- Cradle to Grave management for unsealed sources
  - Each use and disposal is tracked
- Submission to OCRO is required when a source is used up or transferred
- OCRO accepts electronic copy (excel) only – submission of the paper forms/scanned copies will not be accepted

Inventory Use and Disposition Form

Form 2

Inventory of Use and Disposition

(Revised Apr. 15, 2014)

A. Researcher Information

Permit Holder:	
Permit Number:	

Monitoring of Received Package

Box	Bq/cm²
Vial Holder	Bq/cm²
Vial	Bq/cm²
Background	Bq/cm²

$Bq/cm^2 = (cpm - bkgd) / (E_c \times E_w \times 60 \times A)$

Package monitoring

B. Radioisotope Information

Isotope:			
Date Received (m/d/y):			
Storage Location:		Building:	
Supplier:			

In case of multiple vials used with this PO

Purchase Order:		Vial #		of	
Chemical Form:					
Total Activity:					
Vial/Aliquot ID:	Lot #		Other		

Source info.

C. Inventory Use and Disposition

Date Used (dd-mmm-yy)	User Name	Activity (μ Ci)			Disposal Profile (μ Ci)						
					Landfill			Offsite			
		Available	Used	Remaining	Direct	Decay Prior	Drain	LSC	Carcass	Other*	
TOTAL DISPOSAL PER WASTE STREAM:					0	0	0	0	0	0	µCi
					0	0	0	0	0	0	MBq

Use & disposal

*Other is:

Ensure appropriate additional log forms are completed

Send a copy of the completed form to the Radiation Compliance Specialist at ORM by:

Intra Mail: Fax (613-789-5711): E-mail: Date Page: of

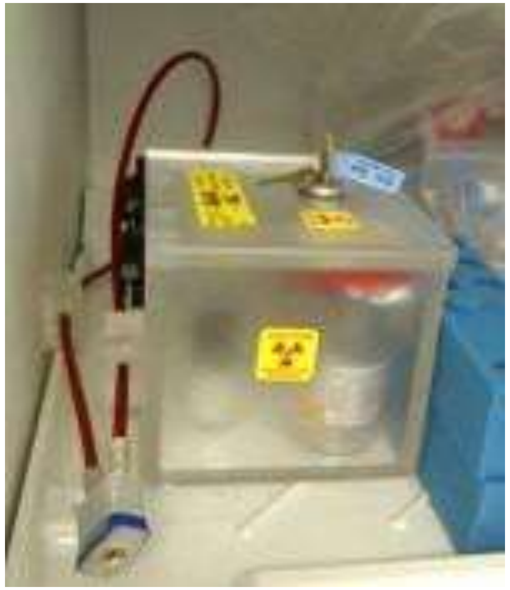
Minimize Your Inventory

- Help reduce exposure and security risks (ALARA)
- Dispose of old stock and samples where the chemical and
- radiological integrity is in question
- Frequently monitor the radiation field around your inventory
- Get rid of what you don't use

Old fridges and freezers are a pain to clean when they fail!

Inventory Security

- Radioactive materials MUST always be secure:
  - Only authorized personnel have access to radioactive materials
  - In common areas, they must be under user's "line of sight"
  - Storage container for unsealed source must be locked
  - Rooms must be locked when not in use



Radioactive sample storage

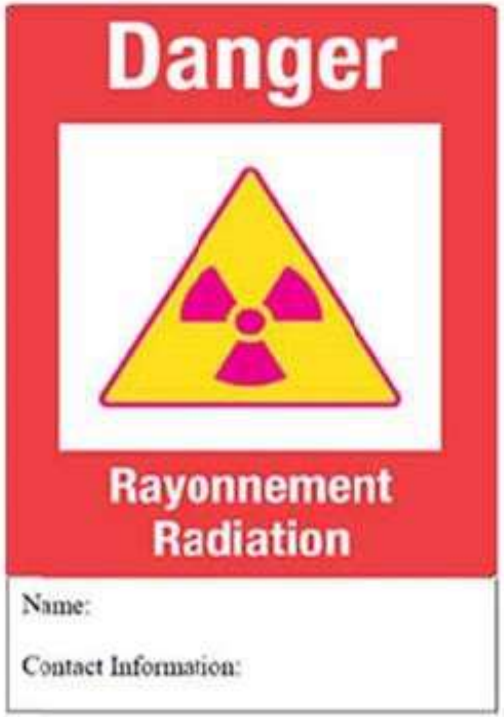
Signage, Posting & Labelling

Posting Requirement

- The following must be posted in the lab:
- Internal Radioisotope Use Permit
- Current list of authorize users
- CNSC posters
  - CNSC safety poster for appropriate lab category
  - CNSC spill procedure poster
  - CNSC proper care and use of personal dosimeters poster
  - CNSC guidelines for handling packages containing nuclear substances poster

CNSC Specific Signage

- A CNSC Specific Signage is required at the entrance if
  - Radioactive substance > 100 EQ, and/or
  - When there is reasonable probability that a person might be exposed to an effective dose rate of greater than 25 *μSv/h*



Signage For Use and Storage

- Signage is required where radioactive substance above EQ is used or stored:
  - Radiation symbol + “Radiation Use Area” label or tape
  - Radiation symbol + “Radiation Storage Area” label

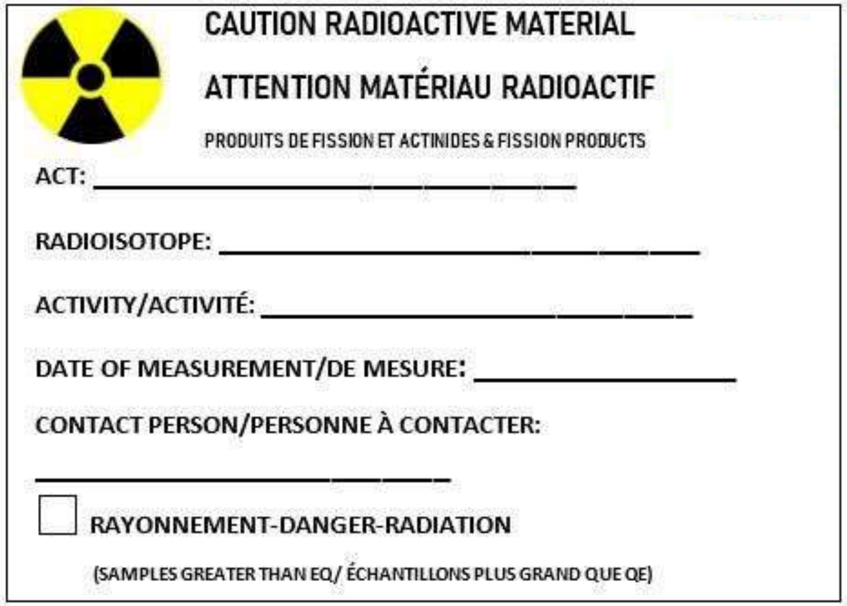
- No signage if all radioisotopes' activities in use and storage are less than 1 EQ

Caution
Radioactive Use Area

Caution
Radioactive Storage Area

Signage For Use and Storage

- Labelling for container and device must include:
- Radiation symbol
- Wording “Rayonnement-Danger-Radiation”
- Radioisotope name
- Activity (*Ci* or *Bq*)
- Reference date
- Permit holder/PI name
- PO# for unsealed sources
- Calibration date (device)
- Form of chemical name


CAUTION RADIOACTIVE MATERIAL

ATTENTION MATÉRIAU RADIOACTIF

PRODUITS DE FISSION ET ACTINIDES & FISSION PRODUCTS

ACT: ____________________

RADIOISOTOPE: ____________________

ACTIVITY/ACTIVITÉ: ____________________

DATE OF MEASUREMENT/DE MESURE: ____________

CONTACT PERSON/PERSONNE À CONTACTER:

____

☐ RAYONNEMENT-DANGER-RADIATION

(SAMPLES GREATER THAN EQ/ ÉCHANTILLONS PLUS GRAND QUE QE)

Label for radioactive material/device

Radioactive Waste Management

Radioactive Waste

- Radioactive waste can be
  - Solid waste
  - Water soluble waste
  - Liquid scintillation waste (LSW)
  - Animal carcasses waste

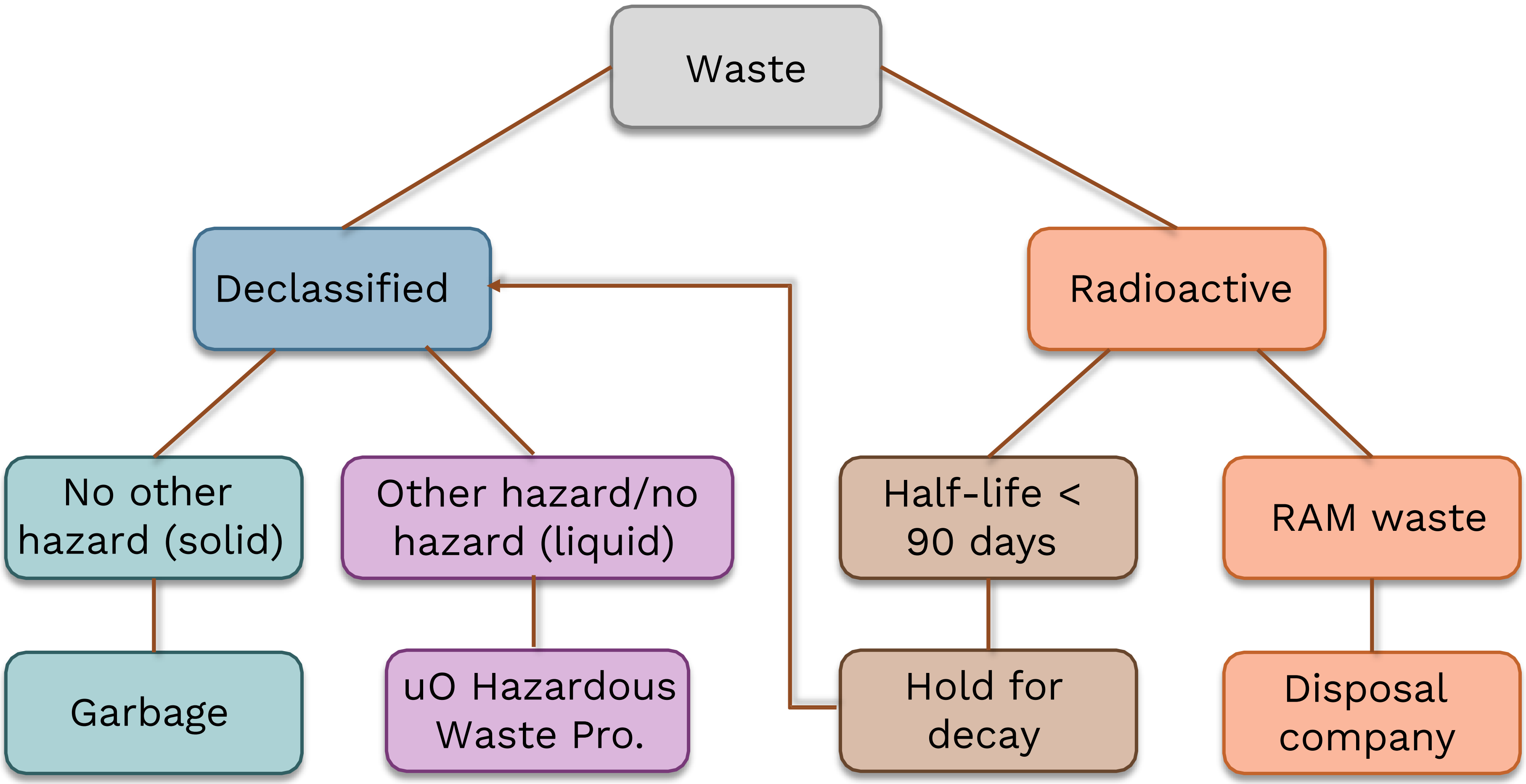
Check uOttawa Radiation Safety Manual for Radioactive Waste Management

- Can be declassified if below the CNSC disposal limits (DL)
  - Regular garbage if no other hazard exists
  - Chemical hazardous waste (e.g., LSW)
  - Regular carcass waste (biomedical waste)

Radioactive Waste Assessment

- It determines waste disposal stream
  - Waste held for decay
  - Declassified waste (chem, bio, regular)
  - RAM waste (special pickup by 3rd party)
- Waste may be declassified upon generation at permit application
- Submit the electronic waste logs (excel format) to OCRO for assessment before final disposal
- Find Waste Logs on uOttawa Radiation Safety Webpage or request from rad.safety@uottawa.ca

Radioactive Waste Flowchart



Solid Radioactive Waste

- Disposal Limits (DL) are listed on uOttawa's CNSC License – disposal to landfill in MBq/kg
  - C-14: 3.7 *MBq* (100 *μCi*)/*kg*
  - H-3: 37 *MBq* (1000 *μCi*)/*kg*
  - I-125: 0.037 *MBq* (1 μ*μCi*)/*kg*
  - P-32: 0.37 *MBq* (10 *μCi*)/*kg*

Check 2nd page of Permit for Disposal Limits

- Radioisotopes with T ½ < 90 days can hold for decay until 1DL is attained

- Off-site transfers when the activity is too great for other disposal options, or CNSC does not allow disposal

Calculate Time Required for Decay

$$A = A_o \left(\frac{1}{2}\right)^{t/t_{1/2}} = A_o\, e^{-\lambda t}$$

$$t = \frac{\ln (A/A_o)}{-\lambda}$$

A = activity at time 't'

A_o = activity at time zero

t = elapsed time

λ = decay constant; $\lambda = \ln 2/(t_{1/2}) = 0.693 / (t_{1/2})$

$t_{1/2}$ = half-life

RadPro calculator: http://www.radprocalculator.com/Decay.aspx

Example: Calculate Time Required for Decay

Given:

100 μCi of P-32 solid waste collected; weight of waste = 0.785 *kg*, disposal limit of P-32 is 0.37 *MBq/kg* (10 *μCi/kg*), half-life (t1/2) of P-32 is 14.3 days

Answer:

Step 1: Determine activity (A) permitted at disposal

Weight = 0.785 kg

1 DL/kg = 10 *μ*Ci/kg

A = Weight x 1 DL/kg

= 0.785 kg x 10 *μ*Ci/kg

= 7.85 *μ*Ci

Step 2: Determine Length of Decay Period (t)

$$t = \frac{\ln (A/A_o)}{-\lambda}$$

A = activity at time 't' (7.85 *μ*Ci)

A_0 = activity at time zero (100 *μ*Ci)

t = elapsed time (?)

λ = decay constant =0.693 / 14.3 days = 0.0485/day

$$t = \frac{\ln (7.85\ \mu Ci / 100\ \mu Ci)}{-0.0485/day} = 52.5 \text{ days}$$

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Office of the Chief Risk Officer

Radioactive Decay Waste Log

Radioactive Decay Waste Log

Permit Holder:		Radioisotope		
Permit Number:		Half Life		days
Decay Container		Disposal Limit		MBq/kg
Identification #:		Expected Date of Disposal		

User (Initial & Surname)	Date (dd-mmm-yyyy)	Estimated Activity µCi	MBq	Remarks
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
			0	
Total Estimated Activity:		0	0.000	

Total Weight of Waste (excluding pail)		kg		Days Held
Last Date of Radiation Use:				

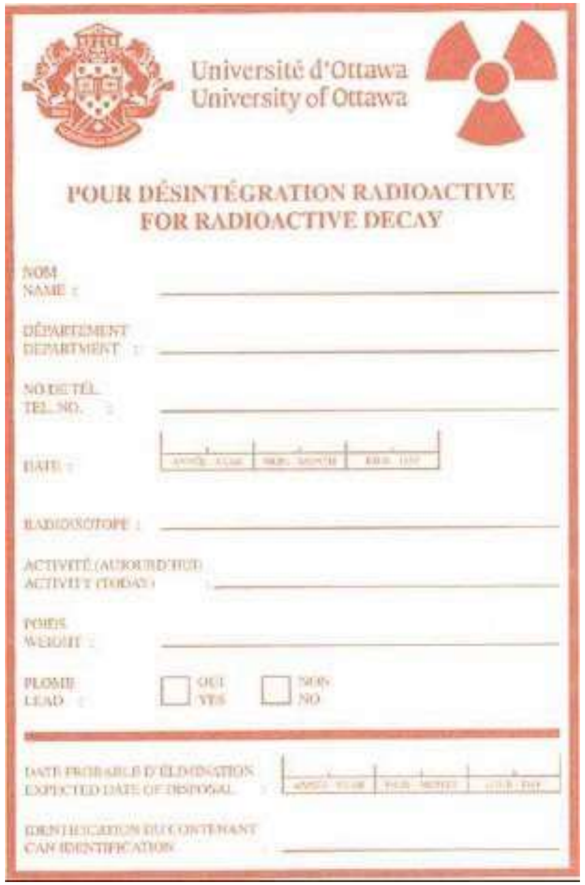
Disposal date

The waste is still part of your inventory until disposal, so you are responsible for keeping records.

Retention time

Radioactive for Decay Label

- Waste held for decay should have a “Radioactive for Decay Label” on container with the calculated numbers filled out:
  - Total activity when transfer for decay
  - Date of transfer for decay
  - Established disposal date
- Can be modified: if the material is not for decay, cross-off "Decay" from label
- Once decay to activity below DL, the label must be removed or defaced



Radioactive decay label

Water Soluble Radioactive Waste

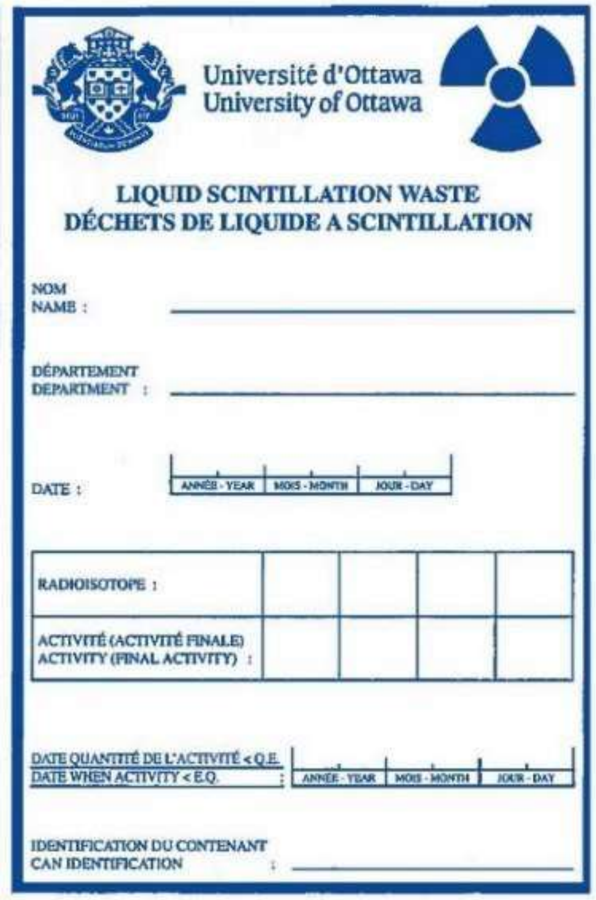
- Disposal limits are assigned by building (CNSC-C-292) and outlined in the NSRD Licence:
  - C-14: 0.01 *TBq/yr*
  - H-3: 1 *TBq/yr*
  - I-125: 100 *MBq/yr*
  - P-32: 4 *GBq/yr*
- The City of Ottawa’s approval is also required
- Should NOT be put down the drain even no chemical hazard exists
- Collected by uOttawa Hazardous Waste Program

Liquid Scintillation Waste

- Keep in mind LS cocktails are chemical hazards
- Put liquid scintillation waste vials directly in a 20L pail
- Waste should be stored in pails with a lid and are double lined with plastic bags
- A "LSW label" should be attached to the pail
- LSW Log should accompany pail or a note indicating where the log can be found
- Do not hold for extended periods as vials can leak
- Assessment must be done before transferred or disposal

Liquid Scintillation Waste Label

- LSW should have a “LSW Label” on container:
  - Radioisotopes
  - Activity of each radioisotope
- Can be modified: if the material is not scintillation waste, cross-off “scintillation" from label
- Once declassified, the label must be removed or defaced


Université d'Ottawa
University of Ottawa

LIQUID SCINTILLATION WASTE
DÉCHETS DE LIQUIDE A SCINTILLATION

NOM
NAME :

DÉPARTEMENT
DEPARTMENT :

DATE : ANNÉE - YEAR | MOIS - MONTH | JOUR - DAY

RADIOISOTOPE :				
ACTIVITÉ (ACTIVITÉ FINALE) ACTIVITY (FINAL ACTIVITY) :				

DATE QUANTITÉ DE L'ACTIVITÉ < Q.E.
DATE WHEN ACTIVITY < E.Q. : ANNÉE - YEAR | MOIS - MONTH | JOUR - DAY

IDENTIFICATION DU CONTENANT
CAN IDENTIFICATION :

Liquid scintillation waste label

Radioactive Animal Carcass Waste

- Disposal via ACVS
- Animal Carcass Waste Log is required
- If sent for incineration, activities must meet regulatory criteria

Check uOttawa Radiation Safety Manual for Radioactive Animal Carcasses Waste Disposal Procedures

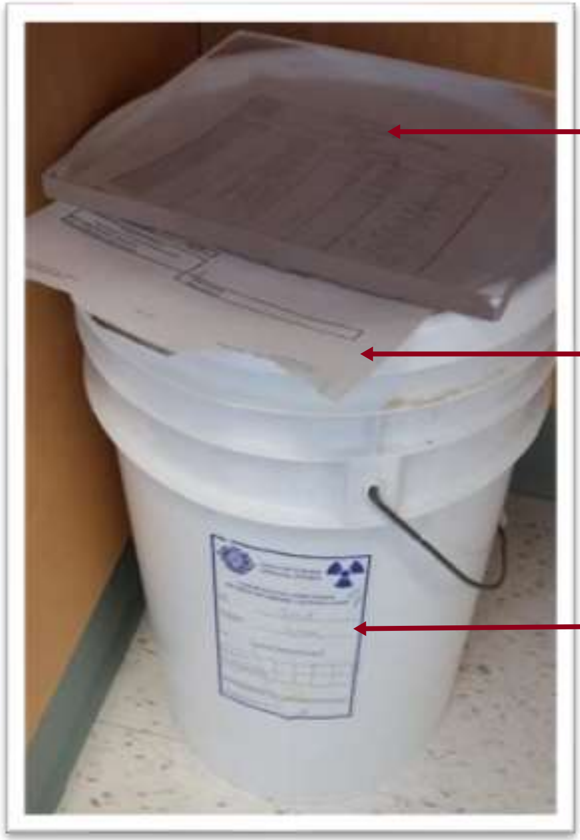
RAM Requiring Off-site Disposal

- Consult RSO and each case will be assessed independently
  - Waste cannot be declassified
  - Sealed sources
  - NORM waste
  - Radioactive chemicals (uranyl acetate, etc.)
- Information must be provided to RSO:
  - Radioisotope(s) in the waste
  - Radioactivity in *Bq* or specific activity in *Bq/kg*
  - Total volume or weight of the waste
  - Chemical compounds in the waste

Radioactive Waste Storage

- Use OCRO approved containers (double lined 20L pail with lid, 10/20L carboy, etc.)
- Access to the waste must be limited
- A radioactive waste label must be attached to the container
- A waste log must be placed on the waste container, or there should be a label indicating where the log is stored
- Shielding may be used to minimize exposure
- Once decayed/declassified/removed: all radioactive waste labels must be removed, de-faced or covered
- Other potential risks must also be considered in determining the storage requirements (e.g., organic vapors)

Example: Waste Storage



Plexiglass shielding

Waste log

Waste label

Monitoring Activities

Radiation Monitoring Activities

- Radiation monitoring involves the measurement of radiation dose or radioactive contamination:
- Radiation detection
- Contamination monitoring
- Dose rate monitoring (around storage, waste, use areas)
- Exposure monitoring
- Leak testing
- Thyroid screening

Radiation Detection Instrument

- Used to measure radiation fields and dose rate
- Must be selected to measure specific α, β, γ, etc.
- Types of instrument
  - Geiger Muller (GM) meter
  - GeLi detector
  - Ionization chamber
  - Liquid scintillation counter (LSC) Gamma counter

Portable detectors – survey meters

Liquid scintillation counter

Direct vs. Indirect Measurement

- Direct Measurement
  - A portable survey meter
  - Checks contamination, radiation field & surface dose rate
  - Result is sum of both fixed and non-fixed contamination

- Indirect Measurement
  - Wipe test by liquid scintillation counter/gamma counter
  - Checks low energy (H-3/C-14)
  - Detects radioactive materials
  - Detects removable (non-fixed) contamination

Liquid Scintillation Counters (LSC)

- LSC can be used to detect low energy (H-3 and C-14) activities are not generally detectable by survey meters or contamination monitors.

- When use LSC for contamination monitoring
  - Select the appropriate energy range
  - Use the “open” (entire) energy range for decommissioning wipe test
  - Know the efficiency for the radioisotope you are monitoring
  - Know how to do an operational check to ensure your results are accurate (use standards)

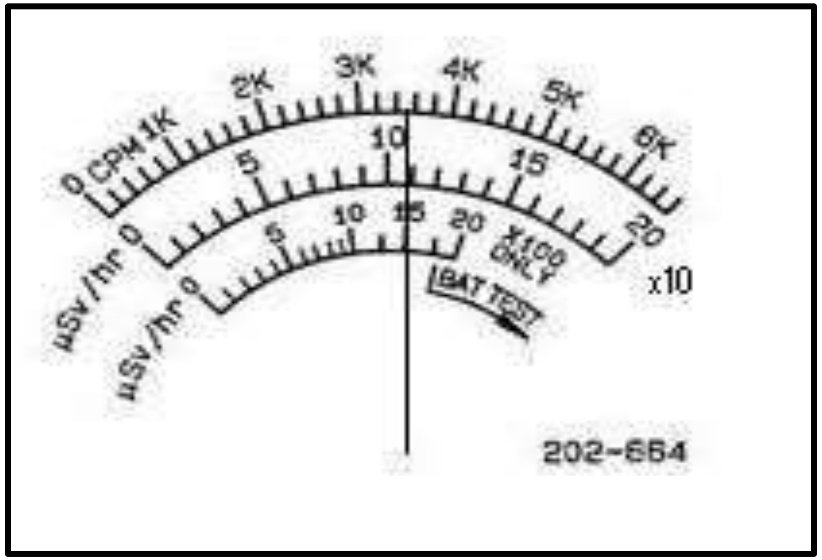
Portable Survey Meters

- Pre-operations check: damage, battery, audible response, calibration check, response setting, electronic connections
- Must be able to demonstrate capacity to detect the CNSC criteria (Class A, B, C radioisotopes)
- Annual calibration is required

Portable survey meters

Reading a Survey Meter

- Example: with range selected to x10, what is the radiation field in *μSv/hr*?
  - Use 2nd scale reading 11 multiply by 10: 110 *μSv/hr*



Contamination Monitoring

- Must be done regularly when radioisotopes are used:
  - If < 5 ALI: basic level - weekly
  - If > 5 ALI: intermediate level - after each use
- Also required for after spill, lab decommissioning etc.
- Track records on a Contamination Monitoring Monthly Log
- Map of lab indicating areas monitored should be up to date
- Results must be documented in ***Bq/cm²***

Link: Contamination Monitoring Monthly Log

Contamination Monitoring Monthly Log

- Record the monitoring results on the monthly log
- If radioactivity not used, record “no radioisotope used”

METHOD OF MONITORING : METER WIPE TEST

	back-ground	area 1	area 2	area 3	area 4	
WEEK 1	22	26	28	89	32	
WEEK 2		“No	Isoto	pe use”		
WEEK 3						

Unit *cpm/cps* must be converted to *Bq/cm*^{2}

POST-DECONTAMINATION RESULTS

	back-ground	area 1	area 2	area 3	area 4	
WEEK 1	24			39		

Converting from cpm into Bq/cm^2

- Use the following equation to calculate the wipe test results from a liquid scintillation counter into *Bq/cm*²

$$\text{Result in } Bq/cm^2 = (\text{reading in } cpm - \text{bkg})/(E_w \times E_c \times 60 \times A)$$

Where bkg = counts per minute of the background,

E_w = wipe efficiency, assume 10% (0.1),

E_c = scintillation counter efficiency (refer to vendor's manual), and

A = area scanned in cm^2

Converting from cpm into Bq/cm²

- Use the following equation to calculate the scanning results from a survey meter into *Bq/cm²*

  Result in Bq/cm² = (reading in *cpm* – bkg)/(E_c x 60 x A)

  Where bkg = counts per minute of the background,

  E_c = survey meter efficiency (refer to vendor's manual), and

  A = area scanned in *cm²* (19.6 *cm²* for a pancake probe)

- Note, as a rule of thumb, when the counter efficiency (E_c) is unknown, the following efficiencies can be used for the purpose of counting wipes:
  - 100% (1) for P-32, C-14, S-35
  - 75% (0.75) for I-125
  - 50% (0.5) for H-3 and unknowns

Contamination Monitoring Criteria

- The CNSC contamination monitoring criteria

Non-Fixed Contamination	Class A radionuclides	Class B radionuclides	Class C radionuclides
In all areas, rooms or enclosures where unsealed nuclear substances are used, or stored	3 *Bq/cm²*	30 *Bq/cm²*	300 *Bq/cm²*
In all other areas and packaging	**0.3 *Bq/cm²***	3 *Bq/cm²*	30 *Bq/cm²*

- uOttawa "Best Practice" is to meet **0.3 *Bq/cm²*** for all contamination monitoring

Dose Rate Monitoring

- Routinely to ensure doses are ALARA
- Dose rate around storage, waste, use areas must not exceed 2.5 *μSv/hr*
- Whenever new sources or samples are received or used
- When new experimental procedures are implemented
- Meter used must be calibrated within 12 months (check the sticker on your meter)

Digital survey meter

Personal Exposure Monitoring

- uOttawa dosimetry service provider: HC – National Dosimetry Service
  - Optical stimulated luminescence (OSL) dosimeters
  - Whole body, extremities (ring, wrist)
- Action level at uOttawa: **0.3 *mSv*** over 3 months wearing period
- Non-NEW criteria: **1 *mSv/yr*** for whole body

Extremity dosimeter (left) and whole-body dosimeter (right)

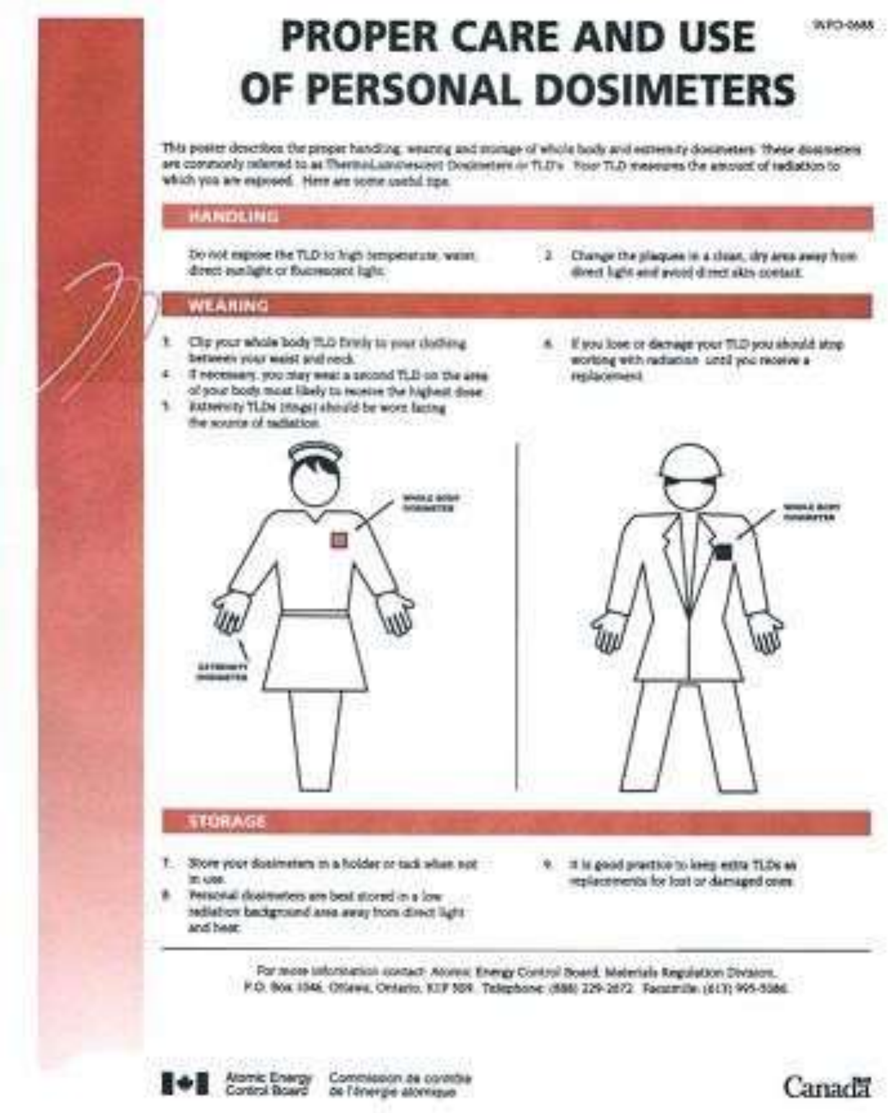
Ring dosimeters

Dosimeter Wearing

- Avoid exposing them to high temperatures, water, direct sunlight and fluorescence light
- Avoid storage in areas of high radiation fields
- Wear securely with the badge facing the source of radiation
- If contaminated or damage stop wearing, replace with a new dosimeter
- Review of all doses that meet action criteria

Example of dosimeter wearing

Dosimeter Wearing



INFO-0685

PROPER CARE AND USE OF PERSONAL DOSIMETERS

This poster describes the proper handling, wearing and storage of whole body and extremity dosimeters. These dosimeters are commonly referred to as ThermoLuminescent Dosimeters or TLD's. Your TLD measures the amount of radiation to which you are exposed. Here are some useful tips.

HANDLING

1. Do not expose the TLD to high temperature, water, direct sunlight or fluorescent light.
2. Change the plaques in a clean, dry area away from direct light and avoid direct skin contact.

WEARING

3. Clip your whole body TLD firmly to your clothing between your waist and neck.
4. If necessary, you may wear a second TLD on the area of your body most likely to receive the highest dose.
5. Extremity TLDs (rings) should be worn facing the source of radiation.
6. If you lose or damage your TLD you should stop working with radiation until you receive a replacement.

STORAGE

7. Store your dosimeters in a holder or rack when not in use.
8. Personal dosimeters are best stored in a low radiation background area away from direct light and heat.
9. It is good practice to keep extra TLDs as replacements for lost or damaged ones.

For more information contact: Atomic Energy Control Board, Materials Regulation Division, P.O. Box 1046, Ottawa, Ontario, K1P 5S9. Telephone: (888) 229-2672. Facsimile: (613) 995-5086.

Atomic Energy Control Board / Commission de contrôle de l'énergie atomique

Canada

CNSC poster should be posted in your lab if dosimeters are used.

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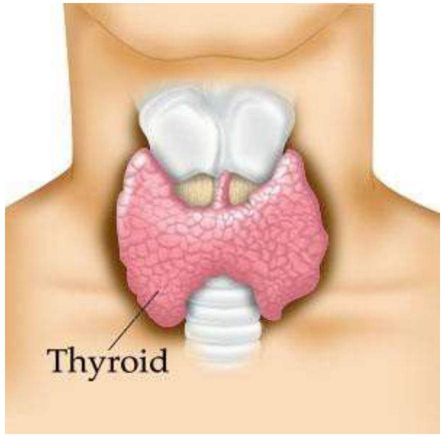
Office of the Chief Risk Officer

Thyroid Screening

- When work with unbound iodine I-125 & I-131, thyroid screening is required if personal contamination has occurred, or if in a 24-hour period the following amounts are exceeded:

Confinement	Quantity of I-125 or I-131: gases, volatile liquids and powders
None	2 MBq
Fumehood	200 MBq
Glovebox	20,000 MBq



Leak Testing for Sealed Sources

- Required for > 50 *MBq* (1.35 *mCi*) sealed sources
- Leak testing frequency:
  - In use – every 6 months
  - In use in a device – every 12 month
  - In storage – every 24 month
- Can be conducted by a qualified 3rd party service
- Reporting criteria is a leakage of 200 *Bq*

Sealed source in device (OSL irradiator)

Radiation Decommissioning

- Required when
  - Lab relocating
  - Permit terminating (personnel leave)
  - Equipment disposal
  - Radioactive material not in use for 1 year

- Requirements
  - Radioactive material/waste is safely relocated/disposed
  - Contamination monitoring is done
  - Signages/postings are removed

Check uOttawa Radiation Safety Manual for Radiation Decommission Guide

Spill Response

Spill Response

- Mitigated by training, appropriate experimental design and good work practices

- Anticipate the type of spill
  - Minor spill < 100 EQ
  - Major spill > 100 EQ

- Spill kit must be available in lab

Materials in a spill kit for radioactive spills

Spill Response

- Quick risk assessment:
  - Type of spill (liquid, solid, aerosol)
  - Size of spill
  - Activity involved
  - Physical characteristic of the radioisotope (decay energy, type of emission, half-life)
  - Biological risks
  - Any other hazard that may exist
- Inform OCRO immediately:
  - Major spills (> 100 EQ)
  - Contamination of personnel, or release of volatile

Spill Response

1. Notify all individuals in the immediate area that a spill has occurred.
2. Increase distance from the spill. If the spill is severe, this may require evacuating the area.
3. If evacuation is required, lock and sign door. The warning sign should include your name, as well as a location of spill and time of return.
4. Limit access to only those individual responding to the spill.
5. If personal contamination has occurred, gently wash skin with a mild soap and tepid water.
6. If personal (skin) contamination has occurred, immediately call x. 5411 and contact OCRO.

Spill Response

If safe to do:

1. Contain the spill with absorbent material (paper towels)
2. Obtain any additional supplies and/or personal protective equipment (overalls, shoe coverings)
3. Push spill toward its center. Clean from outside to inside and collect all contaminated material in one appropriately labelled bag
4. Decontaminate area with appropriate solutions (keep in mind biological or chemical hazards)
5. If fixed contamination remains, contact the RSO

Spill Response


SPILL PROCEDURES

Name and telephone number of the person responsible for enforcing safe work practices with nuclear substances in this work area

Radiation Safety Officer	Telephone number

Person in charge	Telephone number

General Precautions

1. Inform persons in the area that a spill has occurred. Keep them away from the contaminated area.
2. Cover the spill with absorbent material to prevent the spread of contamination.

Minor Spills (Typically less than 100 exemption quantities of a nuclear substance)

1. Wearing protective clothing and disposable gloves, clean up the spill using absorbent paper and place it in a plastic bag for transfer to a labelled waste container.
2. Avoid spreading contamination. Work from the outside of the spill towards the centre.
3. Wipe test or survey for residual contamination as appropriate. Repeat decontamination, if necessary, until contamination monitoring results meet the Nuclear Substances and Radiation Devices licence criteria.
4. Check hands, clothing, and shoes for contamination.
5. Report the spill and cleanup to the person in charge and, if necessary, to the Radiation Safety Officer.
6. Record spill details and contamination monitoring results. Adjust inventory and waste records appropriately.

Major Spills (Major spills involve more than 100 exemption quantities, or contamination of personnel, or release of volatile material)

1. Clear the area. Persons not involved in the spill should leave the immediate area. Limit the movement of all personnel who may be contaminated until they are monitored.
2. If the spill occurs in a laboratory, leave the fume hood running to minimize the release of volatile nuclear substances to adjacent rooms and hallways.
3. Close off and secure the spill area to prevent entry. Post warning sign(s).
4. Notify the Radiation Safety Officer or person in charge immediately.
5. The Radiation Safety Officer or person in charge will direct personnel decontamination and will decide about decay or cleanup operations.
6. In general, decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and mild soap.
7. Follow the procedures for minor spills (if appropriate).
8. Record the names of all persons involved in the spill. Note the details of any personal contamination.
9. The Radiation Safety Officer or person in charge will arrange for any necessary bioassay measurements.
10. If required, submit a written report to the Radiation Safety Officer or person in charge.
11. The Radiation Safety Officer or person in charge must submit a report to the CNSC.

CNSC's Spill Procedures poster must be posted in your lab.

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Good Practices

Know Radioisotope Characteristics

- Know the radioisotope and follow ALARA principles

Type of emission	Internal/external hazard
CNSC exemption quantity	Use limit
Radioisotope classification	Contamination criteria
Method of detection	Dose rate/contamination
Dosimetry wearing	Applicable or not
Safety precautions	Practices

- Resources: CNSC Radionuclide Information Booklet

Example: H-3

H-3

This page has been printed from the Canadian Nuclear Safety Commission's (CNSC) *Radionuclide Information Booklet*. For references to the information provided, consult the booklet available at http://www.nuclearsafety.gc.ca/eng/resources/radiation/radionuclide-information.cfm.

Part 1 – RADIONUCLIDE IDENTIFICATION			
Chemical symbol: H	Common name: Tritium	Atomic weight: 3	Atomic number: 1

Part 2 – RADIATION CHARACTERISTICS

Physical half-life: 12.32 years

Radiation type	Most abundant emissions (>10 keV, >0.01%)	Most energetic emissions (>10 keV, >0.01%)	Shielding information (mm)
Gamma & X-ray	None	None	Not applicable
Beta(-), Beta(+), electrons	18.6 keV (100%)	18.6 keV (100%)	Not applicable

Part 3 – DOSE RATE CONSTANTS AND COEFFICIENTS

External dose

Tritium is not an external radiation hazard.

Internal dose

Dose coefficients for tritium were obtained from the CNSC's *Health Effects, Dosimetry and Radiological Protection of Tritium* INFO-0799, April 2010.

	Ingestion	Inhalation	
Compound type	Unspecified compounds	Tritiated water	Elemental tritium gas
Worker dose coefficient	2.0E-11 Sv/Bq	2.0E-11 Sv/Bq	2.0E-15 Sv/Bq

Example: H-3

Part 4 – CLEARANCE AND EXEMPTION			
CNSC exemption quantity:	1 MBq/g or 1 GBq	**CNSC classification:**	Class C
CNSC unconditional clearance level:	100 Bq/g	**Release of surface contaminated objects:**	100 Bq/cm^2 (fixed + removable)

Part 5 – DETECTION AND MEASUREMENT

Method of detection (gamma dose rate):
Not applicable

Method of detection (contamination):

1. Hand-held: windowless gas-flow proportional
1. Non-portable: liquid scintillation counter

Dosimetry
External: Not applicable
Internal: In-vitro (urinalysis)

Part 6 – SAFETY PRECAUTIONS

For emergency procedures, please refer to appendix B.

For general safety precautions, please refer to appendix C and apply if necessary.

Note: Tritium is an internal hazard only and cannot generally be detected with handheld equipment. Tritium can also migrate through conventional latex/nitrile gloves and plastic bottles. Tritium can be absorbed through the skin.

Good Practices & Safety Precautions

- Know your radioisotopes and conduct risk assessment
- Follow ALARA principles
- Always wear your dosimeter when working with radioactive material (if applicable)
- Conduct monitoring activity (package, radiation field, contamination)
- Good hygiene techniques (no food/drink, handwashing)
- Control contamination with absorbent paper and spill tray
- Use a fumehood when work with airborne radioactivity (e.g., vapors, dust, aerosols, etc.)
- Wear proper PPE such as gloves, safety glasses, lab coats, respirators etc. – consider wearing double gloves

Records Retention is very important

- Records must be kept and made available for inspection:
  - Internal Radioisotope Use Permits
  - Training (certificate, New User Registration Form)
  - Inventory including the Inventory Use and Disposition Form
  - Purchase & transfer forms
  - Contamination monitoring (with up-to-date map, unit in *Bq*)
  - Waste Logs
  - Proof that instruments are calibrated/certified and capable of detecting the CNSC contamination criteria
  - Inspection, incident/accident reports, etc.

Summary

- Ionizing radiation and risks
- Radiation protection & ALARA principle
- Regulatory control & requirement
- uOttawa Radiation Safety Program
- Radioactive inventory/waste management
- Radiation monitoring
- Emergency response
- Security & reporting
- Record retention

Radiation Safety Training

Questions or comments?

rad.safety@uottawa.ca

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