Radiation Safety Institute of Canada
Institut de radioprotection du Canada

Lunch, Learn, & Dance Wellness Webinars

May 27, 2021

NORM Awareness

Followed by Salem Dance Company

Good Science in Plain Language®

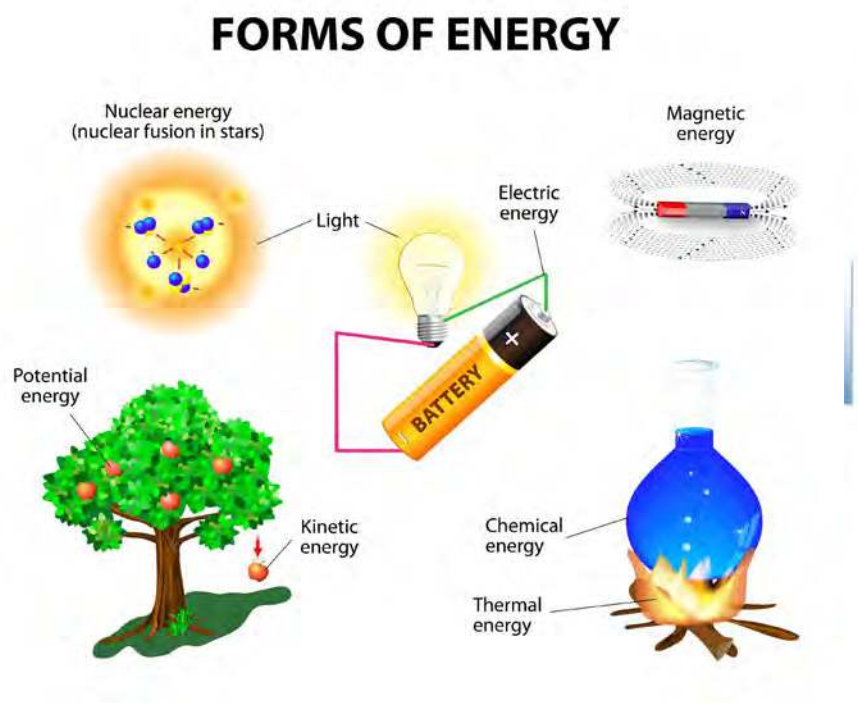
Webinar Functionality

- Audio and video
  - Will be from the presenters only
  - Use computer or telephone (call in)
  - Computer seems to give the best sound quality
- Use the “Chat” feature to enter comments
- Use the “Questions” feature to ask questions
- Posted on webinar page
  - Video, Q&A answers, copy of the slides
- Follow up email will be sent
  - Topics covered, time of attendance
- It may be possible to change your Zoom view if the controls are hiding the closed captioning.

Overview

- What is ionizing radiation?
- Radiation quantities and units
- Radiation health risks from NORM
- Background radiation
- NORM sources
  - Terrestrial
  - Cosmic
- NORM in industry
- ICRP recommendations
- Regulation in Canada
- Canadian NORM guidelines

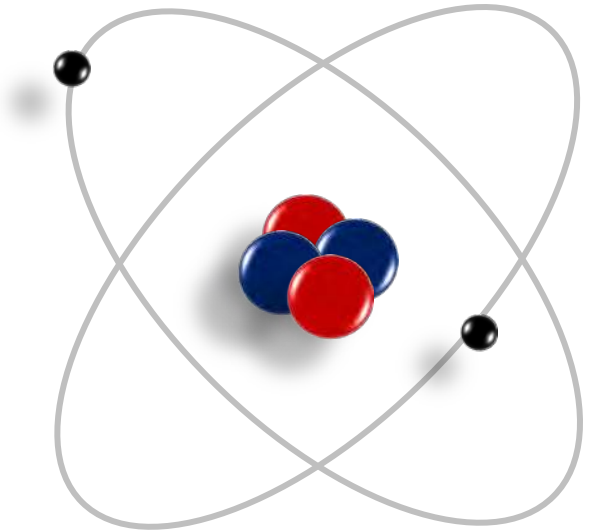
Matter & Energy



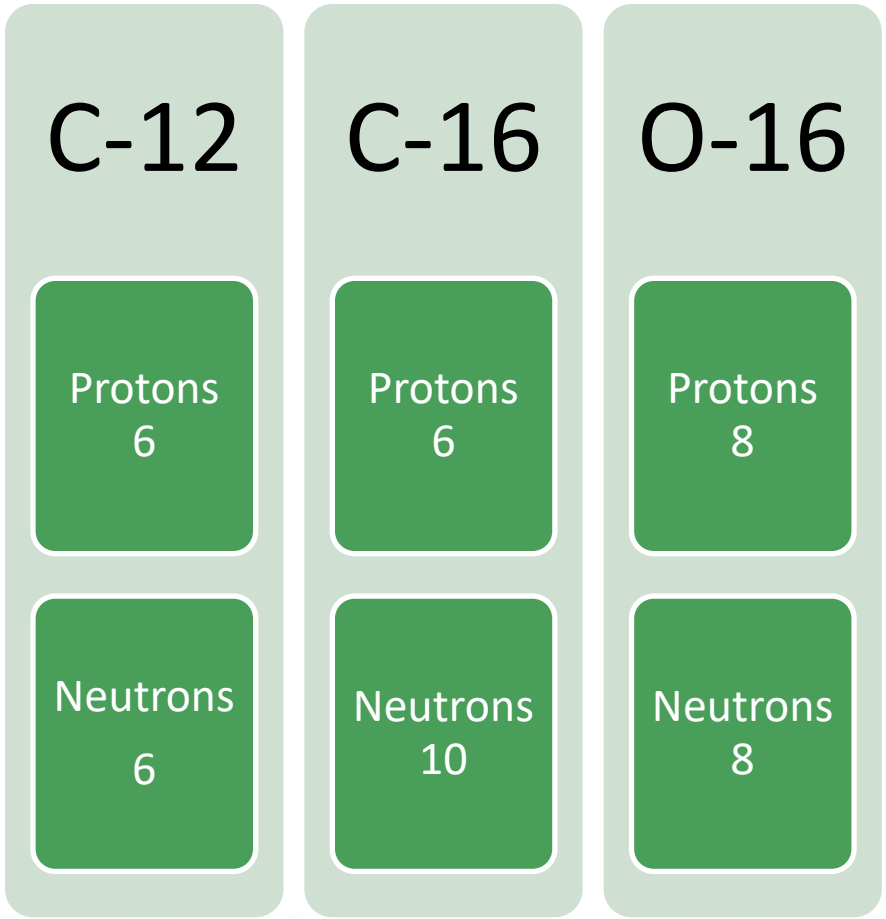
- Matter
  - Has mass
  - Takes up space
- Energy
  - The ability to create change
  - Mechanical energy
    - Kinetic – movement
    - Potential – stored
- Radiation
  - Transfer of energy in a straight line
    - Beams of particles
    - Waves

Parts of the Atom

- Atom made up of
  - Protons (+)
  - Neutrons (0) and
  - Electrons (-)
- Nucleus
  - Protons and neutrons
  - At the center
  - Electrons orbit the nucleus



Nuclides & Isotopes



- Nuclide
  - Number of protons and neutrons
  - Energy state
- Isotope
  - Same number of protons
  - Number of neutrons can be different

Stable and Unstable Isotopes

Most ***nuclides*** in nature are ***stable*** isotopes.

Stable: ***nuclear forces*** are strong enough to hold the nucleus together indefinitely.

Stable and Unstable Isotopes

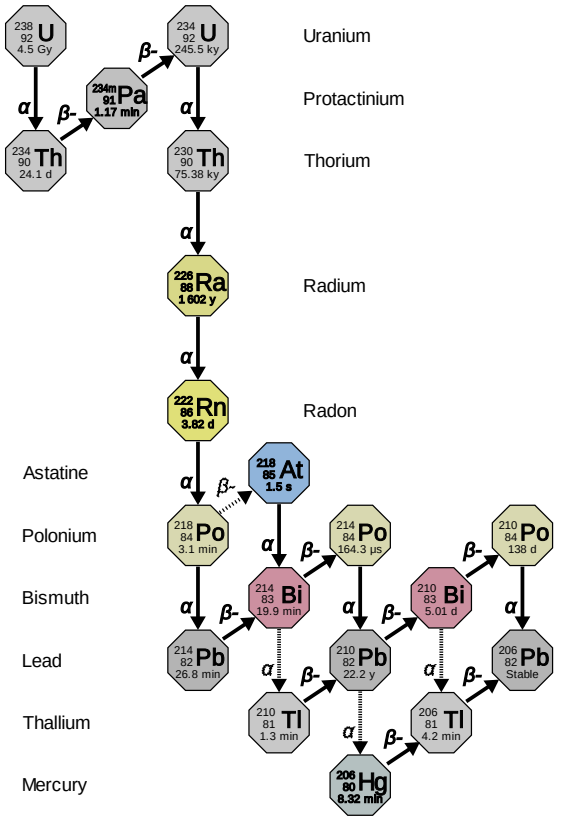
Unstable atom: ***nuclear forces*** are not strong enough to hold the nucleus together indefinitely.

Unstable atoms want to become stable!

While becoming stable, ***unstable*** atoms emit ***radiation***.

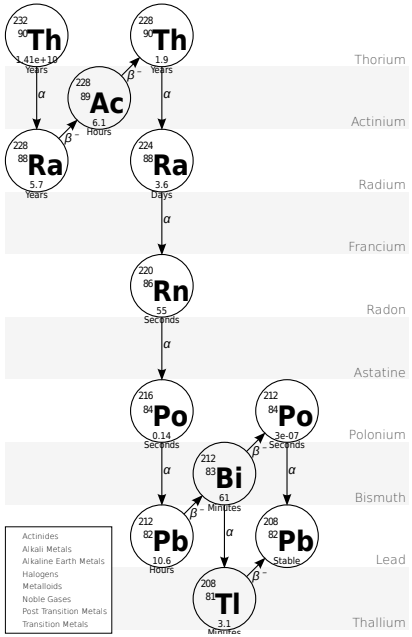
Radioactive Decay

Uranium Decay Series



User:Tosaka, CC BY 3.0

Thorium Decay Series



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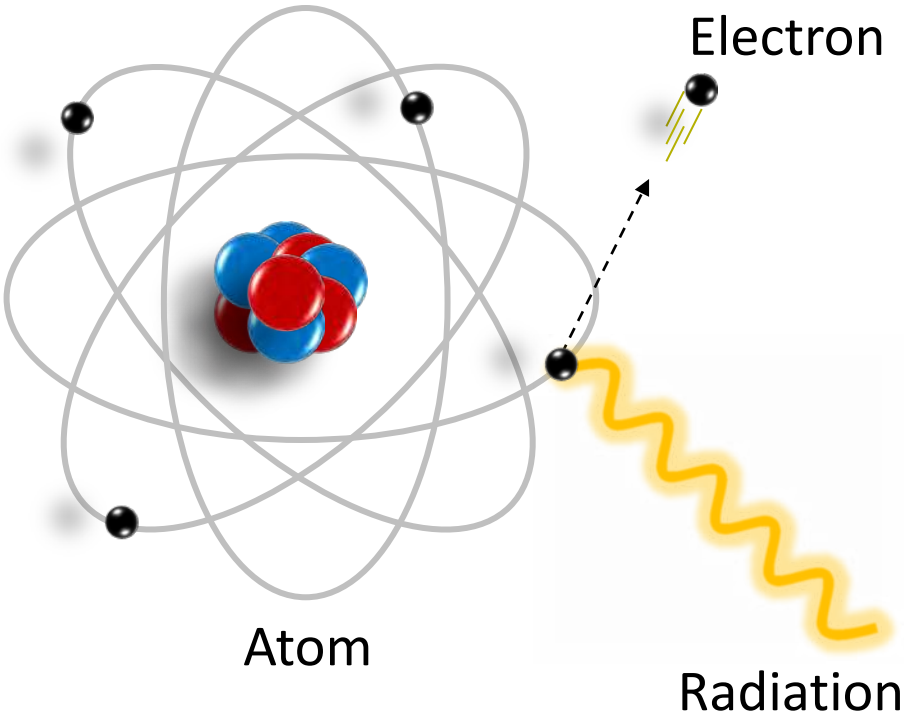
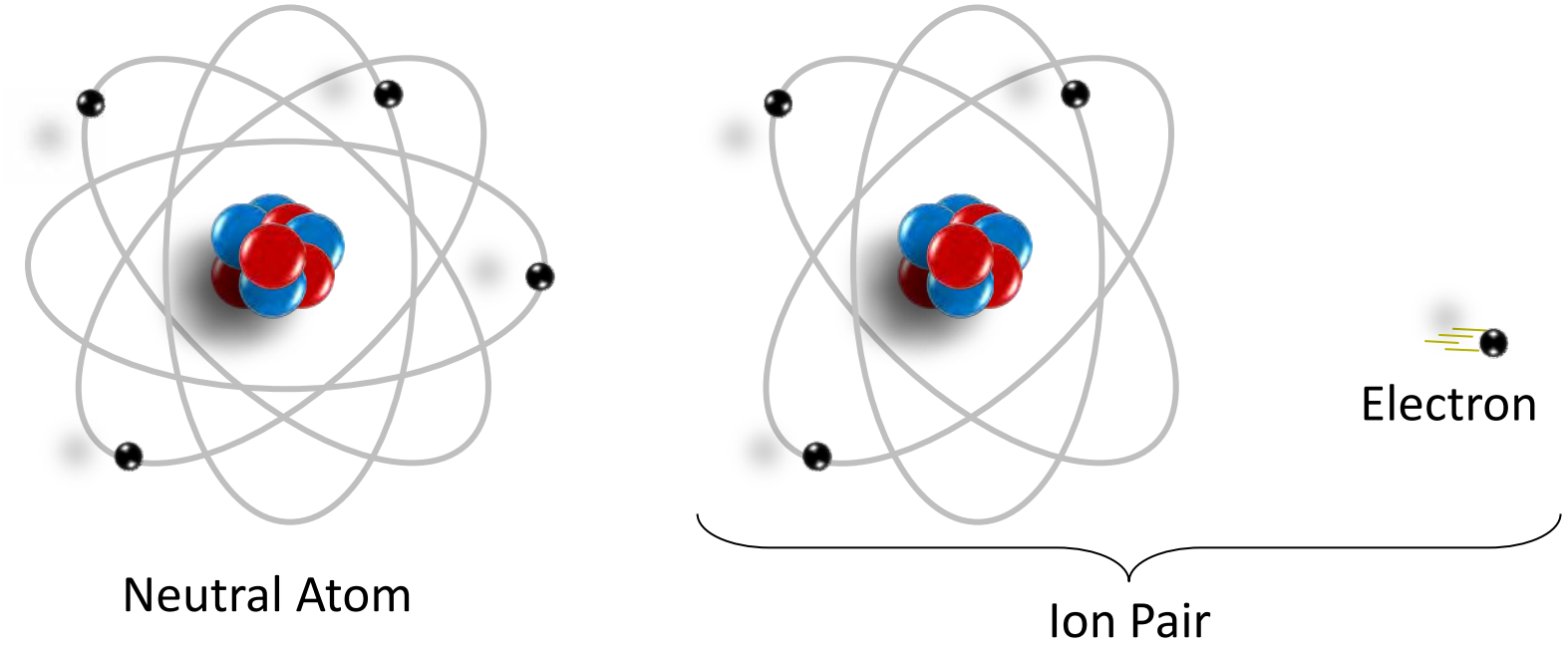
Ionizing Radiation



- When radiation strikes matter, it interacts with the atoms of the matter
- Radiation with enough energy can knock **electrons** out of orbit from the atoms it strikes.

Ionizing Radiation

Radiation that can cause ionization



Ionization: the process of creating ions.

Non-Ionizing Radiation

Radio waves

Infrared light

Non-Ionizing Radiation

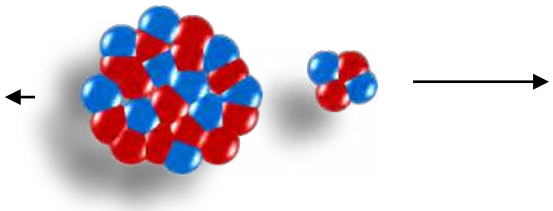
Visible light

Microwaves

Sources of Ionizing Radiation

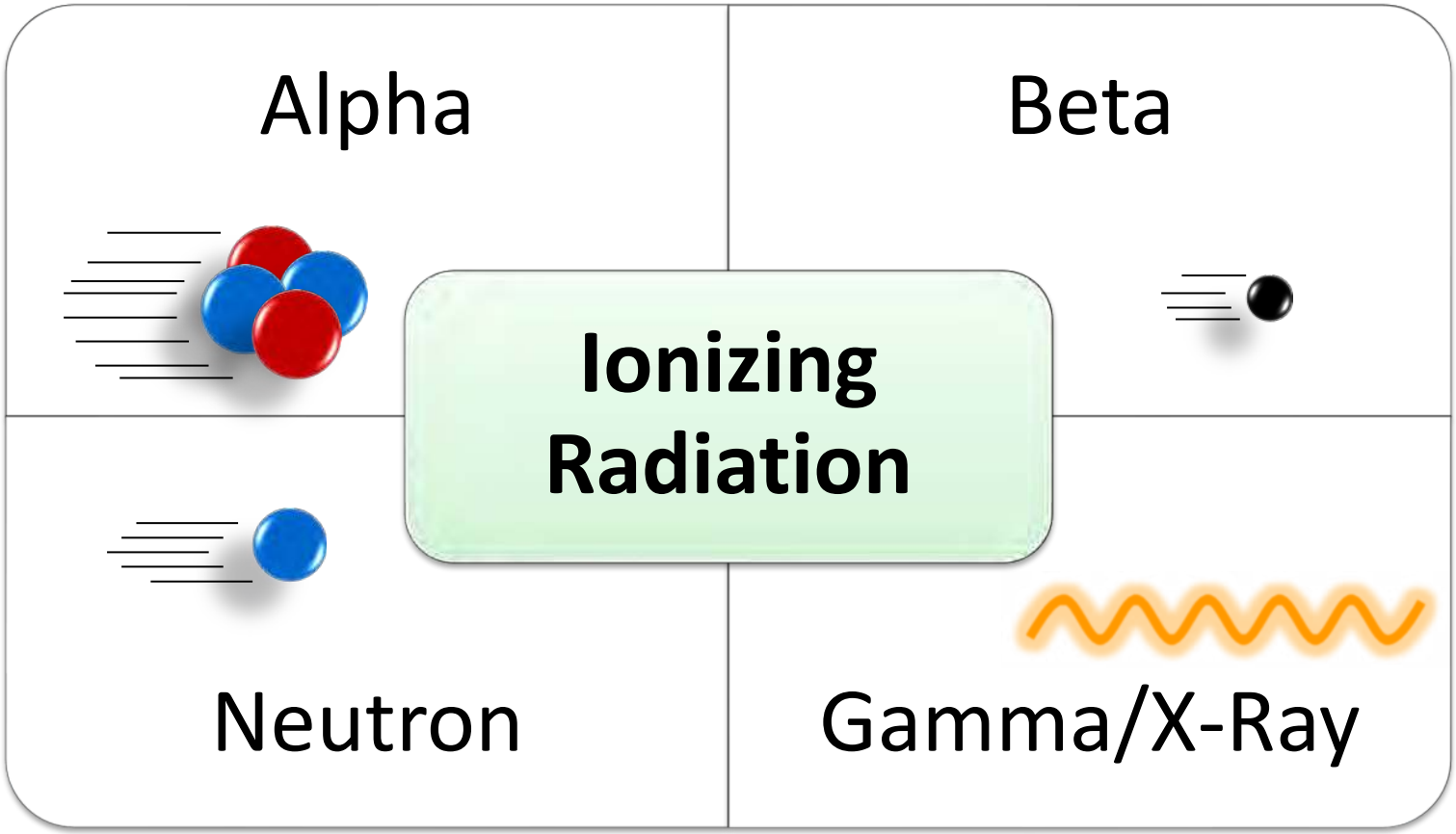
Where does ionizing radiation come from?

Radioactive atoms



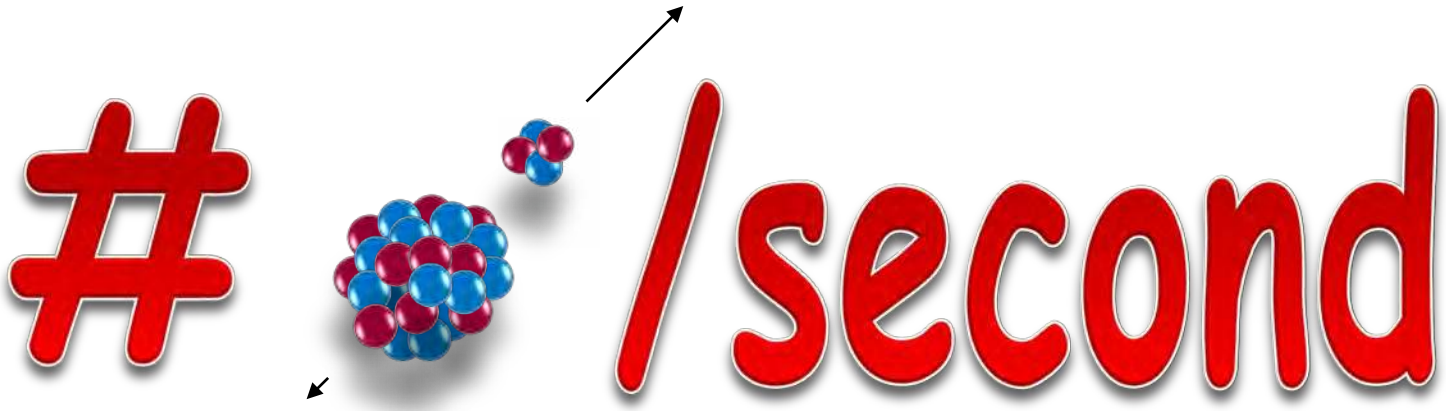
Man-made devices

Types of Ionizing Radiation



Activity

- ***Activity***: The rate of radioactive decay.
  - The number of radionuclide decays per unit of time.



Activity

The unit of activity is the ***becquerel*** (Bq).

1 Bq = 1 radioactive decay per second

Curie (Ci): The historic unit for activity.

1 Ci = 3.7×10^{10} Bq

Activity Examples

1 mg of U-238

- **10 Bq**

1 mg of Am-241

- **100,000,000 Bq**

Half-Life

- Time required for a radioactive sample to lose 50% of its activity by radioactive decay.
- Each radionuclide has its own unique half-life, regardless of the quantity or form.
  - Solid, liquid, gas
  - Element or compound

Radiation Dose

- Energy given to the body by radiation per unit mass
- Measure in Gray (Gy)

Absorbed Dose

Equivalent Dose

- Absorbed dose that also takes the type of radiation into account.
- Measure in Sieverts (Sv)

- Equivalent dose that also looks at the sensitivity of specific tissues to radiation.
- Measure in Sieverts (Sv)

Effective Dose

Types of Effects

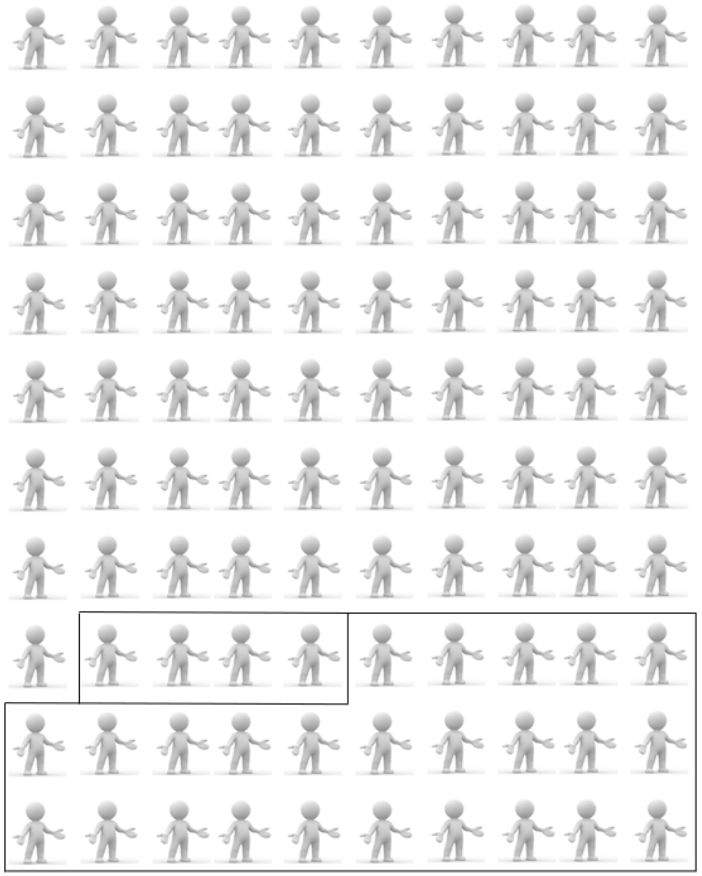
- Deterministic Effects
  - An effect which will certainly result from the exposure
  - There is a minimum exposure (threshold) below which there is NO effect
  - Above the threshold, the SEVERITY of the effect increases with increasing exposure
- Stochastic Effects
  - An effect which *might* occur because of the exposure
  - No threshold
  - The RISK of the effect increases with increasing exposure

The Risk - Some Numbers

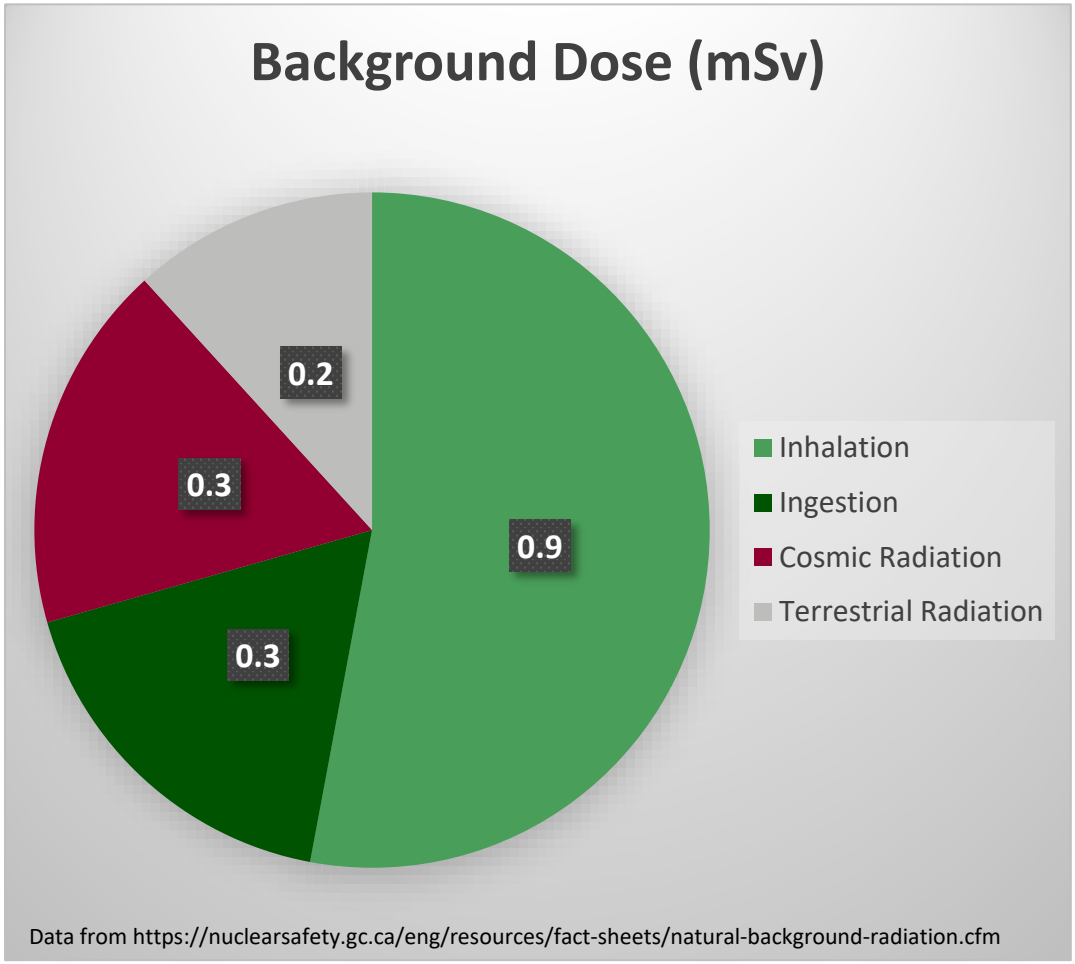
- The risk of developing a fatal cancer as a result of exposure to radiation is approximately 4% per 1000 mSv.
  - Consider a person who worked for 50 years and received 20 mSv per year.
  - This person's total lifetime radiation dose is 1000 mSv.
  - This person will have an extra 4% chance of developing a fatal cancer.

The Risk - Some Numbers

- Approximately 25% of people develop a fatal cancer in their life.
- So, this person's risk of developing a fatal cancer becomes 29% instead of 25%.
- Other professions carry risks too.



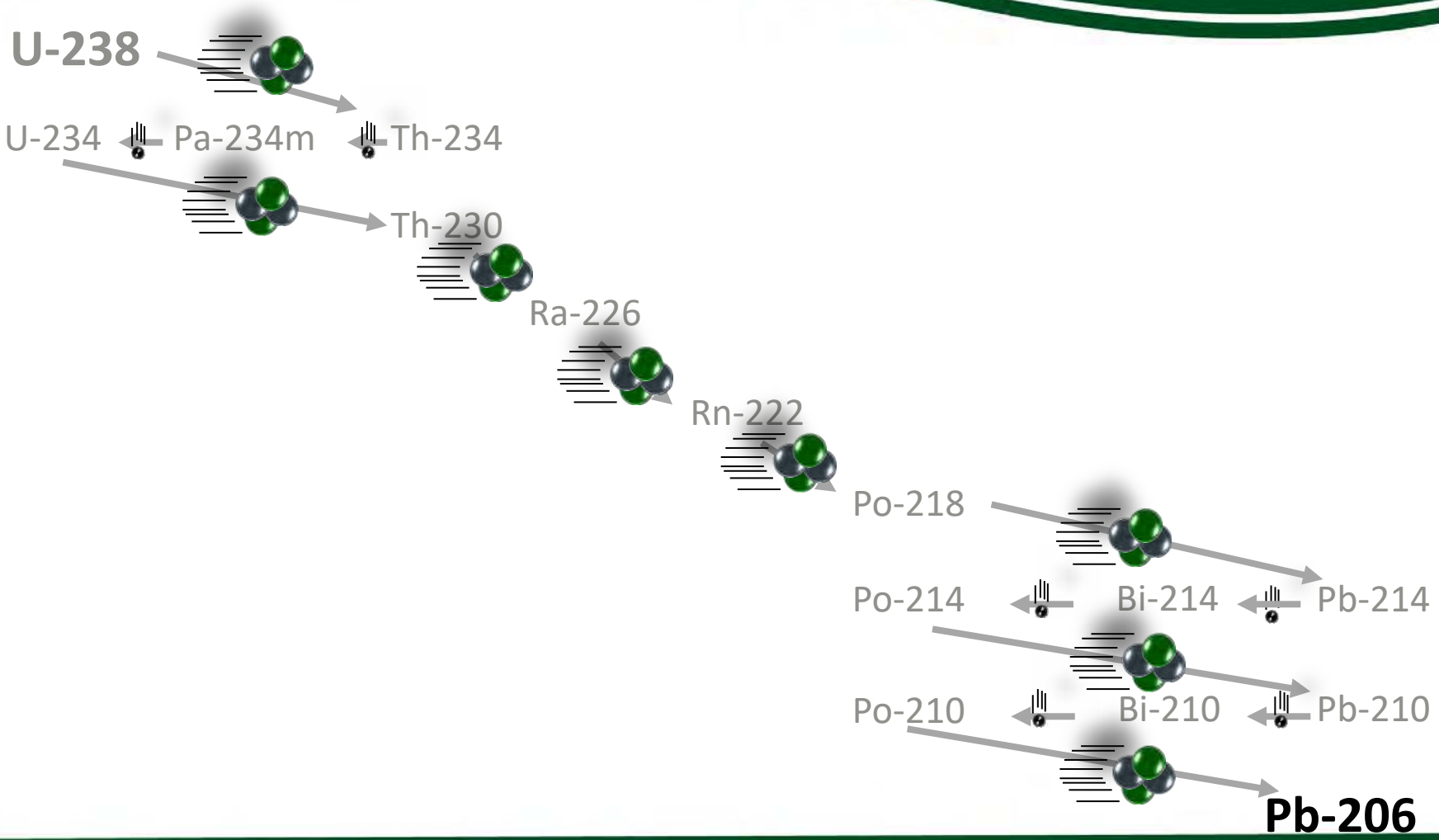
Non-Occupational Radiation Exposures



Data from https://nuclearsafety.gc.ca/eng/resources/fact-sheets/natural-background-radiation.cfm

- Background radiation
  - Soil/water
  - Sunlight
  - Cosmic rays
- Medical
  - Diagnostic
  - Treatment
  - Dental

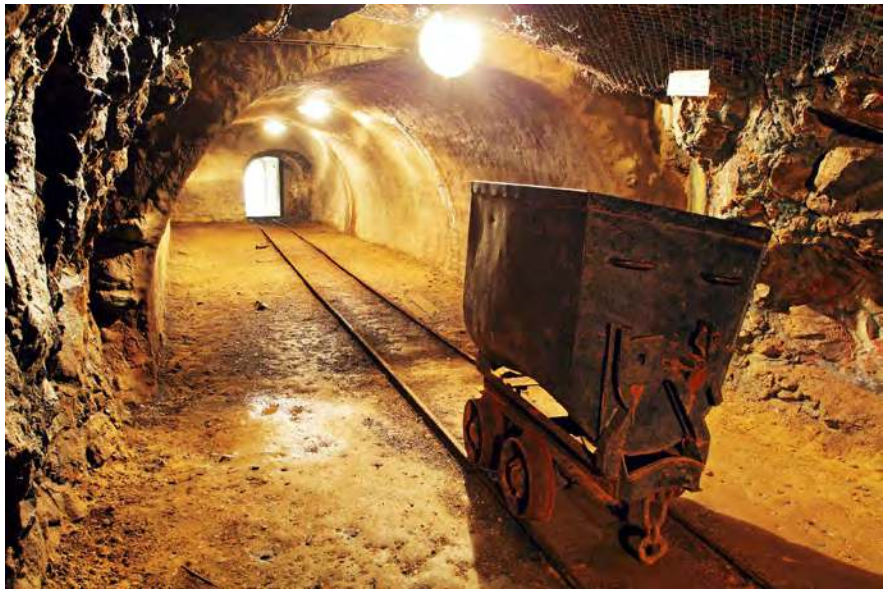
Origins of NORM



Origins of NORM

- Present throughout crust
  - Solid, liquid, gas
- Can naturally release
- Can be released by human activity
- Human activity can concentrate
  - TENORM

NORM in Industry



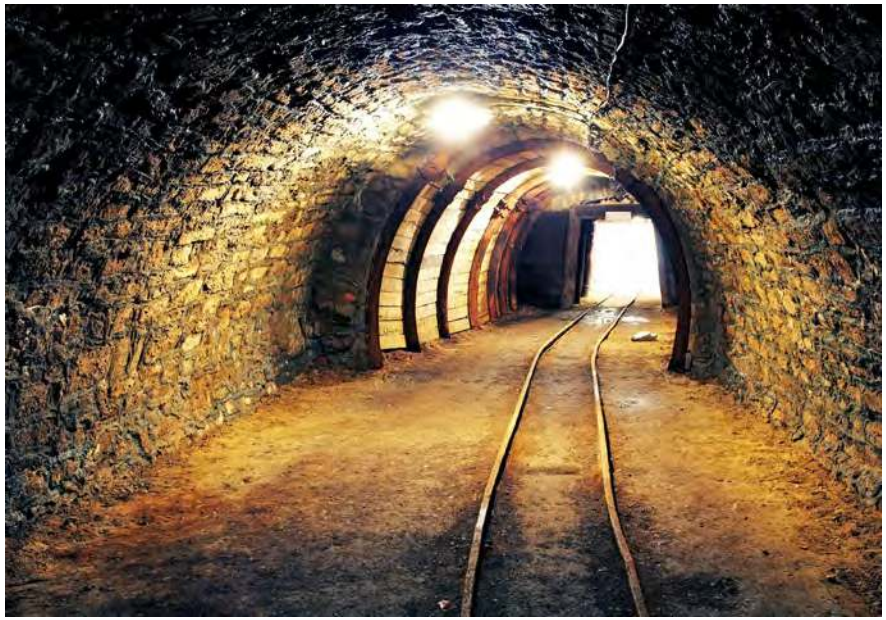
- Mining & production
  - Bauxite and Alumina production waste
  - Hard rock metal mining (Gold, silver, titanium, zircon)
  - Other metal mining and production waste (tin, copper, iron, steel, aluminum, niobium/tantalu, bismuth, etc.)
  - Phosphate mining and processing
  - Production of metallic thorium
  - Rare earths mining waste
  - Uranium mining waste
- Water treatment
  - Drinking
  - Waste water

NORM in Industry

- Consumer products
  - Fertilizer
  - Cement production and maintenance of clinker ovens
  - Cigarettes
  - Building materials
- Energy production
  - Oil and gas recovery
  - Coal combustion
  - Geothermal
- Tunneling and underground work
- Metal recycling

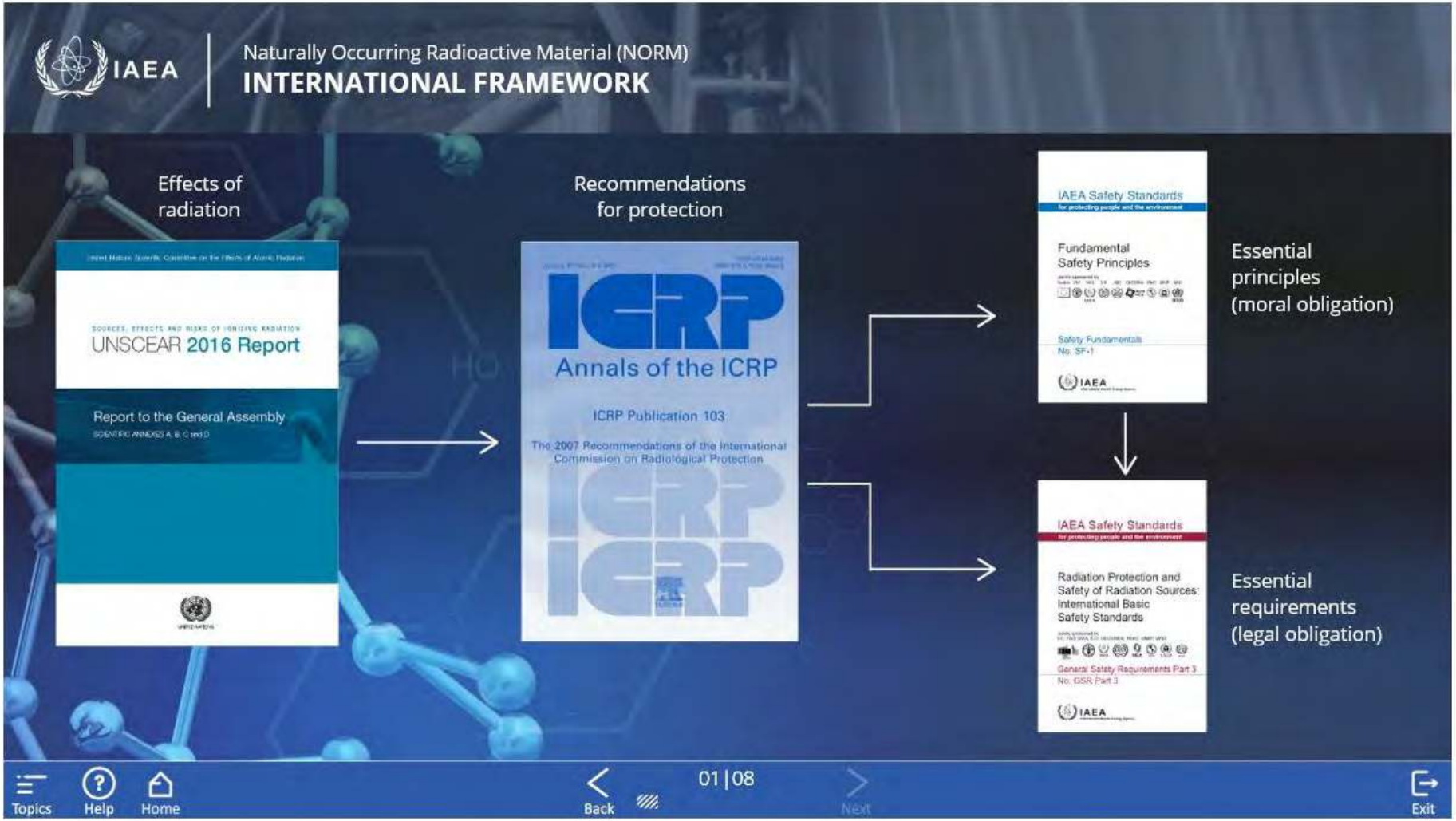
https://nuclearsafety.gc.ca/pubs_catalogue/uploads/March-2011-Info-0813-Alarm-Response-Guildelines-Quick-Reference-Poster_e.pdf

Work Activities

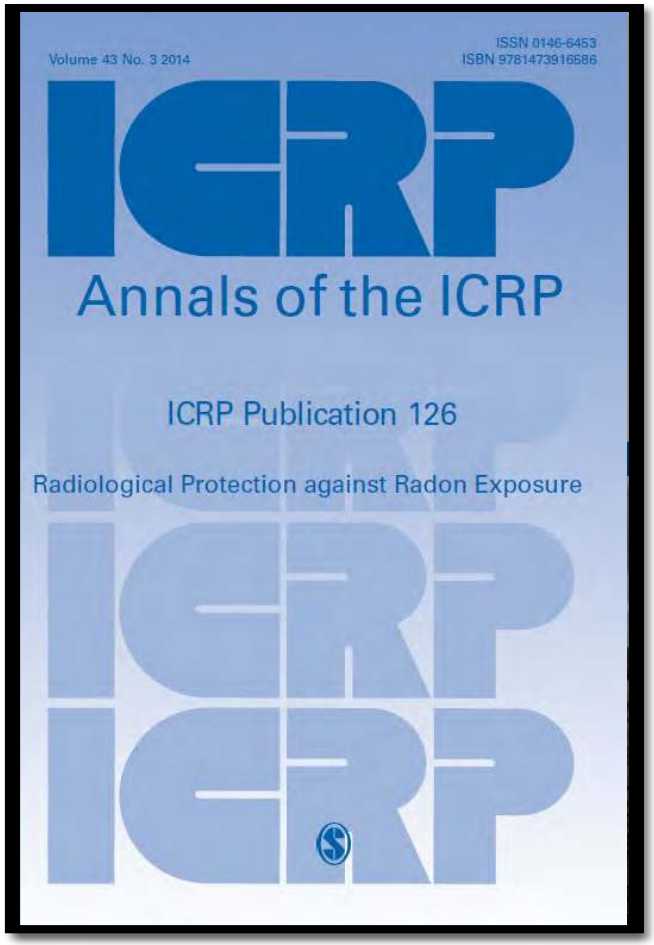


- Equipment maintenance
  - Slag, scale, sludge
- Enclosed spaces
  - Radon
- Airborne dust

UNSCEAR/ICRP/IAEA



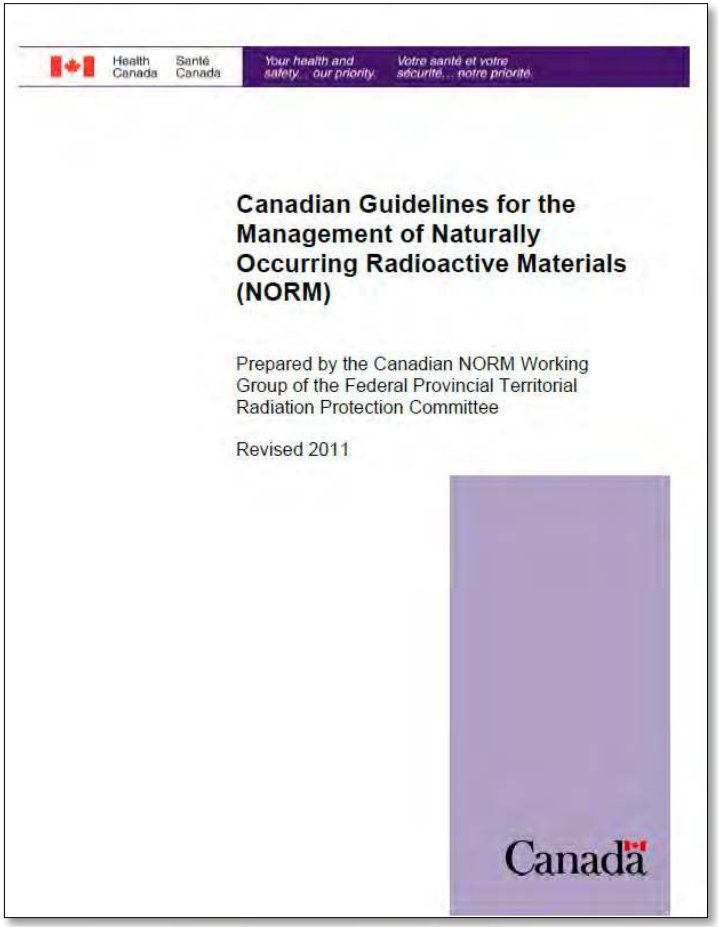
ICRP Publications 142 & 126



- NORM exposure controllable
  - Justification
  - Optimization
- Chronic low dose of concern
- Integrated and graded approach
- Reference levels
  - Workers: typically less than 10 mSv
  - Public: typically a few mSv
- Radon and thoron managed according to ICRP Publication 126 first

Canadian NORM Guidelines: Purpose

- CNSC
  - Nuclear energy and some transport
- Provincial/Territorial jurisdiction
  - Not specifically mentioned in OH&S
- Federal Provincial Territorial Radiation Protection Committee
- Applies same radiation protection standards as for CNSC regulated activities
- Based on ICRP recommendations
- Principles and procedures
  - Detection
  - Classification
  - Handling
  - Material management



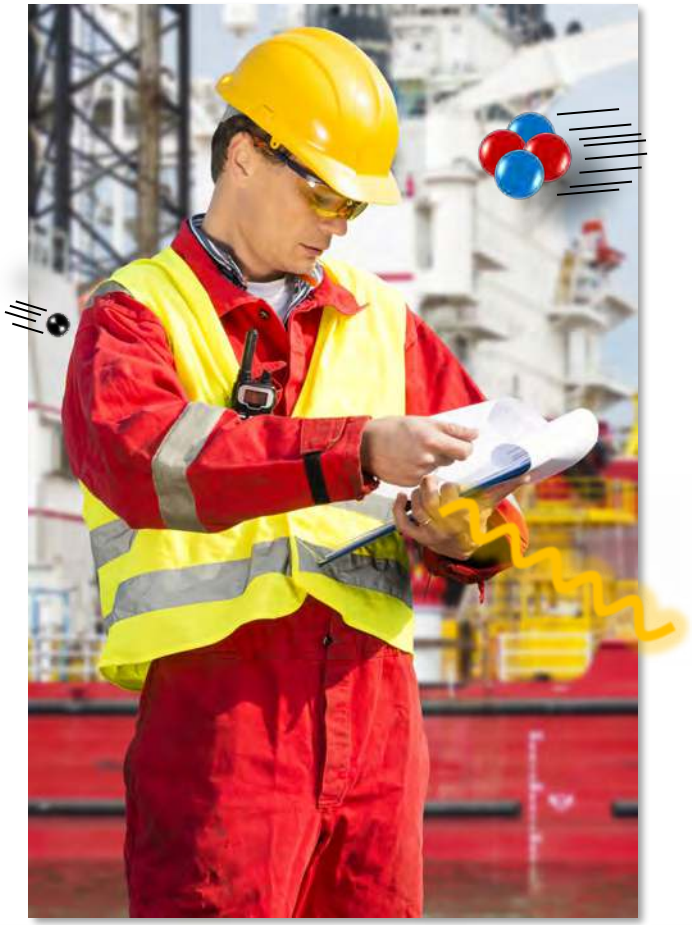
A NORM Management Program

- Assessment
  - Estimate doses
  - Determine program classification
  - Determine worker classifications
- Implement applicable radiation protection program

Canadian NORM Guidelines Section 3.3

Radiation Detection

- No senses to detect ionizing radiation
- Must use instruments to detect and measure it
- Assessment requires measurement



Radiation Detection

Courtesy of Landauer

Dosimeter

Survey Instrument

Courtesy of Thermo Electron Corporation

Survey Instruments

- Measures the ***rate*** of radiation events
  - Count rate, Counts per minute (cpm)
  - Radiation dose rate (µSv/h)
  - Exposure rate (mR/h)
- Usually hand-held
- Battery operated
- Multi-purpose
  - Detector probes
  - Measure all types of radiation

Multi-purpose survey instrument from Thermo Electron Corporation

Worker Classification

- Occupationally Exposed Worker (OEW)
- Incidentally Exposed Worker
- Members of the Public

Canadian NORM Guidelines Section 2.4.2

Recommended Radiation Dose Limits

Person	Period	Effective Dose (mSv)
Occupationally Exposed Workers	1-yr dosimetry period	50
	5-yr dosimetry period	100
Pregnant OEW	Balance of the pregnancy	4
A person who is not an OEW (The Public and Incidentally Exposed Workers)	1 calendar year	1

Dose limits exclude doses from natural background and medical exposures

Canadian NORM Guidelines Section 2.4.2

NORM Program Classifications

Radiation Safety Institute of Canada

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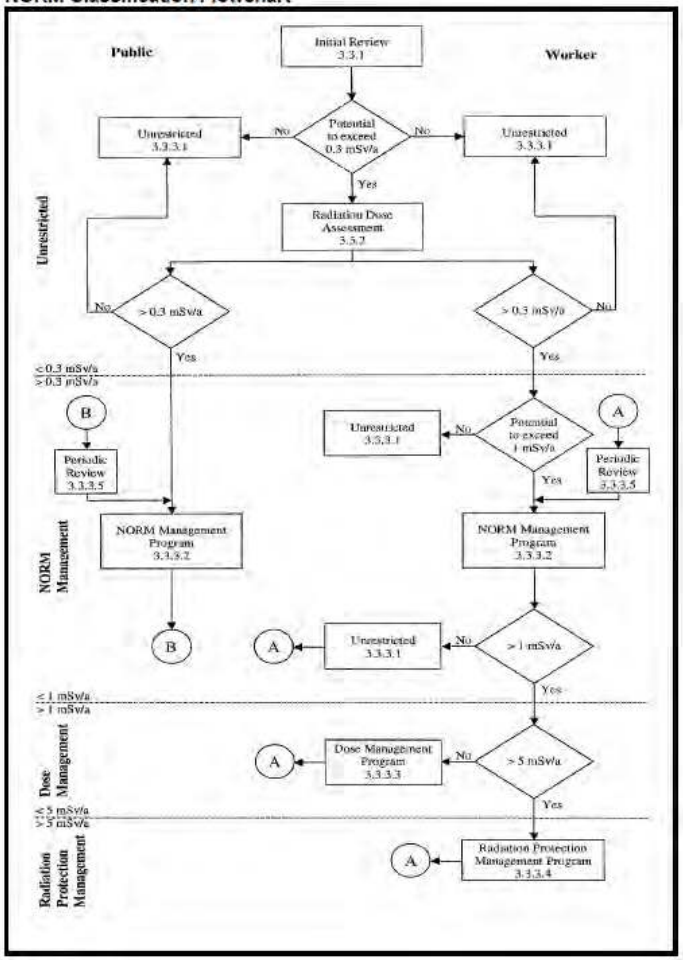
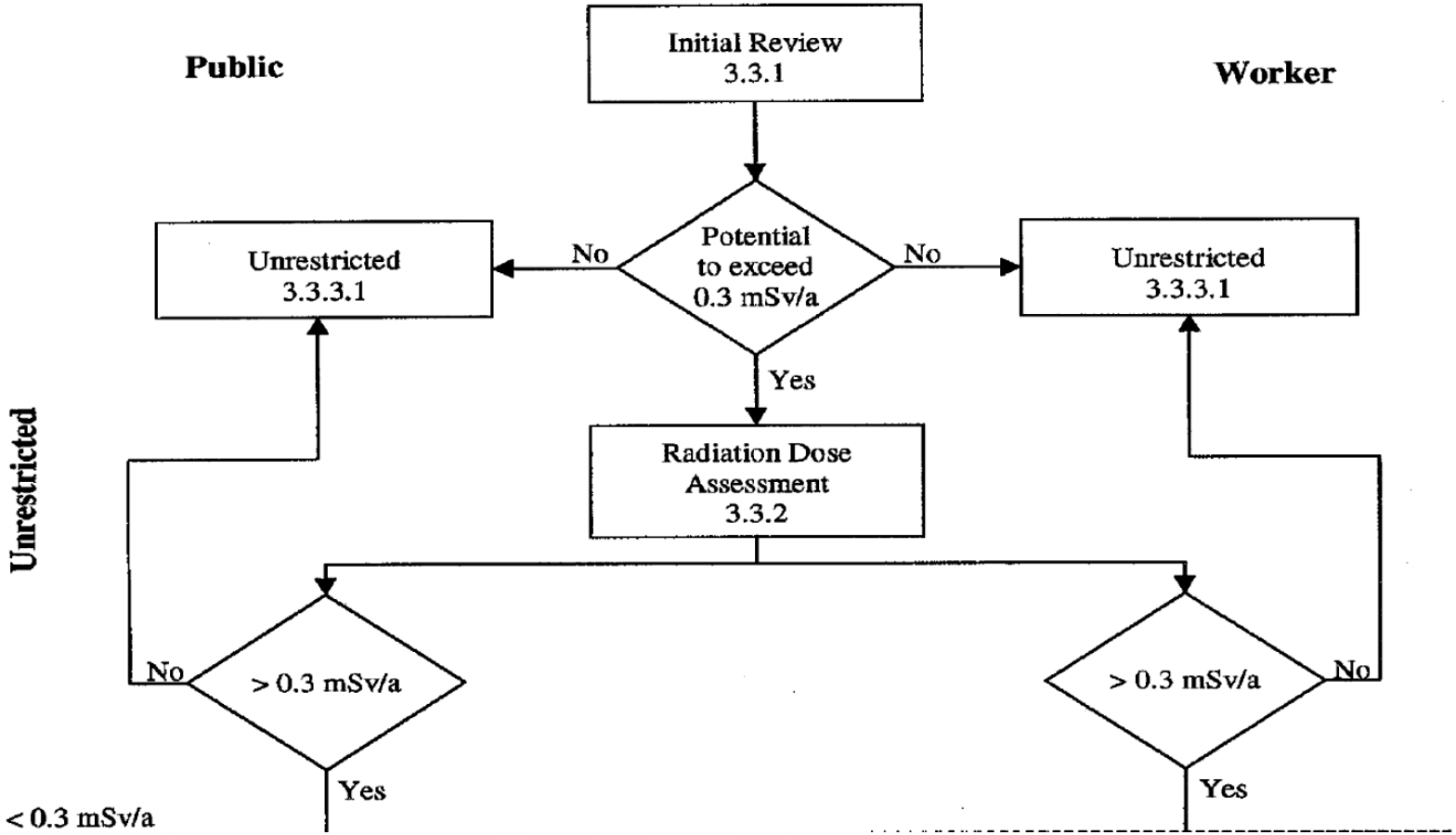
Figure 3.1
NORM Classification Flowchart



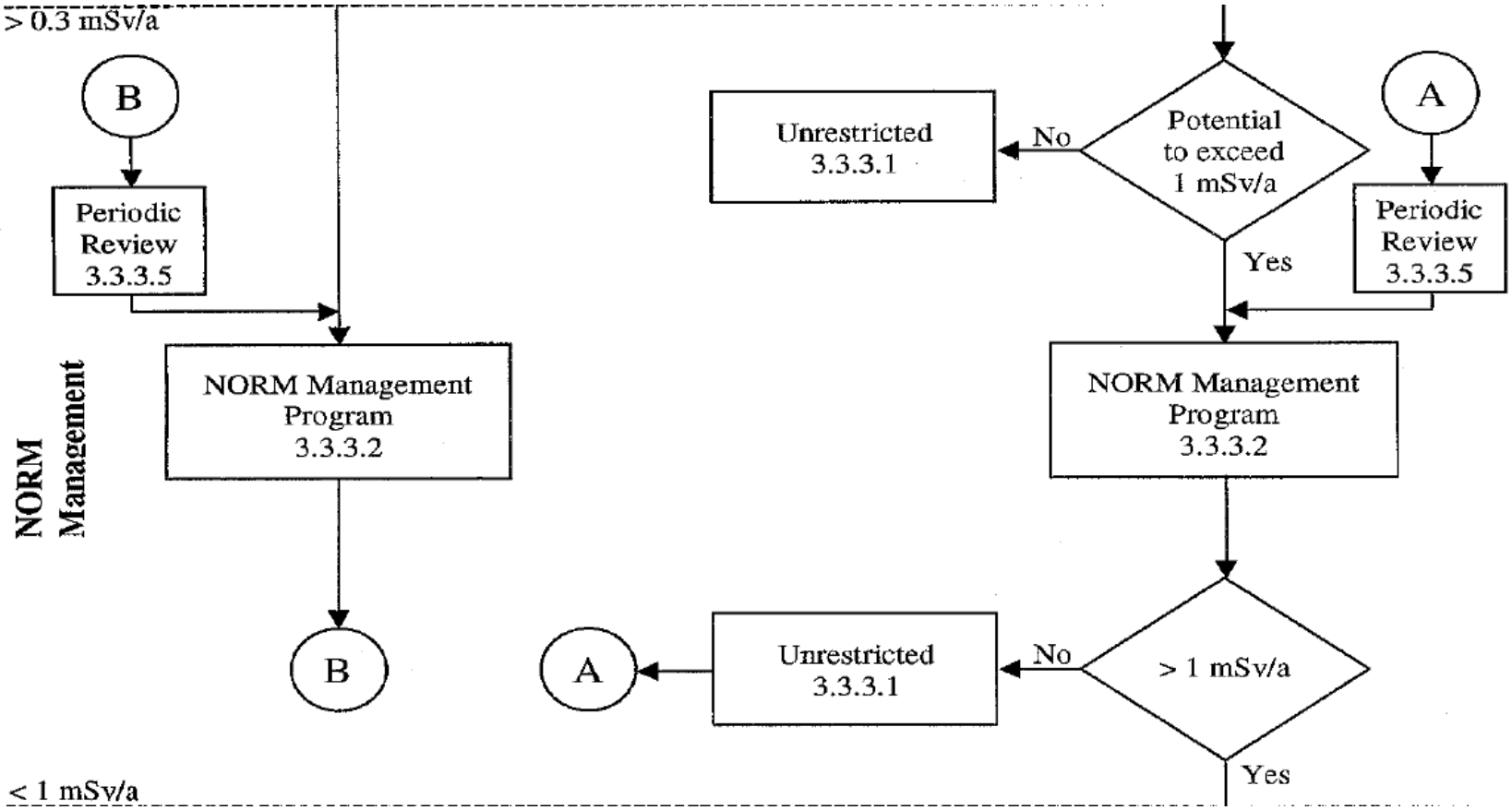
- Canadian NORM Guidelines Section 3.1 and Figure 3.1

Unrestricted Classification



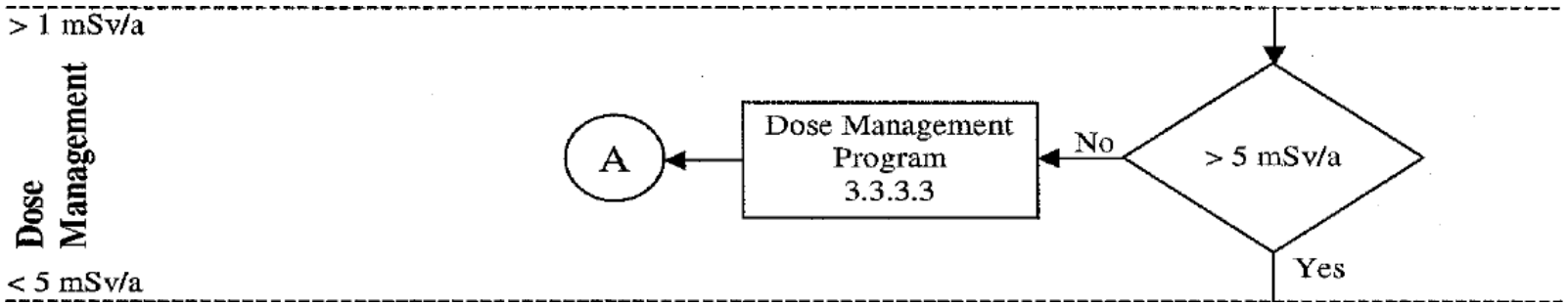
Canadian NORM Guidelines Section 3.3 and Figure 3.1

NORM Management Classification



Canadian NORM Guidelines Section 3.3 and Figure 3.1

Dose Management Classification

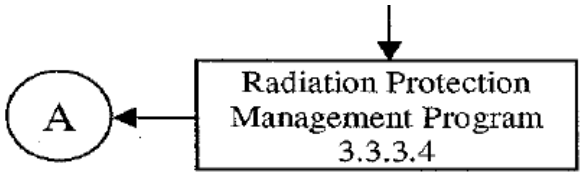


Canadian NORM Guidelines Section 3.3 and Fig 3.1

Radiation Protection Management

> 5 mSv/a

Radiation Protection Management



Canadian NORM Guidelines Section 3.3, Figure 3.1, and Appendix F.

Dosimetry

- Ionizing radiation
  - Cannot detect with our senses
  - Effects can occur years later
- Different types
  - Type of radiation
  - Location
- Internal or external

Periodic Review

- Classification higher than unrestricted
- Any changes to systems affecting dose
- Monitor effectiveness
- Frequency
  - Ability for conditions to change
  - NORM program itself

Canadian NORM Guidelines Section 3.3

NORM Material Management

Information from Canadian NORM Guidelines Section 5

Transport of NORM

- Must assess activity concentration before transport
- >10x exempt material values
  - Falls under Federal jurisdiction
  - Packaging and Transport of Nuclear Substances Regulations
  - Transportation of Dangerous Goods Regulations
  - Offsite over public or private land
- <10x exempt material values but > unrestricted release
  - Transport manifest
  - Securely packaged
  - Account for other properties

Canadian NORM Guidelines Section 6

Disposal of NORM

- Provincially-licensed facilities
  - Pembina Class I Hazardous Waste Landfill, Alberta
  - Unity salt cavern, Saskatchewan
  - Melville salt cavern, Saskatchewan
  - Silverberry Landfill, British Columbia

Canadian NORM Guidelines Section 6 and https://nuclearsafety.gc.ca/eng/resources/fact-sheets/naturally-occurring-radioactive-material.cfm

What to Do?

- Occupational Health and Safety
  - Representative
  - Committee
- Provincial or Territorial Legislation
  - Federally-regulated workplaces fall under the Canada Labour Code

Radiation Safety Institute of Canada
Institut de radioprotection du Canada

"Good science in plain language"®

Thank you for listening!

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