Tier3: Level 2 – Radiation Safety for Nuclear Gauges and X-Ray Equipment

1. Radiation Awareness

1.1 Vale_Slide

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1.2 L and D slide

1.3 Introduction

Radiation Safety Awareness

Nuclear Gauges and X-Ray Equipment

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VALE

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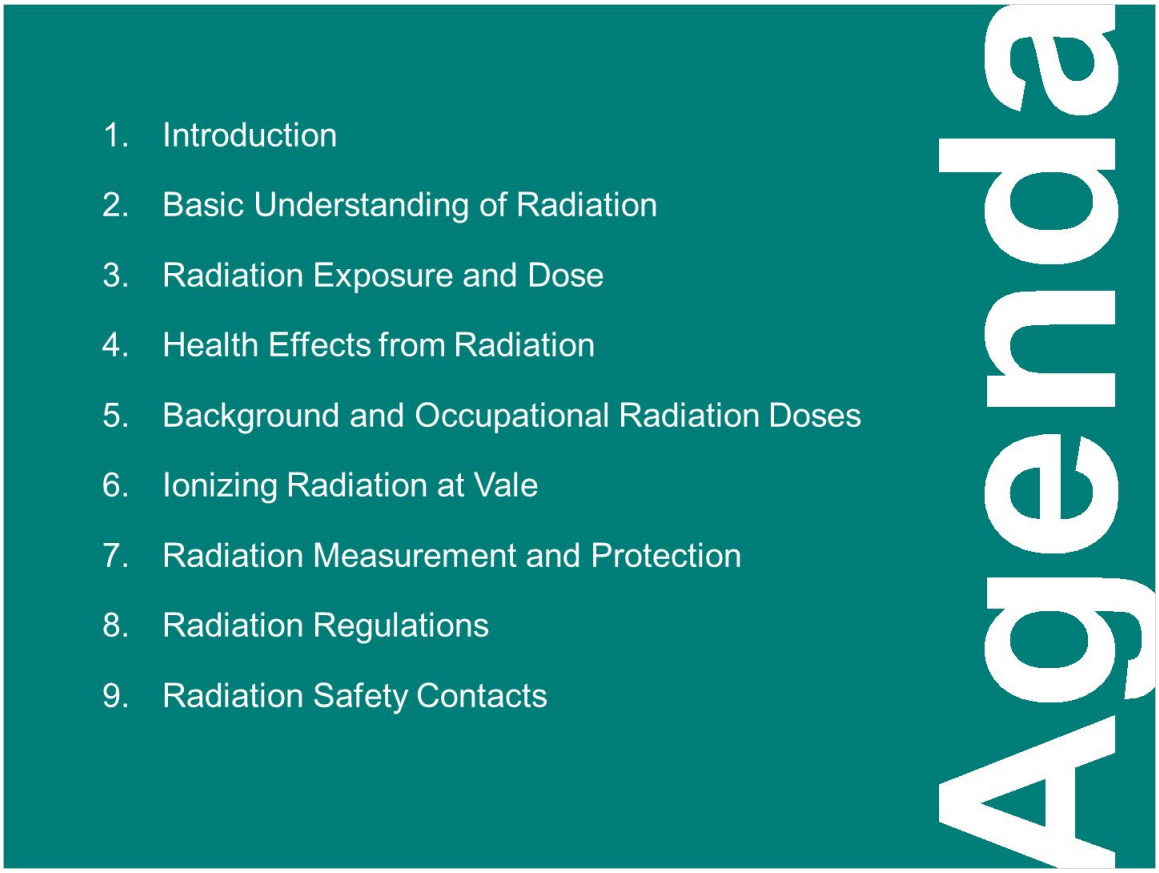
1.4 Divider


Agenda
1. Introduction
2. Basic Understanding of Radiation
3. Radiation Exposure and Dose
4. Health Effects from Radiation
5. Background and Occupational Radiation Doses
6. Ionizing Radiation at Vale
7. Radiation Measurement and Protection
8. Radiation Regulations
9. Radiation Safety Contacts

1.5 Function

Please Note: Sound Required

This eLearning Module is approximately 30 minutes in duration.

The content of this module was derived from the Radiation Awareness PowerPoint presentation and speaker notes and has been recompiled in this format to facilitate distribution over the network and tracking in VES.

As a result, the speaker notes are now presented as narration, so ***you will need your speakers or headphones turned on*** in order to follow along.

To ensure you receive all of the content, the slides are locked down until all of the narration has played, so please be patient with the navigation; you will only be able to move ahead once the timeline (visible on the bottom of each slide) ends.

If you need to leave the presentation before you have finished you may do so and return later to where you left off.

2. Introduction

2.1 Section Title Page

2.2 Introduction

Radiation Awareness

Introduction

This training is for individuals who:

- work with radiation emitting devices (nuclear gauges or x-ray equipment)
- may assist to move nuclear gauges (provided that the radiation energy has already been safely isolated).

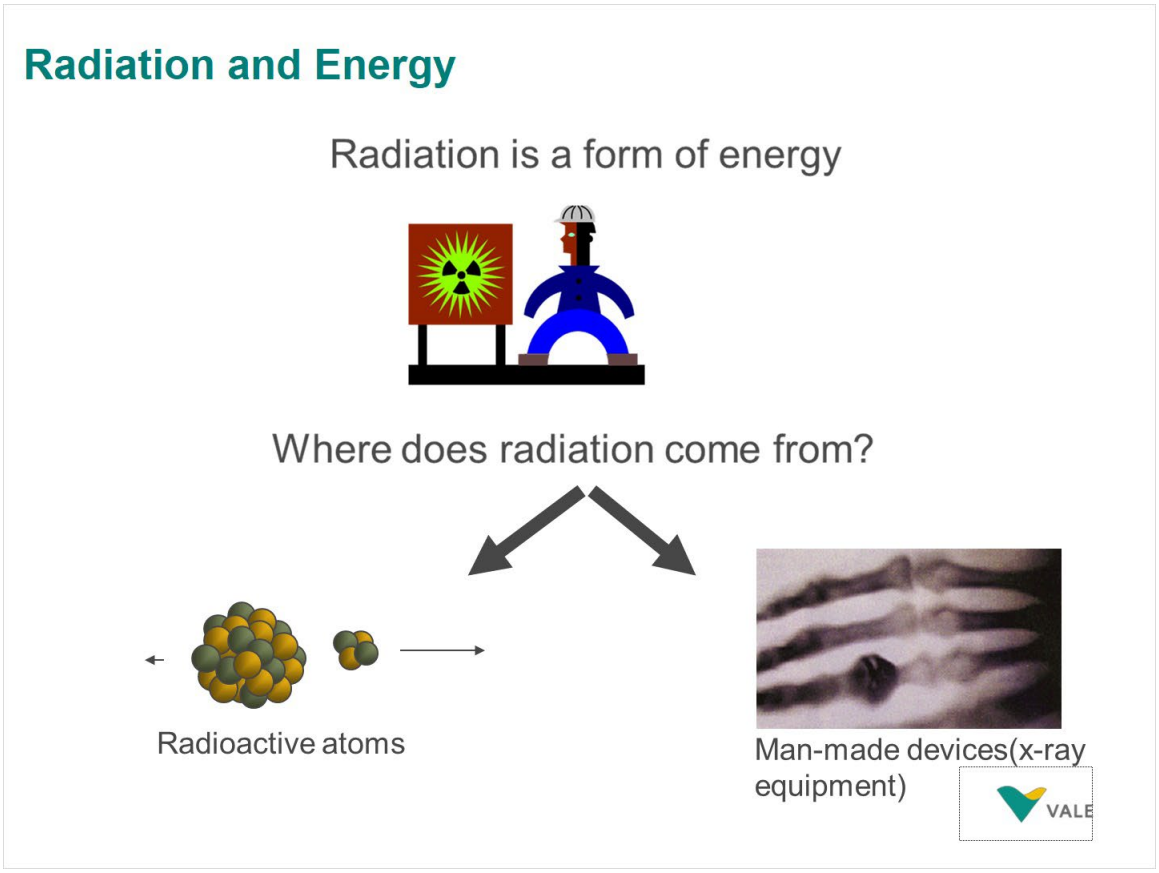
Further training and specific procedures are required for individuals performing work on the actual radiation sources as specified at each site.

Refer to the Vale Radiation Safety Manual and X-Ray Safety Program for more information regarding the management of radiation safety.

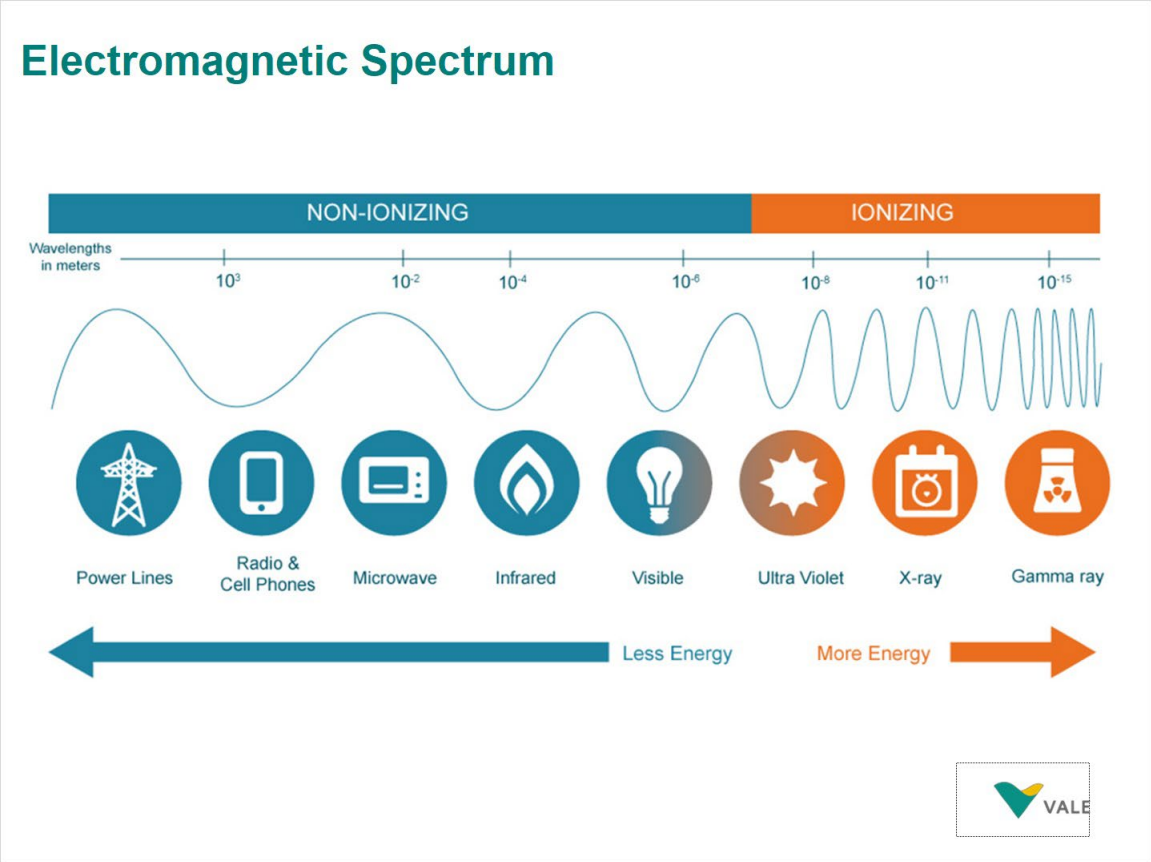
3. Basic Understanding of Radiation

3.1 Section Title Page

3.2 Radiation and Energy



3.3 Electromagnetic Spectrum

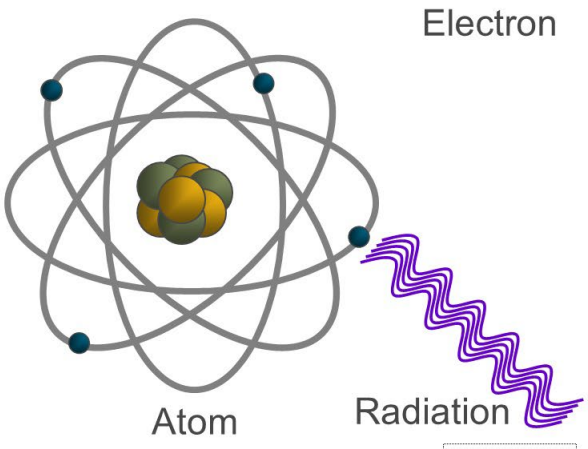


3.4 Interaction with Matter

Interaction with Matter

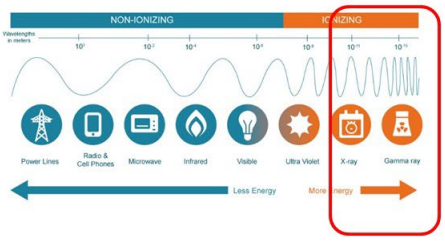
When radiation strikes matter, it interacts with the atoms of the matter.

Radiation with enough energy can knock electrons out of orbit from the atoms it strikes.

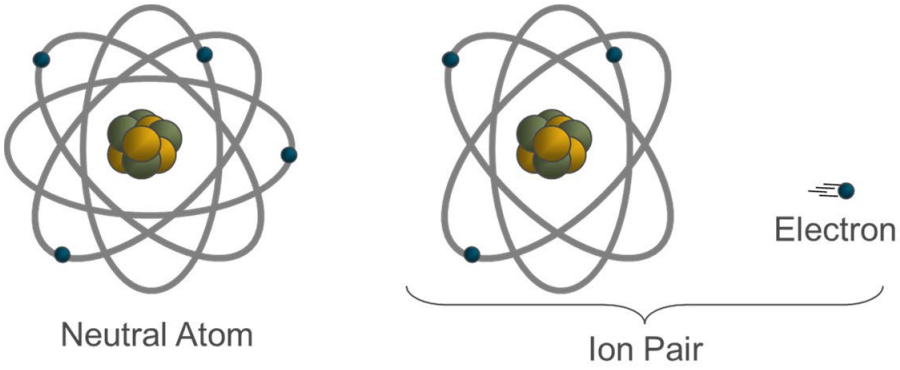


3.5 Ionizing radiation

Ionizing Radiation

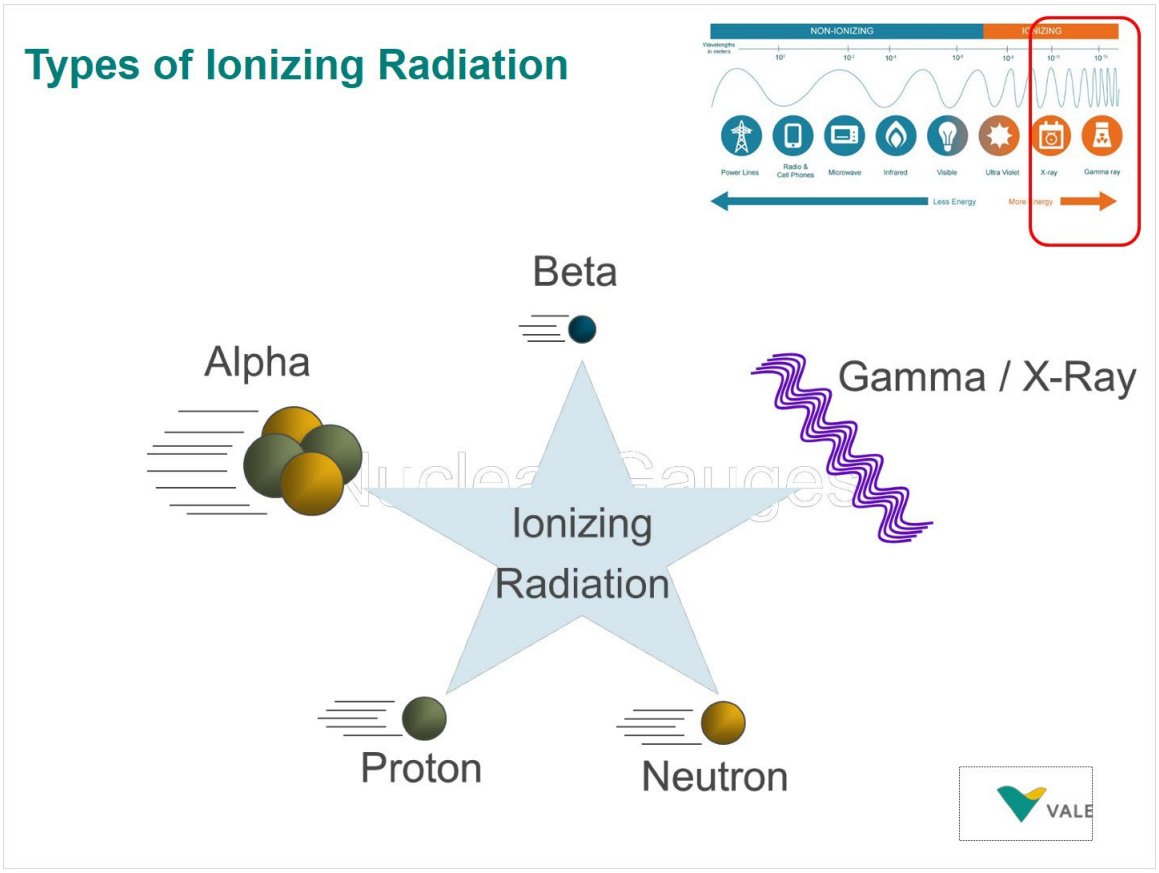


The process of creating ions is called ***ionization***.



Radiation which can cause ionization is known as ***ionizing radiation***.

3.6 Types of Ionizing Radiation



3.7 Gamma/X-Ray Radiation

Gamma/X-Ray Radiation

Gamma and x-ray radiation is made up of ***photons***.

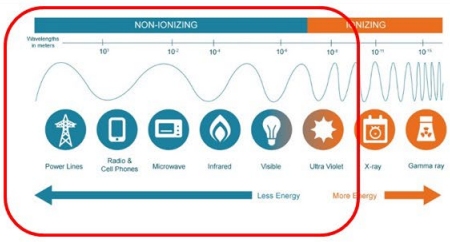
- Photons are packets of energy with no mass.

In other words, gamma and x-ray radiation are electromagnetic radiation just like **ordinary light**.

The energy of gamma and x-ray radiation is **much greater** than that of ordinary light.

3.8 Non-Ionizing Radiation

Non-Ionizing Radiation



Radiation which does not have enough energy to ionize atoms is called ***non-ionizing radiation***.

Visible Light

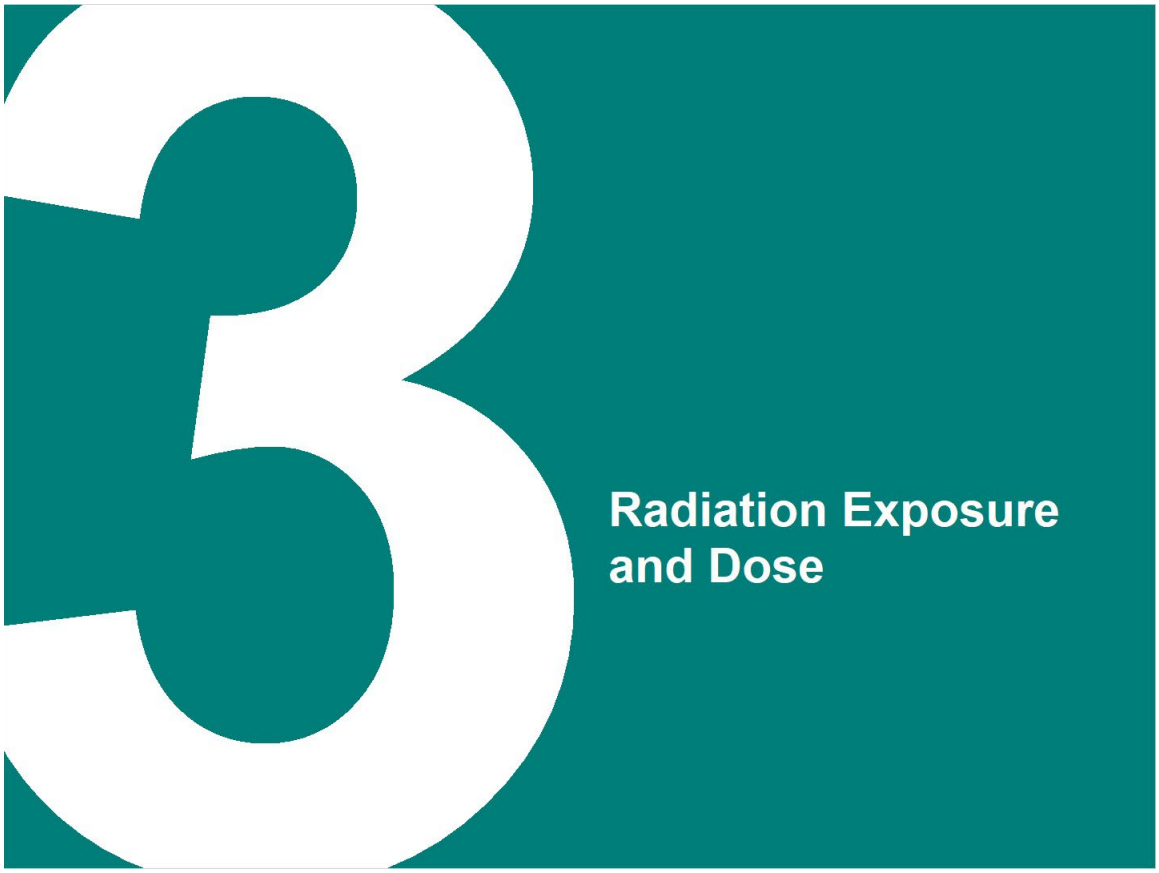
Radio Waves

Microwaves

Infrared Light

4. Radiation Exposure and Dose

4.1 Section Title Page

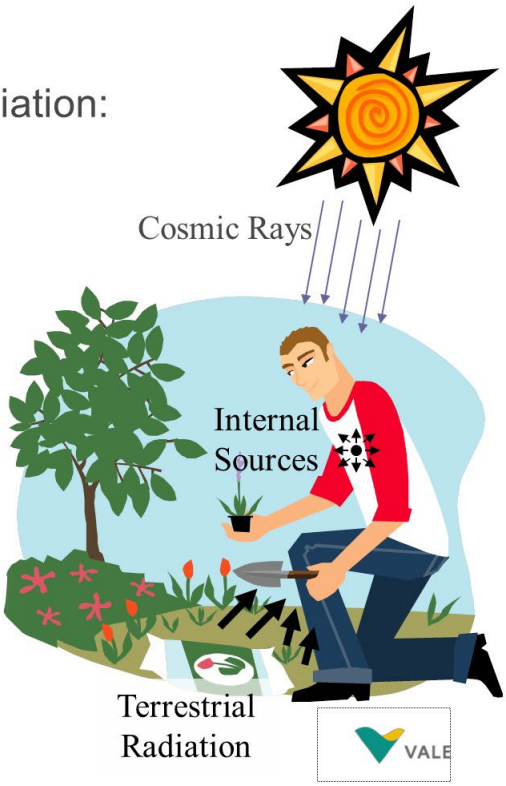


4.2 Radiation Exposure

Radiation Exposure

We are all exposed to ionizing radiation:

- Cosmic radiation
  – sun, space
- Terrestrial radiation
  – soil, rocks
- Internally
  – Food (potassium-40), air
- Medical treatment



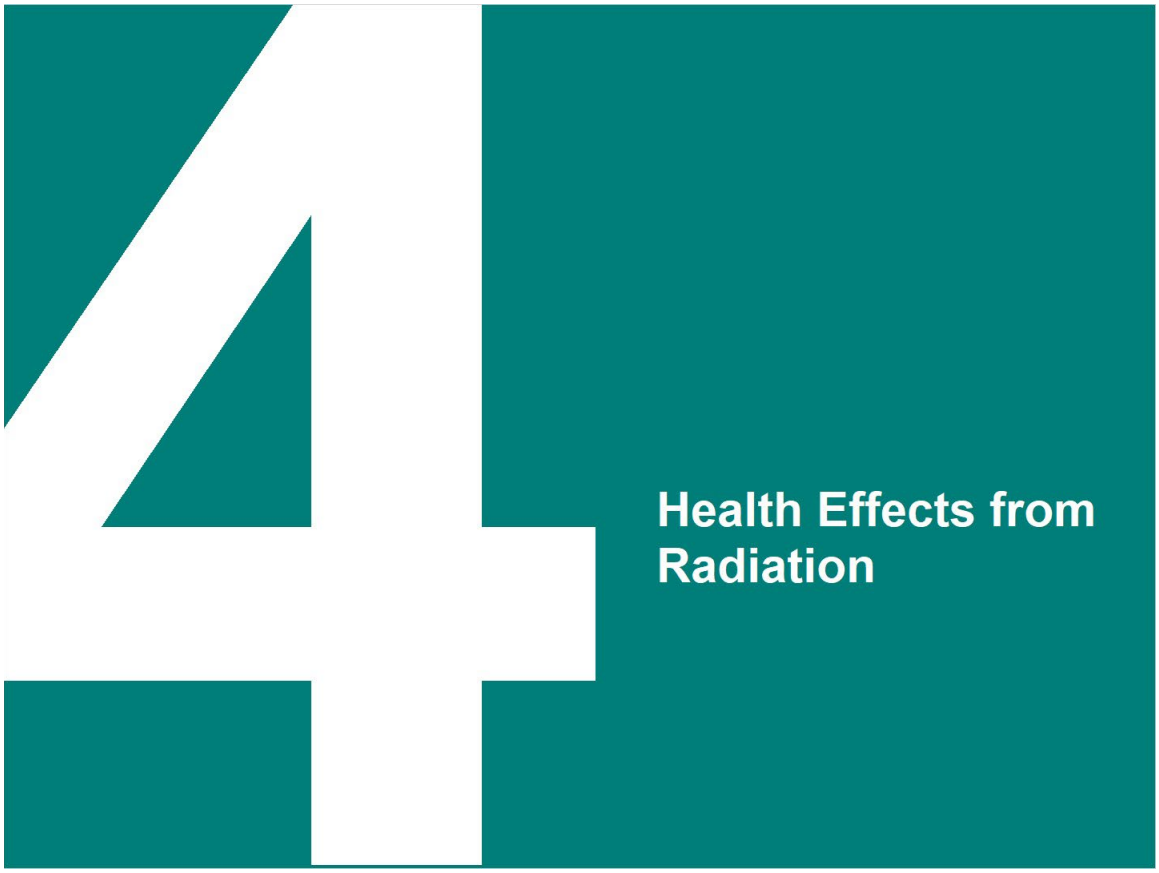
4.3 Radiation Dose

Radiation Dose

- Radiation dose is a measure of the amount of energy deposits in the body, per unit mass.
- The unit of dose is the **sievert** (Sv)
- 1 Sv is a very large dose
  - mSv or μSv are used more often
  - rem is also sometimes used (1Sv = 100 rem)

5. Health Effects from Radiation

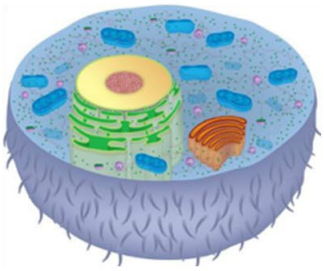
5.1 Section Title Page



5.2 Interactions with the Body

Interactions with the Body

- When radiation strikes a living being it interacts with the atoms and molecules that make up the body in the same way as it would with non-living material.
- Radiation may ionize the DNA molecule of a cell.
- This may produce alterations in the biological properties of the cell. There are a number of possible outcomes:
  - No damage at all
  - Damage to cells that is repaired
  - Damage to cells that leads to cell death
  - Damage to cell chromosomes that is incorrectly repaired.



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5.3 Stochastic/Somatic Effects

Stochastic/Somatic Effects

- **Somatic effects** are the effects experienced by the people exposed to the radiation
- Radiation is a **carcinogen**.
  - A radiation dose to an individual has a probability of mutating cells, which might lead to **cancer** in the future. The cancer may or may not be fatal.
- Cancer is a **stochastic effect**.
  - Random or appears by chance
  - Radiation exposure increases the **likelihood** of developing cancer; the higher the exposure, the higher the likelihood.

5.4 The Risk - Some Numbers

The Risks – Some Numbers

- The risk of developing fatal cancer due to radiation exposure is about 4% per 1000 mSv.
  - A person would have to receive 20mSv each year for 50 years to reach 1000mSv.
- Note that 25% of people develop fatal cancer in their life. So this person's risk of developing cancer becomes 29%, instead of 25%.
- Other professions and daily activities carry risks too.

Profession / Activity	Risk of death per year
Finance	1 in 60,000
Service	1 in 40,000
Accidents at work	1 in 24,000
1 mSv of radiation per year	1 in 20,000
2 mSv of radiation per year	1 in 12,000
Manufacturing	1 in 11,000
Accidents at home	1 in 11,000
Accidents on the road	1 in 5,000
Construction	1 in 3,000
20 mSv of radiation per year	1 in 1,200
Mining	1 in 1,100
Forestry	1 in 900
Fishing and Hunting	1 in 500

6. Background and Occupational Radiation Doses

6.1 Section Title Page

6.2 Annual Radiation Exposure for the Average Canadian

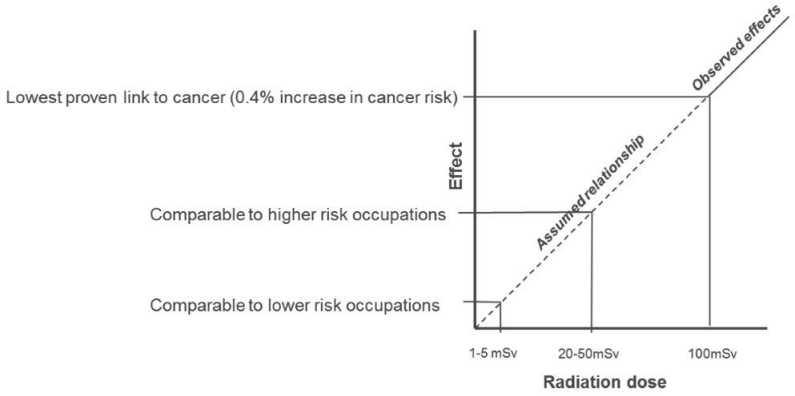
Annual Radiation Exposure for the Average Canadian

Source	Dose	Percent
Radon	2mSv	55
Cosmic	0.27mSv	8
Terrestrial	0.28mSv	8
Internal	0.39mSv	11
Total Natural	**3mSv**	**82**
X-ray diagnosis	0.38mSv	11
Nuclear medicine	0.14mSv	4
Consumer products	0.10mrem	3
Occupational	0.01mSv	<0.3
Nuclear fuel cycle	0.01mSv	<0.3
Miscellaneous	0.01mSv	<0.1
Total Man-Made	**0.65mSv**	**18**

Some people living in other regions of the world have annual natural background doses of around 50mSv, and as high as 250mSv, with no health effects observed.

6.3 Occupational and Public Dose Limits

Occupational and Public Annual Dose Limits



Device type	Nuclear Energy / X-Ray Worker annual whole body dose limit	Any other person (general public) annual whole body dose limit	Nuclear Energy / X-Ray Worker annual dose limit to skin/ extremities	Any other person annual whole dose limit to skin / extremities
Nuclear gauges	50 mSv (and 100 mSv over 5 years)	1 mSv	500 mSv	50 mSv
X-Ray equipment	50 mSv	5 mSv	500 mSv	50 mSv

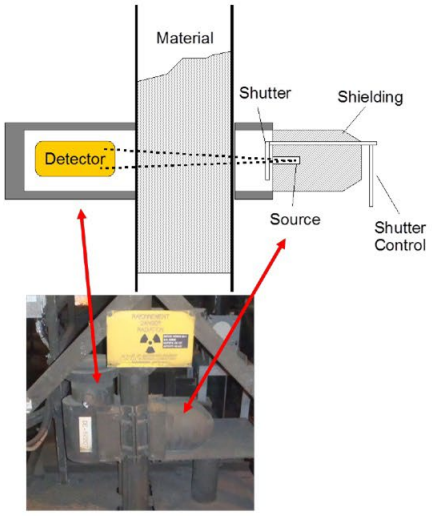
7. Ionizing Radiation Sources at Vale

7.1 Section Title Page

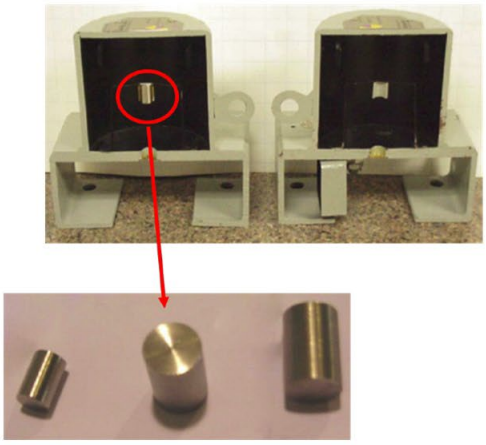
7.2 How a Nuclear Gauge Works

How a Nuclear Gauge Works

Schematic of a typical installation



Cutaway of a source holder

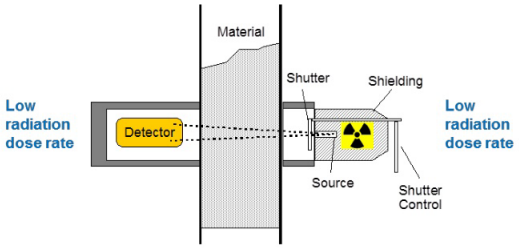


Double sealed metallic capsules containing radioisotope

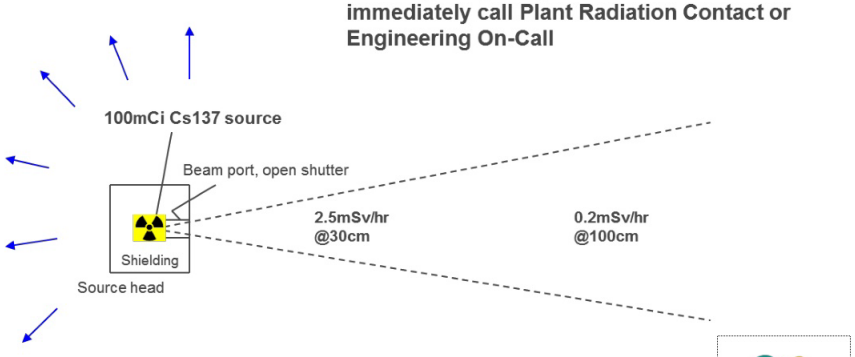
7.3 Radiation from Nuclear Gauges

Radiation from Nuclear Gauges

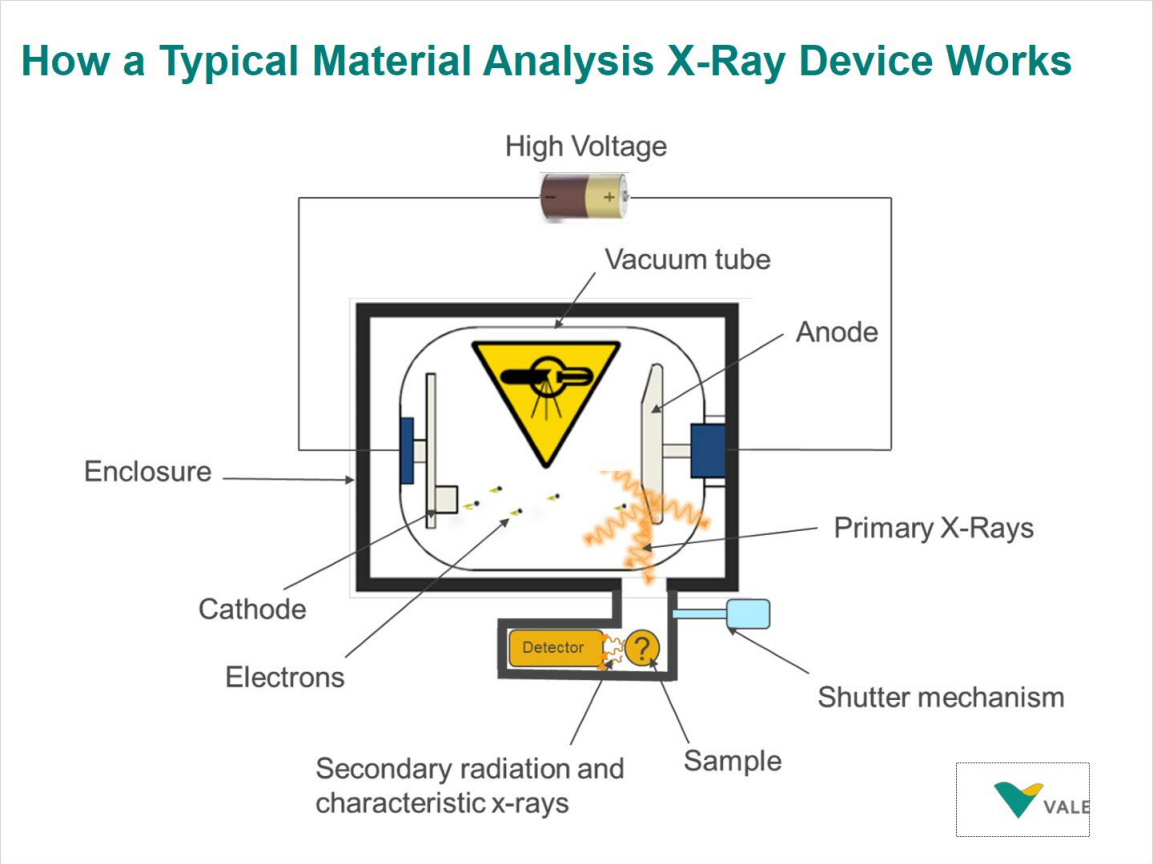
Typical Installation



- **Shutter must always be closed, locked, and the nuclear gauge front face pointed to the floor when not installed on a pipe or vessel.**
- **Ask plant radiation safety contact for source isolation if disconnecting piping within 1 meter of a source, or when entering a vessel with a radiation source**
- **If a source has fallen from an installation, has been struck by equipment, or does not appear installed correctly, stay away from the source and immediately call Plant Radiation Contact or Engineering On-Call**



7.4 How a Typical Material Analysis X-Ray Device Works



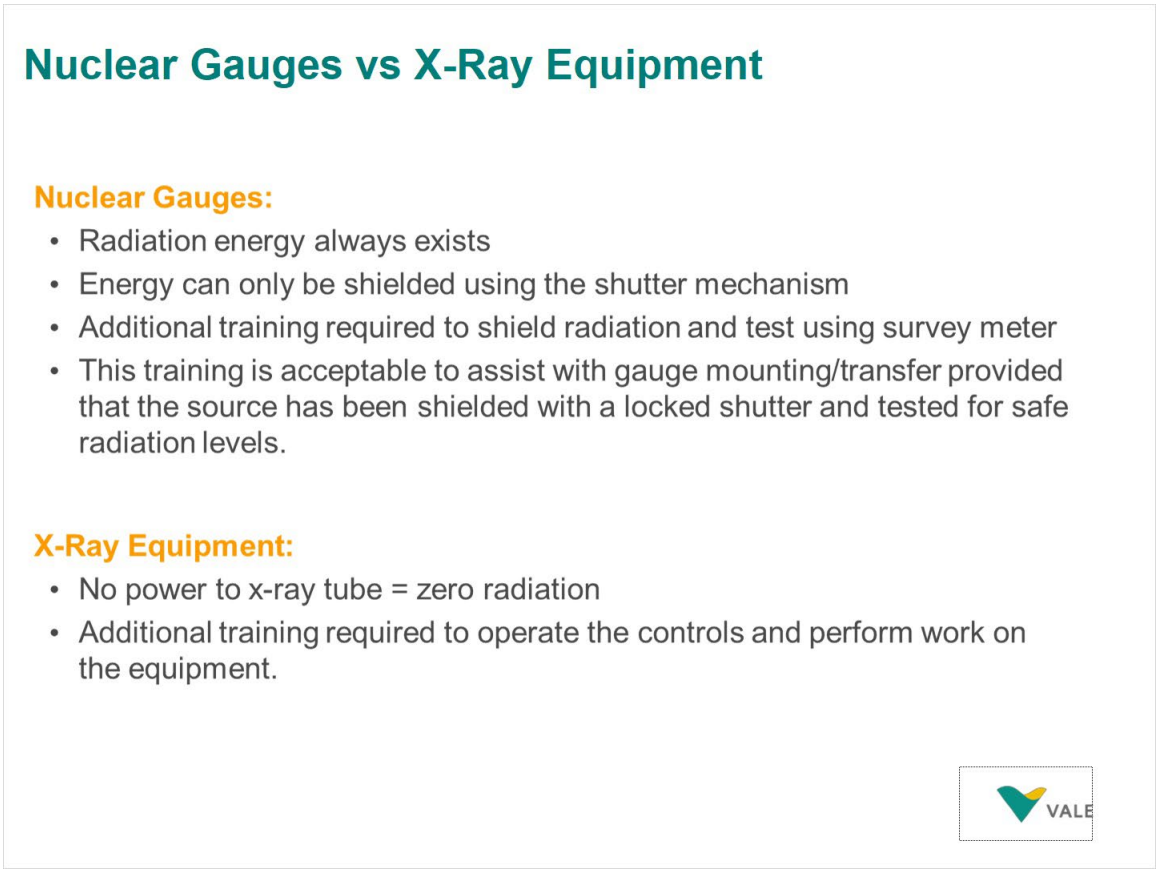
7.5 Radiation from X-Ray Equipment

Radiation from X-Ray Equipment

- X-ray equipment is required to be less that 5 µSv/hr at 5 cm from any accessible surface during operation
- Generally much less than 5 µSv/hr
- No radiation when x-ray power is shut off

Example of x-ray equipment

7.6 Nuclear Gauges vs X-Ray Equipment



8. Radiation Measurement and Protection

8.1 Section Title Page

8.2 Measuring External Radiation Exposure

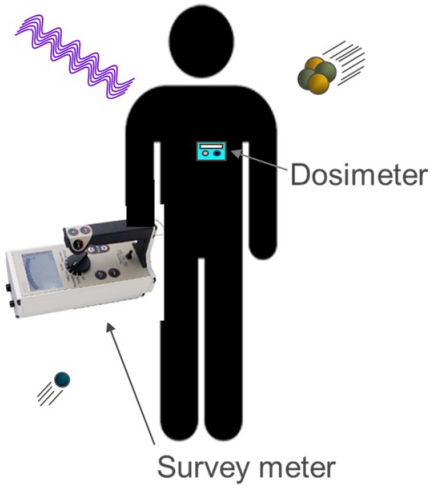
Measuring External Radiation Exposure

Radiation dose rates can be measured with a **survey meter**.

- Portable radiation detection and measurement instrument, used to check personnel, equipment and facilities for radioactive contamination, or to measure external or ambient ionizing radiation fields to evaluate the real-time exposure hazard.

Worker radiation doses can also be measured using ***dosimeters***.

- device that measures exposure to ionizing radiation. It has two main uses: for radiation protection and for measurement of dose



8.3 Radiation Protection Principles

8.4 Specific Radiation Control Measures

Specific Radiation Control Measures

- Safety and technical training for nuclear gauges and x-ray equipment
- Personnel must be qualified, knowledgeable and authorized to work on radiation source equipment
- Safety programs and procedures
- Shielding, shutters, interlocks
- Maintenance programs
- Radiation surveys and leak tests

9. Radiation Regulations

9.1 Section Title Page

9.2 Nuclear Gauge Regulations

Nuclear Gauge Regulations

- Nuclear Gauges and x-ray florescence gauges containing nuclear material are governed by the Nuclear Safety Act of Canada and its regulations.
  - The Canadian Nuclear Safety Commission (CNSC) enforces these regulations
- Each plant with nuclear gauges must have a current license from the CNSC.
- The Vale Radiation Safety Manual contains the company policies and procedures for nuclear gauges that all plants must follow as a CNSC license condition.
  - This document is required for a nuclear gauge license and its contents are reviewed regularly by the CNSC to ensure that the requirements in the regulations are met.
  - The Radiation Safety Manual as well as the regulations can be found on the Vale intranet under Engineering & Maintenance – Radiation
- Vessels with nuclear gauges must also have an up-to-date entry procedure (such as a confined space procedure) that is submitted and reviewed by the CNSC. The entry procedure must contain certain additional requirements set by the CNSC and must be followed as a condition of license.

9.3 X-Ray Equipment Regulations

X-Ray Equipment Regulations

- X-ray equipment that does not contain a nuclear source are governed by the Occupational Health and Safety Act of Ontario and Regulation 861 of this Act.
  - The Radiation Protection Service of the Ontario Ministry of Labour enforces the x-ray regulations.
- X-ray equipment must also conform to the requirements in the Radiation Emitting Devices (RED) Act of Canada and its regulations.
- Health Canada Analytic X-Ray Equipment Safety Code 32 provides additional guidance on safety practices.
- The Vale X-Ray Safety Program outlines all applicable requirements that each plant with x-ray equipment must follow.
  - The program document as well as the regulations and safety code can be found on the Vale intranet under Engineering & Maintenance – Radiation.

10. Radiation Safety Contacts

10.1 Section Title Page

10.2 Radiation Safety Contacts

Radiation Safety Contacts

- All CNSC licensees must have a Radiation Safety Officer (RSO) responsible for ensuring the safe use and security of nuclear gauges and that CNSC regulations and license conditions are followed.
- All X-Ray Equipment must have a "competent person" responsible for ensuring the safe use of x-ray equipment.
- Vale has one Radiation Safety Officer in Ontario who is appropriately trained to act as the RSO for nuclear gauges as well as the "competent person" for x-ray equipment.
- The Vale RSO develops and maintains the Radiation Safety Manual and X-Ray Safety Program that outline the requirements at each plant with radiation devices.
- Each plant with radiation devices will have a Radiation Plant Contact(s), who reports to the RSO for radiation matters and assists the RSO to implement, manage, and audit the safety program requirements.
- The RSO and Plant Contacts are found on the Vale intranet under Engineering & Maintenance – Radiation
- The Radiation Plant Contact should be the primary contact for workers in regard to radiation safety matters including:
  - General questions or concerns
  - Safety issues
  - Compliance issues
  - Radiation safety training
  - Plant procedures and protocols
- In case of emergency, the RSO must be contacted immediately. The RSO or designate can always be reached through the Engineering On-Call number (#1 First Aid has a list of on call numbers) or through the Radiation Plant Contact if on site.