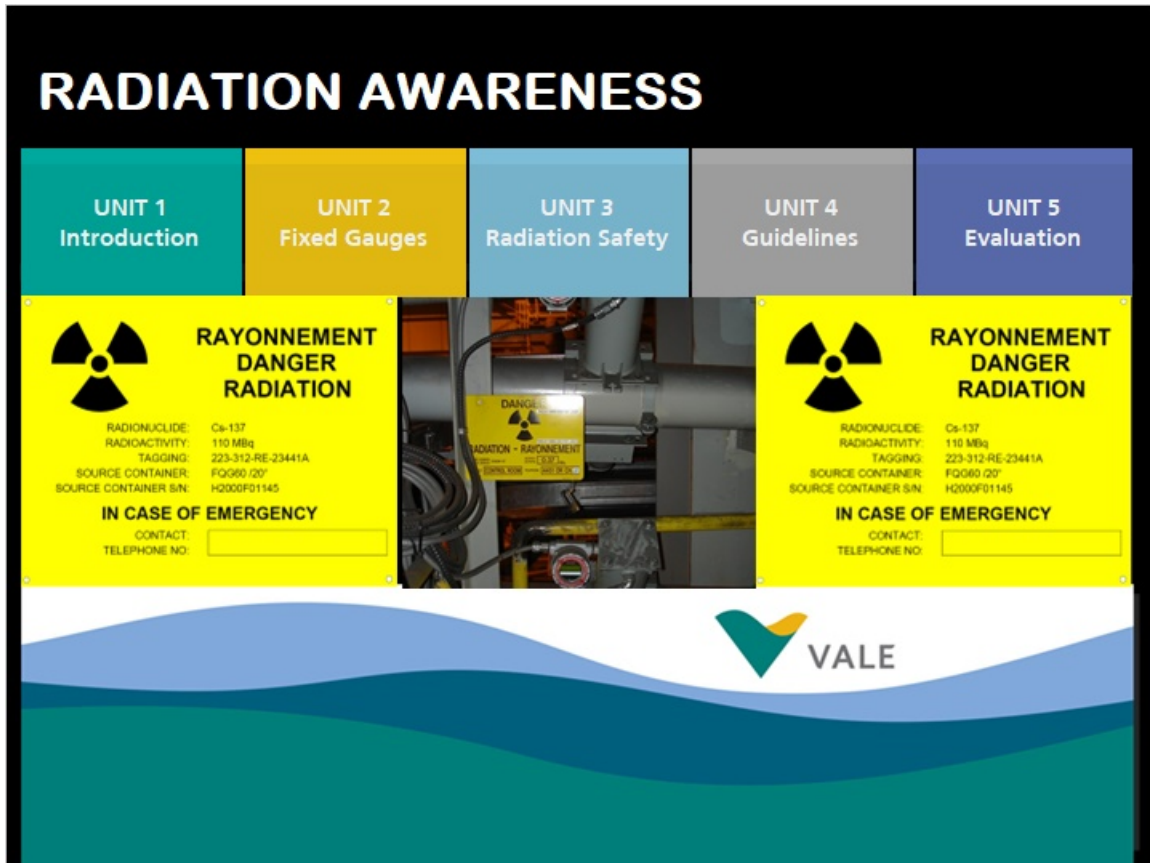


LH: Radiation Awareness CBT Orientation - 63

1. Introduction


1.1 Home



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RADIATION AWARENESS

UNIT 1 Introduction	UNIT 2 Fixed Gauges	UNIT 3 Radiation Safety	UNIT 4 Guidelines	UNIT 5 Evaluation
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**RAYONNEMENT
DANGER
RADIATION**

RADIONUCLIDE: Cs-137
RADIOACTIVITY: 110 MBq
TAGGING: 223-312-RE-23441A
SOURCE CONTAINER: FQ060 /20"
SOURCE CONTAINER S/N: H2000FD1145

IN CASE OF EMERGENCY

CONTACT:
TELEPHONE NO:






**RAYONNEMENT
DANGER
RADIATION**

RADIONUCLIDE: Cs-137
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IN CASE OF EMERGENCY

CONTACT:
TELEPHONE NO:



1.2 Course Objectives

Course Objectives

Unit 1 Introduction	Unit 2 Fixed Gauges	Unit 3 Radiation Safety	Unit 4 Guidelines	Unit 5 Evaluation
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Upon completion of this course you will be able to:

- Explain basic facts about radiation, its origins, types and possible effects.
- Identify natural and human-made sources of radiation.
- Describe the types of gauges and radioactive sources that will be used at the Long Harbour Site.
- State guidelines and methods used to minimize and control risk.
- Describe actions for alarms, accidents, and emergencies.

1.3 CNSC Video

Introductory Video - CNSC

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What is radiation?

00:00 / 0

HINT: CLICK THE PLAY BUTTON TO WATCH A VIDEO CLIP

1.4 How Ionizing Radiation Occurs

How Ionizing Radiation Occurs

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HINT: CLICK IMAGE TO ENLARGE

Most ionizing radiation occurs when the structure of an atom breaks down and energy is released as a wave or particle.



This can happen from an atomic collision or when an unstable atom decays or breaks down on its own.

Radioisotope samples continually release radiation until all of their atoms have become stable.

Such radioactive materials are used in nuclear gauges. Each radioisotope has a predictable **rate of decay**, and the radiation produced has a characteristic "penetrating power".

1.5 Alpha and Beta Particles

Alpha and Beta Radiation

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Four types of radiation connected with radioactive decay:

Alpha Particles: Constructed from 2 neutrons and 2 protons. Alpha particles slow down very rapidly when they interact with an absorber material due to their large mass, relatively slow velocity, and relatively large electric charge. When an alpha particle slows down it grabs 2 electrons from the free electron population around it to become an ordinary helium atom.

Beta Particles: Emitted from the nucleus of an atom. Compared to Alpha particles they are much smaller, travel at much higher speeds (some near the speed of light), carry a much smaller charge and slow down at a lower rate. When a beta particle has slowed down it becomes part of the free electron population.

1.6 Gamma Radiation

Gamma Radiation

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Gamma Photons: A type of radiation called "electromagnetic radiation". Gamma waves are similar to visible light in their make up, however they have shorter wavelengths, higher frequencies and carry much more energy. They also carry no electric charge, have no mass, travel at the speed of light and are very penetrating.

Gamma photons may present a serious external exposure hazard, often having greater penetrating power than medical x-rays. Shielding such as steel or lead provides effective attenuation. **Gamma emitters are often found in fixed gauges.**

Unlike particles, gamma photons do not lose their energy by slowing down. Instead, the atoms of the absorber material absorb gamma photons.

1.7 Neutron Radiation

Neutron Radiation

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Neutron Radiation: Neutrons are "uncharged" particles emitted from the nucleus of certain elements, and may also be artificially produced. Neutron radiation occurs when an atom is involved in a collision with another atom or subatomic particle. The neutrons are forcibly knocked off in the collision and travel away at a wide range of velocities which is determined by the collision.

When a neutron collides with an atom of a molecule, the atom absorbs a portion of the neutron's energy. The hydrogen atom is capable of causing the greatest reduction in energy, so hydrogenous material such as water and wax make the best neutron shields. **Neutron radiation is often used in portable nuclear gauges.**

1.8 Summary - Types of Radiation

SUMMARY - Types of Radiation

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Alpha Radiation - large, high-speed, charged particles

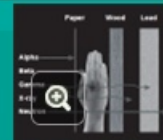
Beta Radiation - small, higher-speed, charged particles

Neutron Radiation - travel at a range of velocities, uncharged particles

Gamma Radiation - travel in waves at the speed of light, gamma photons carry no charge

All four types of radiation have different properties, a main difference being that they penetrate matter to different depths ([click on picture above](#)).

This is important for deciding how to protect ourselves against radiation.



1.9 Measuring Radioactivity - Becquerel

Measuring Radioactivity - Becquerel (Bq)

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The *becquerel (Bq)* describes the radioactivity associated with a radioactive source. The larger the number, the greater the amount of radioactivity.

Numerically, the becquerel describes the number of radioactive decay events that occur per second. One becquerel is a very small amount of radioactivity.

Nuclear gauges have a much higher level of activity and the multiples such as kBq (kilobecquerel), MBq (megabecquerel), and GBq (gigabecquerel) are often used.

In nuclear gauges, the activity of the source is often in the range of a few hundred MBq to a few GBq.

1 kBq = 1000 Bq, 1 MBq = 1000 kBq, 1 GBq = 1000 MBq.

1.10 Measuring Radioactivity - Curie

Measuring Radioactivity - Curie (Ci)

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An old and still popular unit of measuring radioactivity is the curie (Ci).

One curie is a large amount of radioactivity ($1 \text{ Ci} = 37 \text{ GBq} = 37000 \text{ MBq}$)

Commonly used subunits are mCi (millicurie), μCi (microcurie), nCi (nanocurie), and pCi (picocurie).

$1 \text{ Ci} = 1000 \text{ mCi}$; $1 \text{ mCi} = 1000 \mu\text{Ci}$; $1 \mu\text{Ci} = 1000 \text{ nCi}$; $1 \text{ nCi} = 1000 \text{ pCi}$.

NOTE: Becquerel (Bq) or Curie (Ci) measure the rate (not energy) of radiation emission from a source.

1.11 Measuring Radiation - Sievert

Measuring Radiation - Sievert (Sv)

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The **sievert (Sv)** is the international unit for measuring the amount of radiation absorbed by the body. An older unit for the equivalent dose is the **rem** and is still often used in the United States.

Exposure to natural and man-made ionizing radiation varies slightly across Canada, but the average radiation dose is about 2.7mSv per year.

Most of this (about 2mSv) comes from naturally occurring sources (soil and rocks, food, air etc.)

One sievert is a very large amount of radiation risk. The levels encountered around a nuclear gauge source holder range from a few millisieverts (mSv) down to hundreds of microsieverts μ Sv.

sievert (Sv)
milliSievert (mSv)
microSievert (μ Sv)
1 Sv = 1,000 mSv
1 Sv = 10,000 μ Sv
1 Sv = 100 rem
1 Sv = 1,000 μ Sv

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1.12 Natural Radiation in Canadian Cities

Natural Radiation in Canadian Cities

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Canadian City	Cosmic Radiation ($\mu\text{Sv/y}$)	External Terrestrial Radiation ($\mu\text{Sv/y}$)	Inhalation ($\mu\text{Sv/y}$)	Ingestion ($\mu\text{Sv/y}$)	Total (mSv/y)
St. John's	350	175	715	306	1.55
Halifax	325	333	1540	306	2.5
Toronto	350	178	757	306	1.59
Edmonton	450	272	1347	306	2.4
Vancouver	400	1424	926	306	3.05

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1.13 Natural and Man-Made Radiation

Natural and Man-Made Radiation

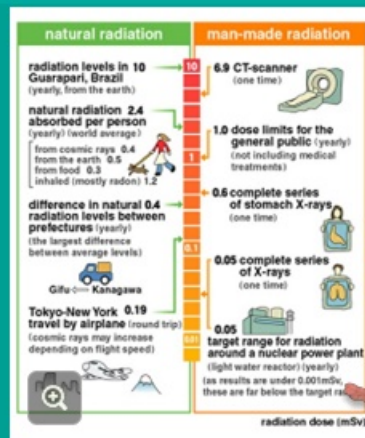
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1.14 Radiation Sources

Radiation Sources

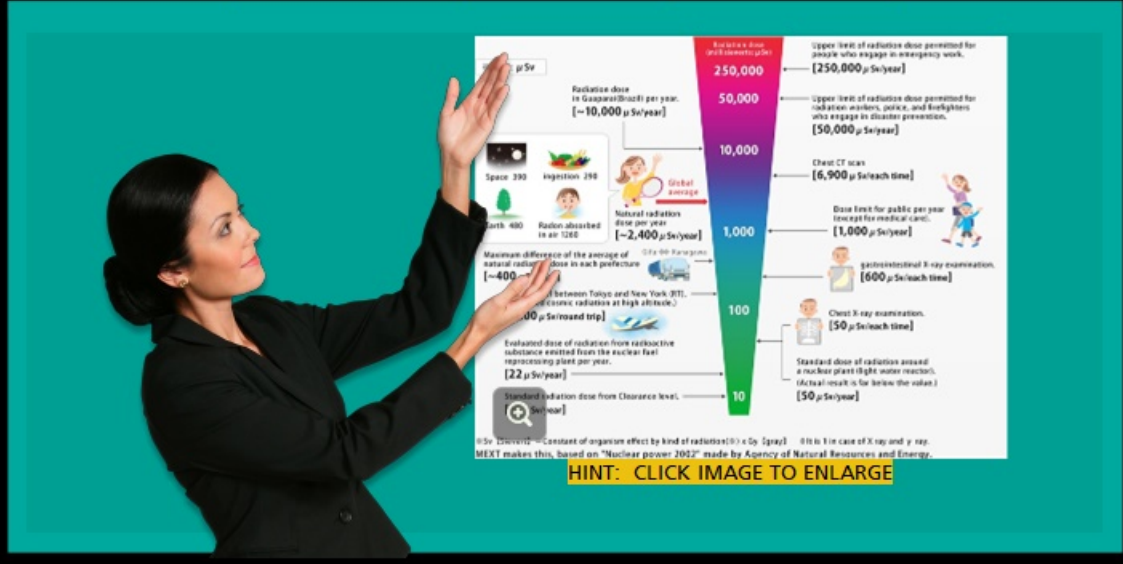
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2. Fixed Gauges

2.1 Nuclear Gauges

Nuclear Gauges

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Many industries use measuring gauges that incorporate a radioactive source.


There are two types of nuclear gauges:

- *Fixed*
- *Portable*

At Long Harbour we are only licensed to use **fixed** gauges. **Portable** gauges may be brought on site by licensed contractors as part of their work.

The use of gauges on site is regulated by the Canadian Nuclear Safety Council (CNSC).

What are nuclear gauges?



2.2 Introduction to Fixed Gauges

Introduction to Fixed Gauges

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Fixed gauges are widely used in factories and processing environments to ensure quality control.

In Long Harbour we are using them to monitor/control processes such as density and level.



Images of
Vendor Gauges



2.3 How Fixed Gauges Work

How Fixed Gauges Work

Unit 1
Introduction

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Fixed Gauges

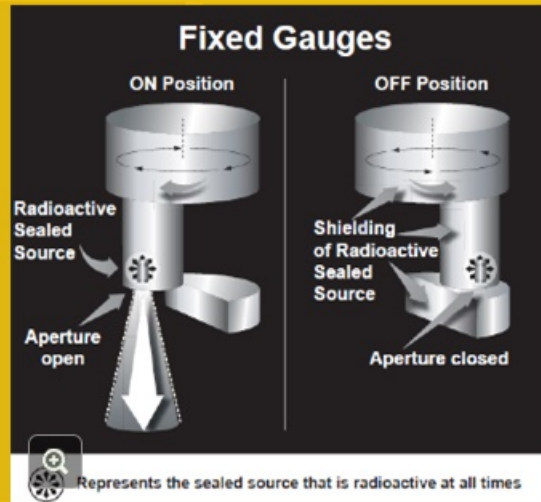
Unit 3
Radiation Safety

Unit 4
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Opening the shutter allows the radiation to pass through the material and to be measured by a detector mounted opposite the source.

The amount of radiation detected indicates the thickness or density of the material. The shutter may be opened manually or electronically.



2.4 Passage of Radiation through Material

Passage of Radiation through Material

Unit 1
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Unit 2
Fixed Gauges

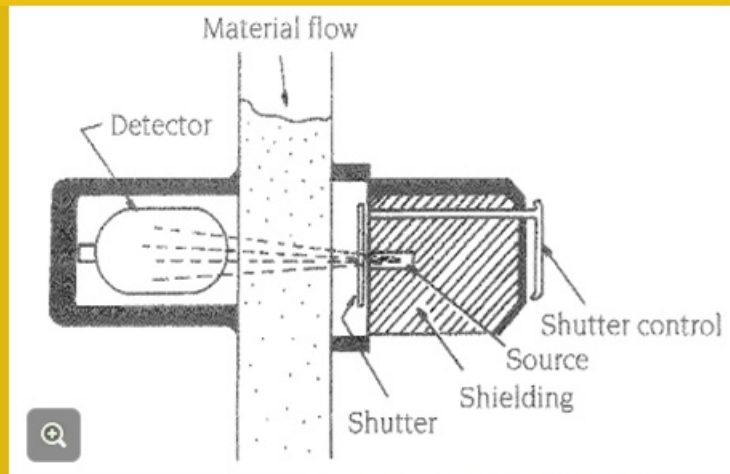
Unit 3
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The passage of radiation through the material does not cause any detectable change, and the material itself in no way becomes radioactive. Main components include:

- *Source*
- *Detector*
- *Shutter*
- *Shielding*



HINT: CLICK IMAGE TO ENLARGE

2.5 Strength of the Source

Strength of the Source

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Each nuclear gauge uses one or two small radioactive sources.

Sources on site are Cesium-137 and Cobalt-60.

The source's strength is measured in terms of how much radioactive energy it gives off.

Although the sources are small (approximately the size of a smartie), they are powerful and radioactive.

It is the amount of radiation you absorb, not the strength of the source, that can pose a danger to your health. The amount of radiation is controlled by the source shielding and by proper handling techniques.

2.6 The Source Holder

The Source Holder

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The **Source Holder** contains the sealed radioactive source capsule providing protection to both the source and people. The majority of the source holder is lead and it is designed to provide shielding.

The Detector is a standard piece of electronics that can observe the radiation intensity produced by the source capsule. There is **NO** radioactive material in the detector.

The source holder is usually constructed with a shutter that can be opened and closed. Closing the shutter prevents the primary beam from escaping. The shutter is usually constructed from lead so that closing the shutter reduces the radiation intensity to safe, controllable levels.

2.7 Identifying a Source Holder


Identifying a Source Holder

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Look for this symbol called the trefoil.

It is the international symbol for radioactivity.

In Canada, all source holders must have the trefoil visible on their surface.



3. Radiation Safety

3.1 Principles of Radiation Protection


Principles of Radiation Protection

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Nuclear gauges are as safe as a power saw or a welding torch.


As with these two tools, safety precautions must be taken.

As the potential harm from radiation is not as obvious as the dangers from a sharp blade or flame, the safety precautions are not as obvious either.



HINT: CLICK IMAGE TO ENLARGE

Are Nuclear Gauges Safe?




3.2 Radiation Protection - 3 Elements

Radiation Protection - Three Elements


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TIME - The less time a person remains in the area of radiation, the less of a radiation dose that person will receive.




HINT: CLICK IMAGES TO ENLARGE

DISTANCE - The intensity of radiation and its effects fall off sharply as you move further away from the source. By moving twice as far away from a radioactive source you are exposed to $\frac{1}{4}$ the amount of radiation.



SHIELDING - Intensity and effect of radiation can also be reduced by placing a dense material (lead plate) in the path of radiation beam. This is how we isolate gauges on site. A shutter is closed across the radiation beam.



3.3 Time, Distance and Shielding

Time, Distance and Shielding

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HINT: CLICK IMAGES TO ENLARGE

The diagram illustrates the ALARA principle (As Low As Reasonably Achievable) for radiation safety. It features a central blue area with the words **DISTANCE** (blue), **TIME** (red), **SHIELDING** (green), and **ALARA** (yellow) arranged diagonally. To the left, a diagram shows a radioactive source emitting radiation, with concentric arcs representing distance (1 m, 2 m, 3 m, 4 m, 5 m, 6 m) and corresponding exposure levels (1/4, 1/9, 1/16, 1/25, 1/36 exposure). A clock icon indicates time. Below this, three panels illustrate the ALARA principle: **Minimize Time** (a person working quickly), **Maximize Distance** (a person using a long-handled tool), and **Incorporate Shielding** (a person using a lead shield).

Minimize Time

Maximize Distance

Incorporate Shielding

3.4 Inspection and Testing

Inspection and Testing

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Once a gauge is in place and being used, regular tests must be performed to ensure that the radioactive source is secure within its capsule and is not leaking out.

A small amount of radiation always penetrates the gauge housing and can be detected in a radiation survey even if the source capsule is intact.

This low level radiation poses no measurable health risk.

3.5 Proper Use of Nuclear Gauges

Proper Use of Nuclear Gauges

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Working with or around nuclear gauges is no different than working with any other type of industrial equipment.

In order to ensure complete safety with nuclear gauges, you must, as with any type of equipment, follow the operating rules, instructions and procedures provided by the manufacturer.

In the event of a discrepancy the CNSC regulations supersede the manufacturer's instructions.

3.6 Radiation Safety Policy and Procedures

Radiation Safety Policy & Procedures

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Long Harbour has a Radiation Safety Policy and Procedures manual that dictates how radioactive sources are to be handled with respect to the topics shown on the right.

This manual has been approved by CNSC and is available through Document Control.

RADIATION SAFETY POLICY AND PROCEDURES MANUAL

- Purchasing
- Transfer/Disposal
- Worker Authorization and Training
- Survey Meters
- Leak Testing
- Storage, Security and Signage
- Packaging and Transport
- Maintenance
- Radiation Exposure Monitoring
- Emergency Procedures
- Operational Procedures
 - Lock Out Tag Out
 - Installation/Removal
 - Confined Space


HINT: CLICK IMAGE TO ENLARGE

4. Guidelines

4.1 Guidelines - Proper Use of Nuclear Gauges

Guidelines - Proper Use of Nuclear Gauges

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General Guidelines

Never use or manipulate a gauge without proper training, knowledge of the instruction manual and authorization.


Read the conditions of the licence.

A copy of the licence shall be posted in a common area where all workers can see it.

4.2 Guidelines (continued)

Guidelines (continued)

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RAYONNEMENT
DANGER
RADIATION

RADIONUCLIDE: Cs-137
RADIOACTIVITY: 110 MBq
TAGGING: 223-312-RE-23441A
SOURCE CONTAINER: FQG60 /20"
SOURCE CONTAINER S/N: H2000F01145

IN CASE OF EMERGENCY

CONTACT:
TELEPHONE NO:

Make sure that the gauge is clearly and durably labeled with the radiation warning symbol and an emergency contact number.

Only the supplier of the gauge, or an authorized person should attempt to repair the source holder or shutter.

Always secure the shutter in the "off" position until maintenance is completed.

4.3 Guidelines (continued)

Guidelines (continued)

Unit 1 Introduction	Unit 2 Fixed Gauges	Unit 3 Radiation Safety	Unit 4 Guidelines	Unit 5 Evaluation
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Radiation warning signs shall be prominently posted.

- In close proximity of the gauge.
- At each entrance to a confined space that involves nuclear gauges.

Participate in Radiation Awareness training.

Worker authorized to maintain gauges will receive additional training.

Avoid physical contact with or direct exposure to the source when performing any maintenance.

Clean the gauge regularly to prevent dirt from getting near the shutter.

Ensure that the gauge is leak-tested annually.

4.4 Guidelines (continued)

Guidelines (continued)

Unit 1 Introduction	Unit 2 Fixed Gauges	Unit 3 Radiation Safety	Unit 4 Guidelines	Unit 5 Evaluation
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Confined Space Entry Requirements

- Only six vessels on our site have radiation sources, all in POL.
- The two Autoclaves, two O2 blowback and two Flash Vessels.
- Periodically we enter these vessels for cleaning and repairs.
- CNSC procedures must be followed prior to entry.

4.5 Guidelines (continued)

Guidelines (continued)

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The CNSC Procedures include:

- All workers entering the space must have this Radiation Awareness training.
- All radiation sources must be locked out.
- A survey of radiation at the point of work must be performed.
- A survey of the background radiation will be recorded outside the vessel.
- If the point of work survey is greater than background the difference will be used to calculate your dose.

4.6 Guidelines (continued)

Guidelines (continued)

Unit 1 Introduction	Unit 2 Fixed Gauges	Unit 3 Radiation Safety	Unit 4 Guidelines	Unit 5 Evaluation
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- Your radiation dose is calculated by multiplying the time in the vessel by the measured dose rate.
- This information will be recorded and attached to the permit.
- After the confined space is closed, all workers who entered will have a dose rate calculated.
- This information is kept on record and can be requested from the site RSO (Radiation Safety Officer).
- The RSOs for Long Harbour are Jason Callan or Jamie Welsh.

4.7 Emergency Procedures

Emergency Procedures

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Cease work immediately and contact security!

If the gauge has been partially damaged or destroyed keep people at least 5 meters away until the source is replaced or shielded or until radiation levels are known to be safe.

Have a leak test performed after any incident that may result in source damage.

In case of an incident or fire, do not use the gauge until any danger from or damage to the source is addressed.

4.8 Equipment - Survey Meter

Equipment - Survey Meters

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We have 2 meters on site.

1. *Surveyor 50 Portable GM survey meter.*
2. *Lyndlum 3 Portable GM survey meter.*

These meters are required to be calibrated annually.

4.9 Summary

Summary

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Nuclear gauges present no major health dangers if basic precautions are taken.

By following proper procedures and the principles of radiation protection, you can feel comfortable and assured that your workplace is a safe one.

4.10 References

References

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4.11 References (continued)

References (continued)

Unit 1 Introduction	Unit 2 Fixed Gauges	Unit 3 Radiation Safety	Unit 4 Guidelines	Unit 5 Evaluation
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Manual - *Radiation Safety Policy and Procedures (85-813-003-XMN-0001)*

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Handout - *Emergency Response Training for Users of Nuclear Gauges*

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4.12 Start The Module Quiz



Thank you for completing the
Vale Online Module Training.

To start the module Quiz

[CLICK HERE](#)