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# Working Safely With Portable Gauges

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Safety Commission

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de sûreté nucléaire

Canada 



# **Working Safely With Portable Gauges**

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# Working Safely With Portable Gauges

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# Introduction

This booklet contains guidelines on the safe handling and use of portable nuclear gauges (gauges), and provides background information about radiation to people working with or near these devices. It is not a substitute for regulatory requirements nor does it relieve a person from complying with those requirements.

This publication is not intended to be the sole source of information for training purposes. Specific information and requirements are found in the operating manuals provided by manufacturers for each portable gauge model, the *Nuclear Safety and Control Act* (NSCA) and applicable regulations, as well as in the licence issued by the Canadian Nuclear Safety Commission (CNSC).

Licensees are responsible for the development and implementation of specific operating procedures and an effective radiation protection program to comply with the NSCA and regulations.

Everyone can help keep the workplace safe by following standard operating procedures and security requirements, and by implementing effective radiation protection principles.

## **The CNSC's role**

The CNSC is the federal agency responsible for regulating the nuclear industry in Canada.

The CNSC regulates the use of nuclear energy and materials to protect health, safety, security and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public.

We enforce the NSCA and its regulations, issue licences and certify radiation devices.

We also continually monitor licensees to ensure compliance with regulatory requirements.

All radiation devices used in Canada must be certified, to ensure they are safe for use for their intended application.

## Portable gauges

Gauges are used in industries such as agriculture, construction and civil engineering to measure moisture and compaction levels in soil and asphalt density in paving mixes.



Two types of radiation are used in gauges: gamma (such as cesium-137) and neutron (such as americium-241/beryllium).

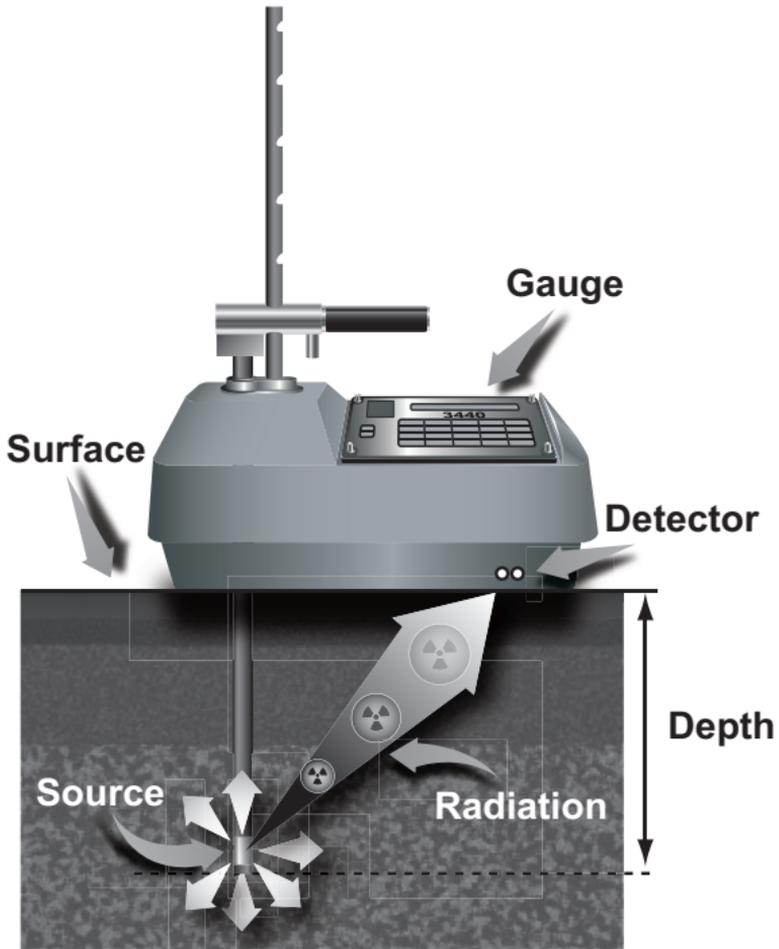
There are two basic methods of measuring material with gauges: the direct transmission method and the backscatter method.

The direct transmission method is considered to be the more precise of the two, as it produces a lesser degree of error in measuring composition and compensates for surface roughness. To measure soil density, for example, the source rod is inserted beneath the surface through a punched access hole. Radiation is then transmitted from the source to a detector in the base of the gauge. The compaction of the soil is determined by the radiation level at the detector.

The backscatter method eliminates the need for an access hole by allowing the source to remain on the surface. Radiation travels beneath the surface, where some radiation is reflected or “scattered” back to the gauge detector by the surface material.

# Portable Gauges

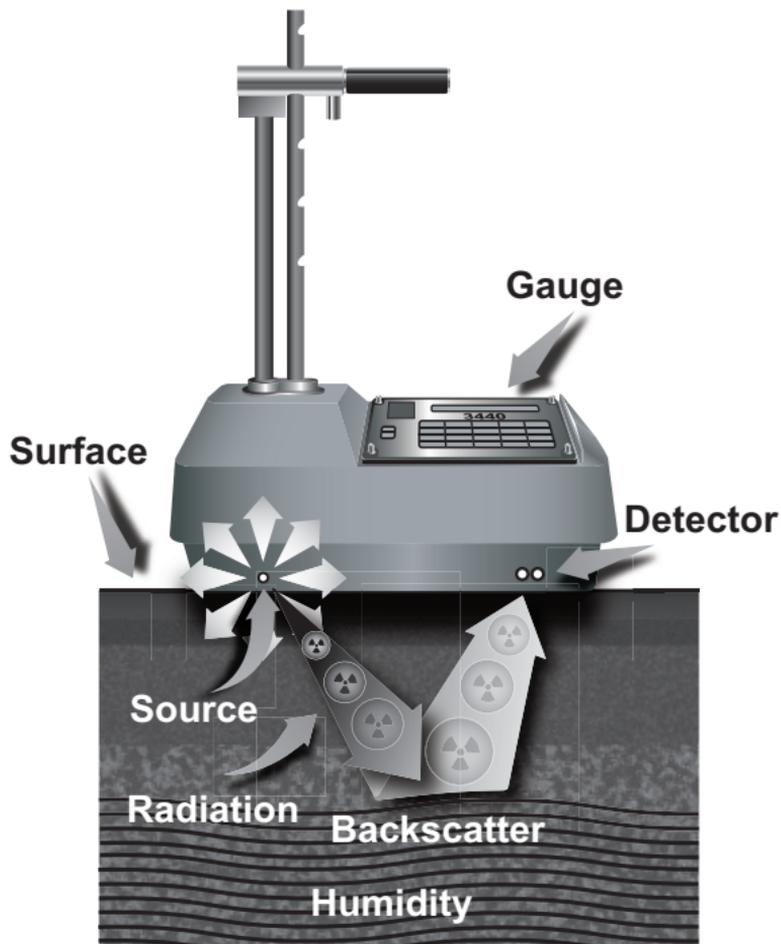
(Direct transmission)



**Figure 1**

The gamma source (cesium-137) is inserted underneath the surface of the ground. Radiation is then transmitted directly to the detector on the bottom of the gauge, allowing accurate measurements of compaction.

# Portable Gauges (Backscatter method)



**Figure 2**

The neutron source (americium-241/beryllium) always remains above the surface. Radiation is emitted into the ground and scattered back to the detector to provide a measurement of the moisture content or density of a material.

The backscatter method can be used either to measure the moisture content of the material using a neutron source, or to measure material density using a gamma source. When used for density measurements, it is less accurate than the direct transmission method due to the large scattering angle and shallow depth of measurement. It is also insensitive to density variations beyond a depth of 5 to 7.5 cm (2 to 3 inches). The backscatter method is more appropriate for uniform material such as asphalt paving.

# What is radiation?

Radiation is energy emitted by an atom or other body as it changes from a higher energy state to a lower energy state. Radiation can be classified as ionizing or non-ionizing radiation, depending on its effect on atomic matter. Nuclear energy produces ionizing radiation.

Natural background radiation is found in cosmic rays, building materials, soil, rocks, air, some foods, and our bodies. It contributes to about three quarters of our annual radiation exposure.

## Radiation dose examples

Dose which may cause symptoms of radiation sickness	1,000 mSv
Five-year dose limit for nuclear energy workers	100 mSv
Annual dose limit for nuclear energy workers	50 mSv
Typical chest CT scan	7 mSv
Average annual dose from natural background radiation in Canada	1.8 mSv
Annual public dose limit	1 mSv
Average annual dose to a portable gauge worker	< 1 mSv
Typical cross-Canada flight	0.02 mSv

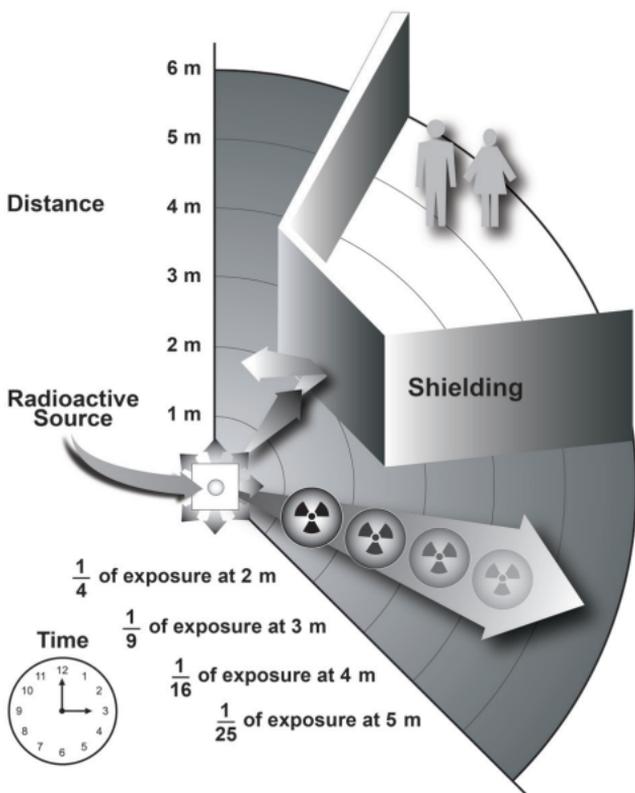
# Radiation protection

The principles of radiation protection include:

**Time** – The shorter the time spent close to the source, the lower the radiation dose received will be.

**Distance** – The intensity of radiation decreases sharply as a person moves farther away from the radioactive source.

**Shielding** – The thicker the protective material placed between the person and the source, the less radiation to which a person will be exposed. The shielding material must be appropriate for the type of radiation.



## **ALARA and nuclear energy workers (NEWs)**

Portable gauge licensees must ensure that doses are kept as low as reasonably achievable (ALARA). The CNSC facilitates this by regulating the use of radiation devices, by assessing radiation protection programs, and by regularly inspecting licensees to ensure compliance with the regulations and licence conditions.

Any worker who is required to perform duties with a reasonable probability of receiving a radiation dose greater than 1 mSv per year is defined as a nuclear energy worker (NEW). The regulatory dose limits for NEWs are 50 mSv per year and 100 mSv over a five-year period.

Gauge workers may or may not be NEWs, depending on the number of shots performed by each individual worker. In general, workers who perform more than 800 shots each year are defined as NEWs, since previous studies indicate that each measurement typically results in an approximate 1.2  $\mu$ Sv dose per shot to the worker.

If a worker is a NEW, the licensee must inform him or her of that status, of the risks associated with the radiation to which they may be exposed, of the regulatory dose limits, and of the dose they receive as a result of their work. The licensee must obtain written acknowledgement from the NEW that they have been informed.

Furthermore, female NEWs must be informed of their rights and obligations should they become pregnant, and they must inform the employer immediately in writing of the pregnancy.

It is highly recommended for licensees to set a threshold or action level (between 650–700 shots), at which point the workers should be informed of their NEW status. This is a proactive measure to ensure workers do not exceed the prescribed dose limits.

Many portable gauge workers are non-NEWs. While doses must still be ascertained, there is implied non-documented consent that an occupational non-NEW will still receive training from the licensee and understand the risks; however, a written acknowledgement is not required.

If there is a reasonable probability that doses may approach 1 mSv/year, the non-NEW must be informed that they are a NEW and the licensee must retain the records of informed consent.

## Keeping track of radiation doses

Licensees must ascertain and record doses for all persons that are present or perform work with or around portable gauges.

There are two ways of determining the radiation doses received by persons working with portable gauges. The ascertainment of doses can be done either by direct measurement (personal dosimetry) or by estimation (counting shots). While both methods are acceptable, it is important to consider that no matter which method is chosen, the doses must be reviewed by the radiation safety officer (RSO) on a regular basis (e.g., monthly or quarterly depending on gauge usage) to ensure doses are within the prescribed limits.

Estimation of the total dose received is based on the number of shots performed in a year. All shots must be considered in the estimation (this includes practice shots). Using the number of shots performed in a year multiplied by a standard of the dose received per shot can give an estimate of the total radiation dose received.

Alternatively, the licensee may choose to monitor their workers using a personal measuring device called a "dosimeter". The most commonly used type of dosimeter is the optically stimulated luminescence dosimeter (OSLD).

Due to the small amount of radiation received by most workers, dosimeters are not normally required and their use is not a requirement.

However, if there is a reasonable probability of receiving a dose greater than 5 mSv in a one-year period, you are **required** to wear an approved dosimeter from a CNSC licensed dosimetry services provider (such as an OSLD).

The dosimeter manufacturer or supplier recommendations should be followed for their care and use. Dosimeters should not be exposed to high temperatures, water, direct sunlight or fluorescent light. Dosimeters must not be shared amongst workers and should be stored as recommended by the manufacturer in low radiation background areas. A personal dosimeter should be worn on the front of the trunk of your body.

# Personal dosimeters

Personal dosimeters are passive dosimeters. The most commonly used are the optically stimulated luminescence dosimeters (OSLDs) and are available from a CNSC licensed dosimetry service provider.

There are also direct reading dosimeters (DRDs), which are real-time dosimeters that monitor the absorbed dose to the worker. They can be checked periodically by the worker to observe doses received.



OSLDs



DRD

## Estimating dose (counting shots)

The method to calculate an estimated dose is as follows:

1. Count the number of shots taken by the gauge operator.
2. Multiply by a standard dose (1.2  $\mu\text{Sv}/\text{shot}$ ).

The result is the estimated dose to the worker. This is shown as the following equation:

Dose = number of shots x standard dose per shot

**Please note:** A shot includes every measurement taken by the user, including practice shots.

The standard dose of 1.2  $\mu\text{Sv}$  per shot takes into account both gamma and neutron dose.

## Example tracking sheet for daily doses

Worker's name	Date	# of shots	Standard dose value per shot	Total dose
Worker 1	2017-05-15	5	1.2 $\mu$ Sv	6 $\mu$ Sv
Worker 2	2017-05-15	10	1.2 $\mu$ Sv	12 $\mu$ Sv
Worker 1	2017-06-20	5	1.2 $\mu$ Sv	6 $\mu$ Sv
Worker 2	2017-06-20	25	1.2 $\mu$ Sv	30 $\mu$ Sv

## Example tracking sheet for annual doses

Worker's Name	Total # shots for 2017	Total annual dose	
Worker 1	100	120 $\mu$ Sv	
Worker 2	500	600 $\mu$ Sv	
Worker 3	650	780 $\mu$ Sv	Approaching annual limit
Worker 4	800	960 $\mu$ Sv	Annual limit almost reached

**Please note:** It is recommended for the RSO to review the shots quarterly at a minimum to ensure no one exceeds the limit and to ensure the worker is informed of their NEW status if required.

# Radiation safety officers

Radiation safety officers (RSOs) are designated by the licensee as persons trained and well-informed about radiation protection principles, methods and practices, as related to the licensed activity.



The RSO is responsible for the effective management and implementation of the radiation protection program.

## **Responsibilities of portable gauge users**

Portable gauge users must ensure the safe conduct of their work, and comply with all applicable regulatory requirements.

Their safety – as well as the safety of the public and the environment – depends at all times on a high level of radiation safety.

Gauge users must comply with the radiation protection program established by their employer, in accordance with regulatory requirements.

Risks that may jeopardize the integrity, safety or security of gauges, safe operations or radiation detection instruments have to be duly considered and mitigated.

The portable gauge must be either under the constant surveillance of a worker, secured in a transport vehicle, or at the storage location.

## Routine maintenance

Routine maintenance of portable gauges is necessary to ensure safe gauge and shutter operation.

Gauges must be leak-tested every 12 months, in accordance with regulatory requirements. Leak tests are conducted to detect a leakage of 200 Bq or more.

Any gauge found to be leaking must be removed from use, and the **CNSC duty officer** must be notified **immediately** at **1-844-879-0805**.

A process must be in place to remove damaged or defective gauges from service and quarantine them until the situation is resolved.

Unusual events, accidents and incidents are to be reported **immediately** to the licensee's radiation safety officer and the **CNSC duty officer at 1-844-879-0805**. If such problems are identified, discontinue use of the gauge until the situation has been addressed.

### **Important:**

The use and maintenance of portable gauges is to be performed in accordance with the operating and maintenance instructions provided by the manufacturer of the gauge, the licensee's radiation protection program and regulatory requirements.

# Radiation survey meters

A radiation survey meter measures the radiation dose rate level at the position checked.

It is a regulatory requirement that a calibrated radiation survey meter be available within two (2) hours' distance of the site where a radiation device (gauge) is used as authorized by the licence.

Radiation survey meters must be calibrated every 12 months in accordance with CNSC expectations.



# Training requirements for portable gauge users



Training your workers is a regulatory requirement.

Training must be provided to all workers using gauges and should include:

- basic radiation safety information, including keeping doses as low as reasonably achievable (ALARA)
- review and understanding of licensee standard operating procedures, the radiation safety program and regulatory requirements
- review of the licence and its conditions
- review of worker obligations
- Transportation of Dangerous Goods (Class 7)
- radiation safety awareness training (particularly to workers who may not use gauges but who may work in proximity of gauges)
- security awareness training
- refresher training recommended (every three years)

## **Transportation of Dangerous Goods (TDG) certification**

Anyone who handles, offers for transport or transports dangerous goods must be trained in accordance with the *Transportation of Dangerous Goods Regulations* (Class 7).

Gauge operators (workers) must have their TDG certificate with them at all times.

**Certificate of Training  
Transport of Dangerous Goods**

\_\_\_\_\_  
Name of employee

\_\_\_\_\_  
Signature of Employee

This certificate certifies that the employee named above has completed the training described on the reverse, in accordance with the requirements of the Transportation of Dangerous Goods Act and Regulations.

Name of Employer: \_\_\_\_\_

Address: 123 name Street  
City, PROV  
Postal Code

\_\_\_\_\_  
Signature of Employer

\_\_\_\_\_  
Expires on

Class and division	X	Training
<b>Handling and Offering for Transport of Class 7 radioactive materials</b>		<b>Classification</b>
		<b>Packaging</b>
		<b>Safety marks</b>
		<b>Shipping documents</b>
		<b>Prescribed special precautions</b>
		<b>Dangerous occurrence reporting</b>
		<b>Emergency measures</b>
		<b>Proper utilization of equipment</b>
		<b>Use of safety equipment</b>
		<b>ICAO TPs</b>
		<b>IMDG Code</b>

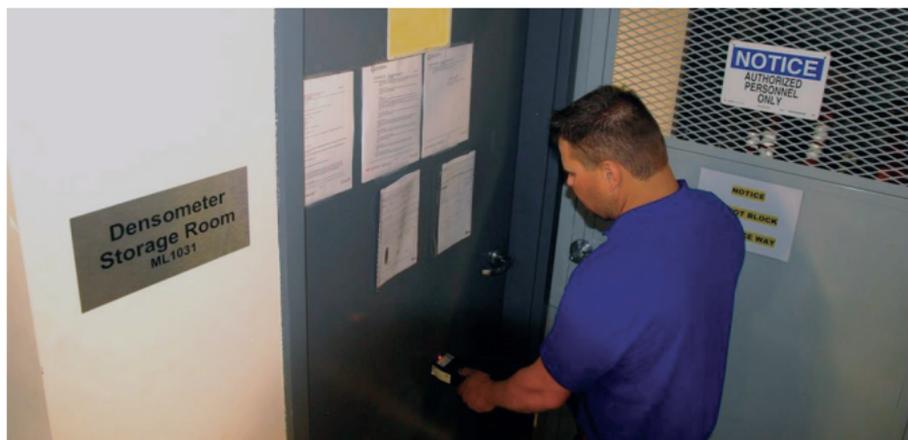
Front and back of sample  
Certificate of Training Transport of Dangerous Goods

## Storage

- Before storing the gauge, make sure the cesium-137 source is fully retracted and the shutter is fully closed.
- Never modify or change the source holder, shielding or safety locks.
- Store the gauge in a locked, tamper-resistant container (such as a Type A labeled transport case).
- Identify the package with the consignor name, in case the gauge is lost, damaged or misplaced.



## Storage areas



Storage areas for portable gauges must be designed and constructed to ensure that doses to members of the public (including non-employees), non-NEWs and NEWs do not exceed the regulatory dose limits and are consistent with the principle of ALARA. Radiation protection principles of time, distance and shielding should be used to ensure that doses remain below regulatory requirements and consistent with the ALARA principle.

Licensees must be aware that if a storage area abuts or is near a location that is not under the licensee's control, then measurements or estimations of the potential exposures to persons in these areas must be performed.

Licensees should perform routine checks of the dose rates in all areas, including those surrounding the storage area(s) using calibrated radiation survey instrumentation. Dose rates should be measured at all occupied locations throughout the site of licensed activity.

These dose rates should then be multiplied by the number of hours the space will be occupied in a year while the gauge(s) is in storage. These dose rates should be taken at maximum capacity of the storage area and whenever changes are made such as an increase in inventory or any changes to the storage area (including design, construction or occupancy near the area).



## Shutters

It is very important to ensure that shutters are properly functioning and fully closed.

A portable gauge with an open or partially open shutter poses a risk of exposure to the worker and the public.

A gauge cannot be transported with an open or improperly closed shutter unless measures are taken to ensure that the gauge is transported in compliance with transport regulations.

If the shutter cannot be closed, the RSO must be notified immediately so that this situation can be reported to the CNSC.

It is a good practice to have measures in place to verify that the shutter is properly closed prior to transport.



Example of a shutter fully open (left) and a shutter that is half-open (right)

The best practice to confirm that a shutter is closed is to use a survey meter, however, there are other methods. The use of a mirror is one method which minimizes unnecessary radiation exposure to the worker.



# Emergency procedures



Your company must have emergency procedures and a plan of action in case of loss, theft, fire, an accident or damage to the portable gauge.

More specifically, detailed procedures are required for responding to and managing situations involving crushed or damaged gauges and motor vehicles with the radiation device onboard, including appropriate actions to be taken and the process to be followed for handling the situation.

The emergency procedures should include information on **immediate** notification to the **CNSC duty officer at 1-844-879-0805** and company personnel.

## **In general, the following steps should be followed:**

- Cease work immediately.
- Keep people at least 2 metres away (approximately 6 feet) until the source is removed or until radiation levels are known to be safe.
- Immediately inform the radiation safety officer.
- If the damage is minor or superficial, and the source is in the safe, shielded position, a Type A transport container (such as the gauge transport case) can be used to transport the device. If you do not have a radiation survey meter, do not move a damaged gauge until its radiation level is checked.
- If the damage is severe or the source rod will not retract, an alternate Type A package may be used. Follow your company's standard operating procedures for this situation. A calibrated survey meter must be used to ensure safe radiation levels.
- Before the site is reopened for regular use, the licensee must ensure that all sources have been recovered.
- In case of an accident or fire, do not use the gauge until the damage is assessed. A leak test must be performed after any incident that may have resulted in source damage.
- Inform the CNSC immediately of any theft, accident or incident.

## Gauge incidents

If an incident occurs while a radiation device (portable gauge) is being used at a job site or transported in a vehicle, a preliminary report shall **immediately** be made by the RSO to the **CNSC duty officer at 1-844-879-0805** describing the location and circumstances of the accident, and any action(s) taken or proposed to be taken as a result of the incident.

The area around an incident is to be controlled by:

- limiting, to the extent possible, the spread of any radioactive material
- restricting and posting the area accordingly and sending for assistance as required.
- placing barriers, signs or personnel at every point of entry into the affected area, to block the access of unauthorized persons
- recording the name, address and telephone number of anyone who may have been exposed to – or contaminated by – radioactive material, and requesting that they remain available for assessment by a radiation protection expert

**Specific examples of transport incidents may include, but are not limited to:**

- A vehicle is involved in an accident.
- The source is outside of the shielded position while being transported (shutter open) and documentation has not been modified for the situation.
- Any other incident or accidents involving the transport of nuclear substances and radiation devices must also be reported **immediately** to the **CNSC duty officer at 1-844-879-0805**.

## Lost or stolen radiation device(s)



- A missing or stolen radiation device containing radioactive source(s) can be a significant hazard if found by members of the public unaware of the radiation danger. It is imperative that anyone working with a radiation device be aware of the security implications.
- **Immediately** report any lost or stolen radiation device or nuclear substance, or vehicle containing a radiation device or nuclear substance to the CNSC by calling the **CNSC duty officer at 1-844-879-0805**.
- The RSO should also immediately report a loss or theft to the local authorities.

## Before you start

- Have you have received sufficient training to properly and safely operate the gauge?
- Do you have your dosimeter or shot tracking sheet? If you have a dosimeter, are you wearing it in the appropriate location?
- Do you have a copy of your TDG training certificate?
- Are you carrying a properly completed shipping document that is for the gauge you are using?
- Do you need to sign an in-out log at your office before departing with the gauge?
- If you are travelling more than 2 hours from your office, are you taking a survey meter with you? Is it functioning and has it been calibrated within the last 12 months and have you been trained to use it?
- Have you verified that the shutter on your gauge is fully closed?
- Do you have a copy of your CNSC licence and a copy of your company's emergency procedures?
- Is the shipping document kept within arm's reach of the driver during transport?
- Is the Type A package secured in the vehicle in a manner to prevent damage during transport?

## **During operations (at the job site)**

- Is the gauge continuously under your immediate care and control to prevent damage and unauthorized access?
- Are you keeping track of how many shots you are taking, including practice shots?
- Are you avoiding all unnecessary exposure and handling of the Cs-137 rod by keeping your hands away from the underside of the gauge at all times?
- Are you keeping all other site employees at least 2 meters away from the gauge at all times?
- When you are taking the measurements, are you also keeping at least two meters away from the gauge? (set it up and step back)
- When the gauge is not in use, is it secured and locked in a safe location at all times?
- If there is an accident involving the gauge, do you immediately initiate your company's emergency procedures by keeping all workers a safe distance away from the gauge and immediately calling your RSO for guidance?

## At the end of the job

- When packing up the gauge, have you confirmed that the shutter is fully closed?
- Do you have all the necessary documentation for transport and is the gauge prepared and ready for transport?
- When returning to the office, if you're wearing a dosimeter have you returned it to its proper storage location (away from all sources of radiation)?
- Have you signed the gauge back in on the in-out log?
- Have you submitted your shot tracking sheet to the RSO or appropriate person?
- Has the gauge been placed in safe and secure storage?

## **Conclusion**

Working with portable gauges presents no major health dangers or significant risks if basic safety precautions are taken and common sense is used. By following proper safety procedures, using effective radiation protection principles, and helping others to do likewise, the workplace will remain safe at all times.

# Glossary of terms

## **As low as reasonably achievable (ALARA)**

A principle of radiation protection that holds that exposures to radiation are kept as low as reasonably achievable, social and economic factors taken into account. Section 4 of the Radiation Protection Regulations stipulates licensee requirements with respect to ALARA.

## **Background radiation**

The dose or dose rate (or an observed measure related to the dose or dose rate) attributable to all sources other than the one specified.

## **Becquerel (Bq)**

The International System of Units (SI) unit of radioactivity. One becquerel (Bq) is the activity of a quantity of radioactive material in which one nucleus decays per second. In Canada, the Bq is used instead of the non-SI unit curie (Ci).

## **Canadian Nuclear Safety Commission (CNSC)**

Canada's nuclear regulator, established under the *Nuclear Safety and Control Act* to regulate the use of nuclear energy and materials to protect health, safety, security and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public.

## **Dose**

The radiation absorbed by the body.

## **Dosimeter**

A device for measuring a dose of radiation that is worn or carried by an individual. There are several types of personal dosimeters such as on optically stimulated luminescent dosimeters (OSLD) and direct reading dosimeters (DRD).

## **Ionizing radiation**

For the purposes of radiation protection, radiation capable of producing ion pairs in biological material(s).

## **Leak tests**

With respect to sealed sources (including sealed sources within prescribed equipment) or nuclear substances used as shielding, a method of verifying the integrity of the encapsulation of the sealed source or ensuring that the nuclear substance used for shielding is not readily removable from the surface of that shielding.

## **Licensee**

A company or person to whom a CNSC licence has been issued for the possession and use of nuclear substances and radiation devices.

## **Nuclear energy worker (NEW)**

A person who is required, in the course of the person's business or occupation 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.

## **Operating procedures**

The instructions supplied by the licensee covering radiation safety and regulatory requirements related to the use and possession of exposure devices.

## **Package**

The complete product of the packing operation, consisting of the packaging and its contents prepared for transport. The types of packages are subject to activity limits and material restrictions, and must meet regulatory requirements.

## **Radiation safety officer (RSO)**

A radiation safety specialist implements and administers a radiation safety program.

## **Radiation survey meter**

An instrument that is capable of measuring radiation dose rates.

## **Shielding**

Materials placed around a radiation source for the purpose of reducing radiation levels.

## **Sievert (Sv)**

The International System of Units (SI) unit of equivalent dose and effective dose, equal to 1 joule/kilogram.

## **Transport**

The handling, carrying or storage in transit and receipt at the final destination of packages. Transport includes normal and accident conditions encountered in carriage and in storage during transit.

# Conversion factors for International System (SI) units

These tables provide the most commonly used ranges:

## **RAD (rad) replaced by the GRAY (Gy)**

1 kilorad (krad)	= 10 gray (Gy)
1 rad (rad)	= 10 microgray ( $\mu\text{Gy}$ )
1 millirad (mrad)	= 10 microgray ( $\mu\text{Gy}$ )
1 microrad ( $\mu\text{rad}$ )	= 10 nanogray (nGy)

## **GRAY (Gy) replaces the RAD (rad)**

1 gray (Gy)	= 100 rad (rad)
1 milligray (mGy)	= 100 millirad (mrad)
1 microgray ( $\mu\text{Gy}$ )	= 100 microrad ( $\mu\text{rad}$ )
1 nanogray (nGy)	= 100 nanorad (nrad)

## **ROENTGEN (R) replaced by the COULOMB/kg (C/kg)**

1 kiloroentgen (kR)	= 258 millicoulomb/kg (mC/kg)
1 roentgen (R)	= 258 microcoulomb/kg ( $\mu\text{C/kg}$ )
1 milliroentgen (mR)	= 258 nanocoulomb/kg (nC/kg)
1 microroentgen ( $\mu\text{R}$ )	= 258 picocoulomb/kg (pC/kg)

## **COULOMB/kg (C/kg) replaces the ROENTGEN (R)**

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1 coulomb/kg (C/kg)	= 3876 roentgen (R)
1 millicoulomb/kg (mC/kg)	= 3876 milliroentgen (mR)
1 microcoulomb/kg ( $\mu$ C/kg)	= 3876 microroentgen ( $\mu$ R)
1 picocoulomb/kg (pC/kg)	= 3876 nanoroentgen (nR)

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## **REM (rem) replaced by the SIEVERT (Sv)**

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1 kilorem (krem)	= 10 sievert (Sv)
1 rem (rem)	= 10 millisievert (mSv)
1 millirem (mrem)	= 10 microsievert ( $\mu$ Sv)
1 microrem ( $\mu$ rem)	= 10 nanosievert (nSv)

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## **SIEVERT (Sv) replaces the REM (rem)**

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1 sievert (Sv)	= 100 rem (rem)
1 millisievert (mSv)	= 100 millirem (mrem)
1 microsievert ( $\mu$ Sv)	= 100 microrem ( $\mu$ rem)
1 nanosievert (nSv)	= 100 nanorem (nrem)

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## **CURIE (Ci) replaced by the BECQUEREL (Bq)**

1 kilocurie (kCi)	= 37 terabecquerel (TBq)
1 curie (Ci)	= 37 gigabecquerel (GBq)
1 millicurie	= 37 megabecquerel (MBq)
1 microcurie	= 37 kilobecquerel (kBq)
1 nanocurie	= 37 becquerel (Bq)
1 picocurie	= 37 millibecquerel (mBq)

## **BECQUEREL (Bq)\* replaces the CURIE (Ci)**

1 terabecquerel (TBq)	= 27 curie (Ci)
1 gigabecquerel (GBq)	= 27 millicurie
1 megabecquerel (MBq)	= 27 microcurie
1 kilobecquerel (kBq)	= 27 nanocurie
1 becquerel (Bq)	= 27 picocurie

**\*1 BQ = 1 disintegration per second ( $s^{-1}$ )**

## Notes

## Notes

## Notes



In case of emergency contact the  
**CNSC duty officer at 1-844-879-0805**