



# Alarm Response Guidelines for Radiation Portal Monitoring Systems



# Alarm Response Guidelines for Radiation Portal Monitoring Systems

© Minister of Public Works and Government Services Canada 2011

Catalogue number CC172-68/1-2011E-PDF  
ISBN 978-1-100-17916-2

Published by the Canadian Nuclear Safety Commission, February 2011

CNSC Catalogue number: INFO-0814

Extracts from this document may be reproduced for individual use without permission provided the source is fully acknowledged. However, reproduction in whole or in part for purposes of resale or redistribution requires prior written permission from the Canadian Nuclear Safety Commission.

Également publié en français sous le titre de:  
Directives d'intervention en cas d'alarme de portiques de détection des rayonnements

## Document availability

This document can be viewed on the CNSC Web site at [nuclearsafety.gc.ca](http://nuclearsafety.gc.ca)

To order a printed copy of the document in English or French, please contact:

Canadian Nuclear Safety Commission  
280 Slater Street  
P.O. Box 1046, Station B  
Ottawa, Ontario K1P 5S9  
CANADA

Tel.: 613-995-5894 or 1-800-668-5284  
(in Canada only)

Facsimile: 613-995-5086

Email: [info@cnsccsn.gc.ca](mailto:info@cnsccsn.gc.ca)

Web site: [nuclearsafety.gc.ca](http://nuclearsafety.gc.ca)

Photos courtesy of: BFI Canada, Overwatch Inc.

# Alarm Response Guidelines for Radiation Portal Monitoring Systems

## Introduction

The Canadian Nuclear Safety Commission (CNSC) created this brochure as well as a poster to offer alarm response guidelines for radiation portal monitoring systems.

These will provide:

- guidance and response actions to be taken in the event that a radiation portal monitor alarm is activated
- safety aspects to consider when dealing with unidentified radioactive nuclear substances
- hazards and risks associated with nuclear substances and radiation devices
- information related to the detection of nuclear substances and radiation devices

Nuclear substances and radiation devices are widely used throughout Canada in many application fields, which include industrial, medical, education and research. Radioactive sources are used in both sealed and unsealed forms. The sealed form generally consists of a nuclear substance encased within a metal capsule, and is usually incorporated into a radiation device designed for industrial use. Unsealed radioactive sources can be in liquid or solid form, and are commonly used in medical diagnostic and therapeutic treatments, as well as in laboratory research applications.

The CNSC is the federal authority responsible for the regulation of nuclear substances and radiation devices in Canada. A licence issued by the CNSC is required for the possession and use of nuclear substances and radiation devices. There are, however, small quantities of nuclear substances that are exempt from licensing, because they represent a low risk to the public and the environment. Examples of items that are exempt from CNSC licensing include residential smoke detectors, building exit signs, naturally occurring nuclear substances and outpatient waste from individuals who have received a nuclear medicine treatment.

Occasionally, radioactive nuclear substances have been found in the public domain, in areas such as waste management and scrap metal recycling facilities. This represents a matter of concern, since undetected radioactive nuclear substances in appreciable amounts may cause unnecessary risk to members of the public, facility workers and the environment. If nuclear substances enter the metal recycling processing stream, equipment and products can be contaminated, resulting in significant financial impacts due to clean-up costs.

Over the years, numerous waste management and scrap metal recycling facilities have purchased and installed radiation portal monitor systems at their locations. These monitoring systems are used to detect the presence of radioactive nuclear substances in incoming shipments of materials to their facilities. The use of radiation portal monitors to detect the presence of radioactive nuclear substances has therefore reduced the potential of these materials entering waste management and metal recycling processing facilities.

In most cases, the alarms are activated by items containing very low levels of radioactive materials that do not require a CNSC licence, being exempt from regulation. Items and materials containing nuclear substances detected at waste management facilities and scrap metal recycling facilities include:

- smoke detectors
- devices that contain a radium luminous compound
- low activity check sources
- naturally occurring nuclear substances
- outpatient waste from individuals who have received a nuclear medical treatment with a nuclear substance

However, in some cases, the alarms may be activated by radioactive material that has not been disposed of appropriately, or has been illegally discarded with normal waste or scrap. On occasion, an orphan source is discovered in normal waste or scrap.

**Smoke detectors** are among the most important fire safety devices found in many homes. One of the most common types of smoke detector contains an ionization chamber and a small quantity of americium-241 (Am-241), which is radioactive. These devices do not require a licence, although their manufacture and initial distribution are licensed by the CNSC. Older smoke detectors containing radium-226 (Ra-226) have been detected occasionally, although this type of smoke detector is no longer manufactured or distributed in Canada.

### Examples of smoke detectors

*Older smoke detector containing radium-226*



*Household smoke detector*



**A device** that contains a radium luminous compound is not radioactive in itself. The radioactivity is associated with the radium-based paint in the device, which causes it to glow in the dark. The luminous compound consists of radium salts mixed with a chemical phosphor. The resulting compound is luminescent, which made it popular during the first half of the 20th century for use in watch and clock faces, maritime compasses, and a variety of military items and aircraft instruments. The production of radium luminous products ended in the 1960s, and the use of radium in consumer products pre-dates the establishment of regulatory control of nuclear substances in Canada. Nonetheless, there are still many items with radium luminous paint. They sometimes show up in places such as antique stores, museums, junkyards, or garage sales, eventually ending up in waste or scrap metal recycling facilities.

Examples of devices that contain a radium luminous compound



For more information on devices that contain a radium luminous compound, please visit the CNSC Web site at: [nuclearsafety.gc.ca/eng/readingroom/factsheets/devices/index.cfm](http://nuclearsafety.gc.ca/eng/readingroom/factsheets/devices/index.cfm)

**Low activity check sources** are composed of a nuclear substance that is deposited on a plastic disc and then sealed with epoxy to prevent leakage and contamination. These items are typically used to verify the response of a variety of radiation detection instruments.

*Example of low activity check sources*



**Naturally occurring nuclear substances** are radioactive substances that are naturally found in the environment. These include uranium, thorium and a radioactive form of potassium, and any of their radioactive decay products, such as radium and radon. These elements have always been present in the Earth's crust and within the tissues of all living beings. Naturally occurring nuclear substances that are not associated with the nuclear fuel cycle do not come under the control of the CNSC, except for Import/Export and Transport. Their presence is detected in everyday items – this includes thorium-232 (Th-232) in items such as brake linings, jet engines, refractory bricks, and ceramic air blasting beads. Depleted uranium is used in armour-piercing projectiles, while uranium-238 is found in various other items such as construction bricks and gypsum board.

*Examples of naturally occurring nuclear substances found in manufactured products*

*Thorium-232 in ceramic air blasting beads*



*Granite roller*



*Ceramic resistors*





*Thorium-232 in brake linings*



*Jet engine, firebrick and shred log containing naturally occurring nuclear substances*



**Nuclear medicine** is the term used when nuclear substances are incorporated into pharmaceuticals for the diagnosis, management and treatment of diseases. They are designed to target specific tissues and organs, allowing the delivery of their radiation to a specific area of the body. The most common nuclear substances used in nuclear medicine are chromium-51 (Cr-51), indium-111 (In-111), iodine-131 (I-131), gallium-67 (Ga-67), technetium-99 m (Tc-99 m), and thallium-201 (Tl-201). Radioactive articles of nuclear medicine patients most commonly appear in household trash bound for solid waste landfill facilities.

Examples of articles used in nuclear medical treatments that may be contaminated with nuclear substances:

*Iodine-131 contaminated saliva on stamps; outpatient personal items contaminated with medical nuclear substances*



**An orphan source** is a radioactive source that is not under proper regulatory control. It may have been abandoned, lost, misplaced, stolen or otherwise transferred without proper authorization. Orphan sources may be dangerous to members of the public or industry workers. They are most commonly found in scrap metal, and typically include radiation devices such as fixed gauges that contain radioactive sources of cobalt-60 (Co-60), cesium-137 (Cs-137), iridium-192 (Ir-192) and americium-241 (Am-241).

*Examples of radiation devices and packages containing nuclear substances.*

*Americium-241 contained in a level gauge*



*Cesium-137 contained in a fixed gauge*



*Americium-241/beryllium and cesium-137 contained within a portable gauge*



*Cesium-137 contained within a transport package*



For more information related to radiation devices please visit the CNSC Web site at: [nuclearsafety.gc.ca/eng/readingroom/publications/gauges/index.cfm](http://nuclearsafety.gc.ca/eng/readingroom/publications/gauges/index.cfm)

# **Actions to be taken when a radiation portal monitoring system alarm is activated**

These guidelines have been developed to provide information on radiation portal alarm response actions. An accompanying poster also summarizes the actions to be taken. If a radiation portal monitoring system alarm is activated, the CNSC recommends adhering to the following guidelines, which are divided into three sections: Validate, Investigate and Report.

## **VALIDATE**

Alarms must be validated, to verify if the alarm is due to a source of radiation within the incoming load. False alarms may be caused by minor fluctuations in background radiation levels. Background radiation is constantly present in the environment, and is emitted from a variety of natural and artificial sources. Normal background radiation may range from 0.05  $\mu\text{Sv/h}$  to 0.2  $\mu\text{Sv/h}$ , depending on the geographical location. The portal monitor alarm setting should be set slightly above normal background levels, to avoid repeated false alarms.

In some cases, alarms are activated due to the driver of the vehicle having received a medical treatment with a nuclear substance. In these situations, the vehicle should be passed through the monitor a second time, with a replacement driver. The original driver should be situated at a location at least 30 metres away from the radiation portal monitoring system. If the alarm does not activate the second time, the load may be considered clear of radioactive material.

If the driver has not recently received medical treatment, pass the vehicle through the monitor for a second time. If the alarm is activated again, move the vehicle to an isolated area for further investigation.

Facilities that operate a radiation portal monitoring system should also possess a handheld radiation survey meter. The radiation portal monitor and the survey meter should be used in conjunction when an

alarm is activated. In most cases, the radiation portal monitoring system readout is in counts per second (cps) or in counts per minute (cpm), while the radiation survey meter readout is in microsieverts per hour ( $\mu\text{Sv/h}$ ).

*Workers who move toward a truck that has triggered the radiation portal monitor should use a gamma survey meter to monitor radiation levels. The information obtained from this instrument will help to determine the appropriate response.*



**Survey meters** are portable radiation detection and measurement instruments, used to measure ionizing radiation fields and the direct exposure hazard to a person. There is a large selection of survey meters commercially available to measure the three types of ionizing radiation: alpha particles, beta particles and gamma rays. The radiation dose rate is normally read in microsieverts per hour ( $\mu\text{Sv/h}$ ). Instruments are also available to identify nuclear substances. A portable gamma-ray spectrometer detects gamma rays and identifies the nuclear substance present. Identification is critical in determining the appropriate response.

All radiation monitoring equipment and instruments should be calibrated periodically and properly maintained for optimum performance.

Personnel should be trained to properly utilize radiation survey meters and instruments to detect nuclear substances.

For those who do not possess a handheld radiation survey meter, the following chart provides a general comparison of radiation portal monitoring readings in counts per second (cps), versus radiation survey meter dose rate readings in  $\mu\text{Sv/h}$ . This is a quick reference for establishing the response actions to be taken, solely based on the radiation portal monitor reading. Any reading from the portal monitor that is more than twice the background reading should be considered a positive alarm.

Radiation portal monitor reading (measured in cps)	Approximate dose rate in microsieverts per hour ( $\mu\text{Sv/h}$ )	Response action
Background reading	0.1	No action required
2 x background	0.2	Re-monitor load and investigate
20 x background	2.0	Isolate the load and investigate
100 x background	25	Isolate and contact a radiation safety expert

*Returning the vehicle to the public roadway may not comply with some or all of the regulations pursuant to the Nuclear Safety and Control Act, and in particular to the Packaging and Transport of Nuclear Substances Regulations and Transport Canada's Transportation of Dangerous Goods Regulations.*

*If the vehicle needs to be moved to another location for validation or investigation of the cause of the alarm, the CNSC should be contacted for further instructions.*

## INVESTIGATE

Investigating an activated alarm is extremely important. The detection of nuclear substances in a load before they enter a facility process line provides the opportunity to take corrective remedial actions, depending on the radiological risk associated with the alarm.

The refusal to investigate an activated alarm can be of major significance, and may result in a number of undesirable consequences, including health or environmental impacts, legal action or financial consequences.

During the investigation process, every reasonable effort should be made to maintain radiation exposures and releases of radioactive material as low as reasonably achievable (ALARA). In order to safely investigate load contents, the CNSC recommends that individuals conducting the investigation be properly trained and have access to a radiation survey meter and appropriate instructions and/or procedures. Their training should consist of several aspects of radiation safety, including:

- operation and use of radiation survey meters
- identification of nuclear substances
- the ALARA principle
- the recovery and handling of unidentified radioactive material
- the procedures for the notification of proper authorities
- contamination check and decontamination procedures

To use radiation detection systems effectively, instructions and/or procedures should be available to all personnel tasked with the investigation of radioactive material.

All the information resulting from the investigation should be recorded and kept for future reference. Recording key information may assist in identifying the appropriate response and will provide a complete and accurate record of the occurrences.

If trained personnel are not available, a radiation safety expert should be contacted to assist with the radiological assessment and evaluation of appropriate remedial actions. Please visit the Canadian Radiation Protection Association (CRPA) at [crpa-acrp.ca](http://crpa-acrp.ca) to obtain information on radiation safety experts.

***Ionizing radiation:*** There are three types of ionizing radiation produced by radioactive decay: alpha particles, beta particles and gamma rays. The radiation is called ionizing because the particles and/or the electromagnetic radiation are charged. The radiation interacts with the electrons within atoms or molecules and creates negatively charged electrons and positively charged ions, thereby changing the characteristic of matter.

*Radiation exposure can be minimized when dealing with unidentified nuclear substances, by following three basic concepts of radiation safety which apply to all types of ionizing radiation. The concepts are time, distance and shielding.*

***Time:*** For people who are exposed to radiation, limiting or minimizing the time spent near the radioactive material will reduce the dose received from the radiation source.

***Distance:*** The intensity and effects of radiation decrease sharply with distance from the source. Always maximize your distance.



**Shielding:** A barrier between a person and the source of radiation will reduce the amount of ionizing radiation to a person. The effectiveness of a material in shielding radiation is determined by the thickness and density of the material that reduces the radiation by half. The amount of shielding required to protect against the source of radiation depends on the type of ionizing radiation.

Alpha and beta particles can often be stopped by a piece of paper or a sheet of plastic. They cause most damage when they are inside the human body. They could enter the human body by being breathed in, swallowed, or absorbed through wounds.

Gamma rays are electromagnetic radiation of high frequency. Gamma rays can cause serious damage when absorbed by living tissue. Gamma rays require a dense shielding material, such as lead or concrete, to reduce the exposure to radiation.

For more information on understanding radiation, please visit the CNSC's Web site at: [nuclearsafety.gc.ca/pubs\\_catalogue/uploads/INFO-0721-1\\_E.pdf](http://nuclearsafety.gc.ca/pubs_catalogue/uploads/INFO-0721-1_E.pdf)

**Identify the origin of the shipment and type of shipment (i.e., scrap metal, waste, etc.)**

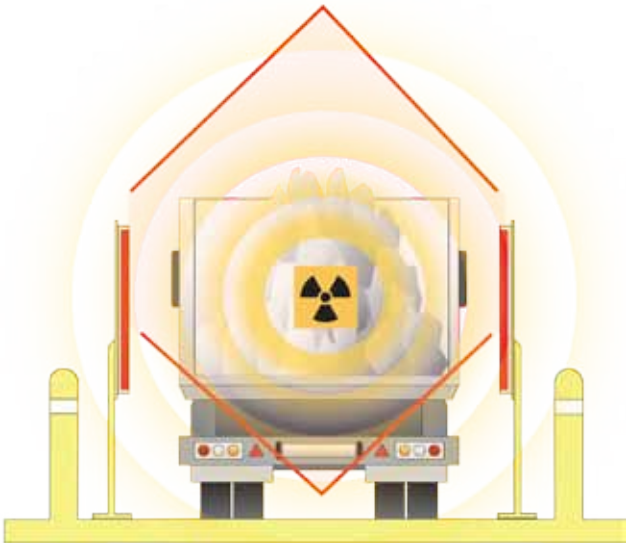
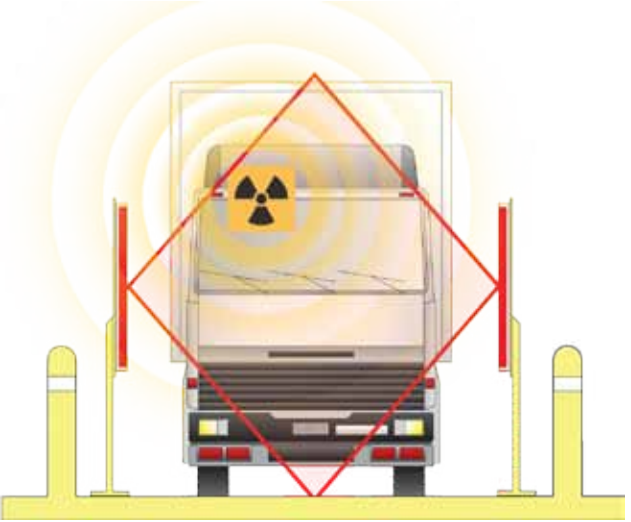
The shipping document may provide key information on the origin of the source of radiation within the material. This information can include the location where the material originated from, therefore providing assistance in identifying the type of application (medical or industrial) in which the nuclear substance was used. This may help with assessing the initial response actions that may have to be taken.

**The following steps should only be carried out by persons trained in radiation safety:**

Survey with a gamma survey meter, following isolation of the load.

Only a trained person should conduct a radiation survey to locate the source of radiation. The dose rate must be continuously monitored, in order to assess the required level of safety. The detection of radioactive material buried within a load can be complex. The ionizing radiation may be shielded by the scrap metal, by other waste, or by the radiation device in which the nuclear substance is contained. The nature of the shielding can cause the dose rates to be reduced. As a result, a thorough survey must be conducted in order to locate the source of radiation.

The diagrams below illustrate the field of view of the radiation portal monitor detectors. If a source of radiation is detected, the exterior of the vehicle should be scanned with a survey meter. The surrounding material within the load may act as shielding; therefore, the detection surface must be within 5 cm of the survey meter.



**If the dose rate exceeds 25  $\mu\text{Sv/h}$ , the following actions should be taken:**

- erect a barrier at least 5 metres away from the load
- contact a radiation safety expert to conduct further radiological assessment and evaluate appropriate remedial actions

**If the dose rate does not exceed 25  $\mu\text{Sv/h}$ , and the retrieval of the source of radiation is initiated, the following must be considered:**

As retrieval steps are undertaken, the radiation dose rate must be continuously monitored, since the radioactive material may be buried under surrounding material that shields the radiation. As material is removed, radiation dose rates could exceed 25  $\mu\text{Sv/h}$ . If this occurs, back away and follow the steps noted above, in the “If the dose rate exceeds 25  $\mu\text{Sv/h}$ ” section.

The safety considerations that must be taken during source retrieval are directly dependent on correctly recognizing the type of ionizing radiation present in the material and its associated level of risk. These considerations include the three basic concepts of radiation safety: time, distance and shielding, as well as other protective measures during the handling and storage of the radioactive material and the use of protective equipment and clothing. All the persons involved in the retrieval of the source of radiation should be aware of contamination risks and procedures.

The identification of the nuclear substance should be performed using an instrument or meter that has the capability to analyze the emitted radiation and identify the corresponding nuclear substance. The best device for this task is a portable gamma spectrometer, which provides key information on the type of ionizing radiation present and whether the nuclear substance originates from a medical or industrial application.

*A portable gamma-ray spectrometer*



In some cases, radioactive items can be identified based on their known shape, size, labels and markings. You can recognize radioactive material by the trefoil sign, which is the international symbol of ionizing radiation.

*A trefoil symbol*



In other situations, items can be identified as a result of acquired knowledge and experience. Identification is critical, in order to undertake the appropriate radiological response.

When an alarm is triggered, response personnel should be able to ascertain if the alarm was caused by a legitimate radioactive source, a naturally occurring nuclear substance, or an industrial or medical isotope. This information could facilitate the remedial actions that could be taken.

In all situations, any retrieved radioactive material should be properly identified, contained and isolated in a secure location, while determining disposal options.

## **Additional Considerations**

### **1) Radioactive contamination**

Contamination of personnel and the environment may result from improper handling of radioactive material. Contamination hazards are dependent on the form of the radioactive material (which may appear as a solid, liquid, powder, sludge, sand, instrument part, dial or a damaged radiation device). Proper protective equipment and clothing (readily available containers, gloves, disposable coveralls, etc.) should be available to all personnel involved in the retrieval process. Precautions should always be taken when attempting to segregate the load, to find the source, or when handling the radioactive material.

While undertaking steps to retrieve the source of radiation, contamination checks should always be performed using the proper methods and techniques. If contamination is detected, steps should be taken to contain the material. Personnel involved in handling the radioactive material should be checked for the presence of contamination. If workers are contaminated, proper decontamination procedures must be followed.

*If the source is not properly sealed, or if the sealed source is leaking, the personnel handling the source may become contaminated, and the contamination may be spread to the environment. Contamination may occur when radioactive material, in the form of dust, powder, or liquid, comes into contact with a person's skin, hair, or clothing. A person is internally contaminated if radioactive material is breathed in, swallowed, or absorbed through wounds. People who are externally contaminated with radioactive material can contaminate other people or surfaces that they touch. Surfaces and workers who are contaminated must be properly decontaminated, to minimize radiation doses to themselves and others.*

*Radiation safety experts can help in training personnel on how to decontaminate themselves, an area, or equipment.*

## 2) Transport

If transportation to another location is required, consideration must be given to properly package the radioactive material. For further information on packaging and transport requirements, please see the *Packaging and Transport of Nuclear Substances Regulations* at: [laws-lois.justice.gc.ca/eng/regulations/SOR-2000-208/index.html](http://laws-lois.justice.gc.ca/eng/regulations/SOR-2000-208/index.html) and the *Transportation of Dangerous Goods Regulations* at [tc.gc.ca/eng/tdg/clear-tofc-211.htm](http://tc.gc.ca/eng/tdg/clear-tofc-211.htm). You may also contact the CNSC at 1-888-229-2672 or [transport@cnsccsn.gc.ca](mailto:transport@cnsccsn.gc.ca).

The following materials and articles may be transported to an appropriate waste management facility, as they are not subject to the classification, packaging, and transport requirements of the regulations:

- a typical household smoke detector
- a material exempt from CNSC regulations
- naturally occurring nuclear substances less than 70 kBq/kg
- any of the medical nuclear substances Cr-51, In-111, I-131, Ga-67, Tc-99m or Tl-201

# REPORT

The CNSC should be notified if any of the following situations arise:

- an orphan source is found
- a radiation device is found (industrial devices such as level gauges, portable gauges, fixed gauges, etc.)
- a device containing a radium luminous compound is found
- the radiation field exceeds 25  $\mu\text{Sv/h}$
- loose contamination is detected
- the source of radiation is not identified

**The CNSC can be contacted at 1-888-229-2672, or through the CNSC Duty Officer at 613-995-0479, for further instructions.**

The information in this brochure is provided for reference only. *The Nuclear Safety and Control Act* and its associated regulations, and any other applicable regulations, should be consulted for official purposes.

For more information, please visit our Web site at [nuclearsafety.gc.ca](http://nuclearsafety.gc.ca) or contact us at: [info@cnscccsn.gc.ca](mailto:info@cnscccsn.gc.ca)









INFO-0814