Canada's Nuclear Regulator

HazMat Team Emergency Response Manual for Class 7 Transport Emergencies

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HazMat Team Emergency Response Manual for Class 7 Transport Emergencies

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1.0 Introduction

1.1 Purpose

This manual aims to:

- provide basic information to hazardous materials (HazMat) responders so they can react expediently and effectively to transport accidents involving radioactive materials.
- help HazMat responders assess an accident's severity, so they can make informed decisions on safe cordons and avoid unnecessary closures or evacuations of highways, airports or buildings.
- act as a general guide for the most common types of calls from HazMat teams to the Canadian Nuclear Safety Commission Duty Officer.

1.2 Scope

This manual:

- addresses emergency response guidelines with respect to shipments that contain goods listed under "Class 7, Radioactive Materials" in the *Transportation of Dangerous Goods Regulations.*
- does not deal with shipments that require an Emergency Response Assistance Plan under the *Transportation of Dangerous Goods Regulations*.
- is not intended as a sole method of training for HazMat teams and should be used in conjunction with the *Emergency Response Guidebook*.
- is meant as an information document only and is not a regulatory document.

1.3 About this document

- Terms appearing in **bolded red text** upon first reference within a section are also listed in the glossary at the back of the manual.
- For quick reference, Appendix A contains a table listing gamma dose rates for common radioisotopes, representative activities and appropriate **hot** and **cold zone** distances.
- Included with this manual are five resource documents :
  - "The Basics of Ionizing Radiation"
  - "Working in a Radiation Environment"
  - "Incident Control and Decontamination"
  - "Radiation Incident Mass Casualty Decontamination"
  - "Radiation Incident – Mass Casualty Radiation Injury Triage"

- This manual provides a general procedure for responding to transport emergencies that involve **Class 7 Dangerous Goods**, as well as incident-specific procedures for emergencies to do with portable gauges, technetium generators, unit doses of technetium and exposure devices.

2.0 Class 7 Dangerous Goods

This section:

- introduces the regulations that apply to the transport of **Class 7 Dangerous Goods** in Canada, and the characteristics and safe handling of these substances
- addresses ways of identifying radioactive materials
- presents types of radioactive packages
- outlines a general procedure for responding to transport emergencies that involve Class 7 Dangerous Goods
- explains the **Transport Index** and its importance to HazMat responders

2.1 Transporting and handling Class 7 Dangerous Goods

All radioactive materials emit ionizing radiation, which can cause harm by damaging cellular structure or tissue. Due to the hazards of ionizing radiation, any radioactive shipment must be packaged according to federal regulations to reduce associated risks in case of accident or emergency.

Two sets of regulations apply to the transport of radioactive materials in Canada:

- the *Packaging and Transport of Nuclear Substances Regulations*, enforced by the Canadian Nuclear Safety Commission
- the *Transportation of Dangerous Goods Regulations*, enforced by Transport Canada

The *Transportation of Dangerous Goods Regulations* lists “Substances defined as Class 7, Radioactive Materials in the Packaging and Tranport of Nuclear Substances (PTNS) Regulations”. Therefore, Transport Canada’s definition of *radioactive material* is any nuclear substance with an activity above its exemption quantity as defined in the CNSC’s PTNS Regulations. This manual will refer interchangeably to these substances as ***Class 7 Dangerous Goods*** and radioactive materials.

In the event of a transport emergency involving radioactive materials, the consignor of the dangerous goods is ultimately responsible for responding. HazMat personnel should only perform recovery operations for Class 7 Dangerous Goods if the incident commander deems it necessary.

HazMat teams who respond to an emergency involving Class 7 Dangerous Goods must consider the following guidelines:

- The three principles of radiation protection—time, distance and shielding, which are discussed below—must be applied.
- The response should be based upon the ALARA (as low as reasonably achievable) principle.
- Recovery action should be planned carefully and well in advance.

Principles of radiation protection

When working with radioactive materials, HazMat responders can minimize personal risk by taking three elements into account:

- ***Time:*** The shorter the time spent near a radioactive source, the lower the radiation dose.
- ***Distance:*** As one moves away from (or approaches) a radioactive source, the dose rate decreases (or increases) significantly.
- ***Shielding:*** Dense objects near a radioactive source can provide protection from radiation exposure.

2.2 Recommended response to transport emergencies involving radioactive materials

The following steps outline the Canadian Nuclear Safety Commission's recommended response to a transport emergency that involves **Class 7 Dangerous Goods**. Other sections of this manual outline more specific procedures for emergencies involving portable gauges, technetium generators, unit doses of technetium and exposure devices.

In case of any transport emergency involving radioactive material, contact the Canadian Nuclear Safety Commission Duty Officer at 613-995-0479, where calls are answered 24 hours a day, 7 days a week.

Step 1

- **Call the Canadian Nuclear Safety Commission Duty Officer at 613-995-0479.**

Step 2

- Secure the scene by cordoning off an appropriate area.
- Use a contamination survey meter* and a calibrated gamma dose rate meter*, both of which measure ionizing radiation, to establish a **cold zone** — an area where radiation measurements are at natural **background levels**. Background levels of radiation are typically measured at:
    - average of 50 counts per minute (cpm) on the ground, with a standard 15 cm^2 contamination survey meter (readings can vary from 0 to 100 cpm)
    or
    - average of 0.25 microSieverts per hour (µSv/h) in air, with a gamma dose rate meter (readings can vary from 0 to 0.3 µSv/h)
- Keep the general public and non-essential personnel in the cold zone.

- Different types of detectors may yield different background readings; it is important to know what natural background levels are on the instrument being used.

  *For information about these instruments, refer to the document “Working in a Radiation Environment” that is included with this manual (see Section 7.2). If you do not have these instruments, you will need to respond according to the *Emergency Response Guidebook* and the advice from the Canadian Nuclear Safety Commission’s Duty Officer.

Step 3

- Establish a **clean/dirty line**.

Step 4

- Determine if anyone at the scene has handled a radioactive package. If so, examine the person(s) for possible contamination.

Step 5

- Obtain the **shipping document** (see Section 2.3.3) if available. Call the **24-hour number** on the document and report the situation if this has not yet been done.

Step 6

- Perform a pre-operational equipment check of your contamination survey meter, calibrated gamma dose rate meter and dosimeter. Upon completing this check, be sure to put on gloves and to wear your dosimeter.

If you do not have a personal dosimeter, proceed only when you obtain one or respond according to the Emergency Response Guidebook and the advice of the Canadian Nuclear Safety Commission Duty Officer.

- Reset the dosimeter to zero or take note of the starting value on the dosimeter.
- Determine your **turn-back dose rate** — the maximum dose rate you will tolerate before backing off and reassessing the scene: 1 mSv/h is recommended.
- Determine the maximum total radiation dose you will tolerate before ceasing work: 500 µSv is recommended.
- Perform a **RECCE** — your first approach to the package or reconnaissance — while visually gathering as much information as possible about the package and the incident scene.
- Use the contamination survey meter and gamma dose rate meter to determine the **hot zone**. Post the hot zone at whichever of the following measurements you reach first:

- 5-10x background on the ground with a contamination meter (~500 cpm with a 15 cm^2 detector)
  or
- 5-10 µSv/h with a gamma dose rate meter

- If the hot zone is in the package's immediate vicinity, post the hot zone at a radius of 2 m around the package, and move the cold zone in accordingly.

Step 7

- Look for the package's **category label** (see Section 2.3.2). If the package has no category label or if it is too damaged to read, look for the shipping document (see Section 2.3.3) that should be within reach of the driver's seat of the vehicle that was carrying the package.
- Read the package's category label or shipping document, which should allow you to determine the following information:

  - the radioisotope inside the package (see Table 1 in Appendix A for gamma dose rates for common radioisotopes)
  - the maximum radiation level at any point on the package's external surface (see Section 2.3.1)
  - the package's **Transport Index** (see Section 2.5)

Step 8

Assess the damage to the package:

- If you can get close enough to it, use gloves and long-handled tools to wipe the package in order to verify if the radioactive contents have been released.

- Measure the count rate on the wipe with a contamination survey meter. A consistent reading of ≥ 2x background measured in the cold zone is considered contaminated.

If the wipe is contaminated (measures ≥ 2x background on a contamination survey meter) or if you observe a high radiation reading*:

> *A radiation reading on a gamma dose rate meter is considered high at a level of:
> - over 2 mSv/h, on contact with the package or device
>
> **or**
>
> - over 100 µSv/h, at 1 m away from the package or device

- Maintain the hot and cold zones as established.

- Immediately call the Canadian Nuclear Safety Commission Duty Officer to provide an update of the situation. This is imperative, as special precautions, packaging and permission may be necessary to transport the damaged

package. The Duty Officer will advise you what to do with the package or have a Canadian Nuclear Safety Commission Duty Liaison Officer contact you with further instructions.

- Do not attempt to move the package unless the Canadian Nuclear Safety Commission Duty Officer or a Liaison Officer instructs you to do so.

If the wipe is negative and the package appears undamaged:

- Recover the package and end the emergency.

2.3 Identifying Class 7 Dangerous Goods

When responding to a transport emergency involving **Class 7 Dangerous Goods**, it is critical to determine the shipment contents. These can be identified by **category labels**, placards and **shipping documents**.

2.3.1 Category labels

Under the *Transportation of Dangerous Goods Regulations*, packages containing radioactive materials (other than excepted packages; see Section 2.4.1) must be marked with one of three **category labels**.

Category labels:

- are classified as Category I-White, Category II-Yellow and Category III-Yellow, in order of ascending risk
- indicate package contents and activity
- are based on the dose rate (normally the gamma dose rate) emitted from the package (see Table 1 in Appendix A)
- classified as II-Yellow or III-Yellow indicate a package's **Transport Index** (see Section 2.5)

Note: Under the *Transportation of Dangerous Goods Regulations*, a package that requires a category label must also be marked with the contents' **UN number** and proper shipping name.

The following chart summarizes the specifications for category labels:

Label type	Maximum radiation level at any point on on the package's external surface	Transport Index
Category I-White 	Not more than 5 µSv/h	N/A
Category II-Yellow 	More than 5 µSv/h but not more than 500 µSv/h	More than 0 but not more than 1 If the measured Transport Index is smaller than or equal to 0.05, the value quoted may be 0

Label type	Maximum radiation level at any point on on the package's external surface	Transport Index
Category III-Yellow 	More than 500 µSv/h but not more than 2000 µSv/h (2 mSv/h)	More than 1 but not more than 10

2.3.2 Placards

A Class 7 placard, as shown in Figure 1, indicates that a vehicle is carrying a shipment of radioactive goods. The word *RADIOACTIVE* may or may not appear on the placard.

Figure 1. Class 7 placard

The *Transportation of Dangerous Goods Regulations* require a Class 7 placard to be posted on all four sides of a vehicle under any of the following conditions:

- a quantity or concentration of radioactive material being shipped requires an Emergency Response Assistance Plan under the *Transportation of Dangerous Goods Regulations*
- it is carrying a package that requires a Category III-Yellow label
- the radioactive material is a liquid or a gas in direct contact with the package and is also defined as "a large means of containment" by the *Transportation of Dangerous Goods Regulations*
- the dangerous goods have a total gross mass of greater than 500 kg

Additionally, a vehicle carrying an exposure device is typically required to display Class 7 placards.

Important: Not all vehicles that carry radioactive materials require placards. Always use a gamma dose rate meter (if available) when approaching a vehicle suspected to contain radioactive material.

2.3.3 Shipping documents

Any vehicle transporting dangerous goods must also carry a mandatory **shipping document** within reach of the driver's seat. A shipping document, a sample of which appears in Figure 2, includes the following information:

- **a 24-hour number** for a contact person who can be reached 24 hours a day in case of emergency
- **the proper shipping name** of the radioactive material(s) and the applicable **UN number**(s);
- **the class of dangerous goods** contained in the shipment (**Class 7** in the case of radioactive materials)
- the **number and type(s) of package(s)** contained in the shipment
- **a summary that lists the information on the category label of each package in the shipment:** label type (I-White, II-Yellow or III-Yellow), radioisotope type and maximum activity. (This information allows a reader to identify the radiation fields being emitted from the package(s) contained in the shipment.)
- the **form**[a] of the radioactive material in the shipment
- if the shipment was classified as an **exclusive use shipment**[b] (this would normally be indicated in the shipping document's top right-hand corner or in the "Additional Handling Information" section)

Notes:

[a]Forms of radioactive material:

A shipping document may indicate goods to be **special form radioactive material**. This information would be included as part of the material's proper shipping name or listed as a special form certificate number on the document.

Special form radioactive material refers to:

- an indispersible solid radioactive material
  or
- a sealed capsule containing radioactive material. Such a capsule must meet specific criteria to ensure it will not break open and its design must be approved by the competent authority (which, in Canada, is the Canadian Nuclear Safety Commission)

If the shipping document indicates that a shipment contains special form radioactive material, the possibility of contamination is reduced to near zero. However, safety practices protecting against contamination must still be followed. If a package is intact and will be handled, perform a wipe to ensure no contamination is present.

Contents that **are not** special form radioactive material will be listed as solid, liquid or gas on a shipping document. (In such a case, the potential for loose contamination exists. Responders should use radiation detection instruments to examine the scene of an accident for potentially radioactive material and cover any detected material with a tarp.)

[b]Exclusive use shipments:

The *Packaging and Transport of Nuclear Substances Regulations* define an exclusive use shipment as one whose "sole use, by a single consignor, of a conveyance (shipment) or a large freight container, in respect of which all initial, intermediate and final loading and unloading is carried out in accordance with the directions of the consignor or consignee." This signifies that the shipment would be under the sole direction and supervision of its consignor, *and that no other party would handle the goods at any time*, during its transport.

Figure 2. Sample shipping document for Class 7 Dangerous Goods

DANGEROUS GOODS SHIPPING DOCUMENT

Consignor:			**EXCLUSIVE USE SHIPMENT**		
Carrier:			**Consignee:**		
Shipping Date:			**24-Hour Number:**		
NATURE AND QUANTITY OF DANGEROUS GOODS					
Proper Shipping Name	**Class**	**UN Number**	**Isotope Max. Activity**	**Labels**	**No. of Packages Dimensions or Mass**
Additional Handling Information:					
Special instructions:					
Special Form Certificate Number:			**Name/Title of Consignor:**		

CONSIGNOR'S DECLARATION

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in all respects in proper condition for transport by road according to the applicable national governmental regulations.

SIGNATURE : **DATE :**

2.4 Types of radioactive packages

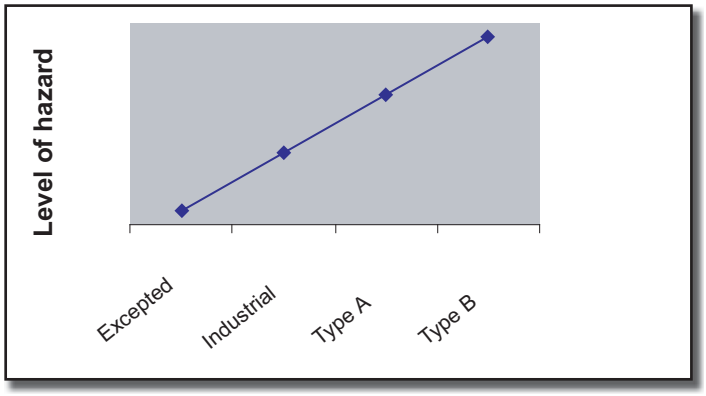
The *Packaging and Transport of Nuclear Substances Regulations* established by the Canadian Nuclear Safety Commission specify packaging and shipping requirements for radioactive materials.

Depending upon its contents and the potential hazard in case of emergency, a package containing dangerous goods must be shipped as one of the following types:

- excepted
- industrial
- Type A
- Type B
- packages containing fissile material

Figure 3 shows the increasing levels of hazard associated with the radioactive material placed inside specific package types, from least hazardous (excepted package) to most hazardous (Type B Package).

Figure 3. Hazard levels associated with radioactive package contents



Note: This guide covers only excepted, industrial, Type A and Type B packages, which are outlined in sections 2.41–2.44. Packages containing fissile material or uranium hexafluoride are subject to additional requirements, such as an approved Emergency Response Assistance Plan as specified in the *Transportation of Dangerous Goods Regulations*. Due to the uniqueness of these packages and the low probability of encountering them, this manual does not address them. However, response procedures similar to those of other package types would apply to a transport emergency that involved a package containing fissile material.

2.4.1 Excepted packages

An excepted package:

- is the easiest type of radioactive package to assemble, but must still meet general packaging criteria specified in the *Packaging and Transport of Nuclear Substances Regulations*
- radiation levels on any external surface of the package cannot exceed **5 µSv/h**
- contains only minor amounts of radioactive materials and has the fewest restrictions of any radioactive package type
- will not have a **category label**, because the activity of the contents is sufficiently low to be exempt from labeling
- does not require **a shipping document**, but rather a document stating the proper shipping name and **UN number** of the materials inside
- must be marked with the contents' UN number and the consignor and/or the consignee on its side
- is unlikely to cause an emergency requiring special protective actions, if it is damaged in transit
- is unlikely to cause ground contamination in the event of a transport emergency, although such a case would require decontamination

The UN numbers and proper shipping names that apply to excepted packages are as follows:

UN number	Proper shipping name
UN2908	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – EMPTY PACKAGING
UN2909	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – ARTICLES MANUFACTURED FROM NATURAL URANIUM or DEPLETED URANIUM or NATURAL THORIUM
UN2910	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – LIMITED QUANTITY OF MATERIAL
UN2911	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – INSTRUMENTS or ARTICLES

2.4.2 Industrial packages

An industrial package:

- may carry larger quantities of radioactive material than an excepted package, but still poses minimal health risks
- is more likely than an excepted package to cause ground contamination during a transport emergency, which may require decontamination and clean up
- may only contain qualified **low specific activity (LSA) materials** or a qualified **surface contaminated object (SCO)** as defined by the *Packaging and Transport of Nuclear Substances Regulations*

There are three types of industrial packages, which are graded based on the hazard posed by their contents:

Type 1 (IP-1)

- identical to an excepted package but is labeled with appropriate safety marks
- meets general package criteria and is normally used to carry **LSA-I** or **LSA-II** materials as defined by the *Packaging and Transport of Nuclear Substances Regulations*
- must meet temperature and pressure requirements beyond those imposed on excepted packages

Type 2 (IP-2)

- must meet all requirements for a Type 1 industrial package
- must also pass a free drop test and a stacking test

Type 3 (IP-3)

- must meet all requirements for a Type 2 industrial package
- must also pass water spray and penetration tests

Industrial packages carry contents with the following **UN numbers** and proper shipping names:

UN number	Proper shipping name
UN2912	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I)
UN2913	RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-I or SCO-II)
UN3321	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-II)
UN3322	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-III)

2.4.3 Type A packages

A Type A package:

- is the most commonly encountered type of package used to transport radioactive materials
- must be clearly marked *Type A*
- only carries materials with radioactivity limits as defined in the *Packaging and Transport of Nuclear Substances Regulations* and therefore poses a low radiological hazard. However, decontamination would be required if an emergency involving a Type A package caused ground contamination
- must meet general package requirements of the *Packaging and Transport of Nuclear Substances Regulations* and also undergo a water spray test, a free drop test, a stacking test and a penetration test
- will have external dimensions of at least 10 cm

A Type A package will be labeled with one of the following **UN numbers** and proper shipping names, with the appropriate **category label**:

UN number	Proper shipping name
UN2915	RADIOACTIVE MATERIAL, TYPE A PACKAGE
UN3332	RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM

2.4.4 Type B packages

A Type B package:

- carries **Class 7 Dangerous Goods** that have too much activity to be shipped in a Type A package
- contains material that can pose serious or immediate health risks
- will have the marking *Type B(U)** or *Type B(M)**
- has a maximum allowable on-contact dose rate of 2 mSv/h, unless special circumstances permit otherwise
- most commonly contains industrial radiography sources, which can carry up to 5180 GBq (140 Curies) of Cobalt-60 (Co-60) or Iridium-192 (Ir-192)
- must have its design approved by the competent authority (Canadian Nuclear Safety Commission)
- will be a issued design certificate, and must meet all, certificate conditions. (The certificate must accompany the package during its transport)

***Notes:**

Type B(U) package:

A package marked *Type B(U)* is subject to unilateral approval; that is, the package must receive approval from the competent authority in *each country* where it is sent. For example, a Type B(U) package that was certified in the United States would still require certification in Canada.

Important: If a *Type B(U)* package contains **special form radioactive material**, this information would not be found under the proper shipping name column in the **shipping document**, but elsewhere on the page (for example, in the section for special instructions).

Type B(M) package:

A package marked *Type B(M)* is subject to multilateral approval; that is, the approval given to the package in one country of competent authority validates the package *for all other destination countries*. For example, a package given a Type B(M) approval in the United States would be exempted from approval in Canada.

The **UN numbers** and proper shipping names that apply to Type B packages are as follows:

UN number	Proper shipping name
UN2916	RADIOACTIVE MATERIAL, TYPE B(U) PACKAGE
UN2917	RADIOACTIVE MATERIAL, TYPE B(M) PACKAGE

The most common Type B packages transported in Canada are industrial radiography cameras, which are also known as exposure devices. Several examples of exposure devices are shown in Figures 26–37 in Section 6.0.

Note: Under the *Packaging and Transport of Nuclear Substances Regulations*, a package carrying an exposure device does not always require a **category label**. However, such a package requires a special warning label (see Fig. 31 in Section 6.2 for an example), and the vehicle carrying it must be labeled with four Class 7 placards.

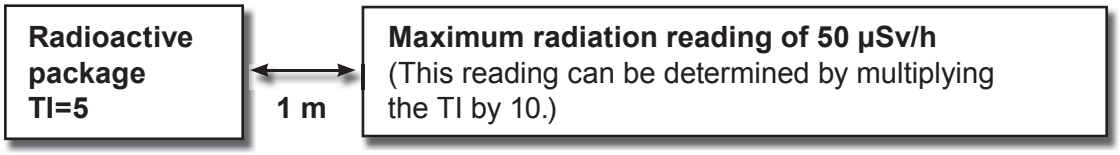
2.5 Understanding the Transport Index

The **Transport Index** (TI), which provides an indication of a package's radiation levels, can be used to control exposure to radiation. It is calculated as follows:

$$TI = \frac{\text{Maximum radiation level, in } \mu Sv/h, \text{ at 1 m from the package}}{10}$$

Note: When dealing with a radioactive package, multiply the TI on the label by 10 to quickly determine the maximum radiation level at 1 m from the package.

Sample TI calculation: If the TI on the package's label was 5, the maximum radiation reading would be 50 µSv/h at 1 m from a package. A TI of 10 is the highest that would be encountered and should be considered the worst case scenario.



3.0 Portable Nuclear Gauges

This section presents:

- a specific procedure for responding to transport emergencies that involve portable nuclear gauges
- a sample **shipping document** for a portable nuclear gauge
- pictures of the most common types of portable nuclear gauges

3.1 Recommended response to transport emergencies involving portable nuclear gauges

Step 1

- **Call the Canadian Nuclear Safety Commission Duty Officer at 613-995-0479.**

Step 2

- Verify any perimeter that may have been set up by users of the gauge or by first responders.
- Ensure that the **cold zone** is at **background levels** of radiation.

  Note: Background levels of radiation are normally measured at:
  - 50 cpm on the ground, with a contamination survey meter
    or
  - 0.25 µSv/h in air, with a gamma dose rate meter

- Keep the general public and non-essential personnel in the cold zone.

Step 3

- Establish a **clean/dirty line**.

Step 4

- Determine if anyone has handled the gauge. If so, examine the person(s) for possible contamination.

Step 5

- Obtain the **shipping document** (see Section 2.3.3.). Call the **24-hour number** on the document and report the situation if this has not yet been done.

Step 6

- Perform a pre-operational equipment check of your contamination survey meter, calibrated gamma dose rate meter and dosimeter. Upon completing this check, be sure to put on gloves and to wear your dosimeter.

If you do not have a personal dosimeter, proceed only when you obtain one or respond according to the Emergency Response Guidebook and the advice of the Canadian Nuclear Safety Commission Duty Officer.

- Reset the dosimeter to zero or take note of the starting value on the dosimeter.
- Determine your **turn-back dose rate** — the maximum dose rate you will tolerate before backing off and reassessing the scene: 1 mSv/h is recommended.
- Determine the maximum total radiation dose you will tolerate before ceasing work: 500 µSv is recommended.
- Perform a **RECCE** and establish or verify the **hot zone** around the gauge.

  Note: The hot zone should be posted at whichever of the following measurements is reached first:
  - 5-10x background on the ground with a contamination meter (~500 cpm with a 15 cm^2 detector)
    or
  - 5-10 µSv/h with a gamma dose rate meter

Step 7

- Read the shipping document or the package's **category label** (see Section 2.3.2), which should allow you to determine the following information:
  - the radioisotope inside the package

    Note: The radioisotope(s) will be **special form radioactive material**, and either one of or both of the following: Cesium-137 gamma (Cs-137 gamma) or Americium-241/Be neutron (Am-241/Be neutron). See Table 1 in Appendix A for gamma dose rates of these radiosotopes.
  - the maximum radiation level at any point on the package's external surface (see Section 2.3.1)
  - the package's **Transport Index** (see Section 3.5)

Step 8

Assess the damage to the package:

- If you can get close enough to it, use gloves and long-handled tools to wipe the package in order to verify if the radioactive contents have been released.

- Measure the count rate on the wipe with a contamination survey meter. A reading of ≥ 2x background is considered contaminated.

If the wipe is contaminated (measures ≥ 2x background on a contamination survey meter) or if you observe a high radiation reading*:

> *A radiation reading on a gamma dose rate meter is considered high at a level of:
> - over 2 mSv/h, on contact with the package or device
>
> **or**
>
> - over 100 µSv/h, at 1 m away from the package or device

- Maintain the hot and cold zones as established.

- Immediately call the Canadian Nuclear Safety Commission Duty Officer to provide an update of the situation. This is imperative, as special precautions, packaging and permission may be necessary to transport the damaged package. The Duty Officer will advise you what to do with the package or have a Canadian Nuclear Safety Commission Liaison Officer contact you with further instructions.

- Do not attempt to move the package unless the Canadian Nuclear Safety Commission Duty Officer or a Liaison Officer instructs you to do so.

If the wipe is negative and the package appears damaged, refer to the following chart for appropriate action:

If you can retract the source	• Retract the source to the fully shielded position. Close the shutter on the bottom of the gauge if possible and place the gauge back in the Type A container.
If you can retract the source, but you cannot close the gauge's shutter ***OR*** ***If the source is severed or cannot be retracted***	• Use a 45-gallon steel drum with a secure lid as a temporary container for the source, with sand and/or gravel as shielding material. • Before placing the damaged gauge in the drum, partially fill the drum with shielding material. • After placing the damaged gauge in the drum, add additional sand or gravel to secure and shield the contents of the drum. • Use a calibrated radiation survey meter to ensure safe radiation levels.

If the wipe is negative and the package appears undamaged:

• Recover the package and end the emergency.

Figure 4 provides an example of a shipping document for a portable nuclear gauge. (Note: This is for illustrative purposes only and is not a legally acceptable shipping document.)

Figure 4. Shipping document for a portable nuclear gauge

DANGEROUS GOODS SHIPPING DOCUMENT

Consignor:			**EXCLUSIVE USE SHIPMENT**		
Carrier:			**Consignee:**		
Shipping Date:			**24-Hour Number:**		
NATURE AND QUANTITY OF DANGEROUS GOODS					
Proper Shipping Name	**Class**	**UN Number**	**Isotope Max. Activity**	**Labels**	**No. of Packages Dimensions or Mass**
RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM	7	UN3332	Cs-137 296 MBq (8 mCi) Am-241/Be 1480 MBq (40 mCi)	II-Yellow TI 0.4	1 package 35 kg
Additional Handling Information: None **Location of Package(s) in Vehicle: Rear of vehicle, passenger side.**					
Special Instructions: None					
Special Form Certificate Number: GB/140/S-85 USA/0632/S			**Name/Title of Consignor:**		
CONSIGNOR'S DECLARATION I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in all respects in proper condition for transport by road according to the applicable national governmental regulations. **SIGNATURE :** **DATE :**					

3.2 Pictures of portable nuclear gauges

Figure 5. Type A package that contains a Troxler series portable nuclear gauge.

Figure 6. Inside view of the package in Figure 5.

Figure 7. Troxler series portable nuclear gauge with source rod in fully shielded position.

Figure 8. Troxler series portable nuclear gauge with source rod extended

Figure 9. Humboldt series nuclear gauge with source rod gauge with source rod in the fully shielded position.

Figure 10. Campbell Pacific Nuclear series portable nuclear gauge in shipping container with a Category-II Yellow label.

Figure 11. Side view of the package in Figure 10, with portable nuclear gauge on top. The gauge's source rod is in the fully shielded position.

4.0 Technetium Generators

This section presents:

- a specific eight-step procedure for responding to transport emergencies that involve technetium generators
- a sample **shipping document** for a technetium generator
- pictures of technetium generators

4.1 Recommended response to transport emergencies involving technetium generators

Step 1

Call the Canadian Nuclear Safety Commission Duty Officer at 613-995-0479.

Step 2

- Verify any perimeter set up by first responders. Ensure that the **cold zone** is at **background levels**.

  Note: Background levels of radiation are normally measured at:
  - 50 cpm on the ground, with a contamination survey meter
  or
  - 0.25 µsv/h in air, with a gamma dose rate meter

- Keep the general public and non-essential personnel in the cold zone.

Step 3

- Establish a **clean/dirty line**.

Step 4

- Determine if anyone has handled the package. If so, examine the person(s) for possible contamination.

Step 5

- Obtain the **shipping document** (see Section 2.3.3). Call the **24-hour number** on the document and report the situation if this has not yet been done.

Step 6

- Perform a pre-operational equipment check of your contamination survey meter, calibrated gamma dose rate meter and dosimeter. Upon completing this check, be sure to put on gloves and to wear your dosimeter.

If you do not have a personal dosimeter, proceed only when you obtain one or respond according to the Emergency Response Guidebook and the advice of the Canadian Nuclear Safety Commission Duty Officer.

- Reset the dosimeter to zero or take note of the starting value on the dosimeter.
- Determine your **turn-back dose rate** — the maximum dose rate you will tolerate before backing off and reassessing the scene: 1 mSv/h is recommended.
- Determine the maximum total radiation dose you will tolerate before ceasing work: 500 µSv is recommended.
- Perform a **RECCE** and establish or verify the **hot zone** around the device.

  Note: The hot zone should be posted at whichever of the following measurements is reached first:

  - 5-10x background on the ground with a contamination meter (~500 cpm with a 15 cm^2 detector)
    or
  - 5-10 µSv/h with a gamma dose rate meter

Step 7

- Read the shipping document or the package's **category label** (see Section 2.3.2), which should allow you to determine the following information:
  - the radioisotope(s) inside the package
    Note: The radioisotope will be Mo-99 and it will be solid, **not special form**. Any liquid present will not be from the source. (Refer to Table 1 in Appendix A to determine the gamma dose rate.)
  - the maximum radiation level at any point on the package's external surface (see Section 2.3.1)
  - the package's **Transport Index** (see Section 3.5)

Step 8

Assess the damage to the package:

- If you can get close enough to it, use gloves and long-handled tools to wipe the package in order to verify if the radioactive contents have been released.
- Measure the count rate on the wipe with a contamination survey meter. A reading of ≥ 2x background is considered contaminated.

If the wipe is contaminated (measures ≥ 2x background on a contamination survey meter) or if you observe a high radiation reading*:

> *A radiation reading on a gamma dose rate meter is considered high at a level of:
> - over 2 mSv/h, on contact with the package or device
>
> **or**
>
> - over 100 µSv/h, at 1 m away from the package or device

- Maintain the hot and cold zones as established.

- Immediately call the Canadian Nuclear Safety Commission Duty Officer to provide an update of the situation. This is imperative, as special precautions, packaging and permission may be necessary to transport the damaged package. The Duty Officer will advise you what to do with the package or have a Canadian Nuclear Safety Commission Liaison Officer contact you with further instructions.

- Do not attempt to move the package unless the Canadian Nuclear Safety Commission Duty Officer or a Liaison Officer instructs you to do so.

If the wipe is negative and the package appears undamaged:

- Recover the package and end the emergency.

Figure 12 provides an example of a shipping document for a technetium generator. (Note: This is for illustrative purposes only and is not a legally acceptable shipping document.)

Figure 12. Shipping document for a technetium generator

DANGEROUS GOODS SHIPPING DOCUMENT

Consignor:	**EXCLUSIVE USE SHIPMENT**
Carrier:	**Consignee:**
Shipping Date:	**24-Hour Number:**

NATURE AND QUANTITY OF DANGEROUS GOODS

Proper Shipping Name	**Class**	**UN Number**	**Isotope Max. Activity**	**Labels**	**No. of Packages Dimensions or Mass**
RADIOACTIVE MATERIAL, TYPE A PACKAGE	7	UN2915	Mo-99 555 GBq (15 Ci) (Solid Form)	III-Yellow TI 4.2	1 package 28 kg

Additional Handling Information Placards: 4 x Class 7

Location of Package(s) in Vehicle: Rear of vehicle, passenger side.

Special Instructions: None

Special Form Certificate Number: N/A	**Name/Title of Consignor:**

CONSIGNOR'S DECLARATION

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in all respects in proper condition for transport by road according to the applicable national governmental regulations.

SIGNATURE : **DATE :**

4.2 Pictures of technetium generators

Figure 13. Box containing a technetium (Tc-99m) generator.

Figure 14. Tc-99m generator as seen after removing styrofoam shown in Figure 13 (note height of about 25 cm).

Figure 15. Top view of Tc-99m generator in Figure 14. Note: The holes would contain sharp needles to accommodate vials.

Figure 16. Decayed Molybdenum-99 (Mo-99) source. All packaging is designed to protect this source.

5.0 Unit Doses of Technetium

This section presents:

- a specific procedure for responding to transport emergencies that involve unit doses of technetium
- a sample **shipping document** for unit doses of technetium
- pictures of unit doses of technetium

5.1 Recommended response to transportation emergencies involving unit doses of technetium

Step 1

- **Call the Canadian Nuclear Safety Commission Duty Officer at 613-995-0479.**

Step 2

- Verify any perimeter set up by first responders. Ensure that the **cold zone** is at **background levels** of radiation.

  Note: Background levels of radiation are normally measured at:
  - 50 cpm on the ground, with a contamination survey meter
    or
  - 0.25 µsv/h in air, with a gamma dose rate meter

- Keep the general public and non-essential personnel in the cold zone.

Step 3

- Establish a **clean/dirty line**.

Step 4

- Determine if anyone has handled the package. If so, examine the person(s) for possible contamination.

Step 5

- Obtain the **shipping document**. Call the **24-hour number** on document and report the situation if this has not yet been done.

Step 6

- Perform a pre-operational equipment check of your contamination survey meter, calibrated gamma dose rate meter and dosimeter. Upon completing this check, be sure to put on gloves and to wear your dosimeter.

If you do not have a personal dosimeter, proceed only when you obtain one or respond according to the Emergency Response Guidebook and the advice of the Canadian Nuclear Safety Commission Duty Officer.

- Reset the dosimeter to zero or take note of the starting value on the dosimeter.
- Determine your **turn-back dose rate** — the maximum dose rate you will tolerate before backing off and reassessing the scene: 1 mSv/h is recommended.
- Determine the maximum total radiation dose you will tolerate before ceasing work: 500 µSv is recommended.
- Perform a **RECCE** and establish or verify the **hot zone** around the package.

  Note: The hot zone should be posted at whichever of the following measurements is reached first:

  - 5-10x background on the ground with a contamination meter (~500 cpm with a 15 cm^2 detector)
    or
  - 5-10 µSv/h with a gamma dose rate meter

Step 7

- Read the shipping document or the package's **category label**, which should allow you to determine the following information:
  - the radioisotope(s) inside the package

    Note: The radioactive material will most likely be Tc-99m or other isotope (Ga-67, In-111, or I-131) and will be in liquid form (refer to Table 1 in Appendix A to determine the gamma dose rate).

  - the maximum radiation level at any point on the package's external surface (see Section 2.3.1)
  - the package's **Transport Index** (see Section 3.5)

Step 8

Assess the damage to the package:

- If you can get close enough to it, use gloves and long-handled tools to wipe the package in order to verify if the radioactive contents have been released.
- Measure the count rate on the wipe with a contamination survey meter. A reading of ≥ 2x background is considered contaminated.

If the wipe is contaminated (measures ≥ 2x background on a contamination survey meter) or if you observe a high radiation reading*:

> *A radiation reading on a gamma dose rate meter is considered high at a level of:
> - over 2 mSv/h, on contact with the package or device
>
> **or**
> - over 100 µSv/h, at 1 m away from the package or device

- Immediately call the Canadian Nuclear Safety Commission Duty Officer to provide an update of the situation. This is imperative, as special precautions, packaging and permission may be necessary to transport the damaged package. The Duty Officer will advise you what to do with the package or have a Canadian Nuclear Safety Commission Liaison Officer contact you with further instructions.

- Do not attempt to move the package unless the Canadian Nuclear Safety Commission Duty Officer or a Liaison Officer instructs you to do so.

- Clean up the spill.

  Note: The risk of contamination to personnel will be high.

If the wipe is negative and the package appears undamaged:

- Recover the package and end the emergency.

Figure 17 provides an example of a shipping document for a shipment containing unit doses of technetium. (Note: This is for illustrative purposes only and is not a legally acceptable shipping document.)

Figure 17. Shipping document for unit doses of technetium

DANGEROUS GOODS SHIPPING DOCUMENT

Consignor:	**EXCLUSIVE USE SHIPMENT**
Carrier:	**Consignee:**
Shipping Date:	**24-Hour Number:**

NATURE AND QUANTITY OF DANGEROUS GOODS

Proper Shipping Name	Class	UN Number	Isotope Max. Activity	Labels	No. of Packages Dimensions or Mass
RADIOACTIVE MATERIAL, TYPE A PACKAGE	7	UN2915	Tc-99m 4 x 555 MBq (4 x 15 mCi) (Liquid Form)	I-White	1 Type A package 5 kg Note: Package contains 4 units

Additional Handling Information: None

Location of Package(s) in Vehicle: Rear of vehicle, passenger side.

Special Instructions: None

Special Form Certificate Number: n/a	**Name/Title of Consignor:**

CONSIGNOR'S DECLARATION

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in all respects in proper condition for transport by road according to the applicable national governmental regulations.

SIGNATURE: DATE:

5.2 Pictures of unit dose shipments of technetium

Figure 18. Type A package containing unit doses of technetium (Tc-99m).

Figure 19. Interior view of the package in Figure 18.

Figure 20. Unit doses of Tc-99m as could be seen inside the package in Figure 18. The blue packages are lined with lead and carry syringes that typically contain from 1 to 3 mL of radioactive material—most likely Tc-99m in liquid form or Ga-67.

Figure 21. Used unit doses of Tc-99m as could be seen inside the package in Figure 18. The blue packages are lined with lead and carry empty syringes with possible traces of radioactive material in liquid form. Note: The packages have no labels because the unit doses have been used.

Figure 22. Type A package containing vials with Tc-99m.

Figure 23. Inside view of the package in Figure 22. Note: The cylindrical “lead pig” would typically contain a labeled vial with Tc-99m or another radioactive liquid used in nuclear medicine. This vial has no label since its use is for educational purposes. It is filled only with water.

Figure 24. Top view of the container in Figure 23.

6.0 Exposure Devices

This section presents:

- a specific procedure for responding to transport emergencies that involve exposure devices
- a sample **shipping document** for an exposure device
- pictures of various exposure devices

6.1 Recommended response to transport emergencies involving exposure devices

Step 1

- **Call the Canadian Nuclear Safety Commission Duty Officer at 613-995-0479.**

Step 2

- Verify any perimeter set up by the users of the exposure device or first responders. Ensure that the **cold zone** is at **background levels** of radiation.

  Note: Background levels of radiation are normally measured at:

  - 50 cpm on the ground, with a contamination survey meter
    ou
  - 0.25 µsv/h in air, with a gamma dose rate meter

- Keep the general public and non-essential personnel in the cold zone.

Step 3

- Establish a **clean/dirty line**.

Step 4

- Determine if any one has handled the package. If so, examine the person(s) for possible contamination.

Step 5

- Obtain the **shipping document**. Call the **24-hour number** on the document and report the situation if this has not yet been done.

Step 6

- Perform a pre-operational equipment check of your contamination survey meter, calibrated gamma dose rate meter and dosimeter. Upon completing this check, be sure to put on gloves and to wear your dosimeter.

If you do not have a personal dosimeter, proceed only when you obtain one or respond according to the Emergency Response Guidebook and the advice of the Canadian Nuclear Safety Commission Duty Officer.

- Reset the dosimeter to zero or take note of the starting value on the dosimeter.

- Determine your **turn-back dose rate** — the maximum dose rate you will tolerate before backing off and reassessing the scene: 1 mSv/h is recommended..

- Determine the maximum total radiation dose you will tolerate before ceasing work: 500 µSv is recommended.

- Perform a **RECCE** and establish or verify the **hot zone** around the device.

  Note: The hot zone should be posted at whichever of the following measurements is reached first:

  - 5-10x background on the ground with a contamination meter (~500 cpm with a 15 cm^2 detector)
    or
  - 5-10 µSv/h with a gamma dose rate meter

Step 7

- Read the shipping document or the package's **category label**, which should allow you to determine the following information:
  - the radioisotope(s) inside the package

    Note: The source will most likely be Ir-192 (gamma) and **special form** (refer to Table 1 in Appendix A to determine the gamma dose rate).

  - the maximum radiation level at any point on the package's external surface (see Section 2.3.1)

  - the package's **Transport Index** (see Section 3.5)

Step 8

Assess the damage to the package:

- If you can get close enough to it, use gloves and long-handled tools to wipe the package in order to verify if the radioactive contents have been released.

- Measure the count rate on the wipe with a contamination survey meter. A reading of ≥ 2x background is considered contaminated.

If the wipe is contaminated (measures ≥ 2x background on a contamination survey meter) or if you observe a high radiation reading*:

> *A radiation reading on a gamma dose rate meter is considered high at a level of:
> - over 2 mSv/h, on contact with the package or device
>
> **or**
>
> - over 100 µSv/h, at 1 m away from the package or device

- Maintain the hot and cold zones as established.

- Immediately call the Canadian Nuclear Safety Commission Duty Officer to provide an update of the situation. This is imperative, as special precautions, packaging and permission may be
necessary to transport the damaged package. The Duty Officer will advise you what to do with the package or have a Canadian Nuclear Safety Commission Liaison Officer contact you with further instructions.

- Do not attempt to move the package unless the Canadian Nuclear Safety Commission Duty Officer or a Liaison Officer instructs you to do so.

If the wipe is negative and the package appears undamaged:

- Recover the package and end the emergency.

Figure 25 presents an example of a shipping document for an exposure device. Because exposure devices are often exempt from labelling, this is stated in the "Additional Handling Information" section of the document. (Note: This is for illustrative purposes only and is not a legally acceptable shipping document.)

Figure 25. Sample shipping document for an exposure device

DANGEROUS GOODS SHIPPING DOCUMENT

Consignor:	**EXCLUSIVE USE SHIPMENT**
Carrier:	**Consignee:**
Shipping Date:	**24-Hour Number:**

NATURE AND QUANTITY OF DANGEROUS GOODS

Proper Shipping Name	Class	UN Number	Isotope Max. Activity	Labels	No. of Packages Dimensions or Mass
Radioactive Material, Type B(U) Package	7	UN2916	Ir-192 Max. activity 3700 GBq (100 Ci) Special Form	N/A	1 x 30 kg

Additional Handling Information: Exempt from labeling under PTNS 16(5)

Location of Package(s) in Vehicle: Rear of vehicle, passenger side.

Special Instructions: Placards: 4 x Class 7

Special Form Certificate Number: ********** **Type B Certificate Number:** **********	**Name/Title of Consignor:**

CONSIGNOR'S DECLARATION
I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in all respects in proper condition for transport by road according to the applicable national governmental regulations.

SIGNATURE: **DATE:**

6.2 Pictures of exposure devices

Figure 26. SPEC 150 exposure device.

Figure 27. Side view of SPEC 150 exposure device shown in Figure 26.

Figure 28. Sentinel 660B or Tech Ops 660B exposure device.

Figure 29. Side view of exposure device shown in Figure 28.

Figure 30. Sentinel 660B exposure device with OPL 660 overpack.

Figure 31. Side view of container shown in Figure 30. Note: This particular package does not require a **category label**, but has a yellow warning label that declares the radioactive contents.

Figure 32. Sentinel 880 exposure device.

Figure 33. Pneumat-A-RAY exposure device.

Figure 34. Side view of Pneumat-A-RAY exposure device shown in Figure 33.

Figure 35. Gammamat TSI5 exposure device.

Figure 36. IR-100 exposure device.

Figure 37. Standard source used inside an exposure device. The radioactive source would be in the tip of the device, near the finger in the photograph. If you see a source like this, do not touch it and immediately back up 400 m and refer to Table 1 in Appendix A to determine the gamma dose rate.

7.0 First Responder Information Sheets

7.1 The Basics of Ionizing Radiation (1 of 1)

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

INFO - 0754 - 3

The Basics of Ionizing Radiation

Produced by the Canadian Nuclear Safety Commission for First Responders

Types of Ionizing Radiation

Alpha (α):
- Heavy charged particle
- Internal hazard
- Travels 2-5 cm in air, stopped by a piece of paper

Beta (β):
- Light charged particle
- Mainly internal hazard, can cause skin burns
- Travels up to 4-5 m in air, stopped by a piece of plastic

Gamma (γ):
- Electromagnetic wave
- External hazard
- Travels several metres in air, requires dense material for shielding

Neutron (n):
- Uncharged particle
- External hazard
- Travels several metres in air, hydrogen-rich material (water/wax) best for shielding

Engineering Units:

p (pico)	$= 10^{-12}$	= 0.000000000001
n (nano)	$= 10^{-9}$	= 0.000000001
μ (micro)	$= 10^{-6}$	= 0.000001
m (milli)	$= 10^{-3}$	= 0.001
k (kilo)	$= 10^{3}$	= 1 000
M (mega)	$= 10^{6}$	= 1 000 000
G (giga)	$= 10^{9}$	= 1 000 000 000
T (tera)	$= 10^{12}$	= 1 000 000 000 000

Activity:

37 TBq	(terabecquerel)	= 1 kCi	(kilocurie)
37 GBq	(gigabecquerel)	= 1 Ci	(curie)
37 MBq	(megabecquerel)	= 1 mCi	(millicurie)
37 kBq	(kilobecquerel)	= 1 μCi	(microcurie)
37 Bq	(becquerel)	= 1 nCi	(nanocurie)

Dose:

1 Sv	(sievert)	= 100 rem	(rem)
1 mSv	(millisievert)	= 100 mrem	(millirem)
1 μSv	(microsievert)	= 100 μrem	(microrem)
1 nSv	(nanosievert)	= 100 nrem	(nanorem)

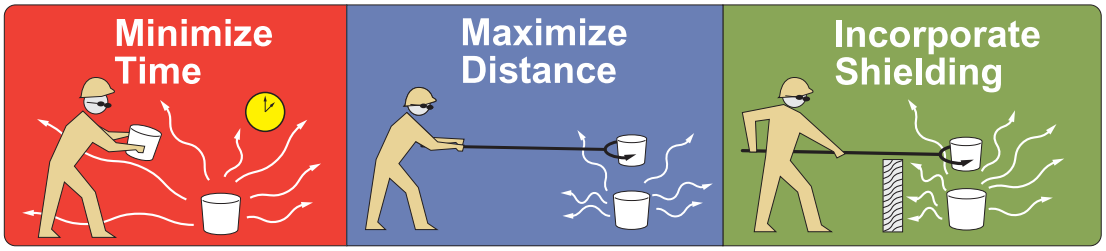
Contamination vs. Radiation

Radiation is emitted from any material that is radioactive. Radiation exposure occurs when a person is in a radiation field. Contamination occurs when control is lost over radioactive material and it ends up in places it should not be. Contamination is either loose (easily spread) or fixed. Generally speaking, the amount of radioactive material found on a contaminated surface is too low to be considered an external hazard. However, contaminated persons should be decontaminated as quickly as possible. Personal protective equipment (PPE) is worn to protect against the hazards of contamination.

Radiation Protection

IT IS RECOMMENDED THAT PERSONAL ALARMING DOSIMETRY EQUIPMENT SHOULD BE WORN AT ALL TIMES AND IS CONSIDERED AS PART OF YOUR PPE. Wear dosimetry under a LEVEL A suit and on the outside of all other types of PPE (ideally in a plastic bag to prevent contaminating it).

Remember the ALARA Principle: As Low As Reasonably Achievable



Remember: DOSE = DOSE RATE x TIME

Minimum PPE: Tyvek® overalls, two layers of nitrile or latex gloves, rubber boots and respiratory protection (N95, SCBA or full-face respirator).

Note: If there is no risk of airborne contamination, then respiratory protection can be removed.

Canadian Nuclear Safety Commission 24-hr Duty Officer's number: (613) 995-0479

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7.2 Working in a Radiation Environment (1 of 2)

Canadian Nuclear Safety Commission / Commission canadienne de sûreté nucléaire

INFO - 0754 - 5 Rev. 1

Working in a Radiation Environment

Produced by the Canadian Nuclear Safety Commission for First Responders

THE FOLLOWING ARE RECOMMENDATIONS ONLY.
LOCAL OR PROVINCIAL PROCEDURES AND PROTOCOLS MUST BE FOLLOWED.

Recommended Practices

INITIAL RECCE AND LIFE SAVING TAKE PRIORITY OVER ZONE DELINEATION

Turn-Back Dose and Dose Rate:

Routine situation (non-emergency):	Dose: 0.5 mSv (500 µSv) Dose rate: 1 mSv/h*
Emergency situation:	Dose: 250 mSv (250 000 µSv) Dose rate: 1000 mSv/h* (1 Sv/h)
Life Saving:	Unlimited (volunteer basis)

* If any meter you are using goes off scale, turn back.

DECONTAMINATION: A reading that is twice the background level on a contamination meter is considered dirty. A full-body scan should take 5 minutes per person. Try to keep the meter less than 5 cm from the person and do not touch the person with the instrument.

COLD ZONE: Background level reading on a contamination meter and a gamma dose rate meter.

HOT ZONE:

Routine situation (non-emergency):	5-10 µSv/h with a gamma dose rate meter or 5-10x background on the ground with a contamination meter (~500 cpm with a 15 cm^2 detector)
Emergency situation:	Up to 100 µSv/h with a gamma dose rate meter

Radiation Instruments

Personal Alarming Dosimeter (PAD):
Used for turn-back dose rates and maximum permissible dose rate alarms. Dosimeters measure gamma radiation. Some models will also measure beta radiation. Dosimetry should be considered as part of your personal protection equipment (PPE).

1 

2 

1. Picture of a Siemens Mk2.3
2. Picture of a MGP SORIT Personal Alarming Dosimeter

Surface Contamination Meter:
Used primarily for contamination checks on personnel and surfaces/objects in low-background gamma fields. Far more sensitive than a gamma survey meter and will respond to alpha (α), beta (β), gamma (γ) radiation. Not suitable for use in a hot zone. It is a yes/no instrument. Typical background is 50 cpm for a 15 cm^2 pancake contamination meter.

3. Picture of a Technical Associates TBM-3S contamination meter

3 

15 cm^2 pancake contamination meter

Continued ⟶ See side 2

Canadian Nuclear Safety Commission 24-hr Duty Officer's number: (613) 995-0479

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7.2 Working in a Radiation Environment (2 of 2)

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

INFO - 0754 - 5 Rev. 1

Working in a Radiation Environment

Produced by the Canadian Nuclear Safety Commission for First Responders

THE FOLLOWING ARE RECOMMENDATIONS ONLY.
LOCAL OR PROVINCIAL PROCEDURES AND PROTOCOLS MUST BE FOLLOWED.

(continued)

Gamma Dose Rate Meter:
Measures gamma dose rate. It is the *only* instrument which should be used in the hot zone and should be placed in a plastic bag to avoid contaminating it. Typical background level is approximately 0.25 µSv/h.

4

5

4. Picture of an Automess 6150 AD6
5. Picture of a Ludlum 2401-ECA survey meter

Gamma Spectrometer:
Calibrating the instrument with the supplied check source is the most important and first step when using a spectrometer. Can be used as a gamma dose rate meter (more sensitive, but less rugged than a standard dose rate meter). Most spectrometers (check the specifications) can only measure gamma dose rates up to 100 µSv/h. Automatic isotope ID functions can easily induce a non-expert user into error. Typical background is 0.05 to 0.2 µSv/h. Some meters also measure in units of cps (counts per second); however, the meter should not be used for contamination monitoring.

*The information provided in this document is not intended to single out or endorse specific radiation detection equipment suppliers.

Canadian Nuclear Safety Commission 24-hr Duty Officer's number: (613) 995-0479

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7.3 Incident Control and Decontamination (1 of 2)

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

INFO - 0754 - 4 Rev. 1

INCIDENT CONTROL AND DECONTAMINATION

Produced by the Canadian Nuclear Safety Commission for First Responders

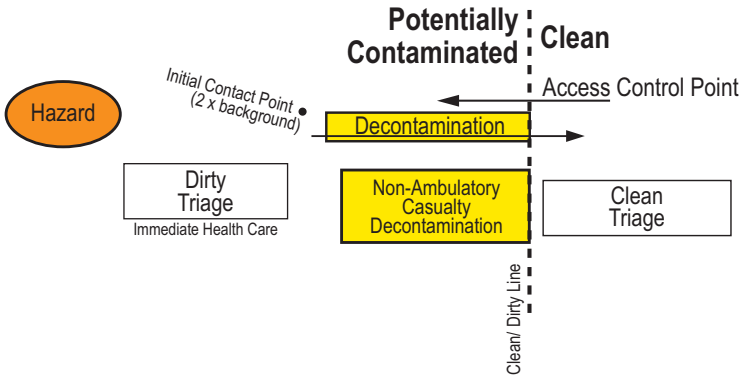
THE FOLLOWING ARE RECOMMENDATIONS ONLY.
LOCAL OR PROVINCIAL PROCEDURES AND PROTOCOLS MUST BE FOLLOWED

Initial Response and Scene Control:

The general procedure at the start of any response is RECCE, Rescue, Decontamination and Zoning. The main priority during the entire response is to manage the Clean/Dirty Line.

Remember:

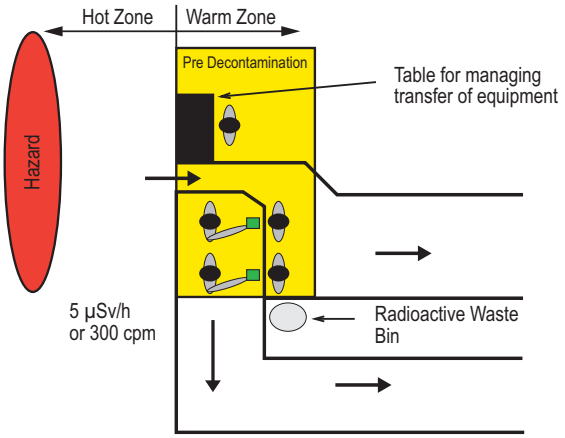
1. Finding 2x background, establishing the Cold Zone
2. RECCE
3. Extraction/Forward Treatment and Triage
4. Decontamination
5. Delineating the Hot Zone



Pre Decontamination:

- At the edge of the hot zone, measure the lowest obtainable reading with a contamination meter. Any reading above this number is to be considered as contamination.
- With back to hazard, scan slowly with contamination meter 2-5 cm from surface of personal protective equipment (PPE) with priority to boots and gloves.
- Remove and bag any PPE that is contaminated.
- If contamination is found under PPE, proceed to final decontamination.

PRE DECONTAMINATION SET UP AT HOT ZONE



Continued ⟶ See side 2

Canadian Nuclear Safety Commission 24-hr Duty Officer's number: (613) 995-0479

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Canada

7.3 Incident Control and Decontamination (2 of 2)

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

INFO - 0754 - 4 Rev. 1

INCIDENT CONTROL AND DECONTAMINATION

Produced by the Canadian Nuclear Safety Commission for First Responders

THE FOLLOWING ARE RECOMMENDATIONS ONLY.
LOCAL OR PROVINCIAL PROCEDURES AND PROTOCOLS MUST BE FOLLOWED.

(continued)

Final Decontamination:

- **Portal Monitor:** Proceed into the Portal Monitor, pause for 5-10 seconds, then rotate 90 degrees and pause again for 5-10 seconds to ensure all four sides of the person are monitored. If alarm sounds, remove PPE and proceed to Secondary Bench. If PPE was already removed prior to using the Portal Monitor or no Portal Monitor is available, move to the Primary Bench.

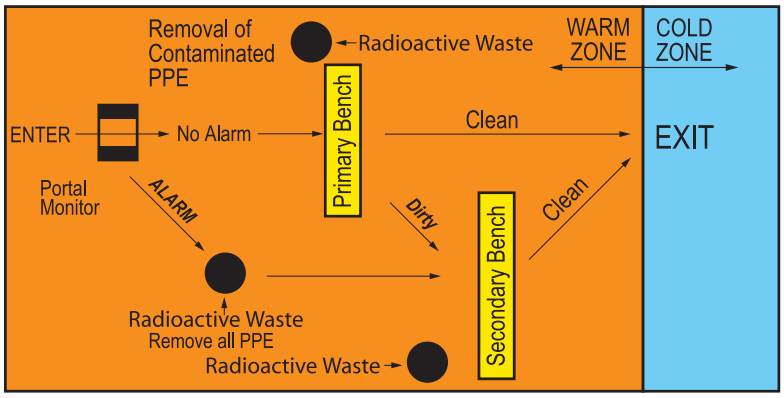
  Remember: most Portal Monitors only detect gamma radiation, therefore monitoring at the Primary Bench is still required.

- **Primary Bench:** Full-body monitoring, starting with hands (both sides), then head, arms (extended out to the side), torso, legs and bottom of the feet (the entire process should take approximately five minutes). Remove contaminated PPE after any measurement exceeding twice background. Once PPE is removed, proceed to Secondary Bench. Clean persons may exit at this point.

- **Secondary Bench:** Repetition of full-body monitoring (with PPE off) and all decontamination cleaning are performed at this location. The least aggressive method should be used to clean the skin. Avoid abrading the skin (wet wipes are effective and easy to dispose of). Any removed clothing must be bagged and tagged.

- Once clean, person and/or object may exit.

FINAL DECONTAMINATION



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Canada

7.4 Radiation Incident – Mass Casualty Decontamination

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

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Radiation Incident Mass Casualty Decontamination

Produced by the Canadian Nuclear Safety Commission for First Responders

THE FOLLOWING ARE RECOMMENDATIONS ONLY.
LOCAL OR PROVINCIAL PROCEDURES AND PROTOCOLS MUST BE FOLLOWED.

To be performed after standard medical triage

Always wear personal protection equipment (PPE) when dealing with loose contamination. Immediate care of critical injuries takes precedence over care of radiation injuries and radioactive contamination control.

Under normal circumstances, contamination checks are made using a contamination meter. A proper scan should take approximately five minutes per person. A reading on a contamination meter that is twice the background level, indicates that a person is contaminated. All contaminated clothing must be removed, bagged and tagged.

In the event that the number of individuals to be checked overwhelms all available resources, the decontamination process will need to be accelerated. The following process is recommended:

Mass Decontamination Process:

Step 1: Is the Individual Grossly Contaminated?

With a contamination meter, check hands and feet thoroughly and then perform a 10 to15-second check over the rest of the person. **A contamination meter reading that is in excess of ten times the background level (or, if no contamination meter is available, a gamma dose rate meter reading greater than 0.5 µSv/h) is an indication of gross contamination. Note:** a gamma dose rate meter is only to be used for decontamination monitoring as a last resort.

If GROSSLY CONTAMINATED: remove contaminated clothing
If NOT: the individual may exit the decontamination line

Step 2: Is the individual still contaminated after removing contaminated clothing?

Check skin with a contamination meter as described above.

If YES (over a large area): clean the contaminated area thoroughly, controlling runoff water
If YES (over a small area): wipe with a damp cloth or wet wipes taking care not to irritate skin
If NO: the individual may exit the decontamination line

Step 3: Is the skin contamination persisting after washing?

Check skin with a contamination meter as described above. Any readings that are above twice the background level indicate contamination. Readings greater than 10 times the background level should be checked with a gamma dose rate meter. A gamma dose rate reading greater than 100 µSv/h 10 cm from the skin could indicate the presence of a highly radioactive particle. This area should be covered with whatever is available and noted. Prompt medical treatment to remove the radioactive particle should be sought. Any information available concerning the radionuclide should also be noted and relayed to hospital staff.

If YES (over a large area): possible internal contamination
If YES (over a small area): areas should be noted and covered if possible
If NO: the individual may exit the decontamination line

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Canada

7.5 Radiation Incident – Mass Casualty Radiation Injury Triage

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

INFO - 0754 - 2 Rev. 1

Radiation Incident
Mass Casualty Radiation Injury Triage

Produced by the Canadian Nuclear Safety Commission for First Responders

THE FOLLOWING ARE RECOMMENDATIONS ONLY.
LOCAL OR PROVINCIAL PROCEDURES AND PROTOCOLS MUST BE FOLLOWED.

To be performed after standard medical triage and decontamination

Always wear personal protective equipment (PPE) when dealing with loose contamination. Immediate care of critical injuries takes precedence over care of radiation injuries and radioactive contamination control.

Time to emesis (vomiting) is an initial but crude treatment indicator for individuals who have been exposed to very high doses of radiation. Physiological responses to radiation doses vary from person to person. Some unexposed individuals will vomit (e.g. due to stress), while others who received very high doses will not.

After a person has been decontaminated, a gamma dose rate measured one metre from the chest is a crude indicator of gross internal radioactive contamination, but is not reliable for all radionuclides. Any information available concerning the radionuclide should be relayed to hospital staff.

Vomiting within 1 hour of exposure	**Seek immediate medical care** Possibly life threatening if left untreated
Gamma Dose Rate > 1 µSv/h one metre from chest	**Seek immediate medical care** Possibility of high levels of internal contamination
Localized otherwise unexplained erythema (skin reddening)	Mark area with surgical marker and **seek immediate medical care** for possible radiation burn to skin
Vomiting 1-4 hours after exposure	**Seek medical care** for possible high radiation dose
Dose Rate approx. twice background level one metre from chest	In case of persistent external contamination, continue cleaning and monitoring the area. **Seek medical care** for possible internal contamination
Nausea, vomiting or diarrhea within 24 hours	**Seek follow-up medical care** for possible external exposure

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Appendix A

Table 1 presents gamma dose rates, half-lives, representative activities, and appropriate distances for **hot** and **cold zones** for common radioisotopes. The figures listed are based on point source calculations only and take into account any shielding, attenuating and buildup provided by air. Be sure to verify all distances quoted with a calibrated gamma dose rate meter.

Table 1. Key figures for common radioisotopes

Isotope	Half-Life	Gamma dose rate in mSv/h, at 1 m from a completely unexposed source, per 37 GBq (1 Ci)	Activity	Approximate distance in m for hot zone (5 µSv/h) from a completely unexposed source	Approximate distance in m for cold zone or background (0.2 µSv/h) from a completely unexposed source
Cobalt-60 (Co-60)	5.27 years	13.5 mSv/h	37 MBq (1 mCi)	2 m	8 m
			18.5 GBq (500 mCi)	31 m	145 m
			37 GBq (1 Ci)	42 m	184 m
			1 850 GBq (50 Ci)	229 m	474 m
			3 700 GBq (100 Ci)	277 m	532 m
			5 180 GBq (140 Ci)	300 m	560 m
Gallium-67 (Ga-67)	3.3 days	1.11 mSv/h	37 MBq (1 mCi)	0.5 m	2 m
			555 MBq (15 mCi)	2 m	7 m
			1.85 GBq (50 mCi)	3 m	22 m
Molybdenum-99 (Mo-99)	66 hours	1.13 mSv/h	37 GBq (1 Ci)	14 m	69 m
			185 GBq (5 Ci)	27 m	133 m
			370 GBq (10 Ci)	45 m	167 m
			555 GBq (15 Ci)	55 m	189 m
Technetium-99m (Tc-99m)	6 hours	1.23 mSv/h	37 MBq (1 mCi)	0.5 m	2 m
			555 MBq (15 mCi)	2 m	8 m
			1.85 GBq (50 mCi)	3 m	22 m
Iodine-125(I-125)	60 days	2.75 mSv/h	18.5 MBq (0,5 mCi)	0.5 m	2 m
			370 MBq (10 mCi)	3 m	13 m
Iodine-131 (I-131)	8 days	2.82 mSv/h	1.11 GBq (30 mCi)	4 m	18 m
			7.4 GBq (200 mCi)	10 m	51 m
Cesium-137 (Cs-137)	30 years	3.3 mSv/h	555 MBq (15 mCi)	3 m	14 m
			3 700 MBq (100 mCi)	8 m	32 m
			18 500 MBq (500 mCi)	16 m	84 m
			37 GBq (1 Ci)	22 m	110 m
Iridium-192 (Ir-192)	74 days	5.92 mSv/h	37 MBq (1 mCi)	1 m	5 m
			18 500 MBq (500 mCi)	20 m	101 m
			37 GBq (1 Ci)	27 m	129 m
			1 850 GBq (50 Ci)	59 m	319 m
			3 700 GBq (100 Ci)	192 m	356 m
			5 180 GBq (140 Ci)	208 m	374 m
Americium-241 (Am-241)	432 years	0.2 mSv/h	1 850 MBq (50 mCi)	1.4 m	7 m
Americium-241/ Beryllium (Am-241/Be)	432 years	0.06 mSv/h	1 850 MBq (50 mCi)	0.8 m	4 m
			185 GBq (5 Ci)	8 m	38 m
			740 GBq (20 Ci)	16 m	77 m

Note: Because Am-241/Be is a neutron source, a neutron dose rate meter would be required for accurate measurements. Therefore, the figures listed are estimates only and err on the side of safety.

Glossary

background radiation levels: An area's natural radiation reading in the absence of man-made sources of radiation.

Class 7 Dangerous Goods: "Substances with a specific activity greater than 70 kBq/kg" (*Transportation of Dangerous Goods Regulations*).

24-hour number: A telephone number, listed on a **shipping document**, for a contact person who can be reached at any time in case of emergency regarding the shipment.

category label: A label that identifies the contents and activity of radioactive material inside a package, as well as the package's **Transport Index**.

clean/dirty line: A boundary that separates an established **cold zone** from the **warm zone**.

cold zone: An area established as a safe region where radiation levels are at **background levels**.

exclusive use shipment: A shipment that requires "the sole use, by a single consignor, of a conveyance (shipment) or a large freight container, in respect of which all initial, intermediate and final loading and unloading is carried out in accordance with the directions of the consignor or consignee" (*Packaging and Transport of Nuclear Substances Regulations*).

hot zone: An area cordoned off by an emergency responder around a radioactive package, where radiation levels can exceed 5 µSv/h (ambient gamma) and/or radiological contamination can be present on the ground in excess of 300 cpm (on a standard 15cm^2 contamination survey meter).

low specific activity (LSA) material: "Radioactive material which by its nature has a limited specific activity, or radioactive material for which limits of estimated average specific activity apply." (*Regulations for the Safe Transport of Radioactive Material*, International Atomic Energy Agency.) LSA material can belong to one of three groups, LSA-I, LSA-II or LSA-III, which are defined in paragraphs 241(a) and 241(b) of the *Regulations for the Safe Transport of Radioactive Material*.

RECCE (reconnaissance): An emergency responder's initial assessment of an accident scene.

shipping document: A mandatory document accompanying a shipment of dangerous goods as defined by the *Transport of Dangerous Goods Regulations*, which lists specific information about the shipment (including the consignor, consignee, **24-hour number**, contents' proper shipping names and **UN numbers**, and number and type of packages).

special form radioactive material: “An indispersible solid radioactive material or a sealed capsule containing radioactive material” (*Regulations for the Safe Transport of Radioactive Material*, International Atomic Energy Agency).

surface contaminated object (SCO): “A solid object, which is not itself radioactive, but that has radioactive material distributed on its surfaces (*Regulations for the Safe Transport of Radioactive Material*, International Atomic Energy Agency.) SCOs are classified as either SCO-I or SCO-II, which are defined in the *Regulations for the Safe Transport of Radioactive Material*.

Transport Index (TI): A number assigned to a package that indicates its radiation levels and is used to provide control over radiation exposure. It is calculated by dividing the maximum radiation level, in µSv/h, at 1 m from a package by 10.

turn-back dose rate: The maximum dose rate a responder has decided to tolerate before backing off and reassessing the scene.

UN number: A four-digit number that identifies a specific dangerous good in the framework of international transport. UN numbers are assigned by the United Nations Committee of Experts on the Transport of Dangerous Goods and are adopted by all UN signatory countries.

warm zone: The area/distance between the edge of the **cold zone** and the start of the **hot zone**. This area could potentially become contaminated.

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