Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)

Volume III: Transportation

November 2021

Federal Provincial Territorial
Radiation Protection Committee

Health Canada Santé Canada

Canada

Health Canada is the federal department responsible for helping the people of Canada maintain and improve their health. Health Canada is committed to improving the lives of all of Canada's people and to making this country's population among the healthiest in the world as measured by longevity, lifestyle and effective use of the public health care system.

Également disponible en français sous le titre :
Lignes directrices canadiennes pour la gestion des matières radioactives naturelles (MRN)

To obtain additional information, please contact:

Health Canada
Address Locator 0900C2
Ottawa, ON K1A 0K9
Tel.: 613-957-2991
Toll free: 1-866-225-0709
Fax: 613-941-5366
TTY: 1-800-465-7735
E-mail: hc.publications-publications.sc@hc-sc.gc.ca

Publication date: November 2021

Cat.: H129-34/3-2020E-PDF
ISBN: 978-0-660-36721-7
Pub.: 200303

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS USED IN THE GUIDELINES

ALARA	An acronym for "As Low As Reasonably Achievable", societal and economic factors being taken into account. ALARA is a guiding principle in radiation protection, and encourages managers to reduce dose levels as low as reasonably achievable, even if they are already meeting allowable levels.
CNSC	Canadian Nuclear Safety Commission is the federal agency that licenses and regulates nuclear facilities and materials.
ERAP	Emergency Response Assistance Plan
FPTRPC	Federal Provincial Territorial Radiation Protection Committee
IAEA	International Atomic Energy Agency
LSA	Low Specific Activity
NORM	Naturally Occurring Radioactive Material
PTNSR	Packaging and Transport of Nuclear Substances Regulations
RPP	Radiation Protection Program
SCO	Surface Contaminated Object
TI	Transport Index
TDGR	Transportation of Dangerous Goods Regulations
UDRL	Unrestricted Derived Release Limit

PREFACE

In 1991 the Western Canadian NORM Committee was formed to produce a definitive document that would provide industry with guidance for the control of Naturally Occurring Radioactive Materials (NORM). The Committee was a joint initiative of industry and government and included representatives from the provincial governments of British Columbia, Alberta and Saskatchewan, and from the oil and gas and fertilizer industries. The result was the *Guidelines for the Handling of Naturally Occurring Radioactive Materials (NORM) in Western Canada*, published in August 1995.[1]

Subsequent to these guidelines, the Canadian NORM Working Group, a working group of the Federal Provincial Territorial Radiation Protection Committee (FPTRPC), was formed to represent the interests of provincial and territorial regulators and included affected industries in the petroleum, fertilizer manufacturing and metal recycling industry sectors. As a result of their efforts, the *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)* was published in October 2005 and revised in 2011.[2]

This document is an extension of the Canadian NORM Guidelines[2] and a publication of the FPTRPC, an intergovernmental committee established to support federal, provincial and territorial regulators in carrying out their respective mandates.

Comments or suggestions concerning this NORM Transport Guideline should be sent to:

Secretariat, Federal Provincial Territorial Radiation Protection Committee
Radiation Protection Bureau
Health Canada, AL 6302D
775 Brookfield Road
Ontario, Canada, K1A 1C1

This document reflects the work of many individuals. It was drafted, prepared and finalized by Cody Cuthill of NormTek Radiation Services Ltd. and Gary Hughes (retired) of Alberta Labour and Immigration.

The contributions of the following organizations whose comments and suggestions helped in the preparation of these Guidelines are gratefully acknowledged:

Canadian NORM Working Group—Federal Provincial Territorial Radiation Protection Committee
Transport Licensing and Strategic Support Division—Canadian Nuclear Safety Commission
Radiation Protection Bureau—Health Canada
Director Nuclear Safety—Department of National Defence

INTRODUCTION

In Canada, the responsibility for ensuring safe transport of radioactive material at the federal level is jointly shared between the Canadian Nuclear Safety Commission (CNSC) and Transport Canada. Transport Canada's *Transportation of Dangerous Goods Regulations (TDGR)*[3] deal with the transport of all classes of dangerous goods, including NORM, while the CNSC's *Packaging and Transport of Nuclear Substances Regulations, 2015 (PTNSR)*[4] are primarily concerned with the health, safety and security of the public, and protection of the environment related to the special characteristics of radioactive material. Both the TDGR and PTNSR apply to all persons who handle, offer for transport, transport or receive nuclear substances.

The International Atomic Energy Agency (IAEA), an international organization formed to promote safe, secure and peaceful nuclear technologies, has developed safety standards for member states. As Canada is an IAEA member state, the CNSC has generally incorporated the requirements of the *IAEA Safety Standards Series, Regulations for the Safe Transport of Radioactive Material No. SSR-6*,[5] into its PTNSR.[4]

The Canadian NORM Transport Guidelines set out principles and procedures for classification, handling and transport of NORM in Canada. These Guidelines also provide guidance for interpretation of the applicable federal regulations as they pertain strictly to NORM and provide the framework for development of more detailed NORM transport practices and guidelines by provincial regulatory authorities, affected industries and specific workplaces. Should a difference between these NORM Transport Guidelines and the applicable federal regulations occur, the federal regulations shall prevail.

CHAPTER 1:

NORM TRANSPORT OVERVIEW

1.0 DEFINITION

NORM is an acronym for *naturally occurring radioactive materials*, which include radioactive elements found in our environment. Although the concentrations of NORM in nature are typically low, industries that produce our natural resources can concentrate these materials to levels that are hazardous. The processing of raw materials by resource-based industries concentrates the radioactive materials in the waste that is formed or within the products that are produced. NORM waste can fall under either provincial transport jurisdiction or federal transport jurisdiction. Products impacted with NORM typically only fall under provincial authority, as the activity levels in manufactured products are unlikely to reach levels associated with federal transport regulations.

Concentrations of radioactive materials above the Unrestricted Derived Release Limits (UDRL), as outlined in the Canadian NORM Guidelines,[2] could be considered hazardous to health and the environment. These materials require special detection, classification, handling, shipping and waste disposal to protect workers, the public and the environment. The greater the concentrations of NORM, the greater the hazards that exist during handling, packaging and transport.

1.1 PURPOSE OF THE NORM TRANSPORT GUIDELINES

As NORM is not part of the nuclear fuel cycle or a man-made radioactive source, it does not come under the control of the CNSC, with the exception of import, export and transport, provided the activities of the NORM-impacted materials exceed the applicable exemption levels. As Canada is an IAEA member state, the CNSC has generally incorporated the IAEA *Safety Standards Series, Regulations for the Safe Transport of Radioactive Material No. SSR-6*[5] into the PTNSR.[4] It has been recognized that industries that produce NORM are not typically involved with associations such as the IAEA and that inconsistency occurs as a result of interpretation of the applicable transport publications. In addition, the majority of content within the *IAEA Regulations for the Safe Transport of Radioactive Material*[5] reference radioactive materials associated with the nuclear fuel cycle and man-made sources, complicating matters for industries associated with NORM. Accordingly, the NORM Transport Guidelines were developed to:

a) Ensure adequate control of NORM shipments by affected industries;

b) Ensure adequate protection to the public, workers and the environment;

c) Provide assistance to industries in interpretation of both provincial or territorial transport requirements and federal transport regulations as they pertain strictly to NORM shipments.

A glossary of terms relevant to NORM transportation is given in Appendix 1.

1.2 INDUSTRIES THAT PRODUCE NORM

All industries that process our natural resources have the potential to concentrate the radionuclides in the raw materials they produce to levels above the UDRL in the Canadian NORM Guidelines.[2] An overview of some of these industries is given in the Canadian NORM Guidelines,[2] with more detailed information given in ICRP Publication 142[6] and IAEA-TECDOC-1712.[7]

1.3 RADIATION PROTECTION

All hazardous materials transported under the *Transport of Dangerous Goods Regulations*[3] are assigned to one of nine United Nations classes. The hazardous materials generally pose an immediate threat to health and safety; however, for radioactive material the threat is the non-immediate risk of cancer, except in extreme situations. These non-immediate risks cannot be taken lightly as they pose a significant hazard to workers during packaging, handling, classification and preparing a shipment for transport.

Occupational health and safety regulations may require employers to assess their workplace for hazards including NORM, develop exposure control plans and provide training to workers. For industries that concentrate NORM, this can be accomplished through the development of a Radiation Protection Program (RPP). The RPP outlines how radiation protection is accomplished within a company, including assessments on radiation exposures to workers and members of the public. Key components of a RPP may identify the following items:

a) Who is in charge of overall radiation protection within a corporation (corporate radiation safety officer) and the structure of how radiation protection is to be achieved.

b) Locations where radiation hazards exist.

c) Hazards and control methods required for radiation protection.

d) Detection and monitoring program requirements (contamination, gamma radiation, radon gas and low-level radioactive dust monitoring).

e) Training requirements for workers handling NORM.

f) Policies and procedures for radiation protection.

g) How external exposures are controlled and records are maintained.

h) How internal exposures are controlled and records are maintained.

For further guidance, refer to CNSC document GD-314: *Radiation Protection Program Design for the Transport of Nuclear Substances*.[8]

Records should be kept for all activities associated with workplace monitoring and individual monitoring. According to the PTNSR,[4] every consignor, carrier or consignee of radioactive material, other than one who only handles or transports excepted packages, must implement a radiation protection program and must, as part of that program, incorporate the ALARA principle (as low as reasonably achievable). Individual exposures to workers and the public from NORM-impacted materials must be kept as low as reasonably achievable and at no time exceed the dose limits outlined in the *Radiation Protection Regulations*.[9]

1.4 EMERGENCY RESPONSE

Unless exempted from the TDGR,[3] emergency response assistance plans (ERAP) must be established prior to shipping any NORM-impacted materials. The shipper, transporter and receiver should be aware of the appropriate ERAP and 24-hour emergency number. The ERAP must take into account other dangerous goods as outlined in the TDGR.[3] Low Specific Activity (LSA-I) in excess of 100 kg requires an ERAP be filed with Transport Canada prior to shipping.

1.5 CONSIGNOR'S RESPONSIBILITIES

A consignor is defined as a person in Canada who is named in the shipping documents as the consignor or the person who has possession of the consignment immediately before they are transported.[3] Consignors of NORM that exceeds the UDRL should have a quality assurance program that ensures the safe transport of NORM. The program should ensure:

a) A documented RPP is in place outlining procedures for NORM monitoring, handling, storage, processing, classifying, packaging and transportation along with methods for monitoring, documenting and controlling exposure to workers and members of the public.

b) Personnel are qualified and properly trained in managing NORM-impacted materials and other dangerous properties for materials being offered for transport.

c) Implementation of an ERAP as required.

d) Identification of a dedicated NORM storage area which has been appropriately labelled for materials being shipped. The storage area must meet applicable regulatory requirements for the hazardous properties being stored.

e) Yearly exposure reports for workers are appropriately maintained in accordance with applicable provincial regulations.

f) Transport documents are properly completed and distributed in accordance with applicable provincial legislation.

g) Waste tracking records are appropriately maintained in accordance with applicable provincial regulations.

h) Radiation levels are kept as low as reasonably achievable and at no time exceed dose limits outlined in the *Radiation Protection Regulations*[9] for incidentally exposed or occupationally exposed workers and members of the public.

i) Carriers and receivers are advised of the materials being transported prior to shipping and that these transporters and receivers have in a place a RPP to protect workers, public and the environment.

j) Carriers and receivers are approved by their respective regulatory authority to accept NORM-impacted materials and the other hazardous properties of the materials being shipped prior to shipping.

1.6 CARRIER RESPONSIBILITIES

A carrier is defined as a person who, whether or not for hire or reward, has possession of a shipment of dangerous goods while they are in transport.[3] A carrier must not take possession of NORM-impacted materials or equipment or dangerous goods unless they have a shipping document for the goods as per applicable provincial requirements.[3] A carrier of NORM that exceeds the UDRL should have a quality assurance program that ensures the safe transport of NORM. This program should ensure:

a) A documented RPP is in place outlining procedures for handling, securing and checking of loads containing NORM-impacted materials during transport and while being stowed in transit, along with methods for monitoring, documenting and controlling NORM exposures to drivers.

b) Drivers are appropriately trained and qualified in transporting NORM and have a valid Dangerous Goods Training Certificate and Class 7 Radioactive Materials training.

c) Designated routes, emergency response plans and emergency contact numbers are understood by and available for drivers.

d) Emergency Response Kits are provided with the transport vehicle including appropriate personal protective equipment (PPE) for NORM.

e) Documents are appropriately completed and signed as per applicable provincial requirements. These documents must be kept within reach of the driver of the transport vehicle or kept in a pocket mounted on the driver's door.[3] If the driver leaves the vehicle, they must place the shipping documents in the driver's door pocket, on the seat or a location clearly visible to anyone entering the power unit from the driver's door.[3] After unloading a shipment of dangerous goods including NORM or disconnecting a cargo unit (trailer) from a power unit, the carrier must place the shipping documents in a waterproof receptacle attached to or near the means of containment of the dangerous goods.[3]

f) Loads are securely fastened during transport.

g) Leaking packages are contained and reported to both shipper and receiver. Leaking packages, motor vehicle accidents or packages damaged in transport which fall under federal jurisdiction must be reported to the CNSC.

h) Only the consignor's goods are shipped while under "Exclusive use" when shipping unpackaged LSA-I materials. Note that this only applies to unpackaged LSA-I since exclusive use can only be used where it is required by regulation.

i) Appropriate placards, markings or labels are affixed to the transport vehicle.

1.7 RECEIVER RESPONSIBILITIES

Receivers of NORM that exceeds the UDRL should have a quality assurance program that ensures the safe receipt of NORM. This program should ensure:

a) A documented RPP is in place outlining procedures for receiving, monitoring, handling, storage, processing, classifying, packaging and transportation of NORM-impacted materials along with methods for monitoring, documenting and controlling exposure to workers and members of the public.

b) Personnel are appropriately trained in handling the materials being accepted, including other dangerous properties to the shipment, and that procedures are in place for opening packages to verify contents.

c) Documents are appropriately completed, signed and kept on hand in accordance with applicable provincial requirements.

d) Appropriate licensing of the receiving facility is in place prior to acceptance of NORM and other dangerous goods.

e) Placards, markings or labels affixed to the transport vehicle are removed, as required, upon removal of radioactive materials or other dangerous goods.

f) Personnel check for contamination within a conveyance and decontaminate prior to the conveyance leaving the receiving facility.

A large majority of NORM shipments are in the form of waste. Employers receiving NORM-impacted waste or equipment with NORM-impacted waste above the UDRL for repair, decontamination or disposal have the potential to expose workers to levels greater than 0.3 mSv/a above background unless appropriate management practices, as described in the Canadian NORM Guidelines,[2] are put in place. In addition, potential exists to contaminate the environment without appropriate waste management policies and procedures. It is recommended all receivers of NORM-impacted materials have written authorization from the applicable provincial authority outlining the activities they are authorized to perform and required waste management practices to be followed.

1.8 CONTROLLING NORM TRANSPORT HAZARDS

The safe transport of dangerous goods takes into consideration the hazards associated with those goods, such as flammability or toxicity, whereas the safe transport of radioactive materials not only takes into consideration the hazards of radioactivity but also the methods in which the materials are packaged and the total amount of radioactivity allowed within a package. Potential exposures to the public and workers handling a NORM shipment can be mitigated by limiting the amount of radioactive materials in a package, and through the design of the package itself to withstand an accident. In addition, exposures to responders in the event of an accident are also controlled through appropriate documentation, labelling and placarding of shipments.

1.9 GENERAL PACKAGE REQUIREMENTS

The general packaging requirements that are most applicable for NORM-impacted materials are as follows (*IAEA Safety Standards Series, Regulations for the Safe Transport of Radioactive Material No. SSR-6*):[5]

a) The package shall be so designed in relation to its mass, volume and shape that it can be easily and safely transported. In addition, the package shall be so designed that it can be properly secured in or on the conveyance during transport.

b) The design shall be such that any lifting attachments on the package will not fail when used in the intended manner and that if failure of the attachments should occur, the ability of the package to meet other requirements of these Regulations would not be impaired. The design shall take account of appropriate safety factors to cover snatch lifting.

c) As far as practicable, the packaging should be so designed to be easily decontaminated and finished so as to be free of protruding features.

d) As far as practicable, the package shall be so designed as to prevent the collection and retention of water.

e) Any features added to the package at the time of transport which are not part of the package shall not reduce its safety.

f) The package should be of such a design so as to be capable of withstanding the effects of acceleration, vibration or vibration resonance which may arise under routine conditions of transport. In particular, nuts, bolts, or other securing devices shall be so designed so as to prevent them from becoming loose or being released unintentionally, even after repeated use.

g) The materials of the packaging and any components or structures shall be physically and chemically compatible with each other and the radioactive contents.

h) All valves from which contents could escape must be protected against unauthorized operation.

i) The design of the package must take into account ambient temperatures and pressures that are likely to be encountered during routine conditions of transport.

j) For packages to be transported by air, the temperature of the accessible surfaces shall not exceed 50°C at an ambient temperature of 38°C with no account taken for insulation. In addition, the package must be capable of withstanding temperatures ranging from -40°C to +55°C and capable of withstanding a reduction in ambient pressure to 5 kPa without leakage.

k) For NORM-impacted materials having other dangerous properties, the package design must take into account those other dangerous properties.

CHAPTER 2:

CLASSIFICATION OF NORM FOR TRANSPORT

2.0 REGULATORY AUTHORITY FOR NORM TRANSPORT

Although NORM-impacted materials in excess of the Canadian NORM Guideline's[2] UDRL could be considered hazardous, they are still exempt from the PTNSR[4] until radionuclide specific activity limits, as measured in becquerels per gram (Bq/g), are reached. The following outlines the reasons higher activity exemptions exist for NORM until they are federally regulated under the PTNSR[4] and TDGR;[3]

a) The transport of dangerous goods takes into account hazards that can be immediately hazardous to health and safety of the public; however hazards associated with NORM are not immediate as they are carcinogenic. Exposure to NORM is from repeated exposures and as such transport hazards pose less risk to the public.

b) It is recognized that the greater the accumulation of NORM, the greater the potential hazards. Transport conveyances have a limited volume of materials which can be transported.

c) Transport packages have limits on radiation levels allowed for safe transport.

d) Radioactive materials with higher activities are packaged in more restrictive manners, to withstand transport accidents while maintaining package contents.

The regulatory authority responsible for NORM transport is dependent on the specific activity of the radionuclides being transported (Bq/g) and the total activity within a shipment (Bq). Since all matter has some amount of radioactivity there are three categories of regulatory authority in the transport of NORM (see Table 1):

I. Unrestricted Derived Release Limit (UDRL)
II. Provincially Regulated NORM
III. Federally Regulated NORM

Table 1. Categories of Regulatory Authority for NORM Transport (adapted from the Canadian NORM Guidelines,[2] PTNSR, 2015[4] and IAEA, 2018)[5]

NORM RADIONUCLIDE	I. Unrestricted Derived Release Limit (UDRL)		II. Provincially Regulated NORM		III. Federally Regulated NORM Follow PTNSR[4] and TDGR[3]	
	Specific Activity Limits[2]	Exempt Package Activity Limits[5]	Specific Activity Limits[2,4,5]	Exempt Package Activity Limits[5]	Specific Activity Limits[4,5]	Exempt Package Activity Limits[5]
Uranium-238 Natural (All progeny in equilibrium)	< 0.3 Bq/g	< 1,000 Bq	0.3 Bq/g to 10 Bq/g	< 1,000 Bq	> 10 Bq/g	< 1,000 Bq
Thorium-230	< 10 Bq/g	< 10,000 Bq	N/A	N/A	> 10 Bq/g	< 10,000 Bq
Radium-226 (All progeny in equilibrium)	< 0.3 Bq/g	< 10,000 Bq	0.3 Bq/g to 70 Bq/g	< 10,000 Bq	> 70 Bq/g	< 10,000 Bq
Lead-210 (In equilibrium with Bi-210 and Po-210)	< 0.3 Bq/g	< 10,000 Bq	0.3 Bq/g to 70 Bq/g	< 10,000 Bq	> 70 Bq/g	< 10,000 Bq
Thorium-232 Natural (All progeny in equilibrium)	< 0.3 Bq/g	< 1,000 Bq	0.3 Bq/g to 10 Bq/g	< 1,000 Bq	> 10 Bq/g	< 1,000 Bq
Thorium-232	< 10 Bq/g	< 10,000 Bq	10 Bq/g to 70 Bq/g	< 10,000 Bq	> 70 Bq/g	< 10,000 Bq
Radium-228 (In equilibrium with Ac-228)	< 0.3 Bq/g	< 100,000 Bq	0.3 Bq/g to 70 Bq/g	< 100,000 Bq	> 70 Bq/g	< 100,000 Bq
Thorium-228 (All progeny in equilibrium)	< 0.3 Bq/g	< 10,000 Bq	0.3 Bq/g to 10 Bq/g	< 10,000 Bq	> 10 Bq/g	< 10,000 Bq

Note:

- Contributions by daughter radionuclides are indicated in parentheses. When calculating the specific activity limit and the exempt package activity limit, you do not add contributions from the daughters.
- The PTNSR[4] do not apply to the packaging and transport of NORM provided that it has a specific activity that is less than or equal to 70 Bq/g or an activity concentration that does not exceed 10 times the activity concentration limit for exempt material values set out in the *IAEA Safety Standards Series, Regulations for the Safe Transport of Radioactive Material No. SSR-6*[5] as amended from time to time.

2.1 SPECIFIC ACTIVITY OF NORM-IMPACTED MATERIALS

Specific activity of a radionuclide is the activity per unit mass of that radionuclide and the specific activity of a material is the activity per unit mass or volume of the material in which the radionuclides are essentially uniformly distributed. The first task is to determine what radionuclides make up the materials being classified. The two most common NORM decay series are Uranium-238 and Thorium-232. Industries that concentrate NORM can do so by concentrating radionuclides from both decay series and, as such, the NORM-impacted waste or materials being transported are considered a mixture of radionuclides.

If only one decay series is involved, the activity used in calculating the specific activity limit (Bq/g), and ultimately the jurisdiction to which the transport of NORM-impacted materials falls under, is the activity of the parent radionuclide, providing the daughters are in equilibrium or at concentrations lower than the parent. If a daughter radionuclide in a series is of higher concentrations than the parent, the materials would be considered a mixture. As such, the basic radionuclides values outlined in Table 1 can only be used if the radioactive materials are in secular equilibrium. For NORM materials not in secular equilibrium, the formula for mixtures is applied as follows:[5]

$$\frac{\text{Concentration Radionuclide A}}{\text{UDRL Radionuclide A}} + \frac{\text{Concentration Radionuclide B}}{\text{UDRL Radionuclide B}} + \cdots + \frac{\text{Concentration Radionuclide N}}{\text{UDRL Radionuclide N}} \leq 1$$

The interpretation of this equation is that if the sum of ratios on the left-hand side is less than or equal to one, the UDRL for that mixture is not exceeded.

In order to determine whether a mixture is under provincial or federal jurisdiction, the following formula is used:[5]

$$\frac{\text{Concentration Radionuclide A}}{\text{Exemption Limit Radionuclide A}} + \frac{\text{Concentration Radionuclide B}}{\text{Exemption Limit Radionuclide B}} + \cdots + \frac{\text{Concentration Radionuclide N}}{\text{Exemption Limit Radionuclide N}} \leq 1$$

The interpretation of this equation is that if the sum of ratios on the left-hand side is less than or equal to one, the activity concentration limit for that mixture is not exceeded and the mixture is provincially regulated. On the other hand, if the sum of ratios is greater than one, the activity concentration limit for that mixture is exceeded and the mixture is federally regulated.

Example: A radiochemical analysis showed the following radionuclides were concentrated within the scale:

Ra-228 @ 5.1 Bq/g,
Th-228 @ 7.8 Bq/g
Ra-226 @ 56.1 Bq/g
Pb-210 @ 50 Bq/g

Pb-210 is in equilibrium with its parent Ra-226 or at concentration less than the parent and is not included in the total activity. Th-228, a daughter to Ra-228, must be included in the total activity as it is not included as a daughter in Table 1 for Ra-228.

Although the specific activities of each individual radionuclide are below the levels for federally regulated NORM shown in Table 1, this does not necessarily mean that the mixture is below the activity concentration limit for that mixture. To verify the jurisdiction in which the shipment will fall, the sum of ratios is calculated, using the equation above:

$$\frac{\text{Concentration Ra-228}}{\text{Exemption Limit Ra-228}} + \frac{\text{Concentration Th-228}}{\text{Exemption Limit Th-228}} + \frac{\text{Concentration Ra-226}}{\text{Exemption Limit Ra-226}}$$

$$= \frac{5.1\ \text{Bq/g}}{70\ \text{Bq/g}} + \frac{7.8\ \text{Bq/g}}{10\ \text{Bq/g}} + \frac{56.1\ \text{Bq/g}}{70\ \text{Bq/g}} = 1.65$$

Since the sum of ratios is greater than one, these materials fall under federal jurisdiction and must be transported under one of the United Nations classifications outlined in section 2.5 of these guidelines.

It is recognized that the majority of NORM shipments in Canada do not fall under federal jurisdiction and, as such, imposing industries to complete radiochemical analysis on all shipments, prior to shipping, would be unnecessarily burdensome. Accordingly, activity levels may be based on radiochemical sample analysis or through estimates of activities based on prior history of the NORM-impacted materials being shipped. If it is suspected the shipment might fall under federal transport regulations, a sample analysis is preferred. Only those individuals experienced and suitably trained should classify and offer shipments of NORM-impacted materials.

2.2 TOTAL ACTIVITY OF A PACKAGE

The total activity of a package is the sum of all radionuclides present in the NORM-impacted waste or materials. This is the specific activity of the materials (typically given in Bq/g or Bq/kg) multiplied by the total weight of the shipment.

2.3 UNRESTRICTED DERIVED RELEASE LIMITS (UDRL)

If neither the specific activity nor package activity levels are exceeded, the materials meet the requirements of the UDRL classification. These materials are considered non-radioactive as the radionuclide concentrations have no measurable health or environmental risks from the radioactive materials present. Other hazardous properties that may be part of the shipment must be taken into consideration prior to shipping.[5]

It is recognized that most shipments of waste or materials in Canada fall under this category. It is not practical to complete a radiochemical sample analysis on every shipment. Industries which concentrate NORM are well recognized. These industries must complete gamma screening and contamination surveys to verify if NORM radionuclides have been concentrated. Gamma readings above background indicate NORM radionuclides have likely been concentrated above this classification. Further radiochemical analysis is required to verify which classification the materials fall under. In addition, surface contamination greater than 1 Bq/cm^2 indicates the materials do not meet the UDRL classification.[2]

2.4 PROVINCIALLY REGULATED NORM

Shipments of NORM-impacted materials which fall within provincial government jurisdiction are materials that, although potentially hazardous to health and the environment, pose little hazard to the public during transport. However, emergency response personnel may be at risk due to the potential for inhalation or ingestion. Shipments of these materials pose a minimal hazard and shippers should ensure the following:

a) A manifest is completed and kept within reach of the vehicle operator.

b) The transport manifest contains the descriptor "Naturally Occurring Radioactive Material—NORM".

c) The materials are securely packaged in a manner that effectively prevents the release of any NORM contamination during transport.

d) Shipment has taken into account any other hazardous materials in accordance with the applicable hazardous waste regulations.

e) The shipper has in place a RPP and emergency response plan to ensure safe handling, packaging and transport of the NORM-impacted materials.

NOTE: No placards or labels should be affixed to a conveyance transported under provincial jurisdiction.

2.5 FEDERALLY REGULATED NORM

Shipments of NORM falling under federal jurisdiction pose a higher risk. The health and safety of the public is maintained through appropriate packaging of NORM-impacted materials, limiting the amount of radioactivity in a package and controlling the radiation levels on the transport vehicle. Safety of responders is maintained through appropriate manifests, labels and placards. NORM shipments which fall under this category are typically shipped as one of the following;

I. **UN 2908 RADIOACTIVE MATERIAL, EXCEPTED PACKAGE—EMPTY PACKAGE**

II. **UN 2910 RADIOACTIVE MATERIAL, EXCEPTED PACKAGE—LIMITED QUANTITY OF MATERIAL**

III. **UN 2912 RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I) non-fissile**

IV. **UN 2913 RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-I, SCO-II, SCO-III) non-fissile**

V. **UN 2915 RADIOACTIVE MATERIAL, TYPE A PACKAGE, non-special form, non-fissile**

For shipments of NORM-impacted materials not meeting one of these classifications the reader is referred to the PTNSR.[4]

2.6 RADIOCHEMICAL ANALYSIS

Radiochemical analysis is not required prior to shipping NORM-impacted materials; however, it is required prior to disposal of any NORM waste. Activity estimates for NORM-impacted materials may be based on history and knowledge of the materials being shipped. Numerous test methods for NORM radionuclides exist; however, there is not one test method that will verify the activities of all NORM radionuclides within the U-238 and Th-232 decay series. Gamma spectrometry is commonly used to measure Ra-226, Ra-228, Th-228, Th-230, Th-234, Pb-210 and K-40. If it is suspected U-238, Th-232 or Po-210 are present or concentrated in the sample being analyzed, a separate analysis must be completed for these isotopes. Typically, this can be completed through inductively coupled plasma mass spectrometry (ICP-MS).

CHAPTER 3:

EMPTY PACKAGING

3.0 UN 2908—RADIOACTIVE MATERIALS, EXCEPTED PACKAGE—EMPTY PACKAGING

An empty package, overpack freight container, tank, or conveyance may be classified as RADIOACTIVE MATERIAL, EXCEPTED PACKAGE—EMPTY PACKAGE if it had previously contained NORM.

3.1 NORM ACTIVITY LIMITS FOR EXCEPTED PACKAGE—EMPTY PACKAGING

All NORM packages can be classified as RADIOACTIVE MATERIAL, EXCEPTED PACKAGE—EMPTY PACKAGE under UN 2908 providing the contents of the package meet the following restrictions:[5]

a) The package is an empty package that previously contained NORM.

b) The package meets the activity limits indicated in Table 2.

c) The internal surface contamination levels do not exceed the following:

- 400 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters, and
- 40 Bq/cm^2 for all other alpha emitters.

Table 2. Excepted Package Limits—Empty Package (adapted from IAEA, 2018)[5]

Excepted Package Limits—Empty Package		
NORM Radionuclide	**Package Activity Limits (Liquid)**	**Package Activity Limits (Solid/Gas)**
Uranium-238 Series (All progeny in equilibrium)	No Limit	No Limit
Thorium-230	100,000 Bq	1,000,000 Bq
Radium-226 (All progeny in equilibrium)	300,000 Bq	3,000,000 Bq
Lead-210 (In equilibrium with Bi-210 and Po-210)	5,000,000 Bq	50,000,000 Bq
Thorium-232 Series (All progeny in equilibrium)	No Limit	No Limit
Thorium-232	No Limit	No Limit
Radium-228 (In equilibrium with Ac-228)	2,000,000 Bq	20,000,000 Bq
Thorium-228 (All progeny in equilibrium)	100,000 Bq	1,000,000 Bq

Mixtures of radionuclides in an excepted package must also meet the following condition:[5]

$$\frac{\text{Package Activity Radionuclide A}}{\text{Package Activity Limit A}} + \frac{\text{Package Activity Radionuclide B}}{\text{Package Activity Limit B}} + \cdots + \frac{\text{Package Activity Radionuclide N}}{\text{Package Activity Limit N}} \leq 1$$

3.2 PACKAGE REQUIREMENTS—EMPTY PACKAGING

A NORM shipment transported as RADIOACTIVE MATERIAL, EXCEPTED PACKAGE—EMPTY PACKAGE under UN 2908 must be a package that is well maintained and securely closed.[5] In addition, the package must meet the general packaging requirements as noted in section 1.9.

3.3 MAXIMUM RADIATION LEVELS—EMPTY PACKAGING

The dose rate at any point on the external surface of an empty package shall not exceed 5 μSv/hr.[5]

3.4 NON-FIXED SURFACE CONTAMINATION LIMITS—EMPTY PACKAGING

The non-fixed contamination on the external surfaces of an excepted package and the internal surface of any overpack, freight container, tank or conveyance shall be kept ALARA and, under routine conditions of transport, shall not exceed the following limits:[5]

- 4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters averaged over 300 cm^2, and
- 0.4 Bq/cm^2 for all other alpha emitters averaged over 300 cm^2.

Packages which are damaged or leaking radioactive contents in excess of the above limits, during transport, should be removed to an acceptable interim location under supervision, but shall not be forwarded until repaired and the external surface of the package decontaminated.[5]

3.5 USE AND DECONTAMINATION OF CONVEYANCES, EQUIPMENT AND PARTS—EMPTY PACKAGING

A conveyance used regularly for the transport of NORM shall be periodically checked to determine the level of contamination.[5] The frequency of such checks shall be related to the likelihood of contamination and the extent to which NORM-impacted materials are transported.[5] Contamination found in excess of those limits in 3.4 above shall be decontaminated as soon as practicable. In addition, empty packages should never be used to store or transport other materials unless decontaminated to below the UDRL for surface contamination in the Canadian NORM Guidelines.[2]

3.6 MIXED PACKAGE CONTENTS—EMPTY PACKAGING

No specific restrictions.

3.7 LOADING AND SEGREGATION—EMPTY PACKAGING

No specific restrictions.

3.8 LABELLING AND MARKINGS—EMPTY PACKAGING

Previous labels and markings must be removed, and the package marked, on the exterior surface, with the United Nations number UN 2908. Packages must also be clearly marked with either the consignor or consignee name.[5] Other dangerous properties within these packages must be labelled and marked in accordance with the TDGR.[3]

3.9 PLACARDS—EMPTY PACKAGING

Class 7 placards are not required for excepted packages;[4] however, placards for other dangerous properties may be required under the TDGR.[3]

3.10 TRANSPORT DOCUMENTS—EMPTY PACKAGING

The consignor shall include in the transport documents the name and address of the consignor with the following waste descriptor:

UN 2908 RADIOACTIVE MATERIAL, EXCEPTED PACKAGE—EMPTY PACKAGE

3.11 STORAGE AND DISPATCH—EMPTY PACKAGING

No specific requirements.

3.12 CARRIAGE OF PACKAGES, FREIGHT CONTAINERS AND TANKS—EMPTY PACKAGING

No specific requirements.

CHAPTER 4:

LIMITED QUANTITY OF MATERIAL

4.0 UN 2910—EXCEPTED PACKAGES—LIMITED QUANTITY OF MATERIAL

Packages may be classified as an "Excepted Package—Limited Quantity of Material" if the package contains limited quantities of radioactive materials. The following provides a summary of the main requirements for transport of NORM in an Excepted Package—Limited Quantity of Material.

4.1 NORM ACTIVITY LIMITS FOR EXCEPTED PACKAGE—LIMITED QUANTITY OF MATERIAL

NORM materials that meet the Federally Regulated Category are suitable for an excepted package providing the total package activity does not exceed the values listed in Table 3. Those radionuclides which are not applicable should not be transported in an excepted package.

Table 3. Excepted Package Limits—Limited Quantity of Material (adapted from IAEA, 2018)[5]

Excepted Package Limits		
NORM Radionuclide	**Package Activity Limits (Liquid)**	**Package Activity Limits (Solid/Gas)**
Uranium-238 Series (All progeny in equilibrium)	N/A	N/A
Thorium-230	100,000 Bq	1,000,000 Bq
Radium-226 (All progeny in equilibrium)	300,000 Bq	3,000,000 Bq
Lead-210 (In equilibrium with Bi-210 and Po-210)	5,000,000 Bq	50,000,000 Bq
Thorium-232 Series (All progeny in equilibrium)	N/A	N/A
Thorium-232	N/A	N/A
Radium-228 (In equilibrium with Ac-228)	2,000,000 Bq	20,000,000 Bq
Thorium-228 (All progeny in equilibrium)	100,000 Bq	1,000,000 Bq

Mixtures of radionuclides in an excepted package must also meet the following condition:[5]

$$\frac{\text{Package Activity Radionuclide A}}{\text{Package Activity Limit A}} + \frac{\text{Package Activity Radionuclide B}}{\text{Package Activity Limit B}} + \cdots + \frac{\text{Package Activity Radionuclide N}}{\text{Package Activity Limit N}} \leq 1$$

4.2 PACKAGE REQUIREMENTS—LIMITED QUANTITY OF MATERIAL

A NORM shipment transported as RADIOACTIVE MATERIAL, EXCEPTED PACKAGE—LIMITED QUANTITY OF MATERIAL under UN 2910 must be in a package that retains its radioactive contents under routine conditions of transport[5] and must meet the general packaging requirements as noted in section 1.9.

4.3 MAXIMUM RADIATION LEVELS—LIMITED QUANTITY OF MATERIAL

The dose rate at any point on the external surface of an excepted package shall not exceed 5 μSv/hr.[5]

4.4 NON-FIXED SURFACE CONTAMINATION LIMITS—LIMITED QUANTITY OF MATERIAL

The non-fixed contamination on the external surfaces of an excepted package and the internal surface of any overpack, freight container, tank or conveyance shall be kept ALARA and, under routine conditions of transport, shall not exceed the following limits:[5]

- 4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters averaged over 300 cm^2, and
- 0.4 Bq/cm^2 for all other alpha emitters averaged over 300 cm^2.

Packages which are damaged or leaking radioactive contents, during transport, in excess of the above limits may be removed to an acceptable interim location under supervision, but shall not be forwarded until repaired and the external surface of the package decontaminated.[5]

4.5 USE AND DECONTAMINATION OF CONVEYANCES, EQUIPMENT AND PARTS—LIMITED QUANTITY OF MATERIAL

A conveyance used regularly for the transport of NORM shall be periodically checked to determine the level of contamination.[5] The frequency of such checks shall be related to the likelihood of contamination and the extent to which NORM-impacted materials are transported.[5] Contamination found in excess of those limits in section 4.4 above shall be decontaminated as soon as practicable. In addition, empty packages should never be used to store or transport other materials unless decontaminated to below the UDRL for surface contamination in the Canadian NORM Guidelines.[2]

4.6 MIXED PACKAGE CONTENTS—LIMITED QUANTITY OF MATERIAL

No specific restrictions.

4.7 LOADING AND SEGREGATION—LIMITED QUANTITY OF MATERIAL

No specific restrictions.

4.8 LABELLING AND MARKINGS OF EXCEPTED PACKAGES—LIMITED QUANTITY OF MATERIAL

Previous labels and markings must be removed, and the package marked, on the exterior surface, with

the United Nations number UN 2910. Packages must also be clearly marked with either the consignor or consignee name.[5] Wastes that exhibit other dangerous properties within these packages must be labelled and marked in accordance with the TDGR.[3]

4.9 PLACARDS—LIMITED QUANTITY OF MATERIAL

Class 7 placards are not required for excepted packages;[4] however, placards for other dangerous properties are required under the TDGR.[3]

4.10 TRANSPORT DOCUMENTS—LIMITED QUANTITY OF MATERIAL

The consignor shall include in the transport documents the name and address of the consignor with the following waste descriptor:

UN 2910 RADIOACTIVE MATERIAL, EXCEPTED PACKAGE—LIMITED QUANTITY OF MATERIAL

4.11 STORAGE AND DISPATCH—LIMITED QUANTITY OF MATERIAL

There are no specific requirements for storage of materials during transport. Shipment by Canada Post is not permitted.

4.12 CARRIAGE OF PACKAGES, FREIGHT CONTAINERS AND TANKS—LIMITED QUANTITY OF MATERIAL

No specific requirements.

CHAPTER 5:

LOW SPECIFIC ACTIVITY

5.0 UN 2912—RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I)

Low Specific Activity means radioactive materials, which by their nature have a limited specific activity or amount of radioactive materials for which limits of estimated average specific activity apply.[5]

5.1 NORM ACTIVITY LIMITS FOR LSA-I MATERIALS

LSA-I NORM materials are suitable for an excepted package providing the total package activity does not exceed the values as listed in Table 4.

Table 4. Package Activity Limits—Low Specific Activity (LSA-I) (adapted from IAEA, 2018)[5]

Low Specific Activity—Package Limits	
NORM Radionuclide	**Package Activity Limit (Solid)**
Uranium-238 Series (All progeny in equilibrium)	No Limit
Thorium-230	30 GBq
Radium-226 (All progeny in equilibrium)	90 GBq
Lead-210 (In equilibrium with Bi-210 and Po-210)	1,500 GBq
Thorium-232 Series (All progeny in equilibrium)	No Limit
Thorium-232	No Limit
Radium-228 (In equilibrium with Ac-228)	600 GBq
Thorium-228 (All progeny in equilibrium)	3 GBq

Mixtures of LSA-I radionuclides must also meet the following condition:[5]

$$\frac{\text{Package Activity Radionuclide A}}{\text{Package Activity Limit A}} + \frac{\text{Package Activity Radionuclide B}}{\text{Package Activity Limit B}} + \cdots + \frac{\text{Package Activity Radionuclide N}}{\text{Package Activity Limit N}} \leq 1$$

5.2 PACKAGE REQUIREMENTS FOR LSA-I MATERIALS

According to the PTNSR,[4] LSA-I NORM must be shipped in Type IP-3 packages unless shipped by the following means:

1. LSA-I material may be transported unpackaged in accordance with the IAEA Regulations, but must be transported in a manner that ensures that, under routine conditions of transport, there will be no escape of the radioactive contents from the conveyance or any loss of shielding.[5]
2. LSA-I material may be transported in Type IP-1 packages and Type IP-2 packages in accordance with the IAEA Regulations if the LSA material

a) is transported in conveyances that are not carrying passengers;

b) is transported in conveyances or freight containers from one consignor only; and

c) is only loaded at the consignor's location and unloaded at the consignee's location.

5.3 MAXIMUM RADIATION LEVELS FOR LSA-I MATERIALS

LSA-I NORM shipment radiation levels must not exceed the following:

a) 2 mSv/hr on contact of the external surface of the package and 0.1 mSv/hr at 1 m from the external surface of the package, except under exclusive use.

b) The radiation level for a package under exclusive use may exceed 2 mSv/hr but not more than 10 mSv/hr providing the vehicle is equipped with an enclosure that prevents access during transport, the package is secured to retain its position within the enclosure and there are no loading or unloading operations between the beginning and end of shipment.

c) Although the packages may exceed 2 mSv/hr on contact under exclusive use, the transport vehicle still cannot exceed 2 mSv/hr on contact and 0.1 mSv/hr at 2 m from the external surface of the conveyance.

d) At no time should packages over 2 mSv/hr on contact be transported by air except under special arrangement.

5.4 NON-FIXED SURFACE CONTAMINATION LIMITS FOR LSA-I MATERIALS

Non-fixed surface contamination on external surfaces of packages and on the internal surfaces and external surfaces of overpacks, freight containers, tanks and intermediate bulk containers should be kept as low as practicable and at no time exceed the following:

- 4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters averaged over 300 cm^2, and
- 0.4 Bq/cm^2 for all other alpha emitters averaged over 300 cm^2.

Packages which are damaged or leaking radioactive contents, during transport, in excess of the above limits may be removed to an acceptable interim location under supervision, but shall not be forwarded until repaired and the external surface of the package decontaminated.

5.5 USE AND DECONTAMINATION OF CONVEYANCES, EQUIPMENT AND PARTS FOR LSA-I MATERIALS

A conveyance used regularly for the transport of NORM should be periodically checked to determine the level of contamination.[5] The frequency of such checks should be related to the likelihood of contamination and the extent to which NORM-impacted materials are transported.[5] Contamination found in excess of those limits in section 5.4 above shall be decontaminated as soon as practicable. In addition, empty packages should never be used to store or transport other materials unless decontaminated to below the UDRL in the Canadian NORM Guidelines.[2]

NOTE: Conveyances dedicated to LSA-I NORM are exempt from these limits only for internal surfaces and only while under exclusive use.

5.6 MIXED PACKAGE CONTENTS FOR LSA-I MATERIALS

LSA-I NORM can be transported with other materials or items if no unsafe interactions can occur.

5.7 LOADING AND SEGREGATION OF LSA-I MATERIALS

Consignments must be segregated from other dangerous goods. If transport is exclusive use, other goods may be carried if the consignment arrangements are under the direct control of the consignor, and other regulations do not prohibit the arrangement.

5.8 LABELLING AND MARKINGS OF PACKAGES, FREIGHT CONTAINERS, TANKS AND OVERPACKS FOR LSA-I MATERIALS

Packages of NORM LSA-I must be assigned an appropriate category I-WHITE, II-YELLOW or III-YELLOW label as noted below.

In order to determine the appropriate label, the transport index (TI) must first be calculated. The TI is calculated by determining the radiation level in millisieverts per hour at a distance of 1 metre from the package, overpack, freight container or unpackaged LSA-I materials. Multiply the radiation level by 100 and the resulting value shall be the TI. The value should be rounded up to the first decimal point (e.g. 1.13 becomes 1.2) with the exception that a value of 0.05 or less may be considered zero.

For large dimensional loads (tanks, freight containers and unpackaged LSA-I NORM), the TI must be further multiplied by the appropriate factor as noted in Table 5.

Table 5. Multiplication Factor for Large Dimension Loads (adapted from IAEA, 2018)[5]

Size of Load (Largest cross-sectional area of load being measured)	Multiplication Factor
Size of Load ≤ $1m^2$	1
Size of Load ≥ $1m^2$ and ≤ $5\ m^2$	2
Size of Load ≥ $5m^2$ and ≤ $20\ m^2$	3
Size of Load ≥ $20\ m^2$	10

The transport index for each overpack, freight container or conveyance can be determined by the sum of transport indices or by direct measurement. In determining the appropriate label both the surface radiation level and transport index shall be taken into account as noted in Table 6.

Table 6. Categories of Packages and Overpacks (adapted from IAEA, 2018)[5]

Conditions		
Transportation Index	**Maximum Radiation Level at Any Point on External Surface**	**Category**
0[a]	Not more than 5 μSv/hr	I-WHITE
More than 0 but not more than 1[a]	More than 5 μSv/hr but not more than 500 μSv/hr	II-YELLOW
More than 1 but not more than 10	More than 500 μSv/hr but not more than 2 mSv/hr	III-YELLOW
More than 10	More than 2 mSv/hr but not more than 10 mSv/hr	III-YELLOW[b]

(a) If the measured TI is not greater than 0.05 then the value shall be zero.
(b) Shall be transported only under exclusive use.

Where the TI satisfies the condition for one category, but the surface dose rate satisfies the condition of a different category, the package shall be assigned to the higher category.[5] Once the appropriate label has been determined, it should be legibly and durably marked as noted below and affixed to two opposite external sides of the package or all four sides of a freight container or tank when used as packages.

a) The contents line of the label should be marked with "LSA-I".

b) The activity line marked in total becquerels with the appropriate SI prefix.

c) The TI marked for categories II-YELLOW and III-YELLOW only.

In addition to the appropriate label, each package must be marked legibly and durably on the outside of the package identifying the consignor or consignee, the UN number "UN 2912" and proper shipping name "RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I) non-fissile" and the package permissible gross mass if over 50 kg.

5.9 PLACARDING OF VEHICLES, FREIGHT CONTAINERS AND TANKS FOR LSA-I MATERIALS

Placards should be marked with the UN number "UN 2912" in the lower half of the class 7 placard and affixed to vehicles, freight containers and tanks as follows:

a) Large freight containers and tanks shall bear four placards. The placards shall be affixed in a vertical orientation to the two external side walls and the two external end walls. As an alternative to placards for large freight containers, enlarged labels (250 mm X 250 mm) may be used.

b) Placards must be affixed in a vertical orientation to the two external lateral walls of a rail vehicle.

c) Placards must be affixed in a vertical orientation to the two external lateral walls and the external rear wall of a road vehicle.

d) Placards for other dangerous properties must be used as required under the TDGR.[3]

5.10 TRANSPORT DOCUMENTS FOR LSA-I MATERIALS

The consignor shall include in the transport documents with each consignment the identification of the consignor and consignee, including their names and addresses and the date the shipping document or an electronic copy of it was prepared or was first given to a carrier as well as the following information, as applicable, in the order given:

a) United Nations number "UN 2912".

b) The proper shipping name "RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I) non-fissile".

c) United Nations class number "Class 7".

d) The subsidiary hazard class or division number(s) corresponding to the subsidiary hazard label(s) required to be applied, when assigned, shall be entered following the primary hazard class or division and shall be enclosed in parentheses.

e) The name or symbol of each radionuclide or, for mixtures of radionuclides, an appropriate general description or a list of the most restrictive nuclides.

f) A description of the physical and chemical form of the material (a generic chemical description is acceptable for chemical).

g) The maximum activity of the radioactive contents during transport expressed in units of becquerels (Bq) with the appropriate SI prefix symbol in units of grams (g), or appropriate multiples thereof, may be used in place of activity.

h) The category of the package, overpack or freight container, as assigned (I-WHITE, II-YELLOW, III-YELLOW).

i) The transport index, if applicable.

j) For consignments of more than one package, the information contained above shall be given for each package. For packages in an overpack, freight container or conveyance, a detailed

statement of the contents of each package within the overpack, freight container or conveyance and, where appropriate, of each overpack, freight container or conveyance shall be included. If packages are to be removed from the overpack, freight container or conveyance at a point of intermediate unloading, appropriate transport documents shall be made available.

k) Where a consignment is required to be under exclusive use, the statement "EXCLUSIVE USE SHIPMENT" must be included.

l) Any additional hazardous waste with the shipment including the subsidiary class or classes, in parentheses, which may be shown as a number only or under the heading "subsidiary class" or "classe subsidiaire" or following the words "subsidiary class" or "classe subsidiaire".

m) A declaration that the contents of the consignment are fully and accurately classified, packed, marked and labelled, and in all respects in proper condition for transport by (insert mode(s) involved) according to the PTNSR.[4]

n) The consignor shall provide in the transport documents a statement regarding actions, if any, that are to be taken by the carrier including any supplementary requirements for loading, stowage, carriage, handling and unloading of the package, overpack or freight containers and any restrictions on the mode of transport or conveyance and any necessary routing instructions or emergency arrangements to the consignment.

5.11 STORAGE AND DISPATCH FOR LSA-I MATERIALS

Segregation during transport or storage should be undertaken so as to not cause an effect on other goods.

5.12 CARRIAGE OF PACKAGES, FREIGHT CONTAINERS, TANKS AND OVERPACKS FOR LSA-I MATERIALS

a) Unpackaged LSA-I Material can *only be transported* under *exclusive use*.

b) No limit on the total TI.

c) Any package or overpack having a TI greater than 10 must be transported under exclusive use.

d) No limit on the total activity limit in a single conveyance.

e) Shipment by Canada Post is not permitted.

f) For transport by road, no person other than the driver and assistants shall be permitted in vehicles carrying packages, overpacks or freight containers bearing category II-YELLOW or II-YELLOW labels.

g) Category II-YELLOW and III-YELLOW packages or overpacks shall not be carried in compartments occupied by passengers except those exclusively reserved for couriers authorized to accompany the packages or overpacks.

h) An ERAP must be filed with Transport Canada for quantities in excess of 100 kg.

CHAPTER 6:

SURFACE CONTAMINATED OBJECTS

6.0 UN 2913—SURFACE CONTAMINATED OBJECTS (SCO-I, SCO-II AND SCO-III)

A surface contaminated object is a solid object which, in itself, is not radioactive but which has radioactive materials distributed on its surface. There are three groups of surface contaminated objects, SCO-I, SCO-II and SCO-III, which differ in the maximum level of contamination permitted.

6.1 NORM ACTIVITY LIMITS FOR SURFACE CONTAMINATED OBJECTS

A solid, non-radioactive object which has radioactive materials distributed on its surface may be classified as SCO-I, SCO-II, or SCO-III when the specific activity of the radioactive materials exceeds the requirements for provincial regulated NORM as outlined in Table 1 and when the fixed and non-fixed surface contamination levels do not exceed levels as outlined in Table 7.

Table 7. NORM Surface Contamination Limits for SCO-I, SCO-II and SCO-III (adapted from IAEA, 2018)[5]

Type of Contamination (Bq/cm^2)				
Type of Emitters		Non-fixed on Accessible Surface	Fixed on accessible surface	Sum of fixed and non-fixed on accessible surface
SCO-I	Beta and gamma emitters and low toxicity alpha emitters	4	4×10^4	4×10^4
	All other alpha emitters	0.4	4×10^3	4×10^3
SCO-II	Beta and gamma emitters and low toxicity alpha emitters	400	8×10^5	8×10^5
	All other alpha emitters	40	8×10^4	4×10^4
SCO-III	Beta and gamma emitters and low toxicity alpha emitters	4	—	8×10^5
	All other alpha emitters	0.4	—	8×10^4

Note:

(a) Contamination limits are averaged over 300 cm^2 or less if the surface area of interest is less than 300 cm^2.

(b) When the activity of the radioactive materials on the surface of objects or equipment cannot reasonably be determined to verify to be less than 10 times the A_2 value to a maximum of 70 Bq/g (determination of exemption from the PTNSR) then surface contamination that exceeds 10 Bq/cm^2 should be considered to fall under the PTNSR as it is 10 times the UDRL as outlined in the Canadian NORM Guidelines.[2]

6.2 PACKAGE REQUIREMENTS FOR SURFACE CONTAMINATED OBJECTS

a) SCO-I can be transported unpackaged if it is transported in such a manner that, under routine transport condition, there is no escape of contents from the conveyance.

b) An unpackaged SCO-I shipment must be transported under exclusive use if it is suspected that non-fixed contamination exists on inaccessible surfaces in excess of 4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters, or 0.4 Bq/cm^2 for all other alpha emitters.

c) SCO-I materials can be transported not under exclusive use, as noted in (b) above, providing the smallest overall dimension of the package is less than 10 cm and it is packaged in a manner that meets the general packaging requirements as noted in section 1.9. Packages that meet these requirements also meet the requirements of an industrial package Type 1 (Type IP-1) as outlined by IAEA.

d) SCO-II must be transported in a package that meets the general packaging requirements outlined in section 1.9 and the following requirements:

   1. The smallest overall dimension of the package shall not be less than 10 cm.
   2. The outside of the package shall incorporate a feature such as a seal, which is not readily breakable and which, while intact, will be evidence that it has not been opened.
   3. Any tie-down attachments on the package shall be so designed that, under normal and accidental conditions of transport, the forces in those attachments shall not impair the ability of the package to meet the requirements of these guidelines.
   4. The design of the package shall take into account temperatures ranging from –40°C to + 70°C for the components of the packaging. Attention shall be given to freezing temperatures for liquids and to the potential degradation of packaging materials within the given temperature range.

Packages that meet the above requirements, also meet the requirements of an industrial package type 3 (Type IP-3) outlined by IAEA.

6.3 MAXIMUM RADIATION LEVELS FOR SURFACE CONTAMINATED OBJECTS

Radiation levels for NORM shipments of surface contaminated objects must not exceed the following:

a) 2 mSv/hr on contact of the external surface of the package and 0.1 mSv/hr at 1 m from the external surface of the package, except under exclusive use.

b) The radiation level for a package under exclusive use may exceed 2 mSv/hr but not more than 10 mSv/hr providing the vehicle is equipped with an enclosure that prevents access during transport, the package is secured to retain its position within the enclosure, and there is no loading or unloading operations between the beginning and end of shipment.

c) Although the packages may exceed 2 mSv/hr on contact under exclusive use, the transport vehicle still cannot exceed 2 mSv/hr on contact and 0.1 mSv/hr at 2 m from the external surface of the conveyance.

d) At no time should packages over 2 mSv/hr on contact be transported by air except under special arrangement.

6.4 NON-FIXED SURFACE CONTAMINATION LIMITS FOR SURFACE CONTAMINATED OBJECTS

Non-fixed surface contamination on external surfaces of packages and on the internal surfaces and external surfaces of overpacks, freight containers, tanks and intermediate bulk containers should be kept as low as practicable and at no time exceed the following:

- 4 Bq/cm^2 for gamma, beta and low toxicity alpha emitters averaged over 300 cm^2, and
- 0.4 Bq/cm^2 for all other alpha emitters averaged over 300 cm^2.

Packages which are damaged or leaking radioactive contents, during transport, in excess of the above limits may be removed to an acceptable interim location under supervision, but shall not be forwarded until repaired and the external surface of the package decontaminated.

6.5 USE AND DECONTAMINATION OF CONVEYANCES, EQUIPMENT AND PARTS FOR SURFACE CONTAMINATED OBJECTS

A conveyance used regularly for the transport of NORM should be periodically checked to determine the level of contamination.[5] The frequency of such checks should be related to the likelihood of contamination and the extent to which NORM-impacted materials are transported.[5] Contamination found in excess of those limits in section 6.4 above shall be decontaminated as soon as practicable. In addition, empty packages should never be used to store or transport other materials unless decontaminated to below the UDRL in the Canadian NORM Guidelines.[2]

6.6 MIXED PACKAGE CONTENTS FOR SURFACE CONTAMINATED OBJECTS

Surface contaminated objects can be transported with other materials or items if no unsafe interactions can occur.

6.7 LOADING AND SEGREGATION OF SURFACE CONTAMINATED OBJECTS

Surface contaminated objects must be transported under exclusive use if, in a single package or overpack, the sum of transport indices is greater than 10 or in the case of a freight container, conveyance or watercrafts the sum of transport indices exceeds 50.

There is no limit on the sum of transport indices for a single conveyance under exclusive use.

6.8 LABELLING AND MARKING OF PACKAGES, FREIGHT CONTAINERS, TANKS AND OVERPACKS FOR SURFACE CONTAMINATED OBJECTS

Packages of surface contaminated objects must be assigned an appropriate category I-WHITE, II-YELLOW or III-YELLOW label as noted below.

In order to determine the appropriate label, the transport index must first be calculated. The transport index is calculated by determining the radiation level in millisieverts per hour at a distance of 1 metre from the package, overpack, freight container or unpackaged surface contaminated objects. Multiply the radiation level by 100 and the resulting value shall be the transport index. The value should be rounded up to the first decimal point (e.g. 1.13 becomes 1.2) with the exception that a value of 0.05 or less may be considered zero.

For large dimensional loads (tanks, freight containers and unpackaged surface contaminated objects) the transport index must be further multiplied by the appropriate factor as noted in Table 8.

Table 8. Multiplication Factor for Large Dimension Loads (adapted from IAEA, 2018)[5]

Size of Load (Largest cross-sectional area of load being measured)	Multiplication Factor
Size of Load ≤ 1 m^2	1
Size of Load ≥ 1 m^2 and ≤ 5 m^2	2
Size of Load ≥ 5 m^2 and ≤ 20 m^2	3
Size of Load ≥ 20 m^2	10

The transport index for each overpack, freight container or conveyance can be determined by the sum of transport indices or by direct measurement. In determining the appropriate label both the surface radiation level and transport index shall be taken into account as noted in Table 9.

Table 9. Categories of Packages and Overpacks (adapted from IAEA, 2018)[5]

Conditions		
Transportation Index	**Maximum Radiation Level at Any Point on External Surface**	**Category**
0[a]	Not more than 5 μSv/hr	I-WHITE
More than 0 but not more than 1[a]	More than 5 μSv/hr but not more than 500 μSv/hr	II-YELLOW
More than 1 but not more than 10	More than 500 μSv/hr but not more than 2 mSv/hr	III-YELLOW
More than 10	More than 2 mSv/hr but not more than 10 mSv/hr	III-YELLOW[b]

(a) If the measured TI is not greater than 0.05 the value shall be zero.
(b) Shall be transported only under exclusive use.

Where the transport index satisfies the condition for one category, but the surface radiation satisfies the condition of a different category, the package shall be assigned to the higher category.

Once the appropriate label has been determined, it should be legibly and durably marked as noted below and affixed to two opposite external sides of the package or all four sides of a freight container or tank when used as packages.

a) The contents line of the label should be marked with the name of the radionuclide or in the case of mixtures the name of the most restrictive radionuclide followed by SCO-I, SCO-II or SCO-III as appropriate.

b) The activity line marked in total becquerels with the appropriate SI prefix.

c) The TI marked for categories II-YELLOW and III-YELLOW only.

In addition to the appropriate label, each package must be marked legibly and durably on the outside of the package identifying either the consignor or consignee, the UN number "UN 2913" and proper shipping name "RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECT (SCO-I, SCO-II or SCO-II) non-fissile" and the package permissible gross mass if over 50 kg.

Surface Contaminated Objects must be packaged in IP-3 packages except in the following circumstances:

1. SCO-I may be transported unpackaged in accordance with the IAEA Regulations, but must be transported in a manner that ensures that, under routine conditions of transport, there will be no escape of the radioactive contents from the conveyance or any loss of shielding.
2. SCO may be transported in Type IP-1 packages and Type IP-2 packages in accordance with the IAEA Regulations if the Surface Contaminated Objects are:
    a) transported in conveyances that are not carrying passengers;
    b) transported in conveyances or freight containers from one consignor only; and
    c) only loaded at the consignor's location and unloaded at the consignee's location.

SCO-I packages should have the external portion of the package marked with the words "Type IP-1" and SCO-II should be marked "Type IP-2".

6.9 PLACARDING OF VEHICLES, FREIGHT CONTAINERS AND TANKS FOR SURFACE CONTAMINATED OBJECTS

Placards should be affixed to vehicles, freight containers and tanks as follows:

a) The primary class placard for each of the dangerous goods contained in a large means of containment, other than a vessel or an aircraft, must be displayed on each side and on each end of the large means of containment (TDGR).

b) Placards for other dangerous properties as required under the TDGR.[3]

6.10 TRANSPORT DOCUMENTS FOR SURFACE CONTAMINATED OBJECTS

The consignor shall include in the transport documents with each consignment the identification of the consignor and consignee, including their names and addresses and the date the shipping document or an electronic copy of it was prepared or was first given to a carrier as well as the following information, as applicable, in the order given:

a) United Nations number "UN 2913".

b) The proper shipping name "RADIOACTIVE MATERIALS, SURFACE CONTAMINATED OBJECTS (SCO-I, SCO-II or SCO-III), non-fissile".

c) United Nations class number "Class 7".

d) The subsidiary hazard class or division number(s) corresponding to the subsidiary hazard label(s) required to be applied, when assigned, shall be entered following the primary hazard class or division and shall be enclosed in parentheses.

e) The name or symbol of each radionuclide or, for mixtures of radionuclides, an appropriate general description or a list of the most restrictive nuclides.

f) A description of the physical and chemical form of the material. A generic chemical description is acceptable for chemical.

g) The maximum activity of the radioactive contents during transport expressed in units of becquerels (Bq) with the appropriate SI prefix symbol in units of grams (g), or appropriate multiples thereof, may be used in place of activity.

h) The category of the package, overpack or freight container, as assigned (I-WHITE, II-YELLOW, III-YELLOW).

i) The transport index, if applicable.

j) For consignments of more than one package, the information contained above shall be given for each package. For packages in an overpack, freight container or conveyance, a detailed statement of the contents of each package within the overpack, freight container or conveyance and, where appropriate, of each overpack, freight container or conveyance shall be included. If packages are to be removed from the overpack, freight container or conveyance at a point of intermediate unloading, appropriate transport documents shall be made available.

k) Where a consignment is required to be under exclusive use, the statement "EXCLUSIVE USE SHIPMENT" must be included.

l) Any additional hazardous waste with the shipment including the subsidiary class or classes, in parentheses, which may be shown as a number only or under the heading "subsidiary class" or "classe subsidiaire" or following the words "subsidiary class" or "classe subsidiaire".

m) A declaration that the contents of the consignment are classified, packed, marked and labelled and, in all respects, in proper condition for transport by (insert mode(s) involved) according to the PTNSR.[4]

n) The consignor shall provide in the transport documents a statement regarding actions, if any, that are to be taken by the carrier including any supplementary requirements for loading, stowage, carriage, handling and unloading of the package, overpack or freight containers and any restrictions on the mode of transport or conveyance and any necessary routing instructions or emergency arrangements for the consignment.

6.11 STORAGE AND DISPATCH FOR SURFACE CONTAMINATED OBJECTS

Segregation during transport or storage should be undertaken so as to not cause an effect on other goods.

6.12 CARRIAGE OF PACKAGES, FREIGHT CONTAINERS, TANKS AND OVERPACKS FOR SURFACE CONTAMINATED OBJECTS

a) SCO-I may be transported where it is suspected that non-fixed contamination on inaccessible surfaces is greater than 4 Bq/cm^2 for gamma, beta and low toxicity alpha emitters or 0.4 Bq/cm^2 for all other alpha emitters providing measures are taken to ensure radioactive materials are not released into the conveyance providing it is under exclusive use.

b) SCO-II must be packaged.

c) For transport by road, no person other than the driver and assistants shall be permitted in vehicles carrying packages, overpacks or freight containers bearing category II-YELLOW or III-YELLOW labels.

d) For transport by air or vessel, Category II-YELLOW and III-YELLOW packages or overpacks shall not be carried in compartments occupied by passengers except those exclusively reserved for couriers specially authorized to accompany the packages or overpacks.

e) Individual packages and overpacks with TI greater than 10 must be transported under "EXCLUSIVE USE".

CHAPTER 7:

TYPE A PACKAGES

7.0 UN 2915—RADIOACTIVE MATERIAL, TYPE A PACKAGE

NORM with activities greater than those allowed for transport under provincial authority, and in quantities that represent a limited radiation risk during transport, may be transported in a Type A package. This type of package is designed to withstand normal conditions of transport for the materials being transported (solids and liquids). The following are requirements for Type A packages.

7.1 ACTIVITY LIMITS FOR TYPE A PACKAGES

If only one decay series is involved, the activity used in calculating the total package activity limits for a Type A package are noted in Table 10. In calculating the total package activity, the daughter radionuclides do not need to be considered if in equilibrium. There is no limit on individual isotope activity (Bq/g), only package activity, for Type A packages.

Table 10. Package Activity Limits—Type A Package (adapted from IAEA, 2018)[5]

NORM Radionuclide	Package Activity Limit A_2 Value
Uranium-238 Series (All progeny)	No Limit
Thorium-230	1 GBq
Radium-226 (In equilibrium with its progeny)	3 GBq
Lead-210 (In equilibrium with Bi-210 and Po-210)	50 GBq
Thorium-232 Series (All progeny)	No Limit
Thorium-232	No Limit
Radium-228 (In equilibrium with Ac-228)	20 GBq
Thorium-228 (In equilibrium with its progeny)	1 GBq

If a daughter radionuclide in a series is of higher concentration than the longer-lived parent, the materials would be considered a mixture and must also meet the following condition:[5]

$$\frac{\text{Activity of radionuclide A}}{\text{Package Limit Radionuclide A}} + \frac{\text{Activity of radionuclide B}}{\text{Package Limit Radionuclide B}} + \cdots + \frac{\text{Activity of Radionuclide N}}{\text{Package Limit Radionuclide N}} \leq 1$$

7.2 PACKAGE REQUIREMENTS FOR TYPE A PACKAGES

In addition to the general requirements for packages outlined in section 1.9, a Type A package must meet the following requirements (adapted from IAEA, 2018):[5]

a) The smallest overall dimensions of a Type A package shall not be less than 10 cm.

b) The outside of the package shall incorporate a feature such as a seal, which is not readily breakable and which, while intact, will be evidence that it has not been opened.

c) Any tie-down attachments on the package shall be so designed that, under normal and accidental conditions of transport, the forces in those attachments shall not impair the ability of the package to meet the requirements of these guidelines.

d) The design of the package shall take into account temperatures ranging from –40°C to +70°C for the components of the packaging. Attention should be given to freezing temperatures for liquids and to the potential degradation of packaging materials within the given temperature range.

e) The design shall incorporate a containment system securely closed by a positive fastening device which cannot be opened unintentionally or by pressure which may arise within the package.

f) If the containment system forms a separate unit of the package, it shall be capable of being securely closed by a positive fastening device which is independent of any other part of the package.

g) The containment system shall retain its radioactive contents under a reduction of ambient pressure to 60 kPa.

h) All valves, other than pressure relief valves, shall be provided with an enclosure to retain any leakage from the valve.

i) The design of a package intended for liquid radioactive material shall make provisions for ullage to accommodate variations in temperature of the contents, dynamic effects and filling dynamics.

In addition to these requirements, according to the IAEA,[5] a Type A package shall be so designed that, if it were subject to the following tests, it would prevent the loss or dispersal of its radioactive contents:

Water Spray Test—The specimen shall be subject to a water spray test that simulates exposure to rainfall of approximately 5 cm per hour rainfall for at least one hour.

Free Drop Test—The specimen shall drop onto a target so as to suffer maximum damage in respect of the safety features to be tested.

The height of the drop measured from the lowest point of the specimen to the upper surface of the target shall not be less than the distance specified in Table 11 for the applicable mass. The target shall be a flat, horizontal surface of such character that any increase in its resistance to displacement or deformation upon impact would not significantly increase the damage to the specimen.

Table 11. Free Drop Distance for Testing Packages under Normal Conditions of Transport (adapted from IAEA, 2018)[5]

Package Mass (kg)	Free Drop Distance (m)
Package Mass < 5000	1.2
Package Mass ≥ 5,000 and ≤ 10,000	0.9
Package Mass ≥ 10,000 and ≤ 15,000	0.6
Package Mass ≥ 15,000	0.3

According to the IAEA,[5] if the Type A package is intended to carry liquids, the distance for any package shall be 9 m.

1. For rectangular fibreboard or wood packages not exceeding a mass of 50 kg, a separate specimen shall be subjected to a free drop test onto each corner from a height of 0.3 m.
2. For cylindrical fibreboard packages not exceeding a mass of 100 kg, a separate specimen shall be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 m.

Stacking Test—Unless the shape of the packaging effectively prevents stacking, the specimen shall be subject, for a 24-hour period, to a compressive load equal to the greater of the following:

1. The equivalent of 5 times the mass of the actual package; and
2. The equivalent of 13 kPa multiplied by the vertical projected area of the package.

The load shall be applied uniformly to two opposite sides of the specimen, one of which shall be the base on which the package would typically rest.[5]

Penetration Test—The specimen shall be placed on a rigid flat, horizontal surface which will not move significantly while the test is being carried out.

1. A bar 3.2 cm in diameter with a hemispherical end and a mass of 6 kg shall be dropped and directed to fall, with its longitudinal axis vertical, onto the centre of the weakest part of the specimen, so that, if it penetrates sufficiently far, it will hit the containment system. The bar shall not be significantly deformed by the test performance.
2. The height of the drop of the bar measured from its lower end to the intended point of impact on the upper surface of the specimen shall be 1 m for Type A Packages intended to carry solids and 1.7 m for Type A packages intended to carry liquids.[5]

NOTE: It is not a requirement that a Type A package be certified by the CNSC; however, a consignor must make available documentary evidence which confirms the package would meet the testing requirements upon request by a competent authority.

7.3 MAXIMUM RADIATION LEVELS FOR TYPE A PACKAGES

Radiation levels for NORM shipments in a Type A package must not exceed the following:

a) 2 mSv/hr on contact of the external surface of the package and 0.1 mSv/hr at 1 m from the external surface of the package, except under exclusive use.

b) The radiation level for a package under exclusive use may exceed 2 mSv/hr but not more than 10 mSv/hr providing the vehicle is equipped with an enclosure that prevents access during transport, the package is secured to retain its position within the enclosure and there are no loading or unloading operations between the beginning and end of shipment.

c) Although the packages may exceed 2 mSv/hr on contact under exclusive use, the transport vehicle still cannot exceed 2 mSv/hr on contact and 0.1 mSv/hr at 2 m from the external surface of the conveyance.

d) At no time should packages over 2 mSv/hr on contact be transported by air except under special arrangement.

7.4 TYPE A PACKAGE CONTAMINATION LIMITS

Non-fixed surface contamination on external surfaces of Type A packages and on the internal surfaces and external surfaces of overpacks, freight containers, tanks and intermediate bulk containers should be kept as low as practicable and at no time exceed the following:

- 4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters averaged over 300 cm^2, and
- 0.4 Bq/cm^2 for all other alpha emitters averaged over 300 cm^2.

Packages which are damaged or leaking radioactive contents, during transport, in excess of the above limits may be removed to an acceptable interim location under supervision, but shall not be forwarded until repaired and the external surface of the package decontaminated.

7.5 USE AND DECONTAMINATION OF TYPE A PACKAGES, OVERPACKS AND CONVEYANCES

A conveyance used regularly for the transport of NORM should be periodically checked to determine the level of contamination.[5] The frequency of such checks should be related to the likelihood of contamination and the extent to which NORM-impacted materials are transported. Contamination found in excess of those limits in section 7.4 above shall be decontaminated as soon as practicable. In addition, empty packages should never be used to store or transport other materials unless decontaminated to below the UDRL in the Canadian NORM Guidelines.[2]

7.6 MIXED PACKAGE CONTENTS FOR TYPE A PACKAGES

No other materials, other than the radioactive materials being packaged, should be contained in a Type A package.

7.7 LOADING OF CONVEYANCE AND SEGREGATION OF PACKAGES FOR TYPE A PACKAGES

Except under conditions of exclusive use, loading of freight containers and the accumulation of packages, overpacks and freight containers aboard a single conveyance or hold of a watercraft shall be limited so that the sum of transport indices does not exceed 50.

There is no limit on the sum of transport indices for a single conveyance under exclusive use.

7.8 LABELLING AND MARKING OF TYPE A PACKAGES

For all Type A packages, any labels which do not relate to the radioactive contents must be removed or covered. Each package must be legibly and durably marked on the outside of the package with an identification of either the consignor or consignee, or both. Type A packages must be assigned an appropriate category I-WHITE, II-YELLOW or III-YELLOW label as noted below.

In order to determine the appropriate label, the transport index must first be calculated. The transport index is calculated by determining the radiation level in millisieverts per hour at a distance of 1 metre from the package, overpack or freight container. Multiply the radiation level by 100 and the resulting value shall be the transport index. The value should be rounded up to the first decimal point (e.g. 1.13 becomes 1.2) with the exception that a value of 0.05 or less may be considered zero.

For large dimensional loads such as tanks or freight containers this value must be further multiplied by the appropriate factor as noted in Table 12.

Table 12. Multiplication Factor for Large Dimension Loads (adapted from IAEA, 2018)[5]

Size of Load (Largest cross-sectional area of load being measured)	Multiplication Factor
Size of Load ≤ 1 m^2	1
Size of Load ≥ 1 m^2 and ≤ 5 m^2	2
Size of Load ≥ 5 m^2 and ≤ 20 m^2	3
Size of Load ≥ 20 m^2	10

The transport index for each overpack, freight container or conveyance can be determined by the sum of transport indices or by direct measurement. In determining the appropriate label both the surface radiation level and transport index shall be taken into account as noted in Table 13.

Table 13. Categories of Packages and Overpacks (adapted from IAEA, 2018)[5]

Conditions		
Transport Index	**Maximum Radiation Level at Any Point on External Surface**	**Category**
0[a]	Not more than 5 μSv/hr	I-WHITE
More than 0 but not more than 1[a]	More than 5 μSv/hr but not more than 500 μSv/hr	II-YELLOW
More than 1 but not more than 10	More than 500 μSv/hr but not more than 2 mSv/hr	III-YELLOW
More than 10	More than 2 mSv/hr but not more than 10 mSv/hr	III-YELLOW[b]

(a) If the measured TI is not greater than 0.05 the value shall be zero.
(b) Shall be transported only under exclusive use.

Where the transport index satisfies the condition for one category, but the surface radiation satisfies the condition of a different category, the package shall be assigned to the higher category.

Once the appropriate label has been determined, it should be legibly and durably marked as noted below and affixed to two opposite external sides of the package or all four sides of a freight container or tank when used as packages.

a) The contents line of the label should be marked with the name of the radionuclide or in the case of mixtures the name of the most restrictive radionuclide.

b) The activity line marked in total becquerels with the appropriate SI prefix.

c) The TI marked for categories II-YELLOW and III-YELLOW only.

d) A Type A package design shall be legibly and durably marked on the outside of the packaging "TYPE A".

In addition to the appropriate label, each package must be marked legibly and durably on the outside of the package identifying either the consignor or consignee, the UN number "UN 2915", proper shipping name "RADIOACTIVE MATERIAL, TYPE A PACKAGE non-fissile" and the package permissible gross mass if over 50 kg.

7.9 PLACARDING OF TYPE A PACKAGES

Placards should be affixed to vehicles, freight containers and tanks as follows:

a) The primary class placard for each of the dangerous goods contained in a large means of containment, other than a vessel or an aircraft, must be displayed on each side and on each end of the large means of containment (TDGR).

b) Placards for other dangerous properties as required under the TDGR.[3]

7.10 TRANSPORT DOCUMENTS FOR TYPE A PACKAGES

The consignor shall include in the transport documents with each consignment the identification of the consignor and consignee, including their names and addresses and the date the shipping document or an electronic copy of it was prepared or was first given to a carrier as well as the following information, as applicable, in the order given:

a) United Nations number "UN 2915".

b) The proper shipping name "RADIOACTIVE MATERIALS, TYPE A PACKAGE, non-fissile".

c) United Nations class number "Class 7".

d) The subsidiary hazard class or division number(s) corresponding to the subsidiary hazard label(s) required to be applied, when assigned, shall be entered following the primary hazard class or division and shall be enclosed in parentheses.

e) The name or symbol of each radionuclide or, for mixtures of radionuclides, an appropriate general description or a list of the most restrictive nuclides.

f) A description of the physical and chemical form of the material. A generic chemical description is acceptable for chemical.

g) The maximum activity of the radioactive contents during transport expressed in units of becquerels (Bq) with the appropriate SI prefix symbol in units of grams (g), or appropriate multiples thereof, may be used in place of activity.

h) The category of the package, overpack or freight container, as assigned (I-WHITE, II-YELLOW, III-YELLOW).

i) The transport index, if applicable.

j) For consignments of more than one package, the information contained above shall be given for each package. For packages in an overpack, freight container or conveyance, a detailed statement of the contents of each package within the overpack, freight container or conveyance and, where appropriate, of each overpack, freight container or conveyance shall be included. If packages are to be removed from the overpack, freight container or conveyance at a point of intermediate unloading, appropriate transport documents shall be made available.

k) Where a consignment is required to be under exclusive use, the statement "EXCLUSIVE USE SHIPMENT" must be included.

l) Any additional hazardous waste with the shipment including the subsidiary class or classes, in parentheses, which may be shown as a number only or under the heading "subsidiary class" or "classe subsidiaire" or following the words "subsidiary class" or "classe subsidiaire".

m) A declaration that the contents of the consignment are fully and accurately classified, packaged, marked and labelled, and in all respects in proper condition for transport by (insert mode(s) involved) according to the PTNSR.[4]

n) The consignor shall provide in the transport documents a statement regarding actions, if any, that are to be taken by the carrier including any supplementary requirements for loading, stowage, carriage, handling and unloading of the package, overpack or freight containers and any restrictions on the mode of transport or conveyance and any necessary routing instructions or emergency arrangements to the consignment.

7.11 STORAGE AND DISPATCH FOR TYPE A PACKAGES

Segregation during transport or storage should be undertaken so as to not cause an effect on other goods.

7.12 CARRIAGE OF TYPE A PACKAGES

a) For transport by road, no person other than the driver and assistants shall be permitted in vehicles carrying packages, overpacks or freight containers bearing category II-YELLOW or III-YELLOW labels.[5]

b) For transport by air or vessel, Category II-YELLOW and III-YELLOW packages or overpacks shall not be carried in compartments occupied by passengers except those exclusively reserved for couriers specially authorized to accompany the packages or overpacks.[5]

c) Individual packages and overpacks with TI greater than 10 must be transported under "EXCLUSIVE USE".

d) Shipment by Canada Post is not permitted.

REFERENCES

(1) *Guidelines for the Handling of Naturally Occurring Radioactive Materials (NORM) In Western Canada*, Western Canadian NORM Committee, Aug. 1995. https://ohs-pubstore.labour.alberta.ca/rad001

(2) *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)*, Federal Provincial Territorial Radiation Protection Committee, 2011. www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/environmental-contaminants/canadian-guidelines-management-naturally-occurring-radioactive-materials-norm-health-canada-2000.html

(3) *Transportation of Dangerous Goods Regulations* (TDGR), *Transportation of Dangerous Goods Act*, 1992. http://laws-lois.justice.gc.ca/eng/regulations/SOR-2001-286/index.html

(4) *Packaging and Transport of Nuclear Substances Regulations* (PTNSR), *Nuclear Safety and Control Act*, 2015. http://laws-lois.justice.gc.ca/eng/regulations/SOR-2015-145/index.html#_blank

(5) IAEA Safety Standards Series, *Regulations for the Safe Transport of Radioactive Material No. SSR-6*, 2018. www.iaea.org/publications/12288/regulations-for-the-safe-transport-of-radioactive-material

(6) ICRP, *Radiological Protection from Naturally Occurring Radioactive Material (NORM) in Industrial Processes*, ICRP Publication 142, Annals of the ICRP, Vol. 48, No. 4, 2019.

(7) IAEA, *Management of NORM Residues*, IAEA-TECDOC-1712, 2013. www-pub.iaea.org/MTCD/Publications/PDF/TE-1712_web.pdf

(8) *Radiation Protection Program Design for the Transport of Nuclear Substances*, GD-314, 2012. www.cnsc-ccsn.gc.ca/pubs_catalogue/uploads/GD-314_Radiation_Protection_Program_Design_for_the_Transport_of_Nuclear_Substances.pdf

(9) *Radiation Protection Regulations*, *Nuclear Safety and Control Act*, 2000. https://laws-lois.justice.gc.ca/eng/regulations/SOR-2000-203/index.html

(10) IAEA, *IAEA Safety Glossary, Terminology Used in Nuclear Safety and Radiation Protection*, 2018 Edition. www.iaea.org/publications/11098/iaea-safety-glossary-2018-edition

APPENDIX 1

NORM TRANSPORTATION GLOSSARY OF TERMS

A_2	Maximum quantity of radioactive material (total NORM radioactivity) permitted in a Type A packaging.
Carrier	Any person, organization or government undertaking the carriage of NORM by any means of transport.[5]
Consignee	Any person, organization or government that is entitled to take delivery of a consignment.[5]
Consignment	Any package or packages, or load of radioactive material including NORM, presented by a consignor, for transport.[5]
Consignor	Means a person in Canada who: (a) is named in a shipping document as the consignor; (b) imports or who will import dangerous goods into Canada; or (c) if paragraphs (a) and (b) do not apply, has possession of dangerous goods (radioactive material) immediately before they are in transport.[3] A *person* may be both a *consignor* and a *carrier* of the same *consignment*, for example, a manufacturer who also transports the *dangerous goods* they produce.[3]
Containment System	The assembly of components of packaging specified by the package designer intended to retain the NORM contents during transport.[5]
Contamination	Radioactive material present on the surface of an object.
Contamination—Non-Fixed	NORM contamination that can be removed from the surface of an object or may become detached from an object during routine conditions of transport.
Contamination—Fixed	NORM contamination that can't be removed from the surface of an object during routine conditions of transport.
Conveyance	For transport by: • road or rail: any vehicle; • water: any vessel or hold, compartment or defined deck area of a vessel; or • air: any aircraft[5]
ERAP	Emergency Response Assistance Plan as required under Part 7 of the *Transportation of Dangerous Goods Regulations*.[3]
Exclusive Use	The sole use, by a single consignor, of a conveyance or large freight container where all initial, intermediate and final loading and unloading is performed in accordance with the direction of the consignor or consignee.[5]

Exempt	The determination by a regulatory body that a source or practice need not be subject to some or all aspects of regulatory control on the basis that the exposure and the potential exposure due to the source or practice are too small to warrant the application of those aspects or that this is the optimum option for protection irrespective of the actual level of the doses or risks.[10]
Freight Container	An article of transport equipment designed to carry goods that are packaged or unpackaged by one or more means of transport, without intermediate reloading. • It must be permanent, enclosed, rigid and strong enough for repeated use. • It must be fitted with handling devices to facilitate transfer between conveyances and from one mode of transport to another. *Small freight container*: A freight container with any overall outside dimension less than 1.5 metres in length or an internal volume less than 3.0 m^3.[5] *Large freight container*: Any other freight container that does not meet the requirements for a small freight container.
Low Specific Activity (LSA)	Low Specific Activity (LSA) material shall mean radioactive material that by its nature has a limited specific activity, or radioactive material for which limits of estimated average specific activity apply. External shielding materials surrounding the LSA material shall not be considered in determining the estimated average specific activity.[5]
Low Toxicity Alpha Emitters	Low toxicity alpha emitters are: natural uranium, depleted uranium, natural thorium, uranium-235, uranium-238, thorium-228 and thorium-230 when contained in ores, or in physical and chemical concentrates; or alpha emitters with half-lives of less than 10 days.[5]
NORM-Impacted Material	Material that comprises or is contaminated by naturally occurring radioactive material (NORM).
Overpack	An enclosure such as a box or a bag which is used by a single consignor to facilitate as a handling unit a consignment of one or more packages for convenience of handling, stowage and carriage.
Package	The packaging and its NORM contents as presented for transport. Performance standards for packaging depend on the quantity and nature of NORM transported and are graded to account for three severity levels (transport conditions): • Routine transport conditions (accident free); • Normal transport conditions (minor mishaps); and • Accident transport conditions. Classes of packaging applicable to NORM include: • Excepted; • Industrial: Type 1, Type 2 and Type 3; and • Type A.

Packaging	• An assembly of components necessary to completely enclose the NORM materials and can consist of:
	  * receptacles, absorbent materials, spacing structures,
	  * radiation shielding, filling/emptying/venting/pressure release equipment,
	  * rolling, mechanical shock, absorption, thermal insulating, and
	  * devices to provide handling and tie-down capability.
	• The assembly can also be a box, drum, freight container or tank that meets the applicable performance standards for the package classification required for transport.

Radiation Level	The dose equivalent rate expressed in millisieverts per hour (mSv/hr).
Radioactive Material	For transport of NORM, any material that emits ionizing radiation in excess of the UDRL specified in the Canadian NORM Guidelines.[2]
Shipment	The specific movement of a consignment from origin to destination.[5]
Special Arrangement	Provisions specified by the Canadian Nuclear Safety Commission and/or Transport Canada and the provinces to transport a consignment that doesn't satisfy all regulation requirements.
Specific Activity	• Radioactivity per unit mass of a particular radionuclide OR • Radioactivity per unit mass of material (NORM) when the radioactivity is uniformly dispersed throughout the material.

Surface Contaminated Object (SCO)	A solid non-radioactive object that has radioactive material distributed on its surfaces. Three types of SCO are: (a) SCO-I • *Non-fixed contamination* levels averaged over a 300 cm^2 accessible surface area are less than or equal to: * 4 Bq/cm^2 (beta, gamma, low toxicity alpha emitters) * 0.4 Bq/cm^2 (all other alpha emitters) • *Fixed contamination* levels averaged over a 300 cm^2 accessible surface area are less than or equal to: * 4×10^4 Bq/cm^2 (beta, gamma, low toxicity alpha emitters) * 4×10^3 Bq/cm^2 (all other alpha emitters) (b) SCO-II • *Non-fixed contamination* levels averaged over a 300 cm^2 accessible surface area are less than or equal to: * 400 Bq/cm^2 (for beta, gamma, low toxicity alpha emitters) * 40 Bq/cm^2 (all other alpha emitters) • *Fixed contamination* levels averaged over a 300 cm^2 accessible surface area are less than or equal to: * 8×10^5 Bq/cm^2 (for beta, gamma, low toxicity alpha emitters) * 8×10^4 Bq/cm^2 (all other alpha emitters) (c) SCO-III • *Non-fixed contamination* levels averaged over a 300 cm^2 accessible surface area are less than or equal to: * 4 Bq/cm^2 (for beta, gamma, low toxicity alpha emitters) * 0.4 Bq/cm^2 (all other alpha emitters) • *Non-fixed contamination* plus *fixed contamination* levels on the inaccessible surface averaged over a 300 cm^2 surface area are less than or equal to: * 8×10^5 Bq/cm^2 (for beta, gamma, low toxicity alpha emitters) * 8×10^4 Bq/cm^2 (all other alpha emitters)
Tank	A tank container, portable tank, road tank vehicle, rail tank wagon or any other receptacle: • with a capacity greater than or equal to 450 litres and capable of containing liquids, powders, granules, slurries, solids or solidified liquids and gases; • with a capacity greater than or equal to 1,000 litres and capable of containing gases; • that is capable of being carried on land or sea and can be loaded and discharged without the need to remove structural equipment; and • that must possess stabilizing members and tie-down attachments external to the shell and can be lifted when full.

Transport Index (TI)	A single number assigned to a package, overpack, tank or freight container or to unpackaged LSA-I or SCO-I materials. To determine the TI number, use the following equation: TI = 100 x [Reading (mSv/hr) at one metre distance]
Uranium	*Natural Uranium*—Chemically separated uranium containing the natural distribution of approximately 99.28% U-238 and 0.72% U-235 by mass. *Depleted uranium*—Uranium containing a lesser per cent U-235 than is present in natural uranium. *Enriched uranium*—Uranium containing a greater per cent U-235 than is present in natural uranium.
Vehicle	A road vehicle, railroad car or railway wagon. Trailers are considered separate vehicles.[5]
Vessel	Any seagoing vessel or inland watercraft used to carry cargo.[5]

APPENDIX 2

CONTACTS FOR FURTHER INFORMATION

Provincial Government Agencies:

Appropriate provincial department contact listings can be found at:
www.canada.ca/en/health-canada/services/environmental-workplace-health/radiation/federal-provincial-territorial-radiation-protection-committee.html#a4

Canadian Nuclear Safety Commission:

Ottawa (24h our emergency)	1-844-879-0805
Duty Officer Line	1-613-995-0479

Transport Canada (CANUTEC):

Information	(613) 992-4624
Emergency	(613) 996-6666