Managing naturally occurring radioactive material (NORM) in mining and mineral processing — guideline

NORM–4.3

Controlling NORM — transport of NORM

Government of **Western Australia**
Department of **Mines and Petroleum**
Resources Safety

The Chamber of Minerals & Energy Western Australia

MIAC

Reference

The recommended reference for this publication is:

Department of Mines and Petroleum, 2010. Managing naturally occurring radioactive material (NORM) in mining and mineral processing — guideline. NORM–4.3 Controlling NORM — Transport of NORM: Resources Safety, Department of Mines and Petroleum, Western Australia, 30pp. <http://www.dmp.wa.gov.au/>

Published February 2010

Contents

List of Figures v

1. General information 1
1.1. Purpose . . . 1
1.2. Scope . . . 1
1.3. Relationship to other NORM guidelines . . . 1

2. Guidance 2
2.1. Introduction . . . 2
2.2. Determination of the applicability of the Code of Practice . . . 2
2.3. Determination of activity concentration and exemptions . . . 3
2.3.1. Material that has not been a subject of chemical or thermal processing . . . 3
2.3.2. Material that has been subject to chemical or thermal processing . . . 4
2.3.2.1. If the complete analysis of the material has been carried out . . . 4
2.3.2.2. If the complete analysis of the material has not been carried out . . . 5
2.3.3. Procedure to follow . . . 6
2.4. Determination if the shipment can be transported as 'excepted package' . . . 6
2.5. Determination of the classification of the material and package categories . . . 7
2.5.1. Transport index (paragraph 526) . . . 7
2.5.2. Category (paragraph 533, Table 7) . . . 8
2.5.3. Specific activity (paragraph 226) . . . 8
2.6. Signposting requirements . . . 8
2.6.1. Location . . . 10
2.6.2. Definition of the vehicle . . . 10
2.7. Conveyances under the 'exclusive use' . . . 10
2.8. Load covering . . . 11
2.9. Blending of different minerals in one conveyance . . . 12
2.10. Surface contamination issue . . . 14
2.10.1. Definitions . . . 14
2.10.2. Practical considerations . . . 16
2.11. Transport of exploration samples . . . 17

A. Appendix with the Consignor's Declaration 19

B. Appendix on transport of uranium oxide concentrate 22
B.0.1. Packaging . . . 22
B.0.2. Transport . . . 23
B.0.3. Transport plan . . . 23
B.0.4. Permit to transport nuclear material . . . 23
B.0.5. Radiation protection, first aid and safety measures . . . 24
B.0.6. What are the risks? . . . 24
B.0.7. Typical UOC logistics chain . . . 24

Bibliography 28

Index **29**

List of Figures

1.1. Relationship to other NORM guidelines 1

2.1. Vehicle and package labels for transporting radioactive materials 9
2.2. Transport of monazite 12

A.1. Consignor's Declaration for Dangerous Goods – front page 20
A.2. Consignor's Declaration for Dangerous Goods – back page 21

B.1. Transport of UOC 23
B.2. Risks from a sealed container 25
B.3. Risks from a sealed container. 26
B.4. Typical UOC logistics chain 27

1. General information

1.1. Purpose

To provide guidance on the practical ways of transporting minerals and mineral concentrates containing elevated concentrations of naturally occurring radioactive materials (NORM).

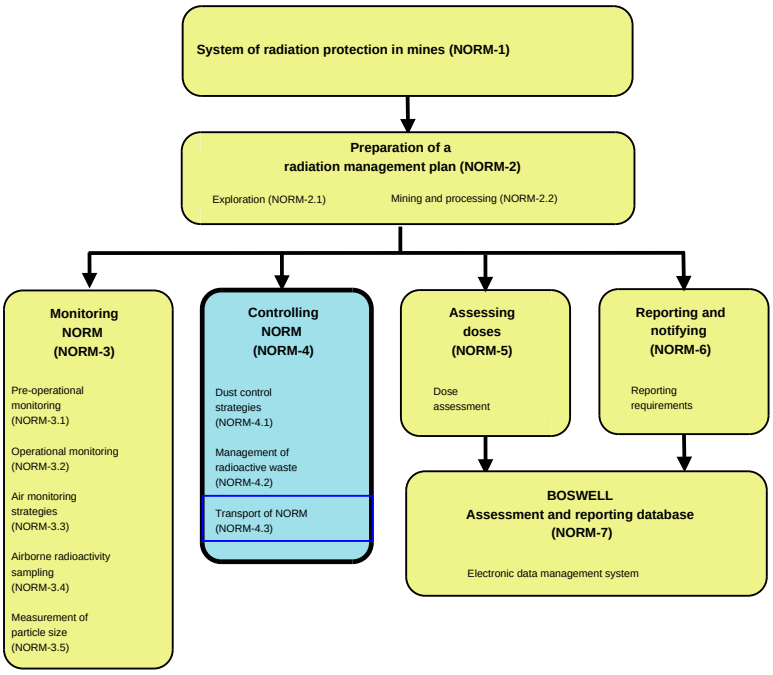
1.2. Scope

This guideline applies to all exploration, mining and mineral processing operations in Western Australia that use or handle naturally occurring radioactive material (NORM) and come within the scope of Part 16 of the Mines Safety and Inspection Regulations 1995 [1] and of the Radiation Safety (Transport of Radioactive Substances) Regulations 2002 [2], which adopts the Australian Code of Practice for the Safe Transport of Radioactive Material [7].

1.3. Relationship to other NORM guidelines

The flowchart in Figure 1.1 shows how the Radiation Safety Guidelines are arranged.

Figure 1.1.: Relationship to other NORM guidelines



2. Guidance

2.1. Introduction

This Guideline establishes uniform standards of safety that provide an acceptable level of control of the radiation and potential hazards to people and the environment that are associated with the transport of naturally occurring radioactive material (NORM). The Guideline must be read in conjunction with the Australian Code of Practice for the Safe Transport of Radioactive Material [7] and relevant documents issued by the International Atomic Energy Agency (IAEA) [8–15]. The latest edition of the International Transport Safety Regulations [14] contains the same limits and safety principles as the previous edition [9] and, therefore, the adoption of these regulations into the Australian legislative framework in the future is not expected to result in major changes to the current requirements and acceptable practices.

The guideline provides a step-by-step guide for the establishment of transport safety program and consists of:

1. Determination of the applicability of the Code of Practice.
2. Determination of activity concentration and exemptions.
3. Determination of the classification of the material.
4. Determination if the shipment can be transported as 'excepted package'.
5. Signposting requirements.
6. Conveyances under the 'exclusive use'.
7. Load covering.
8. Blending of different minerals in one conveyance.
9. Surface contamination issue.
10. Transport of exploration samples.

2.2. Determination of the applicability of the Code of Practice

The first step is to establish if the Code applies to the movement of potentially radioactive material. If the transport is within the boundaries of a mining/processing site, the Regulations are not applicable, in accordance with paragraph 107(b):

> *107. The Regulations do not apply to:*
>
> ...
>
> *(b) radioactive material moved within an establishment which is subject to appropriate safety regulations in force in the establishment and where the movement does not involve public roads or railways;*

If, however, there is a need to use a public road, railway or waterway — the requirements of the Code must be complied with.

2.3. Determination of activity concentration and exemptions

If it is established that compliance with the Code is necessary, the next step is to determine the activity concentration of the material to be transported and compare it with appropriate limits.

Table 1 in Section IV — "Activity Limits and Material Restrictions" gives the values for ^{nat}Th and ^{nat}U at 1.0 Bq/g each (paras 401–406). The value of 1 Bq/g refers to the sum of concentrations of parents of each decay series, i.e. ^{232}Th and ^{238}U.

Paragraph 107 of the Code provides an exclusion for most materials handled and transported by the mining and mineral processing industry:

> *107. The Regulations do not apply to:*
>
> ...
>
> *(e) natural material and ores containing naturally occurring radionuclides that are either in their natural state, or have been processed only for purposes other than for the extraction of the radionuclides, and that are not intended to be processed for use of these radionuclides, provided that the activity concentration of the material does not exceed 10 times the values specified in para. 401(b), or calculated in accordance with paras 402–406;*
>
> ...

The actual limits for the minerals and associated products are raised to 10 Bq/g for ^{nat}Th and ^{nat}U. (The value of 10 Bq/g refers to the aggregate activity concentration of ^{232}Th and ^{238}U). Please note that this exemption is not applicable to uranium mining and milling operations.

In the calculation of specific activity it is important to know if mineral processing may have disrupted the secular equilibrium of thorium and/or uranium decay chains.

2.3.1. Material that has not been a subject of chemical or thermal processing

It is very unlikely that secular equilibrium for both thorium and uranium chains is disrupted during simple physical concentration/separation of mineral concentrates (e.g. gravimetric separation of heavy mineral sands).

The following equation is used to estimate activity of the material (in Bq/g), based on parts per million (microgram per gram) figures typically obtained by laboratory analysis and assumes that thorium and uranium are 100% of ^{232}Th and ^{238}U respectively:

$$\left[Th(\mu g/g) \times \left(4.09 \times 10^{-3} Bq/\mu g\, Th{-}232\right)\right] + \left[U(\mu g/g) \times \left(1.25 \times 10^{-2} Bq/\mu g\, U{-}238\right)\right]$$

Practical example 1:

If the material contains 980 ppm Th and 250 ppm U, the calculation will be:

$$\left[980 \times \left(4.09 \times 10^{-3}\right)\right] + \left[250 \times \left(1.25 \times 10^{-2}\right)\right] = 7.1 Bq/g$$

In cases where:

- It is known that both uranium and thorium decay chains are in the state of secular equilibrium in the transported material; and
- The transported material will not be processed for the use of radionuclides contained in it —

The exemption values given in the Annex B of the Code [7]can be used: 800 ppm (parts per million) for ores or concentrates containing uranium, and 2400 ppm for ores or concentrates containing thorium. Please note that, as confirmed in the Code, these are quite significant concentrations and would lead to external gamma radiation levels that will typically require additional management.

2.3.2. Material that has been subject to chemical or thermal processing

The complete data on the disruption of the secular equilibrium during processing of mineral concentrates is typically not available, but it is prudent to assume that this may occur in case of:

1. Any chemical processing of the material, such as leaching or adding flotation agents to the process.
2. Any thermal processing of the material. Due to the variety of different materials in the industry it is impossible to establish a universal cut-off point for the temperature at which some radionuclides can volatilise and disrupt the equilibrium; however, the value of 250–300℃ is suggested as a general guide at which additional analysis of the material may be required.

2.3.2.1. If the complete analysis of the material has been carried out

Typically, analysis of the material for some isotopes in both thorium and uranium chains is carried out. In some cases, the results for each and every radionuclide in each chain are also obtained. As this may be a very long, costly (and, typically, unnecessary) exercise, the simplified method, based on half-lives of different isotopes (reflected in para 406 and in the footnote (b) to the Table 1 of the Code) is offered:

- For thorium chain, the data is required for ^{232}Th,^{228} Ra, ^{228}Th, and ^{212}Pb; and
- For uranium chain, the data is required for ^{238}U, ^{230}Th, ^{226}Ra, and ^{210}Pb.

Taking into account the "10-times exemption factor" described above, exemption values for these eight radionuclides will be as follows:–

^{232}Th = 100 Bq/g, ^{228}Ra = 100 Bq/g, ^{228}Th = 10 Bq/g, ^{212}Pb = 100 Bq/g.

^{238}U = 100 Bq/g, ^{230}Th = 10 Bq/g, ^{226}Ra = 100 Bq/g, ^{210}Pb = 100 Bq/g.

There are several ways of specific activity calculation; out of which the 'Ratio method' is the easiest.

Step 1: For each radionuclide present, calculate the ratio: $\left(\frac{C_i}{X_i}\right)$, where C_i is the concentration of radionuclide i and is X_i is the appropriate limit from the Table 1 of the Regulations (taking into account the material is 'natural').

Step 2: Sum these ratios over all nuclides: $\sum_j \left(\frac{C_i}{X_i}\right)$, where j is the number of radionuclides.

Step 3: Compare the sum with 1 to make a decision on the exemption: $\sum_j \left(\frac{C_i}{X_i}\right) \leq 1$

If the above is correct, the material is exempt from the requirements of the Code.

Practical example 2:

A mineral has been both chemically and thermally processed , impurities have been removed and it is ready for shipment. The results of the radionuclides' analysis are as follows (radionuclides in brackets assumed to be in equilibrium – see footnote (b) to the Table 1 of the Code):

Th chain: ^{232}Th = 1.2 Bq/g, ^{228}Ra = 1.0 Bq/g ($\sim^{228}$Ac = 1.0), ^{228}Th = 1.2 Bq/g ($\sim^{224}$Ra, ^{220}Rn, ^{216}Po = 1.2 Bq/g), ^{212}Pb = 1.0 Bq/g (~ ^{212}Bi = 1.0 Bq/g, ~^{208}Tl = 0.36 Bq/g, ^{212}Po = 0.64 Bq/g);

U chain: ^{238}U = 0.4 Bq/g ($\sim^{234}$Th, ^{234}Pa, ^{234}U = 0.4 Bq/g), ^{230}Th = 0.5 Bq/g, ^{226}Ra = 0.6 Bq/g ($\sim^{222}$Rn, ^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Po = 0.6 Bq/g), ^{210}Pb = 0.5 Bq/g, ($\sim^{210}$Bi, ^{210}Po = 0.5 Bq/g).

Calculations:

1. The ratios for thorium chain: $\left[\frac{1.2}{100}\right]$ (^{232}Th) + $\left[\frac{1.0}{100}\right]$ (^{228}Ra) + $\left[\frac{1.0}{100}\right]$ (^{228}Ac) +$\left[\frac{1.2}{10}\right]$ (^{228}Th) +$\left[\frac{1.2}{100}\right]$ (^{224}Ra) +$\left[\frac{1.2}{100}\right]$ (^{210}Rn) +$\left[\frac{1.2}{10000}\right]$ (^{216}Po) +$\left[\frac{1.0}{100}\right]$ ^{212}Pb +$\left[\frac{1.0}{100}\right]$ ^{212}Bi +$\left[\frac{0.36}{100}\right]$ (^{208}Tl) +$\left[\frac{0.64}{100}\right]$ (^{212}Po) = 0.206
2. The ratios for uranium chain: $\left[\frac{0.4}{100}\right]$ (^{238}U) +$\left[\frac{0.4}{10000}\right]$ (^{234}Th) +$\left[\frac{0.4}{10000}\right]$ (^{234}Pa) +$\left[\frac{0.4}{100}\right]$ (^{234}U) +$\left[\frac{0.5}{10}\right]$ (^{230}Th) +$\left[\frac{0.6}{100}\right]$ (^{226}Ra) +$\left[\frac{0.6}{100}\right]$ (^{222}Rn) +$\left[\frac{0.6}{100}\right]$ (^{218}Po) +$\left[\frac{0.6}{100}\right]$ (^{214}Pb) +$\left[\frac{0.6}{100}\right]$ (^{214}Bi) +$\left[\frac{0.6}{100}\right]$ (^{214}Po) +$\left[\frac{0.5}{100}\right]$ (^{210}Pb) + $\left[\frac{0.5}{100}\right]$ (^{210}Bi) +$\left[\frac{0.5}{100}\right]$ (^{210}Po) = 0.109
3. The sum is = 0.109
4. The value of 0.315 is less than one; therefore the material is exempt from the regulations.

In the example above, the individual radionuclide activity concentrations in each chain are not especially out of equilibrium. Therefore, a simple comparison of ^{232}Th and ^{238}U with 10 Bq/g may be all that is required subject to approval by the appropriate authority.

2.3.2.2. If the complete analysis of the material has not been carried out

This method can be used when detailed information about radionuclides' concentrations in the material is not available and it is also unknown if both thorium and uranium chains are in secular equilibrium.

Table 2 in para 406 of the Code suggests the values that should be used in these circumstances.

As the limit for 'total activity' in Bq will always be exceeded in case of a bulk shipment of the mineral, the attention must be paid to the third column of Table 2 (*Activity concentration for exempt material*), which has three categories (associated activity concentration limits multiplied by the factor of 10 for 'natural material' are presented in the brackets):

1. Only beta or gamma emitting radionuclides are known to be present (100 Bq/g).
2. Alpha emitting radionuclides, but no neutron emitters, are known to be present (1 Bq/g).
3. Neutron emitting radionuclides are known to be present or no relevant data are available (1 Bq/g).

As it would be very rare for a transported mineral to contain only beta and gamma emitting radionuclides, the value of 100 Bq/g should only be used when the absence of alpha emitting radionuclides has been conclusively proven. For all other practical purposes, the value of 1 Bq/g will be applicable.

Practical example No.3:

The same material as in the practical example 2 on page 4 is ready for shipment. The results of the radionuclides' analysis are not available, the only known value is the concentration of ^{232}Th = 1.2 Bq/g. In accordance with value specified in Table 2 in para 406, the material will *not* be exempt from the Code.

A note on practical examples 2 and 3: The costs and the length of time associated with obtaining full radionuclide-specific information for a material should be weighed against the disadvantages of the potentially incorrect classification of this material as 'radioactive'. The suggested approach is to use the partial data in Section 2.3.2.2 and, if it appears that a material is not exempt, — carry out the detailed analysis and use the method described in Section 2.3.2.1). If the laboratory analysis shows that activity of the material to be transported is very close to the limit (above 9 Bq/g for a physically separated mineral concentrate, or the sum of activity concentrations calculated by the method described in Section 2.3.2.2 is above 0.9) — it would be prudent to take additional samples to ensure that at no time the limits are exceeded.

2.3.3. Procedure to follow

If it has been established that transport regulations apply, the following will be required:

1. The carrier must possess an appropriate licence to deal with radioactive material.
2. Three copies of the appropriate transport declaration must be prepared by a responsible person (typically – a Radiation Safety Officer). Two copies must be given to the driver (one stays with the transporting company, another is given to the receiver of the material), the third copy is kept by the responsible person. In the case of multiple transport of the same material a 'standing declaration' could be acceptable – provided that prior agreement has been reached with an appropriate regulatory authority.
3. Appropriate training must be provided to all workers involved in the transport, loading and unloading the material (paras 311–314 of the Code).
4. Appropriate placards should be placed on the vehicle (paras 534–548 of the Code).

2.4. Determination if the shipment can be transported as 'excepted package'

If the determined activity level of the material to be transported exceeds the limit of 10 Bq/g only by a low margin, there is a possibility that the load can be classified as *excepted package* (please note the difference with *exempted package* [activity less than 10 Bq/g], when Code does not apply at all).

The main criterion for the determination of the excepted package is in para 516:

> *516: The radiation level at any point on the external surface of an excepted package shall not exceed 5 μSv/h.*

Please note that the measurement is taken on the surface, not at a distance of one metre.

Practical example 4:

If the material contains about 20 Bq/g of ^{232}Th, radiation level from its surface will be approximately 12 μSv/hour and the value can be measured or estimated using relevant dose coefficients.

If however, (a) the thickness of the wall of the trailer used for the transport of this material is increased, or (b) bags or drums used for the transport of the material are placed inside a container relatively far from all external surfaces (including top and bottom), the surface radiation level from the package would be lowered to approximately 3–4 μSv/hour, and the materials can be classified as excepted package.

All requirements of Code specified in 2.3.3 on the facing page above must be complied with (licensing, training, declarations), except the last (placarding).

Para 518 gives details of markings required for an excepted package:

> *Packages shall bear the marking "RADIOACTIVE" on an internal surface in such a manner that a warning of the presence of radioactive material is visible on opening the package.*

Para 536 further describes required markings:

> *In the case of excepted packages, other than those accepted for international movement by post, only the United Nations number, preceded by the letters "UN", shall be required.*

Using the data provided in Table 8 of the Code, the conclusion can be made that in the case of minerals' transport as an excepted package, the load/container will be marked only with 'UN2910' instead of the "radioactive" sign. This sign however, will be required to be visible when, for example, the tarp is taken from the top of the truck or when a container is opened (the word "RADIOACTIVE" must be visible upon opening the package). There are different technical ways to address this.

2.5. Determination of the classification of the material and package categories

If the activity of the material exceeds appropriate limits there is a need for a classification of the material — to ensure that proper placards are displayed during the transport. Firstly, there is a need to determine the transport index and the category of the consignment.

2.5.1. Transport index (paragraph 526)

> *1. Determine the maximum radiation level in units of millisieverts per hour (mSv/h) at a distance of 1 m from the external surfaces of the package, overpack, freight container, or unpackaged LSA–I and SCO–I. The value determined shall be multiplied by 100 and the resulting number is the transport index.*
>
> *2. For tanks, freight containers and unpackaged LSA–I and SCO–I, the value determined in step (a) above shall be multiplied by the appropriate factor from Table 6.*

Practical example 5:

Measured radiation level is 3 μSv/hour (0.003 millisieverts per hour) gives the transport index as 0.3. The values in Table 6 of the International Transport Safety Regulations [14] are given in m^2 for the "largest cross sectional area of the load being measured".

For large road trains it is prudent to assume that the value associated with the size of the load > 20 m^2 will be applicable and the multiplication factor will be 10.

For a single truck a different value will apply (associated with the size of the load > 5 m^2, but less than 20 m^2), and the multiplication factor will be 3. Therefore, if material is transported in a single truck, the transport index will be 0.9, if a large road train is used — the transport index will be 3.

2.5.2. Category (paragraph 533, Table 7)

The load category is determined by the transport index and the radiation level on external surface. Please note the difference — transport index is determined by measuring radiation levels at a distance of 1 metre from the truck, for categorisation of the load the measurement *on the surface* is required:

- If the transport index is 0 and the surface radiation level is < 5 μSv/hour, the Category will be I–WHITE;
- If the transport index is more than 0 but less than 1, and the surface radiation level is more than 5 μSv/hour but less that 500 μSv/hour, the Category will be II–YELLOW;
- If the transport index is more than 1 but less than 10, and the surface radiation level is more than 500 μSv/hour but less that 2000 μSv/hour, the Category will be III–YELLOW; and
- III–YELLOW category is also used if material is transported under 'special arrangement' (please refer to para 238 of the Code).

In the minerals industry, the typical categories will be I–WHITE, II–YELLOW and, occasionally — III–YELLOW. These labels are illustrated in Figure 2.1 on the next page.

2.5.3. Specific activity (paragraph 226)

Para 226(a) of the Code — 'Low Specific Activity Material' gives the following definition of LSA–I:

> *LSA material shall be in one of three groups:–*
>
> *(a) LSA–I*
>
> *(i) Uranium and thorium ores and concentrates of such ores, and other ores containing naturally occurring radionuclides which are intended to be processed for the use of these radionuclides;*
>
> . . .
>
> *(iv) Other radioactive material in which the activity is distributed throughout and the estimated average specific activity does not exceed 30 times the values for activity concentration specified in paras 401–406, excluding fissile material in quantities not excepted under para 672.*

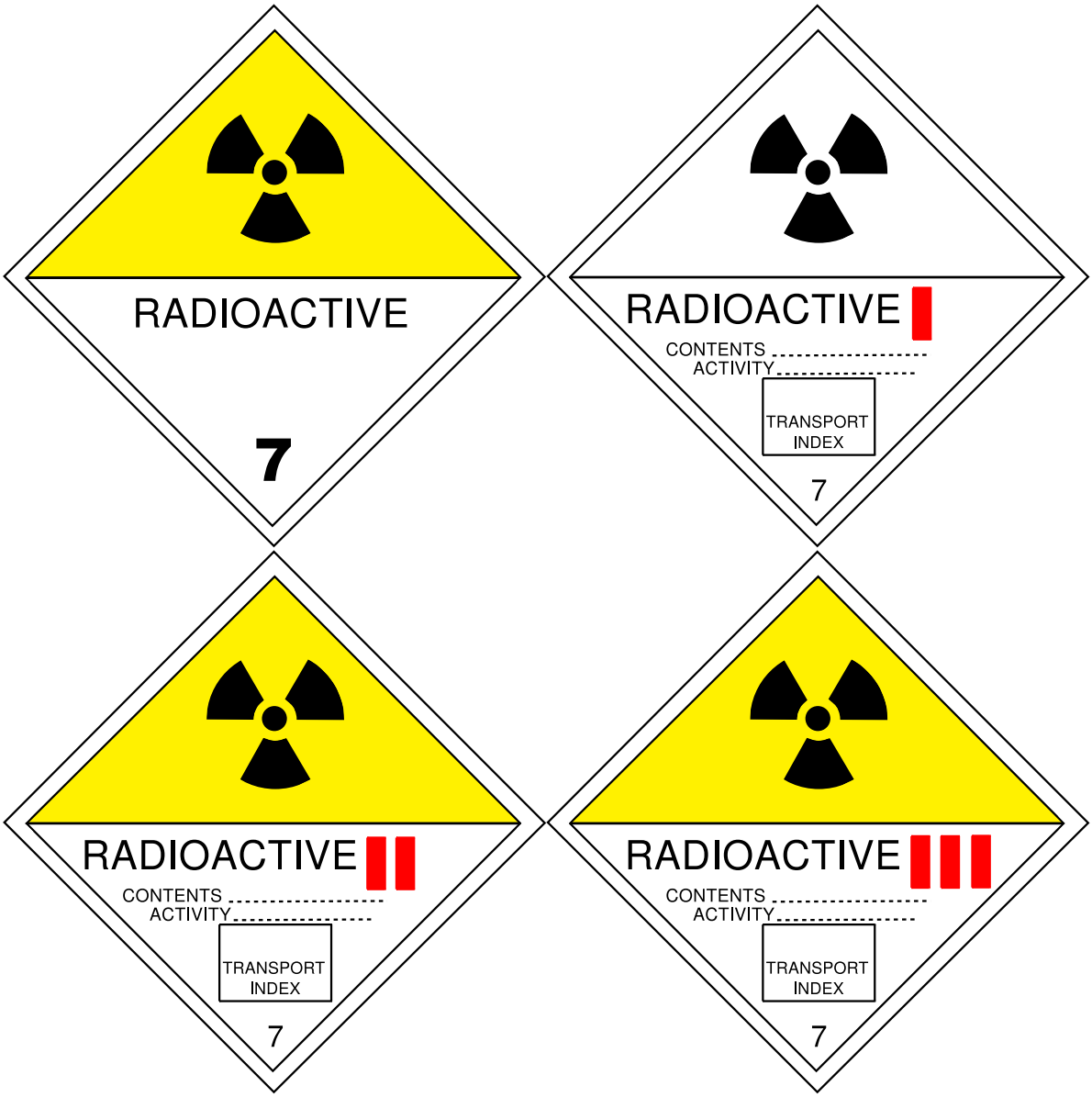
Practical example 6:

If the activity of the material to be transported is less than 300 Bq/g, the marking "LSA–I" should be used on the transport label/placard. If, however, the value exceeds 300 Bq/g (which would be quite rare) – the marking "LSA–II" should be used.

2.6. Signposting requirements

Detailed data on marking, labelling and placarding of loads are provided in paras 534–548 of the Code. There are two important points on the placement of placards associated with location of signs and the definition of a vehicle:

Figure 2.1.: Vehicle and package labels for transporting radioactive materials



2.6.1. Location

Para 571 of the Code specifies that:

> *Rail and road vehicles... shall display the placard shown in Fig. 6 on each of:–*
>
> *1. The two external lateral walls in the case of a rail vehicle;*
>
> *2. The two external lateral walls and the external rear wall in the case of a road vehicle.*

Para 546.1 of the Advisory Material to the International Transport Regulations [10] provides an additional comment:

> *546.1. Placards, which are used on large freight containers and tanks (and also on road and rail vehicles; see para 570) are designed in a way similar to the package labels... in order to clearly identify the hazards of the dangerous goods. Displaying the placards on all four sides of the freight containers and tanks ensures ready recognition from all directions. The size of the placard is intended to make it easy to read, even at a distance. To prevent the need for an excessive number of placards and labels, an enlarged label only may be used on large freight containers and tanks, where the enlarged label also serves the function of a placard.*

2.6.2. Definition of the vehicle

The definition of the vehicle, provided in para 247 of the Code should be taken into account prior to arranging the bulk transport of minerals by road and rail:

> *Vehicle shall mean a road vehicle (including an articulated vehicle, i.e. a tractor and semi-trailer combination) or railroad car or railway waggon. Each trailer shall be considered as a separate vehicle.*

Practical example 7:

A road train (a truck with a semi-trailer) will need to have four signs: one each — at the front and at the back, and two on each side. A longer road train, however, (for example, a truck with two trailers) will require six signs (two more on the second trailer). In the case of transporting radioactive material by rail in several carriages an additional advice from an appropriate regulatory authority on the quantity and location of placards should be sought prior to transport.

2.7. Conveyances under the 'exclusive use'

Most NORM in mining and mineral processing industry is transported unpackaged. In this case, material is typically transported in the conveyance under exclusive use, in accordance with para 523 of the Code. The definition is provided in para 221:

> *Exclusive use shall mean the sole use, by a single consignor, of a conveyance or of a large freight container, in respect of which all initial, intermediate and final loading and unloading is carried out in accordance with the directions of the consignor or consignee.*

Further information is provided in para 221.1. of the Advisory Material to the International Transport Regulations [10]:

> *The special features of an 'exclusive use' shipment are, by definition, first, that a single consignor must make the shipment and must have, through arrangements with the carrier, sole use of the conveyance or large freight container; and, second, that all initial,*

> *intermediate and final loading and unloading of the consignment is carried out only in strict accordance with directions from the consignor or consignee.*

As it is quite uncommon for a truck transporting mineral to deviate for a delivery of a different product for another company, most of the material that is transported by the minerals industry would be classified as 'exclusive use',

Therefore, if a truck transports mineral concentrate from a mine site to a processing plant and then is used by the same company to transport processing tailings back to a mine site it is under the 'exclusive use' classification.

The main benefit of having a vehicle under the 'exclusive use' is the fact that internal surfaces will not need to undergo decontamination between journeys.

Paras 513 and 514 of the Code state:

> *513. Except as provided in para. 514, any conveyance, or equipment or part thereof which has become contaminated above the limits specified in para. 508* [surface contamination limits – please see part 9 of the paper below] *in the course of the transport of radioactive material, or which shows a radiation level in excess of 5 μSv/h at the surface, shall be decontaminated as soon as possible by a qualified person and shall not be re-used unless the non-fixed contamination does not exceed the limits specified in para. 508, and the radiation level resulting from the fixed contamination on surfaces after decontamination is less than 5 μSv/h at the surface.*
>
> *514. A freight container, tank, intermediate bulk container or conveyance dedicated to the transport of unpackaged radioactive material under exclusive use shall be excepted from the requirements of paras 509 and 513 solely with regard to its internal surfaces and only for as long as it remains under that specific exclusive use.*

Further information is provided in para 513.1. and 514.1 of the Advisory Material [10]:

> *513.1. Conveyances may become contaminated during the carriage of radioactive material by the non-fixed contamination on the packages. If the conveyance has become contaminated above this level, it should be decontaminated to at least the appropriate limit. This provision does not apply to the internal surfaces of a conveyance provided that the conveyance remains dedicated to the transport of radioactive material or surface contaminated objects under exclusive use (see para. 514.1).*
>
> *514.1. . . . Decontamination of the internal surfaces after every use could lead to unnecessary exposure of workers. . . .*

2.8. Load covering

The 2000 edition of the Transport Safety Regulations contained a provision, allowing for loads of minerals to be transported without a cover; Schedule V, 2 (a) (i) of [8] stated that, —

> *LSA-I material may be transported unpackaged if: All material other than ores containing only naturally occurring radionuclides are transported in such a manner that under routine conditions of transport there will be no escape of the radioactive contents from the conveyance nor will there be any loss of shielding.*

This provision has been deleted from the 2005 version of the International Regulations [9], which confirms the common industry practice that in order to ensure that there is no escape of radioactive contents mineral that is being transported needs to be covered.

Figure 2.2.: Transport of monazite

Semitrailer placarded for transporting radioactive monazite material.
Note the simple ergonomic system for load covering using a crank handle.

2.9. Blending of different minerals in one conveyance

There are two ways of blending of minerals prior to transport:

1. Several different streams are simultaneously collected in one storage bin prior to transport and then loaded into a vehicle.
2. The same several streams are loaded separately into a vehicle.

While there are no specific notes in the Regulations explicitly prohibiting the practice, the second method is not recommended unless activity concentrations of blended materials do not differ by more than a factor of 10. There are three main reasons for this recommendation:

1. Impossibility of determining the specific activity of the material in accordance with para 240 of the Code:

   > *Specific activity of a radionuclide shall mean the activity per unit mass of that radionuclide. The specific activity of a material shall mean the activity per unit mass of the material in which the radionuclides are essentially uniformly distributed.*

2. Impossibility of the correct classification of the material, in accordance with the definition of LSA–I (para 226 of the Code):

   > *226. Low specific activity (LSA) material shall mean radioactive material which 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.*

Para 226.4 of the Advisory Material [10] provides an additional clarification:

> *226.4. The preamble also does not include wording relative to the essentially uniform distribution of the radionuclides throughout the LSA material. However, it states clearly that the material should be in such a form that an average specific activity can be meaningfully assigned to it. In considering actual materials shipped as LSA, it was decided that the degree of uniformity of the distribution should vary depending upon the LSA category.*

Paras 226.14 and 226.15 of the Advisory Material [10] offer an indication of what may be acceptable:

> *226.14. A simple method for assessing the average activity is to divide the volume occupied by the LSA material into defined portions and then to assess and compare the specific activity of each of these portions. It is suggested that the differences in specific activity between portions of a factor of less than 10 would cause no concern.*
>
> *226.15. Judgement needs to be exercised in selecting the size of the portions to be assessed. The method described in para. 226.14 should not be used for volumes of material of less than 0.2 m^3. For a volume between 0.2 m^3 and 1.0 m^3, the volume should be divided into five, and for a volume greater than 1.0 m^3 into ten parts of approximately equivalent size.*

Therefore, it is theoretically possible to dilute the 'radioactive' material with 'less radioactive' one — provided that their specific activities do not differ more than by a factor of 10.

3. The transport index of the load is determined by measuring of the maximum radiation level at 1 metre from the truck and categorisation is carried out by measuring of the maximum surface radiation level, which would be significantly different on the surfaces of a particular conveyance/container.

Practical example 8:

If two tonnes of monazite concentrate (specific activity of 90 Bq/g) are placed on the bottom of the trailer and then covered with 23 tonnes of the material with much lesser activity — for example sand processing tailings with specific activity of 1 or 2 Bq/g:

- the specific activity and class of the material cannot be determined by simple averaging, as radionuclides are not uniformly distributed; and
- the measured *maximum* radiation levels at both one metre and on the surface will still be high enough at some locations to require appropriate placarding of the truck.

If, however, a material with a specific activity of 15 Bq/g is mixed with the same sand tailings containing 2 Bq/g, the specific activity of the load can be calculated and it is also likely that the surface radiation level from a vehicle/container will be less than 5 μSv/hour. In this case, transporting of the mixed material as an 'excepted package' is possible.

In the absence advice to the contrary, measurements of surface radiation level should be done not only on the side surfaces, but also on the bottom and top of the load. Therefore, any options to transport material with >10 Bq/g as 'excepted package' after some kind of blending in the truck are considered to be impractical.

Practical example 9:

Discussion about the possibility of blending of different materials directly inside the truck/trailer in regards to heavy minerals sands (considering that by prior arrangement with an appropriate regulatory authority the measurement on the bottom of the trailer would not be required):

In the case of blending of monazite concentrate (90 Bq/g) with plant tails (2 Bq/g), the outcome will depend on the amount of monazite concentrate that was placed in the truck prior to covering it with 'other' tailings. If it is only at about 2 m^3 pile in the centre and does not touch the walls from the inside, there is a possibility that this load would be an 'excepted package' (measurements will have to be carried out in any case). That is, unless these 2–3 m^3 are positioned directly in the middle of the load and separated from the walls from all sides, the Code will apply. In practice, a slight inaccuracy in positioning of the radioactive material in the middle of the trailer or minor overloading will require for the trailer to be emptied and the operation repeated.

Additionally, no matter how accurate the positioning and amount of the material in the middle of the trailer may be, the sand will undoubtedly move to at least one side of the trailer during the travel to another storage bin with 'less radioactive' material.

2.10. Surface contamination issue

A different issue is associated with the fact that there are no special provisions for natural material in the Code in regards to surface contamination. However, it should be noted that the surface contamination limits described below do not apply to 'exempted' material. In the case of heavy mineral sands, for example, if even a 0.5 mm thick layer of a sand concentrate is present on the surface of an item to be transported, it is likely to be classified as a 'Surface Contaminated Object'.

2.10.1. Definitions

Para. 214 of the Code and the associated part of the Advisory Material specify what 'surface contamination' is:

> *Code: 214. Contamination shall mean the presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters, or 0.04 Bq/cm^2 for all other alpha emitters.*
>
> *Advisory Material: 214.3. Any surface with levels of contamination lower than 0.4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters or 0.04 Bq/cm^2 for all other alpha emitters is considered a non-contaminated surface in applying the Regulations. For instance, a non-radioactive solid object with levels of surface contamination lower than the above levels is out of the scope of the Regulations, and no requirement is applicable to its transport.*

The definition of 'Low toxicity alpha emitters' is given in para. 227 of the Regulations:

> *227. Low toxicity alpha emitters are: natural uranium; depleted uranium; natural thorium; uranium–235 or uranium–238; thorium–232; thorium–228 and thorium–230 when contained in ores or physical and chemical concentrates; or alpha emitters with a half-life of less than 10 days.*

There are two types of surface contaminated objects, which are defined in para. 241 of the Code:

> *Surface contaminated object*
>
> *241. Surface contaminated object (SCO) shall mean a solid object which is not itself radioactive but which has radioactive material distributed on its surfaces. SCO shall be in one of two groups:*
>
> *(a) SCO–I: A solid object on which:*
>
> *(i) the non-fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 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; and
. . .

(b) SCO–II: A solid object on which either the fixed or non-fixed contamination on the surface exceeds the applicable limits specified for SCO–I in (a) above and on which:

(i) the non-fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 400 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters, or 40 Bq/cm^2 for all other alpha emitters;

Para. 523 of the Code details when surface contamination objects can be transported unpackaged:

523. LSA material and SCO in groups LSA–I and SCO–I may be transported unpackaged under the following conditions:

(a) All unpackaged material other than ores containing only naturally occurring radionuclides shall be transported in such a manner that under routine conditions of transport there will be no escape of the radioactive contents from the conveyance nor will there be any loss of shielding;

(b) Each conveyance shall be under exclusive use, except when only transporting SCO–I on which the contamination on the accessible and the inaccessible surfaces is not greater than ten times the applicable level specified in para.. 214; and

(c) For SCO–I where it is suspected that non-fixed contamination exists on inaccessible surfaces in excess of the values specified in para.. 241(a)(i), measures shall be taken to ensure that the radioactive material is not released into the conveyance.

It is highly unlikely that materials processed by minerals industry will contain alpha emitters that will not be classified as 'low toxicity' ones. The following limits are therefore applicable to any item transported from a mineral mining/processing site on a public road:

1. Surface contamination is less than 0.4 Bq/cm^2– an object is not classified as 'contaminated'.
2. Surface contamination is above 0.4 Bq/cm^2 but less than 4.0 Bq/cm^2 – an object will fall into an "SCO–I" category.
3. Surface contamination is above 4 Bq/cm^2 (but not more than 400 Bq/cm^2) – an object will fall into an "SCO–II" category.

Therefore, it appears that if any object is found to have surface contamination in excess of 0.4 Bq/cm^2 it will need to be transported in accordance with the requirements of the Code, as described in Section 2.3.3 on page 6 above. After the transport, a vehicle used for this purpose will need to be decontaminated – in accordance with para. 504 of the Code:

504. Tanks and intermediate bulk containers used for the transport of radioactive material shall not be used for the storage or transport of other goods unless decontaminated below the level of 0.4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters and 0.04 Bq/cm^2 for all other alpha emitters.

Please note that IAEA 2005 Regulations require that not only potentially contaminated objects but also the conveyance that is used to transport them should be checked for the presence of surface contamination in excess of specified limits.

However, as detailed in the Section 2.3, the Code does not apply to the transported NORM that will not be processed to extract radioactive elements and where radioactivity concentrations are below those specified above. The advice received from ARPANSA in 2008 [16] in regards to the implementation of the new Code [7] was that: as the Code is not applicable to certain materials – the requirements for surface contamination control are also not applicable. ARPANSA noted however, that decontamination of vehicles may be required under separate environmental and/or

radiation protection legislation, but not the Transport Code. An example of a restriction which would require the implementation of all appropriate surface contamination control measures on an exploration, mining and/or minerals processing site is the level to which the radiation monitoring equipment is set on entrances to some landfills and scrap metal yards.

2.10.2. Practical considerations

Potentially all equipment and buildings used in the processing of minerals containing naturally occurring radioactive material may become surface contaminated objects and it is therefore important to ensure that no contaminated equipment and scrap metal is re-used in other industries and/or melted.

In mining and minerals processing industry it would be impractical to carry out wipe tests and send them to be analysed in a laboratory. Therefore, a simple surface contamination test can be carried out. In the case of a single object, only one or two measurements will be required; but in the case of a truck already filled with numerous potentially contaminated items, many separate tests will need to be performed. Therefore, it is advisable to survey the items prior to loading of the vehicle.

A simple check of gamma radiation levels in the vicinity of a potentially contaminated item may reveal the presence of radioactive material on internal and/or external surfaces. When gamma radiation levels at a distance of 1 metre of an item are measurably higher than the background level in the area, it is highly likely that an item will be classified as surface contaminated object. If, for example, it is desired that no objects will be classified as surface contaminated in a load of scrap metal, this particular item will need to undergo additional cleaning prior to any tests for surface contamination.

Surface contamination measurements that typically follow the measurement of gamma radiation levels are quite easy to perform:

1. A monitor capable of measuring surface contamination should be available.
2. A monitor should be appropriately calibrated — i.e. the certificate should state a conversion factor between obtained cpm (counts per minute) and the value in Bq/cm^2.
3. A monitor should have a window that can be opened and closed — shielding the probe from alpha and beta radiation.
4. Measurements are typically carried out over a one-minute interval in a close proximity to the surface (less than 5 mm).
5. It is necessary to ensure that material is dry before surface contamination readings are carried out. Two measurements are taken — first with the window closed (that will be a 'background' reading), second — with the window open, and two values in 'counts per minute' obtained.
6. The 'background' value should then be subtracted from the second reading and the result compared with the limits specified in the Code (using the conversion factor for a particular monitor).

As specified in Section 2.4 on page 6, there is a possibility that surface contaminated items can be transported as 'excepted package' (definition from para. 516 of the Code):

> *The radiation level at any point on the external surface of an excepted package shall not exceed 5 $\mu Sv/h$.*

Additional requirements (described in the practical example 10 below) will need to be satisfied before the load can be transported as 'excepted package' – that is, without a 'radioactive' sign on the outside of the conveyance (all other requirements of transport regulations specified in Section 2.3.3 on page 6 must be complied with - licensing, training, transport declarations).

Practical example 10:

Surface contaminated items need to be transported by road from a processing site to a mining site for the final disposal in a mined out pit. An average gamma-radiation level from items is 2.0 μGy/hour and surface contamination level is, on average, 0.8 Bq/cm^2.

1. It is suggested that all material is to be wrapped in fine mesh shade cloth or covered to ensure that:
   a) There will be no escape of radioactive contents from the conveyance nor will there be any loss of shielding (para. 523(a)).
   b) As contamination on the accessible and the inaccessible surfaces will not be greater than ten times the applicable level specified in para. 214, there will be no need to have each conveyance under exclusive use (para. 523(b)).
   c) If it will be suspected that non-fixed contamination exists on inaccessible surfaces, measures will be taken to ensure that the radioactive material is not released into the conveyance (para. 523(c)).
2. There will be no requirement for trucks to bear the signs 'Radioactive SCO–I', as the package will be classified as 'excepted' (para. 516); and no contamination will be present of any accessible surface of the load.
3. All drivers involved must undergo a specific radiation safety induction.
4. Transport declarations must be prepared and truck will not be allowed to leave site until it has been established that all documentation is in order.
5. Each truck should be surveyed to ensure that these conditions are strictly complied with.

A summary for different levels of surface contamination:

1. $<$ 0.4 Bq/cm^2 — exempted.
2. $>$ 0.4 but $<$ 4.0 Bq/cm^2 (covered/wrapped) — excepted: all documents, no signposting.
3. $>$ 0.4 but $<$ 4.0 Bq/cm^2 (open vehicle) — not excepted: all documents, 'SCO–I' placard.
4. $>$ 4.0 Bq/cm^2 — all documents, 'SCO- II' placard.

Further information on issues associated with surface contamination and a detailed technical advice can be found in the technical document issued by the International Atomic Energy Agency (IAEA) [11]; and on the setting up of the radiation protection program for transport activities and emergency response — in the relevant IAEA Safety Guides [12, 13].

2.11. Transport of exploration samples

The transport of exploration samples from a site to a laboratory should be also carried out in accordance with the Code [7]. As the exact concentrations of radionuclides in the transported material are typically unknown, the following simplified method is suggested:

1. Determine if the package can be classified as *excepted* – the main requirement is that the gamma dose rate on all surfaces of the package does not exceed 5 μSv/h. In this case the process described in Section 2.4 on page 6 needs to be followed.
2. If the level anywhere on the surface of the package exceeds 5 μSv/h, the requirements outlined in Sections 2.5 on page 7 and 2.6 on page 8 (and, in some cases — Sections 2.7 on page 10 and 2.10 on page 14) need to be followed.

The exploration samples must be transported in such a way as to ensure that the material is contained within the conveyance under the normal conditions of transport. There should also not be any contamination on the internal surface of the vehicle (unless it is under the 'exclusive use' – then refer to Section 2.7 on page 10).

Acknowledgement: The guideline is based on a technical paper by N. Tsurikov, P.J. Hinrichsen. M. Omar, H.R.S.M. Fernandes [6].

A. Appendix with the Consignor's Declaration

Road/Rail/Inland Waterways Consignor's Declaration for Dangerous Goods – Class 7 Radioactive Material.

Click here *to open electronic version of Consignor's Declaration*→ 

Figure A.1.: Consignor's Declaration for Dangerous Goods – front page

ROAD/RAIL/INLAND WATERWAYS CONSIGNOR'S DECLARATION FOR DANGEROUS GOODS

CLASS 7 RADIOACTIVE MATERIAL

TWO COMPLETED AND SIGNED COPIES OF THIS DECLARATION MUST BE PROVIDED TO THE CARRIER

CONSIGNOR (SENDER'S NAME AND ADDRESS):	**NAME OF TRANSPORTING COMPANY AND CONSIGNMENT No.**
	CONSIGNOR'S REFERENCE No.
CONSIGNEE (RECEIVER'S NAME AND ADDRESS):	**INLAND WATERWAYS USE ONLY** PORT OF LOADING ..... DATE OF LOADING..... PORT OF DISCHARGE ..... VESSEL..... CONTAINER No.....

NATURE AND QUANTITY OF RADIOACTIVE MATERIAL

See applicable Codes: International Atomic Energy Agency (IAEA) — Safety Requirements No. TS-R-1 (2005) and the Code of Practice for Safe Transport of Radioactive Material 2008 ("The Transport Code")

PROPER SHIPPING NAME Refer overleaf	**UNITED NATIONS DANGEROUS GOODS CLASS**	**UNITED NATIONS NUMBER**	**SUBSIDIARY RISK** (if applicable) Classes 1 to 8	**RADIONUCLIDE** Name or symbol of each radionuclide e.g. Iridium-192, Ir-192 or ^{192}Ir	**PHYSICAL AND CHEMICAL FORM** "special form" or "low dispersible radioactive material" is acceptable, if applicable	**MAX ACTIVITY OF RADIOACTIVE CONTENTS** in Becquerel units (Bq) with appropriate SI prefix or Mass in grams (g) for fissile material
	7	**UN**				
CATEGORY OF PACKAGE Delete category not applicable	**TRANSPORT INDEX** Definition: 100 times the maximum radiation dose in millisievert per hour (mSv/h) at 1 metre For Yellow hazard categories only	**CRITICALITY SAFETY INDEX** For fissile material only	**COMPETENT AUTHORITY APPROVAL CERTIFICATE NUMBER(S)** required for special form r/a material, low dispersible r/a material, special arrangement, package design or shipment	**NUMBER OF PACKAGES** Information to be repeated for each package	**EXCLUSIVE USE SHIPMENT** Delete category not applicable	**TOTAL ACTIVITY OF THE CONSIGNMENT** (for LSA-II, LSA-III, SCO-I or SCO-II only) Multiple of A_2
I-WHITE OR **II-YELLOW** OR **III-YELLOW**					**YES** or **NO**	

WARNING

FAILURE TO COMPLY IN ALL RESPECTS WITH THE APPLICABLE RADIOACTIVE MATERIALS TRANSPORT REGULATIONS MAY BE IN BREACH OF THE APPLICABLE LAW, SUBJECT TO LEGAL PENALTIES. THIS DECLARATION MUST NOT, IN ANY CIRCUMSTANCES, BE COMPLETED AND/OR SIGNED BY A CONSOLIDATOR, A FORWARDER OR CARGO AGENT.

I HEREBY DECLARE THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE BY THE PROPER SHIPPING NAME AND ARE CLASSIFIED, PACKED, MARKED AND LABELLED, AND ARE IN ALL RESPECTS IN PROPER CONDITION FOR TRANSPORT BY ROAD/RAIL/INLAND WATERWAYS (*check transport mode/s below*) ACCORDING TO THE APPLICABLE INTERNATIONAL AND NATIONAL GOVERNMENTAL REGULATIONS.

ROAD ☐ RAIL ☐ INLAND WATERWAYS ☐

NAME OF CONSIGNOR: (PLEASE PRINT)
.....

POSITION .....

SIGNATURE .....
(SEE ABOVE WARNING)

DATE .....

ADDITIONAL HANDLING INFORMATION (e.g. Schedule Number, Special arrangements, Exclusive use, other information)

SEE REVERSE FOR INFORMATION FOR CARRIERS AND EMERGENCY PROCEDURES

Version Date: June 2009

Figure A.2.: Consignor's Declaration for Dangerous Goods – back page

INFORMATION FOR CARRIERS

HANDLING RULES

Radioactive materials presented for transportation are packaged in accordance with the IAEA Regulations which ensure that they are safe to handle under normal conditions. Nevertheless, to prevent unnecessary exposure to radiation there are certain basic rules which should followed as the radiation exposure received will depend on how long and how close a person remains near the packages containing radioactive materials. To minimise radiation exposures:

- Keep contact time with the package short.
- Radioactive material package should be handled a without delay — keep it moving.
- Do not stand around, sit near or sit on a radioactive material package.
- Do not carry out time-consuming tasks, such as paperwork, near a package.
- Keep yourself and other persons as far away as practicable from packages containing radioactive material.
- Store packages well away from offices, rest rooms and occupied work areas
- When transporting packages containing radioactive material any long distance, use a vehicle that will allow you to keep a metre or more between you and the packages.
- Secure packages so that they will not move during transport — small, light packages should be stored in a basket while larger, heavy packages should be properly blocked and braced.
- Do not store in the one location packages with transport indexes that add up to more than 50. You will find the transport index written on the Yellow Category II or Category III label.

DANGEROUS GOODS CLASS LOADING RESTRICTIONS FOR ROAD AND RAIL

(Australian Dangerous Goods Code Sixth Edition 1998 – Clause 9.2.7)

(1) The requirements of this clause are additional to those of the Australian Code of Practice for the Safe Transport of Radioactive Material.

(2) Dangerous goods of Class 7 must be separated from other placard loads of dangerous goods and rolling stock listed below by at least:

(a) 24 metres from:
- dangerous goods of Class 1 or 2.1
- locomotive in power
- guard's brake van
- wagon loaded with logs, rails, beams, pipes etc. without bulkhead
- vehicle carrying passengers;

(b) 12 metres from:
- dangerous goods of Class 3, 4, 5, or 8
- operating refrigerated container.

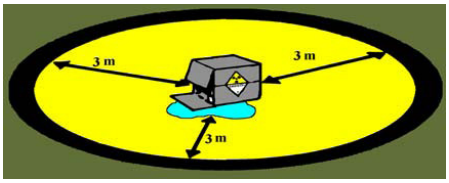
UN NUMBER	PROPER SHIPPING NAME and description	Subsidiary risks
2910	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – LIMITED QUANTITY OF MATERIAL	
2911	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – INSTRUMENTS or ARTICLES	
2909	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – ARTICLES MANUFACTURED FROM NATURAL URANIUM or DEPLETED URANIUM or NATURAL THORIUM	
2908	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – EMPTY PACKAGING	
2912	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I) non fissile or fissile-excepted *	
3321	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-II) non fissile or fissile-excepted *	
3322	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-III) non fissile or fissile-excepted *	
2913	RADIOACTIVE MATERIAL, SURFACE CONTAMI-NATED OBJECTS (SCO-I or SCO-II) non fissile or fissile-excepted *	
2915	RADIOACTIVE MATERIAL, TYPE A PACKAGE, non-special form, non fissile or fissile-excepted *	
3332	RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, non fissile or fissile-excepted *	
2916	RADIOACTIVE MATERIAL, TYPE B(U) PACKAGE, non fissile or fissile-excepted *	
2917	RADIOACTIVE MATERIAL, TYPE B(M) PACKAGE, non fissile or fissile-excepted *	
3323	RADIOACTIVE MATERIAL, TYPE C PACKAGE, non fissile or fissile-excepted *	
2919	RADIOACTIVE MATERIAL, TRANSPORTED UNDER SPECIAL ARRANGEMENT, non fissile or fissile-excepted *	
2978	RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE non fissile or fissile-excepted *	corrosive (UN Class 8)
3324	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-II), FISSILE	
3325	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-III), FISSILE	
3326	RADIOACTIVE MATERIAL, SURFACE CONTA-MINATED OBJECTS (SCO-I or SCO-II), FISSILE	
3327	RADIOACTIVE MATERIAL, TYPE A PACKAGE, FISSILE non-special form	
3333	RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, FISSILE	
3328	RADIOACTIVE MATERIAL, TYPE B(U) PACKAGE, FISSILE	
3329	RADIOACTIVE MATERIAL, TYPE B(M) PACKAGE, FISSILE	
3330	RADIOACTIVE MATERIAL, TYPE C PACKAGE, FISSILE	
3331	RADIOACTIVE MATERIAL, TRANSPORTED UNDER SPECIAL ARRANGEMENT, FISSILE	
2977	RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE, FISSILE	corrosive (UN Class 8)

* "Fissile-excepted" applies only to those packages complying with para. 672 of The Transport Code.

IN CASE OF ACCIDENT

If a radioactive material package has been damaged, and you suspect that the damage may allow leakage of radiation or spillage of radioactive material:

- Stay away from the package and **do not touch it.**
- Keep other people away from it.
- Notify your supervisor or manager, also inform them of any person who might have been contaminated — they will call for expert technical help if necessary.
- Tell anybody who might have touched the damaged package to report to the supervisor or manager — they will arrange the necessary action.
- Wash your hands thoroughly if you have touched the damaged package or objects near it and tell the supervisor or manager of your possible contamination by radioactive material.
- Have yourself checked for possible contamination before you leave work.
- Note any vehicles involved in the accident — the vehicles should remain at the accident site until cleared by the police or a competent person.
- **Do not** eat or smoke or drink or leave until checked for possible contamination.
- Advise the competent authority of details of the accident as soon as possible and follow any instructions subsequently issued.



EMERGENCIES:

AFTER HOURS CONTACT POLICE OR FIRE BRIGADE

AUSTRALIAN COMPETENT AUTHORITIES FOR THE TRANSPORT OF RADIOACTIVE MATERIAL BY ROAD/RAIL/INLAND WATERWAYS

COMMONWEALTH STATE / TERRITORY	CONTACT	COMPETENT AUTHORITY
Commonwealth	Chief Executive Officer ARPANSA PO Box 655 Tel: (02) 9541 8333 Miranda NSW 1490 Fax: (02) 9541 8348 Email: info@arpansa.gov.au	Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)
Australian Capital Territory	Director Health Protection Service Locked Bag 5 Tel: (02) 6205 1700 Weston Creek ACT 2611 Fax: (02) 6205 1705 Email: hps@act.gov.au	Australian Capital Territory Radiation Council
New South Wales	Manager Hazardous Materials and Radiation PO Box A290 Tel: (02) 9995 5000 Sydney South NSW 1232 Fax: (02) 9995 6603 Email: radiation@environment.nsw.gov.au	Department of Environment and Climate Change
Northern Territory (i) for radioactive ores and concentrates	Chief Inspector – Radioactive Ores and Concentrates (Packaging and Transport) NT WorkSafe Department of Justice GPO Box 1722 Tel: (08) 8999 5010 Darwin NT 0801 Fax:(08) 8999 5141 Email: neil.watson@nt.gov.au	Work Health Authority
(ii) for all other radioactive substances	Manager Radiation Protection Department of Health & Families GPO Box 40596 Tel: (08) 8922 7489 Casuarina NT 0811 Fax: (08) 8922 7334 Email: envirohealth@nt.gov.au	Department of Health and Families
Queensland	Director, Radiation Health Unit Department of Health PO Box 2368 Tel: (07) 3328 9200 Fortitude Valley BC QLD 4006 Fax: (07) 3328 9622 Email: radiation_health@health.qld.gov.au	Queensland Department of Health
South Australia	Director, Radiation Protection Division Environment Protection Authority PO Box 2607 Tel: (08) 8463 7814 Adelaide SA 5001 Fax: (08) 8124 4671 Email: radiationprotection@epa.sa.gov.au	Minister for Environment & Conservation
Tasmania	Senior Health Physicist, Health Physics Branch Department of Health & Human Services GPO Box 125B Tel: (03) 6222 7256 Hobart TAS 7001 Fax: (03) 6222 7257 Email: health.physics@dhhs.tas.gov.au	Director of Public Health
Victoria	Team Leader, Radiation Safety Department of Human Services GPO Box 4057 Tel: 1300 767 469 Melbourne VIC 3001 Fax: 1300 769 274 Email: radiation.safety@dhs.vic.gov.au	Secretary, Department of Human Services
Western Australia	The Secretary, Radiological Council Locked Bag 2006 PO Tel: (08) 9346 2260 Nedlands WA 6009 Fax: (08) 9381 1423 Email: radiation.health@health.wa.gov.au	Radiological Council

B. Appendix on transport of uranium oxide concentrate

During processing of uranium ore, the daughter products are separated out and a weakly radioactive uranium oxide concentrate (UOC or U_3O_8) is produced. Uranium is exported in the form of UOC which is both chemically and physically stable. It cannot undergo a chain reaction as in weapons grade uranium.

B.0.1. Packaging

UOC is packaged in sealed 205 litre steel drums. Each drum has a tight fitting lid which is secured to the drum by means of a steel locking ring that is clamped by a locking ring bolt. Drums filled with UOC are stowed securely to international standards, within 6.05 metre International Organisation for Standardization (ISO) sea freight containers by means of a webbed Kevlar based strapping system, commercially known as 'CORDSTRAP'as shown in Figure B.1 on the next page.

This is the preferred packing method and complies with the requirements of the International Maritime Dangerous Goods (IMDG) code and relevant United Nations guidelines for Packing of Cargo Transport Units. This packing method has been formally approved by the Australian Maritime Safety Authority (AMSA).

The packed containers are placarded, inspected and sealed with consecutively numbered bolt-type seals affixed to the door of each container at the mine site. Containers remain sealed throughout the journey from mine to final overseas point of delivery. Container seals are checked for integrity at all transhipment and discharge points.

The Transport Index (TI) is an indicative measure of the potential gamma radiation level at 1 metre from a shipping container. Table B.1 provides a guide to the length of time a person would need to spend continually standing at a distance of 1 metre from a shipping container of UOC in order to exceed the international worker annual limit of 20 millisieverts (mSv).

Table B.1.: Transport Index

Transport Index [TI]	Equivalent hours at 1 metre	Equivalent days at 1 metre
2.0	1000	40
4.5	444	19
6.0	333	14

Source: Values derived using TI as defined in the Code of Practice for the Safe Transport of Radioactive Material [7].

Figure B.1.: Transport of UOC

B.0.2. Transport

UOC is transported worldwide by road, rail and sea. It is classed as a dangerous good under the Australian Dangerous Goods Code (Class 7) and UN number UN2912. The proper shipping name is 'Radioactive Material, Low Specific Activity (LSA–1) Non-Fissile or Fissile — Excepted'. Within Australia, the transportation of UOC by road or rail from mine site to intermodal export facilities is regulated in accordance with Australian Government, state and territory legislation as well as international standards. Sea transport of UOC is regulated according to international standards.

International standards require that each container packed with UOC bear a UN2912 Radioactive Class 7 placard and a Radioactive Category II Yellow placard affixed in a vertical orientation to each side wall and each end wall of the container. Specific documentation, manifesting the load details, is carried in the driver's cabin of each vehicle.

B.0.3. Transport plan

Each producer/shipper of UOC based in Australia has prepared an individual Transport Plan that specifically focuses on the numerous activities and responsibilities that need to be addressed and covered by all parties and individuals involved in the transportation of UOC containers from their mine site to the applicable export shipping port or terminal.

B.0.4. Permit to transport nuclear material

In Australia, all parties involved in production, transport, handling or storage of UOC are required to obtain either a 'Permit to Possess Nuclear Material' or a 'Permit to Transport Nuclear Material' from the Australian Safeguards and Non–Proliferation Office (ASNO). These permits detail the

responsibilities of the Permit Holder, including security and control of the UOC, maintaining documentation and records for UOC shipments, and notifying ASNO of any changes in conditions or incidents relating to the storage or carriage of UOC.

B.0.5. Radiation protection, first aid and safety measures

UOC is harmful only if inhaled or ingested. Provided sensible precautions are taken to avoid inhalation or ingestion, it will not present a health hazard to people handling it. Skin contact should be avoided and personal hygiene is important: wash hands, do not smoke, and minimise exposure to dust.

1. Occupational radiation received during the transportation of low level UOC is a factor of the time spent working around the material and the intensity of radiation emitted by the material.
2. The total time involved handling or transporting the UOC containers combined with the very low levels of radiation emitted by the UOC itself therefore severely reduces the probability of receiving any hazardous exposure from the material in the normal course of events. Indeed, exposure from this source is well below the regulatory limit for transport workers.
3. If appropriate precautions are taken to minimise exposure when handling, transporting or storing UOC materials there will be no risk to health. As UOC has slight chemical toxicity and is weakly radioactive, inhalation and ingestion should be avoided.
4. If a spillage of UOC does occur, the main health consideration will be to prevent yourself and others from breathing in any UOC dust. The likelihood of this occurring is low due to the density of the material and the drum packing and stowage methods employed within the packed container. However it makes good practical sense, irrespective of the size of any spillage, to always remember you must wear a dust mask and gloves.
5. These safety precautions are similar to the expectations and standards required by handlers of other dangerous goods and hazardous materials.

B.0.6. What are the risks?

Figure B.2 on the next page shows the ideal working distance from a container of UOC.

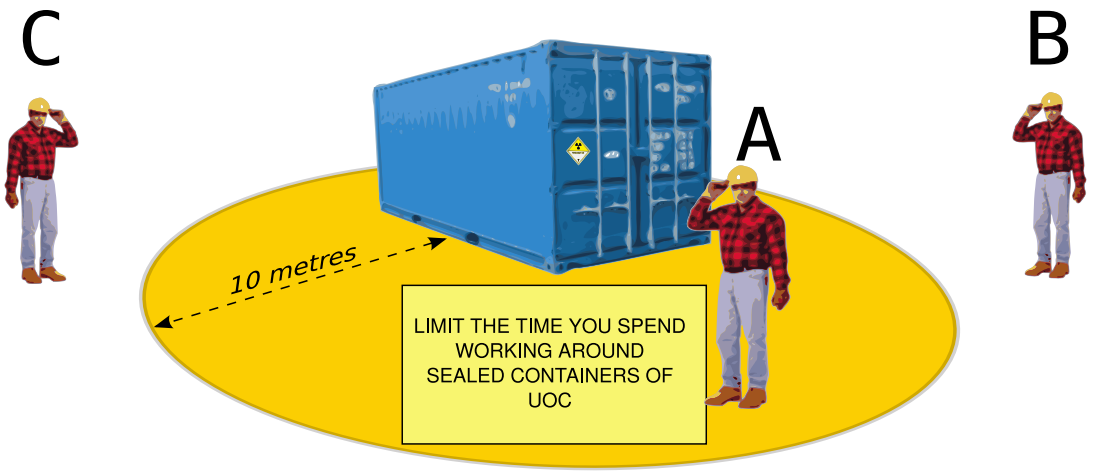
B.0.7. Typical UOC logistics chain

Figure B.4 on page 27 shows the typical transport logistics chain to ensure that the UOC shipping container is safely delivered to its purchaser at the destination.

Acknowledgement: The section in this Guideline about the transport of UOC is based on a leaflet produced by the Commonwealth Department of Industry, Tourism and Resources [17].

Figure B.2.: Risks from a sealed container

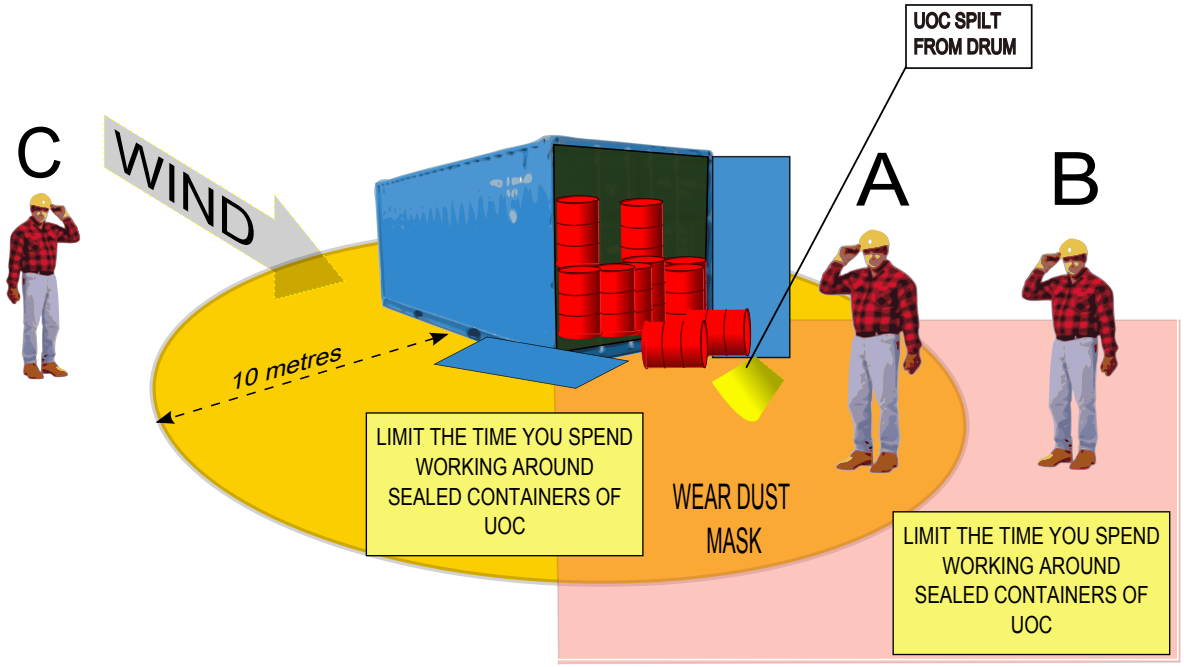
Expect normal background radiation from a sealed container.



Precautions		
A	B	C
Reduce and limit time spent in close proximity.	Expect normal background radiation levels.	Expect normal background radiation levels.

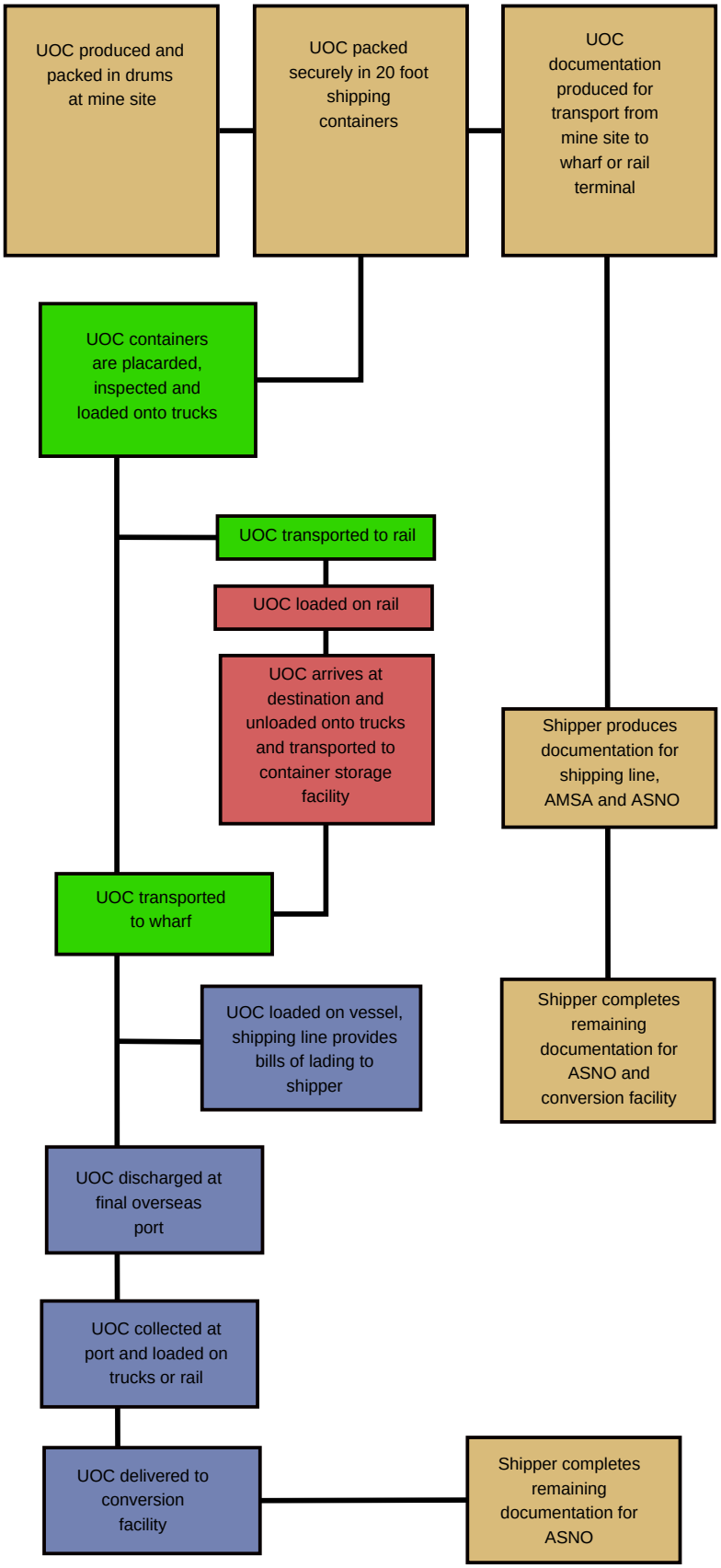
Figure B.3.: Risks from a sealed container.

Expect normal background radiation from a sealed container.



Precautions		
A	B	C
Reduce and limit time spent in close proximity. Wear a dust mask. Wash hands and clothes.	Reduce and limit time spent. Person downwind of spill should wear a dust mask. Wash hands and clothes.	No dust.

Figure B.4.: Typical UOC logistics chain



Bibliography

[1] Part 16 – Radiation Safety, Mines Safety & Inspection Regulations, 1995.

[2] Radiation Safety (Transport Radioactive Substances) Regulations, 2002.

[3] Code of Practice and Safety Guide: Radiation Protection and Radioactive Waste Management in Mining and Minerals Processing, Radiation Protection Series Publication No.9, Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2005.

[4] Sources and Effects of Ionising Radiation; 2000 Report to the General Assembly, with Scientific Annexes, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2000.

[5] *Contaminated Sites Act, 2003.* link

[6] Application of the Regulations for the Safe Transport of Radioactive Material to Bulk Shipments of Materials in Minerals Industry, N. Tsurikov, P.J. Hinrichsen. M. Omar, H.R.S.M. Fernandes – Radiation Protection in Australasia, 2007

[7] Code of Practice – Safe Transport of Radioactive Material, Radiation Protection Series No.2, Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2008.

[8] Regulations for the Safe Transport of Radioactive Material, Safety Requirements No. TS–R–1, International Atomic Energy Agency (IAEA), Vienna, 1996 Edition (Revised in 2000).

[9] Regulations for the Safe Transport of Radioactive Material, Safety Requirements No. TS–R–1, International Atomic Energy Agency (IAEA), Vienna, 2005 Edition.

[10] Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, Safety Guide No. TS–G–1.1, International Atomic Energy Agency (IAEA), Vienna, 2002.

[11] IAEA TECDOC–1449, Radiological Aspects of Non-fixed Contamination of Packages and Conveyances, International Atomic Energy Agency (IAEA), Vienna, 2005.

[12] Radiation Protection Programs for the Transport of Radioactive Material, Safety Guide No. TS-G-1.3, International Atomic Energy Agency (IAEA), Vienna, 2007.

[13] Planning and Preparing for Emergency Response to Transport Accidents Involving Radioactive Material, Safety Guide No. TS-G-1.2, International Atomic Energy Agency (IAEA), Vienna, 2002.

[14] Regulations for the Safe Transport of Radioactive Material, Safety Requirements No. TS–R–1, International Atomic Energy Agency (IAEA), Vienna, 2009 Edition.

[15] Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, Safety Guide No. TS–G–1.1 (Rev.1), International Atomic Energy Agency (IAEA), Vienna, 2008.

[16] Summary of submissions and responses – Draft Code of Practice for the Safe Transport of Radioactive Material, ARPANSA, 2008.

[17] Safe and effective transport of uranium – Uranium Industry Framework Implementation Transport Working Group, Department of Industry, Tourism and Resources, 2007.

Index

10-times exemption factor, 4

activity concentration, 2, 3, 5, 6, 8
activity equation, 3
activity limits, 3
activity per unit mass, 12
advisory material, 13
aggregate activity concentration, 3
alpha emitters, 14
AMSA, 22
ASNO, 23

background, 16
beta emitters, 5, 14, 15
beta gamma emitters, 15
blending, 2, 12, 13
bulk transport, 10

Category I–WHITE, 8
Category II–YELLOW, 8
Category III–YELLOW, 8
chemical processing, 4
classification, 2
consignment, 7
consignor, 10
cordstrap, 22
counts per minute, 16

excepted package, 2, 16
exclusive use, 2, 10
exempted package, 6
exemption, 2

flotation agents, 4

gamma emitters, 5, 14, 15
gravimetric separation, 3

IAEA, 2
IMDG, 22

laboratory analysis, 6
leaching, 4
lead (^{210}Pb), 4
lead (^{212}Pb), 4
load covering, 11
low specific activity, 12
Low Specific Activity Material, 8
low toxicity alpha emitters, 14, 15
LSA, 12
LSA–1, 23
LSA–I, 7, 8
LSA–II, 8

material restrictions, 3
minerals industry, 3
monazite concentrate, 13, 14
multiplication factor, 7

neutron emitters, 5
non-fixed contamination, 15
NORM, 2

placards, 6–8
public road, 2

radiation safety officer, 6
radioactive material, 12
radium (^{226}Ra), 4
radium (^{228} Ra), 4
railway, 2
Ratio method, 4
road train, 10
routine conditions, 11

SCO, 14
SCO–I, 7, 14
SCO–II, 15
scrap metal, 16
secular equilibrium, 3–5
shielding, 11
signposting, 2
special arrangement, 8
specific activity, 4, 12
standing declaration, 6
surface contaminated, 16
Surface Contaminated Object, 14
surface contaminated object, 14
surface contamination, 2, 14, 16, 17

thermal processing, 4

thorium (^{228}Th), 4
thorium (^{230}Th), 4
thorium (^{232}Th), 3, 4, 6
thorium (natural), 3
total activity, 5
training, 6
transport driver, 6
transport index, 7, 8, 13
transport licence, 6
transport of radioactive material, 2

UN2910, 7
UN2912, 23
UOC, 22
uranium (^{238}U), 3, 4
uranium (natural), 3

waterway, 2