TRANSPORTING NORM IN ACCORDANCE WITH THE REQUIREMENTS OF SSR-6

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TRANSPORTING NORM IN ACCORDANCE WITH THE REQUIREMENTS OF SSR-6

TRANSSC NORM WORKING GROUP MEETING 4:

DATE OF MEETING: 26 and 27 November 2018

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<th>Country</th>
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1.0 BACKGROUND

The following Guidance is based on the IAEA Regulations for the Safe Transport of Radioactive Material (SSR-6, 2012) \[^1\] and associated Advisory Material (SSG-26, 2014)\[^2\].

NORM materials (Naturally Occurring Radioactive Materials) differ from other radioactive materials in that NORM is a mixture of radioactive species. In particular, most unprocessed NORM contains the full spectrum of the Uranium/Thorium radionuclides which are defined as “naturally occurring”. If the user does not need to consider the exemption of their material from the need to comply with the IAEA Transport Regulations then the shipment preparation is straightforward. However as soon as we need to consider the possibility of exemption then our considerations become more involved. This aspect is dealt with in detail in the 3rd document in this series.

2.0 PURPOSE

The purpose of this document is to provide guidance to NORM practices with regards to the correct categorisation, packaging, labelling and transport of NORM in compliance with the requirements of the International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Material. Hereafter called the IAEA Regulations.

3.0 TERMS, DEFINITIONS AND ABBREVIATIONS

Any word or expression to which a meaning has been assigned in the IAEA Regulations, should have the meaning so assigned. The exception to this rule is when there is a contradiction with any meaning so assigned in the Local Rules within your country or in any regulations promulgated in terms of the Local Rules. In such instances your Local Rules or regulatory meanings should take preference. If in any doubt you are advised to seek clarity from your Regulator.

3.1 Radioactive Material.

The definition of “radioactive material”, given in paragraph 236 of the IAEA Regulations \[^1\] is as follows;
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236. Radioactive material shall mean any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in paragraphs 402 – 407

3.2 Low specific activity (LSA) material

SSR-6 Paragraph 226:

Low specific activity material

226. 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.

SSR-6 Paragraph 409.

There are three (3) groups of LSA material defined in the IAEA Regulations;

- LSA-I
- LSA-II
- LSA-III

The LSA Classification of your material will determine the permitted packaging options, SSR-6 Table 5, and the conveyance activity limits, SSR-6 Table 6.

Here we only interested in the first group

409 (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;

(ii) Natural uranium, depleted uranium, natural thorium or their compounds or mixtures, that are unirradiated and in solid or liquid form.

(iii) Radioactive material for which the A2 value is unlimited. Fissile material may be included only if excepted under para. 417.

(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 401–405, excluding fissile material in quantities not excepted under para 672.
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It should be noted that in using paragraph 409(a)(iv) to define the upper limit for LSA-I material and the transition to LSA-II, the factor of x10 (from paragraph 107 (f)) is not to be used in conjunction with the x 30 factor.

The above are the four criteria for material to be classified as LSA-I material.

**Generally, NORM materials will be Classified as LSA-I by paragraph 409(a)(iii);**

The reason for this is from Table 2, of the IAEA Regulations, for all the entries for nuclides related to either the U-238 chain or the Th-232 chain almost all have “unlimited” $A_2$ value.

The exception is that, neither Ra-226 nor Ra-228 have unlimited $A_2$ values, in Table 2, hence any materials having significant quantities of either of these radionuclides (as defined by the regulatory authority) should be classified as LSA-II.

### 3.3 Surface Contaminated Object (SCO)

241. Surface contaminated object (SCO) shall mean a solid object that is not itself radioactive, but which has radioactive material distributed on its surface.

A surface Contaminated Object may be defined as a non-radioactive solid object contaminated on any surfaces with surface contamination exceeding $\leq 0.4 \text{ Bq/cm}^2$ for beta and gamma and low toxicity alpha;

or

$\leq 0.04 \text{ Bq/cm}^2$ for all other alpha emitters.

412. Radioactive material may be classified as SCO if the conditions in paras 241, 413, 414 and 517–522 are met.

413. 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.

(ii) The 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 $4 \times 10^4$ Bq/cm$^2$ for beta and gamma emitters and low toxicity alpha emitters, or 4000 Bq/cm$^2$ for all other alpha emitters.
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(iii) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm² (or the area of the surface if less than 300 cm²) does not exceed $4 \times 10^4$ Bq/cm² for beta and gamma emitters and low toxicity alpha emitters, or 4000 Bq/cm² for all other alpha emitters.

6.0 PACKAGING REQUIREMENTS

6.1 Transported as an “Excepted Package”

If the determined activity level of the material to be transported exceeds the Exemption limit only by a low margin there is the possibility that the load may be transported as an Excepted Package. The main criteria here is paragraph 516 of SSR 6;

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

Please note that to prove qualification for an excepted package the measurement must be taken on the surface of the package and not at a distance of 1m.

6.2 Transport of Exploration Samples

The transport of exploration samples from a site to a laboratory should also be carried out in accordance with the IAEA Regulations. 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. In this regard the main requirement is that the gamma dose rate on all surfaces of the package does not exceed 5 µSv/h.

2. If the level anywhere on the surface of the package exceeds 5 µSv/h, then the Transport Index (TI) of the material needs to be determined and the appropriate packaging selected based upon the TI (See Section 10.1.1 for the determination of TI).

Exploration samples must be transported in such a manner as to ensure that the material is contained within the conveyance under normal conditions of transport. Also, there should not be any contamination on the internal surface of the vehicle (unless it is under ‘exclusive use’).
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NORM “Exploration Samples” are generally classified as LSA 1 material and the most suitable packaging for the sample is a Type IP 1 container, if the external gamma doserate exceeds the limit for an Excepted Package.

6.3 Packaged or Non-Packaged;

All NORM, which has been classified as LSA I, may be either transported unpackaged or packaged in an IP-1 transport container.

6.3.1 Transport as Unpackaged Material

NORM material may be transported as Unpackaged, provided that there is no loss of shielding, or escape of radioactive material from the conveyance under routine conditions of transport.

Figure 1: Unpackaged Shipment of NORM Material.
Note the covering on the vehicle to prevent unnecessary spillages

6.3.2 Transport as Packaged LSA 1 Material
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For certain NORM material (Uranium Oxide) it is more in keeping with the ALARA Principle to ship as packaged material in Type IP1 containers as shown above.

The permitted Packaging options are given below;

<table>
<thead>
<tr>
<th>Radioactive Contents</th>
<th>Industrial Package Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LSA-I</strong></td>
<td></td>
</tr>
<tr>
<td>Solid</td>
<td>Type IP-1</td>
</tr>
<tr>
<td>Liquid</td>
<td>Type IP-1</td>
</tr>
<tr>
<td><strong>LSA-II</strong></td>
<td></td>
</tr>
<tr>
<td>Solid</td>
<td>Type IP-2</td>
</tr>
<tr>
<td>Liquid and Gas</td>
<td>Type IP-2</td>
</tr>
</tbody>
</table>

*Under the conditions specified in para. 520, LSA-I material and SCO-I may be transported unpackaged

Additionally, the maximum permitted activity per package is given by;

Conveyance Activity Limits for LSA Material and SCO in Industrial Packages or Un-Packaged

Figure 2: Packaged Transport of Uranium Oxide in Type IPI Packages
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<table>
<thead>
<tr>
<th>Nature of Material</th>
<th>Activity Limit for Conveyances other than Inland Waterway Craft</th>
<th>Activity Limit for a Hold or Compartment of an Inland Waterway Craft</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSA-I</td>
<td>No Limit</td>
<td>No Limit</td>
</tr>
<tr>
<td>LSA-II and LSA-III</td>
<td>No Limit</td>
<td>100 $A_2$</td>
</tr>
<tr>
<td>Non-Combustible Solids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSA-II and LSA-III</td>
<td>100 $A_2$</td>
<td>10 $A_2$</td>
</tr>
<tr>
<td>Combustible Solids and all Liquids and Gasses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCO</td>
<td>100 $A_2$</td>
<td>10 $A_2$</td>
</tr>
</tbody>
</table>

(SSR-6 Table 6)

7.0 **CONTROLS ON TRANSPORT**

The following Controls apply to the transport;

7.1 Maximum Radiation Levels for Conveyances;

- Gamma radiation level not to exceed 2 mSv/h at any point on the external surface of the conveyance (not under Exclusive Use).
- Gamma radiation dose not to exceed 0.1 mSv at 2m from any external surface of conveyance
- Radiation levels within any occupied position must be ALARA and appropriate radiation protection measures must be in place.

See Appendix 1.

7.2 Conveyances under “Exclusive Use”

Most NORM in the mining and mineral processing industry is transported unpackaged. In this case, material is typically transported in the conveyance under exclusive use. The definition of “Exclusive Use” is provided in para 221:
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 [2]:

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

7.3 Decontamination Post Transport

The main benefit of having a vehicle under 'exclusive use' is the fact that internal surfaces will not need to undergo decontamination between journeys, except as might be regarded as good radiation protection practice or in accordance with Paragraph 513 and 514 of SSR-6.

513. Except as provided in para. 514, any conveyance, or equipment or part thereof that has become contaminated above the limits specified in para. 508 in the course of the transport of radioactive material, or that shows a dose rate in excess of 5 μSv/h at the surface, shall be decontaminated as soon as possible by a qualified person and shall not be reused unless the following conditions are fulfilled:

(a) The non-fixed contamination shall not exceed the limits specified in para. 508.
(b) The dose rate resulting from the fixed contamination shall not exceed 5 μSv/h at the surface.

514. A freight container, tank, IBC 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.
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8.0 LABELLING AND PLACARDING

8.1 UN Number and UN Proper Shipping Name

In line with the United Nations Recommendations on the Transport of Dangerous Goods (UN Orange Book [4]) all shipments of Dangerous Goods, as defined, must carry on the outside of the vehicle, as well as in the shipment documentation, the;

- UN Number
- UN Proper Shipping Name

These identifiers are defined in the UN Orange Book (as well as in the IAEA Schedules [5] and serve as information, to the trained eye, on what the dangerous goods cargo consists of. Hence it is not correct to think that these identifiers only apply for cross-border shipments and do not need to be displayed on a shipment which is local (remains within a single country).

The UN Orange Book defines Nine Classes of Dangerous Goods, of which radioactive Material is defined under Class 7.

Most NORM related shipments comprise either LSA-1 material or SCO-1 material (Surface Contaminated Object). Hence the Consignors Note for a shipment will usually carry one of the following;

8.2 Consignors Note (SSR 6):

For Low Specific Activity Material LSA I:

<table>
<thead>
<tr>
<th>UN Proper Shipping Name:</th>
<th>Radioactive Material, Low Specific Activity (LSA-1) non fissile or fissile excepted</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN No:</td>
<td>UN 2912</td>
</tr>
</tbody>
</table>

OR:

For Low Specific Activity Material LSA II:
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<table>
<thead>
<tr>
<th>UN Proper Shipping Name:</th>
<th>Radioactive Material, Low Specific Activity (LSA-II) non fissile or fissile excepted</th>
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<tbody>
<tr>
<td>UN No:</td>
<td>UN 3321</td>
</tr>
</tbody>
</table>

OR:

For Surface Contaminated Objects:

<table>
<thead>
<tr>
<th>UN Proper Shipping Name:</th>
<th>Radioactive Material, Surface Contaminated Objects (SCO-1 or SCO-II), non-fissile or fissile-excepted</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN No:</td>
<td>UN 2913</td>
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</tbody>
</table>
TRANSPORTING NORM IN ACCORDANCE WITH THE REQUIREMENTS OF SSR-6

<table>
<thead>
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<th>UN Number</th>
<th>UN Proper Shipping Name</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>UN-2912</td>
<td>RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I), Non-Fissile or Fissile Excepted</td>
</tr>
<tr>
<td></td>
<td>UN-2913</td>
<td>RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-I OR SCO-II), Non-Fissile or Fissile Excepted</td>
</tr>
<tr>
<td></td>
<td>UN-3321</td>
<td>RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-II), Non-Fissile or Fissile Excepted</td>
</tr>
</tbody>
</table>

Figure 3

9.0 LABELLING AND PLACARDING

Users of the IAEA Regulations are often confused concerning the differences between “Labels” and “Placards”.

The following are “Labels”;

Figure 4
The following are “Placards”;

Figure 5

9.1 Labels

In accordance with paragraph 548 of the IAEA Regulations;

SSR-6 Paragraph 538:

Each package, overpack and freight container shall bear the labels conforming to the applicable models in Figs 2-4, except as allowed under the alternative provisions of para. 543 for large freight containers and tanks, according to the appropriate category. In addition, each package, overpack and freight container containing fissile material, other than fissile material excepted under the provisions of para. 417, shall bear labels conforming to the model in Fig. 5. Any labels that do not relate to the contents shall be removed or covered. For radioactive material having other dangerous properties see para. 507.

Figure 6
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Category I-WHITE label. The background colour of the label shall be white, the colour of the trefoil and the printing shall be black, and the colour of the category bar shall be red.

![Figure 7](image)

Category II-yellow label. The background colour of the upper half of the label shall be yellow and the lower half white, the colour of the trefoil and the printing shall be black, and the colour of the category bars shall be red.

![Figure 8](image)

Category III-yellow label. The background colour of the upper half of the label shall be yellow and the lower half white, the colour of the trefoil and the printing shall be black, and the colour of the category bars shall be red.

Labelling for radioactive contents, SSR6 para.540

540. Each label conforming to the applicable models in Figs 2–4 [Figures 6 – 8 in this report] shall be completed with the following information:

(a) Contents:

(i) Except for LSA-I material, the name(s) of the radionuclide(s) as taken from Table 2, using the symbols prescribed therein. For mixtures of radionuclides, the most
restrictive nuclides must be listed to the extent the space on the line permits. The group of LSA or SCO shall be shown following the name(s) of the radionuclide(s). The terms “LSA-II”, “LSA-III”, “SCO-I” and “SCO-II” shall be used for this purpose.

(ii) For LSA-I material, the term “LSA-I” is all that is necessary; the name of the radionuclide is not necessary.

(b) Activity: The maximum activity of the radioactive contents during transport expressed in units of becquerels (Bq) with the appropriate SI prefix symbol (see Annex II). For fissile material, the total mass of fissile nuclides in units of grams (g), or multiples thereof, may be used in place of activity.

(c) For overpacks and freight containers, the “contents” and “activity” entries on the label shall bear the information required in para. 540(a) and 540(b), respectively, totalled together for the entire contents of the overpack or freight container except that on labels for overpacks or freight containers containing mixed loads of packages containing different radionuclides, such entries may read “See Transport Documents”.

(d) TI: The number determined in accordance with paras 523 and 524 (no TI entry is required for Category I-WHITE).

9.2 Placarding

SSR-6 Paragraph 543:

Large freight containers carrying packages other than excepted packages, and tanks, shall bear four placards that conform to the model given in Fig. 6. The placards shall be affixed in a vertical orientation to each side wall and to each end wall of the large freight container or tank. Any placards that do not relate to the contents shall be removed. Instead of using both labels and placards, it is permitted as an alternative to use enlarged labels only, where appropriate, as shown in Figs 2–4, except having the minimum size shown in Fig. 6.
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Figure 9. Placard. Except as permitted by para. 571, minimum dimensions shall be as shown; when different dimensions are used, the relative proportions must be maintained. The number ‘7’ shall not be less than 25 mm high. The background colour of the upper half of the placard shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black. The use of the word “RADIOACTIVE” in the bottom half is optional, to allow the alternative use of this placard to display the appropriate UN number for the consignment.

Figure 10, placard for separate display of UN number. The background colour of the placard shall be orange and the border and UN number shall be black. The symbol “2912” is an example of the appropriate UN number for radioactive material, as specified in SSR-6 Table 1.

544. Where the consignment in the freight container or tank is unpackaged LSA-I or SCO-I or where a consignment in a freight container is required to be shipped under exclusive use and is packaged radioactive material with a single UN number, the appropriate UN number for the consignment (see Table 1) shall also be displayed, in black digits not less than 65 mm high, either:

(a) In the lower half of the placard shown in Fig. 6 and against the white background [Figure 11 in this report]; or

(b) On the placard shown in Fig. 7 [Figures 11 in this report].

When the alternative given in (b) is used, the subsidiary placard shall be affixed immediately adjacent to the main placard, on all four sides of the freight container or tank.

Hence, the display on the appropriate UN Number on the freight container/vehicle the following two possibilities exist;
Option a

![Figure 11](image)

571. Vehicles carrying packages, overpacks or freight containers labelled with any of the labels shown in Figs 2–5 (Figures 6 – 8 in this report – Fig 5 is not applicable to LSA), or carrying consignments under exclusive use, shall display the placard shown in Fig. 6 on each of:

(a) The two external lateral walls in the case of a rail vehicle;

(b) The two external lateral walls and the external rear wall in the case of a road vehicle.

In the case of a vehicle without sides, the placards may be affixed directly on the cargo carrying unit provided that they are readily visible. In the case of large tanks or freight containers, the placards on the tanks or freight containers shall suffice. In the case of vehicles that have insufficient area to allow the fixing of larger placards, the dimensions of the placard described in Fig. 6 may be reduced to 100 mm. Any placards that do not relate to the contents shall be removed.

Option b

![Figure 12](image)
TRANSPORTING NORM IN ACCORDANCE WITH THE REQUIREMENTS OF SSR-6

Labelling of Individual Drums

![Figure 13: Labelling of Individual Drums]

Placarding the conveyance

![Figure 7: Placarding the conveyance]

10.0 CATEGORISATION OF A SHIPMENT

10.1 Determination of the Correct Categorisation of NORM

This Section discusses the steps used to classify the material for transport labelling purposes. Correct material Classification will ensure that the proper placards are displayed during the transport.
10.1.1 Determination of Transport Index

Firstly, there is a need to determine the Transport Index (TI) and the Category of the consignment.

The TI for a package, over-pack or freight container, or for unpackaged LSA-I or SCO-I, shall be the number derived in accordance with the following procedure:

(a) 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 TI. For uranium and thorium ores and their concentrates, the maximum radiation level at any point 1 m from the external surface of the load may be taken as:

(i) 0.4 mSv/h for ores and physical concentrates of uranium and thorium;

(ii) 0.3 mSv/h for chemical concentrates of thorium.

Typically, there are two transport situations where we need to determine the TI of the shipment.

CASE 1: Non-Packaged NORM in a Transport Vehicle;

If we are presented with a transport containing loose NORM, as in the picture below;

![Figure 8](image)

Determining the TI is a matter of conducting the measurements described above and then multiplying the value from step (a) by a value from Table 7 of the IAEA Regulations;
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<table>
<thead>
<tr>
<th>Size of Load</th>
<th>Multiplication Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of Load ≤ 1 m²</td>
<td>1</td>
</tr>
<tr>
<td>1 m² ≤ Size of Load ≤ 5 m²</td>
<td>2</td>
</tr>
<tr>
<td>5 m² ≤ Size of Load ≤ 20 m²</td>
<td>3</td>
</tr>
<tr>
<td>20 m² ≤ Size of Load</td>
<td>10</td>
</tr>
</tbody>
</table>

(SSR-6 Table 7)

CASE 2: NORM packaged in individual packagings and then loaded onto a transport vehicle.

When the material is being transported in multiple drums inside one container (for example, in the process of a shipment of tantalum concentrates), How do we determine the TI in this case?

SSR-6, Para. 524 provides the method.

524. The TI for each overpack, freight container or conveyance shall be determined as either the sum of the TIs of all the packages contained, or by direct measurement of radiation level, except in the case of non-rigid overpacks, for which the TI shall be determined only as the sum of the TIs of all the packages.

The above paragraph is not explicit in what is implied by the expression “by direct measurement”. However, the following paragraph from SSG-26 [3] clarifies that this expression means measuring the gamma radiation dose from 1 m from the prepared shipment in order to calculate the TI of the prepared shipment.
SSG 26, Para. 524.1 provides the guidance

524.1 For rigid overpacks, freight containers and conveyances, adding the TI’s reflects a conservative approach as the sum of the TIs of the packages contained is expected to be higher than the TI obtained by measurement of the maximum radiation level at 1 m from the external surface of the overpack, freight container or conveyance owing to shielding effects and additional distance with such measurement. In the case of non-rigid overpacks, the TI may only be determined as the sum of the TIs of all packages contained. This is necessary because the dimensions of the overpack are not fixed and radiation level measurements at different times may give rise to different results.

Hence the gamma radiation dose rate needs to be measured from the container/package/overpack. Measuring radiation levels from each individual drum, and summing, is likely to result in an incorrect determination of the Transport Index, as this process will not take into account the shielding offered by the walls of the container/overpack and, sometimes, also by the drums with ballast material which may also be placed inside a transport container.

Once the Transport Index (TI) has been determined we then proceed to Paragraph 529 and Table 8 to determine the Category of the shipment.

In this scenario the Area Correction Factor from Table 7 is NOT used.

529. Packages, overpacks and freight containers shall be assigned to either category I-WHITE, II-YELLOW or III-YELLOW in accordance with the conditions specified in Table 8 and with the following requirements:

(a) For a package, overpack or freight container, the TI and the surface radiation level conditions shall be taken into account in determining which category is appropriate. Where the TI satisfies the condition for one category but the surface radiation level satisfies the condition for a different category, the package, overpack or freight container
shall be assigned to the higher category. For this purpose, category I-WHITE shall be regarded as the lowest category.

(b) The TI shall be determined following the procedures specified in paras 523 and 524.

(c) If the surface radiation level is greater than 2 mSv/h, the package or overpack shall be transported under exclusive use and under the provisions of paras 573(a), 575 or 579, as appropriate.

(d) A package transported under a special arrangement shall be assigned to category III-YELLOW except under the provisions of para. 530.

(e) An overpack or freight container that contains packages transported under special arrangement shall be assigned to category III-YELLOW except under the provisions of para. 530.

The category of the load is determined based on the transport index and the radiation level on external surface.

It is important to note the difference – transport index is determined by measuring radiation levels at a distance of 1 metre from the shipment, for categorisation of the load an additional measurement on the surface is required.

**SSR-6, TABLE 8. CATEGORIES OF PACKAGES, OVERPACKS AND FREIGHT CONTAINERS**

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>TI</td>
<td></td>
</tr>
<tr>
<td>0a</td>
<td>I-WHITE</td>
</tr>
<tr>
<td>More than 0 but not more than 1a</td>
<td>II-YELLOW</td>
</tr>
<tr>
<td>More than 1 but not more than 10</td>
<td>III-YELLOW</td>
</tr>
<tr>
<td>More than 10</td>
<td>III-YELLOW b</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum radiation level at any point on external surface</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not more than 0.005 mSv/h</td>
<td></td>
</tr>
<tr>
<td>More than 0.005 mSv/h but not more than 0.5 mSv/h</td>
<td></td>
</tr>
<tr>
<td>More than 0.5 mSv/h but not more than 2 mSv/h</td>
<td></td>
</tr>
<tr>
<td>More than 2 mSv/h but not more than 10 mSv/h</td>
<td></td>
</tr>
</tbody>
</table>

a If the measured TI is not greater than 0.05, the value quoted may be zero in accordance with para. 523(c).

b Shall also be transported under exclusive use except for freight containers, see Table 10.
11.0 SURFACE CONTAMINATION AND RELEASE OF ITEMS FROM SITES

In cases where solid (possibly SCO) material needs to be Cleared from a regulated site, prior to transport the following advice is offered.

All measurements described below need to be carried out in a ‘clean’ area. Measuring gamma radiation level from a possibly contaminated item in the vicinity of a mineral stockpile or at the wall of a processing plant will almost certainly provide a false reading, as the radiation levels measured from an item in a radiologically contaminated area will reflect an overall radiation level in this area, not the levels from the particular item.

It is acknowledged that establishing an area with a low natural background levels may not be always possible, especially in cases of small processing plants and laboratories – it is, however, recommended that such an area is designated at each site, as far as it is practicable.

The following factors also need to be considered, as they will influence the results obtained by the surveys for surface contamination:

- The size of the probe,
- The efficiency of the probe,
- The distance of measurement,
- The speed of measurement, and
- The geometry of measured objects.

The calibration certificate for the surface contamination probe should include:

- A conversion factor between cps/cpm values, obtained by the monitor, and the value in Bq/cm², and
- The efficiency of the probe for several radionuclides (both alpha- and beta-emitters, typical examples are $^{239}$Pu, $^{238}$U, $^{32}$P, $^{137}$Cs, $^{147}$Pm, $^{60}$Co and $^{90}$Sr).

11.1 Measuring Gamma-Radiation

If in doubt concerning the defined regulatory clearance levels you are advised to seek guidance from your regulatory authority.

At the initial step the items need to be surveyed for gamma-radiation levels – which is easy to do and interpret. An item could be considered as possibly suitable for recycling if gamma radiation levels measured at some distance from it (say at 30-40 centimetres) are the same as the natural background in the area (in some cases the survey of gamma radiation levels may need to be carried out at shorter distances, of about 10 centimetres) or otherwise in
compliance with your regulators defined clearance levels. It should be borne in mind that some radionuclides, such as $^{210}\text{Pb}$, may not be detectable when gamma-radiation monitoring equipment is used — therefore, it is also essential to measure the levels of alpha- and beta- surface contamination, as described below.

It is also important to consider that the vast majority of factories and yards that handle and otherwise deal with scrap metal have specific portal detectors installed at the entrances. If an item exhibiting higher than usual levels of gamma radiation is detected at the entrance — in most situations the whole shipment will be rejected. Bear in mind though, the alarm levels on such portal monitors are usually indicators only and may not necessarily be in line with the clearance levels defined by your regulator. You cannot therefore use these portal monitors as instruments of clearance.

Additional consideration is associated with the fact that, despite being cleared from any form of radiation control and management, the items may still be rejected by a recycling facility — simply because of their origin (such as, for example, a uranium processing plant). In these cases, a detailed guideline would need to be provided by an appropriate authority — to ensure that the items can be legally recycled/melted.

11.2 Surface Contamination — complex and often misinterpreted

The IAEA Regulations provide the definition for ‘surface contamination’ and ‘low toxicity alpha emitters’:

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

227. Low toxicity alpha emitters are: natural uranium, depleted uranium, natural thorium, uranium-235, 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.

Additional information is provided in the IAEA Safety Guide (SSG-26) [4] issued in the support of the Regulations:

214.3 Any surface with levels of contamination lower than 0.4 Bq/cm$^2$ for beta and gamma emitters and for low toxicity alpha emitters, or 0.04 Bq/cm$^2$ for all other alpha emitters, is considered a non-contaminated surface in applying the Transport Regulations. For instance, a non-radioactive solid object with levels of surface contamination lower than the above levels is beyond the scope of the Transport Regulations and no requirement is applicable to its transport.
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Therefore, when the level of surface contamination exceeds 0.4 Bq/cm² the Regulations apply to the transport of such items on public roads.

Typically, objects that may have surface contamination due to NORM will have only ‘low toxicity’ alpha-emitters – with a notable exception of $^{226}\text{Ra}$.

$^{226}\text{Ra}$ is not classified as a ‘low toxicity’ alpha emitter and whilst the limit of 0.4 Bq/cm² generally applies to all NORM, in a specific situation (e.g. when transporting some contaminated items from the oil/gas industry, from the plants for the production of uranium concentrate, tantalum, some rare earth minerals, etc) – the limit of 0.04 Bq/cm² would be applicable for the classification of surface contaminated objects.

There always will be alpha emitting isotopes present in surface contamination in the uranium industry. There are some special cases in the gas industry and titanium pigment production when beta-emitting $^{210}\text{Pb}$ and $^{228}\text{Ra}$ are present and there are almost no alpha-emitters (examples are $^{210}\text{Pb}$ films formed inside gas processing and storage vessels, and $^{228}\text{Ra}$ scale in titanium pigment plants). However, it is normally it is assumed that alpha-emitting radionuclides are always present – taking into account the fact that there will be an ingrowth of alpha-emitting $^{210}\text{Po}$ from $^{210}\text{Pb}$, and alpha-emitting $^{228}\text{Th}$ from $^{228}\text{Ra}$, within a few months.

The level of 0.04 Bq/cm² is the one where the vehicles may need to be signposted as carrying surface contaminated objects, SCO-I. This level applies unless it is known that the material on the surface does not contain a significant proportion of $^{226}\text{Ra}$, in which cases the signposting is needed at levels above 0.4 Bq/cm².

In the following discussion it is assumed that most of the contamination on the surfaces of objects from NORM mines and plants contains $^{226}\text{Ra}$ in an ‘overall mix’ and that only “low toxicity alpha emitters” are present.

In accordance with §413 of the Regulations there are different values for non-fixed and fixed surface contamination. In mining and mineral processing (not in ‘nuclear’ applications) all surface contamination is usually considered to be “non-fixed”, since it can be removed in any case, if there is a real need for it.

The §413(a)(i) states that SCO-I is any object with the levels up to 4 Bq/cm², and §413(b)(i) – that SCO-II is any object with the levels up to 400 Bq/cm². SCO-III that will be introduced in the new 2018 Regulations is not considered in this discussion.

Thus, it may be concluded that there are four types of surface contaminated objects that can be classified in accordance with alpha surface contamination levels ($^{226}\text{Ra}$ excluded):
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- < 0.4 Bq/cm² – not contaminated, no signposting of any kind required;
- > 0.4 Bq/cm², but < 4 Bq/cm² – SCO-I signposting required;
- > 4 Bq/cm², but < 400 Bq/cm² – SCO-II signposting required;
- > 400 Bq/cm² – one would not be allowed to transport these items, but values of this kind are unlikely to be measured in mining and mineral processing. Even if any are found, it should be relatively easy to remove at least some of the contamination to lower the value to be below 400 Bq/cm².

However, it is important to also note that the definition for non-fixed contamination in the IAEA 2007 Safety Glossary is: “Contamination that can be removed from a surface during routine conditions of transport”.

It is, therefore, recommended to ensure that all potentially contaminated objects are cleaned up prior to their transport, to ensure that no residual contamination can be accidentally removed ‘during the routine conditions of transport’.

In these cases, different limits will apply, in accordance with §413(a)(ii): 40,000 Bq/cm² for beta and gamma emitters and low toxicity alpha emitters, and 4,000 Bq/cm² for all other alpha emitters – the levels of this magnitude are not expected in mining and mineral processing industry.

Other practical notes in regards to controls required in the process of transporting surface contaminated items:

There are three more paragraphs in the IAEA Regulations that need to be considered:

508. The non-fixed contamination on the external surfaces of any package shall be kept as low as practicable and, under routine conditions of transport, shall not exceed the following limits:
(a) 4 Bq/cm² for beta and gamma emitters and low toxicity alpha emitters;
(b) 0.4 Bq/cm² for all other alpha emitters.

These limits are applicable when averaged over any area of 300 cm² of any part of the surface.

This paragraph addresses the packages, not the items themselves. It is irrelevant what is being transported and how it is packaged (it may be SCO-I or SCO-II, items inside a container or in a sealed truck, for example), but the limits from this §508 for the levels on the outside surfaces of these ‘packages’ shall not be exceeded.

520. LSA material and SCO in groups LSA-I and SCO-I may be transported, unpackaged, under the following conditions:
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(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 10 times the applicable level specified in para. 214.

(c) For SCO-I where it is suspected that non-fixed contamination exists on inaccessible surfaces in excess of the values specified in para. 413(a)(i), measures shall be taken to ensure that the radioactive material is not released into the conveyance.

Effectively, the radiation safety provisions for SCO-I are less stringent than for SCO-II:

- SCO-II could only be transported appropriately packaged.
- SCO-I could be transported unpackaged, unless, as §520(b) states, the surface contamination levels reach ten times of the ones in §214. Which then make this item an SCO-II – in accordance §413(b)(i).
- If it is suspected (not proven, only suspected) that there may be some non-fixed contamination on inaccessible surfaces of SCO-I objects being transported in excess of values in para. 413(a)(i) – making this potentially SCO-II: one needs to take measures that the material from the inside of the objects cannot ‘escape from the conveyance’. An example is the transport of used pipes from oil production: the pipe may be 8-10 meters long and there is typically no equipment and no possibility to measure what surface contamination may be inside of the pipe, some 4-5 meters “in”. Then the plastic or metal caps are placed on each end of the pipe to make sure that no material may fall out from these pipes when they are transported.

Lastly, following from para. 520 above: after the transport, a vehicle used for this purpose will need to be decontaminated to much lower levels.

505. Freight containers, IBCs, tanks, as well as other packagings and overpacks, 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/cm² for beta and gamma emitters and low toxicity alpha emitters and 0.04 Bq/cm² for all other alpha emitters.

This paragraph provides guidance on what items may be suitable for the release of items to other industries and to the general public. It should be noted that in this case, especially in regards to the possible radiation exposure of the members of the general public – the
lower value (0.04 Bq/cm$^2$) is much more appropriate. Approach your regulator for advice if there is any doubt.

In case of processing uranium ore, the following conclusion is based on alpha surface contamination levels, as:

- Unprocessed ore and concentrates: in the uranium chain, there are 8 alpha emitters and 6 beta emitters, so measuring and ensuring that alpha emitters meet the surface contamination limits would also make sure that the short-lived beta emitters do not exceed the surface contamination levels.
- Freshly extracted uranium, there are obviously more alpha emitters – as it will contain alpha-emitting isotopes, $^{238}$U, $^{234}$U and $^{235}$U.
- Tailings with $^{238}$U and $^{234}$U removed – leaving 6 alpha emitters and 6 beta emitters, so, as in the case (a) above, measuring only alpha surface contamination levels would be sufficient.

11.3 Summary for surface contaminated objects

Taking all of the above into consideration, the general suggestion is to have five types of surface contaminated objects, based on alpha surface contamination – which are simple to differentiate from each other:

(a) Less than 0.04 Bq/cm$^2$ – clean, can go anywhere for any purpose;
(b) More than 0.04 Bq/cm$^2$, but less than 0.4 Bq/cm$^2$ – not contaminated, can be transported unpackaged and not signposted, the only restriction is the release of objects to the general public;
(c) More than 0.4 Bq/cm$^2$, but less than 4 Bq/cm$^2$ – surface contaminated object class SCO-I, signposting and transport declaration required;
(d) More than 4 Bq/cm$^2$, but less than 400 Bq/cm$^2$ – surface contaminated object class SCO-II, control measures, signposting and transport declaration required;
(e) More than 400 Bq/cm$^2$ – typically not allowed to be transported, attempts need to be made to clean the surface and the regulatory authority should be contacted for the advice.
12.0 REQUIREMENT FOR RADIATION PROTECTION PROGRAMMES FOR TRANSPORT OF RADIOACTIVE MATERIAL

This Section offers some advice on the implementation of radiation protection programmes covering the transport of radioactive material. This is offered as advice. The exact requirements within your country should be sought from your regulatory authority.

Requirement

One of the requirements in the IAEA transport regulations is that a Radiation Protection Programme (RPP) shall be established for the transport of radioactive material, and such programmes shall be available, on request, for inspection by the relevant Competent Authority. An RPP contains systematic arrangements that are aimed at providing adequate consideration of radiation protection measures.

12.1 Scope for RPPs in Transport

A Radiation Protection Programme (RPP) should cover all aspects of transport, but the main emphasis should be put on the stages of transport operations giving rise to exposure to radiation. For example packing, preparation, loading, handling, storage in-transit and movement of radioactive material packages and maintenance of packagings.

The first step in establishing a RPP is to make a prior radiological evaluation of the situation. This involves a description of the type, nature and volume of radioactive material being shipped, the magnitude and likelihood of radiation exposures arising from these transport operations, the number of workers potentially involved and the duration of the operations involved and the distance to the RAM. This information will allow the operator to define the scope of the RPP.

RPPs define and document a systematic and structured way for the framework of controls to be applied by a transport organization with the prime aim to optimize protection and safety in the transport of radioactive material. It is generally recognized that optimisation of protection and safety of workers and the public is most effectively addressed at the early stage of transport related activities such as the design, manufacture, scheduling and preparation of the radioactive material packages.
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The implementation of this approach may not be satisfactory for a variety of transport conditions. In particular, for more complex shipping conditions which may involve many organizations and transport related activities, there are transport related operations and related radiation protection considerations that are outside the scope of the radiation protection controls provided for by the designer of a package or manufacturer of packaging. An example would be the lack of safety culture of the carrier or consignor. Even if radiation protection and safety have been optimized at the pre-operational stage of a radioactive material shipment and priority is given to the package design and technical measures for controlling exposure to radiation, there is generally still a need for optimisation of radiation protection arrangements at the various stages of transport operations.

A RPP is required for the operational stages of loading, carriage, in-transit storage, intermodal transfer, unloading and delivery of radioactive material packages at the final destination and maintenance of unloaded packages (if contaminated or containing residual radioactivity).

An RPP is therefore mainly concerned with the loading, carriage, handling, delivery and unloading procedures involved with the operations on packaged or unpackaged radioactive material by the consignor, carrier, in-transit storage and transfer point operator and consignee.

The radiation protection controls employed in an RPP for these operations may encompass a broad set of regulatory or technical safety requirements but should be commensurate to the magnitude and likelihood of radiation exposures being incurred. The controls should be reasonably related to the hazards arising from radioactive material transport and consequently a graded approach is applied as shown in Table 1. Small operations involving only a limited number of package shipments may require a short RPP while more significant operations with very diverse materials and packages being shipped and handled in the public domain need to have a more significant programme in place.

An RPP should cover all aspects of transport and associated conditions of transport including normal, routine and accident conditions of transport. There are cases of a dedicated carrier or shipper organization contracted solely for transport operations of a specific consignor or consignee. The consignor/consignee has a properly developed RPP in place and is the holder of a nuclear authorization issued by the NNR. Hence any
transport of RAM by a contracted shipping agent is done either under the nuclear authorization of the consignor, or under that of the consignee. The radiation protection programme for the particular transport may be that of either the consignor or the consignee, as agreed with the NNR. However, even in cases where the transport is to take place under an RPP supplied by the consignee, this does not relive the consignee from having an RPP on site, covering loading operations on site.

The principal radiation protection consideration to be accounted for in an RPP should, consistent with the programme structure outlined in Table 1, cover the following basic elements contributing to protection and safety. Each element should be documented with the appropriate level of detail:

- roles and responsibilities for the implementation of the programme,
- dose assessment and optimisation,
- surface contamination assessment,
- segregation and other protective measure,
- emergency response arrangements,
- training and information and quality assurance (QA).

The RPP should be reviewed at least annually and, where necessary, revised as appropriate. Upon a request made to the holder by the NNR, the holder must make their radiation protection programme, or any revision of it, available to the NNR for review and/or inspection. For occupational exposures less than 1 mSv in a year no formal Radiation Protection Programme need be prepared. However the responsible organisation should still undertake, and document, measures to ensure that doses are below 1 mSv per annum and that these doses are optimised.

For occupational exposures arising from transport activities, where it is assessed that the effective dose is likely to:

i. be between 1 and 6 mSv in a year, a dose assessment programme via workplace monitoring or individual monitoring should be conducted;

ii. exceed 6 mSv in a year, individual monitoring should be conducted.

Programme documents should be available, on request, for inspection by the NNR.

When individual monitoring or workplace monitoring is conducted, appropriate records should be kept.
The following table summarises the guidance provided above:

<table>
<thead>
<tr>
<th>OCCUPATIONAL DOSE</th>
<th>&lt; 1 mSv/a</th>
<th>&gt;1 mSv/a but&lt; 6 mSv/a</th>
<th>&gt; 6 mSv/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose Assessment Methodology</td>
<td>No Routine Monitoring Required</td>
<td>Routine Workplace or Individual Monitoring</td>
<td>Individual Monitoring Mandatory</td>
</tr>
</tbody>
</table>

12.2 Quantification of Doses for Approved Transports

The following aspects should be covered by such assessment:

i. Potential radiation dose to workers involved in either loading or unloading of the cargo;

ii. Potential radiation dose to the transport driver or other transport persons accompanying the transport;

iii. Potential radiation dose to any persons who may be required to interact with the shipment during transport (e.g. customs officials, weighbridge operators etc); and

iv. Potential radiation dose to members of the public, arising from the transport.

The safety assessment should address the following pathways, as appropriate:

(a) External dose due to gamma radiation;

(b) Potential internal radiation dose arising from surface contamination (where applicable); and

(c) Airborne radiation dose due to particulate matter unless reduced through appropriate packaging (justification to be provided).

Aspects related to RP during the loading of the consignment, at the premises of the consignor, would normally form part of the site-specific RP Programme. If this is the case then this will not be addressed in the transport RP Programme.

Aspects related to RP during the receiving and unloading of the shipment should be addressed by the consignee, as part of their normal site radiation protection programme. As such this does not need to be addressed in the consignor's application for permission.
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to transport, except in cases where the consignors workforce will be involved, or where the workers involved in the unloading operations fall under the consignors authorisation.

Potential worker dose during transport

1. Except where ALL transport workers, accompanying the shipment, are to be monitored, the consignor should identify the “most exposed” shipment worker accompanying the transport and should provide a justification for this choice.
2. Subsequently, it should be determined that the radiation exposure of such a person/s, for the duration of a single shipment, is optimised.
3. Such assessment should be undertaken during the first shipment.
4. When quantifying the dose to all workers, or the most exposed shipment worker, the following aspects should be taken into account:
   i. His/her total accumulated radiation dose for the year up to the proposed transport;
   ii. The possibility that he/she may be involved in multiple shipments throughout the remainder of the year; and
   iii. Dose optimisation through worker rotation.

Potential Public Dose during Transport

Should the assessment of the most exposed shipment worker indicate that they are not exposed to a radiation dose exceeding an Investigation Level, usually defined as 1/10 of the public dose limit, or a value of 100 μSv/a (based on the number of such shipments proposed for the year) then compliance to this Investigation Level may be used as a justification for not assessing the potential dose of the public along the proposed transport routes and involving routine or normal transport operations. However, even in this case it should be demonstrated that, as regards public dose, this potential public exposure is optimised.

Note that this limit of 1/10 is not set by the IAEA Transport Regulations but is here provided as a guide. You are advised to approach your regulator for specific advice on this point.

In the event that the assessment shows the most exposed transport worker to receive a dose in excess of any defined Investigation Level, despite all optimisation considerations,
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then a public dose assessment, covering the planned transport, should be submitted and approved by your regulator before the transport may take place.

The results of such assessment, together with details of steps to be taken to protect the public, or to modify the transport, based upon the assessment, should be submitted to your regulator for approval, prior to the commencement of the proposed transport.

13.0 CONSIGNORS RESPONSIBILITIES

The consignor should comply fully with the consignor responsibilities as detailed in the International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Material para. 545 – 561 (See Appendix X).

14.0 EMERGENCY RESPONSE PLANNING AND PREPAREDNESS

The Consignor should have in place an emergency response procedure appropriate with the level of radiation hazard presented by the shipment.

15.0 QUALITY MANAGEMENT

The holder should ensure that they comply fully with the stipulations of their Quality Management Programme, as referenced within their authorization, particularly as it applies to issues of the transport of radioactive material. Compliance to the holder’s Quality Management Programme will, of necessity, require the implementation of a full programme of self-inspection and self-audit covering all aspects of transport of radioactive material including record keeping and record retention.

The Quality Management Programme should be designed in accordance with quality standards acceptable to your Regulator.

The holder should ensure that they comply fully with the stipulations of their own procedures, as related to transport. Such compliance will, of necessity, require the implementation of a full programme of self-inspection and self-audit covering all aspects of transport of radioactive material.
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15.1 Non Compliance with Regulatory requirements

In the event of any known non-compliance with any limit or requirement of the Transport Regulations such non-compliance should be reported to your regulator in accordance with any existing occurrence reporting mechanisms and will be dealt with in terms of normal none-compliance with the nuclear authorisation.

15.2 Resources and Training

The holder of a nuclear authorization should identify the knowledge, skills and abilities, necessary to be able to perform all the tasks and responsibilities as required by the transport and its associated quality management programme.

The holder should make arrangements for the selection of personnel and for training to ensure that the personnel have the requisite knowledge, skills, abilities, equipment and procedures and other arrangements to perform their assigned transport functions. The arrangements should include ongoing refresher training on an appropriate schedule and arrangements for ensuring that personnel assigned to positions with responsibilities for transport undergo the specified training.
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16.0 REFERENCES


