Radioactive Material Transport Users Committee		
GUIDANCE NOTE	RAMTUC(16)GN14 - Rev 1.0	
LOW SPECIFIC ACTIVITY MATERIAL ACTIVITY DISTRIBUTION INTEPRETATION GUIDANCE		December 2016

1. Introduction

This document provides guidance on how to interpret the activity distribution requirements for some Low Specific Activity (LSA) materials. It has been produced by the Radioactive Material Transport Users Committee to provide guidance to radioactive materials transport users in the UK to enable a clear and consistent understanding and application of the requirements.

The structure of this document is as follows:

- Section 2 sets out the scope of the guidance.
- Section 3 provides the guidance.

An appendix on the technical basis [1] is also available which documents the rationale for the guidance, but does not form part of the guidance itself.

1.1. Document control

Approved at committee at:	December 2016
Review required:	2 years

2. Scope

2.1. The regulations

This document addresses the 2012 edition of the IAEA Regulations for the Safe Transport of Radioactive Material [2]. Those regulations form the basis of the requirements to transport radioactive material in the European agreement concerning the international carriage of dangerous goods by road (ADR) and the regulation concerning the international carriage of dangerous goods by rail (RID), as implemented in UK law by the carriage of dangerous goods regulations [3]. The IAEA Regulations for the Safe Transport of Radioactive Material are supported by advisory material [4]. The advisory material does not itself form part of the legal requirements for the transport of radioactive material. However the advisory material is considered to be relevant good practice in the application of the legal requirements.

2.2. The regulatory requirements

Two requirements concerning the distribution of radioactivity in LSA-II and LSA-III material in an Industrial Package are addressed in this document. These are:

1. Para 409 which requires that LSA-II and some LSA-III material contains radioactivity that is *distributed throughout*.
2. Para 517, which limits the *unshielded dose rate* of the LSA material contained within an Industrial Package.[1]

These requirements apply to different properties of the radioactive material. The first requirement limits the degree of activity distribution of the A_2 content of the material within the volume of material to be transported. The second requirement applies to the distribution of radionuclides that contribute to the external dose rate and to the ability of the material to provide self-shielding. As the requirements apply to different properties of the radioactive material, they have been addressed separately in this document.

2.3. The need for guidance

The regulatory requirements are succinct. This enables flexibility to apply the requirements in a suitable manner in each circumstance. The advisory material provides guidance which may be considered relevant good practice in application of the requirements. As described below, application of the advisory material can result in some uncertainty in the correct interpretation of the requirements.

Para 409.11 of the advisory material sets out a simple method of assessing compliance with the activity *distributed throughout* requirement by notionally splitting the LSA material into portions and comparing the activity within each portion. Taken to its limit, this method would imply that any concentration of radioactive material is acceptable if it is surrounded by a sufficient mass of material with little or no radioactivity. However, para 409.9 of the advisory material states that it is "*important*

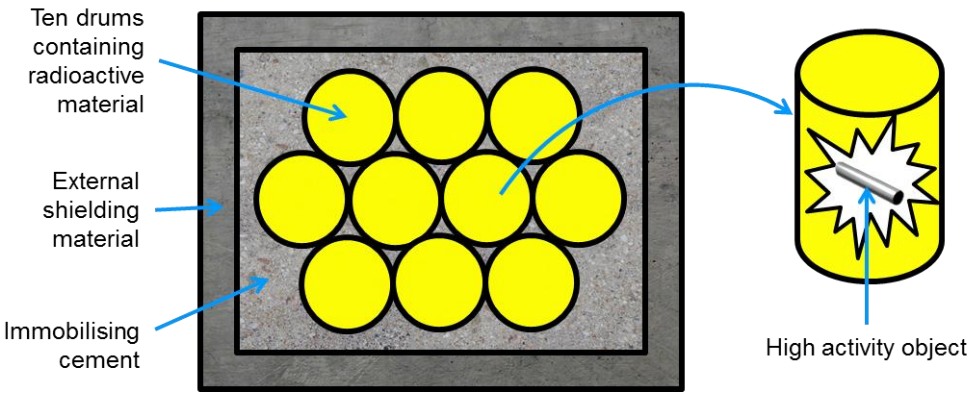
[1] This requirement also applies to Surface Contaminated Objects transported in an Industrial Package and the guidance presented in this document may also be applied to that material.

to recognize that the concept of limiting the estimated specific activity fails to be meaningful if, in a large volume, the activity is clearly confined to a small percentage of that volume". Taken together, these statements result in some uncertainty.

Para 517.2 of the advisory material provides advice on how to assess compliance with the *unshielded dose rate* requirement when the radioactivity is "*essentially uniformly distributed*". It does not provide advice on how to assess the requirement when the radioactivity is less uniformly distributed. Specifically it does not provide advice on how to assess the *unshielded dose rate* when the material has the potential to be subject of significant changes in the external dose rate if it were rearranged.

An example of a package that could cause uncertainty in the correct application of the requirements is shown in Figure 1. There could be uncertainty in whether credit could be taken for the immobilising cement in assessing the mass of a portion for the *distributed throughout* requirement or in respect of its shielding effect when assessing the *unshielded dose rate* requirement. The presence of a high activity item in the centre of the package could create further uncertainty. In assessing the *distributed throughout* requirement the package could be considered to be contrary to the intent of Para 409.9 (as described above). Whereas for the *unshielded dose rate* requirement, it would be expected that geometrical changes could cause significant changes to the dose rate.

Figure 1: Plan view of an example package that could cause uncertainty in the correct application of the requirements



2.4. Applicable materials

Some materials contain radioactivity intimately mixed throughout their mass. Such materials include radioactive liquids, gases, residues, sludges, resins, raffinates and flocculants. These may be considered to meet the requirement of 409 of *distributed throughout* as an intrinsic property of their nature. In addition the guidance provided in para 517.2 of the advisory material on the requirement of para 517 to limit the *unshielded dose rate* is directly applicable to such materials. This document does not address materials which contain radioactivity intimately and consistently mixed throughout their mass as the regulatory requirements and advisory material may be readily understood and applied to such materials.

Other materials that may be candidates for transport as LSA-II or LSA-III material may have radioactivity less evenly distributed throughout their mass. These include, but are not limited to:

- Materials activated by neutron irradiation:
    - Reactor pressure vessels.
    - Non-fuel reactor core components.
    - Irradiated fuel cladding fragments (potentially including quantities of irradiated fuel).
- Materials with surface contamination or absorbed radioactive material:
    - Filters.
    - Miscellaneous alpha or beta/gamma contaminated materials (e.g. metals, plastics, etc.).
    - Soil, sand, gravel, rubble or other bulk contaminated material.
    - Contaminated personal protective equipment.

This document addresses the application of the requirements for activity to be *distributed throughout* and to limit the *unshielded dose rate* to these materials.

2.5. Other interpretations

This document provides guidance on how the regulatory requirements may be interpreted and applied. It has been developed with input from a range of expert UK radioactive materials transport users and is informed by consensus opinion on the suitability and acceptability of a range of interpretations of the regulatory requirements [5]. It is not exhaustive and does not preclude alternative interpretations of the requirements from being applied.

3. Guidance

3.1. Definitions

The following definitions apply to the guidance presented in this document:

Average specific activity means the mass-weighted mean specific activity through the entire material to be transported within an Industrial Package.

Constituent means an identifiable part of the contents of a package that is smaller than a portion and can have its specific activity quantified.

Discrete object means a solid body or assembly with defined and fixed geometry, for instance a piece of activated metal, a sealed source or a filter. Examples of materials not considered to be a discrete object are resins and sludges.

Portion means a contiguous volume of material. This may consist of a collection of discrete objects and may also include inactive material, for instance a compact binding agent.

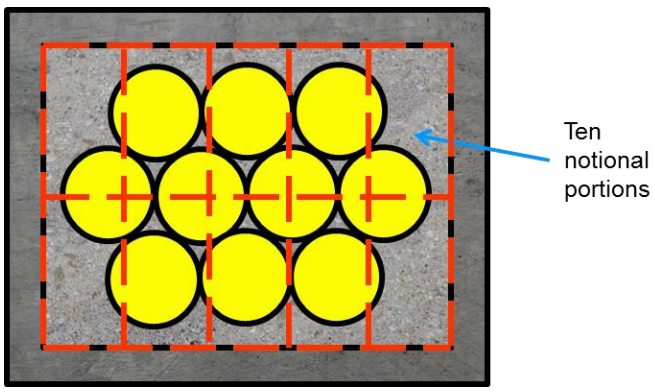
3.2. Distributed throughout

The requirement for activity to be *distributed throughout* may be considered to be met if the following criterion is satisfied:

If the material in a package were split into a number of notional portions, the specific activity of the portion with the greatest specific activity should be less than 10^{-3} A_2/g for LSA-II or $2x10^{-2}$ A_2/g for LSA-III.

An example of the criterion applied to a package is provided in Figure 2[2].

Figure 2: Application of the *distributed throughout* criterion to an example package with a volume greater than 1.0 m^3



[2] An acceptable alternative approach for this example that may be more pragmatic would be to define each of the ten drums as a notional portion.

In applying this requirement it may be noted that:

- For a volume of material greater than 1.0 m^3 the material should be notionally split into at least[3] ten portions of approximately equivalent size.
- For a volume of material up to 1.0 m^3 the material should be notionally split into at least[3] five portions of approximately equivalent size.
- A notional portion may:
    - Be a region of a large discrete object i.e. if a discrete object is larger than a single portion.
    - Consist of a collection of small discrete objects i.e. if the discrete objects are smaller than a single portion.
    - Include the mass of any inactive material that is present in the portion[4].
- The activity distribution within a notional portion need not be controlled to a finer level of granularity or assessed further.
- The requirement is to be met by the material as packaged. The potential for rearrangement of the material during routine, normal or accident conditions of transport need not be assessed[5].

In some instances it may be difficult to assign and assess notional portions on the basis set out above. Acceptable variations are to:

- Define notional portions in terms of regions of approximately equivalent mass (in lieu of volume) e.g. the volume of a portion may not be fixed due to porosity or compaction, whereas mass may be more readily defined[6].
- Assess each discrete item in a package as a notional portion in its own right. This method is acceptable so long as each item is smaller than the required

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3 For instance, if a package's contents are subdivided into a number of inner containers of similar size equal or greater in number than the minimum number of portions, the notional portions could be aligned to the inner containers.

4 In principle, inactive or lower activity material could be added to a notional portion in order to allow it to comply with the requirement for activity to be *distributed throughout*. However, the user should note that other regulations or requirements may prohibit this approach. For instance where the LSA material is waste, if inactive material is added for no other purpose then to demonstrate compliance with the *distributed throughout* criterion, then this approach may not be considered to be use of Best Available Techniques as required by the Environmental Permitting Regulations.

5 It should be noted that other requirements on the performance of the packaging and/or the contents apply and that these may constrain the allowable rearrangement of the contents during routine, normal or accident conditions of transport. For instance the constraints on the radiation levels from a transport package during routine conditions of transport (paragraph 617) and normal conditions of transport (paragraphs 624, 626-630 and 648) must separately be satisfied.

6 For instance if the material is a collection of irregular shaped discrete objects, such as compacted inner containers, it may be that their mass can be more readily defined and used as the basis of defining notional portions.

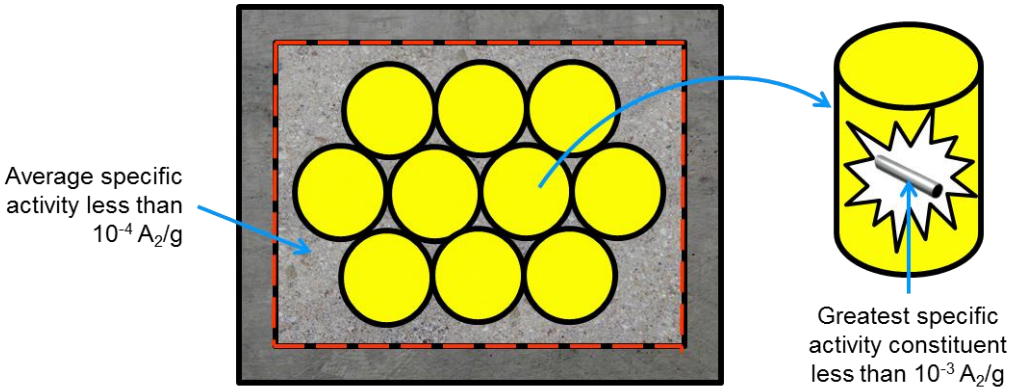
notional portion size, otherwise the discrete item must be notionally subdivided for assessment. In this case the notional portions need not be of equivalent size.

It is not necessary to define and assess notional portions if is it is known that either:

- Each constituent present has a specific activity below the average specific activity limit (i.e. 10^{-4} A_2/g for LSA-II).

- The average specific activity of the material is below the average specific activity limit (i.e. 10^{-4} A_2/g for LSA-II) and that the maximum specific activity of each constituent present is less than ten times the average specific activity limit (i.e. 10^{-3} A_2/g for LSA-II or $2x10^{-2}$ A_2/g). See Figure 3 for an example of this approach.

Figure 3: Application of the *distributed throughout* requirement to an example package for LSA-II material without definition of notional portions



Compliance may be demonstrated by means of reasoned argument, calculation and/or measurement, as is appropriate, taking due account of uncertainty.

3.3. Unshielded dose rate

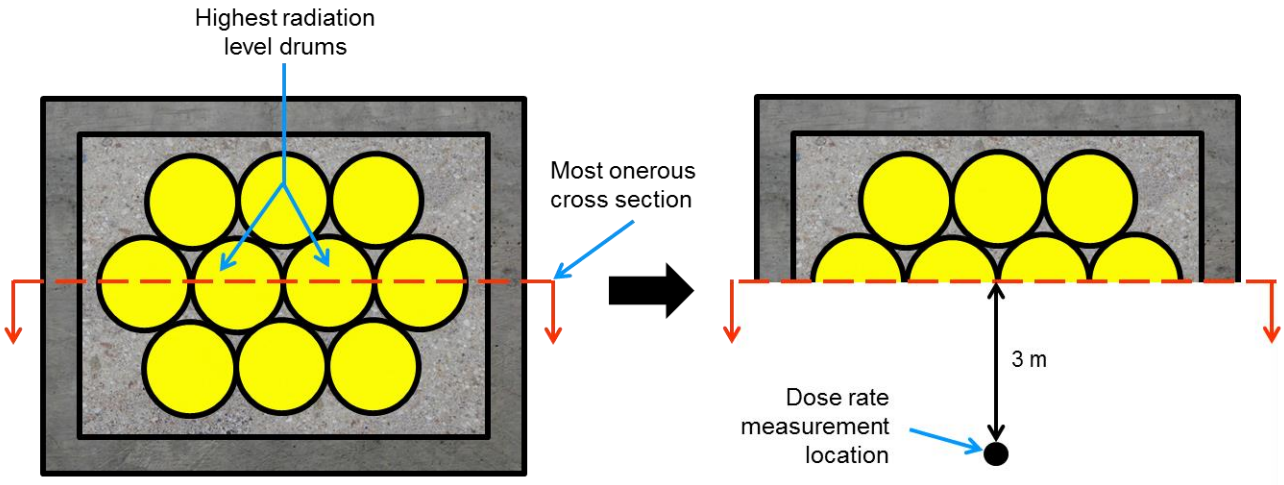
The requirement to limit the *unshielded dose rate* may be considered to be met if the following criterion is satisfied:

> **The dose rate should be less than 10 mSv/h at a distance of 3 m from the single most onerous planar cross-section through the radioactive material.**

An example of the criterion applied to a package is provided in Figure 4 [7].

[7] This approach allows credit to be taken for self-shielding and spacing of the radioactive material reducing the *unshielded dose rate* at 3 m. However the approach prohibits the 'hiding' of a high dose rate item in the centre of a package as a measure to meet the *unshielded dose rate* criterion. Notwithstanding this, the regulations include an overarching requirement that doses to persons should be optimised. The optimised loading of packages should be undertaken where possible to ensure that exposures are as low as reasonably achievable, economic and social factors being taken into account.

Figure 4: Application of the *unshielded dose rate* single most onerous planar cross section criterion to an example package



In applying this requirement it may be noted that:

- The *unshielded dose rate* may be assessed in its geometry as packaged. The potential for rearrangement of the material to change the *unshielded dose rate* during routine, normal or accident conditions of transport need not be assessed[5].
- Shielding effects may be allowed for from the material itself, from adjacent radioactive material and from any inactive material that is present[8].
- Exposure to only one planar cross section need be considered.
- The single most onerous planar cross-section may be identified through inspection or qualitative judgements. In some instances it may be judged that this is equivalent to the edge of the radioactive material. In that case the method in Para 517.2 of the advisory material for essentially uniformly distributed is applicable i.e. direct measurement and correction for external shielding.

In some instances it may be appropriate to apply conservative simplified criteria to avoid unnecessarily complex analysis where margins are large. Acceptable variations are to:

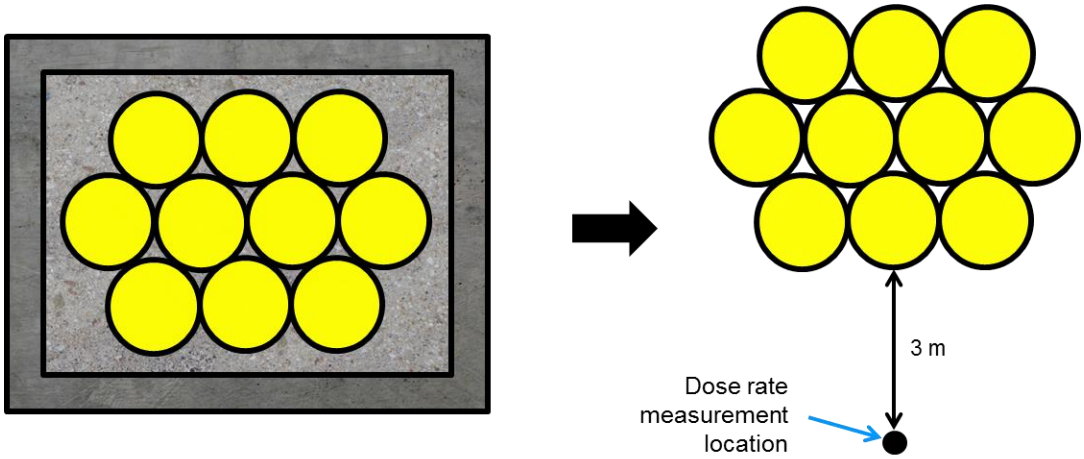
- Disregard self-shielding effects or any shielding effect provided by any inactive material that may be present.
- Disregard all shielding and distance effects provided by the geometry i.e. by assuming the material consolidates to a worst-case geometry.

[8] For instance credit can be taken for the shielding provided by an inactive binding material such as encapsulation cement that is mixed with the radioactive material.

For instance, in the extreme, the above simplifications could result in the u*nshielded dose rate* being assessed as equivalent to exposure at a distance of 3 m from a massless point source composed of the entire radioactive content of the package without self-shielding[9].

Alternatively a balanced use of pragmatic modelling simplifications and conservatism could be to assess the *unshielded dose-rate* at 3 m from the edge of the radioactive material in its geometry as packaged, disregarding any shielding effect from any inactive material present, if it is adjudged that this would bound the most onerous planar cross-section. See Figure 5 for an example of this approach.

Figure 5: Application of a simplified approach to the *unshielded dose rate* criterion to an example package



Compliance may be demonstrated by means of reasoned argument, calculation and/or measurement, as is appropriate, taking due account of uncertainty.

[9] This approach would imply a conservative limit of 0.41TBq of Co-60, using the data from Table II.2 of the advisory material and a point source approximation. A limit calculated in this manner would need to account for the dose rate contributions from all isotopes present.

References

1 RAMTUC, Low Specific Activity Material Activity Distribution Interpretation Guidance: Appendix: The technical basis, RAMTUC(16)P17, December 2016.

2 IAEA, Regulations for the Safe Transport of Radioactive Material 2012 Edition, SSR-6.

3 HMSO, The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009, statutory instrument number 1348, 2009.

4 IAEA, Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2012 Edition), SSG-26.

5 RAMTUC, LSA-II Subgroup: Interpretation survey summary, Rev 1.1, 22 April 2016.