



Transporting radioactive material - Guidance on radiation and contamination monitoring requirements, and determining a Transport Index

Who is this guide for?

This guide has been prepared primarily to help non-nuclear sector duty holders transporting radioactive material by road in Great Britain to determine:

- ✓ **the action they need to take to comply with radiation dose rate and radioactive contamination monitoring requirements; and**
- ✓ **how to appropriately determine a Transport Index (TI)**

Who needs to undertake these tasks and why?

The carriage of dangerous goods, including radioactive materials, is regulated by the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG). Regulation 5 of CDG requires that road transport is also carried out according to ADR specifications. [ADR refers to the European Agreement Concerning the International Carriage of Dangerous Goods by Road which is updated from time to time.] There are various legal requirements in place which require those involved in transport operations to check that packages containing radioactive material are transported safely and securely and according to agreed standards. Those preparing a package for transport have most of the legal responsibilities in this area. They are known as the 'consignor.'

What do I need to monitor?

Radiation dose rate monitoring and contamination monitoring of packages containing radioactive material may be required. You may also need to carry out radiation dose rate monitoring and contamination monitoring of vehicles or other equipment used for the carriage of radioactive material.

It is important to note that monitoring radiation dose rates and monitoring for radioactive contamination are different processes involving different techniques, instruments and units for reporting results. As a consequence, you may need to seek specialist training or support from a person, or organisation, competent in radiation protection to assist you with this. ONR expects that radiation and contamination monitoring equipment will be suitably maintained and tested according to manufacturer's instructions.

Radiation levels:

Consignors should be able to demonstrate that they are aware of the maximum radiation dose rates associated with their packages so that they do not exceed specified maximum (expressed in millisievert per hour, mSv/h) allowable for transporting packages; and so they can label packages appropriately. Radiation monitoring may also be required around vehicles used to ensure that radiation levels do not exceed prescribed maximum values at distances from the vehicle (Table 1 refers.)

Table 1: Maximum permitted radiation levels (in mSv/h) around packages, overpacks and vehicles

	Routine conditions of carriage ¹	Under exclusive use conditions ^{2,3}
Package or overpack⁴ –maximum permitted dose rate at surface	2 mSv/h	10 mSv/h
Vehicle⁵ - maximum permitted dose rate at surface	2 mSv/h	2 mSv/h
Vehicle⁵ - maximum permitted dose rate at 2 metres from surface	0.1 mSv/h	0.1 mSv/h

Notes:

¹ Figures in this column can be found in ADR 4.1.9.1.11 and ADR 7.5.11.CV33 (3.3)

² *Exclusive use* means the sole use by a single consignor of a vehicle or of a large container, where all loading, shipment and unloading is carried out according to the consignor or consignee directions, as required by ADR.

³ Figures in this column can be found in ADR 7.5.11 CV33 (3.5) but note that conditions apply.

⁴ *Overpack* means an enclosure used by a single consignor to contain usually more than one package into a single unit which is easier to handle and stow during carriage.

⁵ Although vehicle is the term referenced here, ADR quotes figures for the *conveyance*, where conveyance means a vehicle or wagon.

Points to consider

In order to perform this monitoring, a consignor will need to have access to suitable radiation monitoring equipment, be trained in the monitoring technique(s) to use, and understand the significance of the results obtained.

The degree of package monitoring undertaken will vary depending on a range of factors. For consignors transporting different types of packages with varying contents, monitoring the radiation levels associated with every package ahead of transport will be appropriate. For other consignors, moving the same type of package with the same contents routinely, then there is scope for an alternative approach to monitoring. ONR expects any alternative approach to be justified in writing.

Where the radioactive material gives off different types of radiation i.e. an americium-241/beryllium source which produces gamma radiation and neutrons, it may not be practical to routinely monitor neutron dose rates. In these circumstances it would be appropriate to factor the neutron component into the overall radiation level. This can be inferred on the basis of gamma dose rate, and verified by periodic measurement using specialist neutron monitoring equipment. Again, ONR would expect to see evidence that this had been suitably considered.

Example:

- A special form gamma source in suitable packaging (a projection-type container) is transported to site each evening for a week to carry out site radiography. Radiation levels associated with this source are not likely to vary appreciably over the week considering the properties of the radioactive material involved. Routine confirmation of radiation levels around the package is appropriate to ensure the source has returned safely to its fully shielded position in the container ahead of transporting the package back to base.

Contamination levels:

Radioactive materials can be solids, liquids or gases. Where that material is not suitably contained, there is the potential for it to be inadvertently spread giving rise to surface contamination. Contamination can take two forms: fixed or non-fixed (removable) contamination.

Packages:

Consignors are required to ensure that the removable contamination on the external surfaces of any package is kept as low as practicable and, under routine conditions of transport, does not exceed prescribed limits of

- 4 Bq/cm² for beta and gamma emitters and low toxicity alpha emitters; and
- 0.4 Bq/cm² for all other alpha emitters

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

Note: For further information on 'low toxicity alpha emitters' please refer to ADR 2.2.7.1.3

In some circumstances, contamination monitoring of external surfaces may be required for each package every time it is consigned, using an appropriate contamination monitoring technique. However where this is justifiably inappropriate and can be justified by the consignor, perhaps on the basis of the working environment, or given the nature of the source/s being transported, it is appropriate to record details of the alternative approach taken, and review this periodically.

Examples

- A radiopharmacy prepares patient 'nuclear medicine' doses which are transported in a Type A package to a nuclear medicine department in a hospital located a few miles away. Contamination monitoring of external surfaces of the package will be required on each occasion the package is consigned. [This may be evidenced by monitoring undertaken as part of the process to transfer material from the production area of a facility to the dispatch area provided the dispatch area is demonstrably 'clean'.] On a return journey, a package is likely to be 'empty' however contamination monitoring may still be required considering a range of factors including the working environment that the package has been used and kept in.
- A nuclear density gauge, incorporating two special form sources, is transported on a daily basis for three weeks during a road construction project. Checks for package contamination are not routinely required considering the nature of the sources being carried and the working environment.

Vehicles:

Transport legislation requires vehicles and equipment used regularly for the carriage of radioactive material to be periodically checked to determine the level of contamination present. The frequency of these contamination checks depends on the likelihood of contamination and how often radioactive material is carried. (ADR 7.5.11 CV33 refers.)

Where the 'used regularly' criteria is met, and ONR interprets this to mean more than once or twice per month, there is some flexibility so those involved can decide on and justify a

suitable monitoring frequency considering the likelihood of contamination and how often material is transported.

The objective of this provision is to introduce a control mechanism to identify whether there is any contamination present, and to minimise its spread. It is ONR's view that it is appropriate to consider whether the dutyholders' transport operations could reasonably foreseeably give rise to vehicle and equipment contamination which can be identified by periodic contamination monitoring, and factor this in alongside the frequency that radioactive material is transported to determine the extent of monitoring.

Examples:

- A vehicle is used on a weekly basis to carry only special form radioactive material between places/premises that do not pose a reasonably foreseeable contamination risk. The sources are unlikely to give rise to contamination unless they are damaged. The dutyholder has evidence that continued source integrity has been given due consideration, and the sources have not been involved in any incidents or events, nor have they been subjected to harsh environmental conditions. As such they may be subject to a less frequent monitoring regime. Annual vehicle monitoring would not be unreasonable in these circumstances. If a dutyholder was to conclude that no contamination monitoring of vehicles was necessary, they should be prepared to substantiate this approach.
- Where vehicles are used to transport liquid radiopharmaceuticals on a daily basis, for instance, these would reasonably require frequent monitoring due to the potential for contamination of these packages. An appropriate monitoring frequency could be monthly where routine package monitoring also takes place.
- A carrier transports large unpackaged items that have naturally occurring radioactive material present on surfaces. They do this according to client demand, which can vary, but experience indicates this typically happens ten times a month. In these circumstances, ONR's view is that undertaking quarterly contamination monitoring would not be unreasonable.

Where a vehicle becomes contaminated in the course of carrying radioactive material, then it is usually the case that decontamination is required as soon as possible by a person competent to undertake this task.

Note: There is an exception to this decontamination requirement for certain containers/vehicles transporting unpackaged material as detailed in ADR 7.5.11 CV33 (5.5)

Is there scope to change the package or vehicle contamination monitoring frequency based on experience?

In the event that vehicle or package contamination is found during routine monitoring, the source of the contamination should be determined where possible, any additional control measures should be introduced, and the monitoring frequencies should be reviewed, and increased as appropriate.

Where monitoring results indicate no contamination is present, there may be scope for decreasing monitoring frequency.

Monitoring associated with packages that are, or are suspected to be, damaged or leaking:

If a package is damaged or leaking, as a result of an accident perhaps, or if this is suspected, then access to it should be restricted until it can be assessed by a person with the competence and monitoring equipment to do this. Emergency arrangements should be in place to address this situation.

The assessment should determine the extent of any contamination and radiation levels associated with the package and conclude whether it can be transported or not. Information regarding any radiological implications to people, property and the environment should follow from this assessment to inform next steps. [Note: A package that has been involved in a radiological emergency must not be carried unless the consignor or the consignor's agent has examined it and certified that it continues to comply with transport legislation. (CDG Regulation 24, Schedule 2, (6) refers.)

Informing ONR:

Packages that are damaged or leaking radioactive contents in excess of allowable limits for normal conditions of carriage may need to be removed to an acceptable interim location under supervision until the necessary remedial work can be undertaken. ONR must be contacted in these circumstances.

ONR also needs to be notified in any case where emergency arrangements have been initiated, or radiation or contamination levels exceed allowable limits for normal conditions of transport. (CDG Regulation 24, Schedule 2 5(4) and ADR 1.7.6 refer respectively.) Contact details provided in Table 2 can be used for this purpose.

Table 2: ONR contact details

Phone (during office hours)	0203 028 0650
Phone (out of hours)	0151 922 9235
Email (at any time)	class7@onr.gov.uk

Transport Index: What does the term mean?

The Transport Index (TI) is a number which is used to provide control over radiation exposure when a package is being transported. This helps to alert individuals in the transport chain of the hazard posed. Not all types of package require a TI, because radiation levels around some types of package are low. Where yellow package labels are required on the outside of a package, a TI must be established and recorded on that label, and in the relevant transport documents. The different categories of package labels are described in Table 3, alongside the associated conditions of their use.

Note: Overpacks and tanks, freight containers and certain unpackaged items are also required to be assigned a TI, and to a particular transport category, where radiation levels merit this. Table 3 applies generally, however there is an exception for containers (ADR 7.5.11 CV33 (3.3) Table D refers.)

How do I calculate the TI for my package?

According to transport legislation (ADR), the TI may be calculated by determining the maximum radiation level at one metre from **all** the external surfaces of the package (where this is appropriate), as measured in **millisieverts** per hour and multiplying this figure by 100.

However, you can also measure the maximum radiation level at 1m from all external surfaces in **microsieverts** per hour and divide this figure by 10. This may be easier if your monitoring instrument reads in these units. In any case, the value you get should be rounded up to the first decimal place (e.g. 1.13 becomes 1.2), except where a value of 0.05 or less is recorded and it may be considered zero.

The TI for your package should be based on the sum of the TIs for each type of radiation present recognising that it may not be reasonable to directly monitor all radiation types yourself. Where this is the case, contributions to the overall TI can be inferred, and verified by periodic measurement using specialist monitoring equipment.

Note: There are special provisions for assigning the transport index where particular radioactive material (uranium ores or concentrates) are being transported, and where you are transporting large loads such as tanks or freight containers, or certain unpackaged items. Consignors and carriers involved in these activities should refer to ADR 5.1.5.3

Example:

- A gauge contains a caesium-137 gamma source and an americium-241/beryllium neutron source. The TI for the gamma source is measured regularly by the company that uses it as being 0.2 but they don't have a neutron monitor. They do engage a radiation protection specialist under a contract for services who has neutron monitoring equipment, and this specialist confirms at routine visits that the neutron radiation level is approximately 1 microsievert per hour at 1 m from the gauge, so the neutron component of the TI is 0.1. The overall package TI is 0.3.

Table 3: Transport Index associated with conditions of use of different categories of package

Transport Index	Maximum radiation level at any point on external surfaces		Package category
	In millisieverts per hours (mSv/h)	In microsieverts per hour (μ Sv/h)	
0	Not more than 0.005	Not more than 5	I-White
More than 0 but not more than 1	More than 0.005 but less than 0.5	More than 5 but less than 500	II-Yellow
More than 1 but not more than 10	More than 0.5 but not more than 2	More than 500 but less than 2000	III-Yellow
More than 10	More than 2 but not more than 10	More than 2000 but less than 10000	III-Yellow (conditional on being under exclusive use)

Where the measured or calculated TI does not align with the maximum radiation levels described in Table 3, then the highest of the transport categories is assigned i.e. where the TI is 1, but the maximum radiation level at the surface of the package is 0.6mSv/h, using Table 3, the package could not be transported with II-Yellow labels, and instead III-Yellow labels would need to be used. (ADR 5.1.5.3.4 refers.)

Note: Where you are consigning multiple packages in an overpack, how you assign the TI of the overpack will depend on whether the overpack is rigid or not. Where rigid, the TI can be measured directly or can be determined by adding together the individual TIs of packages inside. Where non-rigid, individual TIs of the packages within the overpack must be added together.

Are there limits on the overall TI that I can transport?

There are vehicle limits in terms of the TI being carried. It is likely to be the carrier that will have the main responsibility to ensure the TI for the vehicle is known, and this should not exceed 50 unless transport is happening under exclusive use conditions. The overall TI can be determined by adding up all the individual TIs of packages on board, or by directly measuring the radiation level at appropriate points from the vehicle.

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