Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK - 2005 Review

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ABSTRACT

During 2005 there were 16 accidents and incidents, involving the transport of radioactive materials from, to, or within the UK, and this report includes descriptions of each event. None of these reported events involved significant radiological consequences. The number of events in 2005 was less than the 20 reported for 2004 and greater than the 11 reported in 2003. This decrease compared to 2004 is likely to represent a statistical variation in the annual number of events, rather than indicating an overall trend. In recent years the number of incidents of excess contamination on irradiated nuclear fuel flasks has returned to historical levels following an increase in the late 1990s and early 2000s. There were no events involving excess contamination on these flasks in 2005. The details of these events have been entered into the Radioactive Material Transport Event Database (RAMTED), which now contains information on 823 events that are known to have occurred since 1958.

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EXECUTIVE SUMMARY

Up to half a million packages containing radioactive materials are transported to, from and within the UK annually. Accidents and incidents involving these shipments are rare. However, there is always the potential for such an event, which could lead to a release of the contents of a package or an increase in radiation level caused by damaged shielding. These events could result in radiological consequences for transport workers. As transport occurs in the public environment, such events could also lead to radiological consequences for the public. The UK Department for Transport (DfT), together with the Health and Safety Executive (HSE) have supported work to compile, analyse and report on accidents and incidents that occur during the transport of radioactive materials. Annual reports have been produced since 1989, and this report for the year 2005 is the latest in this series. The details of these events are recorded in the Radioactive Materials Transport Event Database (RAMTED), which is maintained by the Health Protection Agency Radiation Protection Division (HPA-RPD) on behalf of DfT and HSE.

During 2005 there were 16 accidents and incidents, involving the transport of radioactive materials from, to, or within the UK, and this report includes descriptions of each event. None of these reported events involved significant radiological consequences. The number of events in 2005 was less than the 20 reported for 2004 and greater than the 11 reported in 2003. This decrease compared to 2004 is likely to represent a statistical variation in the annual number of events, rather than indicating an overall trend. In recent years the number of incidents of excess contamination on irradiated nuclear fuel flasks has returned to historical levels following an increase in the late 1990s and early 2000s. There were no events involving excess contamination on these flasks in 2005.

This report also contains a description of a potentially serious event that occurred in 2002, which led to a joint prosecution by DfT and HSE of the company involved in the transport operation, and which resulted in a large fine for that company. A package was transported while emitting a very high dose rate beam of radiation. However, due to the fact that the beam was directed downwards during transport no person received any significant dose.

The events reported here have been entered into the Radioactive Material Transport Event Database (RAMTED), which now contains information on 823 events that are known to have occurred since 1958.

CONTENTS

1 INTRODUCTION

Reviews of the accidents and incidents involving the transport of radioactive materials within, to and from the UK have been carried out for the years 1958 to 2004 (Gelder et al, 1986; Shaw et al, 1989; Hughes and Shaw, 1990-1999, 1996b; Hughes et al, 2001a, 2001b, 2006; Warner Jones et al, 2002a, 2002b; Warner Jones and Jones, 2004; Watson and Jones, 2004; Roberts et al, 2005). The objectives of those reviews were:

a to assess the radiological impact of such accidents and incidents on both workers and members of the public over the period of study;
b to comment on transport practices;
c to provide information pertinent to future legislation and codes of practice;
d to produce and maintain a database of events covering the period of study.

The initial reviews (Gelder et al, 1986; Shaw et al, 1989) were supplemented by annual analyses (Hughes and Shaw, 1990-1999; Hughes et al, 2001a, 2001b; Warner Jones et al, 2002a; Warner Jones and Jones, 2004; Watson and Jones, 2004; Roberts et al, 2005). A comprehensive review was carried out of events that occurred in the whole period from 1958 to 1994 using an improved event classification system (Hughes and Shaw, 1996b), which has been updated to include events up to and including 2004 (Hughes et al, 2006). The improved classification system was used to provide a summary and analysis of all events to 2000 that was presented at the Sixth International Conference on Radioactive Materials Transport (Warner Jones et al, 2002b).

Throughout this review accidents and incidents are collectively referred to as events. The information on these events is stored in a database: the Radioactive Materials Transport Event Database (RAMTED). In 2004, as the original database was approximately twenty years old and had many limitations compared to typical software and hardware specifications of today, it was reviewed and revised (Watson, 2004). The database is now in a relational database format, which allows for more efficient recording of the details of an event. The classification systems were reviewed, and, though only minor changes were made to the classifications, the change in the database structure now allows for an event to be more efficiently classified with a main category and subsidiary categories if appropriate.

This report describes the events reported during 2005, plus one from 2002, and gives analyses of the 2005 events based on the revised classification system and the main event categories.

The Glossary contains descriptions and definitions of a number of technical terms associated with the transport of radioactive materials.

2 DATA COLLECTION AND ANALYSES

For this review and the previous studies noted above, information on accidents and incidents was obtained from a number of sources. Most of the information was obtained from official files at the Department for Transport (DfT) (www.dft.gov.uk) and the Health and Safety Executive (HSE) (www.hse.gov.uk). Information was also obtained from other sources, such as the Civil Aviation Authority (CAA) (www.caa.co.uk), the Department of the Environment, Northern Ireland (www.doeni.gov.uk) and from independent Radiation Protection Advisers (RPA). Other sources of information for these annual reviews include events occasionally reported to the Environment Agency (EA) and records of incidents reported under the National Arrangements for Incidents involving Radioactivity (NAIR). Under the NAIR scheme, the police attending an incident involving radioactive material can summon assistance from a health physics expert in the region. However, only occasionally do these NAIR events directly involve the transport of radioactive materials.

2.1 Reporting of events and criteria

The transport of radioactive materials involves a number of activities, including the preparation of the package by the consignor, and loading onto a vehicle, followed by the shipment phase by carriers using various modes of transport. The shipment phase may involve a number of loading and unloading operations between different modes of transport, before final delivery to the consignee. The reported accidents and incidents included in these reviews come within the scope of these activities, for shipments and transhipments within the UK. Events involving shipments from the UK are also included if the event was as a result of a failing in the UK. However, events occurring within consignors' and consignees' premises, i.e. “on-site”, are not included unless they are relevant to transport in public areas or if they originated from an incident that occurred during transit.

The normal transport of radioactive materials may give rise to small radiation doses to transport workers and in some circumstances members of the public might also receive very low doses. Conditions of transport that are intended to minimise these exposures are given in national legislation, and international agreements. During 2005 the main relevant legislation was: road (GB Parliament, 2002, 2003; UNECE, 2005), rail (GB Parliament, 2004; DfT, 2005), sea (GB Parliament, 1997; MCA, 2005; IMO, 2004) and air (GB Parliament, 1994, 2004; ICAO, 2004). These conditions include, for example, the specification of segregation distances for packages during stowage.

The most significant accidents and incidents that are included in these reviews are those that give rise to increased radiation exposures during transport. In addition to these, events are included that had the potential for increased radiation exposures. There are some events in this group that may seem trivial, such as those involving administrative errors. However, experience has shown that in some circumstances such errors can have serious consequences. In practice, all but the most trivial of reported events are included in these reviews.

For transport by road in Great Britain (GB), the regulations (GB Parliament, 2002, 2003) require the driver of a vehicle transporting radioactive material to report a notifiable event to the police, fire brigade and consignor. A notifiable event is an event in which:

a radioactive material is lost, escapes or is unlawfully removed from the vehicle carrying the material;
b any package carried in or on a vehicle is opened or otherwise damaged (whether or not the package is still in or on the vehicle);
c the vehicle carrying the radioactive material overturns (including being turned on its side) or suffers serious damage or is involved in a fire; or
d a radiological emergency occurs;
e there is an imminent risk of loss of product;
f a person has suffered personal injury;
g material damage or environmental damage has occurred, or
h the authorities are involved.

Following this, the carrier must report the event to the police (if the driver has not already done so), the consignor and the Secretary of State for Transport. The notification of the latter is fulfilled by informing the Competent Authority; that is, the Dangerous Goods Division of DfT.

In practice, many other less serious events are reported voluntarily by consignors, carriers and consignees. Other types of events that are relevant to the transport of radioactive materials may also be reported by others, such as the police, suppliers and manufacturers. There have also been a few instances where members of the public have found lost packages, and informed the emergency services.

Incidents involving the transport of dangerous goods by rail are subject to standard reporting procedures. This system can result in quite minor events being reported very efficiently. Each year during the transport of irradiated nuclear fuel (INF) flasks there are a number of incidents where the train has been stopped following the detection of overheated axles or brakes. The detectors activate at temperature levels that do not pose a threat to the integrity of the INF flask. However, on occasions the overheating can result in smoke production and fires in the axle or brake areas. The criterion for including such events in these reviews is whether smoke is apparent.

INF flasks are mainly loaded and unloaded underwater in ponds at nuclear power stations and reprocessing plants. The water in these ponds tends to be contaminated with radioactive material, and this contamination may become attached to the flask surfaces. Before transport, the flasks are thoroughly cleaned and monitored. The level of non-fixed contamination by radionuclides must be below the regulatory limit of 4 Bq cm^{-2} for beta emitters, and low toxicity alpha emitters, and 0.4 Bq cm^{-2} for all other alpha emitters. For non-fixed contamination, the operational quantities related to these values are termed derived working levels (DWL). Reports of excess levels of contamination on INF flasks are included in these reviews if at any point on the surface the level is 10 DWL or above. This criterion separates out those events where the regulatory limit is likely to have been exceeded.

These annual reviews do not include any events that may still be subject to legal proceedings at the time of publication. Any such events are reported in later annual reviews.

A system has been established for rating events that occur in the nuclear industry, by the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD), and is known as the International Nuclear Event Scale (INES) (IAEA & NEA, 2001). This system enables a rating, from Level 0 to Level 7, to be applied to an event so as to give a prompt and consistent indication of the severity of the event to the media and members of the public. Level 7 refers to the most severe type of accident and Level 0 refers to an event with no safety consequences. The INES scale has been extended to cover other events, including events involving the transport of radioactive materials. Significant events are reported to the IAEA from where the details are distributed, and made publicly available. The UK, in common with most other countries, only reports events that are rated at Level 2 or above.

3 DATABASE OF REPORTED EVENTS

The details of the reported events have been entered into the RAMTED database. A comprehensive review (Hughes et al, 2006) of the events in the database includes a description of the systems of reporting and scope of the types of events included in the database. Some of the information in the database is held in coded form to facilitate analysis. Descriptions of the information stored, including the coding system used to classify events, are given in the Appendices.

The database contained information on 806 events, up to and including the events in 2004. The earliest reported events were from 1958. During the collection of information for this current review, the details were obtained for 16 events in 2005 and one event in 2002, not previously described, which brings the total number in the database to 823. The collection of information for this review did not reveal any further events from previous years that were not in the database.

The essential details of each event are briefly described in Section 4. Brief descriptions of these events are included in the database record of each event. Other details that are entered in the database record for each event are listed in Appendix A. This includes a broad description of the event as either an accident or incident that occurred during either the transport or handling phase (TI, TA, HI and HA). In addition, events where the main occurrence was radioactive contamination of external surfaces of intact packages, or conveyances, are recorded as category C.

In order to give a better description of the type of event, a classification system has been developed for the RAMTED database that gives more information than the broad descriptive categories noted above. This system enables events to be grouped into logical categories, and facilitates analyses. The classification system covers three aspects: a descriptive classification, the effect of the event on the package and the level of radiological consequences. The descriptions of the codes used in this classification system are given in Appendix B, as detailed in Tables B1, B2 and B3. The classification codes for these three aspects are listed in the last three columns of Table 1 for the 16 events reported in 2005 and the one event reported in 2002. The first four columns of Table 1 give, respectively, the event identifiers listed in Section 4, the material category code, the transport mode code and the package type. The keys to the material category and transport mode codes are given in Appendix A.

The descriptive classification of the event, given in the fifth column of Table 1, specifies the nature of the event, following the descriptive structure set out in Table B1. The first character of the code gives the general subject or area under which the event is categorised; that is, administrative (A), general shipment (S) or INF flask (F). Events involving INF flasks are separated from the other general shipments of radioactive materials for other nuclear, industrial and medical uses because of the special circumstances of INF flask movements. The identification of the second character of the code and following numbers are shown in the full coding system which is given in Table B1. The new database structure allows for events to be classified into a number of categories, as seen in Table 1, where some events have more than one entry in the fifth column. In these cases the event classifications are prioritised within the database and are listed in order of priority in Table 1.

The effect of the event on the package integrity, or the package deficiency, is allocated to 12 categories (D03 - D14), as set out in Table B2. Category D01, “No package”, applies for example when the radioactive material is not within a package. Category D02 is for contaminated conveyances, with no package involvement.

The radiological consequence of an event is allocated into one of four categories, which are set out in Table B3. In the case of lost or stolen packages the circumstances of any contact that a person may subsequently have is usually unknown. If a stolen package is briefly handled, but unopened, the dose to the thief would be in the “Extremely low” category. A higher category might be appropriate if there is evidence that the package was opened. For the purpose of the database of reported events, it is assumed that the package remains unopened after it is lost or stolen unless there is evidence to the contrary. In the case of lost packages where there is no evidence of anyone being exposed the category of consequence is taken to be “None”. This would also apply in cases where a vehicle containing a package is stolen, and where there is no evidence that the package was handled by the thief. If information is subsequently obtained that an exposure was incurred, the event record would be amended accordingly. For these lost or stolen packages for which there is no further information on their fate, an indication is given in Section 5.3 of the potential radiological consequences if they had been opened.

4 EVENTS RECORDED FOR THIS REVIEW

Brief descriptions of the events reported in 2005, and one from 2002, are listed below. The package types used are listed described in Appendix A. The identifying reference numbers allocated to each event are not necessarily in date order.

4.1 2005 Events

January

2005001. Two packages containing radioactive material were consigned to a hospital. Both were excepted packages with a Transport Index (see glossary) of 0.1 and both contained two capsules each containing 0.4 MBq of ^{75}Se. The hospital claimed that only one package was delivered. The Environment Agency was informed, but the missing package was not found and was presumed to be lost.

2005005. A Type B nuclear fuel flask containing a mixture of fission products, activation products and actinides with a combined activity of 11 PBq was transported from a dockyard to a nuclear site. On arrival at the nuclear site the flask was inspected and some minor non-conformities were found. These included an incorrectly fitted cover plate and a wrong type of washer fitted to the water level drain valve. Some irregularities in the consignment documentation were also found. The Nuclear Installations Inspectorate and Department for Transport conducted an investigation and concluded that shortfalls were of minor nuclear safety significance (HMNII, 2005). There were a number of areas identified where improvements were necessary both in the maintenance arrangements and consignment procedures. There were no radiological consequences.

February

2005003. A 4-wheel drive vehicle crashed on a country road. The vehicle was carrying a ‘Troxler’ nuclear density gauge, used for testing the density of soil at construction sites. The vehicle overturned and left the road ending up in a ditch. The driver was uninjured but the vehicle was severely damaged. The nuclear density gauge was a Type A category II yellow package and contained sources of ^{241}Am/Be and ^{137}Cs with activities of 1.85 GBq and 370 MBq respectively. Both sources were in special form. A radiation protection specialist from the driver’s company attended the accident and monitored the vehicle. Radiation levels inside and outside the vehicle were found to be normal and there was no external damage to the packaging, nuclear density gauge or shielding. As the gauge was intact, there were no radiological consequences.

March

2005004. A van carrying a package from a radionuclide supplier was broken into while parked, en route to a hospital, and the package was stolen. The doors of the van were closed but left unlocked. The contents of the package were found about two hours later in a hedge at an allotment near a shopping arcade, and the police reported that it appeared intact. The package was a Type A Category II yellow package and had a transport index of 0.5. It had originally consisted of an outer packaging of a cardboard box with polystyrene filler, enclosing a can containing ^{131}I with an activity of 5.0 GBq. The outer cardboard box and polystyrene had been removed and lost. The can was inspected by a Health Physicist from a nearby nuclear power station under the RADSAFE arrangements, and it was confirmed that the can was intact and undamaged. The package was a 15 cm cube with the can containing the radioactive material having a 10 cm diameter. The dose rates measured on the surfaces of the box and of the can were 0.46 mSv h^{-1} and 1 mSv h^{-1} respectively.

April

2005016. Upon arrival at an airport, several packages of radioactive material (Type A, UN2915) containing ^{137}Cs sources, were found to have been damaged by rainwater. The packages had been transported on wooden planks on flat metal pallets, and covered with protective plastic sheeting. It had been raining during loading at the departure airport and unloading at the destination airport. The operator's policy is to carry packages containing radioactive material in enclosed loading containers and not on pallets. Appropriate operator and handling actions were taken. There was no loss of contents from the packages.

2005006. Three radioactive sources were shipped by sea to the UK without the appropriate consignment documents. Subsequently the consignor sent copies of the consignment documents but the information was incomplete. The packages consisted of two 'Fixed Gauge Mahlo Scanner and Panels', each containing a ^{85}Kr source with an activity of 3.7 GBq, and one 'NDC Systems 103 instrument' containing an ^{241}Am source with an activity of 5.5 GBq. Following the arrival in the UK the NDC Systems 103 was sent to a purpose built facility at a nuclear site, and the Mahlo gauges were transported to another European country. Appropriate documents existed for these movements.

May

No events.

June

2005007. Discharged irradiated nuclear fuel (INF) flasks were dispatched from a nuclear site. However, the train departed without the appropriate transport documents. The consignment notes and related documentation were not on the train or in possession of the driver. When the train reached a railway freight yard it was split into two for onward movements to different destinations. By this time a copy of the consignment note had been provided for one part of the train but not the other. The original documentation had been completed but not handed to the train driver by the responsible despatch officer.

July

2005012. Three packages were dispatched from a radionuclide supplier to a research centre. During the journey, one package was lost from the delivery van and later found in the middle of the road in a village through which vehicle had passed. The package was recovered by the police, and found to be undamaged. It was eventually collected by the consignor. It was an excepted package and its contents were described as 'Liquid Organic Material' containing tritium with an activity of 185 MBq (5 mCi). Since the package was undamaged there were no radiological consequences.

2005008. A Type A package containing three ^{137}Cs sources used in drilling sensors during drilling operations, each with an activity of 74 GBq, was prepared for transport, and all documentation was completed. The package was a container labelled category III Yellow and it was due to be placed on the trailer of a lorry. However, the loading workers accidentally loaded the lorry with a trailer which had a similar container on it which had previously arrived at the site. The driver collected the documents for the intended shipment and departed on the journey. During the outbound journey the consignor was made aware of the error and the driver was contacted and returned the package.

2005010. During the transport of a discharged INF flask by rail from a nuclear site the train driver spotted someone who had climbed onto the train while it was moving. The driver reported the incident and stopped the train. The person ran away but was later found by the Transport Police and admitted to boarding the train at a railway station, where there is a 10 mph speed limit. The train proceeded to a rail yard where checks were carried out. Nothing abnormal was found and the train was allowed to continue its journey.

2005011. A van carrying a ‘Troxler’ nuclear density gauge was stolen. The gauge contained sources of ^{241}Am and ^{137}Cs. At the time that this report was compiled the gauge had not been found.

August

2005017. A package was run over by a fork-lift truck in the carrier’s warehouse at an airport. The damaged package was moved to the ‘Radioactive Materials Holding Area’ within the warehouse by one of their employees, wearing gloves. The warehouse manager contacted the company providing their Radiation Protection Adviser service to request monitoring of the package, but the Radiation Protection Adviser could not be contacted so the event was treated as a NAIR incident. The packaging consisted of an outer layer of cardboard and polystyrene (15 cm cube) and an inner shielded green container, containing a liquid source of ^{67}Ga (1.07 GBq) in a vial. The ^{67}Ga was in the form of liquid gallium citrate intended for medical use. The outer packaging was damaged but the inner container was intact. Swabs were taken of the floor around the package, the outside of the packaging, inside the damaged outer packaging and the outside of the inner container. No contamination readings above background were found on any of these surfaces. The dose rate measured at 30 cm from the outer cardboard container was 10 μSv h^{-1} and at the surface of the inner lead pot was 550 μSv h^{-1}. No contamination was measured on the outer packaging.

September

2005013. During a sea voyage two empty excepted packages, carried in a freight container, were lost overboard during severe weather off the coast of South America. In total three excepted packages were loaded into a soft-top ISO container and secured with four 10 mm retaining wires and turnbuckles. The third package was recovered from the deck but was damaged also the soft-top freight container was severely damaged. There were no radiological safety issues.

October

2005014. Two rail wagons, loaded with INF flasks, were parked overnight at a rail yard. They moved 20 metres due to a brake failure and hit a gate in the sidings, but did not go through the gate. Reassurance monitoring was carried out which revealed that the flasks were not affected. Following inspection the vehicles were declared fit for travel. The carrier's security personnel and control carried out the correct procedures by contacting Network Rail, the emergency services and RADSAFE. However, it was agreed that the event should not have been declared a RADSAFE incident, as the flasks were not affected.

2005018. A rail wagon used to carry INF flasks was monitored at a railhead and a small area on a footplate was found to be contaminated to 41 DWL (see section 2.1). The radiological consequences were negligible.

2005015. A radionuclide supplier reported dispatching an excepted package to a research centre. However, both the consignee and carrier reported not receiving the package. The package consisted of a 15 cm cubic cardboard box containing 9.25 MBq of ^{32}P in a single vial within lead shielding. Searches were carried out at both the consignor's and carrier's premises but the package was not found and was considered lost.

November

No events.

December

No events.

4.2 Previous events

Occasionally events are not reported or discovered until some time later. Also in the case of events that have been subject to legal proceedings there may be a delay in their inclusion in these annual reviews. There was one event that occurred in 2002 which has not been included in previous reviews. This event is described below.

March 2002

2002029. A hospital arranged for an unwanted radiotherapy source to be disposed of by a company that specialises in these operations. The company transferred the 129 TBq ^{60}Co source from the radiotherapy head into a Type B transport container for shipment to a nuclear site for disposal. Before the shipment the company measured the dose rates around the flask as 700 μSv h^{-1} at the surface, and as 30 μSv h^{-1} at 1 m from the surface. The dose rate was measured in the cab as less than 1 μSv h^{-1} by the company. However, radiation measurements were not made beneath the container. Upon arrival at the nuclear site it was found that there was a narrow beam of radiation being emitted vertically down from the package. The peak dose rate in the beam was measured as 3.5 Sv h^{-1}. It was found that a shielding plug had not been fitted to the container before shipment. Fortunately the beam was directed vertically downwards to the road surface during the journey and therefore it is believed that no person received any significant dose during the movement of the consignment. However, the dosimeter of one of the workers involved in the loading operation had a recorded dose of 2.3 mSv. The company involved in the transport operation was jointly prosecuted by DfT and HSE, which resulted in a large fine for that company.

5 DISCUSSION OF 2005 EVENTS

5.1 General

There were 16 events reported during 2005, not including any events that are still subject to legal proceedings at the time of publication. This is less than the 20 that occurred in 2004, and about half of the typical annual number of events that have occurred in the period between 1999 and 2002, when the annual number of events ranged from 28 to 40. The annual number of events may be expected to show a random variation and there is little evidence for an overall trend. Over the past 20 years the annual number of events has fluctuated between eight and 44. The average annual number of recorded events during the period 1958 to 2004 was approximately 17 (Hughes et al, 2006), although in the first decade of that period events were probably under-reported. The number of events in 2005 was therefore similar to this long-term average. The annual incidence of events involving excess contamination on INF flasks and wagons has returned to a very low level following an increase in the late 1990s and early 2000s. There was one such event in 2005.

The numbers of events in each of the descriptive classifications that occurred in 2005 are given in Table 2. Six events were given more than one event classification. Considering the primary event classifications only, the most numerous types of event involved lost or misdirected packages and packages damaged during transport.

Tables 3 and 4 show the distribution of the events by primary classification in the three broad categories: 3 administrative events, 10 general shipment events and 3 INF flask shipment events. This distribution expressed as a percentage of the total is 19%, 62% and 19%, which is similar to the distribution of 16%, 61% and 23% for all the events in the period 1958 to 2004 (Hughes et al, 2006).

Table 3 also shows an analysis of the events by material. During 2005, the majority of events (ten events) involved the transport of medical and industrial radioisotopes. The percentage of events (62%) involving medical and industrial isotopes was significantly higher than the long-term pattern (47%) for events in the period 1958 to 2004 (Hughes et al, 2006). However, the number of events in 2005 in this category (10) was similar to the average annual number (approximately 8) for the period 1958 to 2004 (Hughes et al, 2006). There were two events (13%) involving irradiated fuel, two (13%) with residues, one (6%) with no radioactive material, and one (6%) where other types of material were involved.

Table 4 gives an analysis of the events by mode of transport, and shows that five events involved shipments by rail (32%), one was by air (6%), two were by sea (12%), seven were by road (44%), and one involved a fork-lift truck (6%). The proportion of road events (44%) was higher than the long-term trend (31%), and for rail the proportion of events in 2005 (32%) is also higher than the long-term trend (24%). However, the number of road and rail events in 2005 (12) is almost the same as the average annual number (approximately 10) during the period 1958 to 2004 (Hughes et al, 2006). The number of events involving fork-lift trucks is one (6%), following two years without any events, but is still lower than the long-term trend of 22%. This is due to the fact that there were a large number of these events during the 1970s.

5.2 Effects on packages

Table 5 shows an analysis of the events in terms of the package condition. In four of the 16 events there was no damage to the packages involved. For two events there was no report of damage to the package or increase in dose rate, but potential to cause damage, and in six events there was no report of damage or increased dose rates but packages were subject to major potential for damage. There was one event that had a package in defective or poor condition, one event had minor damage to the package but no increase in dose rate or loss of contents, one event had severe damage to the package but with no increase in dose rate or loss of containment, and one event involved a contaminated conveyance.

5.3 Radiological consequences

Table 6 shows the likely radiological consequences for the events in 2005, analysed by material category. Of the 16 events, 3 were categorised as "Extremely low, not assessed", and 13 as "None", indicating no radiological consequences for those events. It is estimated, so far as possible from the information available, that only two of the events in 2005 could have led to any excess exposure, above trivial levels. These were events 2005004 and 2005017. Event 2005004 concerned the theft of a package from a parked van. The contents of the package (a metal can) were found about two hours later but the outer packaging of a cardboard box with polystyrene filler had been removed and lost. A dose rate of 1 mSv h^{-1} was measured at the surface of the can, so potentially the hands of the thief will have been exposed. It is likely that the can would have been handled for only a few minutes so the dose to the hands are estimated to be in the region of 100 μSv, with an effective dose in the order of 10 μSv.

Event 2005017 involved a package being run over by a fork-lift truck in the carrier's warehouse at an airport. The outer packaging was damaged but the inner container was intact with no loss of radioactive material. A dose rate of 10 μSv h^{-1} was measured a distance of 30 cm from the outer cardboard container. The damaged package was moved to the 'Radioactive Materials Holding Area' within the warehouse by one of their employees, wearing gloves. This would have taken only a few minutes so the dose to the hands was likely to be in the region of a few microsieverts.

Two events involved lost packages, and one involved a stolen van that contained a gauge, which had not been recovered when this report was compiled. It is unknown whether anyone came into contact with these packages. However, the dose rates around these packages were very low and a brief exposure to an unopened package would result in a trivial dose. In the case of lost or stolen packages it is usually unknown whether a person may have been subsequently exposed to the radioactive contents of the package.

For the two lost packages, for which the fate is unknown, an indication of the potential radiological consequences can be made from the activity of the contents, and the type of radionuclide, on the assumption that the package is opened and the contents handled for a few minutes. In event 2005001 the contents was of very low activity and handling the contents could result in a dose to the hands in the order of 10 μSv, while the effective dose would be negligible. In event 2005015, again the activity of the contents was very low and handling those contents would result in a dose to the hands in the order of 100 μSv, while the effective dose would be negligible. Event 2005011 involved a stolen gauge which contained sources of low activity. The dose rate at 1 m from the sources would be a few tens of microsieverts per hour. Handling the source probe for a few minutes could give a dose to the hands in the order of 10 mSv, and an effective dose in the order of 1 μSv.

This report also contains a description of a potentially serious event that occurred in 2002, which led to a joint prosecution by DfT and HSE of the company involved in the transport operation. A package was transported while emitting a very high dose rate beam of radiation. However, due to the fact that the beam was directed downwards during transport it is believed that no person received any significant dose during the movement of the consignment. The dosimeter of one of the workers involved in the loading operation had a recorded dose of 2.3 mSv. It is unclear at what point during the package preparation and loading phases it may have been received. For the purposes of recording the event in RAMTED, it is assumed that the dose was received during this transport operation.

6 CONCLUSIONS

There were 16 reported events in 2005, which is fewer than the 20 events reported in 2004, and generally less than the annual number of events reported in recent years. This reduction is consistent with statistical variation and it is unlikely that it indicates an overall trend.

During 2005 there were two events involving damaged packages that had the potential to give rise to exposures above normal levels, but it is unlikely that any significant doses were received from these events, either by workers or members of the public.

The details of the 16 events in 2005, as well as one event in 2002 not previously described, have been included in the database (RAMTED), bringing the total number of reported events since 1958 to 823.

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8 GLOSSARY

Term	Description
Absorbed Dose	Measured in Grays (Gy), it is the amount of energy absorbed per kilogram of matter, for example tissue, as a result of exposure to ionising radiation.
Activity	The number of radioactive decays per unit time in a given material. Normally measured in disintegrations per second (Bq).
AGR	Advanced Gas-cooled Reactor. Used in the UK's second generation of gas-cooled nuclear power stations.
Alpha emitter	A radionuclide that decays emitting an alpha particle.
Alpha particle	A particle emitted by a radionuclide consisting of two protons and two neutrons (i.e. the nucleus of a helium atom).
Beta emitter	A radionuclide that decays emitting a beta particle.
Beta particle	An electron or positron emitted by a radionuclide.
Category	Packages other than excepted packages and overpacks must be assigned to either category I-White, II-Yellow or III-Yellow, depending on the maximum dose rate at the surface and at 1 m from the surface, and must be labelled accordingly.
Committed Effective Dose	A measure of the total lifetime radiation exposure of an individual from intakes of radioactive material. The effective dose received across the life-time of an individual (taken up to the age of 70 for members of the public), from an ingestion or inhalation of radionuclides.
Effective Dose	Measured in Sieverts (Sv), it is a measure of the overall exposure of an individual from ionising radiation. It is dependent on the absorbed dose, type of radiation and regions of the body affected. Since the Sievert is a large unit, doses are more commonly expressed in millisieverts (mSv) or microsieverts (µSv).
Effective dose rate (or "Dose rate")	The rate at which effective dose from external radiation is received, measured in units of Sv h^{-1}, or mSv h^{-1}.
Flatrol	A type of rail wagon used to carry INF flasks.
Irradiated Nuclear Fuel (INF) Flask	A Type B package used to transport irradiated nuclear fuel (see packages).
Ionising Radiation	Radiation capable of breaking chemical bonds, causing ionisation and damage to biological tissue.
Label	Apart from excepted packages all packages must be labelled with a diamond shaped warning label which gives information on the contents of the package.
Low toxicity alpha emitters	Natural uranium, depleted uranium, natural thorium, ^{235}U, ^{238}U, ^{232}Th, ^{228}Th and ^{230}Th when contained in ores or physical and chemical concentrates; or alpha emitters with a half-life of less than 10 days.
Magnox	The first generation of the UK's gas-cooled nuclear power stations.
NAIR (National Arrangements for Incidents involving Radioactivity)	A scheme designed to provide assistance to the police when dealing with an incident which involves, or is suspected to involve, radioactive material.
Nuclide	A species of atom characterised by a nucleus with a specific number of protons and neutrons.
Overpack	An enclosure such as a box or bag which is used by a consignor to transport a number of packages as a single unit.
Package	There are five main types of packages used to carry radioactive material: • Industrial Packages are industrial containers, such as drums, used to carry bulky low activity materials, or contaminated items. • Excepted packages are simple packages used to carry low activity materials and sources. They are mainly used to transport low activity diagnostic test materials to hospitals. • Type A packages are used to transport medium activity material such

Term	Description
	as medical or industrial isotopes. They must withstand normal conditions of transport including minor mishaps. • Type B packages are used to transport high activity sources and materials, such as Irradiated Nuclear Fuel (INF). They provide shielding from high radiation levels even under extreme circumstances. They must meet severe mechanical and thermal test requirements, which simulate accident conditions. • Type C packages are for the transport by air of greater quantities of radioactive material than is allowed to be transported by air in Type B packages. They must be designed to withstand very serious accidents such as aircraft crashes.
Radionuclide	A nuclide which spontaneously loses energy or disintegrates into another nuclide, resulting in the emission of ionising radiation.
RADSAFE	An emergency response plan operated by the main carriers of radioactive materials.
Special form radioactive material	An indispersible solid radioactive material or a sealed capsule containing radioactive material.
Transport Index	A number equal to the maximum dose rate, at 1 m from the surface of the package, overpack or freight container, measured in mSv h^{-1} multiplied by 100. This number is used to control radiation exposure from a group of packages during transport.

9 TABLES

TABLE 1 Summary list of events included in the 2005 review*

Event number (Section 4)	Material category (Section A7)	Transport mode (Section A6)	Package type (Section A22)	Event classification code(s) (Table B1)	Effect on package code (Table B2)	Radiological consequence code (Table B3)
2005001	M07	V05	E	SP222	D05	N
				AG251		
2005003	M07	V06	A	SC511	D05	N
2005004	M07	V05	A	SP211	D05	E
2005005	M04	V01	BM	FP181	D06	N
2005006	M07	V03	BUP	AG221	D03	N
				AG241		
2005007	M05	V01	BUF	AG211	D03	N
2005008	M07	V04	A	SP221	D03	N
				AG231		
2005010	M05	V01	BUFP	AG411	D03	N
2005011	M07	V05	AP	SP212	D05	N
2005012	M07	V05	E	SP221	D04	N
				AG221		
2005013	M11	V03	E	SP232	D05	N
2005014	M04	V01	BUFP	FC211	D04	N
				FC111		
2005015	M07	V05	E	SP222	D05	N
				AG251		
2005016	M07	V02	A	SP341	D07	N
2005017	M07	V08	A	SP341	D08	E
2005018	M09	V01	CV	FC311	D02	E
2002029 †	M07	V04	BU	SP131	D14	U

Notes

* Details of the coding systems are given in the appendices.

† Event occurred in 2002.

TABLE 2 Numbers of 2005 events in each classification

Event classification code (See Table B1)	1st classification	2nd classification	3rd classification
AG211	1	0	0
AG221	1	1	0
AG231	0	1	0
AG241	0	1	0
AG251	0	2	0
AG411	1	0	0
FC111	0	1	0
FC211	1	0	0
FC311	1	0	0
FP181	1	0	0
SC511	1	0	0
SP211	1	0	0
SP212	1	0	0
SP221	2	0	0
SP222	2	0	0
SP232	1	0	0
SP341	2	0	0
Total	16	6	0

TABLE 3 Classification* of 2005 events by material category

Material		Administrative			General (non-INF) shipments		INF flask shipments		Totals	%†	%, 1958-2004
Code	Category	General	Conveyance	Package	Conveyance	Package	Conveyance	Package			
M00	Unknown	0	0	0	0	0	0	0	0	0	N/A‡
M01	Uranium ore concentrate	0	0	0	0	0	0	0	0	0	4
M02	Pre-fuel material	0	0	0	0	0	0	0	0	0	3
M03	New fuel	0	0	0	0	0	0	0	0	0	<1
M04	Irradiated fuel	0	0	0	0	0	1	1	2	13	13
M05	Residues	2	0	0	0	0	0	0	2	13	14
M06	Radioactive wastes	0	0	0	0	0	0	0	0	0	8
M07	Medical & industrial radioisotopes	1	0	0	1	8	0	0	10	62	47
M08	Radiography sources	0	0	0	0	0	0	0	0	0	10
M09	No radioactive material	0	0	0	0	0	1	0	1	6	<1
M10	Consumer products	0	0	0	0	0	0	0	0	0	1
M11	Other	0	0	0	0	1	0	0	1	6	<1
Totals		3	0	0	1	9	2	1	16	100	100

Notes

* First classifications only. See Table B1 for descriptions of event classifications.

† With a sample size of 16 events, interpretation of these rounded percentages must be made with care.

‡ These material categories are new additions to the database, so no comparison can be made with previous data.

TABLE 4 Classification* of 2005 events by mode of transport

Mode of transport		Administrative			General (non-INF) shipments		INF flask shipments		Totals	%[†]	%, 1958-2004
Code	Category	General	Conveyance	Package	Conveyance	Package	Conveyance	Package			
V00	Unknown	0	0	0	0	0	0	0	0	0	N/A‡
V01	Rail	2	0	0	0	0	2	1	5	32	24
V02	Air	0	0	0	0	1	0	0	1	6	13
V03	Sea	1	0	0	0	1	0	0	2	12	7
	Road:										
V04	> 1.5 t (lorry)	0	0	0	0	1	0	0	1	6	15
V05	< 1.5 t (van)	0	0	0	0	5	0	0	5	32	13
V06	Car	0	0	0	1	0	0	0	1	6	3
V07	Unknown	0	0	0	0	0	0	0	0	0	<1
V08	Fork-lift truck	0	0	0	0	1	0	0	1	6	22
V09	Other	0	0	0	0	0	0	0	0	0	<1
V10	Road and sea	0	0	0	0	0	0	0	0	0	<1
V11	Road and rail	0	0	0	0	0	0	0	0	0	<1
V12	Road and air	0	0	0	0	0	0	0	0	0	<1
Totals		3	0	0	1	9	2	1	16	100	100

Notes

* First classifications only. See Table B1 for descriptions of event classifications.

[†] With a sample size of 16 events, interpretation of these rounded percentages must be made with care.

[‡] These material categories are new additions to the database, so no comparison can be made with previous data.

TABLE 5 Nature of package deficiency by type of package

Package deficiency or damage		Type of package* (as specified or assumed)							
Code†	Description	Excepted	A	B	IP	UK	CV	Others	Total
D02	Contaminated conveyance	0	0	0	0	0	1	0	1
D03	No damage or threat of damage to package	0	1	3	0	0	0	0	4
D04	No report of damage or increase in dose rate, but potential to cause damage to the package (lower category)	1	0	1	0	0	0	0	2
D05	No report of damage/inc. dose rate. Potential for damage (upper category)	3	3	0	0	0	0	0	6
D06	Defective/Poor condition. No increase in dose rate or loss of containment	0	0	1	0	0	0	0	1
D07	Minor damage. No increase in dose rate or loss of containment	0	1	0	0	0	0	0	1
D08	Severe damage without increase in dose rate or loss of containment	0	1	0	0	0	0	0	1
Totals		4	6	5	0	0	1	0	16

Notes

* See Section A22.

† See Table B2 for examples.

TABLE 6 Radiological consequences by material category

Material		Radiological consequences*				
Code	Category	None	Not assessed, extremely low	Assessed, lower category (<1mSv)	Assessed, upper category (>1mSv)	Total
M04	Irradiated fuel	2	0	0	0	2
M05	Residues (inc discharged NFFs)	2	0	0	0	2
M07	Med & Industrial Radioisotopes	8	2	0	0	10
M09	No radioactive material	0	1	0	0	1
M11	Other	1	0	0	0	1
Totals		13	3	0	0	16

Notes

* See Table B3 for description of categories

APPENDIX A Information System Used in the Database of Reported Events of Accidents and Incidents Involving the Transport of Radioactive Material

The details of each event are stored in a computer database by the use of descriptive text and alphanumeric coding systems that are described below.

A1 EVENT ID

The events are numbered using a 7 digit identifier with the format YYYYXXX, where YYYY is the year of the event, and XXX is a sequential figure.

A2 DATE

The date is recorded in the format DD/MM/YYYY

A3 SOURCE

Information regarding events is obtained from the following sources: Civil Aviation Authority, Dangerous Goods Division of the Department for Transport, Health Protection Agency Radiation Protection Division, National Arrangements for Incidents involving Radioactivity, Environment Agency, Health & Safety Executive and others. The source of the information is given for each event, together with the event identifier used by the source organisation.

A4 TYPE OF EVENT

This coding gives the broad type of event, classified as occurring either during the moving phase of transport operations or during handling before or after movement. Furthermore, events occurring during either the moving or handling phases are categorised either as accidents or as incidents. Alternatively, events may be classified as contamination events.

TA – transport accidents

A transport accident is defined as any event during the carriage of a consignment of radioactive material that causes damage to the consignment or significant damage to the conveyance so that the conveyance could not continue its journey.

TI – transport incidents

A transport incident is defined as any event, other than an accident, occurring before or during the carriage of a consignment of radioactive material which caused, or might have caused, damage to or loss of the consignment or unforeseen radiation exposure of workers or members of the public.

HA – handling accidents

A handling accident is defined as an event during the loading, trans-shipping, storing or unloading of a consignment of radioactive material and which caused damage to the consignment, eg a package falling from a fork-lift truck and subsequently being run over or a package being dropped owing to crane failure during handling.

HI – handling incidents

A handling incident is defined as an event, other than an accident, during the loading, trans-shipping, storing or unloading of a consignment of radioactive material which caused, or could have caused, damage to or loss of the consignment or unforeseen exposure of workers or members of the public.

C - contamination

A contamination event is defined as an event where radioactive contamination is found on the surface of the package or conveyance in excess of the regulatory limit.

A5 REGIONAL LOCATION OF EVENT

The location at which the event occurred is given, if known, together with a code assigning the location to one of a number of defined geographical regions.

A6 MODE OF TRANSPORT

The mode of transport is given for each event, coded as follows:

V00 unknown,
V01 rail,
V02 air,
V03 sea,
V04 road – lorry > 1.5 t,
V05 road – van < 1.5 t,
V06 road – car,
V07 road – unknown,
V08 fork-lift truck,
V09 other (including crane).
V10 road and sea
V11 road and rail
V12 road and air

A7 CATEGORY OF MATERIAL

The type of material is given for each event, coded as follows:

M00 unknown,
M01 uranium ore concentrate (UOC),
M02 pre-fuel material,
M03 new fuel,
M04 irradiated fuel,
M05 residues including discharged nuclear fuel flasks,
M06 radioactive wastes,
M07 medical and industrial radioisotopes,
M08 radiography sources,
M09 no radioactive material,
M10 consumer products,
M11 other.

A8 CONSIGNOR

The name and address of the company/organisation that despatched the shipment is given for each event, if known.

A9 CONSIGNEE

The name and address of the destination company/organisation is given for each event, if known.

A10 CARRIER

The name and address of the carrier (and sub-carrier, if appropriate) is given for each event, if known.

A11 DESCRIPTION OF EVENT

A brief description of the event is given in words.

A12 ACTIVITY RELEASE

The activity, in TBq, of any radioactive material released into the environment is given for each event.

A13 WORKER DOSES

The maximum dose received by workers from an event is given in mSv, if known.

A14 PUBLIC DOSES

The maximum dose received by the public from an event is given in mSv, if known.

A15 INES RATINGS

The INES rating assigned to each event is given, if known.

A16 INES CONDITIONS

The INES rating is partly dependent on whether or not certain conditions applied to an event. A record is made of whether these conditions did apply for each event, if this is known.

A17 EVENT IMPLICATIONS

Implications such as worker or public safety implications, or environmental implications are given, if known.

A18 NUCLEAR INDUSTRY AND AIRPORT EVENTS

It is recorded for each event if the event involved the nuclear industry or damage to a package at an airport, if this is known.

A19 EMERGENCY ACTION

It is recorded for each event if emergency action was taken, if this is known.

A20 ADDITIONAL INFORMATION

Any additional information, including photos if appropriate, is recorded for each event.

A21 DESCRIPTION OF PACKAGES

A description of each package is given, if known.

A22 PACKAGE TYPE

For each package, a package type is given, using the following codes.

Type A Package Codes:

A Type A
AP Presumed to be Type A
AF Type A, with fissile material
AFP Presumed to be Type A, with fissile material

Type B Package Codes:

B Type B
BP Presumed to be Type B
BF Type B, with fissile material
BFP Presumed to be Type B, with fissile material
BM Type B(M)
BMP Presumed to be Type B(M)
BMF Type B(M), with fissile material
BMFP Presumed to be Type B(M), with fissile material
BU Type B(U)
BUP Presumed to be Type B(U)
BUF Type B(U), with fissile material
BUFP Presumed to be Type B(U), with fissile material

Type C Package Codes:

C Type C
CP Presumed to be Type C
CF Type C, with fissile material
CFP Presumed to be Type C, with fissile material

Excepted Package Codes:

E Excepted
EP Presumed to be Excepted

Exempt Package Codes:

E Exempt
EP Presumed to be Exempt

Industrial Package Codes:

IP Industrial Package, any type
IPP Presumed to be an Industrial Package, any type
IPF Industrial Package, any type, with fissile material
IPFP Presumed to be an Industrial Package, any type, with fissile material
IP1 Industrial Package, Type 1 (IP-1)
IP1P Presumed to be an Industrial Package, Type 1
IP1F Industrial Package, Type 1, with fissile material
IP1FP Presumed to be an Industrial Package, Type I, with fissile material
IP2 Industrial Package, Type 2 (IP-2)

IP2P Presumed to be an Industrial Package, Type 2
IP2F Industrial Package, Type 2, with fissile material
IP2FP Presumed to be an Industrial Package, Type 2, with fissile material
IP3 Industrial Package, Type 3 (IP-3)
IP3P Presumed to be an Industrial Package, Type 3
IP3F Industrial Package, Type 3, with fissile material
IP3FP Presumed to be an Industrial Package, Type 3, with fissile material

Other Codes:

CV Contaminated conveyance only
NIL No radioactive material carried
NR Packaged item, but not in recognised package type
SC Item carried within load of scrap
UK Unknown packaging status
UPX Unpackaged item, which should be packaged
UPY Unpackaged item, which is OK to be unpackaged

A23 TRANSPORT INDEX

For each package the Transport Index (TI) is given, if known.

The TI is a number used to provide control over radiation exposure. For packages the TI is the maximum dose rate at 1 m from its surface, in mSv h^{-1}, multiplied by 100.

A24 RADIONUCLIDES

The radionuclides contained in each package are listed by their chemical symbol and mass number, with a record of whether or not each nuclide is a sealed source or a fission product (usually caesium-137.)

A25 ACTIVITY

The activity of each radionuclide is given, in TBq, if known.

A26 EVENT CLASSIFICATION SYSTEMS

The analysis of the database of events is facilitated by the use of classification systems that define the description of the event, the type of package damage or deficiency and the extent of any radiological consequence. These three classification systems are set out in Tables B1, B2 and B3. Each event is characterised by the allocation of the alphanumeric codes shown in Table B1, and the radiological consequences of each event are characterised by the allocation of the codes shown in Table B3. Each package is characterised for damage or deficiency by the codes shown in Table B2.

APPENDIX B Event Classification System

The database uses coding systems for event classifications, package deficiencies and potential radiological exposures. Tables B1 to B3 give details of these classification schemes, showing the coding systems used.

TABLE B1 Classification of reported transport events

Area Subject	Item	Sub-item		Description
A Administrative (all packages)				
G General	1 Training	1	1	Insufficient worker training
	2 Documents	1	1	Consignor's certificate incorrect or absent
		2	1	Other shipment documents incorrect or absent
		3	1	Correct contents but wrongly described in documents
		4	1	Material undeclared as being radioactive
		5	1	Accounting error, ie apparent loss of package
	3 Delivery	1	1	Administrative difficulty or error, returned to consignor or re-consigned
	4 False alarm	1	1	Suspected incident but none found
C Conveyance	1 Placards	1	1	Correct vehicle placards not displayed
			2	Placards displayed but no sources carried
	2 Excessive TI	1	1	Excessive TI on conveyance or in stowage hold
P Package	1 Labels	1	1	Insufficient or incorrect package labels
			2	Labels on empty package
		2	1	Incorrect TI on package label
		3	1	Incorrect radionuclide or activity on package label
	2 Marking	1	1	Package type unmarked or wrongly marked
S Shipments, general (not irradiated nuclear fuel flasks)				
C Conveyance	1 Load	1	1	Excessive load on conveyance
	2 Mechanical	1	1	Faulty conveyance, or mechanical failure
	3 Security	1	1	Locks or security devices: insecure, insufficient or defective
	4 Tie-downs	1	1	Tie-downs or similar devices: insufficient or defective
	5 Accidents	1	1	Collisions and other accidents, without fire
	6 Accident/fire	1	1	Collisions and other accidents, with fire
	7 Fire	1	1	Spontaneous fire on conveyance
	8 Stowage	1	1	Inappropriate stowage conditions
P Package	1 Preparation	1	1	Poor standard of packaging or containment
		2	1	Incomplete package, insecure inner container
		3	1	Incomplete package, insufficient shielding
		4	1	Incorrect contents or package type
		5	1	Material in supposedly empty package
		6	1	Contamination inside package

TABLE B1 Continued Classification of reported transport events

Area Subject	Item	Sub-item		Description
		7	1	Contamination outside package
	2 Loss/disposal	1	1	Stolen, and recovered
			2	Stolen, not recovered
		2	1	Lost, found, temporary loss, wrong destination or wrong conveyance
		2	2	Lost, not recovered
		3	1	Lost at sea, and recovered
		3	2	Lost at sea, not recovered
		4	1	Inappropriate disposal
		5	1	Radioactive material in scrap metal
	3 Damage	1	1	Spontaneous mechanical failure of package, including leakage
		2	1	Deliberate damage or interference
		3	1	Damaged by falling from or within conveyance, or by falling object, or by external object
		4	1	Damaged during cargo handling
		5	1	Damaged due to broken or loose tie-downs
F Irradiated nuclear fuel flasks				
C Conveyance	1 Flatrol/ HGV	1	1	Flatrol or HGV problem eg buffers, brakes, canopy not correct, including significant overheating of wheel or axle
	2 Accident	1	1	Collision
		2	1	Derailment during low speed marshalling
		3	1	Inadvertent decoupling
		4	1	Fire on the conveyance
	3 Contamination	1	1	Flatrol or HGV contaminated above 10 DWL
		2	1	Fixed-contamination above 5 μSv h^{-1}
P Package	1 Preparation	1	1	Shock absorber damaged or unsatisfactory
		2	1	Tie-down bolts insufficient or defective
		3	1	Lid, defective or loose bolts
			2	Lid seal unapproved or obsolete
		4	1	Water level valve defective
		5	1	Discharged flask containing fuel rod, excessive deposit, or other incorrect contents
		6	1	Faulty test procedures
		7	1	Fuel not fully covered by water
		8	1	Other minor preparation error
	2 Mechanical	1	1	Mishandled during loading or unloading
		2	1	Venting system or valve problem
	3 Contamination	1	1	Contamination of surface above 10 DWL
		2	1	Other: poor standard of decontamination

TABLE B2 Classification of package deficiency associated with the transport event

Deficiency Code	Deficiency	Examples/Comments
D01	No package	No package involved in event.
D02	Contaminated conveyance	Contaminated conveyance only with no package involved.
D03	No damage to package or threat of damage	Administrative errors and false alarms. Inadequate locks and security devices. Inappropriate or wrong contents. Obsolete lid seals.
D04	No report of damage or increase in dose rate, but potential to cause damage to the package. Lower category	Package temporarily lost or mislaid, or wrong destination, or put on wrong conveyance. Low speed derailments and collisions. Flatrol decoupling. Faulty conveyance or tie-downs.
D05	No report of damage or increase in dose rate, but potential to cause damage to the package. Upper category	Stolen source. Unretrieved lost package. Inappropriate disposal. Severe collision. Fire on the conveyance.
D06	Defective or poor condition, without increase in dose rate or loss of containment	Package of generally poor standard, corroded or other deterioration. Parts missing or mechanical defect.
D07	Minor damage without increase in dose rate or loss of containment	Damage to outer packaging: knocked, dropped or dented. Conveyance overturned.
D08	Severe damage without increase in dose rate or loss of containment	Severely damaged: crushed. Scorched by fire. Part of container, eg lid, knocked off.
D09	Damaged with increase in dose rate but without loss of containment	Increased dose rate outside package caused by damage or fire en route. Includes internal leakage and other mechanical failure. No loss of material outside package.
D10	Damaged with loss of containment	Leakage out of package caused by damage or fire en route. Includes material or source(s) released from package. Usually accompanied by some increase in dose rate.
D11	Contamination inside package	Unexpected contamination or other residual material found inside package.
D12	Contamination outside package	Fuel flask contamination > 10 DWL. Any other contamination above IAEA limits.
D13	Improper package with loss of shielding or containment – inappropriate contents	Activity unexpectedly high for package, leading to dose rates higher than expected.
D14	Improper package with loss of shielding or containment – inadequate shielding	Package shipped with poor, ineffective or damaged shielding, or source exposed en route.

TABLE B3 Radiological consequences resulting from transport events

Code	Circumstances
N None	No dose rates or contamination above those expected during routine transport. No evidence of exposures having been received.
E Extremely low, not assessed	Some increased exposure above that associated with routine transport but considered to be so low that an assessment was of little value.
L Assessed, and below 1 mSv*	Some increased exposure above that associated with routine transport and considered to be of a magnitude worth investigating, but found to be low.
U Assessed, and above 1 mSv* or exposure to significant contamination	Some increased exposure above that associated with routine transport and considered to be of a magnitude worth investigating. Some exposures found to be appreciable.

Note:

* An effective dose of 1 mSv or an extremity dose of 50 mSv.