Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2007 Review

M P Harvey and J S Hughes

ABSTRACT

During 2007 there were 25 accidents and incidents, involving the transport of radioactive materials from, to, or within the UK, and this report includes descriptions of each event. The number of events in 2007 was less than those reported for 2006 (27 events) but was more than reported in 2005 (16 events) and 2004 (20 events). In 2006 and 2007 there was an increase in the number of events (9 in 2007) involving the discovery of radioactive material in supposedly non-radioactive shipments. However, none of the events in 2007 resulted in any significant radiation doses to workers or members of the public.

The details of these events have been entered into the Radioactive Material Transport Event Database (RAMTED), which now contains information on 875 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) has supported work to compile, analyse and report on accidents and incidents that occurred during the transport of radioactive materials. Annual reports have been produced since 1989, and this report for the year 2007 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.

During 2007 there were 25 accidents and incidents, involving the transport of radioactive materials from, to, or within the UK, and this report includes descriptions of each event. The number of events in 2007 was less than those reported for 2006 (27 events) but was more than reported in 2005 (16 events) and 2004 (20 events). In 2006 and 2007 there was an increase in the number of events (9 in 2007) involving the discovery of radioactive material in supposedly non-radioactive shipments. However, none of the events in 2007 resulted in any significant radiation doses to workers or members of the public.

The events reported here have been entered into the Radioactive Material Transport Event Database (RAMTED), which now contains information on 875 events that are known to have occurred since 1958.

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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 2005 (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; Hesketh et al, 2006; Hughes and Harvey, 2007). 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; Hesketh et al, 2006; Hughes and Harvey, 2007). 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 2006 (Hughes and Harvey, 2007). 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 2007 and gives analyses of the 2007 events based on the revised classification system and the main event categories. Some other occurrences of interest that did not meet the criteria for inclusion in the database are also briefly described. These are more numerous than the previous years and they are therefore presented in a table, listed on Appendix A.

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

2 DATA COLLECTION AND ANALYSIS

For this review, 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), the Scottish environmental protection agency (SEPA) (www.sepa.org.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 2007 the main relevant legislation was: road (GB Parliament, 2002, 2003; UNECE, 2007), rail (GB Parliament, 2004, 2005; OTIF, 2007), sea (GB Parliament, 1997; MCA, 2006; IMO, 2006) and air (GB Parliament, 1994, 2007a; ICAO, 2006). Also during 2007 new regulations (GB Parliament, 2007b) were introduced on the transport of all dangerous goods by road and rail. These conditions include, for example, the specification of segregation distances for packages during stowage. It may be noted that 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 imminent loss of product;
f. a person has suffered personal injury;
g. material damage or environmental damage has occurred, or
h. the authorities are involved.

The regulations introduced during 2007 (GB Parliament, 2007b) include similar conditions. 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.

Events involving undeclared radioactive material discovered in packages or cargoes of scrap metal are included when these have involved illegal or unauthorised transport after the radioactive material has been discovered or there is evidence that the radioactive material had been deliberately transported. This is because the regulations (GB Parliament, 2002) state that there is no contravention of the regulations by a person who neither knew nor had reasonable grounds for believing that the material in question was radioactive. For these reviews, which are concerned with contraventions of the regulations in addition to incidents and accidents, similar considerations are applied to radioactive material discovered at ports and airports by installed radiation detectors. Where such intercepted material was known to be radioactive but was not being transported in accordance with the regulations, this is always recorded as an event. Events that involve the discovery of undeclared radioactive material that are notified to DfT but which are not included in the database as transport events, because they do not meet the above criteria, are, never the less, briefly described in Section 5.4 and listed in Appendix A.

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 850 events, up to and including the events in 2006. The earliest reported events were from 1958. During the collection of information for this current review, the details were obtained for 25 events in 2007, which brings the total number in the database to 875. 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 B. 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 C, as detailed in Tables C1, C2 and C3. The classification codes for these three aspects are listed in the last three columns of Table1 for the 25 events reported in 2007. 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 B.

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 C1. 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 C1. 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 C2. 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 C3. In the lowest category “None” applies to events where there are no dose rates or contamination above that expected from normal transport, or where there is no evidence that exposures have been received. In events where there was a small excess dose, but not at a level thought to be worth a detailed assessment, they are categorised in the “Extremely low, not assessed” band. Such excess exposures may be received when a worker repackages a poorly packaged item. In cases where workers are exposed for a significant period and an assessment is carried out of their likely dose, these events would fall into either the “Assessed, lower category” or the “Assessed, upper category”, depending on whether their effective dose exceeded 1 mSv, or an extremity dose exceeded 50 mSv.

4 EVENTS RECORDED FOR THIS REVIEW

Brief descriptions of the events reported in 2007 are listed below. The package types used are listed in Appendix B. The identifying reference numbers allocated to each event are not necessarily in date order.

January

2007001. A member of the public brought a lead lined wooden box into a police station. It contained 7 vials labelled “Thorium Oxide”. The police consulted with a local chemist who informed them that it was radioactive, and they then instigated a NAIR alert. The NAIR first respondent established that the vials contained radioactive material and that the dose rate at the surface of the vials was in the range 40 to 50 μSv h^{-1}. The dose rate at the surface of the box was about 50 μSv h^{-1}, but this decreased to 5 μSv h^{-1} at about 30 cm from the surface. An expert from the Environment Agency later visited the police station suggesting that they could dispose of the waste in 100g consignments based on the radioactive substances exemption order (Prepared Uranium and Thorium compounds). Also the source should be encapsulated before disposal. The package containing the Thorium should have been transported to the police station in an appropriate container with correct UN markings and documentation. The dose rate around the box containing the material was low and the dose received from handling it would have been negligible.

2007020. A consignment that had been imported by sea was held at the port on arrival as it had triggered radiation detecting equipment. The consignment was found to consist of 96 packages, containing 4500 smoke detectors. The packages did not have the appropriate labelling and were required to be labelled with UN2911 markings. However there were no radiological consequences arising from this event.

2007002. A package consigned by a manufacturer of radiopharmaceuticals was temporarily mislaid at an airport. A report of its loss was made but the package was subsequently found. There were no radiological consequences arising from this event.

February

2007003. When a Type A package containing a ^{192}Ir industrial radiography source was delivered to a source supplier, it was found that the vehicle used did not have vehicle placards. Also, documents describing emergency arrangements were not carried with the consignment. The activity of the source was 0.1 TBq. As a result of this event the consignor revised their procedures.

2007021 A consignment that had been imported by sea was held at the port on arrival as it had triggered radiation detecting equipment. The consignment was found to consist of packages, containing smoke detectors. The maximum dose rate found at the surface of these packages was 0.06 μSv h^{-1}. The packages did not have the appropriate transport documents for radioactive material. However, due to the very low dose rates, there were no radiological consequences arising from this event.

2007022 A consignment en-route from one overseas country to another triggered radiation detectors when it arrived during trans-shipment at an airport in the UK. The consignment was found to consist of 7,200 gas mantles. Dose rate measurements made by a Radiation Protection Advisor, showed that the dose rate was about 2 μSv h^{-1} close to the packages. The activity was estimated to be >10 kBq and > 10 Bq g^{-1} of ^{232}Th, which meant that these items met the definition of radioactive material. The packages did not have the appropriate labelling. After two days the packages were relabelled and forwarded. However there were no radiological consequences arising from this event.

2007023 A consignment that had been imported by sea was held at the port on arrival as it had triggered radiation detecting equipment. The consignment was found to consist of packages containing smoke detector units. The packages did not have the appropriate labelling or transport documents. However there were no radiological consequences arising from this event.

2007004. An instrument (LKB Wallace Rack Beta Machine) used in a university department was decommissioned and dismantled for disposal. It was known that it contained a 370 kBq ^{226}Ra source and the part that was assumed to hold the source was sent to a specialist disposal company, while other parts were disposed of as scrap metal. However, the specialist disposal company reported that the source was not in the part that had been sent to them. A search revealed that the source had been located in one of the parts sent for disposal as scrap, and was later detected and recovered from the premises of a specialist steel firm. The source was later disposed of by a specialist disposal company. The scrap metal source had been transported inappropriately to the scrap yard and the steel firm. The radiation dose rate at the surface of the part containing the source was small and it is unlikely that anyone handing the part would have received a hand dose of more than a few μSv, and therefore the radiological consequences were negligible.

2007024 A consignment that had been imported by sea was held at the port on arrival as it had triggered radiation detecting equipment. The consignment was found to consist of packages, containing smoke detectors. The packages did not have the appropriate transport documents for radioactive material. However there were no radiological consequences arising from this event.

2007005. At a large manufacturing site, eight detectors, each containing 12.5 kBq of ^{235}U, were being transported on the back of a vehicle from one part of the site to another. Each detector was packed in a wooden crate, but these were not adequately secured. During the movement one of the crates fell off the back of the vehicle on a part of the route that was on a public road. The crates were not properly labelled but had markings indicating who to contact on the site. Also there were no transport documents. The crate that fell off was retrieved and it was found that there had been no loss or dispersal of its contents. The dose rates at the surface of the crates were at background levels and therefore there were no radiological consequences. As a result of this event the consignor revised their procedures.

March

No events

April

2007025. A consignment en-route from one overseas country to another triggered radiation detectors when it arrived during trans-shipment at an airport in the UK. The consignment was found to consist of 27 boxes of gas mantles. These were labelled as excepted packages UN2911. Dose rate measurements at the surface of the packages were found to be about 6 µSv h^{-1}, with a maximum of 15-25 µSv h^{-1}, at the surface of the gas mantles. The packages did not fulfil the criteria for excepted packages, did not have the appropriate labelling and should have been Category II-Yellow. Radiological consequences arising from this event were likely to be small i.e. in the region of 2-3 µSv to the workers handling the packages.

May

2007006. A canister approximately 15 cm long, and bearing a radioactive warning sign was discovered by a member of the public in a driveway (off a main road). The fire brigade was called, who cordoned-off the immediate area, and a NAIR alert was instigated. The source was found to be a ^{137}Cs source contained in a lead pot of activity 250 µCi (9.25 MBq). The dose rate outside the lead pot was minimal and the dose rate with the lead pot removed was not recorded as it was not opened.

The source was transported in the NAIR respondent's car in an unlabelled package within the lead pot, which took 5 minutes to arrive at the hospital. The EA were notified and the source was consigned to the hospital store in the basement for a year before being transported from the hospital by a firm which deals with hospital waste and disposed of. The source was transported from the hospital as a Type A package. There were no radiological consequences arising from this event as the pot was not opened.

2007007. A discharged Type B(M) irradiated nuclear fuel flask was delivered by rail to an AGR power station. During the acceptance procedure an area within the lid recess was found to be contaminated to 59 DWL. Two other areas were contaminated to 42.9 DWL and 16.3 DWL. The radiological consequences for this event were trivial. However there had been an increase in the number of cases of excess contamination levels on flasks delivered to a number of sites, although until this event none were above 10 DWL. This event, and the apparent deterioration of standards of decontamination, prompted a review of these procedures at the large nuclear site from where these flasks had been despatched.

2007008. A consignment consisting of two empty Type B(U) packages was shipped by air from the UK as low specific activity material (UN2912) since they contained depleted uranium shielding. During handling at an overseas airport a defect was found in one of the packages. The defect was the incorrect bolting of the lid in the outermost packaging: two bolts were missing and the remaining two bolts were not correctly fastened. The lid became separated during loading. Contamination was suspected and the fire service measured elevated dose rates which would not have been allowed by the class of shipment being undertaken. However these dose rates were incorrectly measured and further measurements from a radiation protection specialist confirmed that there was no contamination. The maximum surface dose rate was about 8 μSv h^{-1}. The package was re-secured and released for onward shipment. The package had been shipped from a UK company but it is unclear whether the package was incorrectly assembled by the consignor or it was tampered with during transport (which would have security implications). There were no radiological consequences arising from this event.

June

2007009. A detector unit containing a 370 MBq ^{63}Ni source was despatched by courier to the manufacturer for servicing. However, the package containing the detector unit did not arrive. After 3 months the manufacturer contacted the consignors to remind them of their request for a service, and it was at this time it was realised that the package was lost. A search was carried out of all areas where the package might be and eventually it was found in a depot used by the courier service. The courier admitted that it had been stored overnight in the wrong area of the depot and had been missed being collected the following morning. The package was not damaged and the dose rates from such sources are very low. Therefore, there were no radiological consequences.

2007010. During arrival checks at an overseas airport a Type A package containing special form material was found to have a bolt and screw missing. The seals and two remaining bolts were still intact. The shipment was re-bolted and cleared for road transport. The package was shipped from the same UK company as the package in event 2007008. There were no radiological consequences arising from this event.

July

2007011. A package en-route from one overseas country to another triggered radiation detectors when it arrived during trans-shipment at an airport in the UK. The package was found to contain a radiation monitor and two ^{137}Cs check sources of 37 kBq each. The maximum surface dose rate was 3 μSv h^{-1} and a dose rate outside the container of 0.8 μSv h^{-1}. The consignor should have known the package contained radioactive material and shipped it accordingly with the correct label and packaging. There were no radiological consequences arising from this event.

August

No events

September

2007012. During a freight check at an airport, 25 fibreboard boxes were discovered which were marked as Radioactive Material, Excepted Package –Instruments, UN2911. However, the boxes were not accompanied by the appropriate dangerous goods transport documentation nor were the boxes marked with an excepted quantity label. The freight forwarder was contacted who supplied the appropriate document the following day, and the shipper attached the excepted quantity labels. There were no radiological consequences.

2007013. A small industrial radiography unit containing a 0.317 TBq ^{75}Se source was being used on an offshore platform when it developed a mechanical fault. With this type of remotely operated radiography unit the source is projected from the container to carry out an exposure, and then drawn back in using a cable. However on this occasion, the operators were unable to retract the source back into the container after the exposure. The container is normally transported within a Type A box, bearing Category II-Yellow labels, and with a Transport Index of 0.1. In order to return the unit with the exposed source to the suppliers for repair the operators constructed a box and included lead shielding to reduce the external dose rate. The external dose rate was low: at about 50 cm from the box it was approximately 1 to 2 μSv h^{-1}. However, when the box was examined by an HSE inspector it was found to be of substandard construction, with a large gap in part of the surface. Despite this the radiological consequences to the operators were very low. Their personal dose meters were analysed and had recorded zero dose for the period of the incident. In addition to the deficiencies of the package construction that were noted, the HSE were critical of the thoroughness of the monitoring carried out by the consignor.

October

No events

November

2007015. An empty Type A package was sent to a package supplier for maintenance. It was then returned to the user, but was wrongly labelled and incorrectly described in the documentation. It should have been described as “Radioactive Material, Excepted Package – Empty Packaging” (UN 2908).

2007014. A package triggered radiation detectors when it arrived at an airport in the UK. The package was found to contain two rock samples of pitchblende containing about 10 kBq of natural Uranium. The maximum dose rate at the surface of the package was about 8 μSv h^{-1}. The consignor should have known the package contained radioactive material and shipped it accordingly with the correct label and packaging. The package was re-labelled and forwarded to the consignee. There were no radiological consequences arising from this event.

2007016. A package, consisting of a 20 cm cube cardboard box, arrived by air at a UK airport from overseas, and was due to be trans-shipped overseas to a consignee in another country. However, on arrival at the airport it was noticed that the package had been damaged and it was therefore taken to the shipping company’s depot for investigation and repair. The package also did not contain an invoice, which was required to send the package back to the country of origin. This prompted the investigators to open the package, on advice from the country of origin that it was safe. Inside the package there was a canister containing a brown powder. The shipping company’s operators became suspicious of the nature of the powder, especially since there was no documentation describing the contents. In investigating the powder three of these operators later remembered examining the material with their fingers. The shipping company contacted the shipping agents in the country of origin and arranged for the return of the package.

Some two weeks later the package again arrived at the same airport and was dealt with by the same shipping company. The operators immediately recognised it as the same package they had seen previously, but on this occasion it had documentation indicating that it contained analytical samples of uranium. The package was also described in the accompanying documents, as “Radioactive Material, Excepted Package” with an incorrect numbering of UN 2910. The operators became alarmed that they had come into contact with the material on the previous occasion and called the police, who instigated a NAIR alert.

It was found that the package had a surface dose rate of about 2 μSv h^{-1}. It contained about 2 kg of uranium ore. It was repackaged by a company experienced in transporting radioactive material and sent by courier back to the consignor in the country of origin. The operator who remembered touching the powder and licking his finger was offered a urine test which showed that the dose from this ingestion was less than 2 μSv.

2007017 A Type A package containing 37 MBq of ^{51}Cr was dispatched from a consignor by courier. It was delivered to the consignee but it was discovered that the consignor had not passed the appropriate documents to the carrier. The package was later delivered with the correct paper work.

December

2007018. A van carrying radioactive material was stopped by police and examined, when it was suspected that it was incorrectly placarded. It was found that there was only one orange plate, which was too small, on the rear and none at the front of the vehicle. Also, there were placards on the sides of the vehicle but not on the rear surface. It was carrying a nuclear density gauge within a Type A package. There were no radiological consequences arising from this event.

2007019. A courier company delivered a Type A package containing 13.8 MBq of ^{223}Ra within a liquid solution, to a hospital. However the driver left the package in a public area where access to it was not restricted, i.e. it was temporarily mislaid. Although there were no radiological consequences as the package was undamaged, this incident could have compromised the safe delivery of the package.

5 DISCUSSION OF 2007 EVENTS

5.1 General

There were 25 events reported during 2007, not including any events that are still subject to legal proceedings at the time of publication.

The number of events in 2007 was less than those reported for 2006 (27 events) but was more than reported in 2005 (16 events) and 2004 (20 events). In 2006 and 2007 there was an increase in the number of events (9 in 2007) involving the discovery of radioactive material in supposedly non-radioactive shipments.

Between 1999 and 2005 the annual number of events ranged from 11 to 40, and 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 2007 was therefore higher than this long-term average.

The numbers of events in each of the descriptive classifications that occurred in 2007 are given in Table 2.

Four events were given more than one event classification. Considering the primary event classifications only, the most numerous type of event involved nine instances of undeclared radioactive material. Those materials were discovered by the triggering of installed radiation detectors at seaports and airports. A further similar event involved a routine shipment of smoke detector units. However this was primarily due to a documentation error.

Tables 3 and 4 show the distribution of the events by primary classification in the three broad categories: 15 administrative events, 9 general shipment events and 1 INF flask shipment events. This distribution expressed as a percentage of the total is 60%, 36% and 4%, compared to the distribution of 16%, 61% and 23% for all the events in the period 1958 to 2004 (Hughes et al, 2006). Thus there were an unusually high number of administrative events, which includes the undeclared radioactive material category, as well as documentation and labelling errors. There was one event involving excess contamination on an INF flask, and also a source that was inadvertently disposed of with some scrap metal.

Table 3 also shows an analysis of the events by material. During 2007, the largest group of events (10 events) involved the transport of medical and industrial radioisotopes. The percentage of events (40%) involving medical and industrial isotopes was lower than the annual average (47%) for events in the period 1958 to 2004 (Hughes et al, 2006). However, the number of events in 2007 in this category (10) was similar to the average annual number (approximately 8) for the period 1958 to 2004 (Hughes et al, 2006). There was one event (4%) involving discovery of uranium oxide at an airport and one event (4%) involving residues. Three events (12%) involved industrial radiography sources, seven (28%) involved materials intended for or being used by members of the public (consumer products). This was much greater than the annual average (1%) for events in the period 1958 to 2004 (Hughes et al, 2006) and is thought to be a result of more stringent monitoring at ports and airports. Of the three (12%) remaining events, one involved depleted uranium shielding, one a geological specimen and the other an empty package.

Table 4 gives an analysis of the events by mode of transport, and shows that only one event involving shipments by rail (4%), nine were by air (36%), five were by sea (20%), and ten were by road (40%). The proportion of road events (40%) was slightly higher than the long-term annual average (31%). For rail the proportion of events in 2006 (4%) is much lower than the long-term annual average (24%). This partly reflects the absence of instances of excess contamination on INF flasks in 2007. The number of road and rail events in 2007 (11) is similar to the average annual number (approximately 10) during the period 1958 to 2004 (Hughes et al, 2006). There were no events involving fork-lift trucks, compared to the long-term annual average of 22%. There were a large number of these events during the 1970s, but they now occur infrequently due to better handling techniques.

5.2 Effects on packages

Table 5 shows an analysis of the events in terms of the package condition. For one event there was no package. In 13 of the 25 events there was no damage or threat of damage to the packages involved. For three events there was no report of damage to the package or increase in dose rate, but there was a minor potential to cause damage. For two events there was no report of damage to the package or increase in dose rate, but there was a high potential to cause damage. There were three events which had a package of defective or poor condition. One event had a package with minor damage without increase in dose rate. One event involved a source with loss of containment and one event involved the discovery of contamination outside of the package.

5.3 Radiological consequences

Table 6 shows the likely radiological consequences for the events in 2007, analysed by material category. Of the 25 events, 20 were categorised as "None", indicating no radiological consequences for those events, and four were categorised as "Extremely low, not assessed". Within this latter category are two events which involved handling of material involving thorium, and two events involving contamination outside of the package. The doses would be less than a few microsieverts to the workers involved.

One event was categorised as “Assessed, lower category”. This event (2007016) involved the handling and inadvertent ingestion of uranium oxide, when it was unknown that the material was radioactive. It was estimated that the maximum dose to a worker was approximately 2 μSv.

There were no events in the “Assessed, upper category” involving effective doses above 1 mSv or extremity doses over 50 mSv.

5.4 Other occurrences

During 2007 some occurrences were notified to DfT that have not been included in the database as transport events, since they do not meet the criteria for inclusion. Although they were not transport events for the purposes of this report, they are briefly noted here for completion (See Appendix A for detailed description).

An operation called Programme Cyclamen was set up in April 2003 to provide the capability to routinely screen all forms of traffic at UK points of entry for the illicit movement of radioactive materials.

In 2007 there were a number of consignments which triggered the Cyclamen radiation detector alarms at UK airports and ports. Of these there were twelve where advice from DfT was sought. Nine of these were due to radioactively contaminated steel. These involved four consignments of leather handbags containing steel buckles contaminated with ^{60}Co and five consignments of various items which had steel contaminated with ^{192}Ir or ^{60}Co. All consignments of handbags were sent back to the consignor. All other contaminated items were sent back to the consignor, except for a static frequency generator which was forwarded to the consignee. The maximum dose rate outside of the packages was about 4.5 μSv h^{-1} from a consignment of handbags. This would give a dose to the workers handling the packages of about 1 μSv.

Three types of luminised products containing ^{226}Ra packed in boxes which arrived from overseas at UK airports and ports also triggered installed radiation detector alarms. In all cases these items did not have correct labelling which indicated that they contained radioactive material. The maximum dose rates outside of the packages was about 1μSv h^{-1}, which would give a dose to the workers handling the packages of less than 1 μSv.

6 CONCLUSIONS

During 2007 there were 25 accidents and incidents, involving the transport of radioactive materials from, to, or within the UK, and this report includes descriptions of each event. The number of events in 2007 was less than those reported for 2006 (27 events) and 2002 (29 events). This was more than reported in 2005 (16 events), 2004 (20 events) and 2003 (11 events). This number probably represents a general increase in the annual number of events. In 2006 and 2007 this was due to the increase in the number of events (9 in 2007) involving the discovery of radioactive material in supposedly non-radioactive shipments, including one instance of material sent illegally using the postal services. All of these were found by installed radiation detection equipment at ports. In recent years radiation detectors have been installed in many ports and airports to detect any radioactive materials that are being shipped illegally or that have been inadvertently included in scrap metal. In the latter case this could lead to the incorporation of radioactive materials in reused metal and could give rise to doses to members of the public. For this reason such detectors are also installed in major scrap dealers' premises.

None of the events in 2007 resulted in any significant radiation doses to workers or members of the public. The largest measured doses (approximately 2 μSv) were received by a worker investigating an unknown material and subsequently found to be a sample of uranium oxide. There was one event involving excess contamination on irradiated nuclear fuel flasks in 2007. Also, there was one event where a source was inadvertently disposed of with some scrap metal and which was later detected at a steel plant.

The details of the 25 events in 2007 have been included in the database (RAMTED), bringing the total number of reported events since 1958 to 875.

7 REFERENCES

GB Parliament (1994). The Air Navigation (Dangerous Goods) Regulations, 1994, SI 1994 No 3187. London, TSO.

GB Parliament (1997). The Merchant Shipping (Dangerous Goods and Maritime Pollutants) Regulations 1997, SI 1997 No 2367. London, TSO.

GB Parliament (2002). The Radioactive Material (Road Transport) (Great Britain) Regulations, SI 2002 No 1093. London, TSO.

GB Parliament (2003). The Radioactive Material (Road Transport) (Amendment) Regulations 2003, SI 2003 No 1867. London, TSO.

GB Parliament (2004). The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2004, SI 2004 No 568. London, TSO.

GB Parliament (2005). The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment (Amendment) Regulations 2005, SI 2005 No 1732. London, TSO.

GB Parliament (2007a). The Air Navigation (Dangerous Goods) Amendment Regulations 2007, SI 2007 No28. London, TSO.

GB Parliament (2007b). The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2007, SI 2007 No 1573. London, TSO.

Gelder R, Mairs J H and Shaw K B (1986). Radiological impact of transport accidents and incidents in the United Kingdom over a twenty-year period. IN Proceedings of the International Symposium on the Packaging and Transportation of Radioactive Materials, PATRAM '86, Davos, June 1986.

Hesketh N, Watson S J, Jones A L and Hughes J S (2006). Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2005 Review, Chilton, HPA-RPD-021.

Hughes J S, and Shaw K B (1990). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1989 Review. Chilton, NRPB-M230.

Hughes J S, and Shaw K B (1991). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1990 Review. Chilton, NRPB-M310.

Hughes J S, and Shaw K B (1992). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1991 Review. Chilton, NRPB-M364.

Hughes J S, and Shaw K B (1993). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1992 Review. Chilton, NRPB-M437.

Hughes J S, and Shaw K B (1994). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1993 Review. Chilton, NRPB-M475.

Hughes J S, and Shaw K B (1995). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1994 Review. Chilton, NRPB-M549.

Hughes J S, and Shaw K B (1996a). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1995 Review. Chilton, NRPB-M662.

Hughes J S, and Shaw K B (1996b). Accidents and incidents involving the transport of radioactive materials in the UK, from 1958 to 1994, and their radiological consequences. Chilton, NRPB-R282.

Hughes J S, and Shaw K B (1997). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1996 Review. Chilton, NRPB-M862.

Hughes J S, and Shaw K B (1998). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1997 Review. Chilton, NRPB-M964.

Hughes J S, and Shaw K B (1999). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1998 Review. Chilton, NRPB-M1082.

Hughes J S, Warner Jones S M and Shaw K B (2001a). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 1999 Review. Chilton, NRPB-M1256.

Hughes J S, Warner Jones S M and Shaw K B (2001b). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 2000 Review. Chilton, NRPB-M1320.

Hughes J S, Roberts D, and Watson S J (2006). Review of events involving the transport of radioactive materials in the UK, from 1958 to 2004, and their radiological consequences. Chilton, HPA-RPD-014.

Hughes J S and Harvey M P (2007). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK - 2006 Review. Chilton, HPA-RPD-034.

IAEA & NEA (2001). The International Nuclear Event Scale (INES). User's Manual, 2001 Edition. IAEA & OECD/ NEA. IAEA-INES-2001.

ICAO (2006). International Civil Aviation Organisation. Technical Instructions for the Safe Transport of Dangerous Goods by Air (Class 7) (2007-2008 Edition).

IMO (2006). International Maritime Organisation. Dangerous Goods Code (IMDG Code) (Class 7).

MCA (2006). Maritime and Coastguard Agency. The Carriage of Dangerous Goods and Marine Pollutants in Packaged Form - Amendment 33-06 to the International Maritime Dangerous Goods Code. Merchant Shipping Notice MSN 1806 (M) (2006).

OTIF (2007). Intergovernmental Organisation for International Carriage by Rail. Convention concerning the International Carriage of Dangerous Goods by Rail (COTIF) Appendix B. Uniform rules concerning the contract for the International Carriage of Goods by Rail (CIM) Annex 1, Regulations concerning the International Carriage of Dangerous Goods by Rail (RID) (Class 7) (2007). JERID.

Roberts D, Watson S. J, Jones A. L and Hughes J S (2005). Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2004 Review, Chilton, HPA-RPD-007.

Shaw K B, Hughes J S, Gooding T D, and McDonough L (1989). Review of the radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK from 1964 to 1988. Chilton, NRPB-M206.

UNECE (2007). United Nations Economic Commission for Europe. European Agreement concerning the international carriage of dangerous Goods by Road (ADR) (Class 7) (2007-2008 Edition).

Warner Jones S M, Hughes J S, and Shaw K B (2002a). Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2001 Review, Chilton, NRPB-W29.

Warner Jones S M, Hughes J S, and Shaw K B (2002b). Experience in the Analysis of Accidents and Incidents involving the Transport of Radioactive Materials, RAMTRANS, Vol. 13, No. 3-4, 2002 pp 371-376.

Warner Jones S M and Jones A L (2004). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK – 2002 Review. NRPB-W53.

Watson S (2004). Review of the content and structure of the RAMTED Database. NRPB-EA/1/2004.

Watson S J and Jones A L (2004). Radiological consequences resulting from accidents and incidents involving the transport of radioactive materials in the UK – 2003 Review. NRPB-W64.

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 2007 review*

Event number (Section 4)	Material category (Section B7)	Transport mode (Section B6)	Package type (Section B22)	Event classification code(s) (Table C1)	Effect on package code (Table C2)	Radiological consequence code (Table C3)
2007001	M07	V06	NR	AG241	D05	E
2007002	M07	V02	EP	SP221	D04	N
2007003	M08	V05	A	AC111	D03	N
2007004	M07	V07	SC	SP221	D01	E
				SP251		
2007005	M07	V04	E	SP331	D07	N
				AG221		
2007006	M07	V06	NR	SP221	D05	N
				SP111		
2007007	M05	V01	BM	FP311	D012	E
2007008	M011	V02	BU	SP111	D06	N
2007009	M07	V07	E	SP221	D04	N
2007010	M08	V02	A	SP111	D06	N
2007011	M07	V02	NR	AG241	D03	N
2007012	M010	V02	E	AG221	D03	N
2007013	M08	V03	NR	SP111	D06	N
2007014	M011	V02	NR	AG241	D03	N
2007015	M011	V07	A	AP111	D03	N
				AG231		
2007016	M01	V02	E	AG241	D010	L
2007017	M07	V07	A	AG211	D03	N
2007018	M07	V05	A	AC111	DO3	N
2007019	M07	V07	A	SP221	D04	N
2007020	M10	V03	NR	AG241	D03	N
2007021	M10	V03	NR	AG241	D03	N
2007022	M10	V02	NR	AG241	D03	N
2007023	M10	V03	NR	AG241	D03	N
2007024	M10	V03	NR	AG241	D03	N
2007025	M10	V02	NR	AP111	D03	E

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

TABLE 2 Numbers of 2007 events in each classification

Event classification code (See Table B1)	1st classification	2nd classification	3rd classification
AC111	2	0	0
AG211	1	0	0
AG221	1	1	0
AG231	0	1	0
AG241	9	0	0
AP111	2	0	0
FP311	1	0	0
SP111	3	1	0
SP221	5	0	0
SP331	1	0	0
SP251	0	1	0
Total	25	4	0

TABLE 3 Classification* of 2007 events by material category

Material		Administrative			General (non-INF) shipments		INF flask shipments		Totals	%†	%, 1958-2006
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	1	0	0	0	0	0	0	1	4	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	0	0	0	0	13
M05	Residues	0	0	0	0	0	0	1	1	4	14
M06	Radioactive wastes	0	0	0	0	0	0	0	0	0	8
M07	Medical & industrial radioisotopes	3	1	0	0	6	0	0	10	40	47
M08	Radiography sources	0	1	0	0	2	0	0	3	12	10
M09	No radioactive material	0	0	0	0	0	0	0	0	0	<1
M10	Consumer products	6	0	1	0	0	0	0	7	28	1
M11	Other	1	0	1	0	1	0	0	3	12	<1
Totals		11	2	2	0	9	0	1	25	100	100

Notes

* First classifications only. See Table C1 for descriptions of event classifications.

† With a sample size of 25 events, interpretation of these rounded percentages must be made with care.

‡ This material category is a new addition to the database, so no comparison can be made with previous data.

TABLE 4 Classification* of 2007 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	0	0	0	0	0	0	1	1	4	24
V02	Air	5	0	1	0	3	0	0	9	36	13
V03	Sea	4	0	0	0	1	0	0	5	20	7
	Road:									0	
V04	> 1.5 t (lorry)	0	0	0	0	1	0	0	1	4	15
V05	< 1.5 t (van)	0	2	0	0	0	0	0	2	8	13
V06	Car	1	0	0	0	1	0	0	2	8	3
V07	Unknown	1	0	1	0	3	0	0	5	20	<1
V08	Fork-lift truck	0	0	0	0	0	0	0	0	0	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		11	2	2	0	9	0	1	25	100	100

Notes

* First classifications only. See Table C1 for descriptions of event classifications.

† With a sample size of 25 events, interpretation of these rounded percentages must be made with care.

‡ This material category is a new addition 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	BU	BM	NR	SC	Others	Total
D01	No package	0	0	0	0	0	1	0	1
D03	No damage or threat of damage to package	1	4	0	0	8	0	0	13
D04	No report of damage or increase in dose rate, but potential to cause damage to the package (lower category)	1	1	0	0	0	0	1	3
D05	No report of damage or increase in dose rate, but potential to cause damage to the package (upper category).	0	0	0	0	2	0	0	2
D06	Defective or poor condition, without increase in dose rate or loss of containment	0	1	1	0	1	0	0	3
D07	Minor damage without increase in dose rate or loss of containment	1	0	0	0	0	0	0	1
D10	Damaged with loss of containment	1	0	0	0	0	0	0	1
D12	Contamination outside package	0	0	0	1	0	0	0	1
Totals		5	6	1	1	10	1	1	25

Notes

* See Section B22.

[†] See Table C2 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
M01	Uranium ore concentrate	0	0	1	0	1
M04	Irradiated fuel	0	0	0	0	0
M05	Residues (inc. discharged INF flasks)	0	1	0	0	1
M07	Med & Industrial Radioisotopes	8	2	0	0	10
M08	Radiography sources	3	0	0	0	3
M10	Consumer products	6	1	0	0	7
M11	Other	3	0	0	0	3
Totals		20	4	1	0	25

Notes

* See Table C3 for description of categories

APPENDIX A Summary of Cyclamen events not included as transport events

In all these cases the consignor was not expected to recognise these as radioactive material and they were therefore not classified as DfT transport events.

Table A1- Cyclamen events in 2007 not listed as transport events

Cyclamen event category	DfT Incident number	Additional information
Luminised Products The manufacture of these items used a luminising process involving the use of ^{226}Ra to allow for items to be seen in the dark. In all cases these items did not have correct labelling which indicated that they contained radioactive material.	07-05	A consignment of 15 steel boxes of binoculars arrived at a port These binoculars had level gauges which contained ^{226}Ra. Dose rates at the surface was 50 μSv h^{-1} and outside the box, 1 μSv h^{-1}.
The maximum dose rates outside of the packages was about 1 μSv h^{-1}, which would give a dose to the workers handling the packages of less than 1 μSv.	07-18	An aircraft instrument with a dial luminised with ^{226}Ra paint arrived at a port. The dose rate at surface was 100 μSv h^{-1} and <1 μSv h^{-1} outside package.
Two items were detected at UK ports and one at a UK airport. The items required appropriate packaging before forwarding to the consignee.	07-31	A tachometer luminised with ^{226}Ra paint on the dial arrived at an airport. The dose rate at surface was 50 μSv h^{-1} and 1 μSv h^{-1} at 0.5m.

Table A1 Continued - Cyclamen events in 2007 not listed as transport events

Cyclamen event category	DfT Incident number	Additional information
Contaminated Metal	07-03	Stainless steel bowls containing ^{192}Ir arrived at a port.
A number of consignments were detected at UK airports and ports containing radioactively contaminated steel. These involved four consignments of leather handbags containing steel buckles contaminated with ^{60}Co and five consignments of various items which had steel contaminated with ^{192}Ir or ^{60}Co. All consignments of handbags were sent back to the consignor. All other contaminated items were sent back to the consignor, except the static frequency generator which was forwarded to the consignee.	07-08	Leather handbags with metal attachments containing ^{60}Co arrived at an airport. The maximum dose rate from these was 1 µSv h^{-1}.
The maximum dose rate was about 4.5 µSv h^{-1} from a consignment of handbags. This would give a dose to the workers handling the packages of about 1 µSv.	07-11	A consignment of goods in a wooden crate with nails contaminated with ^{60}Co, arrived at a port. The dose rate close to the nails was 20 µSv h^{-1}. The dose rate outside crate was 0.4 µSv h^{-1}. The activity of each nail was estimated to be 26 kBq with a total of 3.9 MBq for two crates.
	07-12	A large consignment of steel ball bearings used for grinding mills containing ^{60}Co, arrived at a port. The dose rate outside the containers was 0.6 µSv h^{-1}. The activity per ball bearing was estimated to be 1.69 kBq for an activity concentration of 4.83 Bq g^{-1}. The total activity per drum was estimated to be 450 kBq.
	07-13	A large washing machine containing a wheel assembly contaminated with ^{192}Ir arrived at a port. The maximum dose rate outside the container was 0.067 µSv h^{-1}. The total activity was estimated to be 70 kBq for an activity concentration of 4.5 Bq g^{-1}.
	07-14	Leather handbags with metal attachments containing ^{60}Co arrived at an airport. The maximum dose from these was 2 µSv h^{-1}. The total activity was estimated to be 40 MBq.
	07-19	A static frequency converter used for induction furnaces containing ^{60}Co arrived at a port. The surface dose rate was 0.35 µSv h^{-1}. The estimated activity was 160 kBq at an activity concentration of 0.8 Bq g^{-1}.
	07-20	Leather handbags with metal attachments containing ^{60}Co arrived at a port. The maximum surface dose rate was 15 µSv h^{-1}. The dose rate was 0.15 µSv h^{-1} on the surface of the vehicle transporting the items.
	07-26	Leather handbags with metal attachments containing ^{60}Co arrived at a port. The maximum dose rate was 4.5 µSv h^{-1} at 10 cm and 1 µSv h^{-1} at the surface of the transport container. The total activity was estimated to be 72 MBq.

APPENDIX B 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.

B1 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.

B2 DATE

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

B3 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.

B4 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.

B5 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.

B6 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

B7 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.

B8 CONSIGNOR

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

B9 CONSIGNEE

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

B10 CARRIER

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

B11 DESCRIPTION OF EVENT

A brief description of the event is given in words.

B12 ACTIVITY RELEASE

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

B13 WORKER DOSES

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

B14 PUBLIC DOSES

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

B15 INES RATINGS

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

B16 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.

B17 EVENT IMPLICATIONS

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

B18 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.

B19 EMERGENCY ACTION

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

B20 ADDITIONAL INFORMATION

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

B21 DESCRIPTION OF PACKAGES

A description of each package is given, if known.

B22 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

B23 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.

B24 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.)

B25 ACTIVITY

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

B26 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 C1, C2 and C3. Each event is characterised by the allocation of the alphanumeric codes shown in Table C1, and the radiological consequences of each event are characterised by the allocation of the codes shown in Table C3. Each package is characterised for damage or deficiency by the codes shown in Table C2.

APPENDIX C Event classification system

The database uses coding systems for event classifications, package deficiencies and potential radiological exposures. Tables C1 to C3 give details of these classification schemes, showing the coding systems used.

TABLE C1 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 C1 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 C2 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 C3 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.