Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK - 2006 Review

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ABSTRACT

During 2006 there were 27 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 2006 was greater than those reported for 2005 (16 events), 2004 (20 events) and 2003 (11 events). There were 29 events reported in 2002. This increase compared to the previous three years is likely to represent mainly a statistical variation in the annual number of events, rather than indicating an overall upward trend. In 2006 there were an unusual number of events (6) involving the discovery of radioactive material in supposedly non-radioactive shipments, including two instances of materials sent illegally using the postal services. However, none of the events in 2006 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 850 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 occur during the transport of radioactive materials. Annual reports have been produced since 1989, and this report for the year 2006 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 2006 there were 27 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 2006 was greater than those reported for 2005 (16 events), 2004 (20 events) and 2003 (11 events). There were 29 events reported in 2002. This increase compared to the previous three years is likely to represent mainly a statistical variation in the annual number of events, rather than indicating an overall upward trend.

In 2006 there were an unusual number of events (6) involving the discovery of radioactive material in supposedly non-radioactive shipments, including two instances of materials sent illegally using the postal services. Some of these were found by installed radiation detection equipment at ports, and some by the consignee on delivery. The installation of radiation detection monitors at ports is a relatively recent development.

None of the events in 2006 resulted in any significant radiation doses to workers or members of the public. The largest doses (approximately 150 μSv) were received by workers at a consignee's premises carrying out a clean up of some spilled uranium oxide from a drum damaged before being shipped. There were no events involving excess contamination on irradiated nuclear fuel flasks in 2006. Also, there were no events where packages were definitely known to have been lost in transit. In addition to the 27 events, a further event is described which occurred on a nuclear site, and which would therefore not normally be included in these reviews. It is included for general interest as it was reported in the local media. It did not result in any radiological consequences. Some other occurrences of interest that did not meet the criteria for inclusion in the database are also briefly described.

The events reported here have been entered into the Radioactive Material Transport Event Database (RAMTED), which now contains information on 850 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 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). 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). 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 2006 and gives analyses of the 2006 events based on the revised classification system and the main event categories. A further event is described in Section 4 which occurred on a nuclear site, and which would therefore not normally be included in these reviews. It is included for general interest as it was reported in the local media. It did not result in any radiological consequences. Some other occurrences of interest that did not meet the criteria for inclusion in the database are also briefly described.

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 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 2006 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. It may be noted that during 2007 new regulations (GB Parliament, 2007) were introduced on the transport of all dangerous goods by road and rail.

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.

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 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.

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 823 events, up to and including the events in 2005. The earliest reported events were from 1958. During the collection of information for this current review, the details were obtained for 27 events in 2006, which brings the total number in the database to 850. 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 27 events reported in 2006. 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 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 2006 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.

January

2006001. Several consignments of loaded uranium hexafluoride (UF_6) cylinders were sent from one nuclear site to another nuclear site under a special arrangement granted by the competent authority. The UF_6 material contained depleted uranium. It was discovered that the administrative requirements were incorrect. The cylinders were wrongly described with the proper shipping name “Radioactive material, uranium hexafluoride, non fissile or fissile-excepted” under United Nations number UN2978, instead of “Radioactive material, transported under special arrangement, non fissile or fissile-excepted” under United Nations number UN2919. It was also discovered that the cylinders had been marked with labels indicating category II-Yellow dose rate levels, instead of category III-Yellow. However, there were no radiological or significant safety implications.

2006002. A wooden box containing a drum arrived at the site of a supplier of sealed sources after having being shipped by air freight from Africa. The air waybill indicated that the drum was an empty package shipped as an excepted package. There was a Type B source container inside the drum and when this was opened four ^{75}Se (selenium) sources were found inside. Each source was in special form and had an activity of approximately 40 GBq. The package had therefore been shipped without the appropriate labelling or documentation. The dose rate on the surface of the package was 0.5 μSv h^{-1}, and should have been declared as UN2916 radioactive material, Type B package. Source containers at the supplier’s premises are routinely opened inside a shielded enclosure using remotely operated tools, and therefore no excess radiation exposure occurred as a result of this incident.

February

2006003. A freight container carrying drums of natural uranium oxide (UO_3) was shipped by sea to a port in the UK, and then by road to a nuclear site. The material was classified as low specific activity material (LSA-I, UN2912). During the removal of the drums, the operator noticed some UO_3 on the floor of the container and a puncture in one of the drums, where it had mechanical damage. The estimated spillage was about 100 g. Similar damage to other drums was noted (but without further puncturing) indicating the fault during the loading operations was associated with drum handling equipment. It was ascertained that there had been no leakage from the freight container. The spillage was recovered and the small amount gave rise to a negligible extra dose to the operators involved.

March

2006004. A company's Radiation Protection Supervisor reported the loss of two sources to DfT. The Health and Safety Executive and the Environment Agency were also informed. The sources were 740 MBq of ^{55}Fe and 111 MBq of ^{241}Am, which were installed in an X ray fluorescence analyser. Such analysers are used in laboratories for materials analysis and have a negligible external dose rate. The analyser was contained within a box of approximate dimensions 1 m x 0.8 m x 0.3 m, and had been sent as an excepted package to the company by an overseas consignor, for disposal. The shipment had been arranged by a freight forwarding company in the UK, and arrived in the UK in August 2005. After the consignee reported the loss, a thorough search of all likely premises was undertaken and the box was eventually found at the freight forwarder's site. The cause of the delay in delivering the package was apparently because it had been consigned only to the freight forwarder, and the documentation did not include a forwarding address to the consignee. The company stated that it intended to improve its administrative arrangements, by sending return labels to its customers, and to improve the training of its staff dealing with overseas customers. There were no radiological consequences arising from the delayed delivery of the package.

2006005. A lorry carrying a Type B package containing four ^{60}Co sources was involved in a road traffic accident on a motorway when a van, travelling in the same direction, hit the rear of the lorry. The driver parked the lorry on the hard shoulder and called the emergency services. The company transporting the package had removed them from an irradiation facility and were transferring them to another similar facility. The total activity of the sources was 936 TBq. The company's engineers and Radiation Protection Supervisor were travelling in a vehicle a few minutes behind the lorry. A survey was carried out of the package and there had been no change in the measurements. The package was undamaged. The rear lights of the lorry had been damaged and it was driven to a service station under police escort, where they were repaired. Later in the journey the lorry was involved in another incident when part of the tread of one of the rear tyres became detached, possibly after having been damaged in the accident. Again the dose rates around the package were surveyed and no change was found, the highest dose rate was 2.5 μSv h^{-1}. After changing the wheel the consignment continued without further incident. There were no radiological consequences arising from these events.

2006006. An estate car carrying a 'Troxler' nuclear density gauge was involved in a road traffic accident. These gauges are transported as Type A packages and are used to measure the density and moisture of soil, concrete or asphalt. The driver had just left his company's premises and was travelling to a site, when it was struck from the rear by another vehicle while waiting at some traffic lights. The driver checked the package for damage and made measurements using a radiation meter. He also called the company's Radiation Protection Advisor (RPA) before returning to his base on an industrial estate. The RPA also examined the package and confirmed it had not been damaged. The fire brigade had also been called to the premises and set up a large cordon around the area while the checks were taking place. There were no radiological consequences arising from the accident.

2006007. A freight container that had been imported by sea was held at the port on arrival as it had triggered radiation detecting equipment. The container was carrying many items posted overseas and was due to be collected by Royal Mail. The sides of the freight container were surveyed and the maximum dose rate, over a small area, was found to be 1.25 μSv h^{-1}. After examining the items in the container it was ascertained that there were three packages containing radioactive material. One package contained two aircraft instruments with radium luminised dials, with an estimated activity of 4 MBq of ^{226}Ra. Another contained a luminised sextant with an estimated activity of 0.6 MBq of ^{226}Ra. The third package contained a lens with special optical glass containing approximately 0.2 MBq of ^{232}Th. The surface dose rates of the three packaged items were, respectively, 20 μSv h^{-1}, 5 μSv h^{-1}, and 7 μSv h^{-1}. All the items should have been appropriately packaged as excepted packages and accompanied by the appropriate documentation. In view of the very low dose rates around these items the radiological consequences of this illegal shipment were negligible. The Royal Mail were advised to consult a Radiation Protection Adviser to ensure onward shipment of these items was carried out under the provisions of the regulations (GB Parliament, 2002).

2006008. A transport company reported the possible loss of an excepted package that was to be delivered to a hospital. The package contained three ^{75}Se capsules each with an activity of 0.37 MBq. The driver reported that he had delivered this package along with a technetium generator (containing ^{99}Mo) to the hospital. The delivery to the hospital was early in the morning and the packages had been locked in a secure area. The hospital confirmed that the package had not been received by the nuclear medicine department. A thorough search was made of all the other delivery points the driver had visited, but the package was not found. Also, when questioned, the driver was able to give a good description of the package and therefore it is unlikely that it was lost in transit, but on the hospital premises.

April

2006009. On arrival at a UK airport 6 packages were noticed that had Class 7 labels marked “radioactive material, Type A, UN2915”, however no dangerous goods transport document accompanied the shipment as required for Type A packages. It was ascertained that the packages were empty and being returned to the supplier. They should have been labelled “Radioactive material, excepted package, empty packaging, UN2908”. The competent authority of the state of origin was informed. This was a relatively minor administrative error, but could have led to the wrong action in the event of an emergency.

2006010. An excepted package arrived at a UK airport, bearing a label marked with “Excepted limited quantities of Radioactive Material UN2910”. However, there was no dangerous goods information on the air waybill. The package was returned to the shipper for the correction of the administrative error.

May

2006011. A courier company collected some packages containing industrial radiography sources that had been imported by air and delivered them to a company that supplies these sources in the UK. The consignment consisted of four packages containing ^{192}Ir sources, each of activity 5.5 TBq, and three packages each containing a ^{192}Ir source of activity 0.55 TBq. On arrival the company's operators noted that the vehicle had transported the packages without regard to certain requirements of the regulations (GB Parliament, 2002) and European Agreement (ADR, 2005). Specifically there were no placards or orange plates fixed to the vehicle, there were no dangerous goods notes or consignor's certificate and it appeared that the driver had not received the appropriate training. These breaches of the regulations did not in this case result in any radiological consequences.

2006012. While transporting a discharged irradiated nuclear fuel flask to a nuclear power station a locomotive collided with a car on a level crossing. The train was travelling at low speed and the leading locomotive suffered only very superficial damage at the front. There was some damage to the car but there were no injuries. As the discharged flask was unaffected there was no possibility of any radiological consequences. However the Radsafe system was activated as a precaution.

June

2006013. Nine sources were sent for disposal from a hospital. Eight sources, including two ^{252}Cf neutron sources were carried in one Type A package which contained a 60 litre drum. This package required tamper proof seals to be attached before shipment. The remaining ^{241}Am source was carried in a Type B package. On arrival at the disposal facility it was found that the seals on the Type A package were absent. The company carrying out the transport operation admitted that the attachment of the seals had been overlooked on despatch. The lid of the package had been bolted and there were no radiological consequences.

2006014. A freight container carrying drums of UO_3 (containing natural uranium) was shipped by sea to a port in the UK, and then by road to a nuclear site. The material was classified as low specific activity material (LSA-I, UN2912). During the removal of the drums, the operator noticed some UO_3 on the floor of the container and a puncture in one of the drums, probably caused by mishandling by drum lifting equipment. The estimated spillage was about 10 kg. This was a repeat of the incident reported in February at the same nuclear site, involving a shipment from the same consignor. The consignor and competent authority of the country of despatch were informed of these incidents, so that an investigation could be carried out.

It was ascertained that there had been no leakage from the freight container. A temporary controlled area was established around the container and the spillage was recovered by operators working under radiological supervision, wearing protective clothing and respiratory protection. The spillage was a relatively small amount and an assessment showed that this had given rise to a negligible extra dose to the operators involved.

July

2006015. A consignment of metal tubes was delivered to the premises of a supplier of high activity ^{60}Co sources, from a consignor overseas. The package had arrived by air at a UK airport and had been opened by officers of Her Majesty's Revenue and Customs (HMRC) during a routine inspection. As sent, the tubes were not intended to include any radioactive material but during a routine check, the consignee found that one of the tubes was internally contaminated with ^{60}Co.

The material within the tube was estimated to have a total activity of 1.5 kBq, which is below the exemption level for a consignment. This activity would produce a dose rate of some 4 $\mu Sv\ h^{-1}$ at 10 cm from the tube, which would give rise to a small excess dose to those handling or opening the package.

August

2006016. A vacuum cleaner used in contaminated areas at a nuclear power station was sent to another nuclear power station inside a drum and transported as an excepted package. On arrival it was found that the maximum dose rate, found at the base of the drum, was 7.6 $\mu Sv\ h^{-1}$. This exceeded the maximum allowed (5 $\mu Sv\ h^{-1}$) for this type of package. This contravention of the regulations (GB Parliament, 2002) would have had a negligible radiological consequence.

2006017. Contaminated protective clothing from a nuclear power station is routinely sent for cleaning by a company in another European country. The clothing is sealed in bags which are then placed in a purpose built container for transport. The bags and container are monitored before despatch using manually operated instruments. The containers are despatched as excepted packages for which the maximum allowed surface dose rate is 5 $\mu Sv\ h^{-1}$. A consignment of 10 containers were sent to the cleaning company, and on arrival it was found that one of the containers had a maximum surface dose rate, at one particular spot, of 9 $\mu Sv\ h^{-1}$. The cleaning company use automatic monitoring equipment with large detectors, and therefore have a more complete coverage of the surface of the containers, than can conveniently be obtained using manual instruments. The nuclear power station operators stated that they were looking into the feasibility of installing similar automatic monitoring systems. The level of excess dose rate was relatively minor and would have had a negligible radiological consequence.

The power station was the same one from which the package referred to in event 2006016 was despatched. Following this second incident the station voluntarily applied an embargo on all shipments (apart from INF flasks) pending an enquiry.

September

No events.

October

2006019. Three excepted packages were sent by a company in the UK to a consignee in another European country. On arrival at the airport in the UK an error in the documentation was found, and the packages did not have the appropriate labels for excepted packages. For air transport the packages should have been described in the transport documents as "Radioactive material, excepted package – limited quantity of material" (ICAO, 2004). The consignor was informed and in response explained that they had labelled the packages correctly but these had been removed by an untrained operator at the freight forwarder, believing that the packages were to be carried by surface transport modes. Such labels are only required for air transport. The incident was a minor administrative error.

2006020. Two empty Type B containers in wooden crates were sent from the Far East to a company in the UK as non-radioactive items. On arrival it was found that the packages had in-built shielding made of depleted uranium and should have been shipped in accordance with the transport regulations. The consignee contacted the consignor to inform them of the error. The dose rate at the base and sides of the crates was 7 μSv h^{-1}, and at the top surface, 4 μSv h^{-1}. Despite the complete failure to apply regulatory controls the radiological consequences were negligible.

2006021. A businessman who entered the UK by passenger/ vehicle ferry was stopped when an installed radiation detector indicated radioactive material in his car. It was found that he was carrying a package of irradiated gemstones in the boot of the car. The dose rate at the surface of the boot was about 1 μSv h^{-1}, and about 18 μSv h^{-1} at the surface of the package. The topaz gemstones were being taken to an irradiation facility in the UK for further irradiation. This process is carried out to improve the colour and marketability of gemstones. The irradiation process induces short lived radionuclides in the materials by activation of stable nuclides. The radionuclides present in the material during importation were: ^{46}Sc, ^{54}Mn, ^{182}Ta and ^{233}Pa. The package was detained at the port and released when the irradiation facility operator supplied appropriate documentation and packaging for onward transport as an excepted package. The driver knew he needed such documentation and packaging but explained that he had been in a hurry to make the journey. Despite the failure to comply with the transport regulations, the dose rates were low and the radiological consequences negligible.

The port officers handling the package may have received a few microsieverts to the hands, and probably less than one microsievert as an effective dose, assuming handling times of a few minutes.

2006022. A freight container that had been imported by sea was held at the port on arrival as it had triggered radiation detecting equipment. The container was inspected by customs officers and found to be carrying 26,000 smoke detector units that were en-route to a manufacturer of smoke alarms. Each unit contained 37 kBq of ^{241}Am. The total activity was therefore less than the maximum allowed for an excepted package (1 GBq of ^{241}Am). The maximum dose rate at the surface of the freight container was less than 1 μSv h^{-1}. The documentation did not indicate that the freight container was carrying radioactive materials. The consignee subsequently supplied the correct documentation, whereupon the freight container was released. This administrative breach of the transport regulations did not result in any radiological consequences.

2006023. A package from the Middle East triggered an installed radiation detector when it arrived at an airport in the UK. The air waybill did not indicate that the package contained radioactive material. When the package was examined it was found to contain three empty Tech Ops 660 industrial radiography containers. However, these containers have in-built shielding made of depleted uranium. The highest dose rate at the surface of the package was 2.4 μSv h^{-1}, and it should have been transported as an excepted package. The package was released after the air waybill had been annotated with "UN2908 Radioactive material, excepted package – empty packaging". This administrative breach of the air transport regulations (ICAO, 2004) had negligible radiological consequences.

2006024. A train carrying a loaded irradiated nuclear fuel flask from a nuclear power station to another nuclear site was observed by railway workers to have smoke coming from one of its wheels. The train was slowed and was stopped at the next station, where it was noted that the smoke had subsided. However, the installed smoke alarms at the station sounded and it was assumed that smoke from overheated brakes on the train had triggered the alarm. Because of the potential hazard from fumes and or fire the station was evacuated. It was later established that it was fumes from the locomotive's exhaust that triggered the smoke alarm. The position of the main train locomotive while stopped at the station was close to a smoke detector. The train was allowed to continue after engineers had attended to the brakes. During the incident the RADSAFE scheme was operated and health physicists from a nuclear site attended and examined the flask, which was found not to be affected and therefore there were no radiological consequences.

2006025. A container from an oil platform was brought ashore at a quayside and while being moved off the site an installed radiation detector was triggered. There was not supposed to be any radioactive material in the load. When the load was examined a liquid level gauge was found which contained a low activity (18 MBq) ^{60}Co source. The company that had despatched the load were not aware of the regulatory requirements for the transport of radioactive material. The gauge was inside a case, which was carried within a wooden box. The maximum dose rate on the side of the case was 22 μSv h^{-1}. The instrument was repackaged correctly and consigned with the appropriate documentation. The extra handling required to repackage the gauge would have resulted in a very low individual dose of possibly a few microsieverts.

November

2006026. Packages at an airport warehouse were being handled and prepared for export. During these operations an excepted package, carrying a limited quantity of radioactive material, was run over by a fork lift truck. The outer packaging was destroyed and some of the inner packaging damaged but the inner container and vial remained intact. There was no leakage from the package and there were no radiological consequences. The debris was placed in salvage packaging and returned to the consignor.

December

2006027. A lorry carrying postal items from another European country was stopped as it arrived at a UK port, when it triggered an installed radiation detector. The item containing the radioactive material was identified as a small (12 cm cube) package and radiation monitoring equipment indicated that the main radiation was from ^{226}Ra. The radiation dose rate at the surface of the package was 35 μSv h^{-1} from gamma radiation, with a similar dose rate from beta radiation. Further investigation found that it was a piece of rock containing uranium ore, with an activity of ^{238}U of about 350 kBq, and that it was not exempt from the transport regulations. The consignee of this geological specimen was contacted and informed of the transport requirements. The item was released to the consignee following the provision of appropriate packaging and documentation. The extra handling involved would have resulted in a very low individual dose of possibly a few microsieverts to the hands and an effective dose of less than one microsievert.

2006028. An excepted package containing 28.6 MBq of ^{32}P (phosphorus) was sent from an overseas supplier to a university in the UK. The carrier company in the UK delivered it by road to one of its distribution warehouses but it arrived too late to be put on the vehicle that delivers to the area in which the university is situated. Because of this the carrier company had to change the delivery date and the package was eventually delivered to the university. However, this change of delivery date led warehouse staff into believing that the original package had been lost, and it was reported as a missing package. An investigation revealed that this apparent loss had been a misunderstanding.

On-site event

A container carrying four drums of plutonium contaminated waste was moved by rail from a waste disposal facility to a nuclear site. During the unloading of the container from the rail wagon the container fell off the pallet it was resting on. However, the container was not seriously damaged and there was no release of the contents of the drums, and therefore there were no radiological consequences.

5 DISCUSSION OF 2006 EVENTS

5.1 General

There were 27 events reported during 2006, not including any events that are still subject to legal proceedings at the time of publication. This number is greater than those reported for 2005 (16 events), 2004 (20 events) and 2003 (11 events). There were 29 events reported in 2002. This increase compared to the previous three years is likely to represent mainly a statistical variation in the annual number of events, rather than indicating an overall upward trend. 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 2006 was therefore higher than this long-term average.

The numbers of events in each of the descriptive classifications that occurred in 2006 are given in Table 2. Nine events were given more than one event classification. Considering the primary event classifications only, the most numerous type of event involved six instances of undeclared radioactive material. Those materials were discovered both by the triggering of installed radiation detectors at ports, and by the consignee on receipt of a package. 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: 13 administrative events, 12 general shipment events and 2 INF flask shipment events. This distribution expressed as a percentage of the total is 48%, 45% and 7%, 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 were no events involving excess contamination on INF flasks, or packages that were definitely known to have been lost in transit.

Table 3 also shows an analysis of the events by material. During 2006, the largest group of events (10 events) involved the transport of medical and industrial radioisotopes. The percentage of events (37%) involving medical and industrial isotopes was lower than the long-term pattern (47%) for events in the period 1958 to 2004 (Hughes et al, 2006). However, the number of events in 2006 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 (7%) involving spillages of uranium oxide from damaged drums and six (22%) involving other nuclear fuel, residues and wastes. Two events (7%) involved an industrial radiography source, one (4%) involved no radioactive material, and three (11%) involved materials intended for or being used by members of the public. Of the three (11%) remaining events two involved depleted uranium shielding, and the other a geological specimen.

Table 4 gives an analysis of the events by mode of transport, and shows that only two events involved shipments by rail (7%), five were by air (19%), two were by sea (7%), seventeen were by road (63%), and one involved a fork-lift truck (4%). The proportion of road events (63%) (including road/ sea and road/ air) was higher than the long-term trend (31%). For rail the proportion of events in 2006 (7%) is much lower than the long-term trend (24%). This partly reflects the absence of instances of excess contamination on INF flasks in 2006. The number of road and rail events in 2006 (19) is almost twice 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 (4%). This is much 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 12 of the 27 events there was no damage or threat of damage to the packages involved. For 6 events there was no report of damage to the package or increase in dose rate, but there was a minor potential to cause damage. There was one event in which a package was severely damaged but without increase in dose rate or loss of containment. Two events involved damaged drums with loss of containment. One event involved the discovery of contamination inside the package, and 5 events involved improperly packaged material.

5.3 Radiological consequences

Table 6 shows the likely radiological consequences for the events in 2006, analysed by material category. Of the 27 events, 18 were categorised as "None", indicating no radiological consequences for those events, and 7 were categorised as "Extremely low, not assessed". Within this latter category are the events in which inappropriately packaged material was repackaged, resulting in a small excess dose of a few microsieverts to the workers involved.

Two of the events were categorised as “Assessed, lower category”. Both of these events involved spillages of uranium oxide from damaged drums. The damage had occurred at the consignor’s premises overseas and required workers at the consignee’s premises to clean up the spilled material from the floor of the freight containers. It was estimated that the dose to the workers from the first event (2006003) was approximately 15 μSv. and the dose from the second event (2006014) was approximately 150 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 2006 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.

There were three separate cases of freight containers arriving at UK ports from overseas that triggered installed radiation detector alarms. The containers were carrying scrap metal and were found to contain low activity sources. The dose rates close to two of the containers were low in each case. However, the maximum dose rate close to the other container was 2 $\mu Sv\ h^{-1}$, from gamma radiation, and 220 $\mu Sv\ h^{-1}$ from neutron radiation. It was ascertained that this was due to the presence of a $^{241}Am/Be$ neutron source in the scrap metal. Its activity was estimated as 3.7 MBq. The containers were held until DfT issued a Notice of Direction which specified the conditions under which they could be moved to the consignee. In each case the consignee had facilities and equipment to safely deal with the sources. The early detection of the sources on arrival in the UK, and their relatively low activity, ensured that any radiological consequences in the UK were negligible.

Some manufactured items packed in boxes arrived from overseas at a UK airport and triggered installed radiation detector alarms. The items were found to have metal fittings that were contaminated with radioactive material. It is likely that an orphan source had been incorporated into the metal during its manufacture. The dose rates around the items were low, and they were returned to the consignor.

During late 2006 there was an incident in London involving the contamination over a period of time, by ^{210}Po, of public areas. Those areas included vehicles and aircraft and therefore had transport implications. The incident and its radiological consequences were widely reported (HPA-RPD, 2007).

6 CONCLUSIONS

During 2006 there were 27 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 2006 was greater than those reported for 2005 (16 events), 2004 (20 events) and 2003 (11 events). There were 29 events reported in 2002. This increase compared to the previous three years is likely to represent mainly a statistical variation in the annual number of events, rather than indicating an overall upward trend.

In 2006 there were an unusual number of events (6) involving the discovery of radioactive material in supposedly non-radioactive shipments, including two instances of materials sent illegally using the postal services. Some of these were found by installed radiation detection equipment at ports, and some by the consignee on delivery. 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 2006 resulted in any significant radiation doses to workers or members of the public. The largest doses (approximately 150 μSv) were received by workers carrying out a clean up of some spilled uranium oxide from a damaged drum. There were no events involving excess contamination on irradiated nuclear fuel flasks in 2006. Also, there were no events where packages were definitely known to have been lost in transit. In addition to the 27 events, a further transport event is described which occurred on a nuclear site, and which would therefore not normally be included in these reviews. It is included for general interest as it was reported in the local media. It did not result in any radiological consequences. Some other occurrences of interest that did not meet the criteria for inclusion in the database are also briefly described.

The details of the 27 events in 2006 have been included in the database (RAMTED), bringing the total number of reported events since 1958 to 850.

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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 2006 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)
2006001	M02	V04	IP	AG211	D03	N
				AP111		
2006002	M08	V012	BU	SP151	D03	N
				AG211		
				AP111		
2006003	M01	V010	IP2	SP341	D010	L
2006004	M07	V02	E	SP221	D04	N
2006005	M07	V04	B	SC511	D04	N
2006006	M07	V06	A	SC511	D04	N
2006007	M10	V03	NR	AG241	D13	E
				SP141		
2006008	M07	V04	E	SP221	D04	N
2006009	M09	V02	A	AP111	D03	N
				AG211		
2006010	M07	V02	E	AG221	D03	N
2006011	M08	V04	B	AC111	D03	N
				AG211		
				AG111		
2006012	M05	V01	B	FC211	D04	N
2006013	M07	V04	A	SP111	D03	N
2006014	M01	V10	IP2	SP341	D02	L
2006015	M05	V12	X	SP161	D11	E
2006016	M05	V04	E	SP141	D13	E
				SP131		
2006017	M05	V10	E	SP141	D13	E
				SP131		
2006019	M07	V12	E	AG211	D03	N
				AP211		
2006020	M11	V02	E	AG241	D03	N
2006021	M10	V06	NR	AG241	D13	E
2006022	M10	V03	E	AG211	D03	N
2006023	M11	V02	E	AG241	D03	N
2006024	M04	V01	B	FC111	D04	N
2006025	M07	V10	NR	AG241	D03	E
2006026	M07	V08	E	SP341	D08	N
2006027	M11	V10	NR	AG241	D13	E
				SP141		
2006028	M07	V04	E	AG251	D03	N

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

TABLE 2 Numbers of 2006 events in each classification

Event classification code (See Table B1)	1st classification	2nd classification	3rd classification
AC111	1	0	0
AG111	0	0	1
AG211	3	3	0
AG221	1	0	0
AG241	6	0	0
AG251	1	0	0
AP111	1	1	1
AP211	0	1	0
FC111	1	0	0
FC211	1	0	0
SC511	2	0	0
SP111	1	0	0
SP131	0	2	0
SP141	2	2	0
SP151	1	0	0
SP161	1	0	0
SP221	2	0	0
SP341	3	0	0
Total	27	9	2

TABLE 3 Classification* of 2006 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	2	0	0	2	7	4
M02	Pre-fuel material	1	0	0	0	0	0	0	1	4	3
M03	New fuel	0	0	0	0	0	0	0	0	0	<1
M04	Irradiated fuel	0	0	0	0	0	1	0	1	4	13
M05	Residues	0	0	0	0	3	1	0	4	15	14
M06	Radioactive wastes	0	0	0	0	0	0	0	0	0	8
M07	Medical & industrial radioisotopes	4	0	0	2	4	0	0	10	37	47
M08	Radiography sources	0	1	0	0	1	0	0	2	7	10
M09	No radioactive material	0	0	1	0	0	0	0	1	4	<1
M10	Consumer products	3	0	0	0	0	0	0	3	11	1
M11	Other	3	0	0	0	0	0	0	3	11	<1
Totals		11	1	1	2	10	2	0	27	100	100

Notes

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

† With a sample size of 28 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 2006 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	2	0	2	7	24
V02	Air	3	0	1	0	1	0	0	5	19	13
V03	Sea	2	0	0	0	0	0	0	2	7	7
	Road:										
V04	> 1.5 t (lorry)	2	1	0	1	3	0	0	7	26	15
V05	< 1.5 t (van)	0	0	0	0	0	0	0	0	0	13
V06	Car	1	0	0	1	0	0	0	2	7	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	4	22
V09	Other	0	0	0	0	0	0	0	0	0	<1
V10	Road and sea	2	0	0	0	3	0	0	5	19	<1
V11	Road and rail	0	0	0	0	0	0	0	0	0	<1
V12	Road and air	1	0	0	0	2	0	0	3	11	<1
Totals		11	1	1	2	10	2	0	27	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	NR	CV	Others	Total
D03	No damage or threat of damage to package	6	2	2	1	1	0	0	12
D04	No report of damage or increase in dose rate, but potential to cause damage to the package (lower category)	2	1	3	0	0	0	0	6
D08	Severe damage without increase in dose rate or loss of containment	1	0	0	0	0	0	0	1
D10	Damaged with loss of containment	0	0	0	2	0	0	0	2
D11	Contamination inside package	0	0	0	0	0	0	1	1
D13	Improper package with loss of shielding or containment – inappropriate contents	2	0	0	0	3	0	0	5
Totals		11	3	5	3	4	0	1	27

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
M01	Uranium ore concentrate	0	0	2	0	2
M02	Pre-fuel	1	0	0	0	1
M04	Irradiated fuel	1	0	0	0	1
M05	Residues (inc discharged INF flasks)	1	3	0	0	4
M06	Radioactive wastes	0	0	0	0	0
M07	Med & Industrial Radioisotopes	9	1	0	0	10
M08	Radiography sources	2	0	0	0	2
M09	No radioactive material	1	0	0	0	1
M10	Consumer products	1	2	0	0	3
M11	Other	2	1	0	0	3
Totals		18	7	2	0	27

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.