Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2008 Review

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ABSTRACT

During 2008 there were 38 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 2008 was more than reported in recent years: there were 25 events reported in 2007, 27 events in 2006 and 16 events in 2005. Over recent years there has been an increase in the number of events (4 in 2008) involving the discovery of radioactive material in shipments containing material which was thought to be non-radioactive.

Also in 2008 there was an increase in the number of irradiated nuclear fuel flask events (7 in 2008). None of the events in 2008 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 913 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) 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 2008 is the latest in the 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. The database now contains information on 913 events that are known to have occurred since 1958.

During 2008 there were 38 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 2008 was more than reported in recent years: there were 25 events reported in 2007, 27 events in 2006 and 16 events in 2005. Over recent years there has been an increase in the number of events (4 in 2008) involving the discovery of radioactive material in shipments containing material which was thought to be non-radioactive. Also in 2008 there was an increase in the number of irradiated nuclear fuel flask events (7 in 2008). None of the events in 2008 resulted in any significant radiation doses to workers or members of the public.

Almost all the events were of a similar type to those occurring in recent years, and it is unlikely that the increase in 2008 represents a general long-term upward trend. The higher number of events in 2008 is likely to be a manifestation of the statistical variation in the annual number of events. However there was an unusual number (5) of events involving the discovery of parts on INF flasks that were not of the correct specification. These were relatively minor in terms of the overall safety of the flasks. However, it is essential that these flasks are maintained and operated to the highest quality standards.

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 2007 (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; Harvey and Hughes, 2008). The objectives of those reviews were:

- to assess the radiological impact of such accidents and incidents on both workers and members of the public over the period of study;
- to comment on transport practices;
- to provide information pertinent to future legislation and codes of practice;
- 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, Harvey and Hughes, 2008). 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 the RAdioactive Materials Transport Event Database (RAMTED). In 2004, it was reviewed and revised as the original database was approximately twenty years old and had many limitations compared to typical software and hardware specifications of today (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 2008 and gives analyses of the 2008 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 in previous years and they are presented in Table A1 of Appendix A.

The Glossary (see Section 8) 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 series of reviews, information on accidents and incidents has been 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). Information was also obtained from other sources, such as the Health and Safety Executive (HSE) (www.hse.gov.uk), 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 the premises of consignors and consignees, 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 current national legislation, and international agreements, which cover transport by road (UK Parliament, 2007a; UNECE, 2007), rail (UK Parliament, 2007a; OTIF, 2007), sea (UK Parliament, 1997a; MCA, 2006; IMO, 2006) and air (UK Parliament, 1994, 2007b; ICAO, 2006). 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, events are included that had the potential for increased radiation exposures. Some events in this group 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 the UK, there are two sets of regulations, one for Great Britain (UK Parliament, 2007a) and one for Northern Ireland (UK Parliament, 1997b).

For transport by road in Great Britain (GB), the regulations (UK Parliament, 2007a) require the driver of a vehicle transporting radioactive material to report a notifiable event to the police, fire brigade and consignor. A notifiable event (UK Parliament, 2007a) means:

(i) a radiological emergency;

(ii) the theft or loss of the radioactive material being carried; or

(iii) an occurrence subject to report as construed in accordance with Sub-section 1.8.5.3 (of reference UNECE, 2007). That sub-section includes the release of contents, or risk of loss of contents, environmental damage or personal injury.

Similar criteria are given for Northern Ireland.

Following this, the carrier must report the event to the police and 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 they 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 previous regulations (UK Parliament, 2002) stated 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 the purpose of this review, which is 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 involving the discovery of undeclared radioactive material that are notified to DfT but are not included in the database as transport events, because they do not meet the criteria, are briefly described in Section 5.4 and listed in Table A1 of 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. In the past, operational quantities related to these values, termed derived working levels (DWL), were used. Events involving excess levels of contamination on INF flasks were included in previous reviews if at any point on the surface the level was 10 DWL or above.

Recent changes in industry protocols mean that flask contamination is now reported directly in terms of its value in Bq cm^{-2} rather than DWL. Similar pessimistic assumptions are made when calculating the contamination in Bq cm^{-2} as were used in deriving DWL. Therefore when contamination is reported post-shipment as being just over 4 Bq cm^{-2} the flask is unlikely to have actually been transported with contamination above the regulatory limit. A criterion of 20 Bq cm^{-2} (2 Bq cm^{-2} for alpha) has been applied to the calculated contamination level to separate those events where the regulatory limit is likely to have been exceeded (DfT, 2009). The classification of these events given in Table B6 of Appendix B (FP311) has been changed to ‘Contamination of surface above regulatory limits’.

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 known as the International Nuclear Event Scale (INES) (IAEA and NEA, 2001) 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). This system enables a rating, from Level 0 to Level 7, to be applied to an event 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 United Kingdom, 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 Appendices B and C.

The database contained information on 875 events up to and including the events in 2007. The earliest reported events are from 1958. During the collection of information for this current review, the details were obtained for 38 events in 2008, which brings the total number in the database to 913. 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 Tables B6, B7 and B8 of Appendix B. The classification codes for these three aspects are listed in the last three columns of Table1 for the 38 events reported in 2008. 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 definitions of the material category codes, the transport mode codes and the package type codes are given in Tables B3, B4 and B5 of 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 B6 in Appendix B. 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 B6. 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 B7 in Appendix B. In addition category D01, 'No package', applies to events in which 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 B8 in Appendix B. The 'None' category applies to events where there are no dose rates or contamination above that expected from normal transport, or where there is no evidence that individuals have received any dose. Events in which people received a small excess dose, but not at a level thought to be worth a detailed assessment are categorised in the 'Extremely low, not assessed' band. Such doses may be received when a worker repackages a poorly packaged item. Events in which workers are exposed to radiation for a significant period and an assessment is carried out of their likely dose fall into either the 'Assessed, lower category' or the 'Assessed, upper category' band, depending on whether their effective dose exceeded 1 mSv, or an extremity dose exceeded 50 mSv.

Table 1: Summary list of events included in the 2008 review

Event ID (Section 4)	Material category (Table B3)	Transport mode (Table B4)	Package type (Table B5)	Event classification (Table B6)	Effect on package (Table B7)	Radiological consequence (Table B8)
2008001	M06	V00	IP2	SP111	D06	N
2008002	M02	V10	IP2	AG211	D03	N
2008003	M06	V04	IP2P	AP111	D03	N
2008004	M04	V01	BM	FP132	D03	N
2008005	M08	V07	A	SP111	D04	N
2008006	M09	V04	NIL	AC112	D01	N
2008007	M06	V04	IP2	AC111	D03	N
2008008	M11	V07	E	AG211	D03	N
2008009	M07	V10	A	AG211 AC111 AP111	D03	N
2008010	M06	V07	UK	AG231	D03	N
2008011	M07	V07	A	SP331	D07	E
2008012	M04	V01	BMF	FP132	D03	N
2008013	M07	V02	A	AG211	D03	N
2008014	M08	V10	A	SC311	D03	E
2008015	M07	V10	A	AG211	D04	N
2008016	M08	V00	BU	AG221	D03	N
2008017	M07	V02	E	SP341	D07	E
2008018	M04	V01	BMF	FP141	D03	N
2008019	M11	V02	EP	AG241 SP341	D06	N
2008020	M04	V01	BFP	FP311	D12	E
2008021	M11	V07	UK	AG241	D03	E
2008022	M11	V00	BU	SP141 SP161	D06	N
2008023	M07	V05	A	AC111	D03	N
2008024	M07	V08	A	SP341	D08	E
2008025	M11	V02	E	SP141	D13	E
2008026	M03	V03	AF	AG221	D03	N
2008027	M08	V12	NR	AG211 AP211	D03	N

Table 1: Summary list of events included in the 2008 review

Event ID (Section 4)	Material category (Table B3)	Transport mode (Table B4)	Package type (Table B5)	Event classification (Table B6)	Effect on package (Table B7)	Radiological consequence (Table B8)
2008028	M04	V01	BM	FP141	D04	N
2008029	M06	V00	B	AG211	D03	N
2008030	M01	V10	AF	SP141	D04	N
2008031	M00	V07	UK	SC411 AG211	D04	N
2008032	M04	V01	BM	FP141	D03	N
2008033	M04	V01	BFP	FP311	D12	E
2008034	M07	V12	A	SP141	D13	E
2008035	M05	V02	NR	SP141 AG211	D13	E
2008036	M07	V02	A	AG211	D03	N
2008037	M10	V03	NR	AG241	D03	N
2008038	M00	V07	E	AG211	D03	N

4 EVENTS RECORDED FOR THE 2008 REVIEW

Brief descriptions of the events reported in 2008 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.

An event (2007026) occurred in December 2007 that was not discussed in the previous report (Harvey and Hughes, 2008). This event has been described in Section 4.2.

4.1 Events for 2008

January

2008001. A freight container, type 0075 reusable IP2, failed a leak test during annual maintenance. This container is normally used to transport compactable LLW from the customer site to a waste repository site in the UK. A leak test is required for this operation. The problem was found to be a manufacturing fault in the door seal.

2008002. A consignment of 20 type 48Y cylinders containing uranium hexafluoride, were sent with incorrect documentation. The delivery documents on arrival had the incorrect cylinder code. This should have been 491078 instead of 490178.

2008003. A freight container was sent from a nuclear power station to a waste facility with no labelling on the side of the container. The labelling had become detached during transit. The correct labelling was UN3321.

2008004. Following the suspension of INF flask shipments in late 2007 (see Section 4.2) another operator of INF flasks voluntarily suspended shipments pending investigations when it was discovered during biennial maintenance that incorrect lid bolts had been used. Once it had been confirmed that the bolts used on other similar flasks were correct, shipments were resumed.

February

2008006. A vehicle normally used for transport of radioactive material was identified by the placards it displayed. These were a front ADR orange plate and a class 7 placard. However the vehicle was being repaired in a garage, and undergoing a road test. The placards should have been covered or removed in this situation. The vehicle was not carrying radioactive material at the time of the incident.

2008005. A Tech Ops 660 radiography container was found to be fitted with non-standard parts. When it was serviced by a specialist engineering company, an incorrect countersink screw was fitted. The fault was discovered by the supplier of the correct spare parts. To transport this container with an incorrect spare part fitted was an infringement of the regulations.

2008007. A lorry transporting low specific activity waste material from a nuclear site to a landfill site was stopped by the police and found to be displaying incorrect vehicle placards. The lorry was transporting 43 drums of waste (each weighing 210 kg) and should have been displaying UN3321 placards.

2008008. An excepted package containing a ^{85}Kr source was transported from a nuclear site, to an adjacent site, without the correct documentation for movement off-site.

March

2008010. A Type A package containing a depleted uranium flange and a ^{133}Ba source was transported from a Ministry of Defence site to a nuclear site. The depleted uranium flange had been labelled as containing ^{60}Co and therefore the transport documents were subsequently incorrectly completed.

April

2008009. A Type A package (UN3332) containing a Troxler surface moisture density gauge was held at a UK sea port because there were no dangerous goods documents, package labels, or placards. The Troxler gauge was used by a construction company and contained a Am-Be source of 1.48 GBq and a ^{137}Cs source of 0.5 GBq. The paper work was completed and the package was forwarded on to the consignee.

2008011. On arrival at a UK airport a package from a box containing 7 similar packages was found to be damaged. The package contained a medical ^{131}I solid inorganic source of 146 MBq. Only the outer part of the package was damaged and the source remained intact with no spread of contamination. It was believed the package was damaged in transit to the airport. The damaged package was stored at the airport awaiting collection by the consignor.

2008012. Following the resumption of shipments of INF flask movements, (see 2007026 in section 4.2) these shipments were again temporally suspended when some flasks were found to have valves that did not have the required specification.

May

2008013. A package of medical isotopes for export was held at an airport in the UK, because the transport documents were missing. The Type A package (UN2915) contained 9.22 GBq of ^{131}I and had a Transport Index of 0.8. The package which was due to be sent to a European country was quarantined at the airport awaiting receipt of the correct transport documents. When the documents were received the package was sent to the consignee.

2008015. A consignment of 209 Type A packages containing ^{133}I were received by a UK supplier of medical isotopes which had been sent from the same company in Europe with incorrect transport documents. The documents were for 144 packages and not 209. The total activity of the 65 undocumented packages was 480.8 GBq with a Transport Index of 53. The remaining documents were forwarded to the consignee separately and the incident was closed.

2008016. The UK validation certificate for the USA package design USA/9283/B(U)-96 for a Tech Ops 660 Radiography unit had been withdrawn following a change in ownership of the package design on 31st July 2007. The certificate was therefore out of date and the transport of the unit would be non-compliant. A number of users of the unit had this invalid certificate in their possession and therefore illegal transport of this type of unit had occurred. The non-compliance was discovered after a misunderstanding occurred between a consignor and consignee. After this occurrence the consignor implemented a system to monitor when design approval and validation certificates were due for renewal.

2008017. At a cargo warehouse at an airport in the UK, an imported package containing a source was found to be damaged. The package contained a ^{32}P source of 14.3 MBq of activity for medical uses. Only the outer part of the package was damaged and the source remained intact with no contamination and with an external dose rate from the source of less than 1 μSv h^{-1}. It was believed the source was damaged as a result of a larger package being placed on top of it, which moved during transit. The damaged package was subsequently delivered to the consignee.

June

2008018. Three refurbished valves from INF flasks were discovered during an inspection to have washers that were not of the required specification. This inspection was a continuation of a review of a company quality system and INF flask spares, relating to the events in December 2007 (2007026) and April 2008 (2008012). As part of the company's investigations it was concluded that obsolete design specifications had resulted in the procurement of washers with incorrect nickel content, hence with the wrong specification.

2008019. A damaged package arrived at a UK airport. Only the outer packaging of the container was damaged, which revealed the contents to be a steel drum labelled as carrying radioactive materials. However it was an empty drum, normally used for carrying radioactive sources, transported without the correct transport documents. The drum had a depleted uranium inner lining and secondary steel case to carry radioactive sources.

2008014. A Tech Ops radiography container was being used on an oil platform, when the ^{192}Ir source became detached from the holder. The whole radiography unit was placed in a non approved transport container on the rig. The transport container was placed in a Type A overpack and transported to shore and then on to the consignee. On receipt of the package it was found that the overpack was missing a tamper proof seal, which did not conform to the consignee's quality system and was a breach of the regulations.

July

2008020. An INF flask transported to a power station within the UK was found to have surface contamination on the lid calculated to be 20 Bq cm^{-2}. This was calculated at the site 8 days after receipt of the flask.

2008021. A consignment of jet aircraft spares being sent for export set off the radiation alarms at a UK port, and was found to contain radioactive material. The maximum dose rate on the surface of the items was 15 µSv h^{-1}. The consignment was sent back to the consignor in the UK after HM Revenue and Customs were advised by a Radiation Protection Adviser that the goods could be sent without any regard to the transport regulations, as the material contained exempt quantities. However it was later found that this was incorrect and the package should have been sent as a radioactive material package.

2008022. A consignment of a liquid form of ^{238}Pu nitrate was sent in Type B package approved for transporting only solids. The 3 ml glass bottle containing the liquid was damaged in transit, within the inner packaging. However the damaged bottle was contained within the package and there were no radiological consequences.

2008023. A van transporting a Troxler Moisture/Density gauge containing an Am-Be source with an activity of 1.48 GBq and a ^{137}Cs source with an activity of 300 MBq was stopped by the police during a roadside check and was found to have incorrect placards. Further investigations by the DfT revealed a number of non-compliances with the transport regulations which were corrected by the transport company involved.

2008024. A Type A package containing a medical source of ^{131}I fell off a wooden pallet and was run over by a fork lift truck at a UK airport. The outer carton of the package was smashed and the inner containment was also damaged. However the contents remained intact. The area was sealed off and monitored for leakage, but none was found. The package was sealed in a metal drum awaiting collection. The package was later returned to the consignor.

August

2008025. An excepted package triggered radiation detectors when it arrived in an airport in the UK. The container was found to contain sealed sources for a UK university. The surface dose of the package was 10 μSv h^{-1}, which exceeded the value permitted for an excepted package.

2008026. Shipments of nuclear fuel rods were being made from Europe to the USA by sea using the USA approved Traveller package, whose design had not yet received approval for use in the UK. Transit approvals had been issued to permit shipments to pass through a UK port, but with the Traveller packages remaining on board the ship. One such shipment took place before the UK transit approval had been issued, using a similar approval issued for an earlier shipment.

2008027. A wooden package containing a radiography container was sent from abroad to a company in the UK, without any documents. The container had a spent ^{192}Ir source and about 9 kg of depleted uranium shielding. The dose rate at the surface of the wooden package was up to 10 μSv h^{-1} and about 80 μSv h^{-1} at the surface of the container. The company returned the package back to the consignor.

2008033. An INF flask transported to a reprocessing plant from a power station within the UK was found to have non-fixed surface contamination on the lid calculated to be 21 Bq cm^{-2}.

September

2008028. During a routine inspection of INF flasks before dispatch from a nuclear site it was found that two screws were loose on a water level valve assembly on one flask.

2008030. When a consignment of uranium compound in powder form was opened, a plastic bottle top was found in the inner containment, underneath the bags of powder. The bottle top was from a cleaning aerosol container used by staff at the consignor’s premises.

2008029. Two containers, containing 4 drums each of plutonium contaminated waste were consigned from a waste facility to another nuclear site in the UK. On arrival it was found that the consignment did not match with the documentation and it was found that the incorrect containers had been sent. The containers were otherwise compliant with the transport regulations.

2008031. A vehicle carrying radioactive material in packages was stopped by the police and found to have no documentation or any placards on the vehicle. There were also apparent shortcomings in a tie down and a lack of mandatory safety equipment.

October

2008032. A pause in operational transport of INF flasks from a nuclear company to a fuel handling plant was caused by incorrect spares used for INF flasks. These spares were not fully compliant with the design specification. This is related to the incident in January 2008 (incident No. 2008004). Further investigation revealed deficiencies in the consignor's processes. The consignor was unable to demonstrate that components fitted to INF fuel flask valves complied with the approved design specification. This resulted in a pause in the transport of spent fuel flasks from two nuclear power stations.

November

2008035. A consignment triggered radiation detectors when it arrived at an airport in the UK. The consignment was found to contain environmental samples of Low Specific Activity naturally occurring radioactive material (NORM) in oil pipe scale. The dose rate at the surface of the box containing the samples was 10 µSv h^{-1} and the manifest stated that LSA material was being transported. However the material was transported in the wrong package type. The package was placed in storage until it could be repackaged correctly.

2008036. A Type A package (UN2915) containing radioactive material, consisting of 3.7 GBq of ^{14}C, arrived at a UK airport without the correct documentation. The correct consignment note was issued and the package was forwarded to the consignee.

2008037. A consignment triggered radiation detectors when it arrived at a UK seaport. The consignment was found to contain 900 smoke detectors. Consignments of small numbers of smoke detectors are exempted from the transport regulations but such a number of smoke detectors should have been consigned as radioactive material. No documentation was enclosed with the consignment.

December

2008038. An excepted package was sent to a nuclear site with the incorrect consignment note. The consignor investigated the event and found it was due to human error.

2008034. Three packages containing ^{99m}Tc generators were dispatched to a carrier at a UK airport with higher than normal activities and surface dose rates, also without the correct documentation and package labelling. The activity was high because the consignment was sent one day earlier than normal from the consignor's premises due to the availability of carriers over the holiday period. The paperwork had not been produced on the consignor's computer system, which did not recognise packages which contained greater than the Type A limit or had surface dose rates too high for transport.

One of these packages contained about 750 GBq of ^{99}Mo, which exceeded this radionuclide's limiting value of 600 GBq for a Type A package. This package contained heavier shielding than the other packages, which reduced the surface dose rate to within acceptance levels. This package was air freighted abroad to the consignee a day after the incident.

Two further packages had surface dose rates measured as around 2300 μSv h^{-1}. These contained less than the radionuclide's limiting value for a Type A package, but more than the surface dose rate limit for non exclusive use shipments and therefore too high for air transport. The carrier recognised the omissions on the dangerous goods notes and held the packages until they were collected by the consignor.

The consignor has put in place extra controls to prevent further occurrences of this type.

4.2 Previous event

An event was reported to DfT in December 2007, but was still ongoing until after the RAMTED report for 2007 events was published (Harvey and Hughes, 2008). A brief description of the event is given below and it has been included in the RAMTED database.

December

2007026. It was discovered that some irradiated nuclear fuel flasks may have been operated with incorrect components. As result the company imposed a temporary halt to shipments of loaded flasks pending an investigation and appropriate remedial action. Shipments of the affected flasks resumed in March 2008.

5 DISCUSSION OF 2008 EVENTS

5.1 General

There were 38 events reported during 2008, not including any events that are still subject to legal proceedings at the time of publication.

The numbers of events in each of the descriptive classifications that occurred in 2008 are given in Table 2. Using primary classification in the three broad categories, 19 (50%) were administrative events, 12 (32%) general shipment events and 7 (18%) INF flask shipment events. The numbers of events in these three categories in the period 1958 to 2004, expressed as a percentage of the total, were 16%, 61% and 23%, respectively (Hughes et al, 2006). In 2008 therefore, there was a higher than average number of administrative events, which includes the undeclared radioactive material category, as well as documentation and labelling errors. Events in 2008 involving INF flasks are closer to the long-term average than recent years. There were five events involving AGR and Magnox flask components that were not of the correct specification and two events involving excess contamination of INF flasks. Considering the primary event classifications only, the most numerous type of event involved nine instances of administrative error where the consignor's certificate was incorrect or absent. Six events were given more than one event classification.

The number of events in 2008 was more than those reported in recent years: there were 25 events reported in 2007, 27 events in 2006 and 16 events in 2005. Over recent years there has been an increase in the number of events (4 in 2008) involving the discovery of radioactive material in shipments containing material which was thought to be non-radioactive. Also there were 5 events involving INF flask components that did not have the required specification. The problems identified for these events affected both AGR and Magnox flasks and led to temporary suspensions of flask shipments. As a result of these events and similar ones that occurred in early 2009 a wide ranging investigation was instigated across all organisations involved in INF flask operations. A comprehensive report identifying root causes and remedial action to be taken is expected to be presented to the DfT in mid-2009.

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 2008 was therefore higher than this long-term average. However, almost all the events were of a similar type to those in recent years and it is unlikely that this represents a general long-term upward trend. The higher number of events in 2008 is likely to be a manifestation of the statistical variation in the annual number of events.

Table 3 shows an analysis of the events by material. During 2008, the largest group of events (9 events) involved the transport of medical and industrial radioisotopes. The percentage of events (24%) involving medical and industrial isotopes was lower than the annual average (47%) for events in the period 1958 to 2004 (Hughes et al, 2006). There were two events (5%) involving transport of material which was in an undefined category. Seven events involved irradiated nuclear fuel flasks: 5 involving faulty flasks and 2 with excess contamination outside of the flask. Five events (13%) involved transport of radioactive waste, most of which were a result of administrative errors. Four events (11%) involved the transport of radiography sources, which is similar to the long term average. Only one event (3%) involved transport of undeclared consumer products, which is less than recent years. Single events also occurred for uranium ore concentrate, pre-fuel material, new fuel, residues and one in which the event was related to a vehicle not carrying radioactive material. The remaining 5 events (13%) involved the transport of a ^{85}Kr source, depleted uranium shielding, jet aircraft spares, plutonium nitrate and an undefined material.

Table 4 gives an analysis of the events by mode of transport, and shows seven events involving shipments by rail (18%), 8 were by air/road and air (21%), 7 were by sea/road and sea (18%), and 11 were by road (29%). The proportion of sea events (18%) was higher than the long-term annual average (7%). For rail the proportion of events in 2008 (18%) is only slightly lower than the long-term annual average (24%). The number of road and rail events in 2008 (18) is higher than the average annual number (approximately 10) during the period 1958 to 2004 (Hughes et al, 2006). There was one event (3%) where a package was damaged by a fork-lift truck, which was lower than 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.

Table 2: Numbers of 2008 events in each classification

	Event classification code (see Table B6)	First classification	Second classification	Third classification
Administrative	AC111	2	1	0
	AC112	1	0	0
	AG211	9	2	0
	AG221	2	0	0
	AG231	1	0	0
	AG241	3	0	0
	AP111	1	0	1
	AP211	0	1	0
Total		19	4	1
General (non-INF) Shipments	SC311	1	0	0
	SC411	1	0	0
	SP111	2	0	0
	SP141	5	0	0
	SP161	0	1	0
	SP331	1	0	0
	SP341	2	1	0
Total		12	2	0
INF Flask shipments	FP132	2	0	0
	FP141	3	0	0
	FP311	2	0	0
Total		7	0	0

Table 3: Classification* of 2008 events by material category

Material		Administrative			General (non-INF) Shipments		INF Flask shipments			Percentage	
Code	Category	General	Conveyance	Package	Conveyance	Package	Conveyance	Package	Total	2008†	1958-2004
M00	Unknown	1	0	0	1	0	0	0	2	5	N/A‡
M01	Uranium ore concentrate	0	0	0	0	1	0	0	1	3	4
M02	Pre-fuel material	1	0	0	0	0	0	0	1	3	3
M03	New fuel	1	0	0	0	0	0	0	1	3	<1
M04	Irradiated fuel	0	0	0	0	0	0	7	7	18	13
M05	Residues	0	0	0	0	1	0	0	1	3	14
M06	Radioactive wastes	2	1	1	0	1	0	0	5	13	8
M07	Medical & industrial radioisotopes	4	1	0	0	4	0	0	9	24	47
M08	Radiography sources	2	0	0	1	1	0	0	4	11	10
M09	No radioactive material	0	1	0	0	0	0	0	1	3	<1
M10	Consumer products	1	0	0	0	0	0	0	1	3	1
M11	Other	3	0	0	0	2	0	0	5	13	<1
Total		15	3	1	2	10	0	7	38	100	100

Notes

*: First classifications only (see Table B6 for descriptions of event classifications).

†: With a sample size of 38 events, interpretation of these rounded percentages must be made with care. The total of 100% is of the unrounded values.

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

Table 4: Classification* of 2008 events by mode of transport

Mode of transport		Administrative			General (non-INF) Shipments		INF Flask shipments			Percentage	
Code	Category	General	Conveyance	Package	Conveyance	Package	Conveyance	Package	Total	2008†	1958-2004
V00	Unknown	2	0	0	0	2	0	0	4	11	N/A‡
V01	Rail	0	0	0	0	0	0	7	7	18	24
V02	Air	3	0	0	0	3	0	0	6	16	13
V03	Sea	2	0	0	0	0	0	0	2	5	7
	Road	0	0	0	0	0	0	0	0	0	
V04	> 1.5 t (lorry)	0	2	1	0	0	0	0	3	8	15
V05	< 1.5 t (van)	0	1	0	0	0	0	0	1	3	13
V06	Car	0	0	0	0	0	0	0	0	0	3
V07	Unknown	4	0	0	1	2	0	0	7	18	<1
V08	Fork-lift truck	0	0	0	0	1	0	0	1	3	22
V09	Other	0	0	0	0	0	0	0	0	0	<1
V10	Road and sea	3	0	0	1	1	0	0	5	13	<1
V11	Road and rail	0	0	0	0	0	0	0	0	0	<1
V12	Road and air	1	0	0	0	1	0	0	2	5	<1
Total		15	3	1	2	10	0	7	38	100	100

Notes

*: First classifications only (see Table B6 for a description of event classifications).

†: With a sample size of 38 events, interpretation of these rounded percentages must be made with care. The total of 100% is of the unrounded values.

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

5.2 Effects on packages

Table 5 shows an analysis of the events in terms of the package condition. A list of types of packages considered in the database is given in Table B5; definitions of the codes used to identify package conditions are given in Table B7 of Appendix B. For one event there was no package. In 21 of the 38 events there was no damage or threat of damage to the packages involved. For five 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 three events there was defective or poor condition of the package, but without increase in dose rate or loss of containment. Two events had a package with minor damage without increase in dose rate. One event involved a package with severe damage without increase in dose rate. Two events involved the discovery of contamination outside of the package and three events involved improper packaging with loss of shielding or containment.

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	BMF	IP2	Others	Total
D01	No package	0	0	0	0	0	0	1	1
D03	No damage or threat of damage to package	2	5	1	2	2	2	7	21
D04	No report of damage or increase in dose rate, but potential to cause damage to the package (lower category)	0	2	0	1	0	0	2	5
D06	Defective or poor condition, without increase in dose rate or loss of containment	0	0	1	0	0	1	1	3
D07	Minor damage without increase in dose rate or loss of containment	1	1	0	0	0	0	0	2
D08	Severe damage without increase in dose rate or loss of containment	0	1	0	0	0	0	0	1
D12	Contamination outside package	0	0	0	0	0	0	2	2
D13	Improper package with loss of shielding or containment – inappropriate contents	1	1	0	0	0	0	1	3
Total		4	10	2	3	2	3	14	38

5.3 Radiological consequences

Table 6 shows the likely radiological consequences for the events in 2008, analysed by material category. Table B8 in Appendix B provides a description of the categories for radiological consequences. Of the 38 events, 28 were categorised as 'None', indicating no radiological consequences for those events, and 10 were categorised as 'Extremely low, not assessed'. Within this latter category there are two events which involved potential exposure to INF flasks with excess contamination; one event involved handling NORM material in the incorrect package; four events involved exposure to medical sources, three of which had been damaged and one which gave excessive dose rates outside the containment; one event involved repackaging a radiography source and two events involved exposure to miscellaneous materials giving a dose rate greater than 10 $\mu Sv\ h^{-1}$ outside the package. The doses from these events would be less than a few microsieverts to the workers involved.

There were no events categorised as 'Assessed, lower category' involving effective doses below 1 mSv or in the 'Assessed, upper category' involving effective doses above 1 mSv or extremity doses over 50 mSv.

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
M00	Unknown	3	0	0	0	3
M01	Uranium ore concentrate	1	0	0	0	1
M02	Pre-fuel material	1	0	0	0	1
M03	New Fuel	1	0	0	0	1
M04	Irradiated fuel	5	2	0	0	7
M05	Residues (inc. discharged INF flasks)	0	1	0	0	1
M06	Radioactive wastes	5	0	0	0	5
M07	Medical and industrial radioisotopes	4	4	0	0	8
M08	Radiography sources	3	1	0	0	4
M09	Non radioactive material	1	0	0	0	1
M10	Consumer products	1	0	0	0	1
M11	Other	3	2	0	0	5
Total		28	10	0	0	38

5.4 Other occurrences

During 2008 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 Table A1 of Appendix A for detailed descriptions).

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

In 2008 there were a number of consignments which triggered the Cyclamen radiation detector alarms at UK airports and ports. Advice from DfT was sought for 14 of these events. Eight of them were due to radioactively contaminated steel, including four consignments of items contaminated with ^{60}Co, such as TV table top parts, metal flanges, steel bars and elevator parts. In recent years such items have been returned to the consignor. Three consignments involved small sources located within loads of scrap metal and one involved slightly contaminated scrap metal, triggering alarms at a scrap yard. A shipment of wool contaminated with ^{137}Cs also triggered alarms at a UK seaport.

Three consignments of luminised aircraft parts containing ^{226}Ra arrived from overseas at UK ports where they triggered radiation detector alarms. In all cases these items did not have correct labelling which indicated that they contained radioactive material. The maximum dose rate outside the packages was about 9 µSv h^{-1}. This dose rate would give doses to the workers handling the packages of less than a few microsieverts.

Two consignments containing mineral samples did not have correct labelling to indicate that they contained radioactive material. The maximum dose rates outside the packages was about 8 µSv h^{-1}, which would give a dose to the workers handling the packages of less than a few microsieverts.

6 CONCLUSIONS

During 2008 there were 38 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 2008 was more than those reported in recent years: there were 25 events reported in 2007, 27 events in 2006 and 16 events in 2005.

Almost all the events were of a similar type to those in recent years, and it is unlikely that this represents a general long-term upward trend. The higher number of events in 2008 is likely to be a manifestation of the statistical variation in the annual number of events. However, Project Cyclamen has resulted in the discovery of radioactive material and has contributed to the increase the overall number of events compared to previous years. Also, there was an unusual number (5) of events involving the discovery of parts on INF flasks that were not of the required specification. In terms of the overall safety of the flasks these errors were relatively minor. However, it is essential that these flasks are maintained and operated to the highest quality standards.

None of the events in 2008 resulted in any significant radiation doses to workers or members of the public. There were two events involving excess contamination on irradiated nuclear fuel flasks in 2008 and four events involving potentially high dose rates from medical sources three of which required repackaging after damage. However, the maximum dose from these events is likely to be only a few microsieverts.

The details of the 38 events in 2008 have been included in the database (RAMTED), bringing the total number of reported events since 1958 to 913.

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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.

Term	Description
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 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.

APPENDIX A Summary of Cyclamen events not included as transport events

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

Table A1: Summary of Cyclamen events not included in RAMTED database

General information on Cyclamen event category	Additional information on event
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. The maximum dose rates outside of the packages was about 9 µSv h^{-1}, which would give a dose to the workers handling the packages of less than a few µSv. All items were detected at UK sea ports. The items required appropriate packaging before forwarding to the consignee. In one case the items were returned to the consignor.	A package arrived in a sea port in the UK, containing an aircraft instrument. The dose rate close to the instrument was 10 µSv h^{-1}.
	A container arrived in a sea port in the UK, containing 38 luminous switches from a Hawker Hunter aircraft. Each of the switches was found to contain 5 MBq of ^{226}Ra with a dose rate close to the container of 9 µSv h^{-1}.
	A package arrived in a sea port in the UK, contain 9 radium dials to be transported as antiques for an exhibition to a UK city. The dose rate from two dials was in excess of the dose limit for an excepted package of 5 µSv h^{-1}.
Contaminated materials – other than metal	
The contaminated wool was detected at a seaport. Doses to the workers from handling this material would be less than 1 µSv.	A package arrived in a sea port in the UK, containing wool contaminated with ^{137}Cs. The dose rate outside the container was 1 µSv h^{-1}. A check was required to see if the consignment was below the exemption levels.
Contaminated metal	
A number of consignments were detected at UK sea ports and one at a UK airport, containing radioactively contaminated steel. These involved four consignments of manufactured steel parts contaminated with ^{60}Co, two consignments of scrap metal with contaminated items containing Caesium and depleted Uranium. The doses to workers from handling these consignments was likely to be only a few µSv. In most cases the manufactured steel parts were sent back to the consignor or released as exempt material. The scrap uranium was sent abroad for recycling.	An ISO arrived in seaport in the UK to be exported overseas. The container was found to contain 25 tonnes of scrap metal. An RPA was consulted and the dose rate on the surface of the container was found to be 15 µSv h^{-1}. The ISO container was relabelled with UN2915 labels and returned back to the consignor, which was a scrap yard in the UK. After further investigation a small radioactive source was located within the scrap metal. The source was a small brass object about 6 cm long. It is likely the source had an activity of less than 2.4 MBq of ^{60}Co, when it was made. The surface dose rate of the source was found to be 200 µ Sv h^{-1}. The source was later placed in lead pot and remained in a store at the consignor's address.
	Two lorries containing scrap metal triggered portal alarms on arrival at a recycling works in the UK. The maximum dose outside the container was 1 µSv h^{-1}. The consignment was passed through the detectors up two six times to check if there was any false alarms. Further monitoring was required.
	A package arrived in a sea port in the UK, containing a number of TV table top metal discs which had been contaminated with ^{60}Co. There were a total of 2540 discs, with an activity concentration 5.7 Bq g^{-1}, giving a total of 25.4 MBq. The dose rate outside the transported container was only 0.3 µSv h^{-1}.
	An ISO container arrived in a sea port in the UK, containing an aircraft counterweight of depleted Uranium, within a load of scrap metal. The surface dose rate outside of the container was measured to be 1 µSv h^{-1}. The surface dose of the depleted Uranium was between 9.5 and 15 µSv h^{-1} and total activity of 703 MBq and an activity concentration of 1.85 10^4 Bq g^{-1}.

Table A1: Summary of Cyclamen events not included in RAMTED database

General information on Cyclamen event category	Additional information on event
Contaminated metal	
	An ISO container arrived in a sea port in the UK, containing contaminated friable scrap copper debris within a load of 20 tonnes of scrap copper. The highest dose rate on the surface of the container was found to be 17 μSv h^{-1}. The contaminated copper contained ^{137}Cs. The container was stored in the consignee's metal recycling yard, waiting for authorisation for removal of the contents and clean up the container.
	An ISO container arrived in a sea port in the UK, containing two boxes of steel bars, some of which were contaminated with ^{60}Co. The dose rate on the surface of the container was found to be 2 μSv h^{-1}. The activity of one of the bars was found 2.6 Bq g^{-1}, with a total activity from the consignment of 3.56 MBq. The two steel bars with a dose rate 3 μSv h^{-1} were sent back to the consignor in India as exempt material. The other bars, which included 3 bars with a surface dose rate of 0.07 μSv h^{-1}, were cleared for release by the Environment Agency.
	Two containers with 5 boxes of metal flanges arrived at a seaport in the UK. The flanges were contaminated with ^{60}Co with a total activity of 142 MBq. The maximum dose rate close to one box 6.6 μSv h^{-1}. The containers were sent back to the consignor.
	A container with elevator parts arrived at a UK airport, contaminated with ^{60}Co. The total activity was found to be up to 20 MBq. The parts were returned in a Type A container and shipped back to the consignor.
Other	
	A package containing a mineral sample arrived in the UK from the USA. The dose rate at the surface of the package was 3.2 μSv h^{-1}, which was below the maximum required for an excepted package The consignment note was incorrect and the UN number UN2910 was required on the package label. The package was re labelled with a new consignment note and forwarded on to the consignee.
	A consignment of mail destined for the US, was misdirected to Lithuania and then the UK. The package was found to contain a mineral sample of ^{226}Ra, contained in a cardboard box, with a surface dose rate of 7.5 μSv h^{-1}. The correct labels and the consignment note did not declare the sample as radioactive material. The box was placed in a lockable ISO container and the German authorities notified.

APPENDIX B Information System Used in the RAdioactive Materials Transport Event Database (RAMTED)

The details of each event are stored in a computer database by the use of descriptive text and alphanumeric coding systems that are described in Table B1 below.

Table B1: Information on transport events recorded in the RAMTED database

Information	Description
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.
Date	The date is recorded in the format DD/MM/YYYY
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.
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. More information on the types of event is given in Table B2
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.
Mode of transport	A code is given to identify the mode of transport for each event. Codes and their definitions are given in Table B4.
Category of material	A code is given to identify the type of material for each event. Codes and their definitions are given in Table B3
Consignor	The name and address of the company/organisation that despatched the shipment is given for each event, if known.
Consignee	The name and address of the destination company/organisation is given for each event, if known.
Carrier	The name and address of the carrier (and sub-carrier, if appropriate) is given for each event, if known.
Description of event	A brief description of the event is given in words.
Activity release	The activity, in TBq, of any radioactive material released into the environment is given for each event.
Worker doses	The maximum dose received by workers from an event is given in mSv, if known.
Public doses	The maximum dose received by the public from an event is given in mSv, if known.
INES ratings	The INES rating assigned to each event is given, if known.
INES Conditions	The INES rating is partly dependent on whether certain conditions applied to the event. A record is made of whether these conditions did apply for the event, if known.
Event implications	Implications such as worker or public safety implications, or environmental implications are given, if known.
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 known.
Emergency action	It is recorded for each event if emergency action was taken, if known.
Additional information	Any additional information, including photos if appropriate, is recorded for each event.
Description of packages	A description of each package is given, if known.
Package type	For each package, a package type is given, using the codes given in Table B5.

Table B1: Information on transport events recorded in the RAMTED database

Information	Description
Transport Index	For each package the Transport Index (TI) is given, if known (see Glossary for a definition of Transport Index)
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.
Activity	The activity of each radionuclide is given, in TBq, if known.

Table B2: Codes used to identify types of events in the RAMTED database

Code	Definition	Description
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.

Table B3: Codes used to identify the type of material of an event in the RAMTED database

Code	Definition
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

Table B4: Codes used to identify modes of transport of an event in the RAMTED database

Code	Definition
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

Table B5: Codes used to identify the type of package in an event in the RAMTED database

Code	Definition
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

Table B5: Codes used to identify the type of package in an event in the RAMTED database

Code	Definition
Exempt Package Codes	
X	Exempt
XP	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

B1 EVENT CLASSIFICATION SYSTEM

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 B6, B7 and B8. Each event is characterised by the allocation of the alphanumeric codes shown in Table B6, and each package is characterised for damage or deficiency by the codes shown in Table B7. The radiological consequences of each event are characterised by the allocation of the codes shown in Table B8.

Table B6: 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 normally the "Dangerous goods transport document"
		2	1	Other shipment documents incorrect or absent, normally the "Instructions in Writing"
		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
		1	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
		1	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
	7 – 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
		7	1	Contamination outside package
	2 – Loss/disposal	1	1	Stolen, and recovered
		1	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

Table B6: Classification of reported transport events

Area/Subject	Item	Sub-item		Description
P – Package	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 regulatory limits.
		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
		3	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 regulatory limits.
		2	1	Other: poor standard of decontamination

Table B7: 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.

Table B7: Classification of package deficiency associated with the transport event

Deficiency Code	Deficiency	Examples/Comments
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 above regulatory limits. 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 B8: Radiological consequences resulting from transport events

Code	Definition	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.