Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2011 Review

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ABSTRACT

This report includes descriptions of thirty eight accidents and incidents involving the transport of radioactive materials from, to, or within the United Kingdom, which occurred in 2011. The number of events reported in 2011 was higher than in 2010 (30 events), and near the top of the range of the number of events that have occurred in the last five year period: 30 events in 2010, 33 events in 2009, 39 events in 2008, 26 events in 2007 and 29 events in 2006. Of the 38 events included in this review 11 involved irradiated nuclear fuel flasks (there were also 8 such events in 2010). Only one of the events reported, involving the transport of a radiopharmaceutical source, resulted in any potentially significant radiation dose.

The details of these events have been entered into the RAdioactive Material Transport Event Database (RAMTED), which now contains information on 1018 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 United Kingdom every year. Accidents and incidents involving these shipments are rare. However, there is always the potential that such an event could lead to the release of the contents of a package, or an increase in radiation level caused by damaged shielding, and result in radiological consequences for transport workers. Such events could also lead to radiological consequences for the public. The Radioactive Material Transport division (RMT) of the Office for Nuclear Regulation (ONR), formerly part of the UK Department for Transport (DfT), has supported work to compile, analyse and report accidents and incidents that occurred during the transport of radioactive materials. Annual reports have been produced since 1989 and this report for the year 2011 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 Centre for Radiation, Chemical and Environmental Hazards (CRCE) of the Health Protection Agency (HPA) on behalf of ONR. The database now contains information on 1018 events that are known to have occurred since 1958.

This report includes descriptions of 38 accidents and incidents involving the transport of radioactive materials from, to, or within the United Kingdom, which occurred in 2011. The number of events reported in 2011 was higher than in 2010 (30 events), and near the top of the range of the number of events that have occurred in the last five year period: 30 events in 2010, 33 events in 2009, 39 events in 2008, 26 events in 2007 and 29 events in 2006. Of the 38 events included in this review 11 involved irradiated nuclear fuel flasks (there were 8 such events in 2010). Only one of the events reported, involving the transport of a radiopharmaceutical source, resulted in any potentially significant radiation dose to an individual.

Almost all the events were of a similar type to those occurring in recent years. The 11 events involving irradiated fuel flasks were mainly due to minor errors in the preparation of the flask or test procedure and were relatively minor in terms of the overall safety of the flasks. Only one of these events involved a low impact collision. 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 to, from and within the UK have been carried out for the years 1958 to 2010 (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; Harvey, 2009; Harvey, 2010; Harvey and Jones, 2011). The objectives of these 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; Harvey, 2009; Harvey, 2010; Harvey and Jones, 2011). 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, the database was reviewed and revised as the original version was approximately twenty years old and had many limitations compared to typical software and hardware specifications of today (Watson, 2004). The relational format of the current version of the database 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 2011 and analyses these events based on the revised classification system and the main event categories. Two other occurrences of interest that did not meet the criteria for inclusion in the database are also briefly described 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 review, information on accidents and incidents has been mostly obtained from official files at the Office for Nuclear Regulation (ONR), (formerly Department for Transport). Information was also obtained from other sources, such as the Civil Aviation Authority (CAA) (www.caa.co.uk), the Department of the Environment, Northern Ireland (www.doeni.gov.uk), the Scottish Environmental Protection Agency (SEPA) (www.sepa.org.uk) and from independent Radiation Protection Advisers (RPAs). Other sources of information for these annual reviews include events occasionally reported to the Environment Agency (EA), records of incidents reported under the National Arrangements for Incidents involving Radioactivity (NAIR) (www.hpa.org.uk/nair/) and incidents dealt with under RADSAFE (www.radsafe.org.uk). Under the NAIR scheme, the police attending an incident involving radioactive material can summon assistance from a health physics expert in the region. Only occasionally do these NAIR events directly involve the transport of radioactive materials. RADSAFE is a consortium of organisations that offer mutual assistance in the event of a transport accident involving radioactive materials belonging to a RADSAFE member and provides early advice and support to the emergency services.

2.1 Reporting of events and criteria

The transport of radioactive materials involves a number of activities, such as the preparation of the package by the consignor, its loading onto a vehicle, and finally its shipment carried out 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 of the package 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 United Kingdom. Events involving shipments from the United Kingdom are also included if the event was as a result of a failing in the United Kingdom. However, events occurring on site, i.e. within the premises of consignors and consignees, 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, 2009; UNECE, 2007), rail (UK Parliament, 2009; OTIF, 2007), sea (UK Parliament, 1997a; MCA, 2006; IMO, 2006) and air (UK Parliament, 2002, 2007; ICAO, 2008). 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 this and previous 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 those reported events that are deemed to be trivial by the Department for Transport, are included in this review.

For transport by road in the United Kingdom, there are two sets of regulations, one for Great Britain (UK Parliament, 2009) and one for Northern Ireland (UK Parliament, 1997b). For transport by road in Great Britain, the regulations (UK Parliament, 2009) require the driver of a vehicle transporting radioactive material to report a notifiable event to the police, fire brigade and consignor. A notifiable event 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 the European Agreement concerning the international carriage of dangerous Goods by Road (ADR) (Class 7) (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.

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 Radioactive Materials Transport Division of the Office of Nuclear regulation, formerly 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 other parties, 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 where there is evidence that the radioactive material had been deliberately transported. 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. Appendix A includes a summary of events which have come to the attention of ONR but did not meet the inclusion criteria.

Incidents involving the transport of dangerous goods by rail are subject to standard reporting procedures. For some years, during the transport of irradiated nuclear fuel (INF) flasks there have been a number of incidents where the train has been stopped following the detection of overheated axles or brakes. The criteria for reporting such events, should they occur, in these reviews are included in this report.

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 radionuclide 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.

As discussed in the 2008 review of events involving the transport of radioactive materials in the UK (Harvey, 2009), 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).

Similarly to previous reviews this report does not include any events that may still be subject to legal proceedings at the time of publication. Any such events will be 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

As mentioned in Section 1, details of the reported events have been entered into the RAdioactive Materials Transport Event Database (RAMTED). A comprehensive review of the events in the database was undertaken a few years ago (Hughes et al, 2006) and includes a description of the systems of reporting and scope of the types of events recorded 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 Appendix B.

The database contained information on 980 events up to and including the events in 2010. The earliest reported events are from 1958. During the collection of information for this current review, details were obtained for 38 events in 2011, which brings the total number in the database to 1018. The collection of information for this review did not reveal any further events from previous years that were not in the database.

Table 1 provides a summary of the main category code for the 38 events reported in 2011. 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, including 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 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 classification system covers a further 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 are listed in the last three columns of Table1 for the 38 events reported in 2011.

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 ('N' in Table 1) 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 ('E' in Table 1). 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' ('L' in Table 1) 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 2011 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)
2011001	10	2	E	AG241	3	N
2011002	1	5	UK	SP141	13	E
2011003	6	4	E	SP181	13	E
2011004	0	2	E	SP222	5	E
2011005	5	1	BMF	FP181	3	N
2011006	2	10	AF	SP141	4	N
2011007	6	0	UK	SP141	13	N
2011008	7	5	A	SP161 SP121 SP341	9	U
2011009	11	4	E	SC411	4	N
2011010	7	0	UK	SP171	12	E
2011011	8	0	BU	SP321	3	N
`2011012	0	2	E	AG221	3	N
2011013	3	0	BF	FP141	3	N
2011014	5	0	IP2P	SP141	3	E
2011015	0	2	E	AG231	3	N
2011016	1	10	IP2	SP341	10	L
2011017	11	0	E	SP181	13	E
2011018	2	4	IP2P	SP141	13	N
2011019	0	2	E	AG241	3	N
2011020	0	1	BMF	FP181	3	N
2011021	6	4	UK	SP151	13	E
2011022	5	1	B	FP181	3	N
2011023	4	1	BMF	FP131	3	N
2011024	4	1	BMF	FP181	3	N
2011025	0	0	E	SC311	6	N
2011026	6	10	BFP	SP111	3	N
2011027	8	0	E	SP141	3	E
2011028	6	10	BFP	SP171	12	E
2011029	4	6	BM	AG231	3	N
2011030	4	1	BMF	FP131	6	N
2011031	4	1	BMF	FP181	3	N
2011032	3	3	BMFP	FP131	3	N
2011033	6	7	IP2P	SC111	3	N
2011034	0	7	E	AG111	3	N
2011035	11	0	BMF	FP131	3	N
2011036	5	1	BMF	FC211	3	N
2011037	5	4	IP2	SP171 FP211	10	E
2011038	5	4	IP2	SC311	3	N

4 EVENTS RECORDED FOR THIS REVIEW

Brief descriptions of the events reported in 2011 are listed below. The level of detail in the descriptions reflects the level of detail contained in the original reports. The package types used are listed in Appendix B.

4.1 Events for 2011

January

2011001. During security screening at an airport, a consignment was found to contain smoke detectors. The consignment was marked and labelled as dangerous goods but not declared as being an excepted package on the air waybill. The consignor and carrier investigated the event and found that the consignor had failed to declare the consignment correctly and the carrier had not inspected the package upon collection. Extra training of carrier staff was suggested.

2011002. A package containing 100 kBq of a sample of ^{226}Ra was incorrectly consigned as exempted material, when it should have been sent in an excepted package. The consignor carried out an internal investigation.

2011003. A consignment of 47 drums containing low level waste from a nuclear power station was sent to an incinerator to be disposed of. The drums were sent as excepted packages. On arrival, one of the drums was found to have a surface dose rate of 9 μSv h^{-1}, which is greater than that allowed for an excepted package (surface dose of 5 μSv h^{-1}). Since the surface dose rate measured on all drums was less than 5 μSv h^{-1} on dispatch from the power station, it is believed that the waste, which contained laundry items, must have been re-distributed during transit. On opening the drum it was found that one item had a surface dose rate of 30 μSv h^{-1}. The incinerator accepted the drum which was disposed of. An internal investigation was carried out at the nuclear power station and in future the consignor will carry out dose rate measurements on items within packages and impose a dose rate limit on individual components and a surface dose limit of 3 μSv h^{-1} for excepted packages.

February

2011004. Two excepted packages containing ^{153}Gd and ^{137}Cs sources were dispatched overseas by air from the UK. On arrival one package was found to be missing, but the courier had not informed the overseas Civil Aviation Authority of this loss. During the investigation of the lost source information was supplied from the consignor about the package to various authorities. The quantity of radioactivity in the packages was small enough that there was no requirement for the source to have been transported as radioactive material.

2011005. A flask arrived at a nuclear power station with two lid-chock locking bolts less than finger tight. Operating procedures recommend that the bolts should be hand tight.

March

2011006. A package containing powder of a uranium compound arrived at an overseas nuclear site from a UK nuclear site and was found to contain two unidentified foreign objects. The objects were red and looked like plastic tape but this was not confirmed.

2011007. When waste ductwork was received from a nuclear facility to be treated at a recycling plant, it was found to contain a higher activity than originally estimated before leaving the consignor. The initial estimate or waste 'fingerprint' showed that the waste was exempted and further tests showed that the activity was higher than exemption levels, due to high amounts of tritium. The waste had therefore been transported incorrectly.

April

No events.

May

2011008. A vial containing 4616 MBq of ^{99m}Tc tagged to hydroxymethylene diphosphonate (HDP) transported from a regional radiopharmacy to a local hospital was found to be fractured when the transport case containing the vial was opened on arrival. The transport case, dispensing cabinet and a member of staff were contaminated. It was assumed that the individual was exposed to 20% of the vial contents for 1 minute. The type of outer tungsten shield being used to contain the inner glass vial was not permitted under the Certificate of Approval for the Type GP 3708B transport package in use. The cause of the vial fracture was not identified but could have occurred during loading, unloading or transport. Contamination monitoring performed gave readings of 2000 cps on the base of the safety cabinet where dispensing operations are carried out. The technician of the Medical Physics Department at the hospital was working alone and only possessed personal monitoring for effective dose. There was no exposure of the general public.

2011009. A gas circulator stator from a nuclear power station was being transported as an excepted package when it moved during transport on a lorry, after leaving the consignor. The lorry returned to the consignor, where the condition of the package was checked. On investigation it was found that there was no damage to the stator and a review of procedures was carried out by the consignor.

2011010. A nuclear company consigned radiometric instruments in a four-drawer cabinet to a marine construction company. On arrival the cabinet was found to be contaminated with beta emitting radionuclides.

2011011. On arrival in the UK, a type B package approved in the Czech Republic, containing a spent source was found to have been tampered with. On close inspection it was found that the tamper proof seal was intact, but lid nuts were missing from the outer packaging. The outer packaging offered only thermal protection, while the inner packaging offered containment. The consignee requested information about the condition of the package on leaving from the overseas consignor. It was found also that the date of the approval certificate for the innermost containment package had lapsed.

2011012. During security screening at an airport, a consignment was found to contain undeclared radioactive material in an excepted package. The package had the correct label, but no information was added to the waybill. The operator carried out an investigation and both the carrier and the consignor amended their booking procedures and reviewed their dangerous goods training for staff.

June

2011013. During manufacture, an inspection of a valve seal for a nuclear fuel flask showed a defect. Some seals of the same defective batch had been fitted to flasks which were in service. The nuclear company owning the flasks were investigated to determine if the defect was an individual case, rather than a batch problem.

2011014. A consignment of 22 drums, each containing a small quantity of fissile material mixed with water and oil, was sent from a nuclear facility to a fuel manufacturing plant. On arrival it was found that the fissile exception limit was exceeded for one of the drums. The drums were industrial packages with low specific activity category II, approved by the consignor. On investigation it was found that there was a discrepancy between the drum scanner at the nuclear facility and checks made by the nuclear fuel manufacturing plant.

2011015. A consignment of radioactive material in an excepted package was carried by an operator, despite the operator's policy of not carrying radioactive material. The investigation found that one of the reasons that this error occurred was because, although the package was booked as radioactive material, the incorrect UN number was given.

2011016. During unloading of drums of uranium trioxide (UO_3) from an ISO container, shipped from overseas, it was found that a drum had been damaged and approximately 1 kg of the contents had spilled on the floor of the ISO container. The area was evacuated, cleaned and monitored before the unloading continued.

2011017. On arrival at a laundry facility a consignment of contaminated clothing transported in an excepted package was found to have a surface dose rate of 12 $\mu Sv\ h^{-1}$, which is greater than the value allowed for this type of package. The dose rate, when leaving the facility, was below the criteria for an excepted package and the difference was thought to be due to a faulty measuring probe. The corrective actions to prevent this occurring in the future are to use two different measuring devices and to ensure that the monitoring takes place earlier in the packaging process.

2011018. On arrival at a nuclear facility, a cylinder containing natural uranium hexaflouride (UF_6) was found to exceed the weight permitted by the certificate of approval. There was no loss of material during transport and the cylinder was inspected for deformation.

July

2011019. During security screening, a consignment was found to contain undeclared radioactive material in a consignment of excepted packages but the waybill did not contain required information about consignment. The freight forwarder agreed that further training would be provided to warehouse and office staff.

2011020. ONR was notified by a nuclear power company about concerns relating to fuel flask maintenance, specifically to the thickness and diameters of the mild steel cover plates, which were believed to be out of specification. The movement of flasks were suspended until the integrity of the flasks was assured.

August

2011021. A consignment of 46 drums of waste oil triggered the radioactive material monitor alarm, when leaving a nuclear site. The load was returned to the site for further monitoring and a number of drums were found to be contaminated with radioactivity. The drums were securely stored and movement of similar packages from the site were embargoed until better site controls were set up. It was believed that the drums were not contaminated on the surface, but that the oil contained radioactivity.

2011022. On receipt of a fuel flask from a nuclear facility the valve seal was found to be faulty. The purpose of the seal was only to stop dirt and was not a primary containment seal. There was no risk of any flask leakage, but the event was investigated because a similar event had happened in the past.

2011023. On receipt of a fuel flask from a nuclear power station, it was found that one of the lid bolts was not tightened to the correct torque level. There was no sign of debris or other visible issues with either thread or bolt. Records showed that, on leaving the power station the bolt had been tightened in excess of the required level. All other bolts were found to be tightened to the correct torque level. Further investigation recommended checks to see if there was an excess of anti-seize compound in the thread which could have caused the bolt to become loose.

2011024. A nuclear company notified a nuclear power station operator about a quality issue concerning extension ‘o’ ring seals of fuel flasks lid bolts. Records of six fuel flasks showed that they had ‘o’ rings fitted from a stock purchase order that covered only five sets, while the purchase order should have covered six sets. There was a negligible safety issue, as purpose of these rings was to prevent debris entering. Movement of the flasks were embargoed until their seals were checked.

September

2011025. On unloading a shipment of contaminated clothing, the door of the container came open. The container was an industrial package Type 2 (IP-2) but in this consignment was being shipped as excepted package. There was no release of material from the container.

2011026. A consignment of three packages containing high level radioactive waste (HLW) was shipped from the UK back to the country of the origin. During an inspection it was found that on one of the packages, the trunnion cap keeping the bolt was undertightened. After the bolt had been tightened correctly, the packages were allowed to continue being transported to the consignee.

2011027. Four portable radiography instruments were shipped as an excepted package from a nuclear power station to a company for calibration. Following calibration, the consignment was despatched back to the nuclear power station via a normal courier route rather than as it had been received, as an excepted package. Corrective actions were taken to ensure that this mistake did not occur again.

October

2011028. On receipt of packages containing high level radioactive waste (HLW) sent from the UK to an overseas nuclear power company (see event 2011026), 5 of 28 containers within one of the TN28 containers had surface contamination levels above that country's acceptance criteria. The containers were re-checked; the surface contamination levels on two of them were found to be below acceptance criteria; however the other three containers required decontamination.

2011029. During a review of a fuel flask design it was found that the transport regulations required shipment approval from the Competent Authority due to the limited ambient temperature range over which the package can be used. As a result of this finding the operator suspended movement of flasks until the required approval was obtained.

November

2011030. A defect on a cover plate weld on a nuclear flask was identified at a nuclear power station. No leak was identified in the flask, but it was transported to a nuclear facility for further investigation and repair. The investigation was deemed necessary because similar problems with defective flasks had been found in the past.

2011031. On receipt of a fuel flask by a nuclear facility, it was found that the water level valve and padlocks of the cover plate of the purge valve were not locked. An investigation showed that the locks were left open after monitoring was carried out. There was little safety implication because the flatrol which carried the flask was padlocked.

2011032. On receipt of a flask from a nuclear facility it was found that one of 16 lid chock locking bolts was loose. This would cause a negligible risk, but the incident was investigated and further checks will be made in the future to ensure no re-occurrence of this event.

2011033. A consignment of low level radioactive waste (LLW) was on route to a waste facility from a nuclear facility, when, on leaving, it triggered the site weighbridge alarm, because it was overweight. It is being investigated whether it was the weight of the waste or the trailer which was the problem.

2011034. A courier van carrying excepted packages to a nuclear site was stopped by police for a routine check. It was discovered that the driver was disqualified from driving. The packages were subsequently delivered by another driver from the same courier company.

December

2011035. A nuclear site reported to an energy company that a flask that had been consigned by them containing graphite samples had been received with the lid bolts not to the correct torque. An investigation was carried out by the energy company.

2011036. A train carrying nuclear fuel flasks travelling from a power station to a nuclear site hit part of a tree that was on the railway line. The train driver reduced the speed of the train but continued to the next railhead where the loco was exchanged; the train then continued on its journey. No derailment occurred and there was no damage to the flask.

2011037. During the unloading of uranyl nitrate liquor (UNL) from a tanker at a nuclear facility, there was a spillage of 150 ml of UNL within a controlled area.

2011038. On arrival at a nuclear facility, the hatch on a tanker containing a shipment of uranyl nitrate liquor (UNL) was found to be unsecured. The hatch was not part of any containment or safety system and therefore there was no safety risk.

5 DISCUSSION OF EVENTS OCCURRED IN 2011

5.1 General

There were 38 events reported during 2011, not including any events that are still subject to legal proceedings at the time of publication of this report.

The number of events in each of the descriptive classifications that occurred in 2011 are given in Table 2. Using primary classification in the three broad categories, 6 (16%) were administrative events, 21 (55%) general shipment events and 11 (29%) events involving shipment of INF flasks. 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). Two events were given more than one event

classification. Considering the primary event classifications only, the most numerous type of event involved 21 instances of general (non-nuclear industry) events, six incidents occurred where the shipment of the package contents or package type was incorrect. In three other incidents there was contamination on the outside of the package, and in two more incidents an excessive dose rate was measured on the surface of the package. In one incident there was contamination inside the package, where files containing liquids had been broken. The remainder of these events ranged from insufficient defective locks to security devices or tie downs, to poor standard of packaging. In one incident radioactive material was found inside a supposedly empty package and lost or damaged packages. Of the eleven incidents that involved INF flask shipments, five were due to minor preparation errors, four were due to defective or loose lid bolts and of the remaining two, one was due to a minor collision that resulted in no loss of containment or damage to the package and the other was due to a defective water level valve. There were six events classed as administrative and these ranged from insufficient worker training, incorrect shipment documents and one incident where the material in the shipment was undeclared as radioactive.

The number of events in 2011 was higher than in 2010. In the last five years, 30 events were reported in 2010, 33 events were reported in 2009, 39 events in 2008, 26 events in 2007 and 29 events in 2006. 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. Over the past 20 years the annual number of events has fluctuated between 11 and 44 with an average of 26 events. The number of events in 2011 was therefore higher than this long-term average, maybe as a result of the increased number of general shipment incidents and events involving INF flasks compared to 2010, although there were fewer administrative errors than in 2010.

Table 3 shows an analysis of the events by material category. During 2011, there were 7 events (19%) involving transport of material which was in an undefined category. Of the remaining events, the next two largest groups (6 events each) involved the transport of residues and radioactive waste. The percentage of events in these categories (16%) was lower than the annual average (26%) for events in the period 1958 to 2004 (Hughes et al, 2006). There were five events involving the transport of irradiated fuel in INF fuel flasks (the other 6 INF flask events involved empty flasks containing residues), two involving new fuel, pre-fuel material and uranium ore concentrate. There were two incidents involving medical and industrial radioisotopes and two involving radiography sources.

Table 4 gives an analysis of the events by mode of transport: 8 events involved shipments by rail (21%), 5 by air (13%), 5 by sea or road and sea (14%), 11 by road (29%), and for 9 (23%) the model of transport was unknown. The proportion of sea events (14%) was higher than the long-term annual average (7%). For rail, the proportion of events in 2011 (21%) is lower than the long-term annual average (24%). The proportion of air events in 2011 (13%) is the same as the long-term annual average (13%).

Table 2. Numbers of 2011 events in each classification

Event classification	Event classification code (see Table A6)	First classification	Second classification	Third classification
Administrative	AG111	1	0	0
	AG221	1	0	0
	AG231	2	0	0
	AG241	2	0	0
Total		6	0	0
General (non-INF) Shipments	SC111	1	0	0
	SC311	2	0	0
	SC411	1	0	0
	SP111	1	0	0
	SP121	0	0	1
	SP141	6	0	0
	SP151	1	0	0
	SP161	1	0	0
	SP171	3	0	0
	SP181	2	0	0
	SP222	1	0	0
	SP321	1	0	0
	SP341	1	1	0
Total		21	1	1
INF Flask shipments	FC211	1	0	0
	FP131	4	0	0
	FP141	1	0	0
	FP181	5	0	0
	FP211	0	1	0
Total		11	1	0

Table 3. Classification* of 2011 events by material category

Material		Administrative			General (non-INF) Shipments		INF Flask shipments			Percentage	
Code	Category	General	Conveyance	Package	Conveyance	Package	Conveyance	Package	Total	2011†	1958-2004
M00	Unknown	4	0	0	1	1	0	1	7	19	N/A‡
M01	Uranium ore concentrate	0	0	0	0	2	0	0	2	5	4
M02	Pre-fuel material	0	0	0	0	2	0	0	2	5	3
M03	New fuel	0	0	0	0	0	0	2	2	5	<1
M04	Irradiated fuel	1	0	0	0	0	0	4	5	13	13
M05	Residues	0	0	0	1	2	1	2	6	16	14
M06	Radioactive wastes	0	0	0	1	5	0	0	6	16	8
M07	Medical & industrial radioisotopes	0	0	0	0	2	0	0	2	5	47
M08	Radiography sources	0	0	0	0	2	0	0	2	5	10
M10	Consumer products	1	0	0	0	0	0	0	1	3	1
M11	Other	0	0	0	1	1	0	1	3	8	<1
Total		6	0	0	4	17	1	10	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 2011 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	2011†	1958-2004
V00	Unknown	0	0	0	1	6	0	2	9	23	N/A‡
V01	Rail	0	0	0	0	0	1	7	8	21	24
V02	Air	4	0	0	0	1	0	0	5	13	13
V03	Sea	0	0	0	0	0	0	1	1	3	7
V04	Road > 1.5 t (lorry)	0	0	0	2	4	0	0	6	16	15
V05	Road < 1.5 t (van)	0	0	0	0	2	0	0	2	5	13
V06	Road Car	1	0	0	0	0	0	0	1	3	3
V07	Road Unknown	1	0	0	1	0	0	0	2	5	<1
V08	Fork-lift truck	0	0	0	0	0	0	0	0	0	22
V09	Other	0	0	0	0	0	0	0	0	0	<1
V10	Road and sea	0	0	0	0	4	0	0	4	11	<1
V11	Road and rail	0	0	0	0	0	0	0	0	0	<1
V12	Road and air	0	0	0	0	0	0	0	0	0	<1
Total		6	0	0	4	17	1	10	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 of Appendix B; definitions of the codes used to identify package conditions are given in Table B7 of Appendix B. In 22 of the 38 events there was no damage or threat of damage to the packages involved. For two 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 one event there was no report of damage to the package or increase in dose rate, but there was a high potential to cause damage. For two events there was defective or poor condition of the package, but without increase in dose rate or loss of containment. There was one event where the package was damaged with increase in dose rate without loss of containment. Two events involved damaged packages resulting in loss of containment and two events where contamination was found outside the package. There were six events that involved improper packaging with no 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	A	AF	B	BF	BFP	BM	BMF	BMFP	BU	E	IP2	IP2P	UK	Total
D03	No damage or threat of damage to package	0	0	1	1	1	1	7	1	1	6	1	2	0	22
D04	No report of damage or increase in dose rate, but potential to cause damage to the package (lower category)	0	1	0	0	0	0	0	0	0	1	0	0	0	2
D05	No report of damage or increase in dose rate, but potential to cause damage to the package (upper category).	0	0	0	0	0	0	0	0	0	1	0	0	0	1
D06	Defective or poor condition, without increase in dose rate or loss of containment	0	0	0	0	0	0	1	0	0	1	0	0	0	2
D09	Damaged with increase in dose rate but without loss of containment.	1	0	0	0	0	0	0	0	0	0	0	0	0	1
D10	Damage with loss of containment	0	0	0	0	0	0	0	0	0	0	2	0	0	2
D12	Contamination outside package	0	0	0	0	1	0	0	0	0	0	0	0	1	2
D13	Improper package with loss of shielding or containment – inappropriate contents	0	0	0	0	0	0	0	0	0	2	0	1	3	6
Total		1	1	1	1	2	1	8	1	1	11	3	3	4	38

5.3 Radiological consequences

Table 6 shows the likely radiological consequences for the events in 2011, analysed by material category. Table B8 in Appendix B provides a description of the categories for radiological consequences. Of the 38 events, 26 were categorised as ‘None’, indicating no radiological consequences for those events and 10 were categorised as ‘Extremely low, not assessed’. There was one event categorised as ‘Assessed, lower category’ where the effective dose was estimated to be below 1 mSv. It involved a damaged drum containing uranium ore concentrate that had spilled some of its contents onto the floor of an ISO container. The assessed dose for this event was estimated to be around 10 µSv. There was one event in the ‘Assessed, upper category’ involving effective doses above 1 mSv or extremity doses over 50 mSv. This event involved a vial containing a medical isotope that was opened on arrival and found to be broken. The effective dose

was estimated to be below 1 mSv, that is below the limit for this category but the dose to the finger tip was estimated to be greater than 50 mSv, based on an assessment which was carried out at the receiving hospital.

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	6	1	0	0	7
M01	Uranium ore concentrate (UOC)	0	1	1	0	2
M02	Pre-fuel material	2	0	0	0	2
M03	New fuel	2	0	0	0	2
M04	Irradiated fuel	5	0	0	0	5
M05	Residues (inc. discharged INF flasks)	4	2	0	0	6
M06	Radioactive wastes	3	3	0	0	6
M07	Medical and industrial radioisotopes	0	1		1	2
M08	Radiography sources	1	1	0	0	2
M10	Consumer products	1	0	0	0	1
M11	Other	2	1	0	0	3
Total		26	10	2	0	38

6 CONCLUSIONS

During 2011 there were 38 accidents and incidents, involving the transport of radioactive materials from, to, or within the United Kingdom and this report includes descriptions of each event. The number of events reported in 2011 was higher than in 2010 (30 events) and near the top of the range of the number of events that have occurred in the last five year period: 33 events in 2009, 39 events in 2008, 26 events in 2007, 29 events in 2006 and 16 events in 2005. The number of events in 2011 was higher than the annual average over the past 20 years (26 events). This variation can be attributed to statistical fluctuation and is not indicative of any long-term trend. The events reported for 2011 are in general similar to those reported in recent years.

One of the events that occurred in 2011 resulted in a potentially significant radiation doses to an individual. This event involved a vial containing a medical isotope which was damaged and broken during transit. Another event, due to the spillage of uranium ore from a damaged drum, may have resulted in an effective dose to an individual of about 10 μSv.

The details of the 38 events that occurred in 2011 and described in this review have been added to the RAdioactive Materials Transport Event Database (RAMTED), bringing the total number of reported events since 1958 to 1018.

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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.
NORM	Naturally Occurring 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 (TI)	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 portal (air, sea and scrap yard) radiation detector events not included as transport event

Table A1 summarises events in which the consignor could not be reasonably expected to recognise that they involved radioactive material and they were therefore not classified as transport events.

Table A1. Summary of portal detector events not included in RAMTED database

General information on portal detector event category	Additional information on event
Contaminated metal	
A consignment was detected at a UK seaport containing radioactively contaminated steel	On arrival at a UK port an ISO container was found to contain radioactively contaminated scrap metal. A public notice was issued to allow for movement for unloading, inspection and removal of contaminated products.
Source within scrap metal	
A consignment was detected at a UK seaport containing a radioactive source within scrap metal. The dose from handling the source is likely to be less than 1 µSv.	A consignment of scrap metal, triggered radiation detectors when it arrived at a UK seaport. The consignment was found to contain a moisture gauge containing a ^{239}Pu source in a scintillation tube. The gauge was monitored and the surface gamma dose was 0.14 µSv h^{-1}, but with a neutron dose of 3 µSv h^{-1}. The consignee had assumed that the gauge would have been dismantled before being sent, leaving the radioactive component with the consignor overseas. The consignor therefore sent the package without the appropriate documentation relating to transport of radioactive material. An authorisation was issued for onward transport from the port to the consignee.

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 A1 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 A2
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 A4.
Category of material	A code is given to identify the type of material for each event. Codes and their definitions are given in Table A3
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 A5

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
Exempted package codes	
X	Exempted
XP	Presumed to be Exempted
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 A6, A7 and A8. Each event is characterised by the allocation of the alphanumeric codes shown in Table A6 and each package is characterised for damage or deficiency by the codes shown in Table A7. The radiological consequences of each event are characterised by the allocation of the codes shown in Table A8.

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
		8	1	Excessive dose rate
	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

Table B6. Classification of reported transport events

Area/Subject	Item	Sub-item		Description
		5	1	Radioactive material in scrap metal
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.