Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK - 2004 Review

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ABSTRACT

During 2004 there were 20 accidents and incidents, involving the transport of radioactive materials from, to, or within the UK and this report includes descriptions of each event. None of these reported events involved significant radiological consequences. The number of events in 2004 was greater than the 11 reported for 2003, but still much lower than the annual number of events reported for 2002 (28) and 2001 (36). This reduction is likely to represent a statistical variation in the annual number of events, rather than indicating an overall trend. However, in recent years the number of incidents of excess contamination on irradiated nuclear fuel flasks has significantly decreased. There were no events involving excess contamination on these flasks in 2003 and only one in 2004. The details of these events have been entered into the Radioactive Material Transport Event Database (RAMTED), which now contains information on 806 events that are known to have occurred since 1958.

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EXECUTIVE SUMMARY

Up to half a million packages containing radioactive materials are transported to, from and within the UK annually. Accidents and incidents involving these shipments are rare. However, there is always the potential for such an event, which could lead to a release of the contents of a package or an increase in radiation level caused by damaged shielding. These events could result in radiological consequences for transport workers. As transport occurs in the public environment, such events could also lead to radiological consequences for the public. The UK Department for Transport (DfT), together with the Health and Safety Executive (HSE) have supported work to compile, analyse and report on accidents and incidents that occur during the transport of radioactive materials. Annual reports have been produced since 1989, and this report for the year 2004 is the latest in this series. The details of these events are recorded in the Radioactive Materials Transport Event Database (RAMTED), which is maintained by the Health Protection Agency Radiation Protection Division (HPA-RPD) on behalf of DfT and HSE.

During 2004 there were 20 accidents and incidents, involving the transport of radioactive materials from, to, or within the UK and this report includes descriptions of each event. None of these reported events involved significant radiological consequences. The number of events in 2004 was greater than the 11 reported for 2003, but still much lower than the annual number of events reported for 2002 (28) and 2001 (36). This reduction is likely to represent a statistical variation in the annual number of events, rather than indicating an overall trend. However, in recent years the number of incidents of excess contamination on irradiated nuclear fuel flasks has significantly decreased. There were no events involving excess contamination on these flasks in 2003 and only one in 2004.

The events reported here have been entered into the Radioactive Material Transport Event Database (RAMTED), which now contains information on 806 events that are known to have occurred since 1958.

CONTENTS

1 INTRODUCTION

Reviews of the accidents and incidents involving the transport of radioactive materials within, to and from the UK have been carried out for the years 1958 to 2003 (Gelder et al, 1986; Shaw et al, 1989; Hughes and Shaw, 1990-1999, 1996b; Hughes et al, 2001a, 2001b; Warner Jones et al, 2002a, 2002b; Warner Jones and Jones, 2004; Watson and Jones, 2004). The objectives of those reviews were:

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

The initial reviews (Gelder et al, 1986; Shaw et al, 1989) were supplemented by annual analyses (Hughes and Shaw, 1990-1999; Hughes et al, 2001a, 2001b; Warner Jones et al, 2002a; Warner Jones and Jones, 2004; Watson and Jones, 2004). 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). This 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).

As the original database was approximately twenty years old and had many limitations compared to typical software and hardware specifications of today, it was reviewed and revised in 2004 (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 2004 and gives analyses of these events, based on this revised classification system and the main event categories.

2 DATA COLLECTION AND ANALYSES

For this review and previous studies (Gelder et al, 1986; Shaw et al, 1989; Hughes and Shaw, 1990-1999; Hughes et al, 2001a, 2001b; Hughes and Shaw 1996b; Warner Jones et al, 2002a, 2002b; Warner Jones and Jones, 2004; Watson and Jones, 2004), information on accidents and incidents was obtained from a number of sources. Most of the information was obtained from official files at the Department for Transport (DfT) (www.dft.gov.uk) and the Health and Safety Executive (HSE) (www.hse.gov.uk). Information was also obtained from other sources, such as the Civil Aviation Authority (CAA) (www.caa.co.uk), the Department of the Environment, Northern Ireland (www.doeni.gov.uk) and from independent Radiation Protection Advisers (RPA). Other

sources of information for these annual reviews include events occasionally reported to the Environment Agency (EA) and records of incidents reported under the National Arrangements for Incidents involving Radioactivity (NAIR). Under the NAIR scheme, the police attending an incident involving radioactive material can summon assistance from a health physics expert in the region. However, only occasionally do these NAIR events directly involve the transport of radioactive materials.

2.1 Reporting of events and criteria

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

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

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

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

a radioactive material is lost, escapes or is unlawfully removed from the vehicle carrying the material;
b any package carried in or on a vehicle is opened or otherwise damaged (whether or not the package is still in or on the vehicle);
c the vehicle carrying the radioactive material overturns (including being turned on its side) or suffers serious damage or is involved in a fire; or

d a radiological emergency occurs;
e there is an imminent risk of loss of product;
f a person has suffered personal injury;
g material damage or environmental damage has occurred, or
h the authorities are involved.

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

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

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

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

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

A system has been established for rating events that occur in the nuclear industry, by the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD), and is known

* 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.

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

3 DATABASE OF REPORTED EVENTS

The details of the reported events have been entered into a computer database: the Radioactive Materials Transport Event Database (RAMTED). A comprehensive review (Hughes and Shaw, 1996b) of the events in the database includes a description of the systems of reporting and scope of the types of events included in the database. Some of the information in the database is held in coded form to facilitate analysis. Descriptions of the information stored, including the coding system used to classify events, are given in the Appendices.

The database of accidents and incidents contained information on 786 events, up to and including the events in 2003. The earliest reported events were from 1958. During the collection of information for this current review, the details were obtained for 20 events in 2004 which brings the total number in the database to 806. 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, in chronological order. Brief descriptions of these events are included in the database record of each event. Other details that are entered in the database record for each event are listed in Appendix A. This includes a broad description of the event as either an accident or incident that occurred during either the transport or handling phase (TI, TA, HI and HA). In addition, events where the main occurrence was radioactive contamination of external surfaces of intact packages, or conveyances, are recorded as category C.

In order to give a better description of the type of event, a classification system has been developed for the RAMTED database that gives more information than the broad descriptive categories noted above. This system enables events to be grouped into logical categories, and facilitates analyses. The classification system covers three aspects: a descriptive classification, the effect of the event on the package and the level of radiological consequences. The descriptions of the codes used in this classification system are given in Appendix B, as detailed in Tables B1, B2 and B3. The classification codes for these three aspects are listed in the last three columns of Table 1 for the 20 events reported in 2004. The first four columns of Table 1 give, respectively, the event identifiers listed in Section 4, the material category code, the transport mode code and

the package type. The keys to the material category and transport mode codes are given in Appendix A.

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

4 EVENTS RECORDED FOR THIS REVIEW

Brief descriptions of the events reported in 2004 are listed below. The package types used are listed described in Appendix A. Appendix A also provides a definition of the Transport Index. The identifying reference numbers allocated to each event are not necessarily in date order.

January

2004001 A consignment was despatched from the UK to overseas. On arrival one of 60 Type AF packages containing UO_2 powder (enriched uranium) was found to have an internal lid not properly secured. It was found that 12 of the 16 securing bolts had not been fitted and 4 were loosely fitted, but no leakage of the contents had occurred. The consignor was notified and following this, DfT served an improvement notice on the consignor.

February

No events.

March

2004002. A damaged industrial radiography projector with a special form capsule stuck inside was delivered to a UK firm from overseas. The package was Type B(U) and had a Transport Index of 0.3. The special form capsule contained ^{192}Ir (3700 GBq activity). There were concerns over the quality of the package for a number of reasons: there was apparent lack of maintenance; the operating shaft was damaged; non-standard parts had been fitted; the identification label and front cap were missing; an unauthorised welding repair had been carried out on the handle and holes had been drilled in the outer case. The package was later returned to the consignor. There were no unusually

elevated dose rate levels around the package and therefore there were no radiological consequences.

2004004. A van carrying eight 210 litre IP-2 drums of low specific activity material (uranium contaminated citric acid) between two nuclear sites swerved into a ditch about 1 km off site. Some of the drums in the rear of the van had tipped over but no leakage was apparent at the time of the incident. The emergency services were called and, on inspection of the drums during recovery, found that one drum had leaked approximately 10 ml onto the road. The contamination of 35 Bq cm^{-2} was cleaned up from the road and the drums returned to the site of departure.

2004005. A loaded INF flask being shipped between two nuclear sites was found to have two test cover plugs missing. These are plugs used to protect flask components, but despite the absence of the plugs the integrity of the flask was unimpaired. There were no radiological consequences.

2004003. Scrap metal transported from a scrap merchant to a recycling facility was found to be contaminated with radioactive material. On arrival at the recycling facility it was partly crushed before radiation detectors sounded. It was then discovered that within the scrap metal were 30 old aircraft escape hatches, each painted with 12 luminous markers containing ^{226}Ra (approximate activity of 37 MBq per hatch). This paint was partly fixed and partly loose. A maximum dose rate of 300 µSv h^{-1} was recorded at contact with one of the markers. Dose rates around a pile of the hatches ranged up to 20 µSv h^{-1}. The conveyance was also found to be contaminated with some of the loose paint. The material that had not been crushed was returned to the scrap merchants where it had originally come from. The metal had at no time been packaged correctly or labelled as radioactive material. Requirements for driver training had also not been complied with and no contingency plans were in place. After the radioactive material had been discovered further movement that was non-compliant with the transport regulations occurred. DfT imposed a prohibition notice preventing further movement of the contaminated scrap metal unless compliant with the regulations. The incidental exposure of the workers to this paint may have resulted in very low doses after the discovery of the presence of radioactive material.

2004017. A van carrying a small quantity of a medical radionuclide (an excepted package containing ^{125}I (0.2 MBq) to be administered to a patient) from one hospital to another was involved in an accident with three other vehicles. The van was unfit to drive, and the driver was shaken but unhurt. The excepted package was not damaged, and an inspection of the vehicle confirmed that no contamination was present. The excepted package was transferred to another vehicle and returned to its point of departure, where further checks confirmed that the packaging and contents had not been damaged.

April

2004006. A courier's vehicle delivering packages to hospitals was involved in an accident while travelling on a motorway. Some drums containing class 8 liquid UN 3267 (corrosive liquid) were thrown from the vehicle and hit by another vehicle. As well as the corrosive liquid it was confirmed that radioactive material was present, including ^{99}Mo

and ^{201}Tl. It is understood that the dangerous goods classification was made on the basis that the corrosive material was the primary hazard. A NAIR respondent attended and found the packages to be intact and that no leakage had occurred. The packages were transferred to another vehicle and continued on their journey.

2004007. A van travelling from one nuclear power station to another was found on arrival to contain items of equipment that were contaminated. The contamination level was very low and assessed as less than 4 Bq cm^{-2}. The vehicle was impounded and the driver was monitored. There was no contamination found on the driver, though a survey of the vehicle found some contamination over one of the wheel arches. A non-compliance declaration was issued in relation to the regulatory requirements for transport. However, the contamination levels were low and the radiological consequences were extremely low.

2004008. One out of a consignment of 83 Type AF category* II-Yellow packages containing enriched UO_2 powder, that had been despatched from a UK nuclear site to an overseas consignee, was found on arrival to have the thermal insulation missing from the lid. An improvement notice was still in effect for these package types following the event in January described above. A prohibition notice was therefore served to prevent any further movements of these packages pending improvements to procedures.

May

2004009. A parked vehicle at an engineering works contained radiography equipment with an ^{192}Ir source (activity 481 GBq), but did not bear the correct vehicle placards. The vehicle belonged to visiting radiographers and was understood to have been driven to the site without the correct placards being displayed.

June

2004010. A carrier's vehicle loaded with an empty freight container was driven to a scrap merchant's premises to collect a load of scrap metal. Prior to loading the container, it was checked and radioactive contamination was found. The police and the owner of the container were informed. The vehicle carrying the empty container was escorted to another site, where further investigations found 10 areas of contamination inside the container. The contamination levels were low, with up to 0.4 µSv h^{-1} measured externally, and the radiological consequences for the workers involved were therefore extremely low.

2004011. A vehicle was carrying a drum, with a Transport Index of 5, which contained ^{60}Co (activity 233 GBq) in solid form in several stainless steel capsules. Not long after leaving a site the driver heard a bang, and noticed a small increase in the dose rate recorded on his dosimeter. He therefore immediately returned to the despatch site, where the drum was found resting on its side with a minor dent in its surface. The

* 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 1m from the surface, and must be labelled accordingly.

maximum level of radiation at the surface of the drum was found to have increased, to just over 2mSv h^{-1}. There had been no release of radioactivity. Although the tie-down straps inside the vehicle were still in place after the incident, the drum had shifted and toppled over. The radiation dose rate at the driver's position had increased slightly due to the changed position of the drum but was within the normal range for workers carrying out these operations. The drum was off-loaded at the site and an investigation carried out to understand why the drum had toppled over and why the dose rate had changed as a result. The organisation has, as a result, revised its arrangements for securing packages in vehicles and the design of its shielded assembly for this type of package.

2004012. A Type A package containing a ^{192}Ir industrial radiography source was despatched to a nuclear site from an engineering company. The original activity of the source was 400 GBq, but it had decayed to 185 GBq on the day of shipment. On arrival the package was found to have blank category II-Yellow package labels and did not carry other required details. The package was not marked with the name of the consignor or the consignee. Also, the package Type and category label were obscured and the consignment documents were found to be incorrectly completed. A crack was also found in the package case, though not in the internal source container. DfT served a prohibition notice on this package.

2004013. A package, containing a substance detection instrument was despatched from an airport to a UK company with no indication that it contained radioactive material. It was then mislaid by the courier and there is no record of the package being subsequently found. The instrument contains a ^{63}Ni source with an activity of 370 MBq, which represents a very low radiological hazard.

July

No events.

August

2004015. A loaded flask was despatched from a Magnox nuclear power station to another nuclear site, and on arrival the top and sides of the flask were monitored with no elevated levels being found. On despatch back to the power station monitoring of the base as well as the top and sides identified radioactivity. On analysis, debris found on the base of the flask was identified to be Magnox alloy, contaminated with ^{95}Zr, and was assumed to have arrived with the flask from the power station. The contamination level was low and the radiological consequences to the loading and monitoring workers were therefore extremely low.

September

2004014. There was a technical problem with a skip containing radioactive material due to be despatched from a nuclear power station to another nuclear site, so a replacement skip was assigned. However, one set of transport documents was not adjusted to note the change of skip number and the unadjusted set of paperwork was sent off-site with the skip.

2004016. A package despatched by air from the UK arrived at an overseas airport. During handling it was noticed that the outer wooden crate containing a package was partially open and it was found to contain an industrial radiography container labelled “Type A, UN3382” although the outer packaging was unlabelled. A shipper’s declaration accompanied the consignment and it had been subjected to acceptance checks prior to loading in the UK.

October

No events.

November

2004018. A number of sealed IP-I drums containing depleted uranium swarf were in transit from a nuclear site to a firm dealing with radioactive waste. On inspection, 30 g of a substance, believed to be depleted uranium swarf, was found adhered to the underside of one sealed drum. No evidence of a leak in the drum was found. It was also found that two drums, out of 72 in the consignment, were slightly overweight compared to the 202 kg weight allowed by the certificate of approval. The two drums were found to be each about 216 kg.

2004020. A trailer used at a nuclear site for on-site movements was cut up and placed in a skip and removed from the site for disposal. A similar trailer being prepared for disposal was monitored and found to be contaminated with what was believed to be fixed ^{137}Cs. It was decided that the first trailer should be returned to site for monitoring. There had therefore been an oversight in that the first trailer had not been monitored before leaving the site.

December

2004019. A Type B(U) category II-Yellow package, containing decayed isotopes of ^{75}Se (activity 266.4 GBq) and ^{192}Ir (activity 118.4 GBq) was found to have no radioactive material labels on the outer packaging. The package had been consigned by air from overseas to a UK company. The consignor said that the package had been correctly labelled and packaged on despatch. The error is understood to have occurred when the freight forwarding company had put the package into a cardboard box and not transferred or re-affixed labels to the new outside packaging.

5 DISCUSSION OF 2004 EVENTS

5.1 General

There were 20 events reported during 2004, not including any events that are still subject to legal proceedings at the time of publication. This is a greater number than the 11 that occurred in 2003, but about half of the typical annual number of events that have occurred in the period between 1999 and 2002, when the annual number of events

ranged from 28 to 40. The annual number of events may be expected to show a random variation and there is little evidence for an overall trend. Over the past 20 years the annual number of events has fluctuated between eight and 44. However, the number of events involving excess contamination on INF flasks has decreased over recent years.

The numbers of events in each of the descriptive classifications that occurred in 2004 are given in Table 2. Only 4 events were given more than one event classification. Considering the primary event classifications only, the most numerous types of event (three events each) were insufficient or incorrect package labelling and events with collision/accident without fire. There were two events with incomplete packaging as the primary classification, and two events where the primary classification was contamination outside the package.

Tables 3 and 4 show the distribution of the events by primary classification in the three broad categories: 6 administrative events, 12 general shipment events and 2 INF flask shipment events. This distribution expressed as a percentage of the total is 30%, 60% and 10%, which may be compared with a distribution of 13%, 63% and 24% for all the events in the period 1958 to 1994 (Hughes and Shaw, 1996b). Compared to the long-term pattern, the distribution for 2004 has more events in the administration category and fewer events in the INF flask category.

Table 3 also shows an analysis of the events by material. During 2004, the majority of events (five events) involved the transport of medical and industrial radioisotopes. The percentage of events (25%) involving medical and industrial isotopes was significantly below the long-term pattern (50%) for events in the period 1958 to 1994 (Hughes and Shaw, 1996b). There were four events (20%) with radiography sources, four (20%) with radioactive wastes, two events (10%) involving pre-fuel material, two (10%) involving irradiated fuel, one (5%) with no radioactive material, and two (10%) where other types of material were involved.

Table 4 gives an analysis of the events by mode of transport, and shows that three events involved shipments by rail (15%), two were by air (10%), none were by sea, and twelve were by road (60%), (counting both lorries and vans). The proportion of road events (60%) was higher than the long-term trend (28%), while for rail the proportion of events in 2004 (15%) is lower than that in recent years. The number of events involving fork-lift trucks is at zero for the second year, compared to the long-term trend of 30%.

5.2 Effects on packages

Table 5 shows an analysis of the events in terms of the package condition. In six of the 20 events there was no damage to the packages involved. There were three events that had packages that were in poor condition or defective but where there was no increase in dose rate or loss of contents, and two events where there was no report of damage or increased dose rates but packages were subject to major potential for damage. Three events had damaged packages: one event had a package damaged with loss of containment, one event had a package damaged with no loss of containment but an increase in dose rate, and one event had a package with minor damage and no increase in dose rate or loss of containment. In four events contamination was found outside the

package, one event had contamination inside the package and one event involved a contaminated conveyance.

5.3 Radiological consequences

Table 6 shows the likely radiological consequences for the events in 2004, analysed by material category. Of the 20 events, 10 were categorised as "Extremely low, not assessed", and 10 as "None", indicating no radiological consequences for those events. It is estimated, so far as possible from the information available, that only one of the events in 2004 could have led to any excess exposure, above trivial levels. This was event 2004003, which concerned the transport of scrap aircraft components contaminated with radium luminised paint. Measurements indicated that workers could have been exposed to low dose rates in the order of a few microsieverts per hour while in the vicinity of the scrap, and it is therefore unlikely that any significant exposures were received while being handled at the scrap yard. After the discovery of the presence of radioactive material the radiological consequences was subject to control. However before the discovery some very minor exposure could have been received during loading and transport of the scrap material. From the general account of the exposure situation, it is estimated that the dose to the workers involved is unlikely to have exceeded a few microsieverts.

6 CONCLUSIONS

There were 20 reported events in 2004, which is greater than the number reported in 2003 but still less than annual number of events typical of recent years. This reduction is due in part to the lower incidence of INF flask contamination, but is mainly due to statistical variation rather than an overall trend.

Only one event during 2004 had the potential to give rise to exposures of transport workers above trivial levels, but it is unlikely that any significant doses were received from this event.

The details of the 20 events in 2004 have been included in the database (RAMTED), bringing the total number of reported events since 1958 to 806.

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8 TABLES

TABLE 1 Summary list of events included in the 2004 review*

Event number	Material category	Transport mode	Package type	Event classification code(s)	Effect on package code	Radiological consequence code
(Section 4)	(Section A8)	(Section A7)	(Section A17)	(Table B1)	(Table B2)	(Table B3)
2004001	M02	V10	AF	SP121	D06	N
2004002	M08	V07	BU	SP111	D06	N
2004003	M06	V04	SC	SP251	D12	E
2004004	M06	V04	IP2	SC511	D10	E
				SP331		
2004005	M04	V01	BP	FP181	D03	N
2004006	M07	V05	IPP	SC511	D05	E
2004007	M11	V05	UPY	SP171	D12	E
				AG241		
2004008	M02	V10	AF	SP121	D06	N
2004009	M08	V05	BP	AC111	D03	N
2004010	M09	V04	CV	SP161	D02	E
2004011	M07	V05	A	SP331	D09	E
2004012	M08	V07	A	AP111	D07	N
2004013	M07	V12	EP	SP222	D05	E
				AP111		
				AG241		
2004014	M06	V01	UK	AG221	D03	N
2004015	M04	V01	BP	FP321	D12	E
2004016	M08	V02	A	AP111	D03	N
2004017	M07	V05	E	SC511	D03	N
2004018	M06	V07	IP1	SP171	D12	E
				SP141		
2004019	M07	V02	BU	AP111	D03	N
2004020	M11	V04	UPY	AG311	D11	E

Notes

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

TABLE 2 Numbers of 2004 events in each classification

Event classification code (See Table B1)	1st classification	2nd classification	3rd classification
AC111	1	0	0
AG221	1	0	0
AG241	0	1	1
AG311	1	0	0
AP111	3	1	0
FP181	1	0	0
FP321	1	0	0
SC511	3	0	0
SP111	1	0	0
SP121	2	0	0
SP141	0	1	0
SP161	1	0	0
SP171	2	0	0
SP222	1	0	0
SP251	1	0	0
SP331	1	1	0
Total	20	4	1

TABLE 3 Classification* of 2004 events by material category

Material		Administrative			General (non-INF) shipments		INF flask shipments		Totals	%†	%, 1958-1994
Code	Category	General	Conveyance	Package	Conveyance	Package	Conveyance	Package			
M00	Unknown	0	0	0	0	0	0	0	0	0	N/A‡
M01	Uranium ore concentrate	0	0	0	0	0	0	0	0	0	6
M02	Pre-fuel material	0	0	0	0	2	0	0	2	10	2
M03	New fuel	0	0	0	0	0	0	0	0	0	1
M04	Irradiated fuel	0	0	0	0	0	0	2	2	10	12
M05	Residues	0	0	0	0	0	0	0	0	0	14
M06	Radioactive wastes	1	0	0	1	2	0	0	4	20	2
M07	Medical & industrial radioisotopes	0	0	1	2	2	0	0	5	25	50
M08	Radiography sources	0	1	2	0	1	0	0	4	20	11
M09	No radioactive material	0	0	0	0	1	0	0	1	5	N/A‡
M10	Consumer products	0	0	0	0	0	0	0	0	0	N/A‡
M11	Other	1	0	0	0	1	0	0	2	10	2
Totals		2	1	3	3	9	0	2	20	100	100

Notes

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

† With a sample size of 20 events, interpretation of these rounded percentages must be made with care.

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

TABLE 4 Classification* of 2004 events by mode of transport

Mode of transport		Administrative			General (non-INF) shipments		INF flask shipments		Totals	%†	%, 1958-1994
Code	Category	General	Conveyance	Package	Conveyance	Package	Conveyance	Package			
V00	Unknown	0	0	0	0	0	0	0	0	0	N/A‡
V01	Rail	1	0	0	0	0	0	2	3	15	24
V02	Air	0	0	2	0	0	0	0	2	10	9
V03	Sea	0	0	0	0	0	0	0	0	0	9
	Road:										
V04	> 1.5 t (lorry)	1	0	0	1	2	0	0	4	20	12
V05	< 1.5 t (van)	0	1	0	2	2	0	0	5	25	12
V06	Car	0	0	0	0	0	0	0	0	0	4
V07	Unknown	0	0	1	0	2	0	0	3	15	N/A‡
V08	Fork-lift truck	0	0	0	0	0	0	0	0	0	30
V09	Other	0	0	0	0	0	0	0	0	0	0
V10	Road and sea	0	0	0	0	2	0	0	2	10	N/A‡
V11	Road and rail	0	0	0	0	0	0	0	0	0	N/A‡
V12	Road and air	0	0	0	0	1	0	0	1	5	N/A‡
Totals		2	1	3	3	9	0	2	20	100	100

Notes

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

† With a sample size of 20 events, interpretation of these rounded percentages must be made with care.

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

TABLE 5 Nature of package deficiency by type of package

Package deficiency or damage		Type of package* (as specified or assumed)							
Code[†]	Description	Excepted	A	B	IP	UK	CV	Others[‡]	Total
D02	Contaminated conveyance	0	0	0	0	0	1	0	1
D03	No damage or threat of damage to package	1	1	3	0	1	0	0	6
D05	No report of damage/inc. dose rate. Potential for damage (upper category)	1	0	0	1	0	0	0	2
D06	Defective/Poor condition. No increase in dose rate or loss of containment	0	2	1	0	0	0	0	3
D07	Minor damage. No increase in dose rate or loss of containment	0	1	0	0	0	0	0	1
D09	Damaged. Increase in dose rate. No loss of containment (Shielding loss only)	0	1	0	0	0	0	0	1
D10	Damaged with loss of containment	0	0	0	1	0	0	0	1
D11	Contamination inside package	0	0	0	0	0	0	1	1
D12	Contamination outside package	0	0	1	1	0	0	2	4
Totals		1	5	5	3	2	1	3	20

Notes

* See Section A22.

[†] See Table B2 for examples.

[‡] Including an unpackaged item, an item whose packaging did not match any of the recognised package types, and items of scrap metal.

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
M02	Pre-fuel	2	0	0	0	2
M04	Irradiated fuel	1	1	0	0	2
M06	Radioactive wastes	1	3	0	0	4
M07	Med & Industrial Radioisotopes	2	3	0	0	5
M08	Radiography sources	4	0	0	0	4
M09	No radioactive material	0	1	0	0	1
M11	Other	0	2	0	0	2
Totals		10	10	0	0	20

Notes

* See Table B3 for description of categories

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

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

A1 EVENT ID

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

A2 DATE

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

A3 SOURCE

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

A4 TYPE OF EVENT

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

TA – transport accidents

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

TI – transport incidents

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

HA – handling accidents

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

HI – handling incidents

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

C - contamination

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

A5 REGIONAL LOCATION OF EVENT

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

A6 MODE OF TRANSPORT

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

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

A7 CATEGORY OF MATERIAL

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

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

A8 CONSIGNOR

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

A9 CONSIGNEE

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

A10 CARRIER

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

A11 DESCRIPTION OF EVENT

A brief description of the event is given in words.

A12 ACTIVITY RELEASE

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

A13 WORKER DOSES

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

A14 PUBLIC DOSES

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

A15 INES RATINGS

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

A16 INES CONDITIONS

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

A17 EVENT IMPLICATIONS

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

A18 NUCLEAR INDUSTRY AND AIRPORT EVENTS

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

A19 EMERGENCY ACTION

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

A20 ADDITIONAL INFORMATION

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

A21 DESCRIPTION OF PACKAGES

A description of each package is given, if known.

A22 PACKAGE TYPE

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

Type A Package Codes:

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

Type B Package Codes:

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

Type C Package Codes:

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

Excepted Package Codes:

E	Excepted
EP	Presumed to be Excepted

Exempt Package Codes:

E	Exempt
EP	Presumed to be Exempt

Industrial Package Codes:

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

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

Other Codes:

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

A23 TRANSPORT INDEX

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

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

A24 RADIONUCLIDES

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

A25 ACTIVITY

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

A26 EVENT CLASSIFICATION SYSTEMS

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

APPENDIX B Event Classification System

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

TABLE B1 Classification of reported transport events

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

TABLE B1 Continued Classification of reported transport events

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

TABLE B2 Classification of package deficiency associated with the transport event

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

TABLE B3 Radiological consequences resulting from transport events

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

Note:

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