Transportation Accidents/Incidents Involving Radioactive Material (1971 – June 1995)*

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INTRODUCTION

The Radioactive Materials Incident Report (RMIR) data base contains information on transportation-related accidents and incidents involving radioactive materials that have occurred in the United States. The RMIR was developed at Sandia National Laboratories to support its research and development program efforts for the Energy Management and Restoration Division of the U.S. Department of Energy (DOE).

The RMIR database was established in 1981 to provide a computerized compilation of the accidents/incidents involving radioactive materials during transportation operations. Records for inclusion in the data base are obtained from the two Federal agencies which have regulatory responsibilities for the transport of radioactive materials: the U.S. Department of Transportation (DOT) and the U.S. Nuclear Regulatory Commission (NRC). In addition to the accident/incident reports obtained from the DOT and NRC, the RMIR contains data from the DOE Unusual Occurrence Report data base, data from State radiation control offices and media coverage of radioactive transportation accidents/incidents.

This paper addresses the following topics: background information on the Federal regulations for reporting a hazardous /radioactive materials transportation incident, a brief description of the types of packagings used for the transport of radioactive materials,

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overview data of radioactive transportation accidents and incidents, and additional information and summary data on how packagings have performed in accidents.

REPORTING REQUIREMENTS FOR TRANSPORTATION INCIDENTS INVOLVING RADIOACTIVE MATERIALS

The two Federal agencies with primary responsibility for developing and promulgating regulations for the transport of radioactive materials in the United States are the DOT and the NRC. The reporting requirements for these two agencies differ. The DOT regulations for reporting a hazardous materials incident (of which radioactive material is a subset) are specified in the Code of Federal Regulations (49 CFR171.15). The DOT requires that a report be filed after each incident that occurs during the course of radioactive materials transportation (including loading, unloading, handling, and temporary storage) in which one of the following directly occurs: (1) a person dies; (2) a person is injured and requires hospitalization; (3) estimated carrier or other property damage exceeds $50,000; (4) fire, breakage, spillage, or suspected contamination occurs involving radioactive materials; or (5) a situation exists that the carrier believes should be reported. The NRC regulations are also outlined in the Code of Federal Regulations (10 CFR 20.402 and 20.403) and require that the theft or loss of radioactive materials, exposure to radiation, or release of radioactive materials be reported.

RADIOACTIVE MATERIALS PACKAGING DESCRIPTIONS AND TESTING REQUIREMENTS

This paper uses the terms "packaging" and "package" in this section and in the discussion of the behavior of packages in accidents conditions. A "packaging" is defined as a container and all its parts (smaller containers, absorbent materials, radiation shielding, etc.). The term "package" refers to a packaging and its radioactive contents.

The Federal regulations regarding the transport of radioactive materials are mainly concerned with packaging standards. These packaging standards are regulations that are designed to promote and ensure the protection of the public during RAM transport. There are three main objectives for the packaging of radioactive materials:

1. To contain the radioactive materials and allow for heat dissipation, if required.

2. To shield or protect from radiation exposure.

3. To prevent nuclear criticality in fissile materials.

Depending on the type and quantity of radioactive material to be shipped, there are different types of packagings that are used. The strong, tight containers are described in

49 CFR 173.24. These containers must be capable of preventing spills and leaks, and the external radiation dose rate at any point may not exceed 0.5 millirem/hour. Strong, tight containers are used for materials that do not require shielding; generally, low specific activity (LSA) materials such as uranium and thorium ores, uranium metal, and low-level waste are transported in strong, tight packagings.

Type A packaging regulations are outlined in 49 CFR 173.411 and 173.412. Type A packaging must meet the strong, tight container requirements and also pass tests that simulate damage due to normal transport conditions. Although Type A packagings transport lower levels of radioactive materials, they must provide shielding, a strong seal, heat dissipation, limited surface temperature, and a minimum surface radiation level. Typically, Type A packagings transport radiopharmaceuticals used in medical diagnosis and/or treatment or in commercial applications. Some of the Type A materials are iodine-131, copper-64, iron-55, or smaller quantities of americium-241 source material.

Type B packaging requirements and regulations are detailed in 49 CFR 173.413. These packagings transport quantities of radioactive materials that exceed Type A packaging and must be certified by the NRC. Type B packagings must be designed and constructed to withstand the rigors of normal transport and accident conditions. Type B packaging must pass the following tests in the order described below:

1. Drop test - a 30-foot drop onto a flat, unyielding surface, striking the packaging's weakest point.

2. Puncture test - a 40-inch free drop onto a 6-inch diameter solid, vertical steel rod that is mounted onto an unyielding surface.

3. Thermal test - a 30-minute fire at 1475 degrees F.

4. Water immersion test - immersion of the package under 50 feet of water for not less than 8 hours.

SUMMARY DATA PRESENTATION OF RADIOACTIVE MATERIALS TRANSPORTATION ACCIDENT/INCIDENT DATA IN THE UNITED STATES

According to the Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes (1977), it is estimated that during a given year, approximately 500 billion packages of all commodities are transported by all modes throughout the United States. Of those 500 billion packages, approximately 100 million packages are classified as hazardous materials (flammables, explosives, poisons, and radioactive materials). The most recent study of the transport of radioactive materials (Javitz, et al. 1985) captured data on the shipment of radioactive materials for the 1982 calendar year and concluded that approximately 2 million shipments of radioactive materials are made each year. These 2 million shipments constitute about 2.79 million packages of radioactive materials. The 2 million radioactive materials shipments account for only 2% of the total number of hazardous materials transported each year in the United States. Given that the most recent study of the shipment of radioactive materials is more than 10 years old, it is highly probable that there are currently more than 2 million shipments of radioactive materials.

When the RMIR data base was established in 1981, it was designed primarily to accommodate the information on the DOT Form 5800 (Hazardous Materials Incident Report) for the recording of transportation accidents and incidents. In order to better understand the type of reported transportation incidents, the RMIR data base makes a definite distinction between an accident and other reported incidents. The three classifications of reported transportation incidents are defined as follows:

Transportation Accident: Any accident that involves the vehicle that is transporting the radioactive material.

Handling Accident: Damage to a shipping container during loading, handling, or unloading operations; e.g., a forklift puncturing a package at an air terminal.

Reported Incident: Transportation occurrences where there is an actual or suspected release or surface contamination of radioactive materials that exceeds the regulatory requirements from either the package or the transport vehicle. (In the data base structure and query programs, a new category,

Missing or Stolen, has been added to accommodate the request of other Federal agencies using the RMIR data.)

Table 1 tabulates the transportation accidents, handling accidents, and incidents that have occurred for the 24.5 year time frame of 1971 through June 1995. Accidents constitute 22% of the events compiled for the United States, a slight increase over the 19% tabulated for the period 1971-1988. Further, 51% of all transportation occurrences tabulated in Table 1 are classified as other reported transportation incidents and 12% are classified as missing/stolen radioactive materials, an increase of 2% over the data for 1994.

Table 1. U.S. Radioactive Materials Transportation Events (1971- 06/95)

Transportation Accidents	373
Handling Accidents	270
Transportation Incidents	1070
TOTAL	1713

Most radioactive materials are transported on the highway; these highway shipments generally include industrial gauges, radioactive material used in or produced as a result of the nuclear fuel cycle, low-level radioactive materials or waste, and teletherapy sources. Radioactive materials that are shipped by air are generally isotopes with short half-lives and are being shipped over 500 miles from the shipper's location. Upon arrival at an airport, these radioisotopes are generally delivered to their consignees by a courier service. Radioactive materials transported by modes other than aircraft are usually those that do not require immediate delivery.

Table 2 shows the RMIR breakdown for accidents, missing/stolen and other incidents, and handling accidents by transportation mode. As Table 2 illustrates, radioactive material packages transported on highways account for about 74% of all the RAM transportation incidents that have occurred and 89% of all the RAM transportation accidents. Over one-half (56%) of all handling accidents recorded in the RMIR data base have occurred with low-level materials at air terminals. Most of these handling accidents occurred during loading and unloading operations.

Table 2. Transportation Accidents/Incidents by Mode (1971 - 06/95)

Mode	Accidents	Missing/ Stolen & Other Incidents	Handling Accidents
Air	21	167	151
Highway	328	868	108
Rail	23	17	3
Warehouse	0	4	2
Water	1	7	4
Other, unidentified	0	7	2
	373	1070	270

PACKAGING PERFORMANCE IN TRANSPORTATION ACCIDENTS

Generally, an accident condition will be the most severe occurrence that a package will be subjected to during the course of transportation. Between the years 1971 and June 1995, 3,845 radioactive material packages, as documented in Table 3, were involved in transportation accidents. Of that total, 148 (3.8%) were classified as having been damaged with no loss of contents. Industrial packages, or those that are classified as strong and tight, have been involved in 50 accidents. Of the 1,391 strong and tight packages involved in those accidents, only 24 were damaged without loss of contents and 66 were damaged to the extent that they sustained loss of contents. These industrial packages are designed to withstand normal transport conditions; they are not designed nor tested to withstand accident conditions. Type A packages accounted for the majority

(61%) of the packages that were involved in accident conditions. However, like industrial packages, Type A packagings are designed and tested for the rigors of normal transport conditions, not accidents.

Table 3. Package Behavior During Transportation Accidents (1971 - 06/95)

Package Category	No. of Accidents	No. of Packages In Accidents	No. of Packages Damaged With Loss	No. of Packages Damaged Without Loss
Industrial (Strong & Tight)	50	1391	66	24
Type A	231	2361	82	64
Type B	60	93	0	0

The most notable transportation accident that has occurred in the United States over the last 4 years involved the shipment of 12 containers, each of which contained 2 unirradiated nuclear fuel assemblies destined for Vermont Yankee Nuclear Power Plant. The accident occurred on December 16, 1991, at 3:15 a.m. on Interstate 91 in downtown Springfield, Massachusetts. A car was traveling on the wrong side of the interstate, and although the truck driver swerved to avoid a collision, the car struck the tractor-trailer on the right side near the right fuel tank. The truck continued northbound and hit the center guardrail on the opposite side of the road. After striking the outside guardrail, the truck skidded across the highway and came to rest against the center guardrail.

A fire started in the engine compartment of the tractor and spread to the entire tractor and then the trailer. The NRC's report on the accident (Carlson and Fischer 1992) indicated that the fire burned for at least three-quarters of an hour before the cargo was affected. At that time, the entire cargo was entirely intact. However, since the fire was not extinguished, the flatbed trailer and the cargo were burned. The entire fire lasted approximately 3 hours.

The tractor-trailer was completely destroyed by the fire, and there was significant damage to several Type A packages and their contents. Eight containers fell off the trailer and sustained minor damage from the impact. The wooden outer containers were burned, and the inner metal containers sustained damage ranging from minor to severe.

Table 4 provides a tabulation of the 60 accidents involving Type B packages. Of these accidents, eight involved spent nuclear fuel casks (four accidents occurred during rail transport and four occurred on the highway). There has been only one spent nuclear fuel accident that resulted in more than trivial damage to the cask. This accident, which is probably the most well known nuclear transportation accident, occurred on December 8, 1971, on U.S. 25 in Tennessee. The cask was thrown from the trailer and was embedded in the ground. The radiation surveys taken at the accident scene indicated that the structural integrity of the cask was intact and there was no release of contents. Almost one-half of the other accidents involving Type B packages have involved iridium-192 sources, which are commonly transported in trucks and are used in industrial applications.

Table 4. Summary of Accidents Involving Type B Packages (1971 - 06/95)

Date of Accident	Mode	Package Description	RAM Involved	Packages Shipped/ Damaged
07/10/71	Highway	Lead container	Co-60	1/0
12/05/71	Highway	Radiography camera	Ir-192	1/0
12/08/71	Highway	Cask, spent fuel	Spent fuel	1/1
03/10/74	Highway	Container	Ir-192	1/0
03/29/74	Rail	Cask, spent fuel	Spent fuel	1/0
08/09/75	Highway	Cask	U-235, U-238, Pu-239	1/0
05/06/77	Highway	Radiography camera	Ir-192	1/0
08/11/77	Highway	Radiography camera	Ir-192	1/0
08/25/77	Rail	Cylinders	UF6	4/0
10/03/77	Highway	Radiography camera	Ir-192	1/0
02/09/78	Highway	Cask, spent fuel	Spent fuel	1/0
04/10/78	Highway	Radiography camera	Ir-192	1/0
07/07/78	Highway	Cask	MFP	1/0
07/26/78	Highway	Steel cask, lead	Cs-137	2/0
08/13/78	Highway	Cask, spent fuel	Spent fuel	1/0
08/27/78	Highway	Radiography camera	Ir-192	1/0
09/11/78	Highway	Radiography camera	Ir-192	1/0
09/15/78	Highway	Cask	Radium	1/0
11/28/78	Highway	Radiography camera	Ir-192	1/0
01/10/79	Highway	Cylinder	Ir-192	5/0
08/12/79	Highway	Cask	Empty	2/0
12/11/79	Highway	Cylinder	UF6	5/0
01/14/80	Highway	Cask, teletherapy	Co-60	1/0
01/31/80	Highway	Cask	Low level waste	2/0
07/21/80	Highway	Source	Ir-192	1/0
08/22/80	Highway	Cylinder, 30B	UF6	5/0
09/06/80	Rail	Cylinder, 30B	UF6	8/0

09/29/80	Rail	Radiography source	Sr-90, Y-90	3/0
06/09/81	Highway	Source, shielded	Am-241/be	1/0
09/02/81	Highway	Source	Ir-192	1/0
10/26/81	Highway	Radiography camera	Ir-192	1/0
01/18/82	Highway	Radiography camera	Ir-192	1/0
11/03/82	Highway	Cask	Empty LLW	2/0
03/11/83	Highway	Cask	LLW	1/0
05/10/83	Highway	Radiography source	Ir-192	1/0
07/14/83	Air	Cask	Y-90, Ir-192	2/0
12/09/83	Highway	Cask, spent fuel	Spent fuel	1/0
07/16/84	Air	Container	Ir-192	1/0
08/08/84	Highway	Container	Reactor waste	1/0
02/11/85	Highway	Steel drum	Ir-192	1/0
02/13/85	Highway	Steel drum	Ir-192	1/1
04/17/85	Highway	Cylinder	Co-60	1/0
12/04/85	Highway	Radiography source	Ir-192	1/0
01/10/86	Highway	Source	Cs-137	1/0
08/15/86	Highway	Cylinder, 30B	UF6	3/0
03/24/87	Rail	Cask, spent fuel	Core debris	2/0
10/26/87	Highway	Radiography source	Ir-192	1/0
01/09/88	Rail	Cask, spent fuel	Spent fuel	1/0
01/23/88	Highway	Radiography camera	Ir-192	1/0
09/23/88	Highway	Radiography camera	Ir-192	1/0
03/27/89	Highway	Radiography camera	Ir-192	1/0
05/19/89	Highway	Cask	LLW	1/0
11/09/90	Rail	Cask, spent fuel	Empty	1/0
06/08/91	Highway	Radiography camera	Ir-192	1/0
09/15/91	Highway	Radiography camera	Ir-192	1/0
11/03/91	Highway	Radiography camera	Ir-192	1/0
02/07/92	Highway	Radiography camera	Ir-192	1/0
03/04/93	Highway	Cask, LLW	Co-60, -58	1/0
10/10/94	Highway	Radiography camera	Ir-192	1/0
12/23/94	Rail	Cylinders	UF6	2/0

SUMMARY AND CONCLUSIONS

The data provided by the RMIR data base for this paper reflects the adequacy of the transportation regulations that are in effect. That is, the packages that have experienced releases are those that are designed to maintain package integrity during the conditions normally incident to transportation. Federal regulations require that Type B packagings, which are normally used for the transport of larger quantities of nuclear materials, be designed and tested to withstand "hypothetical" accident conditions (NRC regulations 10

CFR 71). The data from RMIR indicate that Type B packages have performed extremely well in accidents. Two Type B packages experienced minor damages, but there has been no release of radioactive materials from a Type B package during an accident condition.

Since its development in 1981, the RMIR data base has evolved to become one of the most comprehensive compilations of information on transportation accidents and incidents involving radioactive materials. Every attempt is made to report a transportation incident as accurately as possible to augment the available resources by establishing a network of contacts in addition to the two primary Federal reporting agencies.

It is important to provide a credible and complete history of radioactive materials transportation incidents, in part because there is heightened awareness and concern about the transport of all hazardous materials but also because the data are used in public information materials, responses to public and Congressional inquiries, and in mitigating institutional concerns. Requests for information on this data base, which has been discontinued, can be obtained by contacting the U.S. Department of Energy, Energy Management and Restoration Division.

REFERENCES

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