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LOW-LEVEL RADIOACTIVE WASTE TRANSPORTATION SAFETY HISTORY

James D. McClure

Sandia National Laboratories
Transportation Systems Analysis Department
Albuquerque, NM 87185-0718

INTRODUCTION

The Radioactive Materials Incident Report (RMIR) database was developed in 1981 at the Transportation Technology Center of Sandia National Laboratories to support its research and development activities for the U.S. Department of Energy (DOE). This database contains information about radioactive material (RAM) transportation incidents that have occurred in the U.S. since 1971. These data were drawn from the U.S. Department of Transportation's (DOT) Hazardous Materials Incident Report system, from Nuclear Regulatory Commission (NRC) files, and from various agencies including state radiological control offices. Support for the RMIR data base is funded by the U.S. DOE National Transportation Program (NTP).

Transportation events in RMIR are classified in one of the following ways: as a transportation accident, as a handling accident, or as a reported incident. This presentation will provide definitions for these classifications and give examples of each.

The primary objective of this presentation is to provide information on nuclear materials transportation accident/incident events involving low-level waste (LLW) that have occurred in the U.S. for the period 1971 through 1996. Among the areas to be examined are: transportation accidents by mode, package response during accidents, and an examination of accidents where release of contents has occurred. Where information is available, accident and incident history and package response for LLW packages in transportation accidents will be described.

Since its development in 1981, the RMIR database has evolved to become a comprehensive compilation of information on transportation events involving radioactive materials. RMIR has been used in the support of the following types of activities: transportation environmental analysis, safety analysis, public information materials, responses to inquiries, and mitigation of institutional concerns.

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DISCLAIMER

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 CFR 171.15). 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.

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 OF RADIOACTIVE MATERIALS TRANSPORTATION ACCIDENT/INCIDENT EXPERIENCE IN THE UNITED STATES

According to the Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes (Ref. 1), 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 (Ref. 2) 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 3 % of the total number of hazardous materials transported each year in the United States.

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 database 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 database 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 25 year time frame of 1971 through 1996. Accidents constitute 21% of the total incidents reported in the United States. Further, 64% of all transportation occurrences tabulated in Table 1 are classified as reported incidents. and 12% are classified as missing/stolen radioactive materials, an increase of 2% over the data for 1994. Handling accidents account for 15 % or the total incidents reported in the U.S.

Table 1. U.S. Radioactive Materials Transportation Incidents (1971-1996) **

Transportation Accidents	385
Handling Accidents	275
Reported Incidents	1136
TOTAL Reported Accidents/Incidents	1796

** Preliminary Incident Count through Calendar 1996

Since the purpose of this presentation is to document U.S. LLW transportation accident experience a search was made of the RMIR database for all accident records with a search code of LLW. Eighteen such accident events were disclosed from this search and the results are shown in Table 2. The accident events were sorted by date of occurrence. Additional information includes the incident report number, the material search code (LLW), the transport mode, the state in which the accident occurred (accident location), the consignee for the shipment, a brief description of the material released (if a release occurred) and the package type (S, strong-tight packaging; A, Type A packaging; B, Type B packaging, or unknown if the packaging type was not reported).

Table 2. Low-Level Waste (LLW) Transportation Accident Experience in the U.S. (1971-1996)

INSERT TABLE 2 (TABLE 2 is in attached EXCEL spreadsheet)

The characteristics of the 18 LLW accidents are summarized in Table 2 are as follows:

a. Seventeen of the 18 LLW transportation accidents were for the highway transport mode, only one of the accidents was for the rail transport mode.

b. The states in which the accident occurred are listed in Table 2. Specific locations of the accidents can be determined by reading the accident report summary in RMIR. This is accomplished by using the accident/incident number as the search code for locating a specific accident/incident in the RMIR database.

c. A brief summary of whether radioactive contents were released from the LLW packages is described under the heading, Material Released on the RMIR accident/incident summary. In 14 of the LLW accidents there was no release of radioactive contents. Minor releases occurred in 4 of the accidents. It should be emphasized at this point that there is a strict limit on the amount of radioactive material that can be in a Type A or lesser quality package. This limit is termed the A1 or A2 magnitude for special form or normal form materials.

d. In the 18 LLW accidents, one accident involved an unknown packaging type. Seven of the accidents had Type S, Strong-Tight industrial packagings. Type A packagings were involved in 9 of the LLW accidents. A Type B accident resistant packaging was involved in one LLW accident and as has historically been true for Type B packagings, there was no release of radioactive contents (LLW) from the Type B package under transportation accident conditions.

CHARACTERISTICS OF LLW ACCIDENTS WHERE RELEASE OF CONTENTS HAVE OCCURRED.

In subsection c, above, it was stated that minor releases occurred in four of the transportation accidents. It must be emphasized that these releases occurred in four accidents, one involving a strong industrial package and three accidents involving Type A packages. Industrial and Type A packages are not designed to withstand accident forces and the safety provided by this class of packages comes from the strict limits placed on the amount of RAM that can be in these packages. As stated above, this limit value depends on the form of the RAM carried in the package. A1 is package limit for special form material, that is, material that is in a very non-dispersable form (essentially in a single solid piece or in a sealed capsule). Normal form material is all material that has not been designated as meeting the requirements of special form material. The limit on normal form material is the A2 magnitude, and normal form material could be a dispersable material. The A1 and A2 magnitudes are tabulated in the packaging regulations 49 CFR 173.435, for all radionuclides and most RAM forms are consist of a composite of several radionuclides. A composite A1 or A2 magnitude can be calculated which is dependent on the amount of each radionuclide in the composite material form.

The release of RAM from a Type A package is limited, as stated above, by the A1 or A2 magnitudes. These limit values are so small that significant health effects cannot be incurred if a Type A package releases all of its contents. Coupled to this type of package response, the packaging certification process for Type B accident resistent involves such rigorous analysis and testing that in all U.S. historical transportation experience, there have been no releases of RAM from certified Type B accident resistant packages.

CONCLUDING REMARKS

This presentation has summarized the transportation accident experience in the U.S. for the period of 1971 through June 1996. The LLW transportation accident experience reported in this paper is also for this same period. The LLW accident experience is typical of the transportation accident experience that has historically taken place in the U.S., that is, there have been no LLW releases from Type B accident-resistant packages. Where releases of radioactive material have occurred, they have taken place in accidents involving Type A or Strong Industrial packages which are not designed to resist the forces of a transport accident.

One of the most important pieces of information to be obtained from this presentation is that the RMIR database has tracked transportation accident and incident experience since early 1971. Updates on this experience can be obtained in one of two ways. First, a personal contact can be made to the Transportation System Analysis Department at Sandia National Laboratories in Albuquerque, NM, (Ref. 3). The second method of obtaining RMIR information is to become an authorized TRANSNET user. TRANSNET is a system of databases and analysis codes for evaluating the environmental effects of radioactive material transportation. The RMIR database is resident in the TRANSNET system and one can address TRANSNET and gain access to RMIR from a personal computer terminal. Searches of RMIR can be made at ones convenience. For access to TRANSNET, contact the TRANSNET system administrator, (Ref. 4).

From the information presented above and based on the analysis and testing upon which radioactive material packagings are certified, and finally from 26 years of documented transport experience, during which transportation accidents have occurred, no significant releases of radioactive materials of LLW have taken place. With this experience as a basis, a claim can be made that LLW transportation is embedded in a transportation system that has historically been safe and can be reasonably assumed to remain safe for the foreseeable future.

REFERENCES

1. U.S. Nuclear Regulatory Commission, 1977, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*, NUREG 0170, Vols 1 and 2, Office of Standards Development, Washington, DC.

2. *TRANSPORT OF RADIOACTIVE MATERIAL IN THE UNITED STATES: Results of a Survey to Determine the Magnitude and Characteristics of Domestic, Unclassified Shipments of Radioactive Materials.*,Contractor Report to Sandia National Laboratories, SRI International, Menlo Park, CA, 1985.

3. Transportation System Analysis Department at Sandia National Laboratories in Albuquerque, NM. (Contact, H.R. Yoshimura, 505-845-8181, or J.D. McClure, 505-845-8753).

4. TRANSNET System Administrator, Sandia National Laboratories Richard Orzel, at 505-845-8094.

	A	B	C	D	E	F	G	H	I
1	TABLE 2								
2									
3	ACCIDENT	ACCIDENT	INCIDENT NUMBER	MATERIAL	TRANSPORT	ACCIDENT	CONSIGNEE	MATERIAL	PACKAGE
4	NUMBER	DATE			MODE	LOCATION		RELEASED	TYPE
5									
6	1	6/14/74	TTC0203	LLW	RAIL	OHIO	Hanford Disposal Site	NO RELEASE	S
7	2	1/12/76	TTC0179	LLW	HIGHWAY	KENTUCKY	Maxey Flats Disposal Site	MATL. RELEASED	S
8	3	8/6/76	TTC0216	LLW	HIGHWAY	SOUTH CAROLINA	Chem-Nuclear Systems, Barnwell	NO RELEASE	UNKN
9	4	8/3/79	NRC0128	LLW	HIGHWAY	SOUTH CAROLINA	Chem-Nuclear Systems, Barnwell	NO RELEASE	A
10	5	12/9/79	TTC0001	LLW	HIGHWAY	MONTANA	Nuclear Engineering Co.	NO RELEASE	S
11	6	12/12/79	PNO7919	LLW	HIGHWAY	MONTANA	Nuclear Engineering Co.	NO RELEASE	S
12	7	1/11/80	PNOI8005	LLW	HIGHWAY	NEW YORK	Unknown	NO RELEASE	S
13	8	2/15/80	TTC0003	LLW	HIGHWAY	ARIZONA	Chem-Nuclear Systems, Barnwell	NO RELEASE	A
14	9	2/22/80	PNOIII8035	LLW	HIGHWAY	OHIO	Nuclear Engineering Co.	NO RELEASE	S
15	10	9/12/80	TTC0180	LLW	HIGHWAY	KENTUCKY	Reynolds Electric	NO RELEASE	A
16	11	1/7/82	TTC0086	LLW	HIGHWAY	IDAHO	U.S. Ecology, Inc.	NO RELEASE	A
17	12	5/6/82	TTC0101	LLW	HIGHWAY	UTAH	Aerojet Nuclear Co.	NO RELEASE	A
18	13	12/14/82	TTC0183	LLW	HIGHWAY	NORTH DAKOTA	Hanford Disposal Site	NO RELEASE	S
19	14	1/16/86	TTC0226	LLW	HIGHWAY	WASHINGTON	U.S. Ecology, Hanford	NO RELEASE	A
20	15	11/22/87	88010081.00	LLW	HIGHWAY	WYOMING	U.S. Ecology, Richland	CONTAMINATED SOIL/ EQUIPT. REL.	A
21	16	12/31/87	880110200.00	LLW	HIGHWAY	WASHINGTON	U.S. Ecology, Hanford	LOCAL CONTAMINATION	A
22	17	10/24/89	89110583.00	LLW	HIGHWAY	VIRGINIA	Chem-Nuclear Systems, Barnwell	CONTAMINATED SOIL RELEASED	A
23	18	3/4/93	PNOIV938	LLW	HIGHWAY	OREGON	U.S. Ecology, Hanford	NO RELEASE	B
24									
25									