A REVIEW OF US ACCIDENT/INCIDENT EXPERIENCE INVOLVING THE TRANSPORTATION OF RADIOACTIVE MATERIAL (RAM) 1971-1980*

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This paper analyzes the transportation accidents and incidents which have occurred in the United States in the period 1971-1980 based upon the information in the Radioactive Material Transportation Accident/Incident Data Base developed by the Transportation Technology Center (TTC) at Sandia National Laboratories. The accident/incident data base incorporates the files of the Hazardous Material Incident Report (HMIR) system operated by the Material Transportation Bureau of the US Department of Transportation (DOT) with additional information obtained from the files of the US Nuclear Regulatory Commission (NRC). A principal objective of this paper is to summarize US accident/incident experience for the past ten years,[1] providing a concise statement of radioactive material (RAM) package failure description for the transport modes of truck, rail and air.

Operated for the US Department of Energy (DOE) by Sandia National Laboratories, the TTC acquires hazardous material incident reports from the DOT on a continuing basis. This information, plus similar information acquired from the NRC, provides a radioactive material accident/incident data base which presently (June 1980) consists of 659 data entries. The present holdings of the HMIR system approximate 86,500 entries for all classes of hazardous materials, including 524 radioactive material entries, or 0.6 percent of the total incidents reported to DOT. This information represents US transportation experience for radioactive materials dating from 1971 to the present. The accident/incident data base is stored on TTC's on-line data base management system for rapid storage, retrieval, editing and analysis.

The DOT regulatory requirements for reporting a hazardous material incident are specified by the Code of Federal Regulations (49 CFR, Para. 171.15). These regulations spe reporting after each incident that occurs during the course of transportati ncluding loading, unloading and temporary storage) in which as a direct resu moving hazardous material: (a) a person is killed, (b) a person receives in s requiring hospitalization, (c) estimated carrier or other property damage exce s $50,000, (d) in the case of radioactive material there is suspected contamination, (e) fire, breakage or spillage occurs involving etiologic agents, (f) continued danger of life exists at the accident scene. From this summary of the requirements for reporting a hazardous material incident, one can conclude that the requirements for reporting an incident vary widely. The 659 data entries in the accident/incident data base are events which meet the regulatory requirements for notification of DOT and NRC of the event occurrence. The main theme of this presentation will be that a detailed examination of the reports in the data base will reveal that some of the events can be classified as transport accidents, some events involve handling accident conditions and others are simply incidents which meet the regulatory requirement for reporting the event and do not involve accident conditions. Such a classification of events is shown in Table I and is necessary to produce, for example, accurate accident rate estimates for

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risk assessment studies. Table I represents an up-to-date representation of US radioactive material transportation experience.

TABLE I

US Radioactive Material Accident/Incident Experience
(1971-1980)

Transportation Accidents	85
Handling Accidents	110
Reported Incidents	464
Total	**659**

In the interpretive analysis of the basic DOT and NRC information, a distinction is made between an accident and a reported incident. Two types of accidents are categorized, as shown in Table I. For the purposes of this analysis, a reported incident is classified as a transportation accident if there is a vehicular accident involving the vehicle transporting the radioactive material. Other incidents are classified as handling accidents if during the course of handling, loading, etc., an accident occurs, for example, a package is dropped or run over by a vehicle.

The remaining classification, the reported incident, excludes transportation accident conditions. An example of a reported incident typically involves the detection of surface contamination on a radioactive material package or on a transport vehicle. These observations are often noted during loading or unloading operations. Such events generally involve no package failure, no release of radioactive contents and the absence of any accident conditions during transport. For this type of event the terminology "reported incident" has been used to classify the event. For the US experience to date, it can be observed from Table I that the total reported events include 85 transportation accidents and 110 handling accidents.

The 85 transportation accidents listed in Table I were classified by transportation mode as shown in Table II.

TABLE II

Radioactive Material Transportation Accidents by Mode

Transport Mode	Number of Accidents	Number of Packaging Failures
Air	5	1 Type A
Rail	5	1 Type A
Highway	75	39 Type A
	85	41 Packaging Failures

Table III summarizes some of the information that can be retrieved from the accident/incident data base. For example, the 85 transportation accidents involved a total of 711 radioactive material packages. Some accidents had only a single package on board the transport vehicle. Other accidents involved a single transport vehicle with a number of packages on board. Table III traces an analysis of the radioactive material packaging failures in the 85 accidents.

TABLE III

Transportation Accident Analysis Summary

RAM Packages Involved in Accidents	Package Description	Description of Events		Description of Material Released
Packaging Failures* (with release)	38 Type A -->	5 Release --> Events	3 Urban ------>	•Uranium Ore •Sand (LSA) •RAM (not otherwise specified)
			2 Non-Urban -->	•Uranium Oxide
Packaging Failures* (no release)	3 Type A			
Packagings in Accident with No Failures	660 Type A 10 Type B			
TOTAL	711 packages involved in 85 accidents			

* The 41 packaging failures involved 38 Type A packages which released radioactive material.

Multiple numbers of packages can be carried on a single vehicle and five separate and distinct release events involving these packages have been defined. Three of the release events occurred in an urban area. Two of the release events occurred in a non-urban area. For example, the Springfield, Colorado, accident involved 29 packaging failures which released approximately 5400 kg of uranium oxide; this was defined as a single release event. For the five release events, the material released was described as uranium ore, radioactive sand (low specific activity), uranium oxide and radioactive material (RAM -- not otherwise specified). It is interesting to note that an examination of the accident data reveals that ten Type B accident resistant packagings were included in the set of packagings which were subjected to accident conditions, but produced no packaging failure and, consequently, no release of radioactive contents.

Tables IV, V and VI present a chronological summary of the data base with respect to the number of reported events, transportation accidents, handling accidents, release of radioactive contents and accident occurrences by transport

TABLE IV

Accident/Incident Data Base Chronological Summary

Year	Annual No. Releases	Annual No. Events	HMIR* Events	NRC** Events	Transportation Accidents	Handling Accidents
1971	5	10	10	N/A	5	0
1972	4	19	19	N/A	1	2
1973	7	24	24	N/A	0	11
1974	9	59	59	N/A	5	14
1975	11	44	44	N/A	5	23
1976	14	59	57	2	2	6
1977	16	112	96	16	10	16
1978	18	140	85	55	19	14
1979	25	170	120	50	29	23
1980 (through 5/8/80)	5	22	10	12	9	1
	114	659	524	135	85	110

*Reported events received from HMIR system, DOT.
**Reported events received from NRC.

TABLE V

RAM Transportation Accident Summary

Year	Transportation Accident Total	Transport Mode				Releases
		Rail	Highway	Air	Other	
1971	5	1	4	0	0	1 Release-1971-Hwy
1972	1	0	1	0	0	
1973	0	0	0	0	0	
1974	5	1	4	0	0	
1975	5	0	5	0	0	
1976	2	0	2	0	0	
1977	10	1	9	0	0	1 Release-1977-Hwy
1978	19	0	18	1	0	1 Release-1979-Air
1979	29	2	23	4	0	1 Release-1979-Rail
1980 (through 5/8/80)	9	0	8	0	1 (Courier Service)	1 Release-1979-Hwy
	85	5	74	5	1	5 Release Events

Enclosure "D"

TABLE VI

RAM Handling Accident Summary

Year	Handling Accident Total	Transport Mode				Releases
		Rail	Highway	Air	Other	
1971	0	0	0	0	0	0
1972	2	0	0	2	0	1, Air
1973	11	0	2	9	0	2, Air
1974	14	0	1	13	0	2, Air
1975	23	0	6	14	2, Freight Forwarder 1, Marine	2, Hwy 1, Air 1, Frt Frd 1, Marine
1976	6	0	2	4	0	1, Air 1, Hwy
1977	16	1	4	9	1, Freight Forwarder 1, Warehouse	4, Hwy 1, Warehouse 1, Rail 1, Air
1978	14	0	7	7	0	1, Hwy
1979	23	0	9	13	1, Courier Service	3, Air 3, Hwy
1980	1	0	0	1	0	0
	—	—	—	—	—	—
	110	1	31	72	6	26

mode. The following observations apply to Table IV. The accident/incident data base receives most of its data entries from the HMIR system of the DOT. The other principal data source is the NRC. The HMIR data originated in 1971 and the NRC data originated in 1976. Any calculation of rate of occurrence of accidents and incidents should be performed with caution since the overall accident/incident data base consists of elements with differing chronological origination dates.

The most representative view of accident and incident rates is to express their occurrence as fractions (or percent) of total shipping volume. The most recent estimate of total shipping activity in the US was performed in 1975.[2] Estimates of present shipping activity are presently being investigated and are the subject of another paper at PATRAM 80 (see PATRAM paper 185). Until new estimates of shipping activity are available it is not possible to gain an accurate assessment of the percentage of accidents and incidents based upon numbers of radioactive material shipments.

To conclude, it is important to note that the accident/ incident data base described in this paper represents the accumulation and organization of existing data sources available in the United States. This data acquisition is followed by interpretive analysis of the information, and this analysis and data can be shared with several government agencies such as the DOE, NRC, DOT, Environmental Protection Agency (EPA), Federal Emergency Management Agency (FEMA) and the

International Atomic Energy Agency (IAEA), as well as other interested state and local governments and public interest groups. One important fact that has come from the preparation of this report is the importance of performing a detailed study of the incident reports and any attached documentation. It is recognized that after such an examination of radioactive material transportation incident data that all of the reported events are not transport accidents, hence the stratification of the accident/incident data as shown in Table I. Such a classification as shown in Table I is necessary because the varying requirements for reporting hazardous material incidents allow a broad spectrum of data entries which must necessarily be sub-classified (i.e., transport accidents, handling accidents and reported incidents).

The information presented above represents an analysis of a transportation accident/incident data base for radioactive materials. The results of such an analysis can be used to provide information about the environmental impacts associated with the transportation of radioactive materials. In addition, such an analysis can provide information which is useful in the formulation of the regulations governing the safe transportation of radioactive materials.

REFERENCES

1. A. W. Grella, A Review of Five Years Accident Experience in the U.S.A. Involving Nuclear Transportation, IAEA-SR-10/5, International Atomic Energy Agency, August 1976.

2. Transport of Radioactive Material in the U.S., A Detailed Summary of Survey of Radioactive Material Shipments in the United States, BNWL-1972, NUREG-0073, Office of Standards Development, U.S. Nuclear Regulatory Commission, May 1976.

ENCLOSURE E

Enclosure "E" - Draft Congressional Letter

Dear Mr. Chairman:

In June 1975 the NRC announced its intention to reevaluate its regulations concerning the air transportation of radioactive material. This evaluation was expanded to include other transport modes because of the requirement to examine alternatives mandated by the National Environmental Policy Act of 1969. As part of its reevaluation, the NRC issued, in December 1977, a Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes, NUREG-0170. The conclusion reached in this environmental statement was that the environmental impacts of normal transportation of radioactive material and the risks attendent to accidents involving radioactive material are sufficiently small to allow continued shipments by all modes.

The NRC staff has now completed its reevaluation of its transportation regulations and has concluded that transportation of radioactive material conducted under the present regulations provides an adequate degree of safety to the public and that no immediate changes to the regulations are needed to improve safety. This conclusion is based on the results of the environmental statement, public comments received throughout this rulemaking proceeding and on staff review of related issues. The NRC will now close the transportation proceeding with a finding of adequacy concerning its transportation regulations and will focus attention on several follow-on studies. These follow-on studies will examine the cost-effectiveness of various regulatory changes for the purpose of reducing the already low transportation risk to a level as low as is reasonably

achievable. Areas to be examined in the follow-on studies include the transport of radioactive material through urban areas, normal exposure of transport workers, accident consequence control, and package qualification tests and acceptance standards for extreme accident environments associated with various transport modes. In addition the NRC is currently developing guidance material to be used by state agencies in developing emergency response plans for transportation accidents involving radioactive material.

There are some changes to the transportation regulations that have been proposed and issued for public comments, but are not related to safety. These changes involve compatibility of domestic transportation requirements with those of the International Atomic Energy Agency, transportation safeguard measures to reduce the risk of unauthorized diversion relating to shipments of special nuclear material of moderate strategic significance being in transit at the same time, and implementation of the Congressional mandate on nuclear waste shipment notification to the States.

Enclosed for your information is a Federal Register notice we plan to issue on this matter within the next few days.

Sincerely,

Ray G. Smith, Acting Director
Office of Standards Development

Enclosure: As stated

Enclosure "E"

ENCLOSURE F

Enclosure "F" - Public Announcement

NRC CLOSES TRANSPORTATION RULEMAKING

The Nuclear Regulatory Commission has concluded that its present regulations governing the transportation of radioactive material are adequate and no immediate changes are needed to improve safety. The conclusion was reached as the result of a public rulemaking proceeding initiated in 1975.

However, in closing the proceeding, the Commission directed the staff to complete ongoing studies that would strengthen the technical data base for the regulations and apply the principle of maintaining radiation exposures from the transportation of radioactive material as low as is reasonably achievable.

The follow-on studies are in the areas of controlling the physical and chemical form of radioactive materials in transit; radiation exposure to transport workers; qualification tests and acceptance standards for radioactive material packages; the transportation of radioactive materials through urban areas; and guidance for responding to transportation accidents involving radioactive materials.

The major bases for the Commission's conclusion that the present regulations are adequate is the Final Environmental Statement on the Transportation of Radioactive Material By Air and other Modes (NUREG-0170) which was issued in December 1977. The report analyzes the impacts of

the normal transportation of radioactive material, the impact of transportation accidents and the deliberate misuse of radioactive material in transportation. Separate rulemaking proceedings could be initiated as a result of these studies.

Also valuable to the Commission were public comments received before and after the Draft Environmental Impact Statement was issued in March 1976 and after the Final was issued.

Apart from the rulemaking which the Commission is closing out, three changes in the regulations have been proposed which do not relate to safety or have been Congressionally-mandated. One would improve the compatibility of the NRC's regulations with those of the International Atomic Energy Agency. Another would upgrade the physical protection requirements for protecting shipments of special nuclear material of moderate strategic significance. A third would implement a Congressional mandate to notify States of shipments of radioactive waste.

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ENCLOSURE G

FOLLOW-ON STUDIES

In section 6 of the FES, the staff evaluates the environmental impacts of various alternative shipping practices. The purpose of these evaluations is to determine which alternatives reduce the expected radiological risk in a cost-effective manner. These alternatives are to be the subject of follow-on studies as described in Enclosure "C" of SECY 77-92A. Consideration of public comments and additional staff review also led to identification of areas that merit further study.

Although there are several areas for further study, this should not be construed as an indication that current regulations are inadequate. These studies would strengthen the technical data base for the regulations and apply the principle of maintaining radiation exposures, from the transportation of radioactive material, as low as is reasonably achievable. Other studies and activities, such as those involving routing and notification requirements for radioactive material shipments, are described in Enclosure "C", Related Activities.

1. Control Physical/Chemical Form

The staff recognizes that while the consequences of very severe accidents may be serious, the very low probability of occurrence of such accidents results in a small risk. Controlling the physical/chemical form of radioactive material in transit may be one cost-effective method of further reducing the radiological impacts. For example, by requiring quantities of highly toxic radioactive material (e.g., plutonium, polonium, americium) above a specified level to be shipped in certain forms, its dispersibility and inhalation potential could be limited so as to limit the consequences of an accidental release.

The staff believes this alternative should be further examined to include the development of an environmental statement to determine the environmental impacts associated with this requirement and its cost-effectiveness.

2. Transport Worker Radiation Exposure

There are some workers, not under NRC's regulatory control, who are occupationally exposed to radiation resulting from radioactive material shipments. These workers include cargo handlers, drivers, and other crew members of transport vehicles. Radiological protection for these workers is provided by DOT regulations that limit surface contamination levels and external radiation levels of radioactive material packages, specify separation distances between workers and packages, and limit the total external radiation level resulting from packages stored in a single location or transported in a vehicle. DOT regulations do not require radiation exposure monitoring of these workers.

As part of the joint NRC/DOT/State transportation surveillance program, states have been measuring the radiation exposure of these transport workers, particularly drivers that deliver radiopharmaceutical packages to hospitals and medical centers. One of the results of this program is the discovery that in a few locations, where a large number of these packages are handled, some drivers receive exposures in excess of the standard applicable to members of the general public, i.e., less than 500 mrem per year above background.

The NRC has initiated a study of this problem in cooperation with the DOT and will provide technical assistance to DOT based on the study results. The study will identify the locations where packages are concentrated and advise DOT of regulatory solutions to any exposure problems. The situation is not considered to involve a serious health and safety problem, but is important for implementing the principle of maintaining radiation exposures as low as is reasonably achievable.

The EPA is currently developing standards to provide radiological protection for occupationally exposed workers. The EPA standards specify a graded approach to radiological protection requiring greater protective measures be taken when higher exposures may occur. It is anticipated that the DOT will establish new regulations to protect transport workers based on the EPA standards and the results of the NRC study.

3. Modal Package Qualification Tests

Current regulations, in Part 71 of 10 CFR, define mode independent hypothetical transportation accident performance tests. To better describe the relation between these performance tests and package behavior in accidents, the staff has initiated research for defining extremely severe accident environments for each transport mode. A set of bounding physical tests will be derived based on these environments and a set of associated acceptance standards for radioactive material packages will be developed. The staff will also evaluate potential package design specifications and/or operational and administrative controls that could contribute to safety. The staff will then determine whether there are circumstances in which certain types or quantities of radioactive materials should be shipped in packages meeting these standards. The research will focus initially on truck and rail shipments of large shielded containers.

4. Urban Transportation Study

The staff recognizes that very severe accidents in areas of high population density can result in large consequences, both in terms of health effects and economic costs. The staff is currently preparing an environmental impact statement on the transport of radioactive material through an urban environment. The draft statement is scheduled for completion in 1981 and is largely based on a draft technical assessment prepared by Sandia National Laboratories under contract to the NRC. The analysis includes features unique to urban locations,

such as the affect of built-up areas on the dispersibility of released radioactive material, the economic cost of decontaminating multi-storied buildings, the consequences of a successful act of sabotage in a city, and the routine exposure of the public from the transport of radioactive material in high density vehicular and pedestrian traffic. If this study shows that changes in NRC regulations are needed, the staff would recommend separate rulemaking actions apart from this general proceeding.

5. Emergency Response Guidance

The Federal Emergency Management Agency (FEMA) has the primary federal responsibility for developing a National Radiological Emergency Preparedness Plan. On October 22, 1980 FEMA issued interim regulations (45 FR 69904) that assign Federal agency responsibilities for assisting State and local governments in radiological emergency planning and preparedness. One of the responsibilities assigned to the NRC is to assist FEMA in providing radiological emergency response guidance to State and local governments. The NRC staff is currently developing, under an interagency agreement with the Environmental Protection Agency, a "Model State Emergency Response Program for Transportation Related Radiological Incidents." In a follow-on effort, the staff will examine the relative values and costs associated with various features of this program. The staff will use results of these efforts to provide input to the Interagency Task Force on Emergency Planning for Transportation Accidents Involving Radioactive Material.