A Comparison of Yearly Radiation Dose to Drivers From Various Types of Radioactive Materials

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The purpose of this paper is to examine the radiation dose to drivers of vehicles carrying radioactive materials shipments by highway. Since a small amount of radiation may be emitted from radioactive materials packages, drivers may be exposed to this radiation. The data on radiation exposure to these drivers are limited. This paper will discuss the radiation doses to such drivers based on various carriers' individual radiation dosimetry programs and studies that have been conducted in the United States. Some of the studies that are compared include the exposure of drivers of vehicles carrying spent nuclear fuel, radiopharmaceuticals, low level radioactive wastes and uranium hexafluoride.

There are approximately 500 billion packages of various types of materials that are shipped in the United States each year. They include about 100 million packages containing over 30,000 different hazardous materials. The packages may contain such classes of hazardous materials as flammables, corrosives, poisons, explosives, oxidizers or radioactive materials. Approximately three million packages of radioactive materials are shipped each year (Sh88).

The routine transportation of radioactive materials has occurred between different types of facilities for over forty years. Various quantities and types of radioactive materials are used in industry, medicine, research and power generation. Almost any operation, in which radioactive materials are used, requires transportation at some point. The continued growth of the nuclear industry depends on the safe transport of radioactive materials. Transportation is the critical link for all phases of the nuclear fuel cycle and the distribution of radiopharmaceuticals.

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Radiation protection in the United States is administered by various federal and state authorities. Therefore, no centralized system has been established to maintain radiation exposure records for workers. Because of this, assessment of exposure has depended upon data from a variety of sources, utilizing complete and incomplete monitoring records to characterize various groups of workers (EPA84).

No attempt will be made to modify any of the exposure data. For data obtained years ago, uncertainties in instrumentation and calibration could lead to significant uncertainty in exposure values reported. Assumptions made based on theoretical calculations may be unrealistic or based on incorrect information. The type and energy of radiation measured and placement of dosimeters are other factors which could give errors. Therefore, the data presented herein have not been modified, but taken to be the best available estimates of radiation exposure to transport drivers.

In this paper, radiation exposure is used to express the radiological impact on the driver of the highway vehicle. There has been no attempt to evaluate this impact in terms of health detriment. The driver's exposure from the penetrating radiation of the radioactive material packages is given in terms of dose equivalent in units of millirem (mrem). Since the driver is only exposed to gamma radiation, exposure (mR) and dose equivalent (mrem) have been used synonymously in this paper. Since numerous studies were reviewed, the terminology used in each study is retained in this paper. Also, the term, "average" is used for the term "arithmetic mean".

SPENT FUEL

An initial study was done by this author to identify the carriers in the United States that transport highway route control quantities of radioactive materials. Spent fuel would be included as a subset of this type of radioactive materials. There have been a total of 4797 assembles of spent fuel shipped from commercial reactors from 1964 through 1979. Therefore, the 16 year average is 300 assemblies/yr (Fi83). In conducting this study, the Hazardous Materials Information System of the U.S. Department of Transportation was used. At the time of this study, all shippers of highway route control quantities of radioactive materials in the United States were required to report to the U.S. Department of Transportation the routes the carrier used and the description of the radioactive materials transported.

From the start of the system in 1982 through the end of June, 1987, there were 1650 shipments of highway route control quantities of radioactive materials transported in the United States. Only four major carriers were identified by this study. Tri-State Motor Transit, Inc., transported sixty-three percent of the shipments. McGil Specialized Carriers, Inc., transported ten percent of the shipments. A. J. Mettler Hauling and Rigging, Inc., transported seven percent of the shipments. Neutron Products, Inc., transported seven percent of the shipments. All four of these carriers were contacted to find out if they transported spent nuclear fuel, and if they had their drivers under a radiation dosimetry program (Co87, Lo87, Ne87, Wi87). Three of

these carriers transported spent nuclear fuel, however, only one carrier provided a dosimetry program. This company was Tri-State Motor Transit, Inc. (TSMT). Since TSMT transports various other types of radioactive materials, an attempt was made to segregate information concerning radiation exposures for drivers of spent nuclear fuel from drivers who transport various other types of radioactive materials.

TSMT provided dosimetry information on ten drivers of spent nuclear fuel shipments. These few drivers represent a very large percentage of the United States population of spent nuclear fuel drivers. Therefore, their exposure histories are good examples. The data show that the collective dose equivalent for these TSMT drivers is 1.02 person-rem for five and one half years. During the period of time covered by this report, TSMT transported approximatley 700 shipments of spent fuel (Lo87). This is equivalent to about 1.5 mrem per spent fuel shipment per driver.

RADIOPHARMACEUTICAL STUDIES

In October 1979, the U.S. Department of Transportation (DOT) received an application for an exemption from certain radioactive material transportation regulations. This exemption was sought by New England Nuclear Corporation (NEN) for relief from Title 49 of the Code of Federal Regulations Sections 177.842(a) and (b). This would allow the carriage of certain radioactive materials by highway exceeding the 50 transport index vehicle limit without compliance with the separation distance limit. This exemption would provide for the transportation of radiopharmaceuticals, radiochemicals and sealed radiation sources used in research and medical diagnosis in fewer vehicles. A chart was supplied in the NEN application giving a five year history (1974-1978) of exposure to drivers prior to issuance of the exemption. This chart showed that the average dose rate per driver during the five year period was 0.67 mR/hr. The average exposure per driver was 1.676 rem/yr.

The request for an exemption was granted as DOT-E 8308 on March 17, 1980. This exemption did require that the carrier have a radiation protection program. Anyone working under this exemption was required to wear radiation dosimetry. Quarterly reports of the results of the radiation dosimetry program were to be submitted to DOT.

Several other carriers have gained party status to DOT-E 8308 since its inception. All of the records pertaining to this exemption, including the applications and all quarterly reports, are located in the U.S. Department of Transportation's Research and Special Programs Administration, Office of Hazardous Materials Transportation, Public Dockets Room filed under DOT-E 8308. This file was reviewed to obtain all of the data in this section. Since there is no prescribed format for the quarterly reports, each carrier presents data in different forms. This author consolidated the various data based on the quarterly reports (Sh88). Table 1 shows the average exposure per quarter for each year by carrier. The average exposure per driver for all of the DOT-E 8308 carriers, since the inception of the exemption, was 243 mrem per quarter.

TABLE 1

AVERAGE DRIVER EXPOSURE PER QUARTER (mrem) FOR ALL DOT-E 8308 CARRIERS

Carrier	1980	1981	1982	1983	1984	1985	1986	1987	Carrier Average
Associated Couriers, Inc.	561	397	356	328	271	221	218	221	322
Caspersen, Inc.	-	336	346	338	185	142	-	-	269
Del-Med, Inc.	-	-	-	-	-	152	206	234	197
MHC Messenges, Inc.	-	141	107	50	62	59	51	54	75
New England Nuclear	406	321	313	255	242	-	-	-	307
Skycab, Inc.	253	317	335	252	196	151	261	328	262
United States Priority Transport Corp.	-	236	267	297	-	-	-	-	267
							Total Average		243 mrem

Source: All data tabulated by author were obtained from (Sh88).

THE REECo STUDY

The U.S. Nuclear Regulatory Commission contracted with Reynolds Electrical and Engineering Company, Inc., (REECo) to collect information concerning personnel radiation exposure. This study (Sm82) investigated seven carriers that handled large numbers of radioactive material packages. There was concern that individual personnel may have been receiving radiation exposures greater than 500 mrem per year. This was confirmed by the the REECo study. The results of dosimetry monitoring of six of the carriers indicated that the average yearly exposure was 1529 mrem per driver (Sh88).

STATE SURVEILLANCE STUDIES

In 1973, the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT) began a joint contractual program whereby various states undertook the surveillance of radioactive material transportation within their jurisdiction. One portion of the program was to assess data on radiation exposures to transportation workers. The different states used various methods to accomplish this task. Since different methods were used, it is hard to compare the data in all cases. This paper is an attempt to assemble the data on driver exposures and present it in a useful format which will assist in comparison of these exposures. No attempt has been made to critique the methodology of the state studies. However, this author has attempted to normalize the data. In the state studies, the units "mR" and "mrem" were both used, however this author has taken the liberty of using only "mrem". Table 2 gives a comparison of yearly exposures for radiopharmaceutical drivers from the various state studies, the REECo study and the DOT-E 8308 study.

Additional studies conducted in South Carolina (So80)(S081)(So82) presented data on the exposures of drivers of low level wastes. These drivers were employees of Chem-Nuclear Systems, Inc. The annual exposure for these drivers was 114 mrem/yr (Sh88).

A study conducted in Kentucky (Ke80) yielded data for uramium hexafluoride transport drivers. The yearly average exposure was 55 mR per driver.

CONCLUSIONS

While this paper demonstrates that the radiation exposures are very low for most drivers, the radiopharmaceutical drivers are receiving substantial exposures. Table 3 gives a comparison of yearly exposures to drivers from various types of radioactive materials. Regulators should be aware of this problem. Many drivers are also involved with the loading and unloading of the vehicle. Packages are frequently hand-carried considerable distances from the truck to the recipient. Therefore, improved working practices which could lower exposure might be realized through better training programs, as well as more specific regulatory requirements for radiation exposure monitoring.

TABLE 2

A COMPARISON OF YEARLY EXPOSURES FOR
RADIOPHARMACEUTICAL DRIVERS FROM VARIOUS STUDIES

Exposure Study		(mrem/yr)*
South Carolina		120
Pennsylvania		213**
Georgia		566**
Michigan		475**
Kentucky		36
Florida		178
Maryland		10
Nevada		44
Washington		492
REECo		1529
DOT-E 8308		972
	Total	4635
	Average	421 mrem/yr

*Note: Since mR/yr and mrem/yr were both used in the various studies, this author has taken the liberty of using only mrem/yr in this table.

**Note: A simple average of all of the yearly averages was used to calculate this number. Several states used this method in their studies.

TABLE 3

A COMPARISON OF YEARLY RADIATION DOSE TO DRIVERS
FROM VARIOUS TYPES OF RADIOACTIVE MATERIALS

Type of Material	Exposure (mrem/yr)*
Spent Fuel	17**
Uranium Hexafluoride	55
Low Level Waste	114
Radiopharmaceutical	421

*Note: Since mR/yr and mrem/yr were both used in the various studies, this author has taken the liberty of using only mrem/yr in this table.

**Note: The projected collective exposure for 1987 was calculated to be zero based on the first two quarters of the year. Therefore, based on 1020 person-mrem divided by 10 drivers divided by 6 years equals 17 mrem/yr per driver.

The U.S. Department of Transportation (DOT) regulations do not require the use of shielding in the vehicle as a method for reduction of radiation exposure in vehicles. These assessments of the origin of exposures, indicate clearly that were the carriers to add shielding, a reduction in the exposure to drivers could be achieved particularly during the carriage of radiopharmaceuticals.

Radiation safety is the "bottom line" in both transportation and health physics. A reduction in driver radiation exposure is a reduction in risk to the driver. Radiation safety in the transportation of radioactive materials has been superb. There have been no observed injuries or deaths of a radiological nature due to transportation of radioactive materials. This does not mean that better methods of operations and improved regulations are not needed. It does mean that everyone must strive to improve safety, thus radiation doses should be kept as low as reasonably achievable.

REFERENCES

Co87 Costley W., 1987, Vice-President, Neutron Products, Inc., Personal Communication.

EPA84 U.S. Environmental Protection Agency, 1984, "Occupational Exposure to Ionizing Radiation in the United States," EPA-520/1-84-005 (Washington, DC: U.S. Environmental Protection Agency).

Fi83 Finley N. C., Luna R. E., Madsen M. M., McClure J. D., Wheeler T. A., Wilmot E. L., 1983, "The Transportation of Radioactive Material (RAM) To and From U.S. Nuclear Power Plants (Draft Environmental Assessment)," U.S. Nuclear Regulatory Commission Report NUREG/CR-2325, SAND 81-0118 (Washington, DC: U.S. Nuclear Regulatory Commission).

Ke80 Kentucky Department for Human Resources, 1980, "Transportation of Radioactive Material in Kentucky," U.S. Nuclear Regulatory Commission Report NUREG/CR-1671 (Washington, DC: U.S. Nuclear Regulatory Commission).

Lo87 Loud G. C., 1987, Director of Nuclear and Hazardous Materials, Tri-State Motor Transit Company, Personal Communication.

Ne87 Nelson B., 1987, Operations Manager, A. J. Metler Hauling & Rigging, Inc., Personal Communication.

Sh88 Shuler J. M., A Comparison of Radiation Exposures of Highway Drivers from Various Types of Radioactive Materials, Georgetown University Library (Thesis Publication), Washington, DC, April 5, 1988.

Sm82 Smith B. P., Doppe M. W., Lantz M. W. and Bicker A. E., 1982, "Radiation Exposure of Transportation Workers Handling Large Quantities of Radioactive Packages," U.S. Nuclear Regulatory Commission Report NUREG/CR-2200 (Washington, DC: U.S. Nuclear Regulatory Commission).

So80 South Carolina Department of Health and Environmental Control, 1980, "Transportation of Low-Level Radioactive Waste Into South Carolina," U.S. Nuclear Regulatory Commission Report NUREG/CR-1434 (Washington, DC: U.S. Nuclear Regulatory Commission).

So81 South Carolina Department of Health and Environmental Control, 1981, "Transportation of Radioactive Material in South Carolina," U.S. Nuclear Regulatory Commission Report NUREG/CR-2195 (Washington, DC: U.S. Nuclear Regulatory Commission).

So82 South Carolina Department of Health and Environmental Control, 1982, "Transportation of Radioactive Material in South Carolina," U.S. Nuclear Regulatory Commission Report NUREG/CR-2842 (Washington, DC: U.S. Nuclear Regulatory Commission).

Wi87 Williams B., 1987, Vice-President, McGil Specialized Carriers, Inc., Personal Communication.