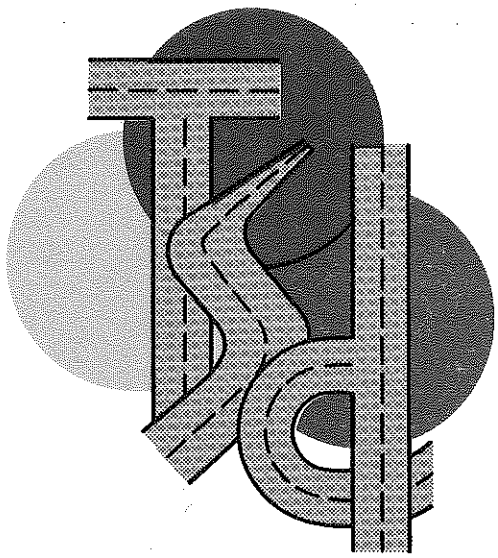
ANALYSIS OF TRUCK ACCIDENTS IN MICHIGAN

TSD-350-77



TRAFFIC and SAFETY DIVISION

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

AND TRANSPORTATION

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Engineering Development Unit
Traffic and Safety Division

June 1977

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ERRATA SHEET

Page 6 Section 2.3(1), line 3: "(560 accidents..." should read "(217 accidents..."

Page 13, line 2: "...[563 accidents..." should read "...[217 accidents..."

Page 13, line 4: "(542)..." should read "(209)..."

Page 21, Section 4.5.2, line 8: "...(386 accidents..." should read "...(149 accidents..."

Page 21, Section 4.5.2, line 9: "...(450)..." should read "...(174)..."

Page 27, Section 5.3, line 1: "...146..." should read "...164..."

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INTRODUCTION

1.1 Purpose of the Study

This analysis was conducted to determine any unusual characteristics of accidents involving trucks and, in particular, involving vehicles carrying a dangerous cargo, and recommend means to minimize the number of such accidents.

The study began as primarily an analysis of all types of truck accidents. But during the data-collection phase, several accidents involving dangerous cargo haulers drew considerable public attention, resulting in a change of emphasis.

This study was not undertaken to find fault with the trucking industry. Trucks form an indispensable link in the transportation system; as long as they are on the highways they will be involved in accidents, sometimes as the cause, sometimes as the victim. As do all vehicles, trucks safely negotiate many thousands of miles for each accident that does occur. Whether their accident rate is higher or lower than the rate for passenger cars is inconsequential to this study; the objective is to reduce the absolute number of their accidents. A second objective for dangerous cargo haulers, which have the potential of causing a catastrophe, is to find conditions under which they are more tolerable.

1.2 Definitions

In this analysis, the following definitions are used. Unless otherwise clearly indicated, all references are to accident data. That is, when the term "driver age" is used, for example, it refers to the age of the drivers involved in accidents, not to the ages of all drivers in general.

"Accident": an incident for which an official accident report was filed and which was eventually encoded on a computer file as occurring on the Michigan state trunkline system. In Michigan, all accidents involving personal injury or property damage exceeding $200 require an official report.

"Truck Accident": an accident for which at least one (of up to three) vehicle was coded as being either a straight truck (single unit) or a semitractor. This definition includes buses and excludes panel and pickup trucks.

"Dangerous Cargo Accident": an accident for which the "special tag" category of the computerized record was encoded as being "an accident in which a vehicle carrying explosive cargo (gasoline, butane, dynamite), radioactive material (atomic, nuclear, waste products), or corrosive cargo (acid, ammonia, etc.) was either physically involved or associated" (10)*. Other items included in the special tag category are school bus, deer, emergency vehicle, and construction zone accidents, and accidents for which traffic engineering attention is requested. Any type of vehicle, not just trucks, can carry a dangerous cargo.

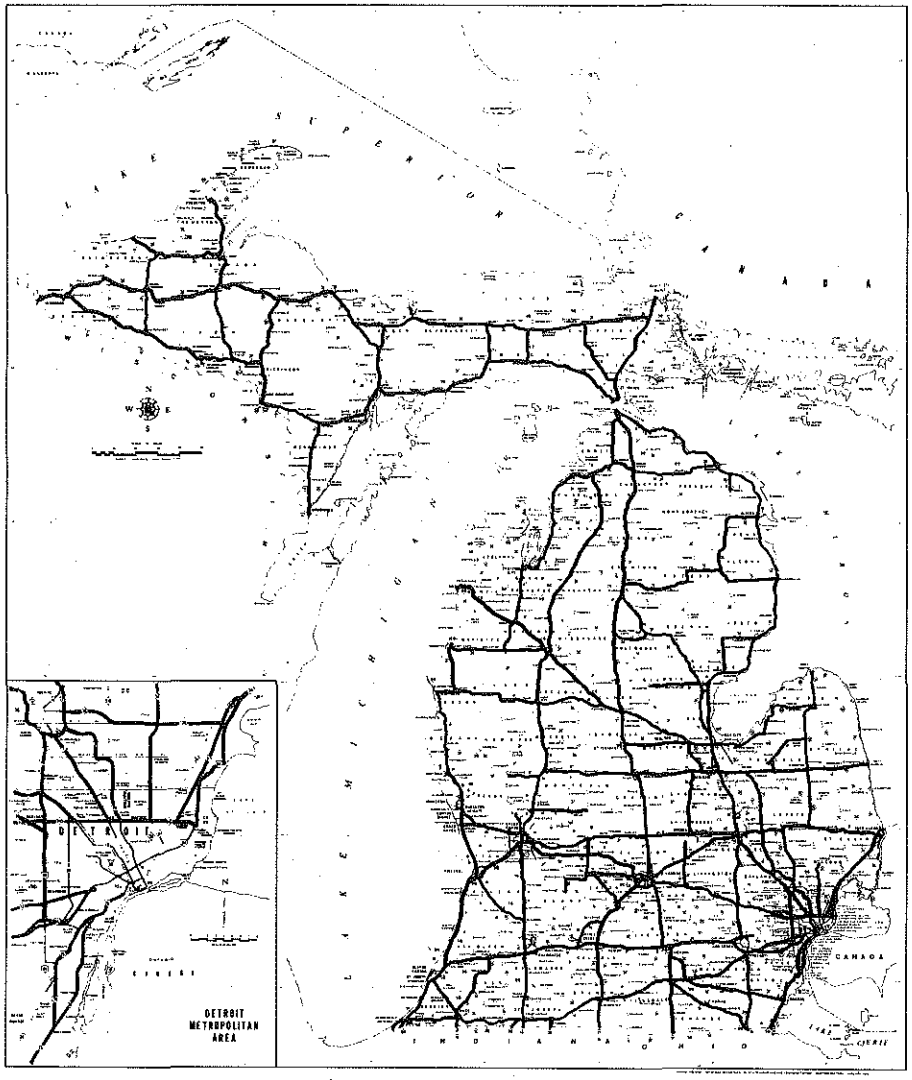
* Underlined numbers in parentheses refer to references.

"Double-Bottom": a combination of a truck or truck-tractor and two trailers. If the overall length is more than 55 feet (16.8 m) (up to a maximum of 65 feet [19.8 m]), such vehicles are restricted to certain routes, which excludes Detroit freeways.

"Single-Bottom": a combination of a truck or truck-tractor and one trailer.

"Injury-Producing Accident": an accident in which at least one personal injury or fatality occurred. This term differs from "personal injury accident" in that the latter does not include accidents resulting in a fatality.

SPECIAL DESIGNATED-65 FOOT TRUCK ROUTES



SOURCE: 1976 Truck Operator's Map

Figure 1

1.3 Maximum Truck Dimensions

The Michigan Vehicle Code (11) places the following restrictions on truck dimensions:

(1) Length (Section 719)

(a) The maximum length of a single unit is 40 feet (12.19 m).

(b) The maximum length of a truck-tractor and trailer or semitrailer (single-bottom) is 55 feet (16.76 m). But if the trailer is designed exclusively to transport motor vehicles or boats the combination may be up to 60 feet (18.29 m) long, 65 feet (19.81 m) on special designated highways.

(c) The maximum length of a truck with a trailer or semitrailer (a single-bottom unit) or of a truck-tractor with a semitrailer and trailer (a double-bottom unit) is 65 feet (19.81 m). But if the length is more than 55 feet (16.76 m), the vehicle is restricted to special designated highways only.

(d) On an experimental basis, double-bottom length may be as much as 100 feet (30.48 m); however, that is highly restricted as to routes and haulers. The performance of such vehicles was reported in Report TSD-279-76, Operational Characteristics of 100-Foot Double Tractor/Trailer Combinations in Michigan (4).

(e) A combination vehicle hauling a mobile home is restricted to 60 feet (18.89 m) with the mobile home itself being restricted to 45 feet (13.72 m). However, under special permit, the overall length may be up to 85 feet (25.91 m) and the mobile home itself may be up to 70 feet (21.34 m) long (65 feet [19.81 m] before January 12, 1976).

The special designated highways, as established by the Michigan Department of State Highways and Transportation, are shown in Figure 1. A vehicle may travel an additional five miles (8 km) on other trunklines for access for its point of departure or to its destination. But trunklines within Detroit are specifically excluded from the designated highways and the 5-mile extension.

A truck is defined in the Vehicle Code as a vehicle designed "...primarily for the transportation of property..."; while a truck-tractor is designed "...primarily for drawing other vehicles and not...to carry a load..." A trailer is "...so constructed that no part of its weight rests on the towing vehicle"; while a semitrailer is "...so constructed that part of its weight and that of its load rests upon or is carried by another vehicle." (All definitions from Chapter I of the Code.)

(2) Width (Section 717)

In general, vehicles are limited to a width of eight feet (2.44 m). Buses may be 8.5 feet (2.59 m) wide. Mobile homes may be 100 inches wide (2.54 m), up to 14 feet (4.27 m) under permit.

(3) Height (Section 719)

The maximum vehicle height allowed is 13.5 feet (4.11 m), except that mobile homes are limited to 12.5 feet (3.81 m).

(4) Weight (Section 722)

(a) For axles spaced nine or more feet (2.74 m) apart, the maximum load is 18,000 pounds (8.18 tonne) per axle.

(b) For axles spaced 3.5 feet (1.07 m) or more, but less than nine feet (2.74 m) apart, the maximum load is 13,000 pounds (5.90 tonne).

(c) For axles spaced less than 3.5 feet (1.07 m) apart, the maximum combined load is 18,000 pounds (8.18 tonne).

(d) However, one tandem axle is permitted a load of 16,000 pounds (7.26 tonne) per axle; two such loadings are permitted if the total gross weight of the vehicle combination is 73,280 pounds (33.24 tonne). For the 100-foot (30.5 m) combinations, the allowable tandem axle loading is increased from 13,000 to 16,000 pounds (5.90 to 7.26 tonne) per axle.

(e) The maximum allowable tire loading is 700 pounds per inch of tire width (12.5 kg per mm).

(f) During March, April, and May, these limits are reduced 25 percent on concrete or concrete-base pavement and 35 percent on other pavements.

Up to 11 axles are allowed on a combination vehicle; thus the maximum weight could reach 154,000 pounds (69.85 tonne).

1.4 Method of Study

To gain an understanding of the truck accident situation, a four-step approach was used:

a. Truck accidents were compared to all trunkline accidents.

To determine trends in truck accidents, data for all truck accidents for the years 1971 through 1975 were used.

To compare the characteristics of truck accidents to those of other vehicles, two separate 5000-accident random samples were taken from the 1975 accident data.

The first sample, referred to as "All-vehicle" in this report, was selected from all 99,874 trunkline accidents. It is used to establish the typical accident characteristics.

The second sample, referred to as "All-truck" was selected from all 10,016 truck trunkline accidents. It is compared to the "All-vehicle" sample to establish differences in the accident characteristics.

b. Accidents involving single-bottom trucks were compared to those involving double-bottoms and also to all truck and all trunkline accidents.

   Two files, consisting of data from the years 1971 through 1975, were used. Multiyear data was used to obtain a large amount of data for comparisons.

   The first, referred to as "Single-bottom," consists of data from all 13,741 accidents involving single-bottom units.

   The second, referred to as "Double-bottom," consists of data from all 3,919 accidents involving double-bottom units.

c. Reports of dangerous cargo accidents were reviewed, and those accidents were compared to all accidents.

   Copies of the official reports, when available, for the period from January, 1971, through September, 1976, were reviewed. A separate computer file of those accidents was prepared.

d. The findings of other research projects were reviewed.

   Much of this information was obtained from the Proceedings of a Symposium on Commercial Vehicle Braking and Handling, held at the Highway Safety Research Institute, University of Michigan, in May, 1975.

All information concerning number of different types of vehicles and vehicle-miles driven was obtained from the department's files and the 1975 Trunkline Vehicle Mile computerized file.

Any differences noted were shown to be statistically significant at the 95 percent confidence level.

CONCLUSIONS

2.1 General

The analysis found several characteristics, outlined below, for which truck accident data differs from data for all accidents. Differences were found by type of truck and between dangerous cargo accidents and other truck accidents.

Much of the data desired, especially data concerning the mileage and routes driven by the different types of trucks, is unavailable. Other accidents involving dangerous cargo that are not included in the computerized file are known to have occurred.

2.2 Trends

Three trends in all truck accidents during the years 1971 through 1975 were found:

(1) The proportion of all accidents that involved trucks has increased. Trucks were involved in an average of 8.0 percent of all accidents in January, 1971, and 10.6 percent in December, 1975.

(2) The percent of truck accidents that produced fatalities has decreased: 1.68 percent in 1971; 0.86 percent in 1975.

(3) The average age of truck drivers involved in accidents has decreased. The proportion of the accidents involving drivers 25 years old and younger has increased from 21 percent in 1971 to 28 percent in 1975.

2.3 Truck Accident Factors

For the year 1975, the following differences were noted among data for all accidents, all trucks, single-bottoms and double-bottoms, also between dangerous cargo accidents and all truck accidents:

(1) The overall accident rates for all trucks were about the same as for all vehicles, about 350 accidents per 100 million vehicle miles (560 accidents per 100 million vehicle-kilometers). For all urban roads, the truck rate was 20 percent higher than the all-vehicle rate; for urban freeways, the truck rate was 42 percent higher than the all-vehicle rate. For both all vehicles and all trucks, the accident rates on freeways were about 1/4 the rates for divided free-access roads and about 1/7 the rates for 2-way roads.

(2) The percent of accidents that produce injuries was lower for all trucks (27.5 percent) than for all vehicles (31.4 percent). But the percent of injury-producing accidents that result in a fatality was higher for trucks (2.8 percent), especially for single-bottoms (7.0 percent) and double-bottoms (7.2 percent) than for all vehicles (2.2 percent). For dangerous cargo accidents, 40 percent produced injuries and 18 percent of those injury-producing accidents resulted in fatalities.

(3) All vehicle types had a concentration of accidents during the afternoon peak hours. For single- and double-bottom trucks, their volume was decreasing during that period so their accident rate during that period was about 30 percent above normal.

(4) All trucks had an insignificantly higher proportion of their accidents on snowy or icy pavement (15.2 percent) than did all vehicles (14.6 percent). The difference was significant for single-bottoms (19.5 percent), double-bottoms (18.0 percent), and dangerous cargo accidents (29.4 percent). The proportion on snow or ice for all vehicle types was highly dependent on roadway type; about twice as high for freeways as f other surface roads, with rural roads having a higher proportion than did urban roads.

As a consequence of having a high percentage on snow or ice, a disproportionate 60 percent of dangerous cargo accidents occurred during the winter months, November through March.

(5) The types of accidents that occurred were highly dependent on vehicle type and road type. Double-bottoms had the highest proportion of their accidents that overturned (8.6 percent for urban freeways, 12.6 percent for rural freeways, 1.2 percent for urban 2-way roads). Those percentages were about 2.5 times as high as the comparable percentages for single-bottoms. For all dangerous cargo accidents, 21 percent overturned.

Single-bottom trucks had a greater proportion of these accidents on 2-way roads that are intersection related, especially right-turn accidents (10.2 percent), than do other vehicle types. The comparable percentage for double-bottoms was 7.3 percent and that for all vehicles was 2.7 percent.

(6) The average age of drivers in accidents is higher for single-bottoms (38.0 years) and double-bottoms (37.4 years) than for all trucks (35.3 years) or for all vehicles (33.4 years). The average age for the truck driver in a dangerous cargo accident was 39.6 years.

(7) Other studies have found that tankers are subjected to a surging force on the side of the truck that does not affect other types of vehicles. This phenomenon is more prevalent when the tankers are partially filled (5) and influences the stability of a second trailer of a double-bottom more than the first trailer (6).

(8) In 19 percent of the dangerous cargo accidents, the cargo burned or was spilled. For those dangerous cargo accidents that overturned, the percentage was significantly higher, 43 percent.

(9) The consequences of an incident on an urban freeway that forces the closing of the freeway are greater than the consequences of a similar incident in a rural area or a surface street. Such an urban freeway closure can cause a breakdown of the entire urban transportation system with considerable, but not completely calculable, economic loss to the public.

III

RECOMMENDATIONS

To reduce the potential for catastrophic accidents involving hazardous material, it is recommended that:

1. Permanent administrative rules governing hazardous cargo transportation be prepared by the Michigan Public Service Commission or alternately by the Michigan State Police Fire Marshal Division; already adopted restrictions should be subject to amendment based on additional facts as they become known.

2. The proposed Michigan Motor Carrier Safety Administrative Rules be adopted and implemented as soon as possible.

3. The placing of operational limits be studied for double-bottom tank trucks carrying dangerous liquid cargo during peak hours in the winter months on crowded urban freeways where the accumulation of accident factors can result in public catastrophe.

4. This department encourage objective nongovernmental vehicle testing of large double-bottom tankers under partial liquid loads to determine effects on stability of short radius cornering and unexpected erratic maneuvers.

To provide a base for more comprehensive analyses of truck accident causes, it is further recommended that:

5. This department, the Department of State Police, the Public Service Commission, and the U.S. Department of Transportation, in cooperation, develop new accident reporting forms and procedures that will provide complete information on each truck accident, including age and model of the different components of combination vehicles and the type and amount of cargo hauled. A means to coordinate the various reports now required for truck accidents should be developed.

6. This department institute a continuing survey collecting detailed data on the vehicle miles, predominant routes, and cargos hauled by various types of commercial vehicle.

IV

TRUCK ACCIDENT FACTS

4.1 Trends

Three trends were noted in the truck accident data for the years 1971 through 1975:

4.1.1 Number of Accidents

Figure 2 shows that the number of truck accidents, as a percent of all accidents, is increasing from an average of 8.0 percent in January, 1971, to 10.6 percent in December, 1975. Due to a change in the accident files (Detroit nonfatal accidents are not included in the 1971 and 1972 files) the trend for actual number of accidents cannot be accurately calculated.

For both all vehicles and all trucks, there is an annual cycle for the accidents: the number is highest in the winter months, lowest in the spring, with an increase in the summer months, and another decrease in the fall.

TRUCK ACCIDENT TRENDS JANUARY 1970 TO DECEMBER 1975

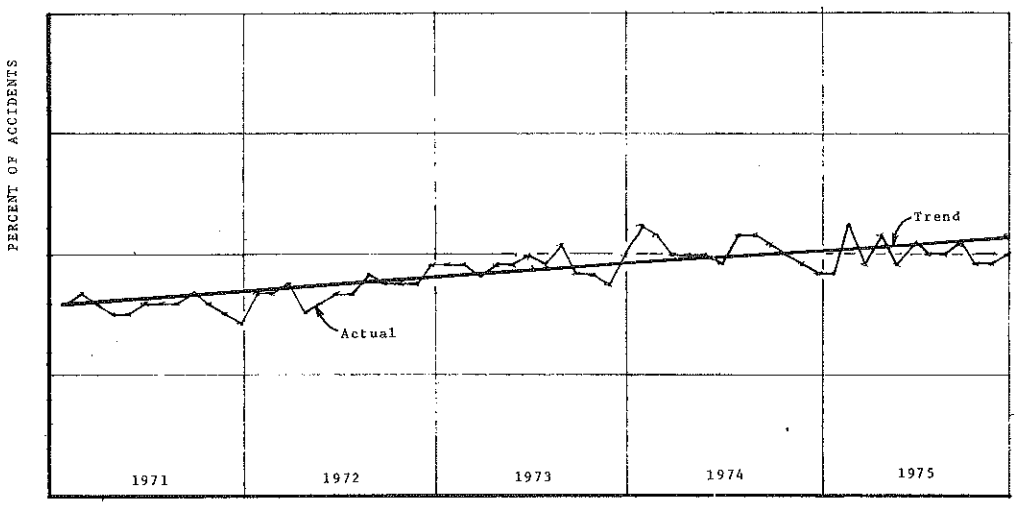


Figure 2

4.1.2 Accident Severity

The percent of truck accidents that results in a fatality has been steadily decreasing. The percent that produces injury or fatality has also decreased slightly.

Percent of Truck Accidents

Year	Fatal	Injury	Prop. Damage	Fatal/Inj-Prod
1971	1.68	26.39	71.43	5.9
1972	1.31	26.73	71.96	4.7
1973	1.23	27.22	71.55	4.4
1974	1.13	26.15	72.71	4.1
1975	0.86	26.30	72.84	3.2

4.1.3 Driver Age

Figure 3 shows that the ages of the truck drivers on truck accidents are decreasing, with young drivers (25 and younger) having an increasing proportion of the accidents. By comparison, in 1973 the average age of all drivers (not just those involved in accidents) was 38.8 years, but the average age of those involved in accidents that year was 34.7, with 40 percent of the drivers being 25 or younger.

TRUCK DRIVER AGE TRENDS 1971 TO 1975

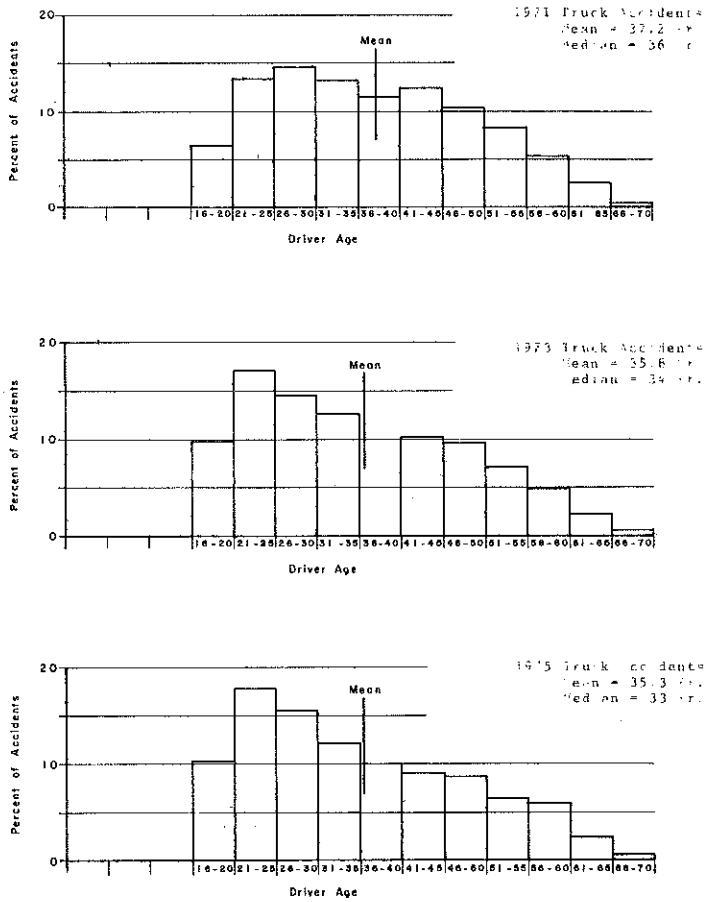


Figure 3

4.2 Comparisons by Vehicle Type

4.2.1. Volume Data

In 1975, there were an estimated 29.6 billion vehicle-miles (47.6 billion vehicle-kilometers) driven on Michigan's trunkline, of which 2.9 billion (9.6 percent) were driven by commercial vehicles. "Commercial" in the volume data is considered to be equivalent to "truck" in the accident data. That is not necessarily true for previous years; before 1971 "commercial" also included smaller vehicles, such as pickup. For several years after the change, some of the smaller-vehicle volume data were included in "commercial."

The number of vehicle miles accumulated by the various types of trucks is unavailable. The best estimate obtainable comes from the department's 1974 truck weight classification study, which produced the following percentage breakdown for the number of vehicles (not vehicle-mileage):

Single Units	24.5%
Single-Bottoms	70.6%
Double-Bottoms	4.9%

It is further estimated that double-bottom tankers hauling hazardous materials constitute less than 2 percent of all trucks (or less than 40 percent of the double-bottoms). It is estimated that there are about 500 double-bottom tankers operating throughout Michigan.

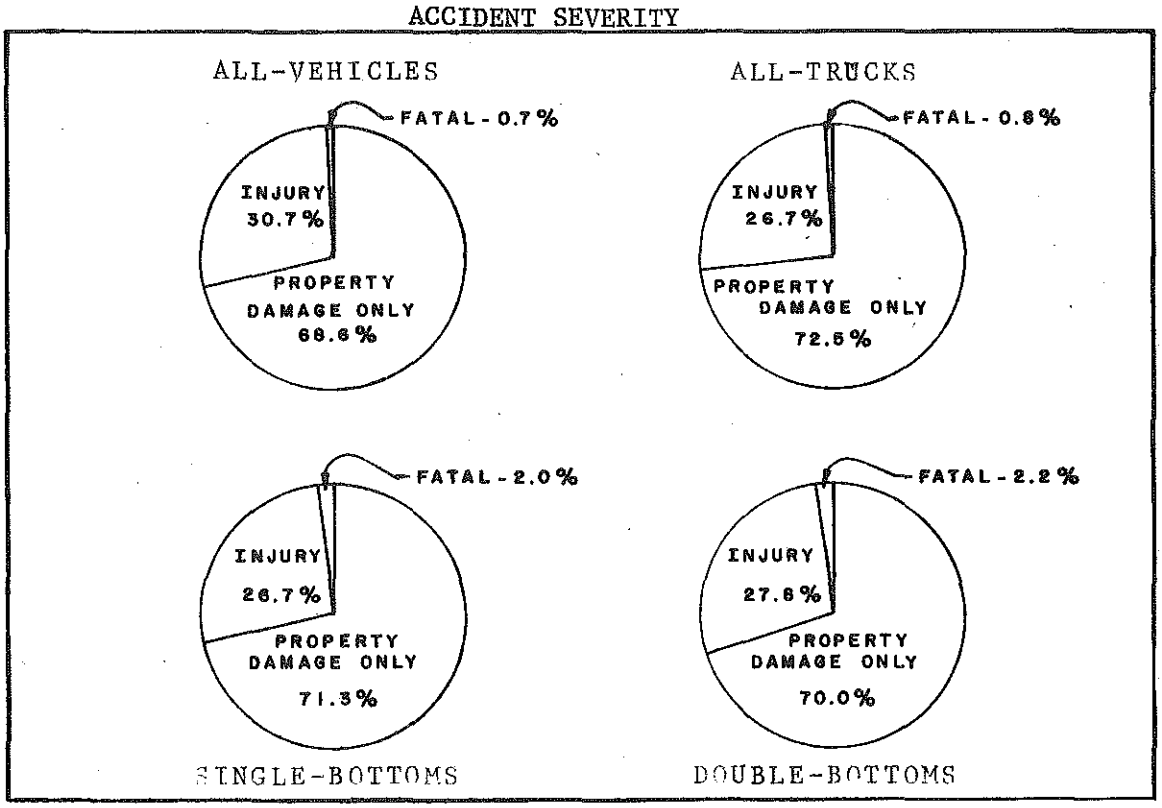


Figure 4

1975 ACCIDENT RATES

BY ROADWAY TYPE

TRUNKLINES

	TOTAL LENGTH (MI)	VEHICLE - MILES DRIVEN		NUMBER OF ACCIDENTS			ACCIDENTS PER 100-MILYN V-M		RATIO TRUCK RATE TO ALL VEH RATE
		ALL VEHICLES	COMMERCIAL	ALL VEH	TRUCK	DNGRS CARGO	ALL VEH	TRUCK	
FREEWAY									
URBAN	515	7,926,400,000	816,000,000	11,438	1,674	3	144	205	1.42 : 1
RURAL	1,024	5,172,700,000	794,800,000	4,702	846	1	91	106	1.17 : 1
TOTAL	1,539	13,099,000,000	1,610,800,000	16,140	2,520	4	123	156	1.27 : 1
DIVIDED									
URBAN	302	3,292,600,000	199,700,000	18,802	1,782	7	571	892	1.56 : 1
RURAL	230	875,400,000	83,500,000	1,625	183	2	186	219	1.18 : 1
TOTAL	532	4,167,900,000	283,200,000	20,427	1,965	9	490	694	1.42 : 1
2-WAY									
URBAN	778	4,773,500,000	287,000,000	38,240	5,263	6	802	1,137	1.42 : 1
RURAL	6,439	7,585,100,000	675,700,000	24,884	2,257	8	328	334	1.02 : 1
TOTAL	7,217	12,355,600,000	962,700,000	63,124	5,520	14	511	573	1.12 : 1
GRAND TOTALS									
URBAN	1,595	15,989,400,000	1,302,600,000	68,480	6,719	16	428	516	1.20 : 1
RURAL	7,693	13,633,200,000	1,554,000,000	31,211	3,286	11	229	211	0.92 : 1
TOTAL	9,289	29,622,600,000	2,856,600,000	99,691	10,005	27	337	350	1.04 : 1

Table 1

1975 ACCIDENT RATES

BY ROADWAY TYPE

--- INJURY-PRODUCING ACCIDENTS ---

TRUNKLINES

	TOTAL LENGTH (MI)	VEHICLE - MILES DRIVEN		NUMBER OF ACCIDENTS			ACCIDENTS PER 100-MILYN V-M		RATIO TRUCK RATE TO ALL VEH RATE
		ALL VEHICLES	COMMERCIAL	ALL VEH	TRUCK	DNGRS CARGO	ALL VEH	TRUCK	
FREEWAY									
URBAN	515	7,926,400,000	816,000,000	4,049	531	0	51	65	1.27 : 1
RURAL	1,024	5,172,700,000	794,800,000	1,340	272	0	26	34	1.32 : 1
TOTAL	1,539	13,099,000,000	1,610,800,000	5,389	803	0	41	50	1.21 : 1
DIVIDED									
URBAN	302	3,292,600,000	199,700,000	5,787	472	1	176	236	1.34 : 1
RURAL	230	875,400,000	83,500,000	518	58	0	59	69	1.17 : 1
TOTAL	532	4,167,900,000	283,200,000	6,305	530	1	151	187	1.24 : 1
2-WAY									
URBAN	778	4,773,500,000	287,000,000	11,522	854	3	242	298	1.23 : 1
RURAL	6,439	7,585,100,000	675,700,000	6,910	588	2	91	87	0.96 : 1
TOTAL	7,217	12,355,600,000	962,700,000	18,432	1,442	5	149	150	1.00 : 1
GRAND TOTALS									
URBAN	1,595	15,989,400,000	1,302,600,000	21,358	1,857	4	134	143	1.07 : 1
RURAL	7,693	13,633,200,000	1,554,000,000	8,768	918	2	64	59	0.92 : 1
TOTAL	9,289	29,622,600,000	2,856,600,000	30,126	2,775	6	102	97	0.96 : 1

Table 2

Table 1 shows that overall the accident rate for trucks (350 accidents per 100 million vehicle miles [563 accidents per 100 million vehicle-kilometers]) is about the same as that for all vehicles, 337 (542). But for the various types of highway, in particular in urban areas, the truck rate is considerably higher than the rate for all vehicles. Freeways had by far the lowest rates; the rate for divided roads was about four times as high and the rate for urban two-way roads was seven times as high as the rate for urban freeways.

A similar table (Table 2) for only injury-producing accidents gives similar information, except that the ratio of truck rate to all-vehicle rate in urban areas is not as great.

4.2.2 Severity

Figure 4 shows that overall, the proportion of accidents that result in injury or fatality is lower for trucks than for all vehicles. Of those injury-producing accidents, the proportion that result in a fatality is higher, but not significantly higher, for all trucks (2.8 percent compared to 2.2 percent). For both single- and double-bottoms, the percent fatal is about 3 times as high as for all vehicles.

4.2.3 Time of Day

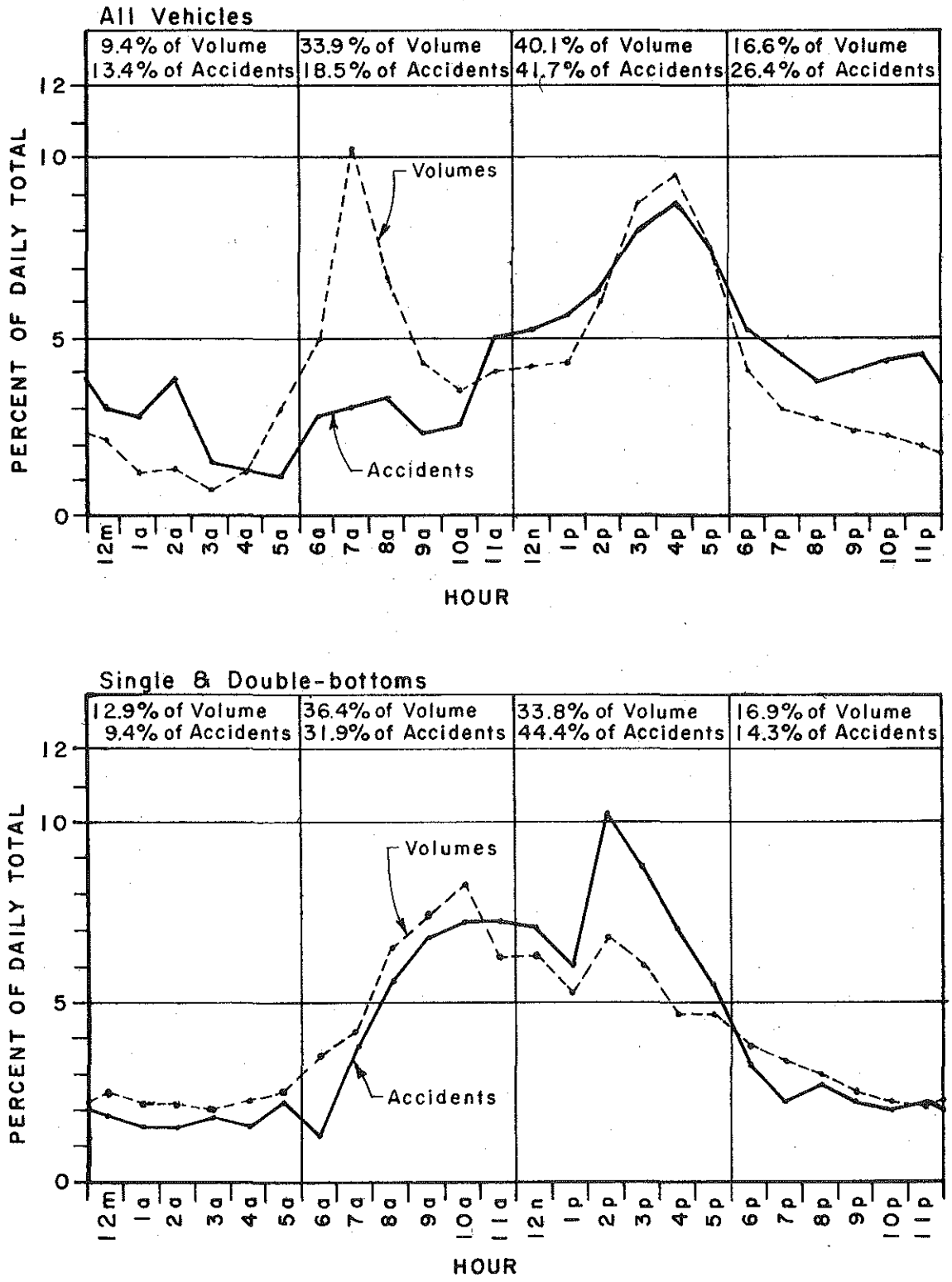
Single- and double-bottom trucks in Detroit had higher than normal accident rates during the afternoon hours, as Figure 5 indicates. For the other hours of the day, the accident rates for those vehicles were fairly constant.

In contrast, the hourly accident rates for all vehicles in Detroit varies considerably; the morning rush hour having far fewer, and the evening hours having more accidents than would be expected from their respective volumes.

4.2.4 Surface

Figure 6 shows that single- and double-bottom trucks have a greater proportion of their accidents on snowy or icy pavement than do all vehicles. As will be shown later (Table 5) the proportion on snowy or icy pavement is highly dependent on highway type, with rural roads having higher proportions than do urban. Again, the proportions of the total vehicle miles that are driven on snowy or icy pavement is unavailable.

TIME OF DAY DISTRIBUTION, CITY OF DETROIT



Volume Data Source: Classification count, River Rouge Bridge, Nov. 1976.

Figure 5

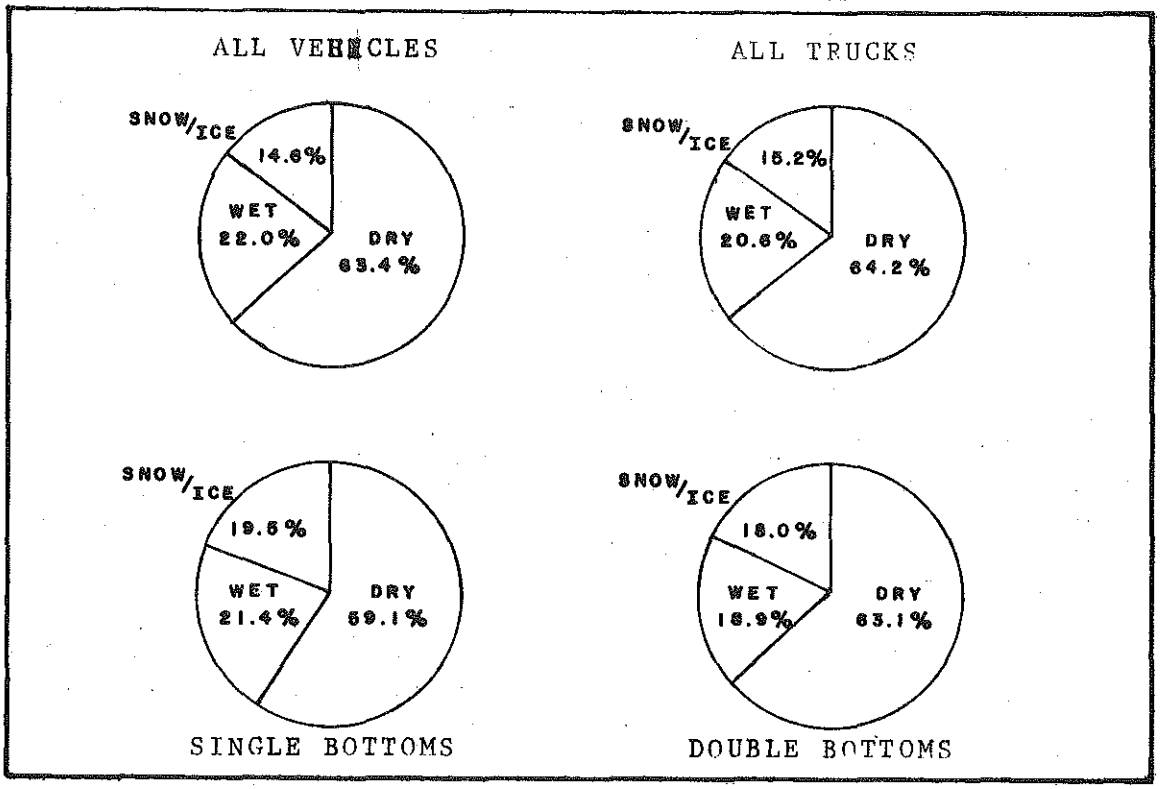


Figure 6

4.2.5 Accident Type, Road Type Relationships

Tables 3, 4, and 5, taken together, show a variety of relationships.

The accident type "Other" is used to describe about 2 percent of truck accidents. For single- and double-bottom trucks for the years 1971 through 1974, 73 percent of "Other" accidents were also classified as separated or jackknifed trailer. Beginning in 1975 that information is no longer included in the computerized file.

4.2.6 Number of Accidents by Truck Type

The following, taken from 1973 data, shows the proportional breakdown of truck accidents by truck type:

Single Unit	53.6%
Single-Bottom	38.5%
Double-Bottom	7.9%

These figures cannot be applied directly to the values given in 4.2.1 as the relative exposures of the different truck types differ.

DISTRIBUTION OF ACCIDENT TYPES

ACCIDENT TYPES	FREEWAY								DIVIDED OR ONE-WAY								TWO-WAY							
	URBAN				RURAL				URBAN				RURAL				URBAN				RURAL			
	*All Veh.	All Truck	Sngl. Btm.	Dbl. Btm.	*All Veh.	All Truck	Sngl. Btm.	Dbl. Btm.	*All Veh.	All Truck	Sngl. Btm.	Dbl. Btm.	*All Veh.	All Truck	Sngl. Btm.	Dbl. Btm.	*All Veh.	All Truck	Sngl. Btm.	Dbl. Btm.	*All Veh.	All Truck		
Overturn	4.1	5.7	3.1	8.6	10.4	10.9	5.7	12.6	0.6	0.9	1.1	3.0	8	8	2.8	7	0.7	0.6	0.5	1.2	5.9	5.7	3.2	7.3
Railroad Train	0	0	0	0	0	0	0	-	0	0	0.3	0	1	1	0.4	1	0.1	0.1	0.2	0.4	0	0.2	0.2	0.4
Hit Praked Vehicle	4.5	3.1	2.7	2.9	5.4	3.1	3.9	2.8	3.2	1.9	1.9	2.0	1	2	2.1	0	4.1	4.6	4.3	2.7	4.9	3.7	2.9	2.9
Hit Moving Vehicle, Other	0.4	0.7	0.7	1.6	0.5	0.5	0.6	0.3	1.1	0.7	3.0	2.8	1	0	1.8	2	1.8	1.8	3.6	3.2	1.8	2.0	1.7	2.1
Head-on	0.7	1.1	1.7	1.6	0.5	0.9	1.3	1.0	0.8	0.6	0.8	1.1	0	2	1.4	0	2.3	2.2	2.3	2.3	3.1	7.9	10.5	12.5
Side-swipe Same Direction	8.3	13.6	14.7	12.8	5.4	8.3	8.9	8.9	5.5	7.9	9.5	9.1	3	8	7.0	6	3.6	7.2	6.2	6.8	1.6	3.6	3.1	2.9
Side-swipe Opposite Direction	0	0.1	0.1	0.3	0	0.2	0	0.2	0.2	0.1	0.4	0.4	0	1	0.4	0	0.5	0.4	0.6	0.5	1.2	2.9	3.9	3.0
Angle	4.3	3.2	3.7	2.7	3.2	1.9	1.0	1.6	19.5	18.7	18.1	16.3	17	15	13.0	14	16.4	16.5	13.7	14.8	8.2	11.1	7.9	8.7
Left Turn	1.3	1.8	1.7	1.8	2.3	1.2	0.9	1.0	7.4	8.1	7.3	9.1	7	6	7.0	8	11.8	8.4	8.4	7.1	4.9	6.3	7.7	5.1
Right Turn	0.5	0.8	1.6	0.5	0	0.5	0.3	0	2.1	5.0	6.1	5.4	0	2	1.4	2	2.7	4.7	10.2	7.3	1.4	4.5	3.8	2.1
Rear-end	46.3	47.7	43.9	41.5	19.5	33.3	33.8	32	39.7	39.8	32.5	31.3	18	20	22.5	20	31.4	33.5	27.7	31.1	13.4	17.0	15.1	16.1
Backing	0.5	0.7	0.4	0.2	0	0.5	0.1	0.2	0.6	1.3	2.0	1.1	0	1	0.4	0	1.0	2.6	2.3	3.2	1.0	2.0	0.8	0.3
Parking/Driveway	0.5	0.5	0.5	0.5	0	0.7	0.4	0	7.7	6.2	5.9	5.0	7	8	5.3	5	13.8	10.8	10.0	9.3	10.9	10.5	10.1	9.4
Pedestrian	0	0.2	0.4	0	1.8	0.5	0.3	0.3	0.5	0.6	0.5	0.7	0	0	0.4	2	1.6	0.9	0.4	0.7	1.0	0.4	0.1	0.7
Fixed Object	25.7	16.0	18.4	18.9	33.9	25.8	26.6	26.9	8.8	6.8	8.0	8.9	16	12	18.2	17	6.5	4.4	7.3	6.8	17.2	10.2	15.4	15.6
On-road Object	0.4	0.2	0.9	0.7	1.4	1.4	1.2	0.7	0	0	0.3	0.2	0	0	0.7	0	0.1	0.1	0.6	0.5	0.3	0.4	0.5	0.4
Animal	1.6	1.2	0.4	0.7	14.5	5.4	5.9	4.3	0.3	0.1	0.1	0	18	10	9.8	5	0.4	0.1	0.1	0	21.5	9.4	7.9	5.0
Bicycle	0.2	0	0	0	0	0	0	0	1.6	0.6	0.4	0	0	0	0	0	1.1	0.4	0.6	0.2	1.0	0.2	0.1	0
Other	0.7	3.2	5.1	4.6	1.4	5.0	9.2	7.7	0.3	0.8	1.9	3.5	1	2	5.6	8	0.2	0.7	1.2	2.0	0.6	2.1	5.0	5.5
TOTAL **	557	837	3016	922	221	423	2224	609	945	899	1655	460	71	88	285	83	1939	1623	2423	562	1253	1121	2470	762

* All Veh: 5,000-Accident Sample of 1975 Trunkline Accidents
All Truck: 5,000-Accident Sample of 1975 Truck Accidents
Sngl Btm: 13,741 Single-bottom Accidents, 1971-75
Dbl Btm: 3,919 Double-bottom Accidents, 1971-75

Values represent precent of Column total

** Number of accidents in sample

Table 3

SEVERITY OF ACCIDENTS

Accident Type	FREEWAY								DIVIDED or ONE-WAY								TWO-WAY							
	Urban				Rural				Urban				Rural				Urban				Rural			
	All Veh	All Truck	Sngl Btm	Dbl Btm	All Veh	All Truck	Sngl Btm	Dbl Btm	All Veh	All Truck	Sngl Btm	Dbl Btm	All Veh	All Truck	Sngl Btm	Dbl Btm	All Veh	All Truck	Sngl Btm	Dbl Btm	All Veh	All Truck	Sngl Btm	Dbl Btm
Overturn	65	48	56	46	48	70	58	35	100	38	39	64	50	14	38	67	69	33	36	57	60	48	42	32
Railroad train	–	–	–	–	–	–	–	–	–	–	40	–	–	–	–	–	–	–	–	–	–	–	–	–
Hit Parked Car	32	35	27	37	25	31	24	47	40	6	6	0	–	–	33	–	11	9	6	7	8	7	7	4
Hit Moving Vehicle	–	0	24	13	–	–	23	–	10	17	12	31	–	–	40	–	18	24	16	0	35	23	26	19
Head-on	–	56	52	53	–	–	48	17	62	20	46	40	–	–	–	–	36	47	46	46	56	36	43	42
Side-swipe, Same Direction	22	32	23	19	25	23	28	15	8	13	6	12	–	43	20	0	11	13	15	10	15	10	20	4
Side-swipe, Opposite Direction	–	–	–	–	–	–	–	–	–	–	33	–	–	–	–	–	33	17	60	–	40	44	37	35
Angle	46	18	40	44	57	25	36	30	36	39	40	43	50	38	51	33	36	33	38	41	36	39	44	38
Left Turn	14	13	30	41	80	60	45	50	40	20	31	24	40	0	45	29	34	24	27	35	39	31	38	46
Right Turn	–	29	6	20	–	–	33	–	15	7	10	8	–	–	–	–	8	14	11	10	33	14	10	12
Rear-End	39	35	37	38	44	41	44	41	35	31	33	28	46	44	45	65	30	29	32	31	30	25	33	29
Backing	–	17	23	–	–	–	–	–	0	0	3	0	–	–	–	–	10	2	4	11	0	0	15	–
Parking/Driveway	–	–	14	40	–	–	67	–	22	16	26	30	40	43	11	–	26	21	24	35	24	20	38	47
Pedestrian	–	–	92	–	–	–	100	–	100	100	100	–	–	–	–	–	100	80	100	–	92	100	–	100
Fixed Object	33	33	29	37	36	17	21	26	26	18	18	5	18	18	6	14	34	18	11	10	36	25	21	23
On-road Object	–	–	25	17	–	17	7	–	–	–	40	–	–	–	–	–	–	–	0	–	–	0	15	–
Animal	11	0	0	0	3	0	2	0	–	–	–	–	8	0	0	–	0	–	–	–	4	1	2	5
Bicycle	–	–	–	–	–	–	–	–	73	60	100	–	–	–	–	–	90	71	100	–	92	–	–	–
Other	–	22	18	14	10	15	6		–	57	9	31	–	–	0	0	–	36	20	18	25	22	14	5
T O T A L	37	33	32	35	35	32	31	30	33	27	27	26	34	30	31	36	31	25	25	27	28	25	29	29

* All Veh: 5,000-Accident Sample of 1975 Trunkline Accidents
All Truck: 5,000-Accident Sample of 1975 Truck Accidents
Sngl Btm: 13,741 Single-bottom Accidents, 1971-75
Dbl Btm: 3,919 Double-bottom Accidents, 1971-75

Values represent percent of accidents in each cell that produced an injury or a fatality
(omitted if less than 5 accidents in cell)

Table 4

PERCENT OF ACCIDENTS ON SNOW OR ICE

ACCIDENT TYPES	FREEWAY								DIVIDED OR ONE-WAY								TWO-WAY							
	URBAN				RURAL				URBAN				RURAL				URBAN				RURAL			
	*All Veh.	All Truck	Sngl. Btm.	Dbl Btm.	*All Veh.	All Truck	Sngl Btm.	Dbl. Btm.	*All Veh.	All Truck	Sngl Btm.	Dbl. Btm.	*All Veh.	All Truck	Sngl Btm.	Dbl. Btm.	*All Veh.	All Truck	Sngl Btm.	Dbl. Btm.	*All Veh.	All Truck	Sngl Btm.	Dbl. Btm.
Overturn	22	15	14	10	35	28	25	30	17	38	6	21	17	71	25	17	8	0	0	0	28	30	22	12
Railroad Train	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Hit Parked Car	32	27	20	30	33	23	24	24	17	6	3	0	-	-	33	-	16	12	11	0	25	17	21	32
Hit Moving Vehicle Other	-	17	19	13	-	-	23	-	20	17	14	0	-	-	0	-	9	10	8	6	4	27	23	31
Head-on	-	22	14	27	-	-	28	0	25	20	8	0	-	-	-	-	33	28	21	8	20	20	21	17
Side-swipe, Same Direction	17	13	19	12	17	37	41	32	19	11	12	10	-	29	30	0	6	7	6	13	15	15	17	18
Side-swipe Opposite Direction	-	-	-	-	-	-	-	-	-	-	17	-	-	-	-	-	11	17	20	-	13	28	20	13
Angle	4	4	17	12	0	12	41	20	6	6	4	8	17	15	3	17	7	11	10	8	14	11	13	11
Left Turn	14	0	2	24	0	20	15	17	14	4	8	12	0	20	10	14	6	10	7	8	10	13	12	13
Right Turn	-	0	2	0	-	-	17	-	5	4	8	8	-	-	-	-	11	8	4	5	22	12	15	12
Rear-end	20	20	19	18	28	36	30	27	11	9	9	11	8	17	25	12	9	9	6	4	16	17	17	18
Backing	-	0	8	-	-	-	-	-	17	8	6	20	-	-	-	-	5	9	4	0	0	23	15	-
Parking/Driveway	-	-	14	40	-	-	11	-	8	12	5	13	0	0	0	-	8	8	8	6	12	11	12	8
Pedestrian	-	-	8	-	-	-	17	-	0	0	0	-	-	-	-	-	3	0	0	-	8	0	-	0
Fixed Object	43	28	31	24	43	38	50	40	24	18	12	20	18	46	35	29	24	16	14	8	39	33	28	25
On-road Object	-	-	14	0	-	0	22	-	-	-	0	-	-	-	-	-	-	-	0	-	-	0	15	-
Animal	0	10	0	0	6	0	2	4	-	-	-	-	15	11	0	-	0	-	-	-	5	3	4	3
Bicycle	-	-	-	-	-	-	-	-	0	0	0	-	-	-	-	-	0	0	0	-	0	-	-	-
Other	-	33	38	40	-	48	60	64	-	0	31	25	-	-	50	43	-	0	13	18	12	35	36	40
TOTAL	24	20	21	18	28	32	37	32	12	9	9	11	14	26	20	17	10	10	8	6	17	17	18	17

* All Veh: 5,000-Accident Sample of 1975 Trunkline Accidents
All Truck: 5,000-Accident Sample of 1975 Truck Accidents
Sngl Btm: 13,741 Single-bottom Accidents, 1971-75
Dbl Btm: 3,919 Double-bottom Accidents, 1971-75

Values represent percent of accidents in each cell that occurred on snowy or icy pavement
(omitted if less than 5 accidents in cell)

Table 5

4.2.7 Driver Age

The average ages and the 5-year span that contains the largest proportion of the drivers were:

	Average	Mode
All Vehicles	33.4 years	17-21 years (26.2%)
All Trucks	35.3 years	19-23 years (18.8%)
Single-Bottoms	38.0 years	30-34 years (16.0%)
Double-Bottoms	37.4 years	29-33 years (16.6%)

This indicates that the drivers of the larger trucks are older than other drivers. Age, however, does not necessarily relate to experience. The age statistics for all truck drivers, not just those involved in accidents, are unknown.

4.3 Economic Factors

4.3.1. Loss due to Road Closures

Accidents involving large trucks, especially those carrying a hazardous material, have resulted in the closing of freeways, for as long as ten hours. These closings represent an economic loss to the public, in addition to the physical damage resulting from the accident.

Part of that economic loss, calculated (3) on the basis of 1000 vehicles (10 percent commercial) is:

a.	Cost to stop from 45 mph (72 km/hr)	$ 59
b.	Cost to idle for 1 hour (approximately 615 gallons [2,330 litre] of excess fuel consumption)	379
c.	Value of time delay (Based on $2.82 per hour and 1.5 occupants per vehicle)	4,230
	Total	$4,660 per 1000 veh./hour

Thus the loss if a Detroit freeway, carrying 7500 vehicles at the peak hour, is closed is approximately $35,000 per hour with an extra 4,600 gallons of fuel consumed. These figures may be high in that not all vehicles may be delayed for a full hour; some may find alternate routes. But these figures also exclude a number of factors, the values of which cannot be computed, such as the added slowdowns and delays on the alternates, the increased accident potential on both the blocked freeway and the alternates, and the cost of police, fire, and other emergency personnel. Such accidents have caused an overloading of other freeways in Detroit, resulting in complete breakdown of the freeway system.

4.3.2. Cost of Operating Trucks and Truck Capacities

Attempts to determine the operating costs of the various truck types were unsuccessful.

The trucks come in a wide variety of sizes, with no clear indications of what sizes are currently used in Michigan. Typical capacities for tankers are about 15,000 gallons (56,000 litre) for 55-foot single-bottoms and 16,800 gallons (63,500 litre) for 65-foot double-bottoms. Thus the 65-foot double-bottoms have about 12 percent more capacity than the 55-foot single-bottoms. Not all double-bottoms are 65 feet long; however, those used in Detroit are legally limited to 55 feet.

4.4 Locations of Single- and Double-Bottom Accidents

Thirty-five percent of the accidents involving single- or double-bottoms occurred on the interstate system, compared to 21 percent for all trucks and 12 percent for all vehicles. Of those single- and double-bottom accidents, 16 percent occurred on I-94 and 12 percent occurred on I-75.

In probable relationship to the common routes used by these vehicles, their accidents were concentrated south and west of Detroit.

The sites that had high numbers of these accidents are sites that normally appear on high-accident listings. No particular location appeared as presenting unusual problems to the large trucks.

Of the accidents that occurred on the interstate system, 45 percent occurred at interchanges; of which 30 percent occurred on the ramps, 70 percent occurred on the main road. Figure 7 shows where those accidents occurred on the four most common types of ramps. There are considerably more direct ramps than loop ramps in Michigan, so those ramps received most of the accidents.

The usage of each type of ramp by the large trucks is unknown, so it is unknown if one type presents a greater problem than another. Off-ramps, however, appear to give the trucks more difficulty than do on-ramps.

4.5 Other Factors

4.5.1 Tanker Stability

Appendix 1 summarizes several reports and discussions with truck stability. These show that tankers are subjected to a surging force on the side of the tank, particularly when the tank is partially filled. This phenomenon is more prevalent for the second trailer of a double-bottom than it is for single-bottoms.

DISTRIBUTION OF SINGLE- AND DOUBLE-BOTTOM ACCIDENTS ON RAMPS

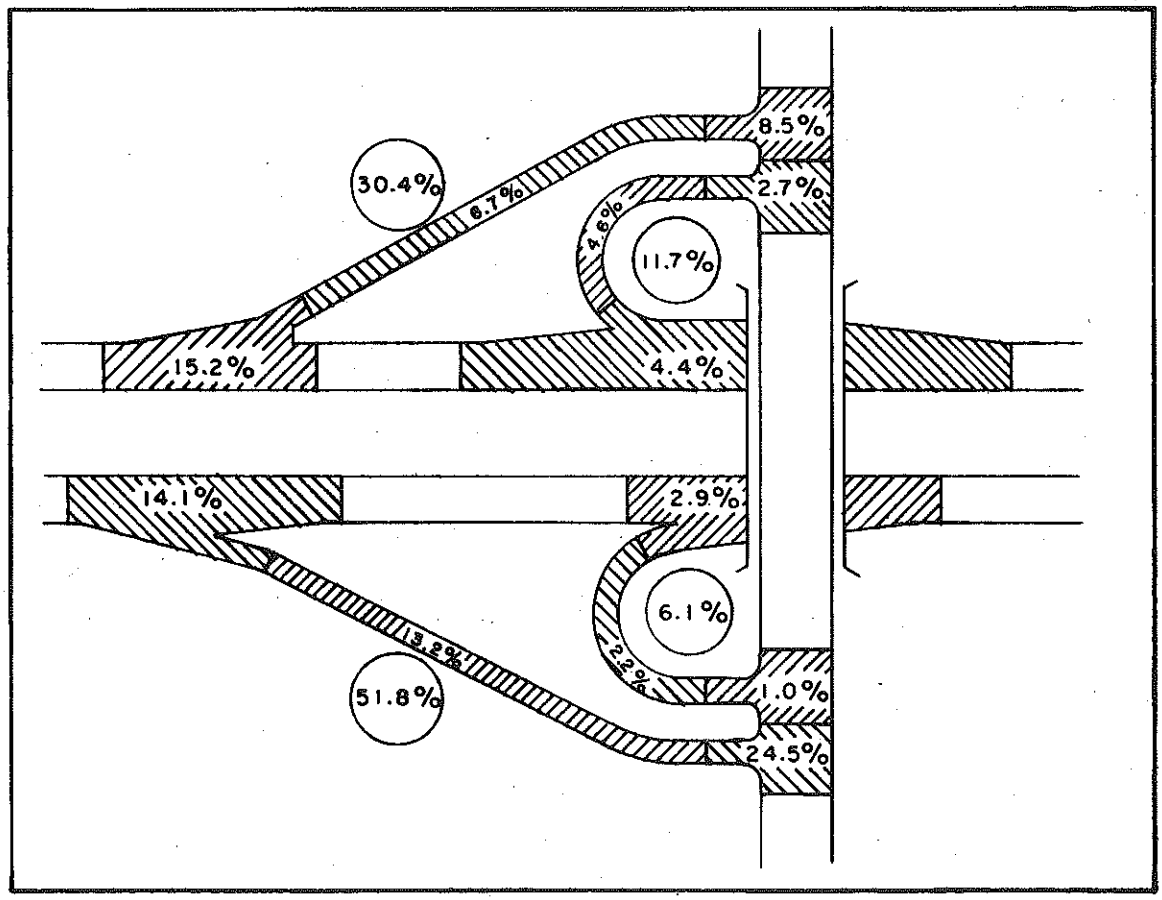


Figure 7

4.5.2 Other Accident Studies

A study of truck accidents in Ontario (14) found that for double-bottoms, fatalities occurred 2.6 times more often, with 1.5 times more fatalities per fatal accident, than for single-bottoms. The dollar loss for double-bottoms was 2.4 times greater than that for single-bottoms.

Mr. Jack Lanstrom, Manager of Wagoner Transportation Company, (7) reported that a study he conducted in 1970 found accident rates of 240 accidents per 100 million vehicle-miles (386 accidents per 100 million vehicle-kilometers) for single-bottoms and 280 (450) for double-bottoms.

4.5.3 Federal Requirements

Two new federal requirements concerning trucks have recently gone into effect. These are summarized in Appendix 2.

The first, Federal Motor Carrier Safety Regulations, are applicable to all trucks that are subject to the Department of Transportation Act.

Michigan is now developing Administrative Rules for intrastate travel, based on new federal regulations; these will not take effect until fall 1977.

The proposed Michigan Rules are similar to the Federal regulations except:

1. The rules will also apply in commercial zones.

2. Driver's hours of service are more restrictive. Time required for loading and unloading will be included as "logged" or driving time. After a driver accumulates 15 consecutive hours of duty he will be required to be off duty for eight hours.

3. All vehicles that are 10,000 pounds (4.53 tonne) or less will be excluded.

The second federal regulation, Handling Hazardous Materials, is concerned primarily with the proper labeling of cargo to facilitate emergency measures after an accident.

V

DANGEROUS CARGO ACCIDENTS

5.1 Number of Accidents

5.1.1 Trunkline Accident Files

The computerized accident files for the years 1971 through December, 1976, the latest available, were searched for accidents encoded as "dangerous cargo," then the reports for those accidents were obtained from this department's or the Department of State Police's files. After several which appeared to be miscodings, there being no indication on the report of any dangerous cargo, were discarded, there remained 109 accidents in the 6-year period. These accidents are listed in Appendix 3 and their sites are shown in Figure 8.

SITES OF DANGEROUS CARGO ACCIDENTS (EXCLUDES DETROIT)

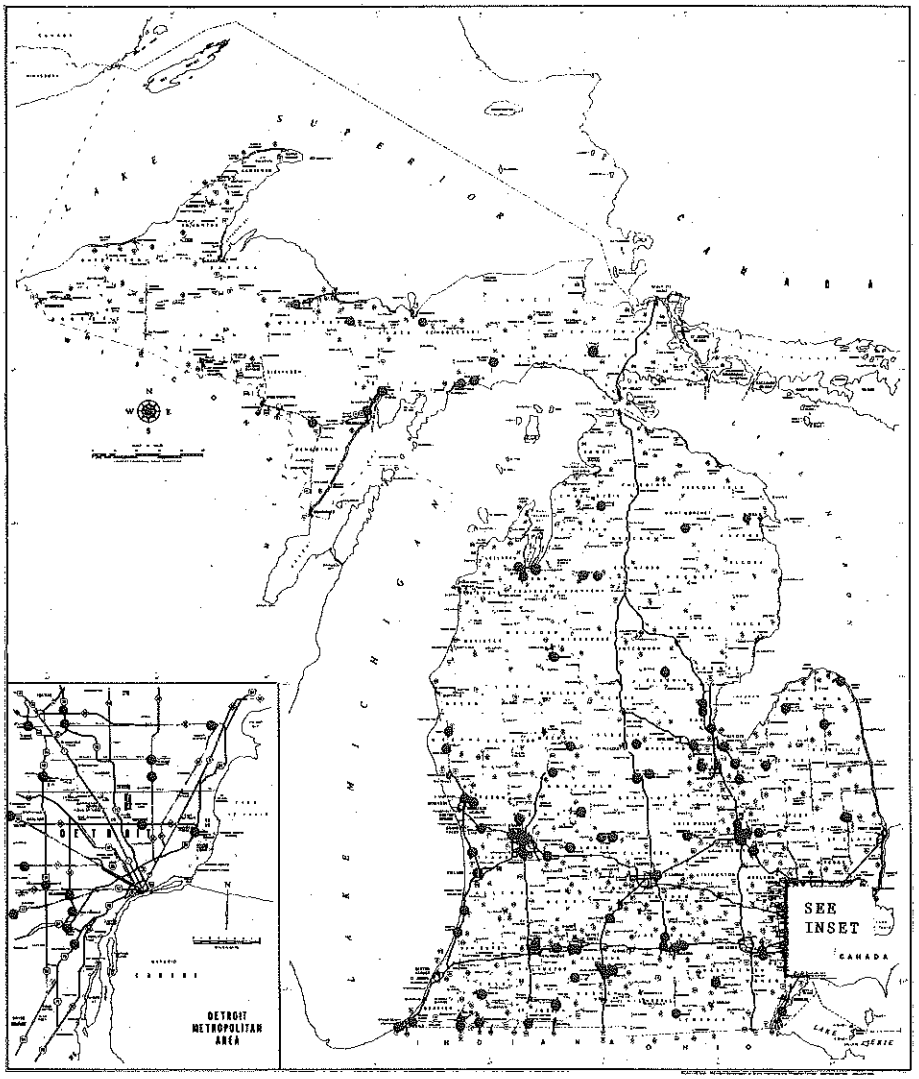


Figure 8

None of the accidents found occurred within Detroit. Computer files of all Detroit accidents, including nontrunkline, for the years 1972, 1974, and 1975 were then searched. Of the 190,000 accidents on those files, only one coded as dangerous cargo was found.

5.1.2 U.S. Department of Transportation Files

Any "unintentional release of hazardous material from a package (including a tank)" must be reported by the carrier to the Office of Hazardous Materials, U.S. Department of Transportation (Code of Federal Regulations: Title 49, Part 171). An incident must also be reported, even if no spillage occurs, if there is a fatality, an injury requiring hospitalization, or estimated property damage exceeding $50,000 "as a direct result of hazardous materials." The Department of Transportation gathers this information to evaluate its packaging regulations.

During the years 1971 through 1975, there were 32,000 such incidents reported nationwide, of which 951 (904 highway) occurred in Michigan. The number of reported incidents has increased steadily for each year which has been attributed more to better reporting than to an increase in the actual number of incidents (17).

The commodities most often involved are shown below.

Commodity	Michigan Incidents	Percent of Michigan Highway Flam.	Nonflam.	Total	National Total
Paint, Enamel, Lacquer	171	35		19	20.5
Gasoline	138	28		15	13.5
Wet Storage Battery	90		21	10	11
Compound Cleaning Liquid	57		14	6	7

Fuel oil was not a regulated commodity under that part of the Code during those years, and is therefore not included in the table. Note that this table does not rank the commodities by relative risk; most paint spills are trivial, five gallons or less, but spills of gasoline account for more fatalities than do spills of any other commodity.

The Office of Hazardous Materials reviewed the incidents involving a tank-truck or tank-trailer that were reported nationwide in 1975. The spillage was due to a vehicular accident in 253 (16 percent) of those incidents. Gasoline was by far the commodity most commonly involved, it being cited in 161 accidents, or 64 percent of the 253 accidents involving a spill. There were, of course, many minor accidents involving a carrier of a hazardous material in which the cargo did not spill; such accidents would not be reported to the Office of Hazardous Materials.

The Office of Hazardous Materials also reviewed all tank-truck or tank-trailer incidents from 1971 through October, 1975. There were 102 fatalities in those tanker incidents, which is 80 percent of all 128 fatalities reported for all spillages of hazardous materials. Of the 102 tanker fatalities, 55 involved gasoline and 23 involved liquified petroleum gas.

The nature of the failures most commonly cited in the tanker incidents were:

Defective fitting, valve, or closure	689	11.7%
Loose fitting, valve, or closure	463	7.9%
External puncture	377	6.4%
Internal pressure	104	1.8%
Body or side failure	63	1.1%
Weld failure	63	1.1%
"Other condition"	3,948	67.4%

More than one factor was cited on some reports; frequently both "defective" and "loose" fitting valves or closure were checked, indicating that the reporter was unable to determine which applied. The "other condition" cited included such items as traffic accident and fire.

5.2 Analysis of Accidents

Table 6 relates the accident type by road type, vehicle type, surface, and severity.

A high proportion of these accidents, 21 percent, were classified as "overturn," the type of accident that has drawn the most concern. Although double-bottoms had a still higher proportion of overturn accidents, 31 percent, the sample size is too small to show statistical significance. There were also several accidents in which the truck overturned after impact with another vehicle or a fixed object.

In five of these accidents the cargo burned; in 16 others it spilled. That total of 21 constituted 19 percent of the 109 accidents. Ten of the 23 overturning accidents (43 percent) resulting in either fire or spillage; that increase in percentage is statistically significant.

"DANGEROUS CARGO" ACCIDENT TABULATIONS

ACCIDENT TYPE	TOTAL ACCIDENTS	ROAD TYPE						VEHICLE TYPE				SURFACE			SEVERITY		
		FREEWAY		DIVIDED		2-WAY											
		URB.	RUR.	URB.	RUR.	URB.	RUR.	Unit Single	Single Bottom	Double Bottom	Other	Dry	Wet	Snow or Ice	F	PI	PD
Overturn	23	2	7	1		3	10	3	9	9	2	12	3	8	1	9	13
Railroad Train	1						1		1			1			1		
Hit Parked Veh.	2					1	1	1	1		2						2
Hit Moving Veh., Other	0																
Head-on	4				1	2	1	2	2			3		1	1	4	1
Side-swipe, same Direction	8	1	3		1	1	2	2	4	2		6	1	1		4	4
Side-swipe, Opposite Direction	3					1	2	1	1	1		1	1	1	1	2	
Angle	9	1		1	1	3	3	3	5	1		6	1	2	2	3	4
Left Turn	1					1			1					1			1
Right Turn	0																
Rear-end	23	5	4	7		2	5	6	11	6		10	6	7	1	10	12
Backing	3					1	2	3				1	1	1		1	2
Parking/Driveway	3			1		2		2		1		2		1			3
Pedestrian	0																
Fixed Object	11	3	3		1	1	3	1	5	5		4	1	6	1	4	6
On-road Object	2		1				1		1		1	2					2
Animal	6		1			1	4	1	3	2		5		1			6
Bicycle	0																
Other	10	2	1	1		3	3		7	2	1	6	2	2		1	9
TOTAL	109	14	20	11	4	22	38	25	51	29	4	61	16	32	8	36	65

Values represent number of dangerous cargo accidents, January 1971 through December 1976.

Table 6

Figure 9 shows the breakdown of these accidents by month and by surface. The percentage on snow and ice (29 percent) for all dangerous cargo accidents is significantly higher than the 15 percent for all trucks. This information is reflected in a disproportionate number of accidents occurring in the winter months: 60 percent occurred in the 5-month period November through March, compared to 45 percent for all trucks.

The average age of the truck drivers in these accidents was 39.3 years with no significant differences by vehicle type.

The severity of these accidents, also shown in Figure 9, is high. Of the 44 injury-producing accidents, eight (18 percent) produced a fatality.

Because of the small sample size, it is not possible to compare various combinations such as surface vs. accident type.

DANGEROUS CARGO ACCIDENT STATISTICS

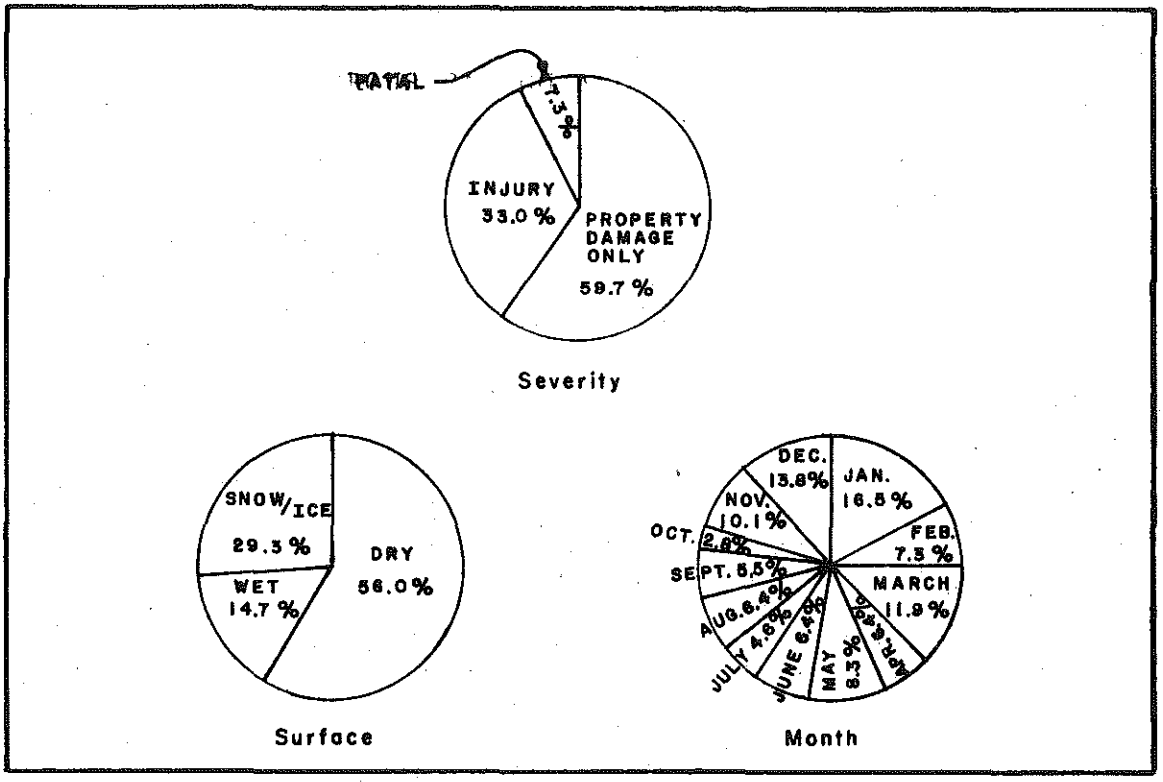


Figure 9.

5.3 Department of State Police Summary

The Michigan Department of State Police summarized 146 "Hazardous Cargo Tank Vehicle" accidents that occurred in Michigan during the first ten months of 1976. (9) The State Police obtained their data by first selecting several thousand truck accidents then phoning the trucking firms involved to determine if a hazardous cargo and a tank truck were involved.

The State Police separated single-bottoms from double-bottoms and tabulated the data by a variety of categories: Severity, Time of Day, Day of Week, Month, Hazardous Action, Road Surface, and Type of Highway.

Of these 164 accidents, 117 occurred on the trunkline system; 46 on freeways, and 71 on other trunklines. Detroit accidents are included in these figures. In contrast, the 109 Dangerous Cargo accidents analyzed above include only 19 accidents in the first ten months of 1976. Thus, although the State Police were considering only tank-truck accidents, their data consists of about five times as many accidents over the same time period.

The State Police data differs from the Dangerous Cargo data in just one aspect: percent fatality. The percent of accidents resulting in a fatality were 2.4 for the State Police data and 7.7 for the Dangerous Cargo accidents. The State Police percentage agrees with the percentages that this study found (Section 4.2.3) for all single-bottoms (2.0 percent) and all double-bottoms (2.2 percent). No differences were found in the percent of injury producing.

The State Police data differs from the all-single-bottom and all-double-bottom data in one aspect: percent on wet pavement. The State Police found that for their tanker data, the single-bottom trucks had a lower percentage on wet pavement (9 percent) than did the double-bottoms (27 percent). But in this study the opposite relationship was found; for all single-bottoms, the percent on wet pavement (21) was significantly higher than that for the all-double-bottoms (19 percent).

For both single- and double-bottoms combined, there were no significant differences among the three sets of data in percentages on wet pavement: 17 percent for the State Police data, 15 percent for this study's truck data, and 15 percent for this study's Dangerous Cargo data.

The State Police data shows 27 percent of the tank-truck accidents occurring on snowy or icy pavement, which is not different from the Dangerous Cargo percentage (26 percent).

5.4 Michigan Tank-Truck Carriers Volume Data

The Michigan tank-truck carriers reported the following data for 1976 (8):

	Double-Bottoms	Single-Bottoms	Total
Number of Units in Use	343	330	673
Total Miles Driven (millions)	20.57	18.47	39.05
Average Miles Per Unit (1 mile = 1.609 kilometers)	60,000	56,000	
Total Gallonage Hauled (millions)	2,786.8	1,348.1	4,134.9
Average per unit (millions) (1 gallon = 3.79 litre)	8.12	4.09	

These statistics do not include independent truckers' data. The total number of units in use and the total quantity hauled is unknown.

As discussed in 4.3.2, a 65-foot double-bottom tanker has about 12 percent more capacity than a 55-foot single-bottom. The average capacities of the vehicles in actual use are not known. The volume data above shows that double-bottoms hauled twice the gallonage than single-bottoms with only 11 percent more vehicle-miles; this indicates that either there are differences in the types of trips taken by those two vehicle types, or that the average double-bottom currently in use has about twice the capacity of the average single-bottom currently in use.

The tank-truck volumes probably vary by time of year, more hauls of fuel oil being needed during the winter months. However, a monthly distribution is unavailable.

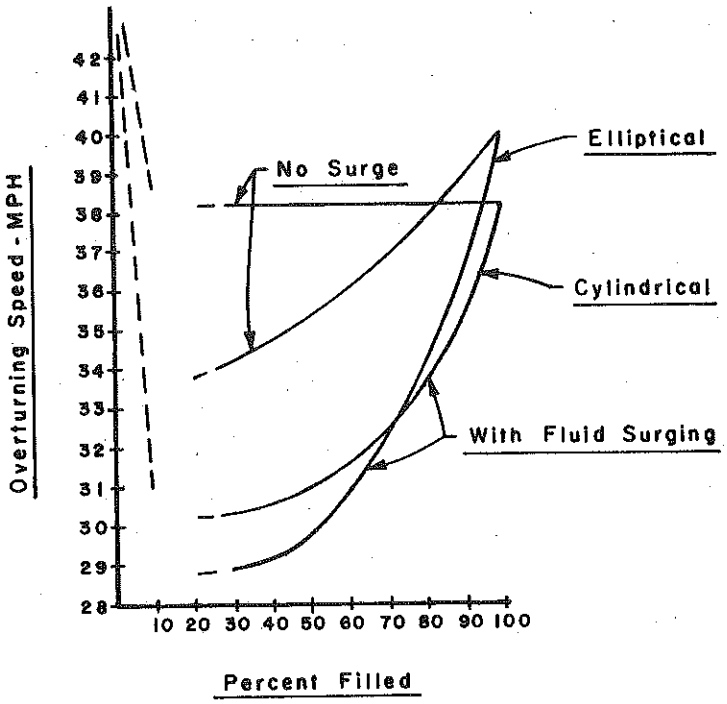
APPENDIX 1

TANKER STABILITY

The Surge Phenomenon

When a liquid cargo is being transported through a curve, the cargo will shift to the outside of curve, thus riding up the wall of the tank. This causes two factors that both tend to decrease the stability of the vehicle: The center of gravity is raised and shifted to the outside of the curve; and a force is applied on the wall of the tank, acting in the same direction as the centrifugal force.

The factors which most influence the amount of surging are vehicle speed, radius of vehicle's path, shape of the tank, and amount of cargo. The most stable condition occurs when the tank is empty, the next most stable condition occurs when the tank is filled (5). Based on a 200-foot radius (a 29-degree curve), the following chart shows the theoretical overturning speed for elliptical and cylindrical tanks (5).



That chart shows that a cylindrical tank has a higher overturning speed than does an elliptical tank if the tank is less than 70 percent filled. For high-density chemicals, the capacity is limited by the maximum weight allowed; the tank cannot be filled.

Simulation tests indicate that the rearmost unit of an articulated vehicle is most susceptible to overturning. The dominant design parameters are number of articulation, steered axle location, tire design, roadway geometrics and condition, and roll stiffness (6).

(15)

Truck Design

To compensate for centrifugal force and liquid surge, vehicles are being considered with single rather than dual-wheel trailers; this allows the springs to be spread thus providing for a longer moment arm to resist lean of the load. However, some material may be hauled by dual-wheeled vehicles only. To also increase stability, Air Ride and torsion bar suspension systems connected to the rigid axle have been considered.

The pintle hitch has been redesigned to decrease lateral movement and resultant sway. Short tongues are used to shorten the overall length of the vehicles, but such tongues are considered by some to be more unstable.

Single trailers with closely spaced axles (42-inch [1.07 m] center-to-center) have shorter and stiffer springs which are believed to improve stability. In all vehicles the tractor adds significantly to the stability of the vehicle, provided it remains connected (13).

Although the single trailers are more stable, the closely-spaced axles make the vehicle more difficult to turn. The trailer is dragged or skidded laterally in the direction of the turn; on slippery pavement the assembly has a tendency to continue on a straight path.

Test of single-bottom tankers with compartment sizes of 3600 gallons (13,600 litre) showed that baffles are not required to minimize surging. Those tests were conducted on a 130-foot (40 m) radius curve at 25 mph (40 km/hr); the report concludes that proper steering and braking have a greater effect on stability and control than does liquid surge (6).

The locking of the wheels during braking is also cited as a cause of lateral instability (2). Federal Motor Vehicle Safety Standard 121, adopted March 1, 1975, requires braking systems that will eliminate wheel lockup. The new braking systems are quite expensive and have been challenged as not being cost-effective (2).

National Transportation Safety Board Recommendation

The National Transportation Safety Board investigated a May 11, 1976, single-bottom accident in Houston, Texas (12). That vehicle, carrying 7500 gallons (28,400 litre) of anhydrous ammonia broke through a bridge rail on a ramp and landed on the freeway below. The Board noted that:

> If the vehicle had been transporting a solid load of equal weight and the same center of gravity height, it could have negotiated the curve at a speed of 69 mph (111 km/hr) without overturning. The vehicle in this accident was loaded to only 71.8 percent of its capacity and overturned at approximately 53.6 mph (86.3 km/hr). This suggests that a lateral cargo surge combined with the normal centrifugal force at that speed to supply the necessary force to overturn the vehicle.

Among other recommendations made as a result of its investigation, the Board reiterated two of its previously made recommendations:

-- to the Federal Highway Administration:

> "The Bureau of Motor Carrier Safety (Federal Highway Administration) in cooperation with affected industries, as represented by the Tank Truck Technical Council, conduct an investigation designed to resolve the overturn stability problems created by liquid surging of partially loaded tank-truck combinations. The ultimate objective of such a research program should be the promulgation of Federal regulations to limit the effects of surge to a specific degree. Such regulations might be based on acceptable liquid cargo outage and/or dampening requirements, consistent with safe tank-truck operations." [originally recommended in 1972]

-- to the U.S. Department of Transportation:

> "Initiate a research program to identify new approaches to reduce the injuries and damages caused by the dangerous behavior of pressurized, liquefied flammable gases released from breached tanks on bulk transport vehicles." [originally recommended in 1976]

APPENDIX 2

FEDERAL REGULATIONS

Federal Motor Carrier Safety Regulations

(U.S. Department of Transportation, Bureau of Motor Carrier Safety) October 1, 1975, Revision. (15)

These regulations apply to common carriers, contract carriers, and private carriers subject to the Department of Transportation Act. These regulations specify:

Part 391 - Qualifications of Drivers

The driver must:

(1) Be at least 21 years old, speak English, hold a valid operators license, pass a written examination, and pass a road test given by the common carrier.

(2) Pass a physical examination, and be free of a number of listed physical impairments. This examination must be reported every two years.

(3) Not be guilty of several specified offenses while operating a motor vehicle.

Part 392 - Driving of Motor Vehicle

This part specifies standard practices, such as safe loading practices, that are to be followed.

Part 393 - Parts and Accessories for Safe Operation

This part specifies a number of standards for the vehicle, including braking system and coupling devices.

Part 394 - Notification, Reporting, and Recording of Accidents

An accident must be reported to the Federal Highway Administration if it involves a fatality, an injury requiring treatment at a hospital, or property damage of $2000 or more.

Part 395 - Hours of Service of Drivers

Drivers are limited to:

(1) Not more than 10 hours of driving time following eight hours of off-duty.

(2) No driving after 15 hours of on-duty time (which includes activities other than driving).

(3) Not more than 60 hours on-duty in seven consecutive days.

(4) Not more than 70 hours on-duty in eight consecutive days.

Part 396 - Inspection and Maintenance

A systematic inspection and maintenance program, with recordkeeping, is specified. If a vehicle becomes hazardous to operate, it shall not be operated until repairs are made. The driver is to inspect and report on his vehicle each day.

Part 397 - Transportation of Hazardous Materials

Vehicles hauling a hazardous material must avoid routes through populated areas if a practical alternate route exists. If the vehicle has dual tire axles, the tires must be inspected by the driver every two hours or 100 miles. Vehicle markings are also specified.

Hazardous Materials Regulations
(U.S. Department of Transportation,
Office of Hazardous Materials Operations)
Effective January 1, 1977 (1)

These regulations are concerned with the proper identification of hazardous materials and of the labeling of the containers. The shipping papers must be visible and accessible to aid emergency operations. Some types of materials may not be loaded with other types, such as a poisonous gas may not be loaded with an explosive.

An accident or other incident must be reported to the Department of Transportation by phone if there is a fatality or an injury requiring hospitalization, damage of $50,000 or more, or fire, breaking, or spillage of radioactive materials or etiologic (disease-causing) agents. An incident must be reported in writing, on a specified form, for any of the above situations or for any unintentional release of hazardous materials. This is in addition to the report required by the Federal Motor Carrier Safety Regulations.

APPENDIX 3

DANGEROUS CARGO ACCIDENTS

ON MICHIGAN TRUNKLINES JANUARY 1971 THROUGH DECEMBER 1976

DAY/HOUR	ROAD	LOCATION			ACC TYPE	SEVERITY	DC-VEH	AGE	HAZ. ACT	CARGO		DESCRIPTION OF ACCIDENT
JAN 11 '71 8 AM	RURAL 2-WAY	US 2 MENOMINEE CO	WEATHER: CLEAR SURFACE: ICY LIGHTING: DAY		1-VEH OTHER	PROPERTY DAMAGE	DOUBLE BOTTOM	56				TRUCK JACK-KNIFED WHEN STOPPING FOR SCHOOL BUS.
JAN 19 '71 9 AM	URBAN 2-WAY	US12 YPSILNT WASHTENAW CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		2-VEH PARKED VEHICLE	PROPERTY DAMAGE	SINGLE UNIT	33		FUEL OIL		PARKED TRUCK ROLLED AWAY, HITTING ANOTHER VEHICLE.
JAN 19 '71 10 AM	RURAL 2-WAY	US 41 MARQUETTE CO	WEATHER: CLEAR SURFACE: ICY LIGHTING: DAY		2-VEH BACKING	PROPERTY DAMAGE	SINGLE UNIT	31		EXPLOSIVES		TRUCK BACKING AWAY FROM A CAR ON FIRE HIT ANOTHER VEHICLE.
JAN 26 '71 8 AM	RURAL 2-WAY	M 72 LEELANAU CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY		2-VEH REAR-END	PERSONAL INJURY	SINGLE UNIT	39				TRUCK HIT SNOW PLOW IN REAR. VISIBILITY VERY POOR.
FEB 1 '71 7 PM	URBAN DIVIDED	US24 BING FW OAKLAND CO	WEATHER: CLEAR SURFACE: ICY LIGHTING: DARK		4-VEH OVERTURN	FATAL	DOUBLE BOTTOM	47		GASOLINE	FIRE	TRUCK JACK-KNIFED & PAVEMENT, OVERTURNED, AND BURNED.
FEB 3 '71 1 PM	URBAN FREEWAY	I94 & US131 KALAMAZOO CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY		1-VEH OTHER	PROPERTY DAMAGE	SINGLE BOTTOM	49	TOO FAST			TRUCK JACK-KNIFED DURING EMERGENCY STOP.
FEB 12 '71 5 PM	URBAN 2-WAY	M 21 IONIA CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DUSK		1-VEH OTHER	PERSONAL INJURY	DOUBLE BOTTOM	39		11,000 GAL GASOLINE	FIRE	SPARKS FROM WHEEL STARTED FIRE IN REAR TRAILER. TRUCK LEFT ROADWAY.
FEB 12 '71 11 PM	URBAN 2-WAY	M 21 IONIA CO	WEATHER: CLEAR SURFACE: ICY LIGHTING: DARK		2-VEH HEAD-ON	PERSONAL INJURY	SINGLE BOTTOM	45		12,000 GAL PROPANE		ON-COMING CAR OUT-OF-CONTROL, CROSSED CENTERLINE, STRUCK TRUCK.
MAR 1 '71 6 PM	URBAN 2-WAY	US 27 CLIVET EATON CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DUSK		2-VEH S-SWIPE SAME DIR	PROPERTY DAMAGE	SINGLE BOTTOM	42		FUEL OIL		CAR ENTERING ROAD FROM ALLEY HIT TRUCK.
MAR 3 '71 10 AM	URBAN 2-WAY	843 S HAVEN VAN BUREN CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		2-VEH OTHER	PROPERTY DAMAGE	OTHER	21		BOTTLE GAS		BOTTLE GAS TANK FELL FROM PICKUP, HIT BY ANOTHER VEHICLE.
MAR 5 '71 8 AM	URBAN 2-WAY	US 2789 GRATIOT CO	WEATHER: CLEAR SURFACE: ICY LIGHTING: DAY		2-VEH S-SWIPE OPPOSITE	PERSONAL INJURY	SINGLE UNIT	64	TOO FAST			TRUCK TURNING RIGHT HIT CAR TURNING LEFT.
MAR 12 '71 12 NOON	URBAN DIVIDED	M 24 OAKLAND CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		2-VEH REAR-END	PROPERTY DAMAGE	DOUBLE BOTTOM	29		GASOLINE	SPILL	SLOW TRUCK HIT IN REAR BY STEEL-HAULER, BEAM PUNCTURED TANK, 567 GAL LOST
MAR 14 '71 3 AM	URBAN FREEWAY	I 75 FLINT GENESSEE CO	WEATHER: CLEAR SURFACE: ICY LIGHTING: DRK-SL		3-VEH OVERTURN	PERSONAL INJURY	DOUBLE BOTTOM	45		OIL	SPILL	TRUCK JACK-KNIFED WHILE TRYING TO AVOID OUT-OF-CONTROL CAR.
APR 5 '71 1 PM	URBAN FREEWAY	I 75 TCDY OAKLAND CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		2-VEH S-SWIPE SAME DIR	PROPERTY DAMAGE	DOUBLE BOTTOM	61	IMP TURN			TRUCK CHANGING LANES HIT ANOTHER VEHICLE.
APR 6 '71 3 AM	RURAL FREEWAY	US 127 JACKSON CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK		1-VEH ANIMAL	PROPERTY DAMAGE	DOUBLE BOTTOM	43		GASOLINE		TRUCK STRUCK A DEER.
APR 30 '71 1 PM	URBAN 2-WAY	M 142 PIGEON HURON CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		3-VEH BACKING	PERSONAL INJURY	SINGLE UNIT	65		OIL		CAR BACKED OUT OF DRIVEWAY INTO TRUCK, TRUCK HIT 3RD VEHICLE.
MAY 4 '71 11 AM	RURAL 2-WAY	M 46 GRATIOT CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		2-VEH OTHER	PROPERTY DAMAGE	SINGLE BOTTOM	27		OIL		TRUCK THREW STONE INTO WINDSHIELD OF ON-COMING CAR.
MAY 13 '71 7 AM	RURAL FREEWAY	I 196 ALLEGAN CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		1-VEH OVERTURN	PERSONAL INJURY	SINGLE BOTTOM	33	TOO FAST			TRAILER STARTED TO SWAY, VEHICLE LEFT ROAD (POSSIBLE DEFECT)
JUN 14 '71 11 AM	RURAL 2-WAY	M 66 CALHOUN CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		2-VEH ANGLE	PROPERTY DAMAGE	SINGLE BOTTOM	36	OTHER			TRAILER BROKE LOOSE DURING TURN, TRAILER HIT CAR.
JUL 13 '71 8 AM	RURAL 2-WAY	M 32 ALPENA CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		2-VEH PARKED VEHICLE	PROPERTY DAMAGE	SINGLE BOTTOM	26				TRUCK LOST WHEEL; WHEEL STRUCK PARKED CAR.
AUG 5 '71 1 PM	RURAL 2-WAY	M 28 ALGER CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		3-VEH S-SWIPE OPPOSITE	FATAL	SINGLE BOTTOM	48		GASOLINE	FIRE*	CAR PASSING ON CURVE HIT TRUCK'S TRAILER ON SIDE. *CAR BURNED.
OCT 29 '71 11 AM	URBAN 2-WAY	M 25 HURON CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		2-VEH REAR-END	PERSONAL INJURY	SINGLE UNIT	56				TRUCK UNABLE TO AVOID CAR STOPPING ABRUPTLY IN LANE.
DEC 9 '71 6 PM	RURAL 2-WAY	M 21 SHIAWASSEE CO	WEATHER: CLEAR SURFACE: WET LIGHTING: DARK		2-VEH REAR-END	PERSONAL INJURY	DOUBLE BOTTOM	25				TRUCK STOPPED TO TURN LEFT WAS STRUCK IN REAR.
DEC 28 '71 3 AM	RURAL FREEWAY	I 94 WASHTENAW CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK		2-VEH REAR-END	FATAL	DOUBLE BOTTOM			GASOLINE		CAR HIT DISABLED TRUCK PARKED ON SHOULDER.
JAN 11 '72 3 PM	RURAL DIVIDED	US 31 G TRAVERSE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY		2-VEH ANGLE	PERSONAL INJURY	SINGLE UNIT	46				CAR RAN STOP SIGN, HIT BY TRUCK.

D A N G E R O U S C A R G O A C C I D E N T S

ON MICHIGAN TRUNKLINES JANUARY 1971 THROUGH DECEMBER 1976 PAGE

DAY/HOUR	ROAD	LOCATION		ACC TYPE	SEVERITY	DC-VEH	AGE	HAZ. ACT	CARGO		DESCRIPTION OF ACCIDENT
JAN 13 '72 9 AM	URBAN 2-WAY	US12 & PIGN ST JOSEPH CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	2-VEH LEFT TURN	PROPERTY DAMAGE	SINGLE BOTTOM	44				CAR TURNED LEFT IN FRONT OF TRUCK, HIT BY TRUCK.
JAN 14 '72 11 PM	RURAL FREEWAY	I 96 OTTAWA CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DARK	1-VEH OVERTURN	PERSONAL INJURY	SINGLE UNIT	45	TOO FAST	FUEL OIL (FULL)		TRUCK LOST CONTROL IN SNOW STORM, LEFT ROADWAY.
JAN 22 '72 1 AM	RURAL FREEWAY	I 96 OAKLAND CO	WEATHER: FOG SURFACE: WET LIGHTING: DARK	2-VEH S-SWIPE SAME DIR	PROPERTY DAMAGE	SINGLE BOTTOM		IMP TURN			TRUCK CHANGED LANE IN FRONT OF CAR, HIT CAR. (HIT & RUN)
FEB 11 '72 8 AM	RURAL FREEWAY	I 127 RAMP JACKSON CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	DOUBLE BOTTOM	44	TOO FAST	FUEL OIL (1/2 FULL)		REAR TRAILER OVERTURNED DURING LEFT TURN ONTO RAMP.
MAR 8 '72 4 PM	URBAN 2-WAY	M33 ATLANTA MONTMORENCY CO	WEATHER: CLEAR SURFACE: ICY LIGHTING: DAY	2-VEH PARKING/ DRIVEWAY	PROPERTY DAMAGE	SINGLE UNIT	52				CAR BACKING OUT OF DRIVEWAY HIT TRUCK.
MAR 10 '72 4 PM	URBAN 2-WAY	US12 EDWARD CASS CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH OTHER	PROPERTY DAMAGE	SINGLE BOTTOM	49				TRUCK THREW STONE INTO WINDSHIELD OF ON-COMING CAR.
MAR 23 '72 11 AM	URBAN 2-WAY	M 19 IDLY ALBON CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	2-VEH ANGLE	PROPERTY DAMAGE	SINGLE UNIT	55				TRUCK TURNING RIGHT HIT CAR TURNING LEFT.
MAY 10 '72 1 PM	URBAN DIVIDED	M78 E LANSNG INGHAM CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH REAR-END	PERSONAL INJURY	SINGLE BOTTOM	16	TOO CLOS	GASOLINE (FULL)		TRUCK HIT CAR THAT HAD STOPPED FOR AMBULANCE.
JUN 29 '72 3 AM	URBAN 2-WAY	M-53 WARREN MACOMB CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK	2-VEH ANGLE	FATAL	DOUBLE BOTTOM	26				CAR RAN RED LIGHT IN FRONT OF TRUCK, HIT BY TRUCK.
NOV 1 '72 6 PM	URBAN FREEWAY	I296 WALKER KENT CO	WEATHER: CLEAR SURFACE: WET LIGHTING: DRK-SL	2-VEH REAR-END	PROPERTY DAMAGE	SINGLE BOTTOM	52		GASOLINE (FULL)		CAR DROVE INTO BACK OF TRUCK.
JAN 2 '73 6 PM	RURAL FREEWAY	I 75 MONROE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK	2-VEH OTHER	PROPERTY DAMAGE	SINGLE BOTTOM					TRUCK THREW STONE INTO WINDSHIELD OF FOLLOWING VEHICLE.
APR 12 '73 1 PM	RURAL FREEWAY	M 21 GENESEE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH FIXED OBJECT	PROPERTY DAMAGE	SINGLE BOTTOM	35		12,000 GAL PROPANE		TRUCK-TRACTOR TIRE BLEW, TRUCK LEFT ROADWAY.
APR 20 '73 12 MDNT	URBAN 2-WAY	M 21 IONIA CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK	1-VEH ANIMAL	PROPERTY DAMAGE	DOUBLE BOTTOM	36				TRUCK HIT A DEER.
MAY 7 '73 5 PM	URBAN FREEWAY	US131 S RPDS KENT CO	WEATHER: RAIN SURFACE: WET LIGHTING: DAY	1-VEH OTHER	PROPERTY DAMAGE	SINGLE BOTTOM	38	TOO FAST	GASOLINE		TRUCK JACK-KNIFED WHEN TRYING TO STOP.
MAY 23 '73 4 AM	RURAL 2-WAY	US 41 MARQUETTE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK	1-VEH ANIMAL	PROPERTY DAMAGE	SINGLE BOTTOM	47				TRUCK HIT A DEER.
JUN 2 '73 1 PM	URBAN DIVIDED	M39 ALLEN PK WAYNE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH REAR-END	PROPERTY DAMAGE	SINGLE BOTTOM	56				TRUCK CROSSED LANE-LINE, HIT CAR ON RAMP.
JUN 25 '73 4 PM	RURAL 2-WAY	M 53 SANILAC CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	OTHER	16		AMMONIA	SPILL	PICK-UP PULLING 2 TRAILERS, HITCH BROKE, TRAILER OVERTURNED.
JUN 26 '73 12 AM	RURAL FREEWAY	I 75 GENESEE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	4-VEH S-SWIPE SAME DIR	PERSONAL INJURY	SINGLE UNIT		IMP TURN	GASOLINE		TRUCK HIT CAR STOPPED IN CONSTRUCTION ZONE.
JUL 12 '73 7 PM	RURAL 2-WAY	US 31 BARRIEN CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH HEAD-ON	PERSONAL INJURY	SINGLE BOTTOM	25				ONE CAR FORCED ANOTHER ACROSS CENTER LANE, INTO PATH OF TRUCK.
JUL 16 '73 7 AM	RURAL FREEWAY	I 75 GENESEE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH S-SWIPE SAME DIR	PERSONAL INJURY	SINGLE BOTTOM	25		CHLORINE (FULL)		CAR HIT TRUCK ON SIDE.
AUG 1 '73 1 AM	RURAL 2-WAY	M 15 SAGINAW CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK	1-VEH RR TRAIN	FATAL	SINGLE BOTTOM	40	NO YIELD	SULFURIC ACID	FIRE*	TRUCK HIT RAILROAD TRAIN, *TRUCK-TRACTOR BURNED.
SEP 10 '73 11 PM	RURAL FREEWAY	I 69 CALHOUN CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK	2-VEH REAR-END	PERSONAL INJURY	SINGLE BOTTOM	47	TOO FAST	55,000 GAL VINYLTOLENE		TRUCK HIT CAR IN REAR, TRUCK LEFT ROADWAY AND OVERTURNED.
OCT 11 '73 8 PM	URBAN FREEWAY	M 78 FLINT GENESEE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DRK-SL	3-VEH REAR-END	PROPERTY DAMAGE	SINGLE BOTTOM	59				CAR STOPPED ABRUPTLY IN FRONT OF TRUCK, HIT BY TRUCK.
OCT 20 '73 1 PM	RURAL 2-WAY	M 57 MONTCALM CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH ON-ROAD OBJECT	PROPERTY DAMAGE	OTHER	20		GAS TANK		GAS TANK FELL FROM TRAILER OF CAR AND WAS HIT BY OTHER CAR.
NOV 9 '73 12 NOON	RURAL 2-WAY	US 131 CHARLEVOIX CO	WEATHER: CLEAR SURFACE: WET LIGHTING: DAY	2-VEH S-SWIPE OPPOSITE	PERSONAL INJURY	DOUBLE BOTTOM	47	WRNG LNE			TRUCK PASSING CAR THAT WAS TURNING LEFT, CAR HIT TRUCK.

C A N G E R O U S C A R G O A C C I C E N T S

ON MICHICAN TRUNKLINES JANUARY 1971 THROUGH DECEMBER 1976

DAY/HOUR	ROAD	LOCATION		ACC TYPE	SEVERITY	OC-VEH	AGE	HAZ. ACT	CARGO		DESCRIPTION OF ACCIDENT
NOV 15 '73 4 PM	URBAN FREEWAY	I94 ALLEN PK WAYNE CO	WEATHER: CLEAR SURFACE: WET LIGHTING: DAY	1-VEH OVERTURN	PERSONAL INJURY	DOUBLE BOTTOM	37		OIL	SPILL	UNKNOWN CAR CUT I. FRONT OF TRUCK, TRUCK JACK-KNIFED TRYING TO STOP.
NOV 17 '73 11 AM	URBAN FREEWAY	M39 DEARBORN WAYNE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH ANGLE	PROPERTY DAMAGE	SINGLE UNIT	46	NO YIELD			TRUCK ON ENTRANCE RAMP HIT CAR ON FREEWAY.
NOV 30 '73 3 PM	RURAL 2-WAY	M 30 GLADWIN CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	DOUBLE BOTTOM	23				VEHICLE BEING PASSED BY TRUCK FORCED TRUCK OFF ROADWAY.
DEC 7 '73 2 PM	RURAL 2-WAY	M 20 ISABELLA CO	WEATHER: CLEAR SURFACE: WET LIGHTING: DAY	2-VEH BACKING	PROPERTY DAMAGE	SINGLE UNIT	24	IMP BACK			TRUCK BACKED INTO CAR
DEC 27 '73 3 PM	URBAN FREEWAY	I 96 WALKER KENT CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DRK-SL	1-VEH FIXED OBJECT	PROPERTY DAMAGE	DOUBLE BOTTOM	42	TOO FAST	GASOLINE (FULL)		TRUCK SKIDDED ON ICE, HIT GUARDRAIL.
FEB 6 '74 11 AM	URBAN FREEWAY	I 94 JACKSON CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	1-VEH FIXED OBJECT	PERSONAL INJURY	DOUBLE BOTTOM	34				TRUCK, AVOIDING VEHICLE, HIT CONCRETE MEDIAN AND OVERTURNED.
FEB 9 '74 9 PM	RURAL 2-WAY	M 60 CALHOUN CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK	1-VEH OTHER	PROPERTY DAMAGE	SINGLE BOTTOM	39				TRUCK FORCED OFF ROADWAY BY ONCOMING VEHICLE AND OVERTURNED.
MAR 11 '74 1 PM	RURAL 2-WAY	US 12 BARRIEN CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH FIXED OBJECT	PERSONAL INJURY	DOUBLE BOTTOM	34		EMPTY		TRACTOR TIRE BLEW, TRUCK HIT TREES. TRACTOR GAS TANK SPILLED FUEL.
MAR 25 '74 11 AM	URBAN DIVIDED	US2 ESCANABA DELTA CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	2-VEH REAR-END	PERSONAL INJURY	SINGLE UNIT	19		1,500 GAL FUEL OIL	SPILL	CAR LOST CONTROL, INTO PATH OF TRUCK. AFTER IMPACT, TRUCK OVERTURNED.
MAY 26 '74 7 PM	RURAL 2-WAY	M 72 KALKASKA CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH OVERTURN	PERSONAL INJURY	SINGLE BOTTOM	21		GASOLINE (FULL)		TRUCK LEFT ROADWAY TO AVOID OTHER VEHICLE AND OVERTURNED.
AUG 21 '74 5 PM	URBAN 2-WAY	US 24 WAYNE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH HEAD-ON	FATAL	SINGLE UNIT	23		ROAD OIL		CAR CROSSED CENTE LINE IN FRONT OF TRUCK.
SEP 30 '74 10 AM	URBAN 2-WAY	M 81 TUSCOLA CO	WEATHER: CLEAR SURFACE: WET LIGHTING: DAY	1-VEH OVERTURN	PERSONAL INJURY	SINGLE BOTTOM	45	OTHER	AMMONIA	SPILL	TRAILER OVERTURNED DURING LEFT TURN.
NOV 23 '74 3 PM	URBAN DIVIDED	US31 HOLLAND OTTAWA CO	WEATHER: CLEAR SURFACE: WET LIGHTING: DAY	2-VEH REAR-END	PROPERTY DAMAGE	SINGLE UNIT	38	TOO CLOS			TRUCK HIT CAR IN REAR.
NOV 25 '74 8 AM	RURAL 2-WAY	US 31 BR OCEANA CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	SINGLE UNIT	26	TOO FAST			TRUCK LOST CONTROL, LEFT ROADWAY, AND OVERTURNED.
NOV 27 '74 7 AM	RURAL 2-WAY	M 46 MONTCALM CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH REAR-END	PROPERTY DAMAGE	DOUBLE BOTTOM	54	TOO FAST	12,000 GAL GASOLINE		TRUCK HIT ANOTHER TRUCK IN REAR.
NOV 27 '74 12 NOON	URBAN 2-WAY	US31 NEW ERA OCEANA CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	1-VEH FIXED OBJECT	PROPERTY DAMAGE	SINGLE UNIT	26	TOO FAST			TRUCK LOST CONTROL, LEFT ROADWAY.
JAN 24 '75 2 PM	URBAN DIVIDED	US 24 WAYNE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH ANGLE	PERSONAL INJURY	SINGLE BOTTOM	39	WRNG LNE	GASOLINE (FULL)		TRUCK CHANGED LANE IN FRONT OF CAR.
JAN 28 '75 5 AM	RURAL 2-WAY	M 72 KALKASKA CO	WEATHER: CLEAR SURFACE: ICY LIGHTING: DARK	1-VEH FIXED OBJECT	PERSONAL INJURY	DOUBLE BOTTOM	32				TRUCK TIRE BLEW, TRUCK LEFT ROADWAY.
MAR 3 '75 2 PM	URBAN 2-WAY	M 84 SAGINAW SAGINAW CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH REAR-END	PERSONAL INJURY	DOUBLE BOTTOM	50	TOO CLOS			TRUCK HIT CAR WAITING T. TURN LEFT.
MAR 14 '75 1 PM	RURAL DIVIDED	M 13 BAY CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH HEAD-ON	PROPERTY DAMAGE	SINGLE UNIT	59				DRIVER SUFFERED STROKE, CROSSED MEDIAN HIT OTHER. (MEDICAL FATALITY)
APR 2 '75 7 PM	URBAN FREEWAY	I75 ALLEN PK WAYNE CO	WEATHER: RAIN SURFACE: ICY LIGHTING: DARK	2-VEH REAR-END	PROPERTY DAMAGE	SINGLE BOTTOM	33	TOO FAST			TRUCK HIT CAR STOPPED ON ROADWAY BECAUSE OF ANOTHER ACCIDENT.
MAY 1 '75 6 AM	RURAL 2-WAY	US 12 BARRIEN CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAWN	2-VEH ANGLE	FATAL	SINGLE BOTTOM	46		6,400 GAL TOLUOL	FIRE	CAR RAN STOP IN FRONT OF TRUCK, TRUCK LEFT ROADWAY OVERTURNED & EXPLODED.
MAY 7 '75 8 AM	URBAN DIVIDED	M102 WARREN MACOMB CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH PARKING/ DRIVEWAY	PROPERTY DAMAGE	SINGLE UNIT	22		SULFURIC ACID	SPILL	TRUCK HIT CAR ENTERING FROM DRIVEWAY.
JUN 25 '75 9 AM	RURAL 2-WAY	US 2 DELTA CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH S-SKIPE SAME DIR	PERSONAL INJURY	SINGLE UNIT	60				TRUCK HIT CAR WAITING AT INTERSECTION.
AUG 27 '75 12 NOON	URBAN FREEWAY	I94 BR WOODS WAYNE CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	3-VEH REAR-END	PROPERTY DAMAGE	DOUBLE BOTTOM	34	OTHER	18,000 GAL GASOLINE	FIRE	TRUCK HIT CAR & MEDIAN BARRIER, TRAILER OVER-TURNED AND EXPLODED.

DANGEROUS CARGO ACCIDENTS

ON MICHIGAN TRUNKLINES JANUARY 1971 THROUGH DECEMBER 1976

DAY/HOUR	ROAD	LOCATION			ACC TYPE	SEVERITY	DC-VEH	AGE	HAZ. ACT	CARGO		DESCRIPTION OF ACCIDENT
SEP 18 '75 10 AM	URBAN 2-WAY	M34 HUDSON LENAWEE	CC	WEATHER: RAIN SURFACE: WET LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	SINGLE UNIT	28	TOO FAST	GASOLINE		TRUCK MAKING RIGHT TURN, GAS SURGED IN TANK, TRUCK OVERTURNED.
SEP 28 '75 1 PM	URBAN 2-WAY	M37 WALKER KENT	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH PARKING/ DRIVEWAY	PROPERTY DAMAGE	DOUBLE BOTTOM	48	IMP TURN	FUEL		TRUCK MAKING LEFT TURN INTO DRIVEWAY HIT REAR OF OTHER VEHICLE.
DEC 4 '75 5 AM	RURAL 2-WAY	US 2 SCHOOLCRFT	CC	WEATHER: RAIN SURFACE: ICY LIGHTING: DARK	1-VEH ANIMAL	PROPERTY DAMAGE	SINGLE BOTTOM	38				TRUCK HIT A DEER.
DEC 5 '75 6 PM	URBAN DIVIDED	US 12 WAYNE	CC	WEATHER: CLEAR SURFACE: WET LIGHTING: DARK	1-VEH OTHER	PROPERTY DAMAGE	SINGLE BOTTOM	30	TOO FAST	GASOLINE (1/2 FULL)		TRUCK JACK-KNIFED AT START OF LOOP RAMP.
DEC 11 '75 7 PM	RURAL DIVIDED	US 31 OTTAWA	CC	WEATHER: SNOW SURFACE: ICY LIGHTING: DARK	1-VEH FIXED OBJECT	PROPERTY DAMAGE	DOUBLE BOTTOM	53	TOO FAST			TRUCK SLOWED TO TURN, JACK-KNIFED AND LEFT ROADWAY.
DEC 12 '75 1 PM	URBAN DIVIDED	US 10 OAKLAND	CC	WEATHER: CLEAR SURFACE: WET LIGHTING: DAY	3-VEH REAR-END	PROPERTY DAMAGE	SINGLE BOTTOM	46	TOO CLOS			TRUCK HIT CARS STOPPED AT SIGNAL.
DEC 14 '75 9 AM	URBAN 2-WAY	M 14 LIVONIA WAYNE	CC	WEATHER: CLEAR SURFACE: WET LIGHTING: DAY	2-VEH ANGLE	PERSONAL INJURY	SINGLE BOTTOM	53				TRUCK HIT BY CAR THAT RAN RED LIGHT.
DEC 18 '75 6 AM	RURAL FREEWAY	US 31 MUSKEGON	CO	WEATHER: SNOW SURFACE: ICY LIGHTING: DARK	1-VEH OVERTURN	PROPERTY DAMAGE	SINGLE BOTTOM	58		GASOLINE (FULL)	SPILL	TRUCK LEFT ROADWAY, OVERTURNED. 200 GAL SPILLED
DEC 18 '75 9 AM	RURAL FREEWAY	I 94 KALAMAZOO	CC	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	SINGLE BOTTOM	52	TOO FAST	6,000 GAL NAPTHA		TRUCK ATTEMPTED TO STOP FOR PREVIOUS ACCIDENT, LOST CONTROL & OVERTURNED
DEC 27 '75 9 AM	RURAL 2-WAY	M 52 LENAWEE	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH ANIMAL	PROPERTY DAMAGE	SINGLE UNIT	48				TRUCK HIT A DEER.
JAN 2 '76 10 AM	RURAL FREEWAY	I 75 BAY	CC	WEATHER: CLEAR SURFACE: ICY LIGHTING: DAY	2-VEH REAR-END	PROPERTY DAMAGE	SINGLE BOTTOM	33				CAR PASSING TRUCK LOST CONTROL, HIT TRUCK.
JAN 2 '76 10 AM	RURAL FREEWAY	I 75 BAY	CC	WEATHER: CLEAR SURFACE: ICY LIGHTING: DAY	2-VEH REAR-END	PROPERTY DAMAGE	SINGLE BOTTOM	25				CAR HIT TRUCK STOPPED FOR PREVIOUS ACCIDENT.
JAN 6 '76 9 AM	RURAL 2-WAY	US 2 SCHOOLCRFT	CC	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	SINGLE BOTTOM	39		FUEL OIL (FULL)	SPILL	TRUCK STOPPED ON SHOULDER BRAKE FAILED, TRUCK LEFT ROADWAY & OVERTURNED.
JAN 9 '76 5 AM	RURAL DIVIDED	M 37 & I 96 KENT	CC	WEATHER: CLEAR SURFACE: ICY LIGHTING: DRK-SL	2-VEH SIDESWIPE SAME DIR	PROPERTY DAMAGE	SINGLE BOTTOM					TRUCK ENTERED LEFT LANE NEXT TO CAR, HIT CAR WITH REAR TIRES (HIT & RUN)
JAN 17 '76 4 PM	URBAN 2-WAY	M 29 MACOMB	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	DOUBLE BOTTOM	23	IMP TURN	9,200 GAL GASOLINE		TRUCK MAKING LEFT TURN, OVERTURNED. (SECOND TRAILER WAS EMPTY)
JAN 21 '76 11 AM	RURAL FREEWAY	I 94 CALHOUN	CC	WEATHER: SNOW SURFACE: WET LIGHTING: DAY	1-VEH FIXED OBJECT	PROPERTY DAMAGE	SINGLE BOTTOM	51	TOO FAST			TRUCK LOST CONTROL ON ICE JACK-KNIFED AND LEFT ROADWAY.
JAN 22 '76 11 AM	URBAN DIVIDED	M 53 MACOMB	CC	WEATHER: CLEAR SURFACE: WET LIGHTING: DAY	2-VEH REAR-END	PERSONAL INJURY	SINGLE BOTTOM	37	TOO FAST	FUEL OIL		TRUCK HIT REAR OF CAR STOPPED FOR A RED LIGHT.
FEB 11 '76 4 PM	RURAL FREEWAY	US 10 BAY	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	DOUBLE BOTTOM	47		ACETIC ACID	SPILL	SECOND TRAILER OVERTURNED ON RAMP. POWDER WEED KILLER SPILLED.
MAY 16 '76 1 AM	RURAL 2-WAY	US 2 SCHOOLCRFT	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK	1-VEH ANIMAL	PROPERTY DAMAGE	SINGLE BOTTOM	52		39,300 LB FUEL		TRUCK HIT A COW.
APR 13 '76 1 PM	RURAL 2-WAY	M 115 WEXFORD	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	SINGLE BOTTOM	34		DIESEL FUEL /FULL		TRACTOR TIRE BLEW, TRUCK LEFT ROADWAY AND OVERTURNED.
MAY 4 '76 8 PM	RURAL 2-WAY	M 19 ST CLAIR	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH OVERTURN	PERSONAL INJURY	SINGLE BOTTOM	28	TOO FAST	LP GAS		TRUCK LOST CONTROL ON CURVE AND OVERTURNED.
JUN 10 '76 11 AM	RURAL 2-WAY	M 20 MECOSTA	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH OVERTURN	PERSONAL INJURY	OTHER	21	TOO FAST	RADIO- ACTIVE MTL		TRUCK LOST CONTROL ON CURVE AND OVERTURNED.
JUL 15 '76 4 PM	RURAL 2-WAY	M 13 BAY	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH OVERTURN	PROPERTY DAMAGE	DOUBLE BOTTOM	46		GASOLINE (FULL)	SPILL	TRAILER DISCONNECTED DURING TURN AND OVERTURNED. 760 GAL SPILLED.
JUL 28 '76 1 PM	URBAN FREEWAY	I 69 FLINT GENESSEE	CC	WEATHER: RAIN SURFACE: WET LIGHTING: DAY	1-VEH REAR-END	PERSONAL INJURY	SINGLE BOTTOM	51	TOO FAST			TRUCK LOST CONTROL ON RAMP, HIT GUARDRAIL. TRAILER OVERTURNED.
AUG 6 '76 2 PM	RURAL FREEWAY	I 94 CALHOUN	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH FIXED OBJECT	PERSONAL INJURY	SINGLE BOTTOM	52		CAUSTIC SODA(FULL)	SPILL	TRUCK TRYING TO AVOID OTHER VEHICLE, JACKKNIFED LEFT ROAD & OVERTURNED.

DANGEROUS CARGO ACCIDENTS

ON MICHIGAN TRUNKLINES JANUARY 1971 THROUGH DECEMBER 1976

DAY/HOUR	ROAD	LOCATION			ACC TYPE	SEVERITY	DC-VEH	AGE	HAZ. ACT	CARGO		DESCRIPTION OF ACCIDENT
AUG 14 '76 9 AM	RURAL FREEWAY	I 94 JACKSON	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	1-VEH ON-ROAD OBJECT	PROPERTY DAMAGE	SINGLE BOTTOM	23	TOO FAST		SPILL	TRUCK HIT CONSTRUCTION ZONE BARRICADES, TRUCK'S FUEL TANK PUNCTURED.
AUG 19 '76 7 PM	URBAN FREEWAY	I 69 & I 75 GENESEE	CC	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	9-VEH FIXED OBJECT	FATAL	SINGLE BOTTOM	34	OTHER	PROPANE	FIRE	TRUCK LOST CONTROL ON RAMP, HIT BRIDGE RAIL; TRAILER EXPLODED.
SEP 14 '76 4 AM	RURAL FREEWAY	I 96 KENT	CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DARK	1-VEH OVERTURN	PROPERTY DAMAGE	DOUBLE BOTTOM	57	TOO FAST	GASOLINE (FULL)		SECOND TRAILER WENT OUT-OF-CONTROL AND OVERTURNED
SEP 22 '76 8 AM	RURAL 2-WAY	M 60 CALHOUN	CO	WEATHER: CLEAR SURFACE: DRY LIGHTING: DAY	2-VEH S-SWIPE SAME DIR	PERSONAL INJURY	DOUBLE BOTTOM	34	TOO FAST	GASOLINE (FULL)	SPILL	TRUCK HIT ANOTHER VEHICLE STOPPED TO TURN RIGHT.
NOV 4 '76 9 AM	RURAL 2-WAY	M 62 CASS	CC	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	1-VEH OVERTURN	PERSONAL INJURY	SINGLE BOTTOM	27	TOO FAST	8,000 GAL GASOLINE	SPILL	TRUCK PASSING LEFT-TURN CAR ON RIGHT, FORCED OFF ROAD. 100% GAL SPILLED.
NOV 29 '76 9 AM	RURAL 2-WAY	US 31 G TRAVERSE	CO	WEATHER: CLEAR SURFACE: ICY LIGHTING: DAY	2-VEH ANGLE	PROPERTY DAMAGE	SINGLE BOTTOM	33		12,000 GAL GASOLINE		TRUCK HIT ON SIDE OF TRAILER BY CAR UNABLE TO STOP AT STOP SIGN.
DEC 2 '76 8 AM	RURAL 2-WAY	M 66 ST JOSEPH	CC	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	2-VEH REAR-END	PERSONAL INJURY	SINGLE UNIT	48	TOO FAST	ACETYLENE TANKS	SPILL	TRUCK HIT REAR OF CAR TURNING INTO PARKING LOT. TRUCK OVERTURNED.
DEC 2 '76 11 AM	RURAL 2-WAY	M 123 CHIPPEWA	CC	WEATHER: SNOW SURFACE: ICY LIGHTING: DAY	2-VEH REAR-END	PROPERTY DAMAGE	SINGLE UNIT	18				TRUCK HIT IN REAR BY CAR; CAR DRIVER BLINDED BY BLOWING SNOW.
DEC 9 '76 8 AM	RURAL 2-WAY	M 46 MUSKEGON	CC	WEATHER: CLEAR SURFACE: ICY LIGHTING: DAY	1-VEH FIXED OBJECT	PROPERTY DAMAGE	SINGLE BOTTOM	39	TOO FAST	EMPTY		TRUCK JACK-KNIFED WHILE TRYING TO AVOID SCHOOL BUS; HIT MAILBOX.

REFERENCES

1. AMERICAN TRUCKING ASSOCIATION, Handling Hazardous Materials. (January, 1977)

2. CHOSY, EUGENE (Fruehauf Corporation), Panel Discussion, Proceedings of a Symposium on Commercial Vehicle Braking and Handling. (May, 1975)

3. CURRY, DAVID A., AND ANDERSON, DUDLEY G., Procedures for Estimating Highway User Costs, Air Pollution, and Noise Effects. National Cooperative Highway Research Program Report 133 (1972).

4. ENGINEERING STANDARDS UNIT, Operational Characteristics of 100-Foot Double Tractor/Trailer Combinations in Michigan, Report TSD-279-76, Michigan Department of State Highways and Transportation, Lansing. (December, 1976)

5. FRUEHAUF CORPORATION, Tank Trailer Stability, Engineering Data No. 126. (August, 1970)

6. FRUEHAUF CORPORATION, Tank Test, Engineering Data No. 129. (March, 1971)

7. LANSTROM, JACK, Wagoner Transportation Company, Verbal Meeting. (February, 1977)

8. LANSTROM, JACK, Wagoner Transportation Company, Muskegon Heights, Michigan, Letter to G. J. McCarthy, Michigan Department of State Highways and Transportation. (March 21, 1977)

9. MICHIGAN DEPARTMENT OF STATE POLICE, "Hazardous Cargo Tank Vehicles" Summaries. (March, 1977)

10. MICHIGAN DEPARTMENT OF STATE POLICE, Motor Vehicle Accident Coding Instructions. (1972)

11. MICHIGAN SECRETARY OF STATE, Michigan Vehicle Code, Revision of 1973 and 1974-1975 Supplement.

12. NATIONAL TRANSPORTATION SAFETY BOARD, Safety Recommendations H-77-4, H-77-5, and I-77-1. (April, 1977)

13. POST, EDWARD R., et al, Truck Tests of Texas Concrete Median Barrier, Highway Research Record 460, Traffic Safety Barriers and Lighting Supports. (1973)

14. SNELGROVE, F. B., Articulated Vehicle Research in Ontario, Procedings of a Symposium on Commercial Vehicle Braking and Handling. (May, 1975)

15. STANDBERG, et al, Safety Problems in Commercial Vehicle Handling, Procedings of a Symposium on Commercial Vehicle Braking and Handling. (May, 1975)

16. U.S. DEPARTMENT OF TRANSPORTATION, Federal Motor Carrier Safety Regulations. (Revision of October 1, 1975)

17. U.S. DEPARTMENT OF TRANSPORTATION, Office of Hazardous Materials, various materials sent to Michigan Department of State Highways and Transportation. (December, 1976 and March, 1977)