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LARGE-TRUCK ACCIDENTS INVOLVING TIRE FAILURE

FINAL REPORT

prepared for
THE RUBBER MANUFACTURER'S ASSOCIATION

by
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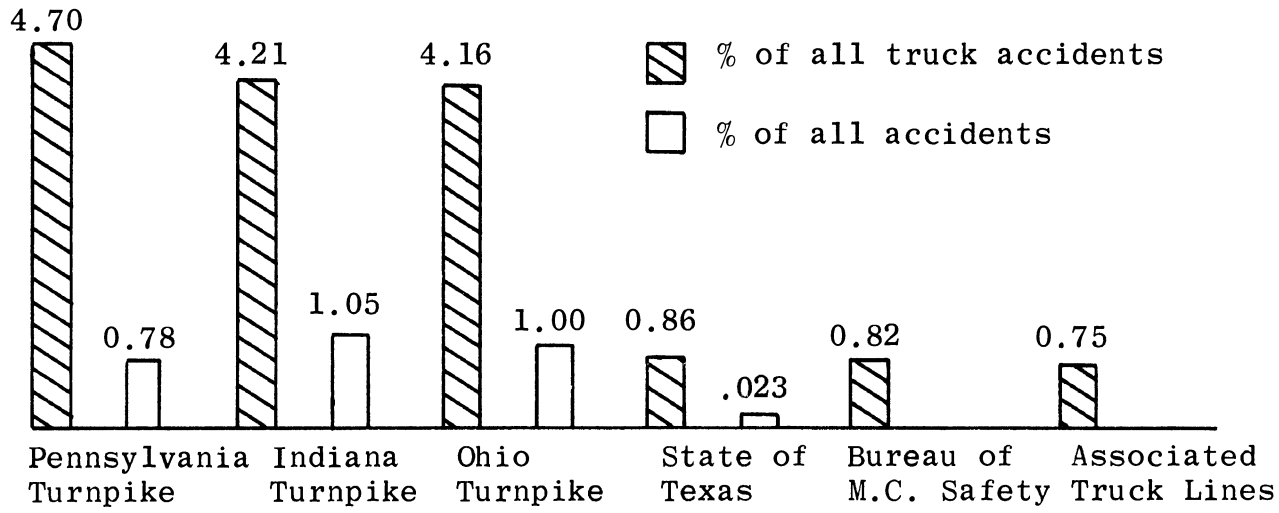
SUMMARY

LARGE-TRUCK ACCIDENTS RESULTING FROM TIRE FAILURES

DATA SOURCE	RATE, COMPARED TO ALL TRUCK ACCIDENTS	RATE, COMPARED TO ALL ACCIDENTS
Pennsylvania Turnpike 1969-1972	4.70% (1 in every 21)	0.78% (1 in every 128)
Indiana Turnpike 1966-1970	4.21% (1 in every 24)	1.05% (1 in every 95)
Ohio Turnpike 1966-1970	4.16% (1 in every 24)	1.00% (1 in every 100)
State of Texas 1969-1972	0.86% (1 in every 116)	0.023% (1 in every 4350)
U.S. Bureau of Motor Carrier Safety 1968-1971	0.82% (1 in every 122)	(no data)
Associated Truck Lines, Inc. Records 1970-1973	0.75% (1 in every 133)	(no data)
Grow Chemical Corp. Records 1963-1973	0.00% (0 out of 79 accidents)	(no data)



LARGE-TRUCK ACCIDENTS RESULTING FROM TIRE FAILURES

NOTE: Although the bar graphs might appear to be saying that about four times as many tire-failure accidents occur on the Turnpikes as on all roads in the State of Texas, the graphs are, in fact, not directly comparable. The number of accidents per vehicle mile is substantially lower on the Turnpikes than on most Texas roads. The proportion of tire-failure accidents on the Turnpikes is higher mainly because the proportions of other types of accidents are lower. In addition, trucks make up a larger proportion of the traffic mix on the Turnpikes, and the kinds of accidents occurring on the Turnpikes--i.e., mainly single-vehicle or same-direction collisions--are much less varied than in Tex.

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16. Abstract

Truck accidents involving truck tire failure were examined by reviewing existing literature, interviewing local cargo haulers, and analyzing several computerized accident data files. As reported in the literature, such accidents account for between 0.68% and 0.82% of all truck accidents in the United States. Data reported by two specific cargo haulers showed that truck accidents resulting from truck tire failure account for 0.43% to 0.75% of all their recorded accidents, and that a truck accident resulting from truck tire failure occurs about once in every 10 million to 17 million truck vehicle miles. Further, only about one truck tire failure in 1,300 to 2,200 such failures results in an accident. HSRI accident-data files indicated that truck accidents resulting from truck tire failure constitute from 0.02% of all accidents (i.e., all types of accidents and vehicles) in Texas to an average of about 0.9% of all accidents on the Indiana, Ohio, and Pennsylvania Turnpikes. Further, such accidents account for about 0.9% of all truck accidents in Texas and average about 4.4% of all truck accidents on these Turnpikes. Truck accidents involving front tire failures usually are a consequence of loss of control. From 85% to 99% of such accidents involve just one vehicle. Accidents resulting from trailer-tire failures almost always involve a tire fire. In general, truck accidents resulting from tire failure were found to be so rare as to make only a minor contribution to the total body of accident statistics.

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ABSTRACT

Truck accidents involving truck tire failure are examined by reviewing existing literature, interviewing local cargo haulers, and analyzing several computerized accident data files. As reported in the literature, such accidents are shown to account for between 0.68% and 0.82% of all truck accidents in the United States. Similar data reported by two specific cargo haulers show that truck accidents resulting from truck tire failure account for 0.43% to 0.75% of all their recorded accidents, and that a truck accident resulting from truck tire failure occurs about once in every 10 million to 17 million truck vehicle miles. Further, only about one truck tire failure in four to five thousand of such failures results in an accident. Data derived from various HSRI data accident files indicate that truck accidents resulting from truck tire failure constitute from 0.02% of all accidents (i.e., accidents involving all types of vehicles) in the State of Texas to an average of about 0.9% of all accidents on the Indiana, Ohio and Pennsylvania Turnpikes. Further, such accidents account for about 0.9% of all truck accidents in Texas and average about 4.4% of all truck accidents on these Turnpikes. Truck accidents involving front tire failures (most often the right front tire) usually are a consequence of loss of control. From 85% to 99% of such accidents involve just one vehicle. Accidents resulting from trailer-tire failures almost always involve a tire fire. In general, truck accidents resulting from tire failure were found to be so rare as to make only a minor contribution to the total body of accident statistics.

PREFACE

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1.0 INTRODUCTION

The failure of a tire on a tractor-semitrailer rig can result in a serious accident--particularly if the tire is on a steering axle. Understandably there is much concern about minimizing those accidents. To place such accidents in proper perspective, however, it is necessary to establish their frequency and compare that with the frequency of accidents resulting from causal factors other than tire failure. Moreover, the effectiveness of existing regulation and maintenance practices needs to be assessed, and the costs and benefits associated with additional regulation need to be defined and compared.

This report presents information on only the first two of these needs, i.e., the character and frequency of truck accidents resulting from tire failure, and a comparison of tire failure with other accident-causation mechanisms. A summary of the study findings is given in Section 2. Section 3 reviews the existing literature. Section 4 presents tire failure data obtained from local cargo haulers. Section 5 presents analyses of tire-failure data in several computerized accident data files. Conclusions and recommendations are given in Sections 6 and 7 ,respectively.

2.0 SUMMARY

The seriousness of truck accidents involving tire failure was examined by reviewing existing literature, by gathering data from local trucking firms, and by analyzing several computerized accident files at the Highway Safety Research Institute.

Several studies of accidents involving tire failures were found in the literature, but only a few of those dealt specifically with truck tire failures. The most informative of these was a single report on front-tire failure accidents [1], and a series of reports on vehicle defect accidents [2-5], all published by the Bureau of Motor Carrier Safety. These reports indicate that accidents resulting from truck tire failures constitute about 0.82% of all truck accidents and 0.87% of all fatalities in truck accidents. More limited studies in the State of Washington [6] showed that truck accidents attributed to tire failure accounted for 0.68% of all truck accidents. Studies of such accidents in the United Kingdom [8-12] showed that between 3% and 25% of accidents involving trucks were caused by tire failure. Such numbers must be viewed with suspicion, however, since a careful review of accidents involving tire failure by Baker and McIlraith [19-22] has shown that tire failure is frequently cited erroneously as an accident-causation mechanism.

Tire maintenance practices have been reported upon by the Bureau of Motor Carrier Safety in connection with its Safety Road Check Program [13-18]. The BMCS found that about 1.3% of all tires inspected on some 24,655 units were so defective as to require replacement. The percentage varied as follows for various types of units: Authorized, 1.4%; Private, 0.8%; "Exempt," 2.0%; Other, 3.2%. The percentage of defective tires on tractors varied from 0.5 to 1.2% for the various categories, and, on trailers, from 1.3 to 4.8%. In a field survey of maintenance practices [1], the BMCS found that up to 4% of the front axle tires were overloaded, and that a much greater percentage (perhaps 60%) were

probably underinflated. Right-side tires were found to be somewhat more likely to fail than those on the left. Tire fires were found to occur as frequently as 15 to 25% of the time in tire-failure accidents.

A comparison of tire-failure accident rates for passenger cars and trucks showed that the apparent rates are somewhat similar—0.82% as reported by the BMCS for trucks, and 0.59 to 1.64% as reported by Baker and McAlraith for passenger cars. Further, if tire fires are not counted as "accidents," the rate for truck accidents involving tire failure is 0.66%. The statistics for passenger cars were established by determining whether a tire failed before or during an accident. A similar investigation of truck tire-failure accidents might further reduce this percentage by as much as one-half.

Accident and tire-failure statistics were gathered from two firms engaged in carrying cargo. Both firms apparently employ tire maintenance and replacement procedures which are well above average. Associated Truck Lines reported that tire-failure accidents account for 0.43 to 0.75% of all their recorded accidents. On the average they experienced a tire-failure accident about once in every ten to seventeen million vehicle miles. Grow Chemical Corporation, a manufacturer and hauler of flammable chemical solvents, has recorded 79 traffic accidents in the last ten years—none due to tire failure. During this period the total mileage exposure of its fleet has been between eight and nine million miles. The firm has records which indicate an overall tire failure frequency of about one in every 7,600 vehicle miles of travel. For front axles the rate is about one failure in every 700,000 vehicle miles. About 50% of the tire failures occur in low-speed city hauling, while city mileage exposure is about 20% of the total. If data from Associated Truck Lines and Grow Chemical are combined, this produces a rate which shows that about one tire failure in every 1,300 to 2,200 results in an accident.

Existing computerized accident data files at the Highway Safety Research Institute were interrogated to determine the frequency of truck accidents resulting from tire failures. Files for the Ohio, Indiana, and Pennsylvania Turnpikes and for the State of Texas were examined. For the turnpikes, the data are remarkably similar: Truck accidents resulting from tire failure make up about 4 to 4.75% of all truck accidents and about .75 to 1.1% of all accidents. From 93 to 99% of the tire-failure accidents are single-vehicle involvements, with 75 to 90% of the vehicles involved being tractor-semitrailer rigs. The fatality rate is between 0.011 and 0.017 per accident, and the injury rate between 0.20 and 0.41 per accident.

The Texas data differ somewhat from the Turnpike data, in that they represent conditions over the entire State. Traffic conditions vary widely from those of turnpikes, and the makeup of the vehicle population is different; about 60% of the truck accident involvements resulting from tire failure were with straight trucks. The percentage of such involvements is about one-fifth that on the turnpikes, but the fatality rate, given the occurrence of a tire-failure accident, is higher. The main findings of the study are summarized in Table I.*

It is evident that truck accidents resulting from tire failure are relatively rare. Because such accidents are almost always single-vehicle involvements, the traveling public is not greatly endangered by the occasional accident resulting from the failure of a truck tire.

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* In examining the percentages shown in Table I, the reader should bear in mind that percentage figures established on the basis of very small numbers (e.g., the turnpike fatalities in tire-failure accidents) are less stable or reliable than percentage figures based on larger numbers. Small numbers are much more susceptible to change significantly with a very small change in the raw data (as in a doubling of fatalities, from one to two).

Table I

SUMMARY OF ACCIDENT STATISTICS

Data Source	Total Accidents of All Types	Total Truck Accidents (%)[1]	TRUCK ACCIDENTS INVOLVING TIRE FAILURE								
			Total (Percent)	Fatalities (Rate)[3]	Inj. (Rate)[3]	TYPE VEHICLE			NUMBER OF VEHICLES		
						Straight Truck (Percent)[3]	Tractor Semi- (Percent)[3]	Other (Percent)[3]	1 (Percent)[3]	2 (Percent)[3]	> 2 (Percent)[3]
BMCS 1968-71	-	195,801	1,598 (0.82%)[2]	56 (0.035)	705 (0.44)	--	--	--	85%	--	--
Assoc. Truck Line 1970-73	-	1,853	14 (0.75%)[2]	0 (0.00)	--	--	--	--	--	--	--
Grow Chemical Corp. 1963-73	-	79	0 (0.0%)[2]	0 (0.00)	0 (0.00)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ohio Turnpike 1966-70	8,663	2,093 (24.2%)	87 (4.16%)[2] (1.00%)[1]	1 (0.011)	36 (0.41)	5 (6%)	78 (89%)	4 (5%)	86 (99%)	1 (1%)	0 (0%)
Indiana Turnpike 1966-70	5,744	1,422 (24.8%)	60 (4.21%)[2] (1.05%)[1]	1 (0.017)	12 (0.20)	7 (11%)	52 (86%)	2 (3%)	59 (93%)	1 (2%)	0 (0%)
Penn. Turnpike 1969-72	11,492	1,914 (16.7%)	90 (4.70%)[2] (0.78%)[1]	1 (0.011)	35 (0.39)	19 (21%)	68 (76%)	3 (3%)	84 (93%)	5 (6%)	1 (1%)
State of Texas 1969-72	1,567,000	41,277 (27.4%)	354 (0.86%)[2] (0.023%)[1]	12 (0.034)	144 (0.41)	212 (60%)	127 (36%)	15 (4%)	319 (90%)	35 (10%)	0 (0%)

[1] Based on total accidents

[2] Based on total truck accidents

[3] Based on total truck accidents involving tire failure

3.0 LITERATURE REVIEW

This review of the literature on accidents caused by truck tire failures is discussed in several parts: first, studies dealing directly with truck tire failures as an accident-causation mechanism; second, a wider body of truck literature dealing with vehicle defects as an accident-causation factor; third, the literature on experience in the United Kingdom; fourth, literature on truck tire maintenance practices. Finally, statistics from the literature on truck accidents resulting from tire failure are compared with similar statistics for automobiles.

3.1 Specific Studies

The only known study dealing specifically with truck tire failures as an accident causation factor is that of the Bureau of Motor Carrier Safety (BMCS) [1]. This study states that tire failures are the second leading cause (after brake failures) of mechanical defect accidents involving trucks. During the years 1968, 1969, and 1970, a total of 1,186 accidents involving truck tire failures were reported nationwide. Of these,775 (or 65.4%) involved front, or steering axle, tire failures. The 1,186 truck tire failure accidents (less than 1% of all truck accidents) represent 16.6% of a total of 7,136 truck accidents reported as resulting from mechanical defects of all types. The data cover accidents involving all common and contract carriers engaged in interstate or foreign commerce where fatalities, serious injury, or property damage in excess of $250 was involved.*

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* There are some exempt carriers, so that this does not necessarily include "all" trucks as defined here.

3.2 Studies of Accidents Caused by Vehicle Defects

The data reported in reference 1 represent a summary of data taken from a wider study of accidents resulting from vehicle (mechanical) defects [2-5]. During the years 1968 through 1971, the total of 195,801 accidents reported to the BMCS included single-unit trucks, tractor-semitrailer units, tractor and full trailer units, tractor and semi-full trailer units, and tractors only. The 11,852 accidents involving vehicle defects constitute 6.1% of the total, while the 1,598 accidents resulting from truck tire failures account for only 0.82%. A complete summary of the data is shown in Table II.

As Table II shows, 3.3 fatalities occur for every 100 truck accidents of all kinds. Comparatively, 1.96 fatalities occur for every 100 mechanical-defect accidents, and 3.5 fatalities occur for every 100 tire-defect accidents. The respective figures for injuries per 100 accidents are 32, 35, and 44. Thus, the chance of being a fatality in a tire-failure accident is not much different than for truck accidents as a whole, but the chance of injury is somewhat greater.

The data in Table II show that accidents resulting from tire failures make up approximately 0.8% of all truck accidents. In all likelihood the percentage is less than even this small value. A careful examination of tire-failure accidents involving automobiles [22], for example, has shown than in 1,432 accidents, 235 had one or more tires disabled after the accident. Drivers claimed that 42 of these disablements occurred prior to the accident. Police officers investigating the accidents felt that only 30 had occurred prior to an accident. Careful examination by the project study team, however, showed that only 13 tires definitely had failed before the accident, while some 23 others were questionable. Thus, a careful analysis of the truck accidents claimed to have resulted from tire failures would likely show a smaller percentage than that shown on Table II.

TABLE II

BUREAU OF MOTOR CARRIER SAFETY ACCIDENT DATA
SUMMARY

	Total Accidents[1]			Vehicle Defect Accidents[2]			Tire Failure Accidents Only[2]											
										Fatalities			Injuries			Fire			
Year	Number	Fatalities (Percent)[4]	Injuries (Percent)[4]	Number (Percent)[4]	Fatalities (Percent)[5]	Injuries (Percent)[5]	Front	Other	Total (Percent)[4]	Front	Other	Total (Percent)[6]	Front	Other	Total (Percent)[6]	Front	Other	Total (Percent)[6]	Single Vehicle (Percent)[6]
1968	43,116	1,588 (3 7%)	15,012 (35%)	2,209 (5 1%)	44 (2 0%)	1,007 (46%)	247	147	394 (0 91%)	6	4	10 (2 5%)	123	41	164 (42%)	---	---	95 (24%)	---
1969	47,630	1,631 (3 4%)	15,844 (33%)	2,640 (5 5%)	63 (2 4%)	1,059 (40%)	264	146	410 (0 86%)	11	9	20 (4 9%)	150	45	195 (48%)	---	---	94 (23%)	335 (82%)
1970	50,000[3]	1,600[3] (3 2%)	15,500[3] (31%)	2,287 (4 6%)	48 (2 1%)	862 (38%)	264	118	382 (0 76%)	8	5	13 (3 4%)	136	37	173 (45%)	---	---	60 (15 7%)	319 (84%)
1971	55,055	1,592 (2 9%)	16,200 (29%)	2,082 (3 8%)	33 (1 58%)	753 (36%)	317	95	412 (0 75%)	10	3	13 (3 2%)	155	18	173 (42%)	19	43	62 (15 0%)	365 (89%)
1972	61,918	1,748 (2 8%)	17,345 (28%)	2,310[1] (3 7%)	57[1] (2 5%)	831[1] (36%)	---	---	---	--	--	--	---	--	---	---	---	--	---
Totals[7]	195,801	6,411 (3 3%)	62,556 (32%)	9,218 (4 7%)	188 (2 0%)	3,481 (38%)	1,092	506	1,598 (0 82%)	35	21	56 (3 5%)	564	141	705 (44%)			311 (19 5%)	

1 - Data from BMCS Accident Data Tapes at HSRI
2 - Data from BMCS Mechanical Defect Report Series (2-5)
3 - Estimate - This tape has been damaged
4 - Based on total accidents
5 - Based on total mechanical defect accidents
6 - Based on total tire failure accidents
7 - 1968, 1969, 1970, 1971 only

A similar but more limited study was conducted by the Washington State Patrol in 1972 [6]. A total of 6,471 trucks (i.e., single units over 10,000 lbs, truck tractors, trucks and trailers, trucks and semi-trailers, and other truck combinations) were involved in 6,220 accidents. A total of 4,527 of these trucks were inspected for defects which may have contributed to the accident in which the truck was involved. 418 or 9.2% of these 4,527 vehicles were found to have at least one such defect. Of the defects which contributed to the accident, 31 were tire punctures or blowouts. These 31 tire defects represent 0.68% of the total number of vehicles inspected for defects. One driver fatality was recorded as the result of a tire defect causing an accident. No data are available concerning the number of injuries incurred by drivers or the number of fatalities and injuries incurred by other involved parties.

A second accident study was also conducted in 1972 by the Washington State Patrol for the specific category of logging trucks [7]. The study included 401 accidents, with 298 vehicles examined for mechanical defects which probably contributed to the accident. Twenty-four of these vehicles had at least one contributing defect. In two of the vehicles the defect was a puncture or a blowout. These two represent 0.67% of the total number of vehicles inspected. No fatalities resulted from these two tire-defect accidents.

These studies indicate that truck tire failures are a minor factor in overall truck accident statistics. An accident resulting from a truck tire failure, although a relatively infrequent event, can be very spectacular and serious. Such accidents can be easily sensationalized and blown out of proportion, much in the way that airliner accidents are handled. An example is an article which appeared in the California Highway Patrolman [8]. Three truck accidents which involved tire failures are cited in this article. The three accidents were similar, in that each occurred on a freeway and in each case a front tire blew out on a tractor-semi-trailer

rig, causing the rig to cross the median and strike oncoming vehicles. In one case, the Los Angeles County Supervisor was fatally injured as a passenger in a county-owned limousine. The gist of the article was that bad tires (e.g., defective, overloaded, worn out), not necessarily your own, can be dangerous, and that strong manufacturing regulations and operating inspection programs are required. No attempt was made to put tire failure accidents in perspective, however, in that no data were presented to indicate the relative frequency of tire failures and tire-failure accidents. In studies of accidents over several years on the Ohio. Indiana and Pennsylvania Turnpikes, which are discussed later, for example, no accidents of this "cross median" type were recorded.

3.3 Experience in the United Kingdom

Several studies of accidents caused by tire failures have been conducted in the United Kingdom, although they were not specifically concerned with heavy trucks. In a 1961-1962 study, 763 accidents were investigated on the London-Birmingham Motorway [9]. Of those, 96 involved light goods trucks (i.e., trucks weighing less than $1\frac{1}{2}$ tons) and 493 involved trucks carrying heavy goods (i.e., greater than $1\frac{1}{2}$ tons). The remainder were automobiles and motorcycles. A statistical summary of the data is given in Table III. If these data are accurate (subsequent discussions question their accuracy) tire failure was a major accident-causation factor in England a decade ago. Accurate or not, however, the data show that the incidence of tire-failure accidents for automobiles is twice that for heavy trucks. The accuracy of the data is open to question in terms of absolute percentages because of the more recent findings of Baker and McIlraith. They found tire failure to be blamed for an accident far more frequently than careful investigation shows to be actually true.

In a later study on the same section of roadway from October, 1962, to July, 1963, it was reported that tire failures occurred in nearly one-fourth of all reported accidents [10]. Of all

Table III

Tire Failure Accident Rate on the London-Birmingham Motorway 1961-62.

Type of Vehicle	Total Accidents	Number w/ Tire Failure	Percent w/ Tire Failure	No. of accidents in which tire failures and personal injury occurred	Vehicle mileage (per cent of total)	No. of failures per percent vehicle mileage		Failure rate per vehicle mile, relative to cars	
						All accidents	Personal-injury only	All accidents	Personal-injury only
Automobiles	539	65	12.1	42	56.2	1.16	0.75	1.0	1.0
Light Goods Trucks ($< 1\frac{1}{2}$ T.)	96	13	13.5	6	7.4	1.76	0.81	1.5	1.1
Heavy Goods Trucks ($> 1\frac{1}{2}$ T.)	493	18	3.7	9	34.0	0.53	0.26	0.5	0.3

the tire-failure accidents, 47% involved commercial vehicles weighing more than $1\frac{1}{2}$ tons. The tire-failure accident rate per vehicle mile for commercial vehicles was twice as great as the rate for automobiles. On the other hand, the tire-failure accident rate per tire mile was about the same. The conclusion was that commercial vehicles tended to drive on tires of poorer quality (i.e., average greater wear) than did automobiles. It was found that one tire in eight on a commercial vehicle was in poor condition, and one tire in ten was in bad condition. Further, it was found that recapped (remoulded) tires had a failure rate two to four times greater than average.

Two more recent studies of accidents involving tire failures were also conducted in the United Kingdom. Godley [11] found that out of 1,910 personal injury accidents occurring on the M1 and M4 motorways, 311, or 16.3%, were preceded by a tire failure. The average was about 18% for M1 and 13% for M4. The difference between the two rates was attributed to the longer length of M1 (suggesting greater heat build-up in the tires) and the greater speeds traveled there. Two-wheeled vehicles experienced the highest percentage of personal injury accidents resulting from tire-failures--some 36%. Of the personal injury accidents involving automobiles and heavy trucks, 10% and 3%, respectively, resulted from tire failures. Not given were tire-failure accidents as a percentage of total accidents.

In a second study, Lowne [12] collected data on both tire failures occurring separately on the M5 Motorway and on accidents caused by tire failures. The data are summarized on Table IV. As indicated, 24% of the personal injury accidents are a direct result of tire failure, but these represent only 20% of the tire failures. Further results of the study showed that a tire on a heavy goods vehicle was about $2\frac{1}{2}$ times more likely to fail (on the basis of tire failures per tire-km). than one on a car. A significantly greater proportion of car tire failures led to accidents than did tire failures on heavy trucks.

Table IV

Accidents as a direct result of tire failure

	No. of Accidents as a direct result of tire failure	Total number of accidents	Proportion of accidents as a direct result of tire failure	No. of vehicles w/ tire failure	Proportion of vehicles with tire failure leading to accidents (%)
M5 Tire failure survey - Jurisdictions 4-8 Sept.-Nov. 1971					
Injury acc.	6	25	24.0*	294	2.0
All accidents	9	59	15.3*	294	3.1

* These are not significantly different.

3.4 Tire Maintenance Practices

Several studies have been carried out in an effort to determine the extent to which tread wear and tire maintenance practices contribute to tire failure. The BMCS has published a series of reports on their "Safety Road Check Program" [13-18] which documents the results of their tire inspection effort. A typical summary of tire inspection data for July through December of 1972 is given in Table V. On the table, an "Out of Service Defect" is a defect of such type and degree as to render a vehicle imminently hazardous to operate until repaired. "Exempt" carriers are those which are exempt from economic regulation by the Interstate Commerce Commission. "Other" carriers are those not otherwise identified. It is clear from Table V that the carriers with the best tire maintenance practices are the private operators. "Exempt" carriers are the worst. It is also clear that tire maintenance practices on tractors are of a higher quality than on trailers. These findings are not surprising, since it is widely recognized that a tire failure on the tractor unit, particularly on the steering axle, is far more dangerous than one on a trailer.

Along with its study of front tire failures on commercial vehicles [1], the BMCS also conducted a two-day check on tire operating practices. The check was conducted at a scales stop on I-70 in Odessa, Missouri. Out of 576 trucks checked, 22, or 3.9%, had front axles which were potentially overloaded. (The front axles would have been overloaded if the tires used were 10.00 - 20, or 11-22.5--tire sizes commonly used on most tractor front axles. Unfortunately, tire size was not recorded in the study, however, and overloading could not be clearly established). Of 44 vehicles chosen for a detailed weight and inflation check, 31 had at least one front tire which was underinflated (a total of 55 front tires were underinflated). Further, six trucks had a total of twelve overloaded front tires. In an additional three-month study of 61 truck accidents involving front tire failures,

Table V

Tire Defects in Inspected Motor Carrier Units

TRACTOR AND TRAILER UNITS

Type of Carrier	Authorized	Private	"Exempt"	Other	All Carriers
Number of Tire Defects	1,042	713	345	66	2,166
% Tire Defects	9.5	6.9	11.9	13.0	8.8
Number of Out of Service Tire Defects	151	85	59	16	311
% of Out of Service Tire Defects	1.4	0.8	2.0	3.2	1.3
Total Inspected Units	10,944	10,311	2,894	506	24,655

TRACTORS ONLY

Type of Carrier	Authorized	Private	"Exempt"	Other	All Carriers
Number of Tire Defects	304	218	118	24	664
% Tire Defects	5.5	3.8	8.0	8.7	5.1
Number of Out of Service Tire Defects	31	28	18	5	82
% of Out of Service Tire Defects	0.6	0.5	1.2	1.8	0.6
Total Inspected Units	5,529	5,788	1,469	277	13,063

Table V Continued

TRAILERS ONLY

Type of Carrier	Authorized	Private	"Exempt"	Other	All Carriers
Number of Tire Defects	738	495	227	42	1,502
% Tire Defects	13.6	10.9	15.9	18.3	13.0
Number of Out of Service Tire Defects	120	57	41	41	229
% of Out of Service Tire Defects	2.2	1.3	2.9	4.8	2.0
Total Inspected Units	5,415	4,523	1,425	229	11,592

it was found that the mean tread depth on vehicles involved in accidents was 11/32". In the 44-vehicle study the tread depth was 14.4/32". In only one tire involved in the 61 accidents studied, however, was the tread depth less than 4/32". One other tire was listed in poor condition. The evidence suggests, therefore, that worn tread is not a major cause of front tire failures. Finally, it was found that tires on the right front tend to fail more frequently and cause more accidents than those on the left front. In the years 1968-1970, 444 right front tires failed and caused accidents, while 304 left front tires did so. This is probably because tires on the right are more subject to road hazards (curbs, cracked pavement, etc.) than those on the left.

Similar studies of accidents resulting from tire failures, categorized by tire type, have also been reported in the BMCS defect and mechanical failure series [2-6]. The available data are presented in Tables VI-IX. It is evident that the majority of tires which fail in tire-failure accidents are tires with original grooves. Even though the relative usage of recap tires in comparison with tires with original grooves is not given, the high frequency of original groove tires in tire-failure accidents is not surprising. As already stated, most accidents resulting from tire failures are due to front tire failures. In general, recaps are not mounted on the front axle. Thus if a tire fails and causes an accident, it will typically be a front tire with original grooves. An additional finding, commented upon in Section 5.0, is the high frequency of fires attendent in truck tire-failure accidents. Fires occur between 15% and 25% of the time in truck tire-failure accidents, with the frequency being at the upper level in 1968-69 and at the lower level in 1970-1971. Again the data for 1971 (Table IX) indicate that tires on the right are more subject to failure (at least right-side tires cause more tire-failure accidents) than those on the left.

Table VI

Trucks -- Tire Failures - 1968

	Number	Fire	Fat.	Inj.
Original groove	21	1	0	11
Recap or retread	8	2	0	2
Type unknown	233	59	6	88
Tube, valve	5	0	0	0
Other or unknown	127	33	4	63
Totals	394	95	10	164

Table VII

Trucks -- Tire Failures - 1969

	Number	Fire	Fat.	Inj.
Original groove	118	32	10	55
Recap or retread	19	12	1	5
Type unknown	270	48	9	135
Tube,valve	3	2	0	0
Totals	410	94	20	195

Table VIII

Trucks -- Tire Failures - 1970

	Number	Fire	Fat.	Inj.
Puncture or blowout				
Original groove	159	10	6	89
Recap or retread	16	2	0	1
Type unknown	198	46	5	79
Tube or tube valve	7	0	1	4
Other or unknown	2	2	1	0
Totals	382	60	13	173

Table IX

Trucks - Tire Failures - 1971

	Number	Fire	Fat.	Inj.
Puncture or blowout				
Original groove	300	24	8	150
Recap or retread	19	3	0	6
Type unknown	87	35	5	25
Tube or tube valve	6	0	0	2
Totals	412	62	13	183

Front Tire Failures Only-1971

	Number	Fire	Fat.	Inj.
Right front	175	11	1	78
Left front	136	7	7	73
Front, side not reported	6	1	2	4
Total front	317	19	10	155

3.5 Comparison with Automobile Statistics

The seriousness of the problem of accidents resulting from truck tire failures can be determined on a relative basis by comparing the truck data with similar data for automobiles. The most important work yet carried out in determining the extent of tire failures among automobiles as an accident-causation mechanism is that of Baker and McIlraith [19-22]. The study was conducted in four phases:

1. Frequency of Tire Disablements
2. Use and Condition of Tires
3. Tire Disablements Not Followed by Accidents
4. Tire Disablements Followed by Accidents

A major finding of the study was that the frequency of tire failures which actually cause accidents is very low. It was found that somewhere between one in 1,700 and one in 4,600 flats causes an accident. In general, drivers blamed a flat tire as an accident cause $2\frac{1}{2}$ times more than was justified. The study investigated 1,486 accident cases involving 2,196 vehicles. In 235 of the accident reports pertaining to these accidents, tire failure was listed as an accident-causation mechanism. Upon careful investigation, however, only 13 of the 235 accidents definitely resulted from a tire failure having occurred prior to the accident. Another 199 definitely did not have a prior tire failure, and the other 23 cases were questionable. Thus tire failure was an accident-causation factor in somewhere between 0.59 and 1.64% of all 1,486 accidents investigated.

These percentages can be compared with the 0.82% of truck accidents which result from tire failures, as reported by the BMCS and as listed on Table I. It should be remembered, however, that the BMCS percentage does not reflect a careful analysis of each accident to determine the actual occurrence of a tire failure prior to the accident. Further, many of the "accidents" reported by the BMCS are tire fires and do not involve a collision event. If just

the tire-fire accidents are removed from the total of tire-failure accidents on Table II, for example, the percentage of truck accidents involving tire failure is reduced to 0.66%. Thus, the true incidence of truck tire failure as an accident-causation mechanism could be as low as one-half that for automobiles.

4.0 TIRE FAILURE EXPERIENCE OF MOTOR CARRIERS

Three motor carriers were contacted in the study to determine the actual frequency of tire failures and accidents resulting from tire failures among operating cargo haulers. Data from two of the carriers, Associated Truck Lines, Inc., and the Grow Chemical Corporation, are discussed here. The third carrier did not maintain tire records of sufficient detail for use in the study.

4.1 Associated Truck Lines, Inc.

Associated Truck Lines, Inc. (ATL) is one of the larger general motor carriers in Michigan, currently operating with a fleet of 679 tractors, 1,871 semi-trailers, and 56 straight trucks. Eighty percent of the mileage incurred by the carrier is in intercity operation, and 20% is intracity. From 80% to 95% of the intercity operations occur at night.

A summary of mileage exposure and accident data for the truck line is given in Table X. As indicated, accidents resulting from tire failures account for about 0.75% of all accidents. Further, such accidents occur about once in every ten million vehicle miles. Several of the accidents attributed to tire failure were not the direct result of failure of the tire carcass under ordinary conditions. Other tire failures resulted from a defective tire compound. In still others, there is some doubt as to whether the tire failed prior to the accident. If all of these cases are removed, 0.43% of all accidents resulted from tire failure, and about six of these accidents occurred in every one-hundred million vehicle miles (i.e., about one tire-failure accident occurred in every seventeen million vehicle miles). A detailed summary of all accidents resulting from tire failure, as experienced by ATL during 1970-73, is given on Table XI. All tires causing accidents were on the front steering axle; ten were on the right front and four were on the left front.

Table X

Associated Truck Line, Inc. Mileage and Accident Data Summary

Year	Mileage		Total Accidents				Accidents Caused by Tire Failure		
	Road Haul	Steel and Special Prod.	Road Haul	Steel and Special Prod.	City	Total	Number	Percent[d]	Accidents per 10^7 Vehicle mi.
1970	21,341,992	6,196,494	102	66	263	431	4	0.93	1.45
1971	25,880,830	6,725,164	106	60	268	434	3[a] (0)	0.69 (0.00)	0.92 (0.00)
1972	26,356,391	8,040,900	136	63	253	452	5[b] (4)	1.10 (0.88)	1.45 (1.16)
1973	29,506,892	9,954,212	122	112	302	536	2[c] (0)	0.37 (0.00)	0.51 (0.00)
Totals	103,086,105	30,916,770	466	301	1,086	1,853	14 (8)	0.75 (0.43)	1.04 (0.60)

a Two tires were made of a defective rubber compound and one blew out after hitting an abandoned wheel hub lying in the road

b Tire failure may not have occurred in one of these accidents.

c One tire blew out after running over scrap metal on the road; the other lost a recap which hit another vehicle and broke the windshield. The second tire did not blow out.

d Based on total accidents.

Table XI

Associated Truck Line, Inc.

Summary of Tire Failure Accidents

Date	Time	Weather	Light	Road	Speed	C = City I = Inter-city	Tire	Tread Depth, in.	Comment
3/3/70	3:17 p	Clear	Daylight	No. Def.	55mph	I	LF-1*	?	Hit guardrail
4/3/70	4:50 a	Clear	?	No. Def.	50	I	RF-1	20/32	Went into ditch
6/11/70[a]	10:00 p	Cloudy(?)	Dark	No. Def.	?	I	RF-1,2	6/32	Tire about to be replaced
7/31/70	4:00 p	Clear	Daylight	No. Def.	55	I	RF-1	?	
8/13/70[a,c]	12:15 a	Clear	Dark	Dry	50-55[b]	I	RF-1,2	0/32	
1/20/71	5:15 a	Cloudy	Dark	Blowing Snow	58	I	RF-1,5	?	Hit wheel hub lying in road
6/17/71	1:00 a	Clear	Dark	Dry	60	I	RF-1,4,5,6	7/32	Tread separated from sidewall, 71,000 mi. on tire
6/24/71	5:30 a	Clear	Daylight	Dry	60	I	LF-1,4,8	6/32	RF blew out after accident
4/12/72	4:30 p	Clear	Daylight	Dry, No. Def.	55	I	RF-1	?	New tire on new tractor
4/14/72	3:30 p	Clear	Daylight	Dry, No. Def.	15	C	?	?	Tire failure may not have occurred in the accident.
5/16/72	12:05 p	Clear	Daylight	Dry, No Def.	55	I	RF-1	13/32-19/32	35,000 miles on tire.

Table XI continued

Date	Time	Weather	Light	Road	Speed	C = City I = Inter-city	Tire	Tread Depth, In.	Comment
6/28/72	3:30 a	Clear	Dark	Dry,	55	I	LF-1,2	14/32	Tire 3 months old
8/17/72	6:00 a	Clear	Daylight	Dry, No. Def.	50	I	LF-1,7(?)	?	May have been recap
6/4/73	11:15 p	Cloudy	Dark	No. Def.	60	I	RF-7	?	Recap hit windshield of other vehicle, no collision or blowout
9/10/73	2:00 p	Clear	Daylight	Dry	55	I	RF-1,3,5	?	

a Private Owner-Operator
b Speed stated to be above legal limit
c Running empty

*1 Blowout - Lost Control
2 Clear evidence of blowout on pavement
3 Blowout claimed by driver, but uncertain
4 Experimental tire compound
5 Ran over metal or object
6 No cuts found in tire
7 Recap broke loose
8 Overloaded or underinflated

As a part of this study it was hoped that the numbers and kinds of tire failures which occurred during 1970-73 could also be obtained from ATL, so that these could be compared with the tire failures that caused accidents. That is, it was hoped that the frequency of tire failures in general could be compared with tire failures that cause accidents. Although ATL fully intended to cooperate in this matter, a last-minute shift in priorities precluded their doing so.

The tire maintenance and replacement practices employed at ATL reflect a serious concern for minimizing tire failures on the road. Only new tires are used on the front axles of tractors, and these are replaced when the tread is worn to a depth of between 6/32" and 7/32". (This depth compares with the minimum of 4/32 in. tread depth for front tires by the BMCS Regulations [23]). Re-capped tires are used only on trailers for long-haul service and on trailers and tractor drive axles for city use. Drivers are required to check for loss of tire pressure every three hours, or every 100 miles, although it is admitted that this requirement is not always complied with. Front axles are weighed to conform to both the maximum load limits specified in the Tire and Rim Association Year Book [24] and the axle loading limits specified in the states within which ATL operates. Tires are carefully matched for brand, construction, size, and wear on the front axles and on each dual pair of each drive axle. In fact, all four tires on a dual drive axle are matched as carefully as practical.

In-service tire wear has been found to vary considerably among various tires. A summary of the variation in mileage per 1/32 in. of tire wear is given as follows:

FRONT AXLES	MILEAGE PER 1/32 IN. OF WEAR
Single-Drive-Axle Tractors	3,300 - 19,800
Tandem-Drive-Axle Tractors	2,700 - 10,800
DRIVE AXLES	
Single-Drive-Axle Tractors	1,100 - 5,200
Tandem-Drive-Axle Tractors	3,200 - 36,500

It is evident that tires on the front axle wear better than those on the drive axle, and that tires on tandem-drive axles wear better than those on single-drive axles. After use on the front axles, tires are moved to the trailer where service life prior to recapping averages about 100,000 miles. Tires may be recapped one or more times for trailer use, depending upon the condition of the tire.

4.2 Grow Chemical Corporation

Grow Chemical Corporation is a manufacturer of commercial solvents operating out of Detroit, Michigan. The company currently maintains a fleet of 32 tractors and 30 trailers for transporting its products, most of which are flammable. Most of the trailer units are tankers. Eighty percent of the mileage incurred by the transport fleet is long haul. Long-haul operations are carried out uniformly around the clock. Since 1963 the company has recorded 79 traffic accidents, including 16 serious enough to require reporting to the BMCS. None of the 79 accidents resulted from tire failure.

A summary of the mileage exposure and tire repair experience for the Grow Chemical fleet during 1971-1973 is given in Table XII. For these years, a tire failure of some type occurred about 1.3 times every 10,000 vehicle miles of travel, or about once every 7,600 miles. A front axle tire failure occurred about twice a year, or about once in every 700,000 vehicle miles. Tire repair costs averaged between 1.5¢ and 1.7¢ per mile. These statistics, of course, do not include tires removed from service due to excessive wear.

Since the Grow Chemical fleet carries primarily flammable cargo the firm's policies on tire maintenance and replacement are generally more stringent than the average carrier. (Drivers are also more carefully selected than is average practice.) For long-haul operations, tires on the front steering axle are replaced when

Table XII

Grow Chemical Corp. Summary of Fleet Mileage Exposure and Tire Repair Experience

Year	Number of Units		Total Fleet Mileage Exposure (Approx.)	Tire Repairs[1]		Total Repairs	Tire Repair Costs (Approx.)
	Tractors	Trailers		Simple Flat Repairs	Section 3 Repairs		
1971	30	30	1.0×10^6	--	--	--	---------
1972	30	30	1.3×10^6	76	83	159[2]	$20,000
1973	31	30	1.4×10^6	134	62	196	$23,000
Current	32	28	---------	---	--	---	---------

1 About six blow outs were experienced in 1971-73, inclusive, and were not repairable. One additional tire was traded in on a warranty claim.

2 Many new tires were purchased by the company during 1972 so that the quality of the average inservice tire in 1972 may be somewhat better than in 1973 and thus may account for the lower number of repairs in 1972.

3 Section repairs involve removing and replacing a damaged section of a tire. Such repairs may involve damaged tires that have not gone flat.

the tread is worn to a depth of 8/32". No recap tires are used for long hauls on either tractors or trailers. For city use, recaps are used on both trailers and drive axles. Tires may be recapped as many as two times for city use, but no more. Of the tire failures listed on Table XII, roughly 50% occurred in city driving, while city mileage exposure was only 20% of the total mileage. Since city travel speeds are substantially below those characteristic of long-haul operations, however, the danger associated with more frequent tire failures in city operations is minimal.

Standard maintenance policies at Grow Chemical are to have drivers check tire condition once every hour while on long-haul operations. In practice, however, this interval is probably more like once every two to four hours. Drivers in a two man driving team generally switch every two hours and it is at these intervals when most tire checks are probably made. This check consists of grossly examining each tire for cuts, abrasions, heat build up, and low air pressure. The air pressure check is made with a "tire bat" - a device which is used to detect low pressure by striking each tire individually. Tire pressures are checked with a tire gauge when the vehicles are serviced. City rigs are checked every day for flats, but not necessarily for tire pressure.

Truck axles are carefully weighed for long haul operations, but not necessarily so for city travel. As with ATL, maximum weight limits conform to the Tire and Rim Association recommendations [24], and to specific state pavement loading limits. Typically, trucks in city use are not loaded anywhere near the maximum load limits. Tires are carefully matched for long haul operations on both the front and drive axles. A device similar to a carpenter's square is used to match tires for equal diameter on a dual set on one side. Much less care is exercised in matching tires for city use.

4.3 Summary of Motor Carrier Tire Failure Experience

Associated Truck Lines and Grow Chemical are characteristic of the better truck lines in terms of tire failure experience and maintenance practices. It was hoped that a carrier having less concern for tire maintenance could also be interviewed and included in the report. Several such carriers were contacted, but none had records of sufficient quality from which useful information could be derived. The data concerning tire failures and accidents caused by tire failures, as presented in this section, is therefore probably optimistic when compared to the average among all motor carriers.

Notwithstanding this shortcoming, it is still of interest to recap the information available. From the ATL data it was found that an accident resulting from a tire failure occurs about once in every 10 million to 17 million vehicle miles. From the Grow Chemical data it was found that a tire failure of some type occurs about once in every 7,600 vehicle miles. If, for the sake of conjecture, it is assumed that the tire failure rate at ATL is the same as that at Grow Chemical (an assumption with little merit on statistical grounds, of course), then only about one tire failure in four to five thousand such failures results in an accident.

5.0 ACCIDENT DATA ANALYSES

Existing accident data tapes at the Highway Safety Research Institute were examined to determine the frequency of accidents resulting from truck tire failures. Accident files for the Ohio, Indiana, and Pennsylvania Turnpikes were interrogated as well as a file for the State of Texas. Accident data from the BMCS file has already been discussed in Section 3.0 and will only be mentioned in a comparative sense.

5.1 Ohio Turnpike Accident Data

Ohio Turnpike accident data were analyzed by first searching the computerized accident files at HSRI and then by individually examining each accident report involving a truck tire failure. In searching the accident files, 125 accident cases were tentatively identified as truck accidents resulting from tire failure. Subsequently, only 87 of these were found to have probably resulted from the failure of a truck tire. The discussions which follow deal primarily with these 87 cases.

The Ohio Turnpike vehicle (accident) file is a computerized data bank covering 8,663 accidents of all types which occurred on the Ohio Turnpike during January 1, 1966 to June 30, 1970. Of these 8,663 accidents, 2,093 (or 24.2%) involved trucks. Eighty-seven of these truck accidents (4.2% of all truck accidents and 1.00% of all accidents) involved a tire failure on the part of the truck. A "truck" in the present context is a vehicle which is coded in one of the following three ways in the vehicle file:

Truck
Tractor Semi-trailer
Truck tractor, full trailer

or which falls into the Ohio Turnpike toll classes 4-9, i.e., a weight range of 16,000 to 90,000 lb.

During the period that the data were collected, truck traffic on the Ohio Turnpike amounted to some 9.96×10^8 vehicle miles. On the average, a truck accident occurred once every 476,000 truck vehicle miles, and a truck accident involving a truck tire failure occurred once every 11,460,000 truck vehicle miles. Comparatively, the average accident rate for passenger cars is one accident per 762,000 vehicle miles. In addition, the average number of miles driven per accident involving a tire failure is 8,040,000 miles for all vehicles and 8,690,000 for passenger cars alone. If passenger car accidents are accorded a weighting of 1.00, accidents involving trucks (as weighted by mileage exposure) are more likely to occur by a factor of 1.60. By the same comparison, truck accidents involving truck tire failures are less likely to occur than passenger car accidents involving tire failures by a factor of 0.93. In proportion to mileage exposure, then, accidents involving trucks are more likely to occur than those involving passenger cars, but the likelihood of accidents involving tire failures is slightly less for trucks than for passenger cars.

A summary of the truck accidents which involved tire failures is given on Table XIII. Of the 87 recorded cases, 37 resulted from blowouts on the right front tire, 18 were from left front blowouts, and 32 (36.8%) were tire fires. Right-side tires apparently fail more frequently because of greater exposure to roadside surface irregularities. All tire fires except one were on trailer units; the exception was a tire fire on a drive axle. All tire-fire accidents were of the non-collision variety and presented no hazard to other traffic. If these are subtracted from the total number of tire-failure accidents, the total reduces to 55. Truck accidents involving tire failure then become 0.63% of all accidents and 2.6% of all truck accidents.

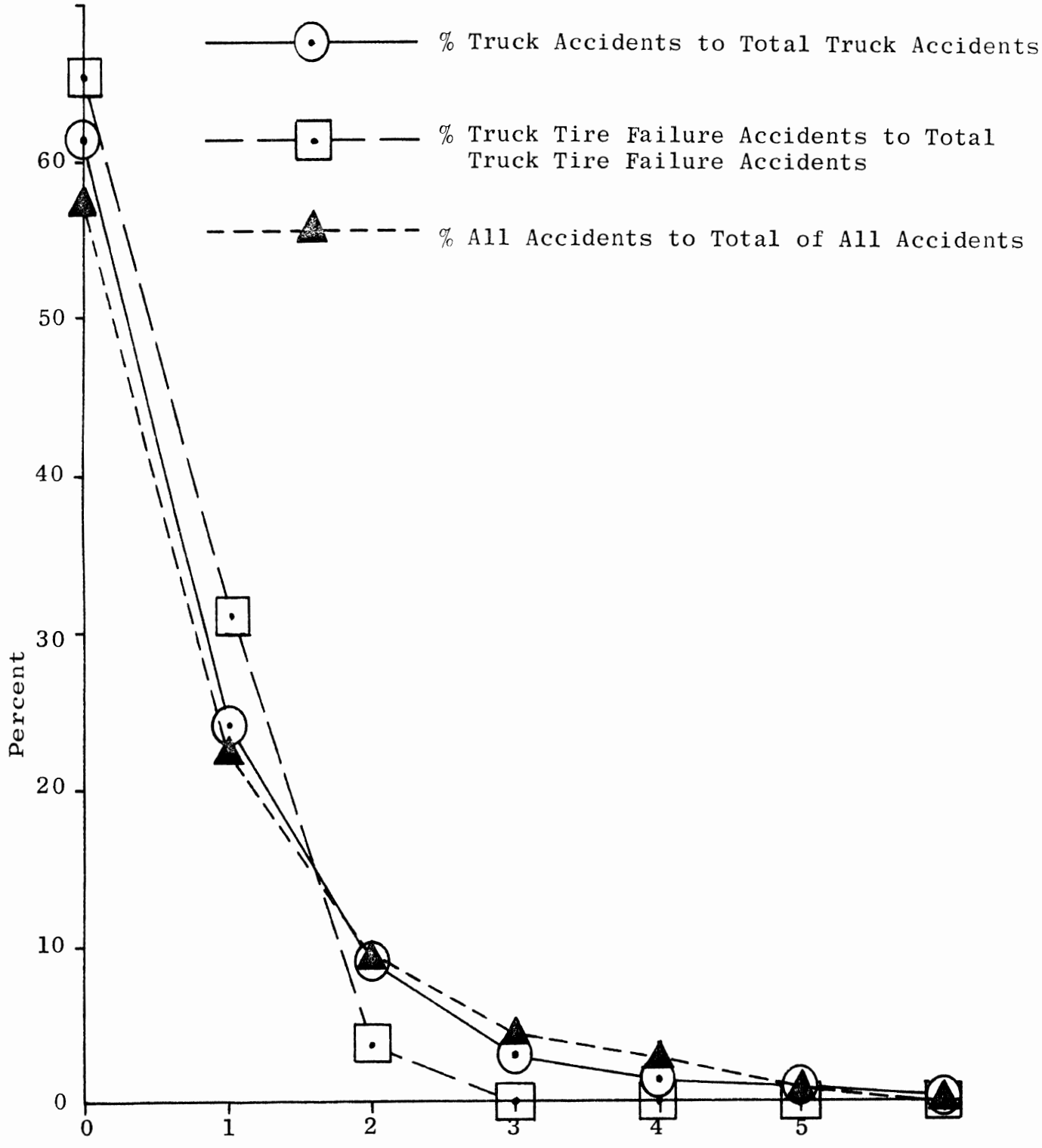
As can be noted in Figure 1 and Table XIV, the severity of accidents involving trucks is not much different than that of all vehicles. Further, the severity of truck accidents involving tire

Table XIII

Summary of Truck Accidents Involving Tire Failure
Ohio Turnpike
Jan. 1, 1966 to June 30, 1970

Year	Truck Accidents Involving Tire Failure		Fatalities	Injuries	Blow Outs		Tire Fires	Type Vehicle		
	Confirmed	Questionable			Right Front	Left Front		Straight Truck	Tractor-Semi	Tractor-Semi & Trailer
1966	33	0	1	9	14	6	13	3	29	1
1967	18	3	0	7	4	4	10	0	17	1
1968	11	1	0	6	4	4	3	1	9	1
1969	12	0	0	8	10	1	1	1	11	0
1970[1]	13	0	0	6	5	3	5	0	12	1
Totals	87	4	1	36	37	18	32	5	78	4

1 First 6 months only.



Injuries per Accident - Ohio Turnpike
Jan. 1, 1966 - Jun. 30, 1970

Figure 1

Table XIV

Severity of Accidents Involving Truck Tire Failure
Ohio Turnpike

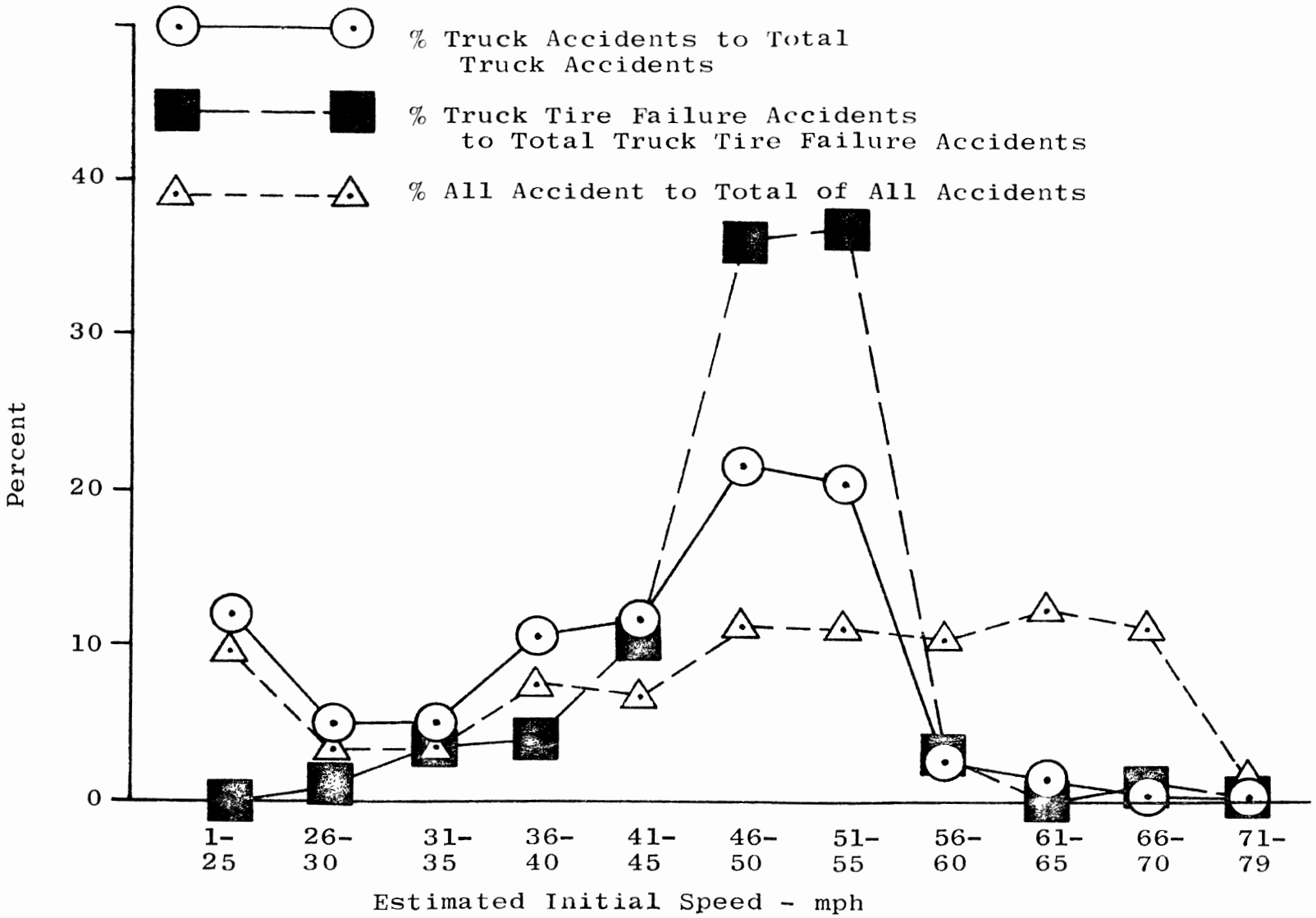
No. of Injuries	0	1	2	3	4	5	6	>6
% of All Truck Accidents Involving Tire Failure	65.5	31.0	3.5	0	0	0	0	0
% of All Truck Accidents	61.1	24.2	8.7	3.1	1.4	0.8	0.3	0.4
% of All Accidents	61.5	22.6	8.5	3.6	1.8	1.1	0.4	0.5

failures is not much different than that of all truck accidents or of all vehicles. The chance that one or more persons will be injured in a truck accident involving truck tire failure is slightly less than the chance of being injured in all types of truck accidents -- 35% versus 38%. On the other hand, the chance of one or more injuries in all types of accidents is about 43%.

The single fatality occurred when a driver jumped out of his tractor after it had gone out of control following a blowout of the right front tire. When the driver landed on the ground, a large concrete slab being carried by the truck fell on him, pinning his head and right arm. The victim's head was crushed and his right arm pulled from the socket. Had he remained in the cab of his tractor, the driver would more than likely have been uninjured.

The single fatality amounts to 1.1% of all truck tire failure accidents, with an average of 0.011 fatalities per accident. For the total of 8,663 accidents recorded on the Turnpike, 181 (or 2.1%) resulted in at least one fatality, with the total number of fatalities amounting to 240. This reduces to a rate of 0.028 fatalities per accident. Since only one fatality accident involving truck tire failures was recorded, however, the findings are not statistically significant.

The speed at which accidents involving truck tire failures occur seems to be confined within more narrow bounds than are the speeds for all truck accidents and for accidents involving all vehicles. As shown on Figure 2, truck accidents involving tire failure are concentrated primarily between 46 and 55 mph, with a lesser but still sizable amount falling between 41 and 45 mph. Truck accidents as a whole also fall most heavily between 46 and 55 mph, but the level of incidence is only about 58% of that for truck tire-failure accidents. A sizable concentration of truck accidents also occurs between 36 and 45 mph. The distribution of speeds for all accidents falls somewhat evenly between 36 and 70 mph, with the concentration a little higher on the upper end and a little lower on the lower end. These findings suggest that (1) accidents involving



% Truck Accidents by Speed - Ohio Turnpike, Jan. 1, 1966 - Jun. 30, 1970

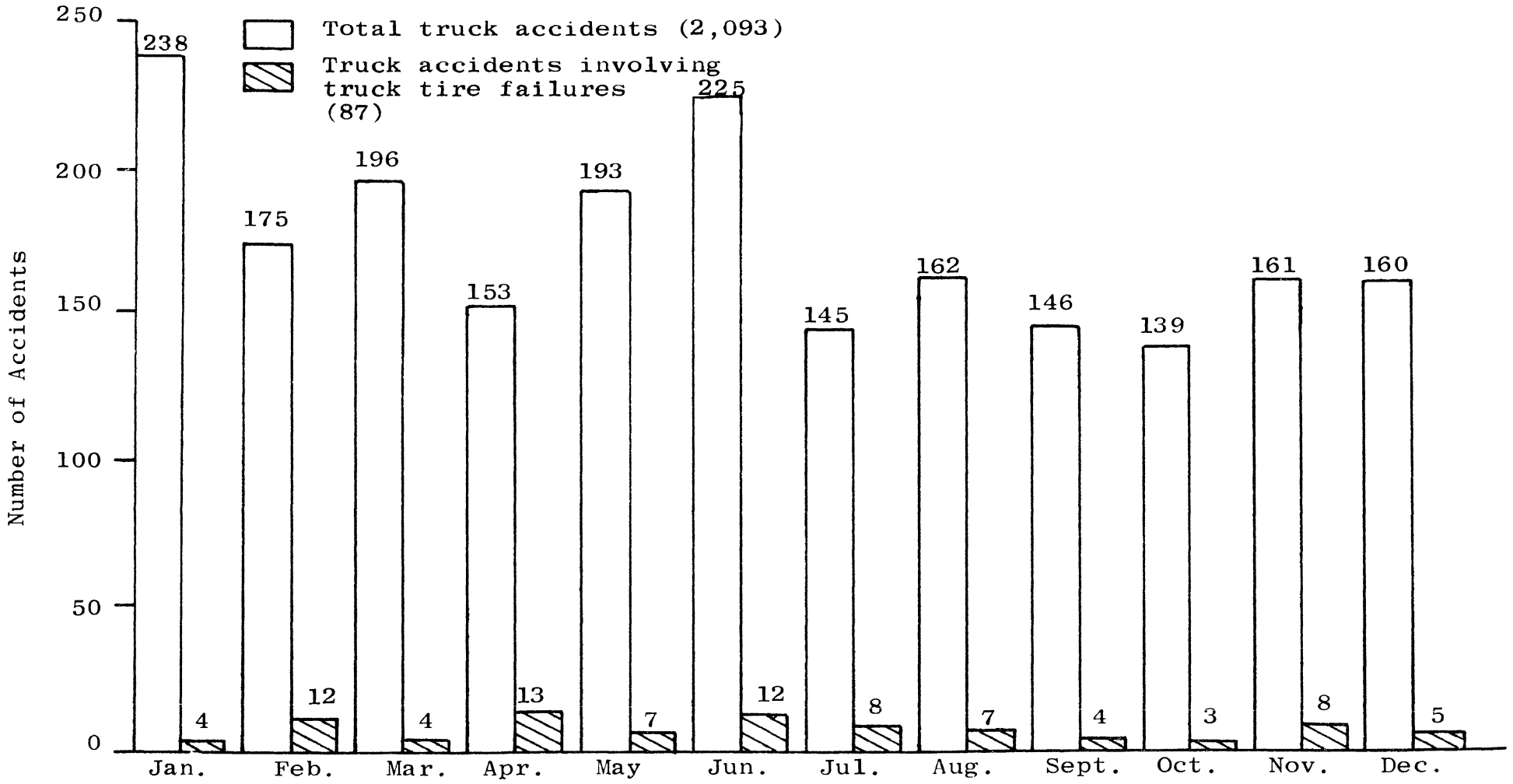
Figure 2

truck tire failures occur at the upper end of the truck speed distribution; (2) truck accidents, in general, occur within a more concentrated speed range than do all traffic accidents; (3) truck accidents of all types are relatively infrequent above 55 mph, while all accidents are most heavily represented between 55 and 70 mph. It should be kept in mind, however, that truck speeds as a group are generally lower.

The distribution of truck accidents by month is shown on Figure 3. Two peaks are indicated, in January and June. The percentages by month of truck accidents alone, and of truck accidents involving tire failure, are shown on Figure 4. It is apparent that some of the highest concentrations of tire failure accidents (the square data points) are in April, June, July, and August. These are some of the hottest months of the year. This finding tends to confirm other reports which identify high ambient temperature as a factor in tire failure. There are also peaks in February and November, however. Thus, for the small numbers of tire failure accidents in the sample, evidence of a temperature effect is not conclusive. (Note that the period for this data is Jan. 1, 1966 to Dec. 31, 1969. The data for the first half of 1970 were not included, since this would have biased the results--weighting the first six months heavier and the last six months lower. On the average, 8.33% of the accidents should occur each month, in the absence of external influences.)

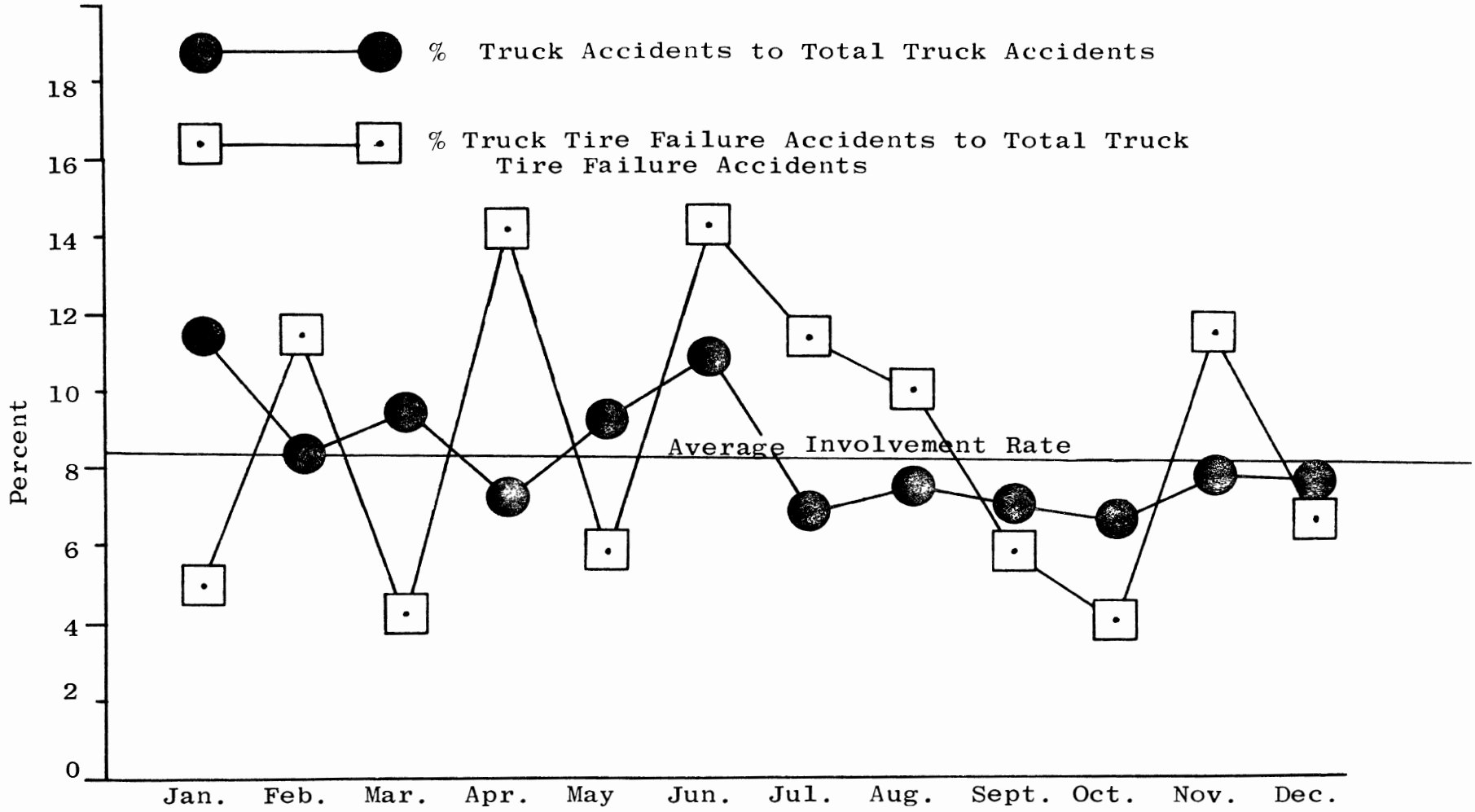
Truck accidents by day of week are presented in Figure 5. It is evident that the majority of accidents occur during mid-week. This undoubtedly corresponds to the density of truck traffic. Truck tire-failure accidents as a percentage of all accidents varies between 2.9% and 5.3%.

The variation of truck accidents by time of day is shown in Figures 6 and 7. The density of accidents is relatively even throughout the day, with perhaps a heavier representation between midnight and 9:00 a.m. This finding reflects the fact that truck traffic is relatively uniform throughout the day. Interestingly, however, truck tire-failure accidents peak between 3:00 a.m. and 6:00 a.m. and again between 3:00 p.m. and 12:00 p.m. These periods



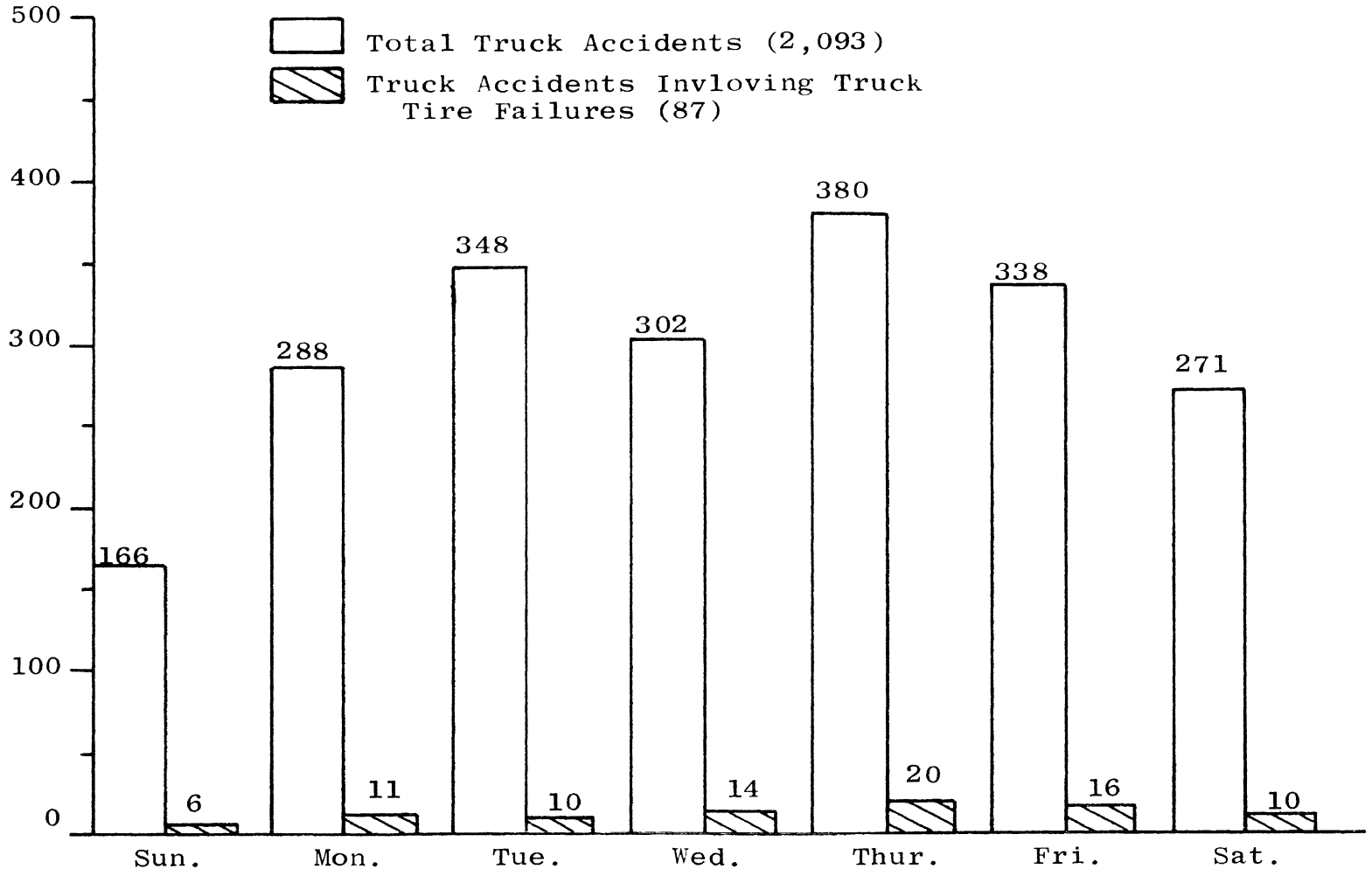
Truck Accidents by Month - Ohio Turnpike
Jan. 1, 1966 - Dec. 30, 1970

Figure 3



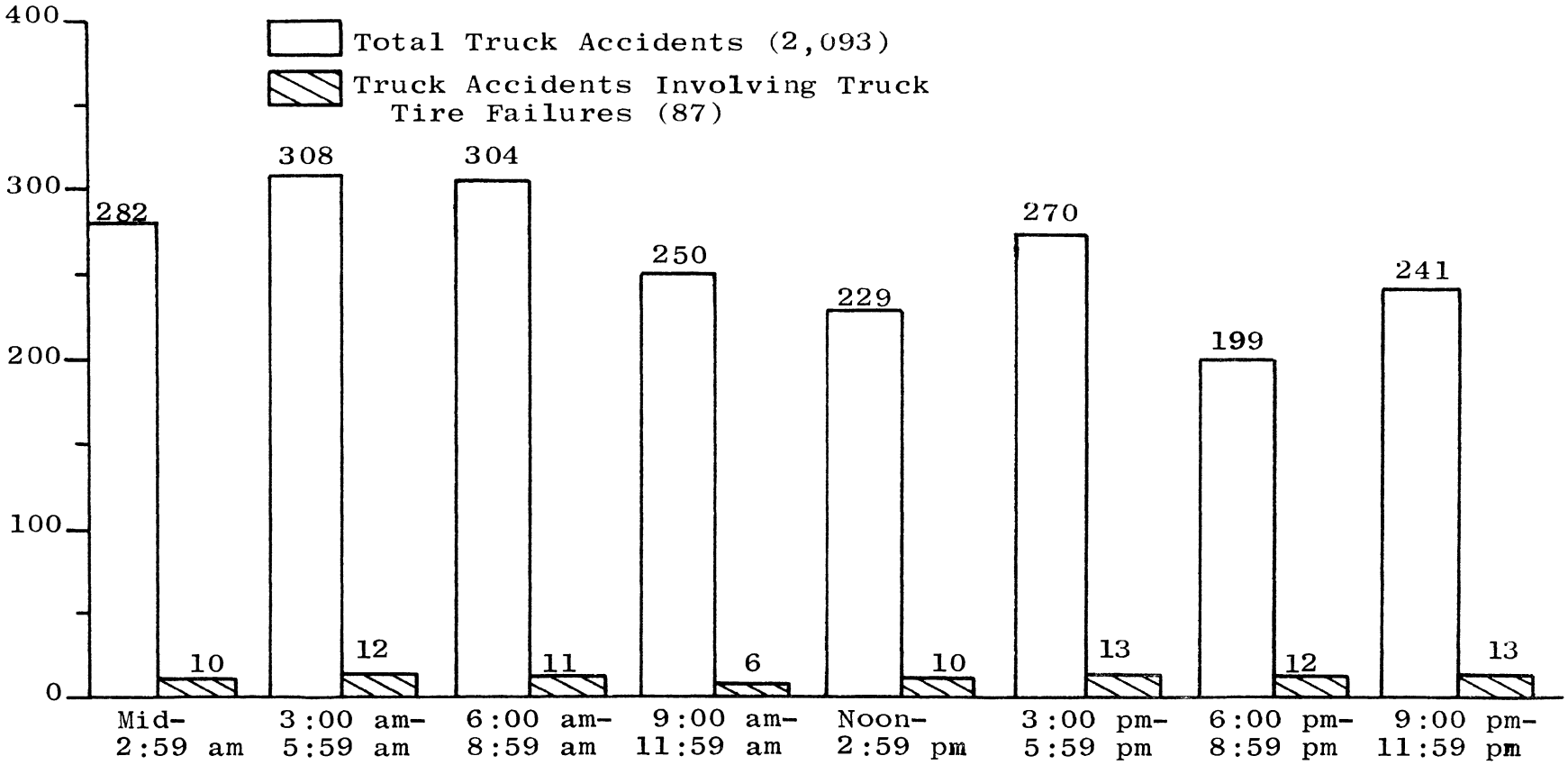
% Truck Accidents by Month - Ohio Turnpike,
Jan. 1, 1966 - Dec. 31, 1969

Figure 4



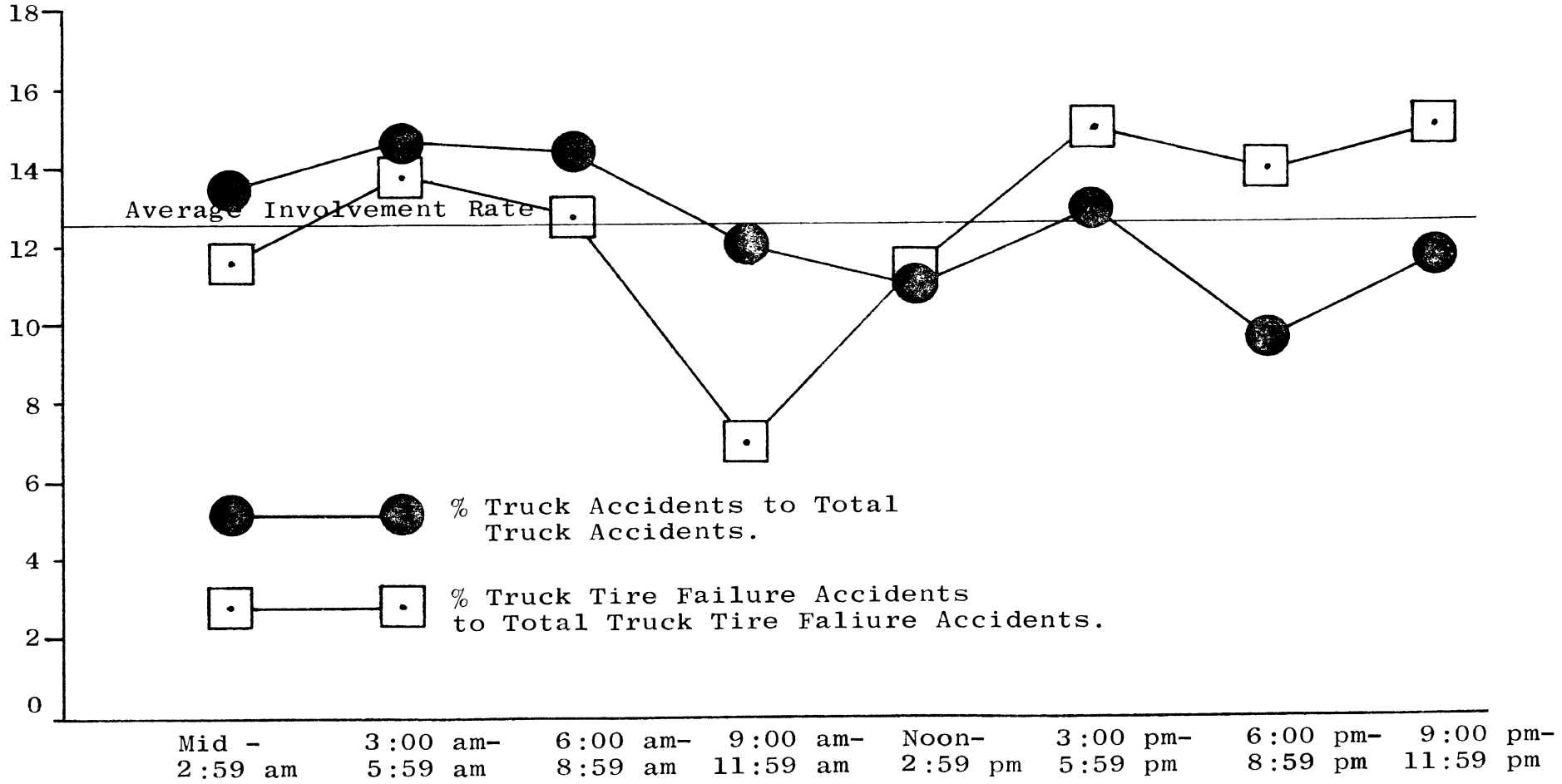
Truck Accidents by Day of Week - Ohio Turnpike,
Jan. 1, 1966 - Jun. 30, 1970

Figure 5



Truck Accidents by Time of Day - Ohio Turnpike
Jan, 1, 1966 - Jun. 30, 1970

Figure 6



% Truck Accidents by Time of Day - Ohio Turnpike, Jan. 1, 1966 - Jun. 30, 1970

Figure 7

do not correspond to the warmest periods of the day. In fact, the lowest accident rate occurs between 9:00 a.m. and 12:00 a.m., with the period between 12:00 a.m. and 3:00 p.m. also being slightly below average.

All truck accidents involving tire failures occurred on the main line of the Ohio Turnpike, as opposed to interchange areas, toll booths, service plazas, etc. All but one of the 87 truck tire-failure accidents were single-vehicle accidents involving a commercial vehicle only. One was a two-vehicle accident. Approximately 38% of the vehicles were eastbound and 62% were westbound.

About 77% of the truck accidents resulting from tire failure occurred during clear or cloudy weather. Eighteen percent occurred during rain and about 5% when it was snowing. Seventy-five percent of the time the pavement was dry; the pavement was wet during 22% of the accidents and snowy during 2%.

Forty-seven percent of the accidents occurred during daylight, 44% occurred during darkness. About 9% occurred during either dawn or dusk.

The truck population involved in tire-failure accidents consisted of 6% straight trucks, 90% tractor-semitrailer rigs, and 4% truck tractors with two trailers. Most of the vehicles involved in truck tire-failure accidents were registered in the northern midwest states: Ohio - 30%, Pennsylvania - 22%, Michigan - 12%, Indiana - 8%, Illinois - 8%, and Wisconsin - 2%. While only 4.2% of all truck accidents resulted from tire failures, 18% of the truck accidents of Illinois registry were of this type. Illinois is the only state with a significant number of accidents which appears to be over-represented in the proportion of truck tire-failure accidents to all truck accidents.

In conclusion, truck accidents resulting from tire-failures constituted between 0.63% and 1.0% of all accidents on the Ohio Turnpike. The severity of these accidents was about the same as other accidents on the Turnpike.

Of the 87 reported truck accidents resulting from tire failure, 37 (42%) were due to blowout of the right front tire, 18 (21%) were left-front blowouts, and 32 (37%) resulted from tire fires on trailer (31) and drive axles (1). The speed at which tire-failure accidents occurred was concentrated between 46 and 55 mph. In general, tire failure accidents occurred more frequently in the spring and summer months. It is not clear whether temperature is a controlling factor, however, since almost half the accidents occurred at night. Most accidents occurred during the middle days of the week, while during the day most accidents occurred between 3:00 a.m. and 6:00 a.m. and between 3:00 p.m. and 12:00 p.m. Almost 99% of these accidents were single-vehicle accidents.

Ninety percent of the accidents involved tractor semi-trailer rigs. Seventy-seven percent of the accidents occurred during clear or cloudy weather, and the pavement was dry 75% of the time. Vehicles of Illinois registry were three times more heavily involved in tire-failure accidents than would ordinarily be expected.

5.2 Indiana Turnpike Accident Data

Indiana Turnpike accident data were also analyzed by searching the computerized accident files and by individually examining each accident report involving a truck tire failure. Seventy-five such accidents were tentatively identified from interrogating the files; 60 of these were identified as truck accidents which probably resulted from tire failure. The following discussions cover these 60 cases.

The Indiana Turnpike accident file consists of a data bank covering 5,744 accidents which occurred between January 1, 1966 and December 31, 1970. Of these accidents, 1,422 (or 24.8%) involved trucks described as:

Truck
Tractor-Semitrailer
Tractor, full-trailer
Tractor & double bottom

Sixty of these truck accidents (11.7% of all truck accidents and 1.05% of all accidents) involved a tire failure on the truck.

During the period the data were collected, 5.04×10^8 vehicle miles were logged by trucks on the Indiana Turnpike. On the average, a truck accident occurred once every 897,000 vehicle miles, and a truck accident involving a tire failure occurred once every 8,400,000 vehicle miles. Comparatively the average accident rate for passenger cars is one accident per 616,000 miles. The average number of miles driven per accident involving a tire failure is 10,080,000 miles for all vehicles and 10,480,000 miles for passenger cars alone. If passenger-car accidents are given a weighting of 1.00, accidents involving trucks (as weighted by mileage exposure) are less likely to occur by a factor of 0.69. By comparison, truck accidents involving truck tire failures are more likely to occur than passenger-car accidents involving tire failure by a factor of 1.25. In proportion to mileage exposure, then, truck accidents are less likely to occur than passenger car accidents, but accidents involving truck tire failure are more likely to occur than passenger-car accidents resulting from tire failure.

A summary of truck accidents involving tire failure on the Indiana Turnpike is given on Table XV. Of the 60 cases, 25 resulted from blowouts of the right front tire, 16 were from blowouts of the left front tire, and 5 were from blowouts on the drive axles or on trailers of tractor-semitrailer rigs. Fourteen (23.4%) resulted from tire fires. All accidents were single-vehicle involvements except one. In this one case a tread from a blown tire became detached, and the tread struck a trailing passenger car. Essentially, then, virtually all tire-failure accidents involving trucks were non-collision accidents. If the tire-

Table XV

Summary of Truck Accidents Involving Tire Failure
Indiana Turnpike
Jan. 1, 1966 to Dec. 31, 1970

Year	Total Truck Accidents	Truck Accidents Involving Tire Failure		Fatalities	Injuries	Blow Outs			Tire Fire	Type Vehicle		Tractor Semi & Trailer
		Confirmed	Questionable			Right Front	Left Front	Other		Straight Truck	Tractor Semi	
1966	193	19	0	1	1	8	3	0	8	1	17	1
1967	192	5	0	0	1	1	2	0	2	0	5	0
1968	249	14	0	0	4	6	4	2[1]	2	4	10	0
1969	251	15	0	1	4	8	4	2[2]	1	1	14	0
1970	255	7	1	0	2	2	3	1[2]	1	1	5	1
Totals	1,140	60	1	2	12	25	16	5	14	7	52	2

1 These two blow-outs each occurred on the right rear of a straight truck.

2 These cases involved blow-outs on trailers of semi-rigs which led to loss of control.

fire accidents are deleted from the total, the number of accidents reduces to 46. Truck accidents involving tire failure then account for 0.80% of all accidents and 8.2% of all truck accidents. The percentage of all accidents compares favorably with the equivalent number for the Ohio Turnpike. However, the percentage of truck accidents is about three times as great.

The severity of accidents involving truck tire failure on the Indiana Turnpike is compared with that of trucks alone and with all vehicles on Table XVI. The chance of not being injured in a truck accident involving tire failure is slightly better than for the other kinds of accidents listed. The chance of exactly one injury is greater, however, but it should be noted that no accidents involving more than one injury were recorded. This finding is probably the result of the fact that truck accidents involving tire failure are almost always single vehicle accidents, with the truck driver typically the only occupant of the vehicle.

Two fatalities were listed as having resulted from truck accidents involving tire failure. A description of only the 1969 accident is available. In this accident, a tractor-semitrailer was headed eastbound, hauling a load of steel bars, near milepost 96, in Elkhart County, Indiana. The fifth wheel on the tractor was moved forward about 30 inches, ostensibly for the purpose of distributing more of the hitch load to the front wheels of the tractor. The right front tire of the tractor blew out and caused the driver to lose control, with the result that the vehicle was pulled into the right-hand ditch. As the vehicle proceeded in the ditch, it struck an embankment. The chains holding the steel bars then gave way and the bars slid forward, crushing the tractor. The driver was thrown to the floor of the car, suffering a crushed pelvis, compound fractures of the left leg, lacerations to the abdomen and right leg, and possible back and internal injuries. He subsequently expired in a Chicago hospital.

The front tires of the tractor were worn about 60%; the rear-drive-axle tires about 30%. The chains holding the load

Table XVI

Severity of Accidents Involving Truck Tire Failures
Indiana Turnpike

No. of Injuries	0	1	2	3	4	5	6	>6
% of All Truck Accidents Involving Tire Failure	80.0	20.0	0	0	0	0	0	0
% of All Truck Accidents	78.3	14.6	4.6	1.1	0.8	0.3	0.2	0.1
% of All Accidents	78.8	12.5	5.3	1.5	1.0	0.5	0.2	0.2

were noted to have been mended several times with repair links. Tires in better condition, stronger load chains, and less load, all or singly would probably have prevented this fatality.

Two fatalities were recorded as resulting from truck tire-failure accidents on the Indiana Turnpike. These reduce to a fatality rate of 0.033 fatalities per accident. For the total of 5,744 accidents recorded on the Turnpike, 69, or 1.20%, resulted in at least one fatality. The total number of fatalities was 103. This reduces to a rate of 0.0179 fatalities per accident. Thus, on the Indiana Turnpike, the likelihood of at least one person being killed in a truck accident resulting from tire failure is almost three times as great as the likelihood for all accidents, while the average number of fatalities per accident is about twice as much. These findings are not statistically significant, however, due to the small number of fatalities in truck tire-failure accidents.

The truck population involved in tire-failure accidents consisted of 11% straight trucks, 86% tractor-semitrailer rigs, and 3% tractors with two trailers.

Truck accidents resulting from tire failures constituted between 0.80 and 1.05% of all accidents on the Indiana Turnpike. The severity of these accidents was slightly less than for other accidents. Further, such accidents almost never involved more than one injured party. Of the 60 reported truck accidents resulting from tire failure, 25 (42%) were due to a blowout of the right front tire, 16 (27%) were left-front blowouts, and 5 (8%) resulted from blowouts on the drive or trailer axles. Fourteen (23%) of the tire failures were the result of a tire fire on a trailer. Virtually all accidents involved only a single vehicle.

5.3 Pennsylvania Turnpike Accident Data

The Pennsylvania Turnpike accident data were analyzed in less detail than were the Ohio and Indiana Turnpike data. Only

the computerized data were interrogated; individual accident reports were not examined. Thus the relative numbers and percentages of truck accidents involving tire failures are somewhat higher than they would have been after the winnowing process of examining each accident report for relevance.

The Pennsylvania Turnpike accident file consists of 11,492 accident cases which occurred between January 1, 1967, and June 30, 1969. Of those accidents, 1,914 (or 16.7%) involved trucks described as follows:

Tractor trailer
Single body truck
Truck pulling trailer
Highway Department truck
Truck

Ninety of these truck accidents (7.0% of all truck accidents and 0.73% of all accidents) involved tire condition as an accident-causation factor.

During the period the data were collected, 10.93×10^8 vehicle miles were logged by trucks on the Pennsylvania Turnpike. On the average, a truck accident occurred once every 571,000 vehicle miles, and a truck accident involving tire failure occurred once every 13,020,000 vehicle miles. By comparison, the average accident rate for passenger cars was one accident in every 574,000 vehicle miles. The rate for all vehicles involved in tire-failure accidents is one accident every 12,380,000 vehicle miles. If passenger-car accidents are given a weight of 1.00, accidents involving trucks (as weighted by mileage exposure) would be weighted by a factor of 1.005 as more likely to occur. On the other hand, truck accidents resulting from tire failure are less likely to occur by a factor of 0.95. The accident rates for trucks and automobiles, then, are virtually identical in both categories.

A summary of truck accidents involving tire failure on the Pennsylvania Turnpike is given on Table XVII. Twenty-one percent of the vehicles involved were straight trucks, 75% were tractor-semitrailers, and 4% were of the other types listed earlier. The vast majority of accidents, 94%,were again single-vehicle involvements. No accidents involving more than two vehicles were recorded.

The severity of truck accidents involving tire failure on the Pennsylvania Turnpike is compared with that of trucks alone and with all other vehicles on Table XVIII. The comparison is generally similar to like comparisons for the Ohio and Indiana Turnpikes, in that the likelihood of not being injured in a truck accident involving tire failure is higher than for other accidents.

The single fatality resulting from a truck tire failure accident amounts to 1.2% of all such accidents on the Pennsylvania Turnpike. This corresponds to a fatality rate of 0.012 fatalities per accident. A total of 232 fatalities were recorded in 184 fatal accidents of all types on the Turnpike during this period. In terms of the total of 11,492 accidents, 1.60% of the accidents resulted in at least one fatality, while the overall fatality rate was 0.020 fatalities per accident. On the Pennsylvania Turnpike, then the likelihood of at least one person being killed in a truck accident involving tire failure is about 3/4 as great as the likelihood for all accidents, while the fatality rate per accident is about half as great. Again, however, these findings are not statistically significant due to the small number of fatalities in truck tire-failure accidents.

Summarizing, truck accidents resulting from tire failures account for about 0.73% of all accidents on the Pennsylvania Turnpike. As with the Ohio and Indiana Turnpikes, the severity of these accidents is slightly less than accidents as a whole. Ninety-four percent of the accidents were single-vehicle involvements. Past experience in reviewing specific accident reports would suggest that many two-vehicle involvements recorded as

Table XVII

Summary of Truck Accidents Involving Tire Failure
Pennsylvania Turnpike

Year	Total Accidents of All Types	Total Truck Accidents	Truck Accidents Involving Tire Failure	Fatalities	Injuries	Type Vehicle			Number of Vehicles		
						Straight Truck	Tractor Semi	Other	1	2	3
1967	4,461	692	27	1	8	10	15	2	25	2	0
1968	4,992	826	36	0	16	4	31	1	34	1	1
1969[1]	2,039	396	27	0	11	5	22	0	25	2	0
Totals	11,492	1,914	90	1	35	19	68	3	84	5	1

1 First 6 months of year, only.

Table XVIII

Severity of Accidents Involving Truck Tire Failure

Pennsylvania Turnpike

No. of Injuries	0	1	2	3	4	5	6	>6
% of All Truck Accidents Involving Tire Failure	74.4	17.8	5.6	0	1.1	1.1	0	0
% of All Truck Accidents	68.1	21.1	6.7	2.4	0.8	0.5	0.1	0.3
% of All Accidents	65.0	20.5	8.2	3.1	1.6	0.7	0.3	0.6

resulting from truck tire failure are often coded incorrectly--incorrectly, that is, in terms of the needs of this study (e.g., a truck parked at the side of the road for purposes of repairing a tire and then being struck by a second vehicle would be coded as a two-vehicle accident involving truck tire failure). Thus, it is likely that the percentage of single-vehicle involvements is even greater.

5.4 Texas Accident Data

Accident data for the State of Texas are stored at HSRI in several sets of accident files. These include Bexar County (San Antonio), a 5% sample of accidents from the entire State, fatal accidents, and truck accidents. The data cover the years 1969 through 1972. These discussions will be centered on the truck accident files. As with the Pennsylvania Turnpike data, only the accident data files were interrogated; individual accident reports were not examined. Therefore, the numbers of truck accidents resulting from tire failure are probably inflated somewhat, as are the number of accidents involving more than one vehicle.

A summary of truck accident statistics involving tire failure for the State of Texas is given in Table XIX. About 2.6% of all accidents in Texas during 1969-72 involved trucks. Of all truck accidents, 0.86% were reported as having been caused by tire failure. These represent 0.023% of all accidents. Sixty percent of the vehicles involved were straight trucks, 36% were tractor-semi-trailer rigs, and 4% were other types. Just over 90% of the accidents were single-vehicle involvements. No accidents involving more than two vehicles were recorded.

The severity of truck accidents involving tire failure is compared with trucks alone and with all other vehicles on Table XX. Unlike the turnpike data, truck tire-failure accidents were a bit more severe than other accidents in Texas. The chance of no injuries in a truck tire-failure accident is less than for the other kinds of accidents compared, and the chance of at least one injury is greater.

Table XIX

Summary of Truck Accidents Involving Tire Failure
State of Texas

Year	Total accidents of All Types[1]	Total Truck Accidents	Truck Accidents Involving Tire Failure								
			Total	Fatalities	Injuries	Type Vehicle			Number of Vehicles		
						Straight Truck	Tractor Semi	Other	1	2	>2
1969	377,000	11,590	95	0	34	51	41	3	88	7	0
1970	388,000	10,680	86	5	43	45	36	5	78	8	0
1971	382,000	8,172	71	3	22	53	16	2	65	6	0
1972	420,000	10,835	102	4	44	63	34	5	88	14	0
Totals	**1,567,000**	**41,277**	**354**	**12**	**144**	**212**	**127**	**15**	**319**	**35**	**0**

1 Estimate based on 5% sample.

Table XX

Severity of Accidents Involving Tire Failure
State of Texas

No. of Injuries	0	1	2	3	4	5	6	>6
% of All Truck Accidents Involving Tire Failure	68.1	27.7	2.5	1.1	--	--	--	--
% of All Truck Accidents	82.6	13.1	3.3	0.7	0.2	0.1	--	--
% of All Accidents[1]	79.9	14.0	4.2	1.1	0.5	0.2	0.1	--

1 5% sample of All Texas Accidents

The 12 fatalities resulting from truck accidents involving tire failure occurred in 11 accidents - 3.0% of all such accidents. This results in a fatality rate of 0.034 fatalities per accident. A total of 764 fatalities were recorded in 634 fatal accidents in the 5% sample of all accidents in the State of Texas for this period. In terms of the total of 78,317 accidents in the 5% sample, 0.81% of the accidents resulted in at least one fatality. The overall fatality rate in the sample is 0.0097 fatalities per accident. In the State of Texas, then, the chance of at least one person being killed in a truck accident involving tire failure is about three times as great as for all accidents.

In summary, truck accidents involving tire failure as a causation factor account for about 0.023% of all accidents in Texas. The severity of these accidents is somewhat greater than the typical accident. About 90% of these accidents involved just a single vehicle, while no accidents were recorded which involved more than two vehicles. The makeup of the vehicle population in the Texas data is somewhat different than that found in similar turnpike data files. While the proportion of straight trucks varied between 6 and 21% in the data for the three turnpikes, the same percentage for the Texas data was about 60%. This difference, coupled with the fact that the general character of the road system in Texas is substantially different than that of the turnpikes, probably accounts for the differences in results.

6.0 CONCLUSIONS

A summary of the various sources of accident data is shown on p.5, Table I. Although the data represent several kinds of traffic environments, tire maintenance practices, etc., comparative measures are remarkably similar in many respects. The primary conclusions are listed as follows:

1. In general, a truck accident resulting from tire failure is a single-vehicle accident (85% to 99% of the time) which involves neither injury (60% to 80% of the time) nor death (96% to 99% of the time).
2. Truck accidents involving tire failures on the Ohio, Indiana, and Pennsylvania Turnpikes represent about 4 to 5% of all truck accidents and about 0.75% to 1.1% of all accidents.
3. Truck accidents involving tire failure represent about 0.8% of all accidents reported to the Bureau of Motor Carrier Safety and about 0.02% of all accidents reported in the State of Texas.
4. Accident data from a specific commercial carrier indicates that a tire failure accident occurs about once in every 10 million to 17 million vehicle miles.
5. Other data from a second commercial carrier indicates that a tire failure occurs about once every 7,600 vehicle miles.
6. The combined rates of 4. and 5. suggest that about one tire failure in 1,300 to 2,200 results in an accident.
7. The injury rate in truck accidents involving tire failure is lower than that for other truck accidents and for accidents as a whole on each of the turnpikes. The rate in the State of Texas is higher.

8. The fatality rate for truck accidents involving tire failure is greater than that for accidents as a whole in the State of Texas and on the Indiana Turnpike, but less than that for accidents as a whole on the Ohio and Pennsylvania Turnpikes.
9. Between 7% and 13% of all tractor and trailer units inspected in the BMCS "Safety Road Check Program" were found to have had at least one defective tire. Defective tires were found on 4% to 9% of the tractor units and on 11% to 18% of the trailer units.
10. In a two-day check of tire operating practices, the BMCS found that about 4% of the inspected tractor-semitrailer units had front axles which were potentially overloaded. Detailed checks further suggested that as much as 60% of the front tires were underinflated.
11. Truck accidents involving front tire failure (most often the right front tire) are usually caused by loss of control; accidents resulting from trailer tire failures almost always involve a tire fire.

7.0 RECOMMENDATIONS

Should there be interest in pursuing this topic further, there are several additional studies which are recommended which would yield additional and more specific conclusions. The first of these would involve a program similar to the one carried out by Baker and McIlraith [19-22] for automobile tires.

1. Each truck accident purportedly resulting from tire failure should be carefully investigated to determine whether the tire failed before or as a result of the accident.
2. A more detailed review of tire use practices, involving inspections at weighing stations, truck stops, etc. should be undertaken to define statistics for overloading, under-inflation, tread wear, use of recaps, etc.
3. A more detailed review of truck tire failure rates (not necessarily followed by an accident) is needed so that a more accurate view of truck tire failures can be established.

Such studies would lead to a broader and more objective understanding of the various factors surrounding truck tire failures. Second, with regard to existing and proposed regulations:

4. Proposed regulations and maintenance practices should be critically assessed to develop a clear definition of their benefits and associated costs. As a basis for doing this, existing regulations and maintenance practices should be similarly examined.

The studies referred to in the above four recommendations would lead to a more definitive picture of the status of safety in truck tire use.

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