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PRELIMINARY FINDINGS ON THE SAFETY IMPACT OF FMVSS 121

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16. Abstract

This report presents preliminary findings on the national accident experience of heavy trucks equipped with air brakes manufactured in compliance with Federal Motor Vehicle Safety Standard 121. These findings are based on an analysis of national accident data files for 1976 and 1977, containing information on late model air-braked trucks involved in over 3000 fatal accidents and over 9000 injury accidents. National projections of vehicle mileage for the pre- and post-standard trucks are based on odometer readings for over 3000 vehicles. Using these data, accident rates are computed as the number of accidents per hundred million vehicle miles.

It is unlikely that the safety of heavy trucks equipped with 121 brakes has improved. The national statistics assembled show that the frequency of accidents has increased for the newer trucks. In particular, the rate for combination units completely equipped with 121 brakes is 70-90% higher than the rate for combination units completely equipped with pre-standard braking systems.

It is not yet known whether these differences are statistically significant. At a minimum, however, the elevated accident rates must raise doubts as to the safety of vehicles equipped with the FMVSS 121 braking systems.

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METRIC CONVERSION FACTORS

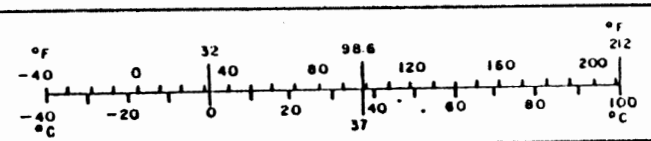
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. METHOD

The University of Michigan Highway Safety Research Institute has been conducting a study of the safety impact of Federal Motor Vehicle Safety Standard No. 121, Air Brake Systems for the past three years under the sponsorship of NHTSA (Contract No. DOT-HS-6-01286, "Fleet Accident Evaluation of FMVSS 121"). This standard was developed by NHTSA with the expectation that substantial reductions in truck-involved accidents, injuries, and fatalities would result. The primary objective of this study is to assemble national statistics on the exposure (mileage) and accident experience of air-braked trucks so that overall accident rates (accidents per hundred million vehicle miles) can be computed for trucks manufactured before and after FMVSS 121 became effective.

An overview of the study design is shown in Figure 1. The basic study period is calendar years 1976 and 1977. Three major data sources were utilized. Information on brake system maintenance, mileage, and accidents was obtained from the owners of a random sample of trucks manufactured in 1974 and 1975 in our "fleet monitoring program." The data collected in this program allow national exposure (mileage) estimates to be computed. These estimates are central to the study since they allow accident rates to be computed using national accident data files. Two such files are the other major data sources used.

The first of these is the NHTSA Fatal Accident Reporting System (FARS). This file contains a census of all accidents which result in a fatality (as reported by state police). Notification on all fatal accidents involving a late model (1974 or newer) heavy truck was obtained through this system at the state level. HSRI conducted additional interviews to collect supplementary data on these accidents for our analysis.

Reports filed with the Bureau of Motor Carrier Safety (BMCS) were the other major source of accident data. All carriers involved in the interstate transportation of goods are required by law to file a report with BMCS on any accident resulting in an injury or $2000 of property damage. Only injury accidents reported by Authorized Carriers were used in our analysis since their reporting is believed to be more consistent.

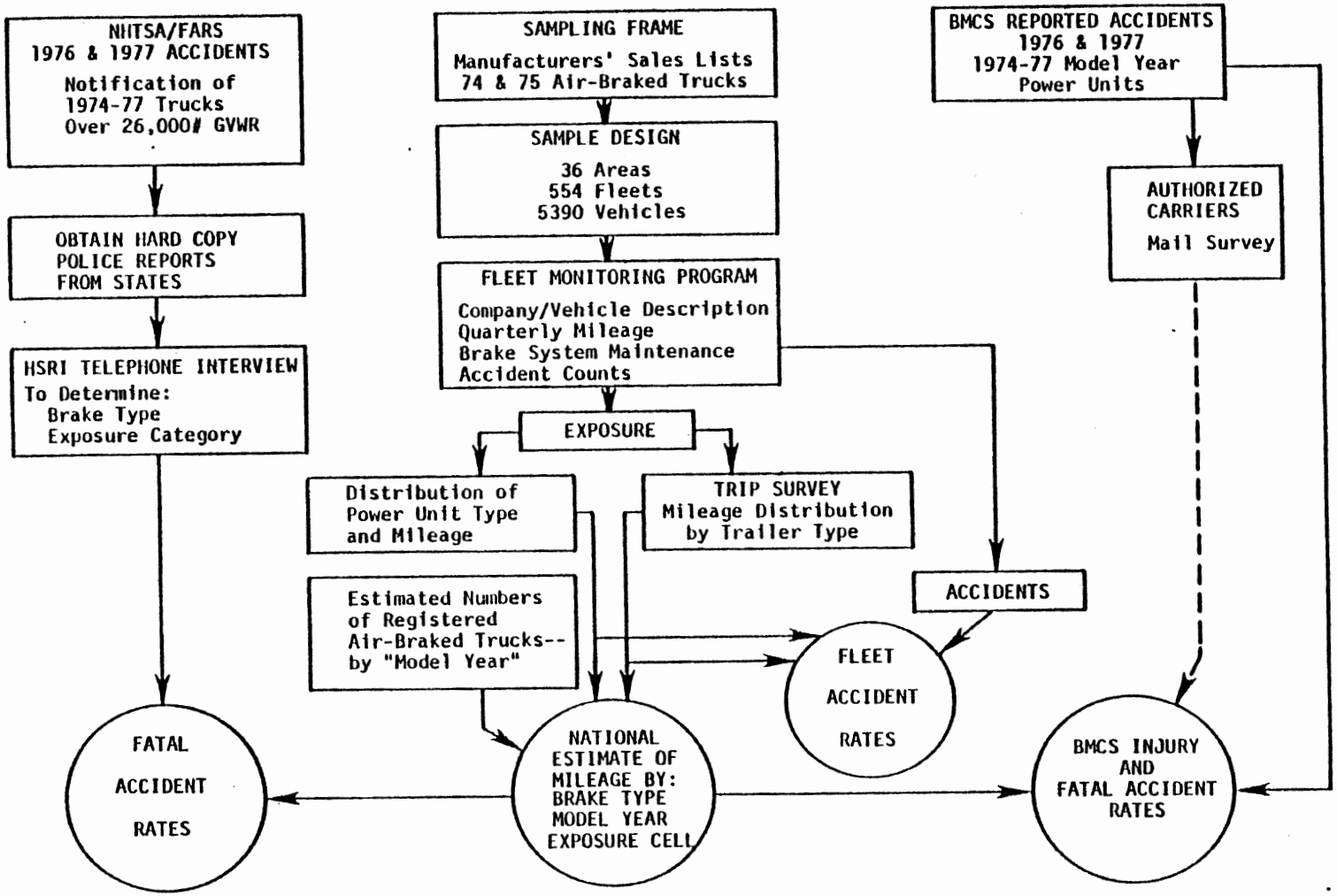

FIGURE 1. STUDY DESIGN

These carriers operate predominantly combination vehicles on intercity routes and constitute the vast majority of the "for hire" trucking industry.

Last year, preliminary findings were reported from the fleet monitoring program indicating a 19% reduction in the overall accident rate for 121-equipped vehicles. We emphasized that this result was not statistically significant. It was based on fleet-reported accidents collected during the first year of the two-year fleet monitoring program. Completion of this survey and subsequent reexamination of these data firmly establish bias and omissions in the reporting of accidents to HSRI. While the computation of accident rates for these vehicles is no longer tenable, we believe the exposure information collected provides a sound basis for national projections.

The results described in this report are based on a preliminary analysis of the accident data contained in the FARS and BMCS data files for the years 1976 and 1977. These files contain information on over 3000 fatal accidents involving 1974 or newer air-braked trucks and over 9000 injury accidents reported by Authorized Carriers involving 1974 or newer air-braked trucks. Rates for fatal and injury accidents are computed using national exposure projections based on the usage data obtained for the 3500 vehicles participating in the fleet monitoring program.

These results are described in the next three sections, which present the exposure data, the fatal accident rates, and the injury accident rates, respectively. A discussion of these results is presented in the final section.

2. EXPOSURE

The purpose of the exposure data is to allow the accident experience of the pre- and post-standard vehicles to be compared on a per mile basis for similar types of vehicles in similar types of use. The basic measure of exposure, then, is vehicle miles. Furthermore, the mileage data are categorized by vehicle type (straight truck and tractor) and trip distance (local and intercity).

The exposure data were collected as part of the fleet monitoring

program. A total of 554 owners of 5390 vehicles were selected for this program from manufacturers' sales lists for 1974 and 1975. Approximately equal numbers of pre- and post-standard vehicles were selected using statistical sampling techniques[1]. Field data collection personnel visited the fleets periodically during 1976 and 1977 to obtain odometer readings, brake system maintenance records, and accident reports. Information was actually obtained on about 3500 vehicles, 67% of those selected. Accident reporting to HSRI in the fleet monitoring program has subsequently been found to be deficient. However, the odometer readings were not regarded as "sensitive" information by the fleets, and were much easier to obtain. Subsequent review of the mileage data indicates that it is consistent and reasonable. Anomalous data (such as odometer changes) are easily found and corrected.

Mileage data obtained for the study vehicles are shown in Tables 1, 2, and 3. Table 1 shows the actual number of vehicles participating in the fleet monitoring program by vehicle type and typical trip distance. While buses were included in the original sample, they were deleted when FMVSS 121 was amended, and are not discussed in this report. The information presented here is based on six to eight odometer readings taken at intervals during 1976 and 1977 on each of 2838 vehicles.

Also shown in Table 1 are the percentages of pre- and post-standard vehicles in each of the four categories defined by vehicle type and trip distance. The percentages shown have been weighted according to the selection probabilities, and therefore are "population estimates." That is, they represent estimates of the percentages in the manufacturers' sales lists from which the samples were drawn.

Of particular importance are the percentages of tractors and straight trucks. Nearly 67% of the pre-standard vehicles are tractors, while only 43% of the post-standard vehicles are tractors[2]. Clearly

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[1]Sales lists were obtained for trucks (power units only). No trailing units were monitored.

[2]These differences reflect changes in the sales of air-braked trucks during the years 1974 and 1975. Large fleets may have over-bought pre-standard vehicles to avoid purchasing the more expensive 121-equipped trucks. And as large fleets tend to buy tractors for

these two populations of vehicles are different in ways that must be taken into account when comparisons are made.

TABLE 1

DISTRIBUTION OF VEHICLES BY VEHICLE TYPE, BRAKE TYPE, AND TRIP DISTANCE

Vehicle Type and Brake Type	Trip Distance: Local *No. Veh.	Local **Weight. Percent	Intercity *No. Veh.	Intercity **Weight. Percent	Total *No. Veh.	Total **Weight. Percent
Straight Truck						
Pre-121+	239	21.2%	148	12.1%	387	33.3%
Post-121++	345	34.7%	336	22.9%	681	57.6%
Tractor						
Pre-121+	225	15.6%	874	51.2%	1099	66.8%
Post-121++	153	10.2%	518	32.2%	671	42.4%
Total						
Pre-121+	464	36.8%	1022	63.3%	1486	100.0%
Post-121++	498	44.9%	854	55.1%	1352	100.0%

* Number of vehicles in the survey.
** Estimated percentage of vehicles in the pre- and post-121 populations.
\+ Pre-121 vehicles selected from manufacturers' sales records for the period January 1974 through February 1975.
++ Post-121 vehicles selected from manufacturers' sales records for the period March 1975 through February 1976.

intercity use (rather than straight trucks), these differences would be explained. Further, the trucking industry experienced an economic slump in late 1975, which may have affected purchasing by "for hire" fleets more than the private fleets.

Average daily mileages are shown by vehicle type and trip distance in Table 2. Within any category of vehicle type and trip distance, the average daily mileage is comparable for pre- and post-standard vehicles. In other words, although the composition of the two groups of vehicles is different, the exposure of comparable vehicles is similar.

TABLE 2

DAILY MILEAGES
BY VEHICLE TYPE, BRAKE TYPE,
AND TRIP DISTANCE

Vehicle Type and Brake Type	Trip Distance			
	Local		Intercity	
	Daily Mileage	95% Confid. Interval	Daily Mileage	95% Confid. Interval
Straight Truck				
Pre-121+	42.3	(±12.7)	113.0	(±48.6)
Post-121++	47.0	(±15.7)	88.2	(±35.7)
Tractor				
Pre-121+	111.6	(±47.9)	239.8	(±45.6)
Post-121++	85.3	(±37.1)	248.2	(±52.6)

\+ Pre-121 vehicles selected from manufacturers' sales records for the period January 1974 through February 1975.
++ Post-121 vehicles selected from manufacturers' sales records for the period March 1975 through February 1976.

The percentage distribution of total mileage is shown in Table 3 by vehicle type and trip distance. Again the difference in the composition of the two groups shows up, with tractors accounting for 86% of the mileage of pre-standard vehicles, but only 70% of the mileage of post-standard vehicles. These differences, however, are not quite statistically significant at the 95% confidence level.

TABLE 3

MILEAGE DISTRIBUTION BY VEHICLE TYPE,
BRAKE TYPE, AND TRIP DISTANCE

Vehicle Type and Brake Type	Trip Distance				Total	
	Local		Intercity			
	%	95% Confid. Interval	%	95% Confid. Interval	%	95% Confid. Interval
Straight Truck						
Pre-121+	5.4	(±3.2)	8.3		13.7	
Post-121++	13.3	(±7.4)	16.5		29.8	
Tractor						
Pre-121+	10.4		75.8	(±9.1)	86.2	
Post-121++	5.7		64.5	(±13.4)	70.2	
Total						
Pre-121	15.8		84.1		100	
Post-121++	19.0		81.0		100	

\+ Pre-121 vehicles selected from manufacturers' sales records for the period January 1974 through February 1975.
++ Post-121 vehicles selected from manufacturers' sales records for the period March 1975 through February 1976.

These tables describe the exposure during 1976 and 1977 of the pre- and post-standard power units manufactured in 1974 and 1975. However, in analyzing the accident experience of the tractors, one would also like to know whether the trailers pulled had pre- or post-standard brakes. When an accident occurs, collecting information on the brake type of both tractor and trailer does not pose any serious conceptual problems. But since any particular tractor will normally pull many different trailers, determining the exposure for the four combinations of pre- and post-standard brakes possible on tractor-trailer units is

more difficult.

For this study, a separate survey was conducted to supply this information. Approximately 800 of the study vehicles were randomly selected for this survey. For each vehicle, four dates uniformly spaced over a six-month period were randomly assigned to each vehicle for a total of approximately 3200 surveys. On each survey date the owner was queried as to whether the vehicle was in service, whether it pulled a trailer, what kind of brakes the trailer had, and how many miles were traveled.

Approximately 74% of the surveys were completed. The results of this survey are shown in Table 4. In this table the percentage of tractor mileage accumulated while pulling no trailer, a pre-standard trailer, and a post-standard trailer are shown separately for pre- and post-standard tractors. Pre-standard tractors were found to put on about 15% of their mileage while pulling post-standard trailers, while post-standard tractors put on about 21% of their mileage while pulling post-standard trailers. Again, this difference is not statistically significant. Our finding that tractors are coupled to trailers without any attempt to match the braking systems is consistent with the stated practice of the industry.

This survey was conducted during the last six months of 1977. Since the proportion of 121 trailers in the total population is steadily increasing with time, the proportions of mileage measured should represent a maximum for the two year period, 1976 and 1977.

Ordinarily, going from the data presented to national exposure estimates would be straightforward. However, one additional problem is presented in making this estimate for trucks. Vehicles for the fleet monitoring program were selected from the 1974 and 1975 production years. In the FARS and BMCS accident data, trucks are identified by model year. In most states, the "model year" for trucks is assigned as the calendar year in which the vehicle is first registered. New U.S. truck registration data by weight class is published monthly by R. L. Polk. We estimate the number of air-braked vehicles to be 15% of

TABLE 4

MILEAGE DISTRIBUTION BY BRAKE TYPE
OF TRACTOR AND TRAILER
FOR INTERCITY TRACTORS ONLY

Trailer Brake Type	Power Unit Brake Type: Pre-Standard+ %	Pre-Standard+ 95% Confid. Interval	Post-Standard++ %	Post-Standard++ 95% Confid. Interval
None	0.7	(±0.9)	1.6	(±3.2)
Pre-121	84.6	(±12.6)	76.9	(±14.1)
Post-121	14.7	(±12.5)	21.5	(±14.0)
Total	100.0		100.0	

\+ Pre-121 vehicles selected from manufacturers' sales records for the period January 1974 to April 1975.
++ Post-121 vehicles selected from manufacturers' sales records for the period March 1975 to February 1976.

Class 6 plus 85% of Class 7 plus all of Class 8[3]. This allows an estimate of the number of pre- and post-standard vehicles for all years except 1975. The effective date for the 121 standard was a production date of March 1, 1975 or later. In order to complete the estimation, it is necessary to determine the amount of time between production and registration for these vehicles. In most years, this lag is about three months. However, production inventories were larger than usual in both 1974 and 1975, and a six-month lag has been assumed here. This assumption is reinforced by the fleet data. Looking at model year as reported by the owner implies a minimum of 35,000 121-equipped vehicles registered as 1975 model year. Estimated numbers of registered vehicles

[3]These are categories based on the Gross Vehicle Weight Rating. Class 6 comprises trucks from 19-26 thousand pounds. Class 7 is 26-33 thousand pounds. Class 8 includes all vehicles with a GVWR of over 33 thousand pounds.

by model year are shown below.

Model Year	Number of Registered Air-Braked Vehicles
1974	185,000
1975 Pre-Standard	87,000
1975 Post-Standard	41,000
1976	130,000
1977	177,000

Exposure information was collected for vehicles produced in 1974 and 1975. Computation of accident rates in this report has been extended to 1976 and 1977 model year vehicles since the accident data was readily available. In order to carry out exposure calculations for these vehicles, one has to assume the proportion of tractors and straight trucks for these model years. We have assumed this proportion to be the average of the pre- and post-standard vehicles produced in 1974 and 1975. The implicit assumption is that whatever transient factors resulted in the observed differences in purchase patterns had stabilized by 1976.

The 1977 model year has been omitted whenever model years are combined into two groups: pre-standard and post-standard. Since most manufacturers put the "Notice 7[4]" modifications in at the beginning of the 1977 model year, combined results for the post-standard vehicles are limited to pre-Notice 7 vehicles. One reason for omitting the 1977 vehicles in the combined results is that a recent contract modification includes the collection of exposure data on the 1977 vehicles. This survey is currently in progress. When it is completed at the end of this year, direct information on the exposure of these vehicles will be available. No exposure data collection is planned for the 1976

[4]Notice 7 was a major modification of the standard. It increased minimum stopping distances in order to eliminate the necessity for high-torque brakes and anti-lock devices on the front axle of trucks.

vehicles.

One final area of the exposure computations which requires special treatment is the use of the 1976 model year vehicles during calendar year 1976 and the 1977 model year vehicles during calendar year 1977. The fact that these vehicles were put into service throughout the calendar year must be taken into account in estimating their total exposure. This aspect was incorporated by using monthly registration data published by R.L. Polk. Vehicles registered in January were assumed to have 11.5/12 vehicle years of service, February, 10.5/12 years, and so on. Summing over the twelve months produced a total of 46% of a year's service for the 1976 model year vehicles in calendar year 1976 and 45% of a year's service for the 1977 model year vehicles in calendar year 1977.

3. FATAL ACCIDENTS

Uniform data on all fatal accidents in the United States is collected through the NHTSA Fatal Accident Reporting System (FARS). Notification on all fatal accidents involving 1974 or newer heavy trucks during the years 1976 and 1977 was provided to HSRI. This subset totals over 3000 cases. We then attempted to obtain a copy of the police reports for these accidents from the individual states. Approximately 94% of the reports were obtained. HSRI then conducted interviews to obtain additional information on the type of brakes and usage of the vehicle on the accident trip. These interviews were successful about 80% of the time resulting in an overall response rate of about 70%.

Using the national exposure projections developed from the data collected in the fleet monitoring program, fatal accident rates can be computed. The rate of involvement in fatal accidents per hundred million vehicle miles is shown in Table 5 by model year of the power unit and by accident year. In general, the rates increase with the model year of the vehicle. Rates for the two calendar years are quite stable for the pre-standard vehicles, but show more variability for the post-standard vehicles.

In Table 6, fatal accident rates are presented by vehicle type and an overall accident rate is shown for pre- and post-standard vehicles.

TABLE 5

FATAL ACCIDENT* RATES
BY ACCIDENT YEAR AND MODEL YEAR
Accidents Per Hundred Million Vehicle Miles

Power Unit Model Year	Accident Year 1976			1977		
	10^8 V.M.**	Acc.	Rate	10^8 V.M.**	Acc.	Rate
1974	110.2	600	5.4	109.9	593	5.4
1975 Pre	51.8	321	6.2	51.7	340	6.6
1975 Post	18.8	79	4.2	18.7	124	6.6
1976	31.6	230	7.3	68.3	393	5.8
1977				42.0	394	9.4

* Reported by NHTSA Fatal Accident Reporting System (FARS).
** Hundred million vehicle miles.

For this table the two accident years have been combined. The pre-standard category was obtained by combining the 1974 model year and the pre-standard 1975 model year power units. The post-standard category was obtained by combining the post-standard 1975 model year and the 1976 model year power units. Note that the post-standard straight trucks show a 50% reduction in the fatal accident rate, while the post-standard tractors show a 20% increase. Only about 10% of the air-braked trucks involved in fatal accidents are straight trucks. Overall, the fatal accident rate for the 121-equipped vehicles is 5% higher.

Table 7 looks at tractors used in intercity trips only. Here accident rates are broken down by brake type for both tractor and trailer. The fatal accident rate for combination vehicles with 121 brakes on both tractor and trailer is 70% higher than the rate for the pre-standard combination vehicle. The two mixes of pre- and post-standard brakes on combination vehicles show a somewhat reduced rate.

As part of the follow-up interview on these accidents, information

TABLE 6

FATAL ACCIDENT* RATES
BY VEHICLE TYPE AND BRAKE TYPE
(1976 and 1977 Accidents combined)

Vehicle Type and Brake Type	10^8 V.M.**	Accidents	Rate
Straight Truck			
Pre-121+	44.3	207	4.7
Post-121++	33.0	70	2.1
Tractor			
Pre-121+	278.9	1647	5.9
Post-121++	104.4	756	7.2
Total			
Pre-121+	323.6	1854	5.7
Post-121++	137.4	826	6.0

* Reported by NHTSA Fatal Accident Reporting System (FARS).
** Hundred million vehicle miles.
\+ 1974 and pre-121 1975 vehicles.
++ Post-121 1975 and 1976 vehicles (all pre-Notice-7).

on the type of accident was also obtained. In particular, we asked if jackknifing of the vehicle occurred prior to the impact. These results are shown as a percentage of all fatal truck accidents by brake type for both tractor and trailer in Table 8. The rows in this table correspond to the four combinations of pre- and post-standard brakes on a tractor-trailer unit. The frequency of pre-impact jackknifing as a percentage of all accidents is 40% lower for the combination vehicles completely equipped with 121 brakes as compared to the pre-standard combination units. Of equal importance is the overall observation that pre-impact jackknifing occurs in only about 5% of all fatal truck accidents. It should also be pointed out that the frequency of jackknife accidents per

TABLE 7

FATAL ACCIDENT* RATES
BY TRACTOR AND TRAILER BRAKE TYPE

INTERCITY TRACTORS ONLY
(1976 and 1977 Accidents Combined)

Brake Type	10^8 V.M.**	Accidents	Rate
1974 and Pre-121 1975 Tractor			
Bobtail	1.7	21	12.4
Pre-121 Trailer	207.5	1310	6.3
Post-121 Trailer	36.1	158	4.4
Total	245.3	1489	6.1
Post-121 1975 and 1976 Tractor			
Bobtail	1.5	27	18.0
Pre-121 Trailer	72.5	389	5.4
Post-121 Trailer	20.2	218	10.8
Total	94.2	634	6.7

* Reported by NHTSA Fatal Accident Reporting System (FARS).
** Hundred million vehicle miles.

vehicle mile is not reduced. The reduction in jackknifing as a percentage of all truck accidents for the combination vehicles completely equipped with 121 brake systems is not large enough to offset the observed increase in the overall accident rate (accidents per vehicle mile). Table 9 shows the distribution of all collision types by brake type of tractor and trailer. Differences are quite small here.

In order to gain more insight into the role of braking in these accidents, a case-by-case review of approximately 250 cases was conducted. Cases selected were divided equally between pre-standard

TABLE 8

FREQUENCY OF PRE-IMPACT JACKKNIFE
BY TRACTOR AND TRAILER TYPE

1976 and 1977 FARS-Reported Fatal Accidents*

Tractor and Trailer Brake Type	Pre-Impact Jackknife	%
Pre-Pre	39	4.3
Pre-Post	9	8.5
Post-Pre	12	4.6
Post-Post	4	2.6

Total Accidents=1433

* Telephone interview supplement.

combination vehicles and combination vehicles with 121 brakes on both tractor and trailer. Out of this review came the general finding that there was evidence of braking in only a small proportion of these accidents (on the order of 20%). In most cases which were judged to involve braking, avoiding the accident by brake system improvement seemed to be impossible. Cases where a brake defect was indicated were also examined. The 121 brakes did not appear to be a causal factor in any greater proportion of accidents than the pre-standard brakes. (This proportion was on the order of 1%.)

It should be pointed out that the emphasis in the overall study was on national statistics, rather than a determination of accident cause on a case-by-case basis. No accident investigations were conducted. The case-by-case review was based on police reports which provide little information for assessment of accident causes or the role of braking.

4. INJURY ACCIDENTS

Computerized data files containing accidents reported to the Bureau of Motor Carrier Safety (BMCS) for calendar years 1976 and 1977 were

TABLE 9

DISTRIBUTION OF COLLISION TYPES
FOR INTERCITY TRACTORS
BY TRACTOR AND TRAILER BRAKE TYPE

1976 and 1977 Fatal Accidents*

Collision Type	Tractor Brake-Trailer Brake							
	Pre-Pre		Pre-Post		Post-Pre		Post-Post	
	N	%	N	%	N	%	N	%
Single Veh.	87	10.3	13	13.5	56	15.1	36	13.6
Headon	217	25.7	21	21.9	102	27.4	69	26.1
Rear								
Striking	62	7.3	3	3.1	41	11.0	27	10.2
Struck	84	10.0	11	11.5	30	8.1	21	8.0
Angle								
Striking	157	18.6	21	21.9	48	12.9	40	15.2
Struck	86	10.2	12	12.5	44	11.8	26	9.8
Sideswipe	32	3.8	7	7.3	12	3.2	11	4.2
Other	57	6.8	5	5.2	25	6.7	18	6.8
Unknown	62	7.3	3	3.1	14	3.8	16	6.1
Total	844	100.0	96	100.0	372	100.0	264	100.0

* Telephone interview supplement.

also obtained. All carriers involved in the interstate transportation of goods are required to file a report with BMCS on any accident resulting in an injury or $2000 of property damage. Our analysis is limited to injury accidents reported by Authorized Carriers. The Authorized Carriers are believed to report accidents more consistently. These carriers operate predominately combination vehicles on intercity

routes.

A mail survey of the carriers to collect supplemental information was attempted for the 1976 accidents. Response rate on this was only 39%, however. A partial explanation for this may lie in the fact that the American Trucking Association was questioning the study design at that time. Some carriers may have been discouraged from participating.

Our analysis of these data was made with computer files received from BMCS. The primary shortcoming arising from the failure of the mail supplement is an inability to separate the 1975 model year power units into the pre- and post-standard categories as was done with the fatal accident data. The 1975 trailers have been assumed to be 121-equipped. This assumption may result in an overestimation of the number of 121 trailers by up to 20%, since no lag between production and sales was assumed.

TABLE 10

ACCIDENT RATES DERIVED FROM 1976 & 1977
BMCS-REPORTED ACCIDENTS BY TRACTOR MODEL YEAR
FOR INTERCITY TRACTORS
AND AUTHORIZED CARRIERS ONLY

Power Unit Model Year	10^8 V.M.*	Injury		Fatal	
		Acc.	Rate	Acc.	Rate
1974	113.0	4143	36.7	455	4.0
1975	48.1	2282	47.4	267	5.6
1976	39.7	1760	44.3	245	6.2
1977	17.5	1275	72.9	179	10.2
Total	218.3	9460	43.3	1146	5.3

* Hundred million vehicle miles.

Injury and fatal accident rates computed from counts of accidents

reported to BMCS by Authorized Carriers and involving intercity tractors are shown in Table 10. Data for calendar years 1976 and 1977 have been combined. Fatal accident rates were computed for the same subset using the FARS data and were found to agree very well with the results obtained using the BMCS data. In that sense, the two accident data sources seem consistent. The injury accident rates can be seen to be increasing with the model year of the power unit, as in the fatal accident data. For example, the injury accident rate for the 1976 power units is 20% higher than the rate for the 1974 power units.

TABLE 11

ACCIDENT RATES DERIVED FROM 1976 & 1977
BMCS-REPORTED ACCIDENTS
BY TRACTOR AND TRAILER BRAKE TYPE

For Intercity Tractors and Authorized Carriers Only

Tractor Model Year and Trailer Type	10^8 V.M.*	Injury		Fatal	
		Acc.	Rate	Acc.	Rate
1974 Tractor					
Bobtail	0.80	134	168	12	15.0
Pre Trail.	97.3	3396	35	348	3.6
Post Trail.	16.9	613	36	95	5.6
Total	115.0	4143	36	455	4.0
1976 Tractor					
Bobtail	0.64	55	86	15	23.0
Pre Trail.	30.9	1134	37	155	5.0
Post Trail.	8.6	571	66	75	8.7
Total	40.1	1760	44	245	6.1

* Hundred million vehicle miles.

Table 11 shows injury and fatal accident rates for these vehicles broken down by brake type of both tractor and trailer. Here the injury accident rate for the completely 121-equipped combination vehicle is nearly double that of the pre-standard combination vehicle.

The incidence of jackknifing was also examined in the BMCS data. This result is shown in Table 12. Property damage accidents were also included for this table. Here the 121 combination shows only a 20% reduction in the proportion of accidents in which jackknifing was the primary event.

TABLE 12

DISTRIBUTION OF "NON-COLLISION" TYPE
BY TRACTOR AND TRAILER BRAKE TYPE
FOR INTERCITY TRACTORS AND AUTHORIZED CARRIERS ONLY

1976 & 1977 BMCS-Reported Accidents

Non-Collision Type	Tractor Brake - Trailer Brake							
	Pre-Pre		Pre-Post		Post-Pre		Post-Post	
	N	%	N	%	N	%	N	%
Ran Off Road	601	11.5	110	10.2	344	11.3	211	12.4
Jackknife	262	5.0	87	8.0	153	5.0	72	4.2
Overturn	430	8.2	99	9.2	296	9.7	191	11.3
Units Separate	13	0.2	2	0.2	11	0.4	5	0.3
Fire	35	0.7	2	0.2	24	0.8	11	0.6
Loss Of Cargo	24	0.5	2	0.2	11	0.4	10	0.6
Cargo Shift	23	0.4	6	0.6	7	0.2	4	0.2
Other	39	0.7	7	0.6	20	0.7	6	0.4
Not Applicable	3792	72.6	766	70.9	2171	71.5	1184	69.8
Total	5219	100.0	1081	100.0	3037	100.0	1694	100.0

5. DISCUSSION

This section presents a discussion of the findings, including confidence intervals and conclusions.

5.1 Confidence Intervals. Variance in the results arises from three sources. The first of these is simply the random variations in the observed results. These are quantified in the variance computation and are illustrated by the confidence intervals associated with Tables 1-4. In general, the size of these errors is reasonable.

In a survey such as this, one must also take into consideration the possible effect of non-response. In each of the various surveys, 30-40% of the interviews could not be completed. A contact could not be established, or cooperation was not obtained. The question one must ask is whether the results for the non-respondent group would be any different than the results obtained from the respondents. Often, there is reason to assume that the non-respondents are different, as a group, from the respondents. If assumptions can be made on the magnitude of this difference, this information may be incorporated into the variance estimate.

A final source of error results when one wishes to extrapolate beyond the sampling frame. This is necessary when the sampling frame does not entirely cover the population one wishes to describe. If there is uncertainty regarding the actual size of the target population, then this should also be taken into account.

These are preliminary results. Their primary shortcoming is that variance estimates, and therefore confidence intervals, have not yet been computed for the accident rates. This work is still in progress. However, a careful review has been made of the sources of variability, their expected magnitude, and the sensitivity of the findings. Based on this review, some conclusions appear sound.

5.2 Conclusions. The increase in the overall accident rates, when viewed by model year of the power unit, is only 5-20%, well within the expected variance. On the other hand, there is virtually no evidence that accident rates have been reduced for the 121-equipped vehicles. The weight of the evidence at this time clearly suggests that 121 brakes

do not reduce accidents.

Although a reduction in the fatal accident rate is shown for straight trucks, these accidents are only a small proportion of all fatal accidents involving air-braked trucks. And while jackknifing is reduced as a percentage of all truck accidents, the frequency on a per mile basis is not reduced.

Of particular interest is the 70-90% increase observed for the combination units with 121 brakes on both tractor and trailer. The current information is not conclusive in this regard. It may or may not prove to be statistically significant, At a minimum, however, the greatly increased accident rates for the completely 121-equipped combination vehicles must raise doubts as to the safety of these vehicles in actual use.

This determination is only part of the question, however. As a parallel finding, we hold that the proportion of all accidents whose outcome can be altered by an improved braking system is small. It would also seem that the proportion of accidents influenced by an inferior braking system should be small. In fact, this study is able to offer no evidence that would establish the actual causal mechanism responsible for the observed increase in the accident rate. Unfortunately, this is one of the shortcomings of a study designed to produce national statistics.

In light of the relative unimportance of improved braking in preventing accidents, it would seem unrealistic to expect even properly functioning 121 systems to alter appreciably the overall accident rates. We would expect jackknife accidents, for example, to be strongly affected by the improved braking system, and reductions are indicated. These accidents, however, are only about 5% of all truck accidents, and the effect is not noticeable in an overall statistic.

Another factor which cannot be ignored in evaluating the new brake system is the maintenance/reliability problem. While some of the operators surveyed in this study devoted a substantially increased amount of time and effort to the maintenance of the 121 braking system, many had neither the training nor the equipment necessary. As reported

in our Interim Report in 1977, the frequency of maintenance increased by 35% for the 121 brake system as compared with the pre-standard system. The increase was reflected for all major components of the system, not just the anti-lock.

In summary, there is virtually no evidence of any safety benefit associated with FMVSS 121. In fact, the results indicate that the frequency of injury and fatal accidents may actually be higher for the vehicles equipped with FMVSS 121 brake systems.