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VEHICLE HANDLING STUDY: AN ASSESSMENT OF TIRE CONDITIONS

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16. Abstract

Seven hundred sixty randomly selected accidents occurring in Washtenaw and part of Oakland Counties, Michigan were investigated. Data relevant to determination of the potential role of vehicle handling in accident causation, principally tire data, were collected on 1044 vehicles in these accidents.

Limited tire data were also obtained during random Michigan State Police checklane inspections in the summer of 1976. The checklane and accident samples were compared on tire pressure, tread depth, and carcass construction. Additional comparisons were made between subsets of the accident sample.

The data reveal generally poor tire maintenance practices in both samples, with evidence that mixed carcass constructions and large inflation pressure imbalances are overrepresented in accidents, and low tread depth is overrepresented in accidents on wet or slippery roads. These conclusions are tentative because of the limited number of vehicles in the accident sample, and because the control group may not adequately represent the population which generated the accident sample.

More definitive control-group data and development of a definition of vehicle-handling accidents are recommended.

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SUMMARY

This final report of a project entitled "Vehicle Handling Study" describes work conducted during the period September 1, 1975 to April 1, 1978. It presents findings of analyses of tire data collected on 1054 vehicles involved in accidents in Oakland and Washtenaw Counties.

The analyses were conducted to assess the role of tires in accident causation. Given that under-inflated, mismatched, or worn tires negatively affect vehicle-handling properties, the tire data were examined to determine the frequency of such factors and whether they may relate to accident causation.

The data were obtained from cars and light trucks involved in 438 single-vehicle and 322 two-vehicle accidents. Comparative data were also obtained from the Michigan State Police checklane inspections conducted in the summer of 1976. Those inspected vehicles were randomly selected. Thus their tire data represent a quasi-control sample drawn from an exposed population.

The analytical approach consisted of comparing the checklane tire pressure and tread-depth data with similar data from the accident population and with the following subsets of the accident population: single-vehicle accidents; two-vehicle, intersection-type accidents; and two-vehicle, non-intersection-type accidents. More detailed data about the carcass type and about tread depth were available for the accident population, and further comparisons were made on these variables for the accident subsets.

Findings

1. A statistically significant difference was found between the mean inflation pressures of the two samples for three of the four tire positions as well as all four tires combined, with the accident-involved vehicles having lower tire pressures than the non-accident involved vehicles. The difference in the means is less than 0.6 psi for each of the four tire positions and for the aggregate of all four tires. Although the differences in the means are statistically significant, they are so small that they would not be operationally significant and may result from instrumental errors (see page 290).

2. Vehicles involved in single-vehicle accidents had the highest

pressure imbalances, as measured by the difference between the tires with the highest and lowest pressure on each vehicle. The comparison of vehicles involved in single and multi-vehicle accidents was statistically significant. (Page 29).

3. Vehicles which ran off the road before impact had significantly higher pressure differences than those vehicles which did not, but this variable is highly correlated with single-vehicle accidents. (Page 20).

4. The tire pressure imbalances in the accident sample were significantly greater than those in the control sample. The significant difference resulted from higher differences among the vehicles in the single-vehicle subset of the accident sample. (Page 29).

5. In both the accident and checklane samples, pressure imbalances were greater in subcompacts and trucks than they were in compact, intermediate, and full-size body types. The greatest imbalances were found in vehicles in the smallest body type. For each body type, differences between the accident and checklane samples were insignificant. (Page 30.)

6. The difference between the average front pressure and the average rear pressure was computed for each passenger vehicle in the accident and checklane samples. The two resulting distributions differ significantly, with the checklane distribution being displaced in the direction of higher front minus rear differences, compared to the accident distribution. This difference is largely the result of cases near the center of the distributions, i.e., cases with front and rear pressure differentials of only 1 or 2 psi. These small differentials may not be operationally significant. The tails of the distribution are much more important--that is, the regions where the absolute value of the front to rear pressure differential is large. When the tails of the distributions of the two samples were compared, it was found that the accident sample has a higher incidence of front to rear differences of 5 or more psi, including both cases of the front pressure higher than the rear and vice versa. The accident sample also had significantly more cases of the rear pressure exceeding the front by 3.5 or more psi. (Page 32-36).

7. Tread depth was significantly correlated with maximum tire pressure imbalance in the accident and control samples. Vehicles with 0-2/32's of an

inch of tread had the highest tire pressure imbalances and as the amount of tread increased the maximum pressure imbalance decreased. The relationship was statistically significant in both samples. However, the accident sample had higher imbalances than the checklane. (Page 37).

8. Mixing tires of different types of carcass construction on the same vehicle is overrepresented in the accident sample. In the accident sample, 10.3 percent of the vehicles had tires with mixed construction, while only 1.6 percent of the vehicles in the checklane sample were equipped with mixes. Radial ply tires were mixed with non-radials on 1.0 percent of the checklane vehicles, but on 2.1 percent of the accident vehicles. Some of the mixing in the accident sample resulted from the use of snow tires (whereas the checklane data were collected only in summer months). Discounting such cases leaves mixing on 6.8 percent of the accident vehicles, or still four times the rate in the checklane sample. (Pages 39-40).

9. Comparisons of the accident and checklane samples show no significant difference in the amount of remaining tread (after controlling for differences in the ages of the vehicles in the two groups), or in the proportions of vehicles with 2/32 inch or less of tread remaining on at least one tire. (Pages 43-54).

10. Vehicles having a tire with 2/32 inches or less tread were overinvolved in accidents on wet roads by a factor of 1.8. No significant difference was found in the mean tread depth of the most-worn tire on vehicles involved in single-vehicle and two-vehicle crashes. However, those in head-on crashes had less tread than those in intersection collisions. (Pages 55-59).

11. The pattern of wear across individual tires was found to vary by wheel position. More rear tires wear with concave patterns (less tread in the center than near the sides) than do front tires. Twice as many radial tires had a linear wear pattern as did either regular-bias or belted-bias tires. Series 60 (aspect ratio equal to 0.6) tires had a substantially higher incidence of concave patterns than either series 70 or 78 tires. The pattern of wear has little association with observed inflation pressures. (Pages 62-67).

12. Front tires had the greatest tread wear on the inside more frequently on the left tire than on the right tire. Conversely, rear tires had the greatest wear on the inside more frequently on the right tire. (Pages 68-69).

Conclusions and Recommendations

Comparisons of the accident and checklane samples showed that cars with (1) a mix of tire carcass construction; or (2) an imbalance of 5 psi or more in the average inflation pressures of the front tires vs. the rear tires were overrepresented in accidents. Although the causal mechanism was not established on a case-by-case basis, the overrepresentation suggests a causal link between these factors and accidents. This conclusion must be tempered however, because the checklane sample was less than an ideal control group. The checklane data were collected in a separate county at a different time, and only during daylight hours. Thus the sample may not be truly representative of the at-risk population from which the accidents were drawn. In any case, the proportion of accidents which might be "caused" by the carcass mixes or inflation pressure differences is small. Evidence from the accident sample suggests that tires with no more than 2/32 inch of tread are overrepresented in accidents on wet roads.

The current lack of broad agreement on a practical definition of "a vehicle-handling accident" continues to inhibit development of methods for identifying such accidents and their causes. Certainly collection and analysis of more and better pre-crash data are essential to further progress in a study of vehicle handling, but the value of such data may still be limited without a better definition of vehicle-handling accidents.

More definitive control group data should be obtained. The statistical inference approach depends fundamentally on the ability to compare the characteristics of an accident sample with the characteristics of the exposed, at-risk population from which it comes. The pseudo-control group used in this study is not detailed enough to carry out the desired comparisons. It may also be insufficiently representative in time and space to serve as a definitive comparison group.

Manufacturers' recommended tire pressures at average load, and deviations from them, should be obtained for both accident and control groups on a vehicle-by-vehicle basis.

Companion studies to define handling characteristics of the at-risk population of vehicles should be expanded (cf. MVMA Project 4.29, "Develop Accident Causation Investigation Techniques"). Those study results can be used in conjunction with results of studies such as this to clarify the role of vehicle handling as an accident-causation factor.

1.0 INTRODUCTION

The purposes of this final vehicle handling report are to update the Second Interim Report with the inclusion of data collected since the previous report was issued, and to present the more important findings that have emerged from analysis of the enlarged set of data. This report is based on the aggregate of all data collected in the Vehicle Handling Study from its beginning on September 1, 1975 through termination of the field effort on April 1, 1978.

The previous reports reviewed accident investigation procedures relative to vehicle handling, discussed some of the various methodological approaches then under consideration, and identified various strengths and weaknesses of the several approaches. The full discussion contained in the previous reports will not be repeated here, but it is important to note some of the characteristics that underlie the approach that has been adopted.

Our basic approach to determining the potential role of vehicle handling as a possible contributing factor to accident causation has been the statistical inference approach. In general terms, data elements believed to be relevant to accident causation are identified, and these data elements are then collected on a representative sample of accidents. Ideally, the same data elements are also collected on a representative sample of the exposed, at-risk population of vehicles using the highways at the times and places where the accidents occur. The analysis in this approach consists essentially of comparing the two samples and looking for the overrepresentation or underrepresentation of selected variables in the accident population compared to the control population. Variables that are found to be overrepresented in the accident population with respect to their proportions in the control population are presumed, at the first level of analysis, to be causally related to the occurrence of accidents.

The extent to which the overall statistical inference approach can be implemented in any single project is governed primarily by practical issues. The amount of time that can be spent on any single accident by the field investigators, the number of such cases that can be investigated, and the resources available for a detailed description of the control population are all highly relevant. In the present project it has been necessary to limit the scope of the overall investigation by focusing the data collection activities on a particular topic of interest. Tires were selected initially because it is well known that tires have a highly significant effect on vehicle handling characteristics, and presumably, on vehicle-handling accidents if such exist[1,2]. Further, it was believed that improperly maintained or used tires could be detected relatively easily (compared to other vehicular components that influence vehicle handling) in the accident population.

Project resources were allocated to accident and accident-involved vehicle investigations, and no resources were devoted to obtaining a comparably detailed description of the control population. A pseudo-control population was available, however, in the form of the checklane data collected by HSRI in its evaluation of the Michigan vehicle inspection program. The data from this program, sponsored by the Michigan Department of State Police, are described subsequently and compared to the accident data.

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[1]Bernard, James E. et al., Vehicle-In-Use Limit Performance and Tire Factors, Technical Report UM-HSRI-PF-75-1-2, Contract DOT-HS-031-3-693, Highway Safety Research Institute, The University of Michigan, January 1975.

[2]Bundorf, R.T. and R.L. Leffert, The Cornering Compliance Concept for Description of Directional Control (Handling) Properties, Engineering Publication 2771, General Motors Proving Ground, Milford, Michigan, 1971.

2.0 DATA SET

The data collection procedures and detailed information about the specific data elements, including data collection forms, were presented in the first interim report. These are reviewed briefly below, and the contents of the data set in its final form are given in terms of several descriptive variables.

2.1 Selection Criteria

At the beginning of the current project—September 1, 1975—the case-selection criteria were set to investigate all accidents in which one or two vehicles were involved and in which all involved vehicles were towed from the scene because of damage sustained during the accident sequence. Passenger cars and light trucks with four wheels were required to be among the five most recent model years, whereas all other trucks and buses could be up to ten model years old. Thus 1972 and subsequent model year cars and light trucks were eligible initially, and 1977 and 1978 vehicles were added as they were introduced into the driving population in late 1976 and 1977 respectively.

Simple random sampling from vehicles meeting both the accident and case-vehicle selection criteria given above was employed. This reduced the accidents and vehicles to be investigated to a number consistent with the size of the field investigation staff. The sampling fraction has been maintained at 0.2 in Washtenaw County. For the Oakland County jurisdictions—Bloomfield Township, Pontiac, Royal Oak, Southfield, Troy, and Waterford Township—the sampling fraction was set initially to 0.2 and subsequently increased to 0.3 on April 1, 1976. (It was reduced to 0.2 on April 11, 1977, and maintained at that level for the duration of the project).

2.2 Data Elements

All data elements have been collected on the Annotated Collision

Performance and Injury Report, Revision 3, Edition 1/76, VH/IC Study, 4/76. The entire form may be found in Appendix D. It should be noted that extensive data were collected for each wheel and tire. These data elements include whether the wheel was original equipment and if it was damaged, the tread type, intended use (passenger car, light truck, etc.), size, brand, DOT code, and load range of the tire. Tire construction information including carcass type, number of plies, ply material, and the presence of a tube or retread is also collected. The in-use condition of the tire is characterized by tread depth, cupping, and pressure, and the suspected loss of pressure, damage to the tire and involvement of the damage in accident causation are also noted.

2.3 Accident Population

The accident data set utilized in the subsequent analyses contains data from 760 accidents meeting the selection criteria and occurring between September 1, 1975 and April 30, 1978 in Washtenaw County and the six Oakland County jurisdictions given earlier. Of these 760 accidents, 438 (58%) were single-vehicle accidents and 322 (42%) were two-vehicle accidents.[1] Of the 322 two-vehicle accidents, data were obtained on both vehicles in 284 cases, and data were obtained on only one vehicle in 38 cases. The result is that the data set contains 1044 vehicles, 438 (42%) of which were involved in single-vehicle accidents, and 606 (58%) from two-vehicle accidents. Data are missing, of course, on variables even though the vehicle is contained in the file, with the result that the number of vehicles is reduced further in the analytical runs, particularly in those where several variables are used.

The majority--59%--of the 760 accidents occurred at night, with 41% occurring during the day. Of the single-vehicle accidents, 70% occurred at night, whereas only 43.2% of the two-vehicle accidents occurred at night.

2.4 Drivers

Of the 1044 vehicles involved, eleven were parked cars and one was a driverless moving vehicle, leaving 1032 involved drivers. For all

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[1] The requirement that both vehicles of two-vehicle accidents meet the model-year and tow-away criteria results in the disproportionately high number of single-vehicle accidents.

accidents, 68% of the involved drivers were male. This increases to 74% for male involvements in night-time accidents. Similarly, 73% of the drivers involved in single-vehicle accidents were male.

The mean age of all drivers is 31.4 years, and 43.7% of the drivers are 24 years old and younger. The youngest driver is 14 years old and the oldest is 83 years old. The percentage distribution of the drivers by bracketed age is given in Table 1.

Table 1

Percentage Distribution of Drivers by Age Group

N	Age						
	14-17	18-20	21-24	25-29	30-39	40-59	60-83
1032	7.9	16.3	19.5	14.0	17.3	18.3	5.6

Alcohol was noted as an impairing factor by the accident investigators for 28.8% of the 960 drivers for whom an "impairment" judgement was made, and "asleep" was noted for an additional 4.3% as shown in Table 2. A further breakdown by number of vehicles involved and a simple day/night dichotomy shows that alcohol impairment was noted in 47.9% of the single-vehicle accidents, and "alcohol" and "asleep" together increase this to 57.1%. As expected, further subsetting of the single-vehicle accidents into "day" and "night" categories shows that 60.1% of the single-vehicle, nighttime accidents involve drinking to some degree.

The extent of impairment in those drivers for whom alcohol was noted cannot be inferred from the data on hand. This is principally because blood alcohol content (BAC)--in quantitative terms--is rarely determined for accident-involved drivers in Michigan. Only 18 drivers were tested, and results were available for only 9 of these. Further, it is known that not all drivers are equally impaired at the same BAC. Young drivers frequently experience greater impairment than do older drivers at the same BAC. Table 3 shows the distribution, by age, of the 276 drivers for whom impairment due

Table 2

Percentage Distribution of Drivers by Accident Subsets and Impairment

Drivers	N	Impairment*			
		None	Alcohol	Asleep	Other
All	960	64.0	28.8	4.3	8.8
Sngl. Veh, Day .	123	64.2	19.5	5.7	13.8
Sngl. Veh, Night	288	31.9	60.1	10.8	10.4
Sngl. Veh. . . .	411	41.6	47.9	9.2	11.4
Two Veh, Day . .	309	91.6	2.3	0.6	6.1
Two Veh, Night .	240	66.7	30.0	0.4	7.5

* Rows do not add to 100% because impairment is a multiple-response variable and one driver may have two impairments (i.e., asleep and drinking).

to drinking was noted. The table shows that drinking-impairment occurs among all age groups, and the drivers in the 21-24 year age group account for nearly a quarter of all alcohol-impaired drivers.

Table 3

Percentage Distribution of Alcohol-Impaired Drivers by Age Groups

N	Age						
	14-17	18-20	21-24	25-29	30-39	40-59	60-83
276	4.7	15.6	24.3	14.5	19.9	18.8	2.2

Table 4 shows the frequency of all drivers by age and the proportion noted to be impaired by alcohol. The tabulated proportion is the number of alcohol-impaired drivers (from Table 3) in an age group divided by the total number of accident-involved drivers in that age group. It can be seen that, except for the youngest and oldest age groups, the alcohol-impaired proportion ranges from about one-quarter to one-third. While it is highest for the 21-24 age group, it is only slightly higher for this group than for the 30-59 year groups.

Table 4

Frequency of Drivers and Proportion of Alcohol-Impaired Drivers by Age Group

	Age							
	All Ages	14-17	18-20	21-24	25-29	30-39	40-59	60-83
N . .	960	68	161	199	136	168	173	55
Prop.	0.288	0.191	0.267	0.337	0.294	0.327	0.301	0.109

The purpose of the foregoing discussion is to provide a vantage point for considering the detailed analyses that are presented subsequently. The central point is not that alcohol-impaired drivers or young drivers are common among accident-involved drivers; those facts have been thoroughly demonstrated and driver analyses are not the focus of this report. A conclusive study of driver factors would require exposure (control) data on driver factors--data not available for this project. Nonetheless, driver and vehicle performance are so closely coupled in the vehicle-handling context that it is meaningful to consider vehicle/driver-handling performance as a single entity. The driver, in such a conceptualization, would be considered a component in the same sense as tires, brakes, steering linkages, and the like. In this context, differences between accident subsets--such as single-vehicle versus two-vehicle accidents--are shown more sharply by differences in the age and alcohol factors than they are by differences in the tires discussed in the subsequent sections.

2.5 Control Population

One of the basic analytic techniques in the following sections is the comparison of the accident sample with a control population on selected variables available for both populations. The purpose of this comparison is to determine overrepresentation (or underrepresentation) of these variables in the accident sample, compared to an at-risk population of non-accident-involved vehicles.

Since May, 1975, HSRI has participated in the evaluation of the Michigan checklane vehicle inspection program. During the summer of 1975, tire pressures were measured on a random sample of all vehicles stopped at State Police random checklane sites in Monroe and Jackson Counties. These data, used as a sample of a control population, were compared with accident-involved vehicles, and the results were given in the first interim report.

During the summer of 1976 the State Police checklane sites, mainly 'feeder' routes with adequate traffic flow, were re-sampled in Jackson County. It became possible, with the cooperation of the Michigan State Police, to gather a small amount of additional data on checklane vehicles. A form designed to obtain more data pertinent to the current study was filled out on randomly selected vehicles. A copy of this form with selected univariate percentages may be found in Appendix A. The data represent primarily passenger cars, although some light trucks and utility vehicles are also included. These data on 1430 vehicles have been used for comparison with the accident population in the following sections.

Ideally the control sample used for comparison with the accident sample would be obtained from the same county, locale, and time as the accident population of vehicles. However, the Jackson County comparison population provided a convenient sample at no cost to the project and is certainly better than any alternatives available.

3.0 RESULTS

This section presents results from analyses of the cases now in the digital file. The digital file contains 1054 vehicles as of June 1, 1978. Of these, 1044 fully met the study criteria. (The other 10 vehicles were included because data collection had been completed and the data serve the injury-causation portions of the overall study). Univariate distributions of tire variables and other selected variables of interest are also contained in this section as well as analyses of selected variables pertaining to tires. Tire characteristics examined are (1) inflation pressures, (2) mixes of carcass type, and (3) remaining tread depth.

The basic analytic technique involves comparison of various subsets of the accident population and comparison of the accident population to a control population. The object of the analysis is to compare accident-involved vehicles with "at risk" vehicles on selected variables to determine overrepresentation or underrepresentation of tire parameters in the accident population. The first method, using subsets of the accident population, uses the "induced exposure" technique while the second method, comparison with a control population, uses a group external to the accident population.

Measurement of overrepresentation by comparing two populations is a common and appropriate analytical technique. There are cautions that should be observed in its use, however. Determination of real differences between the populations--rather than observed differences resulting from chance--is based on methods of statistical inference. If statistical significance is achieved, two questions must be addressed. One is whether the differences, even if real, are operationally significant, i.e., are important or relevant. The second is whether there is truly a deterministic relationship--a causal effect--as opposed to correlation with an unidentified causal factor whose influence has been neither controlled for nor studied.

3.1 Univariate Distributions of Selected Variables

The distributions of the principal variables--other than inflation pressure and tread depth--which have been added to the data collection form specifically for the vehicle-handling study are presented in Table 5. The total number of cases is 1044 and thus entries of 0.1 and 0.2 indicate frequencies of 1 and 2, respectively.

Table 5

Distributions of Selected Variables in Percent of Cases

I. Variables on Wheels and Tires

Variable	Tire Position			
	LF	RF	LR	RR
Wheel O.E.?				
(1) Yes	98.8	98.2	97.8	98.1
(2) No	0.3	0.6	0.6	0.5
(9) Unknown	1.0	1.2	1.6	1.4
Wheel Damaged?				
(1) Yes	12.6	12.5	6.1	5.8
(2) No	86.9	86.5	92.9	93.4
(9) Unknown	0.5	1.0	1.0	0.8
Tire Tread Type				
(1) Regular	96.4	96.1	81.5	81.6
(2) Non-studded Snow	3.3	3.3	17.5	17.5
(9) Unknown	0.2	0.4	0.6	0.8
Tire Intended Use				
(1) Passenger Car	95.0	94.8	94.7	94.7
(2) Light Truck	4.5	4.2	4.3	4.3
(9) Unknown	0.5	1.0	1.0	1.0
Tire Load Range				
(2) B	89.8	89.6	88.9	89.2
(3) C	2.3	2.3	2.2	2.3
(4) D	2.0	2.0	2.3	2.1
(5) E	0.6	0.5	0.5	0.5
(9) Unknown	5.3	5.7	6.1	5.9

Table 5 (Continued)

Variable	Tire Position			
	LF	RF	LR	RR
Tire Retread?				
(1) Yes	0.2	0.3	0.4	0.2
(2) No	98.5	98.1	97.7	97.3
(9) Unknown	1.3	1.6	1.9	2.5
Tire Tube?				
(1) Yes	0.6	0.6	1.0	0.8
(2) No	97.7	97.3	96.9	96.6
(9) Unknown	1.3	2.1	2.1	2.7
Tire Carcass Type				
(1) Bias Ply	18.5	18.9	19.3	18.9
(2) Belted-Bias Ply	25.6	24.7	24.3	24.6
(3) Radial Ply	54.8	54.6	54.0	54.1
(9) Unknown	1.1	1.8	2.4	2.4
Cupping?				
(1) Yes	2.7	2.5	1.8	1.5
(2) No	95.2	94.8	95.6	96.0
(9) Unknown	1.8	2.7	2.6	2.5
Pressure Loss Suspected?				
(1) None	81.2	82.0	89.9	91.1
(2) Pre-Crash	0.1	0.1	0.1	0.1
(3) At Crash	15.2	14.3	6.3	5.5
(4) Post Crash	0.2	0.2	0.1	0.2
(5) Loss Unknown Time	3.1	3.1	3.0	2.7
(9) Unknown If Loss	0.2	0.4	0.6	0.5
Tire Damaged?				
(1) Yes	6.7	6.2	2.5	2.5
(2) No	90.8	90.2	96.1	96.2
(9) Unknown	2.4	3.5	1.4	1.3
Damage Contributory to Accident?				
(1) Yes	0.1	0.0	0.0	0.0
(2) No	7.8	8.3	2.7	2.9
(3) Not Applicable (No Damage)	90.6	90.2	96.0	96.2
(9) Unknown	1.5	1.4	1.3	1.0

Table 5 (Continued)

II. Vehicle Variables	
Variable	Percent of Vehicles
Steering Wheel Original Equipment?	
(1) Original Equipment	98.7
(2) Non-original Equipment	0.2
(9) Unknown	1.1
Glazing Obstructions?	
(1) Glazing Obstructions	0.7
(2) No Glazing Obstructions	86.6
(9) Unknown	12.7
Suspension Alterations?	
(1) Suspension Alterations	0.5
(2) No Suspension Alterations	97.9
(9) Unknown	1.6
Fuel Level?	
(1) Full	10.3
(2) 3/4	14.6
(3) 1/2	23.9
(4) 1/4	23.8
(5) Empty	2.2
(9) Unknown	25.2
Air Conditioning?	
(1) Air Conditioning	58.0
(2) No Air Conditioning	39.9
(9) Unknown	2.1
Cargo?	
(1) Cargo	12.1
(2) No Cargo	83.4
(9) Unknown	4.5

3.2 Tire Inflation Pressure

Tire inflation pressure is one of the most important factors that determines tire performance, and it is by far the most important such variable completely under control of the motorist. In this section tire pressures of the accident and checklane samples are discussed, and pressure comparisons between accident subsets and between the accident and checklane samples are presented.

3.2.1 Accident Comparisons on Environmental Variables.

Environmental data, collected from the scene of each accident, include several roadway, weather, and location variables which potentially could be related to vehicle control. Subsets of the accident population, formed by the levels of these environmental variables, were tested by the analysis of variance technique (ANOVA) to see if the mean tire pressures and mean tire pressure differentials in the above mentioned subsets were significantly different. Three pressure difference variables were also computed for vehicles which have neither missing data nor a flat tire in any tire position. Front-to-rear difference is the maximum difference between the two front tires and the two rear tires, i.e., the largest of the absolute values of the differences. Side-to-side difference is the maximum difference in the two right tires and two left tires. The third variable, maximum difference, represents the maximum pressure differential between any two tires on the car and is, in effect, the maximum of the two previous variables for each vehicle.

Most environmental variables did not produce significantly different subsets (at the 0.05 level) of the accident population when tested on the difference variables mentioned above. Among these non-significant variables were type of road surface (asphalt, concrete, etc.), horizontal and vertical roadway alignment, precipitation type and rate, roadway surface condition, and the descriptive variable "Case Vehicle Speed." The mean tire pressure differentials of the subsets defined by the levels of these variables were not significantly different.

The descriptive variable "Ran Off The Roadway Before First Impact" is shown in Table 6. This variable is coded 'Yes' when the case vehicle leaves the normal travel lanes of the roadway before first impact (although the vehicle may subsequently return to the roadway during the collision phase). The difference variables are all significant at the 5 percent level with the difference variable means of the vehicles running off the road about 1 psi higher than those not running off the road. Of the 176 vehicles which ran off the road, 169 were single-vehicle accidents, while of the 391 vehicles which did not run off the road, only 17 were single-vehicle accidents. There was no significant difference between the mean pressure differences on vehicles in single-vehicle crashes when subset on "Ran Off The Road." Only seven vehicles involved in multi-vehicle crashes ran off the roadway before impact and the mean psi differences of these vehicles were more than 2 psi higher than vehicles involved in multi-vehicle crashes which did not run off the road. This difference, however, is not statistically different due to the small cell size.

Table 6
Mean Tire-Pressure-Difference Variables Subset on Ran Off the Road Before First Impact

Variable	Ran Off the Road	N	Mean	S.D.	Sig. (F Statistic)
Side-to-side Difference	Yes	176	6.17	5.91	0.036
	No	391	5.15	5.09	
Front-to-rear Difference	Yes	176	6.33	6.12	0.021
	No	391	5.20	5.05	
Maximum Difference	Yes	176	6.52	6.22	0.031
	No	391	5.43	5.28	

(Vehicles with missing data on one or more tire pressures or with non-load range B tires are excluded)

The "Surface Slippery" variable—with levels yes, no, and unknown--is shown in Table 7 for the three difference variables previously described. The significance is based on the comparison of the means and standard deviations of the subsets defined by the yes and no responses. The mean tire pressure differential of vehicles on slippery roads was significantly higher than those on non-slippery roads in the previous interim report but is no longer so. The increase in the data set size resulted in increasing the mean pressure differentials of vehicles on non-slippery roads while lowering the means of the pressure differentials on slippery roads.

Table 7
Mean Tire Pressure Difference Variables
Subset on Surface Slippery

Variable	Surface Slippery	N	Mean	S.D.	Sig. (F Statistic)
Side-to-side Difference	Yes	150	5.96	5.68	0.202
	No	388	5.29	5.33	
Front-to-rear Difference	Yes	150	6.13	5.96	0.150
	No	388	5.37	5.30	
Maximum Difference	Yes	150	6.34	6.06	0.157
	No	388	5.57	5.52	

(Vehicles with missing data on one or more tire pressures or with non-load range B tires are excluded)

In Table 8 the mean maximum pressure imbalance is compared for vehicles in single- and two-vehicle accidents on slippery and non-slippery roads. There are 6 individual comparisons of pairs of means that are possible with the data in Table 8. None of these is significant at the 0.05 probability level. Nor does an F-test using ANOVA for the entire table indicate significant differences between the four individual groups.

Many tests, using the analysis of variance technique, were also done on combinations of pressure differentials, tread depth, and environmental variables. Very few of these produced significant differences. Most of these tables are not included in the present report because of this, and those tables which are included may or may not have operational meaning.

To investigate the interaction of tread depth and tire pressure imbalances, the minimum tread depth (in groove #3) of the four tires on each

Table 8
Mean of Maximum Pressure Differences for Vehicles in Single and Multi-Vehicle Accidents on Slippery and Not-slippery Roads

Surface Slippery	Single				Multi			
	N	Mean	S.D.	Sig.	N	Mean	S.D.	Sig.
Yes	69	6.64	6.58		81	6.09	5.61	
No	110	6.27	5.85	0.699	278	5.29	5.37	0.244

Overall sig.= 0.193

vehicle was determined. Table 9 shows mean maximum pressure imbalances for groupings of minimum tread depths dichotomized on surface slippery as well as the mean imbalances for all surfaces. Table 9 is highly significant (0.0000) and indicates that vehicles on non-slippery roads with at least one tire with 0-2/32 inch or less tread have the highest mean tire pressure imbalances (10.08 psi), and vehicles on slippery roads, with the same minimum tread depth, have the next highest mean pressure imbalance (9.57 psi). This is the reverse of the finding in the previous report where vehicles on slippery roads had higher psi differences. If vehicles in multi-vehicle accidents are removed from the dichotomized portion of Table 9 the table is no longer significant (sig. = 0.0589), but if single-vehicle accidents are removed (leaving only vehicles in multi-vehicle accidents) the table remains significant (sig. = 0.0006). Just as in Table 8, the mean pressure imbalance of single-vehicle-accident involved vehicles not on slippery roadways is higher than multi-vehicle-accident involved vehicles on any surface and partially accounts for the lack of significance for single-vehicle accidents only. The mean differences for vehicles on all surfaces is significantly different (sig.= 0.0000) by tread depth groupings and indicates that surface condition is not the critical factor, but rather simply that tire pressure imbalance on a vehicle is correlated with tread depth. Unlike the upper section, the lower portion of Table 9 is significant for both single-vehicle and multi-vehicle accidents.

The maximum placard difference variable, derived by taking the minimum

Table 9

Mean of Maximum Pressure Difference of Accident Vehicles by Tread Depth and Surface Condition

Surface		Minimum Tread Depth (groove #3) of 4 tires			
		0-2/32	3-5/32	6-8/32	9+/32
Slippery	N	14	39	50	31
	Mean	9.57	6.87	6.04	4.06
	SD	9.27	7.34	4.27	4.04
Not-Slippery	N	24	80	145	98
	Mean	10.08	6.51	5.49	4.07
	SD	8.67	7.21	4.55	3.96
sig.= 0.0000					
All Surfaces	N	40	124	206	137
	Mean	9.93	6.55	5.61	4.12
	SD	8.58	7.12	4.43	4.04
sig.= 0.0000					

pressures in the front and rear, subtracting them from the respective manufacturers' recommended pressures (at maximum load), and then taking the larger of the two differences for each vehicle, is shown in Table 10. In this case, vehicles having accidents on slippery roads had significantly higher (sig.= 0.0005) mean tire pressure deviations from recommended pressure than those on non-slippery roads.

Table 10

Mean of Maximum Placard Differences by Surface Condition

		N	Mean	SD	Sig.
Surface Slippery	Yes	127	6.57	5.83	0.0005
	No	342	4.57	5.33	

Another tire pressure difference, the difference between the mean front and mean rear tire pressures was also derived. This difference is, of course, highly correlated with other tire pressure differentials, but it was found not to be significantly different on levels of the environmental variables previously discussed. The collision configuration variable, however, did have statistically significant differences between types of collisions (f=2.45, sig. =0.024), but the differences in the means were less than 1 psi

3.2.2 Accident Population Subsets. In Table 11 subsets of the accident population, as defined by collision configuration, are compared on the three pressure imbalance variables. Single-vehicle accidents have the highest pressure imbalances of any of the configuration subsets, although the single-vehicle to non-intersection comparison is not statistically significant.

Table 11

Comparison of Accident Subsets on Mean Pressure Differences

Var.	Sngl	Multi	Sig.	Sngl	Int.	Sig.	Sngl	Non-int	Sig.	Int.	Non-Int	Sig.
Max. S-S Diff.												
N	186	381	0.049	186	271	0.053	186	110	0.227	271	110	0.740
Mean	6.11	5.16		6.11	5.11		6.11	5.30		5.11	5.30	
S.D.	5.79	5.14		5.79	5.15		5.79	5.13		5.15	5.13	
Max. F-R Diff.												
N	186	381	0.030	186	271	0.037	186	110	0.165	271	110	0.787
Mean	6.26	5.21		6.26	5.16		6.26	5.32		5.16	5.32	
S.D.	5.99	5.10		5.99	5.17		5.99	4.93		5.17	4.93	
Max. Diff.												
N	186	381	0.042	186	271	0.050	186	110	0.196	271	110	0.778
Mean	6.45	5.43		6.45	5.39		6.45	5.55		5.38	5.55	
S.D.	6.08	5.34		6.08	5.43		6.08	5.14		5.43	5.14	

The manufacturers' recommended tire pressures (at maximum load) minus the actual tire pressures are shown by tire position for the accident population subsets in Table 12. Negative mean values are the result of average tire pressures higher than those recommended.

Most of the comparisons are not statistically significant and the means for the subsets are quite similar. Only the right-front tire comparisons between single-vehicle vs. multi-vehicle and single-vehicle vs. intersection accidents are significant. These cells represent the lowest means (single vehicle) compared with the highest front means (multi-vehicle and intersection accidents). The operational significance of these differences is unclear. Mean rear pressure differences are all 2-3 psi below recommended pressure. This is probably a result of the fact that, for maximum loading, rear recommended pressures are generally higher than front recommended pressures.

Table 12

Manufacturers' Recommended PSI
(at Maximum Loading) Minus Actual PSI by
Tire Position for Accident Population Subsets

Tire	Sngl	Multi	Sig.	Sngl	Int	Sig.	Sngl	Non-Int	Sig.	Int	Non-Int	Sig.
LF												
N	255	420	0.16	255	291	0.21	255	129	0.32	291	129	0.94
Mean	0.16	0.85		0.16	0.83		0.16	0.88		0.83	0.88	
S.D.	6.82	5.83		6.82	5.65		6.82	6.24		5.65	6.24	
RF												
N	255	427	0.00	255	299	0.00	255	128	0.12	299	128	0.25
Mean	-.35	1.19		-.35	1.39		-.35	0.73		1.39	0.73	
S.D.	6.54	5.47		6.54	5.25		6.54	5.95		5.25	5.95	
LR												
N	284	452	0.52	284	303	0.89	284	149	0.21	303	149	0.26
Mean	2.90	3.19		2.90	2.97		2.90	3.66		2.97	3.66	
S.D.	6.06	6.08		6.06	6.18		6.06	5.88		6.18	5.88	
RR												
N	279	462	0.76	279	314	0.69	279	148	0.99	314	148	0.75
Mean	2.94	3.07		2.94	3.13		2.94	2.95		3.13	2.95	
S.D.	5.93	5.61		5.93	5.69		5.93	5.45		5.69	5.46	

The comparisons involving inflation pressure differences have stressed differences of actual inflation pressures measured in the field. While the various observed pressure differences have been contrasted by partitioning the accident data, little has been done to compare observed pressures with manufacturers' recommended pressure.

Such comparisons are appropriate and indeed could be highly valuable, but have been severely limited by lack of data. Recommended pressures are given on a placard on all cars in accordance with S4.3 of FMVSS 110. Most manufacturers have elected to list the recommended inflation pressures for an "average" or "normal" load in addition to that required for the maximum load, and the data collection protocol includes recording the placard data.

The placard is usually affixed to the inside of the glove-box door, the rear edge of a front door, or to a B-pillar. Unfortunately, these locations are frequently inaccessible to the investigator because the glove-box or car is locked, or because doors are jammed closed. Consequently, the desired data are missing on about 70 percent of the cases.

Using published data, we have been able to obtain the recommended pressure for maximum load conditions for most vehicles and reduce the missing data to about 25 percent. We have not found a reference source for recommended inflation pressures for "average" or "normal" loads. This is unfortunate, as most cars involved in accidents (and probably in normal use) are lightly loaded. Since the recommended pressures, and in particular the front-to-rear differential that results from recommended practice, can vary substantially between average and maximum load conditions, use of the maximum-load recommendations can lead to inappropriate inferences.

Another method of partitioning the accident population, using the weight of the vehicle, also produced significant results. Table 13 shows the mean maximum pressure differences for 1000-pound weight groupings of the accident vehicles. The mean pressure differences decrease as the weight of the car increases. The weight of the car is correlated with the size, of course, and comparisons of the accident and control populations by size is made in the next section.

3.2.3. Accident vs. Checklane. Figure 1 shows the distributions of all tires with valid pressures for the accident and control populations.

Table 13

Mean Maximum Pressure Difference for
Accident Vehicles by Weight

Weight	N	Mean	S.D.	Sig.
0-2500 lbs.	79	7.43	6.22	0.007
2501-3500	181	6.19	6.93	
3501-4500	224	5.24	4.57	
4501-5500	49	4.47	3.33	

The distributions are significantly different, (sig. = 0.0001) with the accident distribution being somewhat "flatter" than the control distribution.

Comparison of the accident population and the control population on actual tire pressure, by tire position, is shown in Table 14. Three of the four comparisons are statistically significant at the 5% level with the accident population having a lower mean pressure than the checklane by about 0.5 psi The fourth tire position, right rear, is lower by 0.19 psi which is not statistically significant. The finding differs drastically from the finding in the first interim report where the earlier control population had pressure means about 3 psi higher in each tire position. We had postulated that the pressures in the first control population were higher due to the conditions under which the pressures were measured, hot vs. cold. The new control population, however, was measured in the same manner as the old and the difference between the accident and control populations was still expected to exist. It is possible that the two control populations were different, but this is not the most likely explanation. The difference in tire pressure gauges is the more likely explanation since the gauges used in the first checklane were not calibrated, while the gauges used by the HSRI investigators in the second checklane were calibrated and known to be accurate.

Despite the similarity of actual pressures in the two populations, the difference of tire pressures on wheels of the same vehicles is believed to be the best measure of tire pressure deviation, and we have continued to use the difference variables here. Table 15 shows the comparison of the

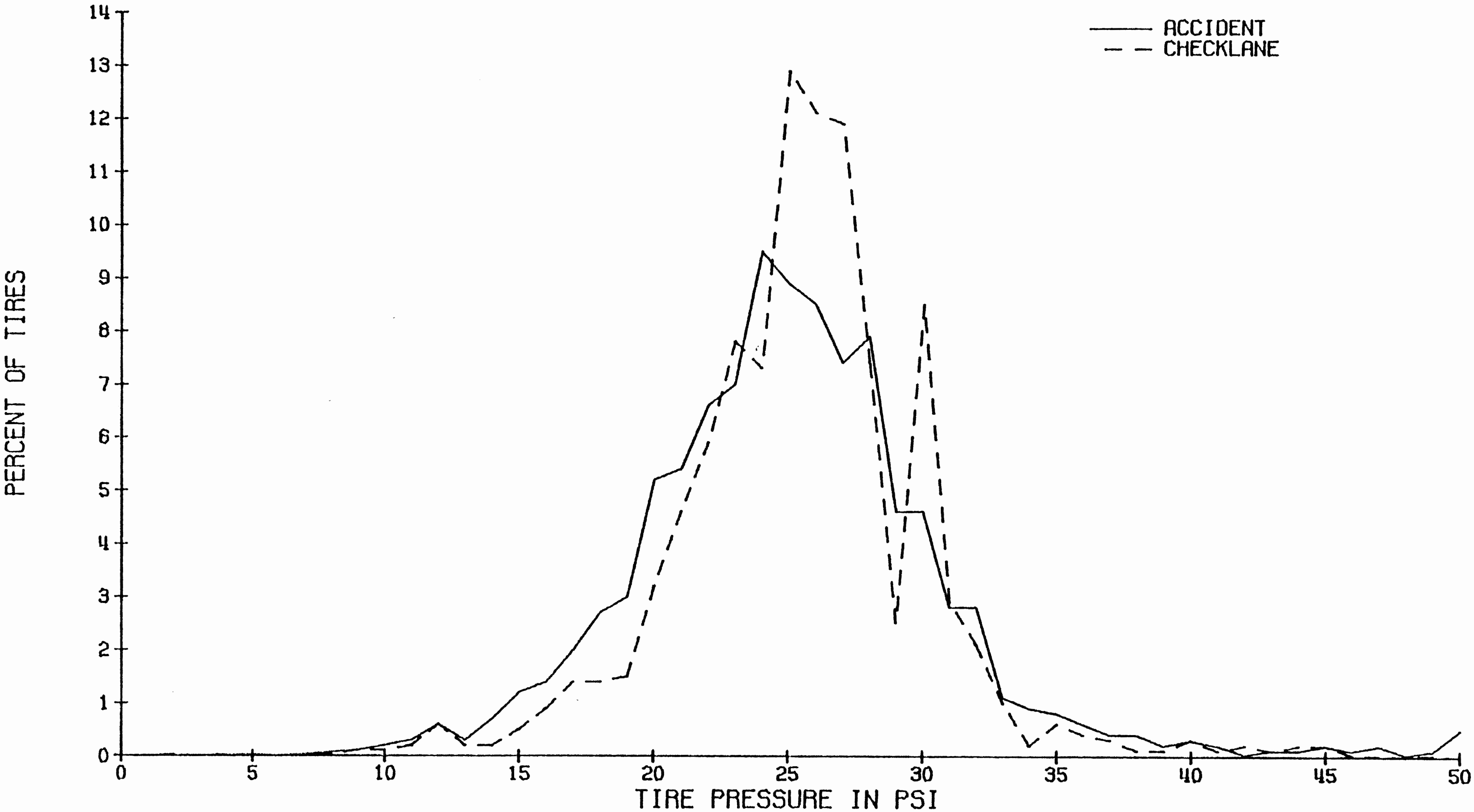

FIGURE 1
DISTRIBUTIONS OF TIRE PRESSURES
IN ACCIDENT AND CHECKLANE SAMPLES

Table 14

Accident and Checklane Tire Pressures
by Tire Position

Tire Position	Accident			Control			(F-stat.)
	N	Mean	S.D.	N	Mean	S.D.	Sig.
LF	785	25.40	5.89	1340	25.83	4.25	0.0511
RF	784	25.41	5.70	1362	25.89	4.19	0.0248
LR	864	24.84	5.98	1312	25.38	4.72	0.0145
RR	872	24.89	5.58	1305	25.08	4.95	0.3960
All Tires	3305	25.12	5.79	5324	25.54	4.65	0.0001

accident and control populations on the pressure imbalance variables for 1972-1977 vehicles. All three variables are significantly different between the two populations, and the accident-involved vehicles have higher pressure differences than the control population for each variable.

Subsets of the accident population are compared to the control population for 1972-1977 vehicles in Table 16. Only the single-vehicle subset is significantly different from the control population and those differences are highly significant. A comparison of the two populations by model year (for the model years for which both have data) is shown in Table 17 on the same three variables. The accident population means are higher for each of the model years, however only the three 1972 cells and the front-to-rear and maximum difference cells for 1973 are significantly different (P<.05). Comparisons of the populations on the difference variables with the 5 model years pooled are significant at the 0.01 level.

Comparisons of the tire pressure imbalances for the checklane sample are presented in Table 18 and the same comparisons are presented in Table 19 for the accident sample. Pressure imbalances are significantly different by body type within each sample, and subcompacts and truck (pickups, vans, utility vehicles) imbalances are higher in both data sets. A cell-to-cell comparison of the two tables showed no significant difference between the

Table 15

Mean Pressure Differences for 1972-1977
Accident and Checklane Vehicles

	Accident	Checklane	Sig.
Side-to-side Difference			
N	567	708	0.0014
Mean	5.47	4.62	
S.D.	5.37	4.08	
Front-to-Rear Difference			
N	567	708	0.0012
Mean	5.55	4.68	
S.D.	5.42	4.20	
Maximum Overall Difference			
N	567	708	0.0014
Mean	5.77	4.88	
S.D.	5.61	4.29	

two samples for any body.

Another series of tests was performed on the distributions of the difference D formed by subtracting the average of the rear tire pressures from the average of the front tire pressures for each passenger car in the checklane and accident samples.[1] The difference D ranged from -14.5 psi to +15.5 psi for 622 checklane vehicles, with a mean of +0.55 psi and a standard deviation of 3.1 psi Comparative figures for the 501 accident-vehicles are: range, -12.5 psi to +24.5 psi; mean, +0.50 psi; and standard deviation, 4.5 psi. Little operational meaning would be attached to a statistically significant difference between the means of the D measures for the two samples even if such existed. The fact is, however, that the two

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[1] Vehicles in the accident sample were excluded if any of the four tires was suspected of having lost pressure during the accident sequence.

Table 16

Comparison of Accident Subsets with the Control Population (Model Years 1972-1978) on Mean Tire Pressure Differences

Var.	Single	Check	Sig.	Inter	Check	Sig.	Non-Int	Check	Sig.	Multi	Check	Sig.
S-S												
N	186	708	.00	271	708	.12	110	708	.12	381	708	.06
Mean	6.11	4.62		5.11	4.62		5.30	4.62		5.16	4.62	
S.D.	5.79	4.08		5.15	4.08		5.13	4.08		5.14	4.08	
F-R												
N	186	708	.00	271	708	.13	110	708	.15	381	708	.07
Mean	6.26	4.68		5.16	4.68		5.32	4.68		5.21	4.68	
S.D.	5.99	4.20		5.17	4.20		4.93	4.20		5.10	4.20	
Max.												
N	186	708	.00	271	708	.13	110	708	.14	381	708	.06
Mean	6.45	4.88		5.38	4.88		5.55	4.88		5.43	4.88	
S.D.	6.08	4.29		5.43	4.29		5.13	4.29		5.34	4.29	

means do not differ in a statistical sense, and the difference in means of 0.05 psi is of no operational consequence. We note, however, that the positive means of the D measures require that, on the average, the front tires have higher pressures than the rear tires for both populations.

The two D distributions were also compared using Flora's RIDITS[1] on grouped data as shown in Table 20, and also using the Mann-Whitney U-statistic and the median test statistic on the individual measurements. The former was not significant at the 5% level while the latter two tests were significant. The difference is such that the checklane D distribution is "more positive" than the accident D distribution. In other words, the checklane D distribution is somewhat to the right of the accident D in a manner analogous to the mean of the checklane D (+0.55 psi) being more positive and to the right of the mean of the accident D (+0.50 psi). In terms of tire pressures, it can be inferred that the trend to having higher front pressures than rear pressures is stronger in the checklane sample than

[1] J.D. Flora, Jr. "RIDITS: A New Look at an Old Technique for the Analysis of Accident Injury Data," HIT LAB REPORTS, Vol. 5, NO. 3, Highway Safety Research Institute, The University of Michigan, November, 1974.

Table 17

Accident and Control Populations by
Mean Tire Pressure Differences by Model Year

		Side Diff.		F to R Diff.		Max.Diff.	
		Acc.	Check	Acc.	Check	Acc.	Check
1972	N	87	154	87	154	87	154
	Mean	6.39	4.90	6.36	4.96	6.83	5.23
	S.D.	5.62	3.94	5.94	4.04	6.29	4.18
1973	N	104	177	104	177	104	177
	Mean	5.86	4.68	5.92	4.69	6.10	4.85
	S.D.	4.44	3.96	4.48	4.05	4.13	4.07
1974	N	112	164	112	164	112	164
	Mean	5.71	4.82	5.98	4.88	6.13	5.11
	S.D.	5.29	4.33	5.74	4.54	5.75	4.62
1975	N	93	121	93	121	93	121
	Mean	5.47	4.65	5.48	4.71	5.66	4.92
	S.D.	5.85	4.53	5.79	4.63	5.90	4.73
1976	N	96	92	96	92	96	92
	Mean	4.49	3.66	4.54	3.76	4.75	3.88
	S.D.	4.02	3.31	4.00	3.44	4.06	3.57

in the accident sample, but only slightly so.

However, the statistically significant difference that has been observed may have arisen from the numerous observations in the central part of the D distributions wherein the small pressure differences--2 or 3 psi--have little meaning in a vehicle dynamics context. Therefore the tails of the two D distributions were compared in a series of 2 x 2 Chi-square tests as shown in Table 21. It can be seen that only the test of the positive tail of the accident D versus that of the checklane D--with the positive tail defined by $D \geq 3.5$[1]--did not show statistically significant differences between the accident and checklane samples at the 5 percent level. The negative tail of more than 3.5 psi absolute difference and both the positive and negative tails of more than 5 psi absolute difference are significant at

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1 Rear tire pressure less than front tire pressure by at least 3.5 psi

Table 18

Mean Tire Pressure Differences by Model for 1972-1977
Vehicles in the Control Population

	Side-to-Side Difference	Front-to-Rear Difference	Maximum Difference
Full			
N	248	248	248
Mean	4.08	4.07	4.26
S.D.	3.39	3.33	3.47
Intermediate			
N	195	195	195
Mean	4.92	4.96	5.20
S.D.	4.48	4.48	4.52
Compact			
N	105	105	105
Mean	4.21	4.21	4.39
S.D.	3.37	3.27	3.39
Sub-Compact			
N	74	74	74
Mean	5.97	6.28	6.42
S.D.	5.50	5.90	5.93
Trucks			
N	59	59	59
Mean	5.42	5.51	5.75
S.D.	4.75	4.94	5.05
Sig.	0.0020	0.0004	0.0006

the 2 percent level. All of these observations support the inference that the two D distributions differ in the tails of their distributions as well as in the central regions.

Station wagons carry a wide range of loads compared to other passenger cars. Because of this, their handling properties can differ from other passenger cars, and vary over a wider range. These attributes make the inflation pressures on wagons particularly interesting. However, the number of wagons in the two data sets is small, 84 in the accident sample and 66 in the checklane sample. The wagons with no pressure loss in the accident and

Table 19

Mean Tire Pressure Differences by Model for
1972-1977 Accident Vehicles

	Side-to-Side Difference	Front-to-Rear Difference	Maximum Difference
Full			
N	132	132	132
Mean	4.80	4.84	5.06
S.D.	4.38	4.37	4.44
Intermediate			
N	117	117	117
Mean	4.94	4.89	5.07
S.D.	4.19	4.11	4.22
Compact			
N	123	123	123
Mean	4.81	5.26	5.32
S.D.	4.62	5.29	5.32
Sub-Compact			
N	142	142	142
Mean	7.06	7.10	7.37
S.D.	7.37	7.24	7.58
Trucks			
N	51	51	51
Mean	5.47	5.22	5.69
S.D.	4.46	4.21	4.60
Sig.	0.0015	0.0028	0.0025

with valid pressure measurements on all four tires, thus permitting computation of pressure differences among the tires on a vehicle, number 45 in the accident sample and 62 in the checklane sample.

A comparison of the tails of the distributions of D for station wagons in the accident and checklane samples is shown in Table 22. The structure of Table 22 is the same as Table 21. The results are similar to those for passenger cars. That is, the frequency of cars with rear and front means which differ by more than 3.5 or 5 psi (the tails of the distributions of D) is greater in the accident sample than in the checklane sample. While none

Table 20

Distributions of Front Average PSI Minus
Rear Average PSI (D) for Accident and Checklane
Samples of Passenger Cars

	Pressure Difference Interval (Inclusive)		Checklane		Accident	
			N	%	N	%
R>F	-15	-12	2	0.3	4	0.8
	-11.5	- 8.5	5	0.8	6	1.2
	- 8	- 5	12	1.9	21	4.2
	- 4.5	- 3.5	28	4.5	35	7.0
	- 3	- 2	56	9.0	56	11.2
	- 1.5	- 1	77	12.4	68	13.6
	- 0.5	+ 0.5	189	30.4	122	24.4
F>R	1	1.5	78	12.5	57	11.4
	2	3	81	13.0	37	7.4
	3.5	4.5	41	6.6	27	5.4
	5	8	44	7.1	44	8.8
	8.5	11.5	6	1.0	10	2.0
	12	15	2	0.3	9	1.8
	15.5	24.5	1	0.2	5	1.0
Total			622	100.0	501	100.0

RIDITS Test: Odds Ratio=1.14, Sig. Level=0.058; X^2 sig. = 0.0004

of the comparisons is statistically significant because of the small number of cases, the results are comparable to those shown in Table 21 but with even greater differences between the two samples [1].

Most manufactures recommend higher pressures in the rear than in the front for station wagons. This corresponds to a recommendation of a negative D. Thus the positive tails are particularly noteworthy since they represent higher pressure in the front, a condition that decreases the understeer coefficient. The accident sample of wagons has a substantial proportion with a mean front pressure greater than mean rear pressure by

[1] The Fisher exact probability was used because of the small numbers of cases.

Table 21

Comparisons of the Tails of the Distributions of D

D=F-R	Tests of Positive Tails				Tests of Negative Tails			
	Tail		Tail		Tail		Tail	
	<3.5	≥3.5	<5	≥5	>-3.5	≤-3.5	>-5	≤-5
Checklane	528	94 (15.1%)	569	53 (8.5%)	575	47 (7.6%)	603	19 (3.1%)
Accident	406	95 (19.0%)	433	68 (13.6%)	435	56 (13.2%)	470	31 (6.2%)
Chi-Square	2.7		6.9		9.1		5.7	
Sig. Level	0.102		0.009		0.003		0.017	

five psi or more (15.6 percent). It is also interesting to note that nearly half of the station wagons in both samples have mean front pressures greater than the mean rear pressures (43.5 percent in the checklane sample and 42.2 percent in the accident sample). Thus a large proportion of wagon users are driving with pressures that are not consistent with the manufacturers' recommendations.

From Table 9 it is apparent that tread depth and maximum pressure difference are correlated. A comparison of the accident and checklane samples shows that the mean minimum tread depth for all vehicles (model years 1972-1978) is 5.5/32 inch for the checklane and 6.6/32 inch for the accident sample. Vehicles with missing data on one or more tire pressures are excluded from the above means so that the means represent mean minimum tread depths for the vehicles in Table 9 and Table 23. Table 23 shows the mean maximum pressure differences for vehicles in the checklane and the accident samples by minimum tread depth groupings. Note that within each sample the variation in mean maximum pressure difference among the minimum tread depth groupings is statistically significant (at less than the 0.01 level using an ANOVA F-test).

Table 22

Comparisons of the Tails of the
Distributions of D for Station Wagons

D=F-R	Tests of Positive Tails (Front mean greater than rear)				Tests of Negative Tails (Rear mean greater than front)			
	Tail		Tail		Tail		Tail	
	<3.5	≥3.5	<5	≥5	>-3.5	≤-3.5	>-5	≤-5
Accident	36	9 (20.0%)	38	7 (15.6%)	41	4 (8.9%)	41	4 (8.9%)
Checklane	57	5 (8.15)	58	4 (6.5%)	52	10 (16.1%)	58	4 (6.5%)
Sig. Level (Fisher's exact prob.)	0.065		0.11		0.212		0.45	

Table 23

Mean Maximum Pressure Difference of Accident
and Checklane Vehicles by Minimum Tread Depth

Sample		Minimum Tread Depth (groove #3) of 4 tires				
		Total	0-2/32	3-5/32	6-8/32	9+/32
Check-lane	N	1129	164	361	406	198
	Mean	5.57	8.15	5.74	5.02	4.27
	S.D.	5.02	5.87	4.65	4.63	4.91
Acci-dent	N	507	40	124	206	137
	Mean	5.78	9.93	6.55	5.61	4.12
	S.D.	5.71	8.58	7.12	4.43	4.04

Both distributions sig.=0.0000

Other variables, in particular environmental variables available in the accident file only, were tested using ANOVA (F-test) with the rear minus the front mean PSI of all passenger cars as the dependent variable. Most of the comparisons did not produce significant results, and the means of the subsets formed by these environmental variables were quite similar. Variables tested included surface slippery, precipitation and road surface condition variables, road alignment, and the derived variable wet/dry. The two descriptive variables ran off the roadway before first impact and collision configuration were both significant ($p<.05$). However, the mean pressure differences on the levels of these variables were less than 1 psi

3.3 Mixing of Types of Carcass Construction

Mixing tires of different types of carcass construction (regular bias, belted bias, and radial ply) can substantially affect the handling characteristics of vehicles.[1] In general, the different types of construction provide different cornering stiffnesses, and altering the relative front/rear cornering stiffness changes the understeer characteristics. This can be most pronounced if radials are mixed with non-radials.

The checklane data collected in 1976 contain 22 vehicles with mixed carcass types among 1381 vehicles with no missing data on construction, or 1.6 percent. The 1001 vehicles in the accident with complete data on carcass construction sample include 103 with mixed or 10.3 percent. The difference is statistically significant at less than the 0.000 percent level, with X^2=78 and d.f.=1.

The accident data collection period includes winter months so a number of cars equipped with snow tires were investigated. Since the checklane data were collected in late summer, the greater mix of carcass constructions found in the accident sample could have resulted partly from the use of snow tires. If the vehicles in the accident sample with carcass mixes and snow tires (with snow tires and regular tread of different carcass types) are removed from the mixed category and treated as not-mixed, the frequency of mixes in the accident sample becomes 6.8 percent.[2] While 34 percent of the mixes in the accident sample are eliminated by this procedure (for purposes of a comparison with the summer checklane data), the frequency is still significantly greater than in the checklane sample at less than the 0.0001 level with X^2=45 and d.f.=1.

There are alternative ways of dealing with the problem created by the snow tires in the accident sample. One is to exclude vehicles with snow

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[1] Bernard, James E. et al., Vehicle-In-Use Limit Performance and Tire Factors, Technical Report UM-HSRI-PF-75-1-2, Contract DOT-HS-031-3-693, Highway Safety Research Institute, The University of Michigan, January 1975.

[2] Vehicles with one or three snowtires and with mixed construction, cars with two snow tires but with construction mixed on the same axle, and cars with radials mixed with non-radials were included as cases of mixed construction.

tires completely, i.e., both from the numerator and denominator of the proportion representing mixed constructions. When this is done, the proportion of vehicles in the accident sample with mixed constructions becomes 55 out of 820 or 6.7 percent. This result is almost identical to that given in the paragraph above. Mixed constructions were found on 27 percent of the 180 vehicles equipped with snow tires. Another comparison is provided by including vehicles with snow tires, but restricting the proportion to vehicles in accidents during summer months. The proportion of vehicles in accidents from April through October inclusive with mixed constructions is 8.4 percent.

All of the results presented above indicate a much greater mixing of types of carcass construction among accident-involved vehicles than in the control sample.

The cases of mixed types of carcass construction discussed in the paragraphs above include all combinations of regular bias, belted-bias, and radial. Mixing radials with non-radials is frequently noted as a particularly dangerous practice. There are 14 such samples in the checklane data, or 1.01 percent of the vehicles. The accident sample contains 21 vehicles with radials mixed with non-radials, or 2.1 percent--twice the proportion in the checklane sample. The apparent overinvolvement of vehicle with tires of mixed carcass construction is of interest. When the vehicles in the accident sample are partitioned into those in single-vehicle crashes and those in multi-vehicle crashes, 11.5 percent of those in single-vehicles are found to have mixed carcass types, compared with 9.6 percent for those in multi-vehicle crashes. The difference is not significant.

A comparison of carcass mixing with a trichotomous variable for road surface condition is shown in Table 24. A greater proportion of the vehicles with mixes were involved on roads which were either wet or covered with ice or snow. The differences are significant at the 0.03 level (X^2=6.8, d.f.=2). When the carcass mixes resulting from the use of snow tires are treated as non-mixes the results shown in Table 25 are obtained. The differences are not significant (X^2=0.98, d.f.=2). Neither are the differences in surface condition mixes discounting snow tires (the left two columns of Table 25) compared to the distribution in cases without mixes (the right two columns of Table 24). In this case the significance level is 0.55 with X^2=1.1, d.f.=2.

These results indicate that the association of mixed carcass construction with surface condition shown in Table 24 results from the use of snow tires in the winter months when there is a greater incidence of wet or snow covered roads.

Of the 35 cases of mixes of carcass constructions resulting from the use of snow tires, only four involved radials with non-radials. However, the four were cases of radials on the front and non-radials on the rear, a particularly unacceptable configuration.

The Interim report indicated a significant association between an indication of the use of alcohol and mixed carcass construction. The current data set of 1044 accident involved vehicles does not provide a significant association.

Table 24

Mixing of Carcass Types
by Road Surface Condition

Surface	Carcass Types			
	Mixed		Non-Mixed	
	N	%	N	%
Dry	50	48.1	549	61.3
Wet/Water Covered	31	29.8	196	21.9
Ice/Snow	23	22.1	150	16.8

The Rubber Manufacturers Association publishes a wall chart for the use of tire dealers that describes acceptable and non-acceptable combinations of tire construction and aspect ratios.[1] Three categories of combinations are

[1] "Tire Application Guide for Passenger Cars," published by the Rubber Manufacturers Association, 1901 Pennsylvania Avenue, N.W., Washington, D.C. 20006.

Table 25

Mixing of Carcass Types
by Road Surface Conditions
Discounting Mixes Possibly Resulting
from the use of Snow Tires

Surface	Carcass Type			
	Mixed		Non-Mixed	
	N	%	N	%
Dry	39	56.5	560	60.2
Wet/Water Covered	19	27.5	208	22.4
Ice/Snow	11	15.9	162	17.0

listed. These are "preferred" (for identical aspect ratio and carcass construction), "acceptable", and "no." The guide is rather liberal. For example, it lists as acceptable the use of radials on the rear and non-radials on the front unless the front tires are of the 50 or 60 series.

Using the RMA guide as criteria, 13 of the carcass mixes in the checklane sample are unacceptable mixes or a proportion of 0.9 percent, while 3.9 percent (25) of the vehicles in the accident sample have unacceptable mixes. While the incidence of unacceptable mixes is about half that for all mixes of carcass constructions, the difference between the two samples is still highly significant with X^2=29, d.f.=1.

The higher frequency of carcass mixes in the accident-involved vehicles compared to the checklane vehicles is just the sort of overrepresentation that would implicate carcass mixes as a factor associated with accidents, either causally or through correlation with a causal factor. However, a causal inference from the data presented here must be tempered. Basic differences between the populations from which the checklane and accident samples were taken may account for the difference in the observed carcass mixes. Evidence of this will be discussed relative to tread depth in

Section 3.4.1, where the analyses include control for the effects of confounding variables whose distributions differ in the two populations. The number of cases of mixes of types of carcass construction is too small to permit such statistical control.

The 21 vehicles having radial tires mixed with non-radial tires are insufficient for any but the cursory analysis given above. Because the number is small, a brief summary of each case is included in Appendix B. Of the 21 cases, 12 were unrelated to vehicle handling. It is not obvious that any did involve vehicle handling, but of the 9 for which it cannot be ruled out, 4 involved drinking drivers, another 3 were on roads covered by ice or snow, and one involved a puddle on an expressway.

3.4 Tread Depth

This section presents an examination of tread depth measured on the accident sample. The section is divided into three subsections. Subsection 3.4.1 presents comparisons of the accident sample with the control (checklane) sample. Since only one measurement was made per tire in the checklane data collection, the comparisons are limited to the use of one groove measurement on each tire in the accident sample.

In 3.4.2, subsets of the accident sample are compared. The objective of 3.4.2 is to examine the overall tread depth in the accident sample. Since all grooves were measured on the accident vehicles, the mean depth of all grooves on each tire is used as the measure of overall tread depth. Much of the material in this section is based on the minimum mean depth on the vehicle--that is, the mean depth of the tire which had the lowest mean depth of all four tires.

Lastly, two characteristics of the pattern of wear that can be deduced from measurements of all grooves are examined in 3.4.3 for subsets of the accident sample. The two pattern characteristics are the concavity/ convexity of the pattern, and lateral asymmetry of wear on each tire.

3.4.1 Tread Depth Comparisons of Accident and Checklane Samples.

Tread depths were measured in both the accident and control samples. The measurement for the control group was made while the cars were waiting in line for the Michigan State Police checklane, and thus the time available was limited. Because of this, only one tread depth measurement was made on each of the four tires. The single measurement was made in the center groove of tires with an odd number of grooves, or in the groove nearest the center on the side toward the observer (outside) in the case of an even number of grooves. The observer was instructed to take the time necessary to be sure the measurement was not over a tread wear indicator. All comparisons of tread depths in the accident and control groups are based on a consistent depth measurement. This is accomplished by using the depth of the groove in the accident data that corresponds to the groove measured in the checklane data.

The checklane sample collected in the summer of 1976 included vehicles over 20 years old. Tread depth is correlated with age, and since the vehicles in the accident sample are no more that 6 years old (model years 1972-1978), the use of the checklane data has been limited to those vehicles that were no more than 6 years old at the time of the data collection.

The distributions of tread depths on the tires in the two samples are shown in Figure 2. Since the checklane data were collected in the summer, presumably with few snow tires, snow tires which have deep treads have been deleted from the accident data in Figure 2. Tires with missing data on tread depth are also excluded. Consequently, Figure 2 is based on 4191 tires from the checklane sample and 3278 tires from the accident sample. The distributions are very similar in both samples, with both having a mode at 9/32. However, the curve for the accident sample is displaced slightly to the right above 4/32, indicating the tires in the accident population had slightly more tread. The difference between the two distributions is statistically significant at the 0.0000 level.[1] The proportion of tires with tread depths of 0-2/32 is 3.78% in the accident sample, and 4.15% in the checklane sample. This difference is not significant (X^2=0.7, d.f.=1).

Figure 3 gives the distribution of the minimum tread depth on each vehicle, i.e., the minimum of the four tires. Those vehicles are included

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[1] The RIDITS Technique of Flora was used for the tests. This technique was used because it is a distribution-free method of determining if the numbers (scores) of one population are greater than those of a second. The significance levels given by Flora's technique are the same as those given by the Mann-Whitney (U) test to which it is closely related.

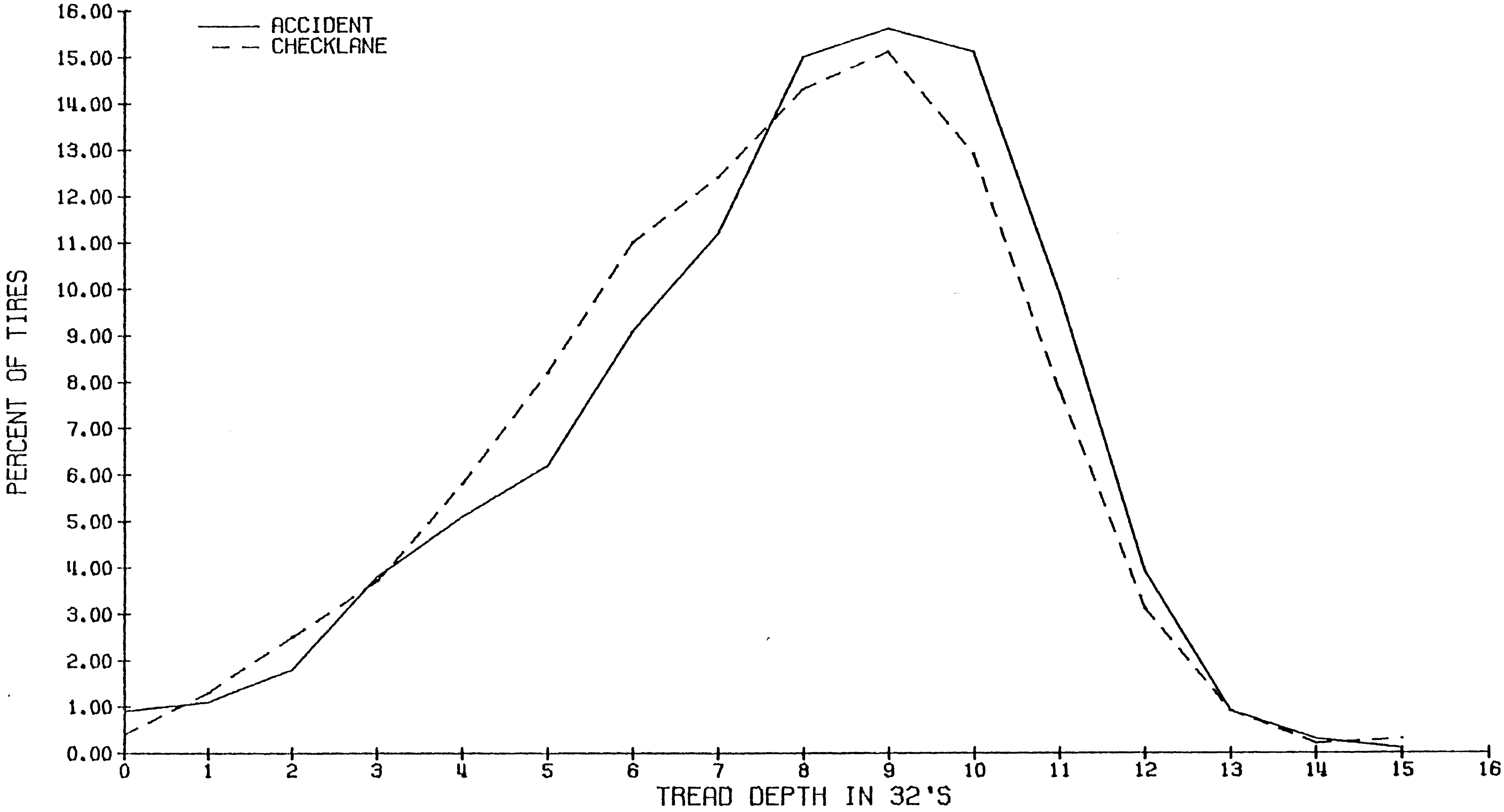

FIGURE 2
DISTRIBUTION OF TREAD DEPTH OF EACH TIRE
0-6 YEAR OLD VEHICLES

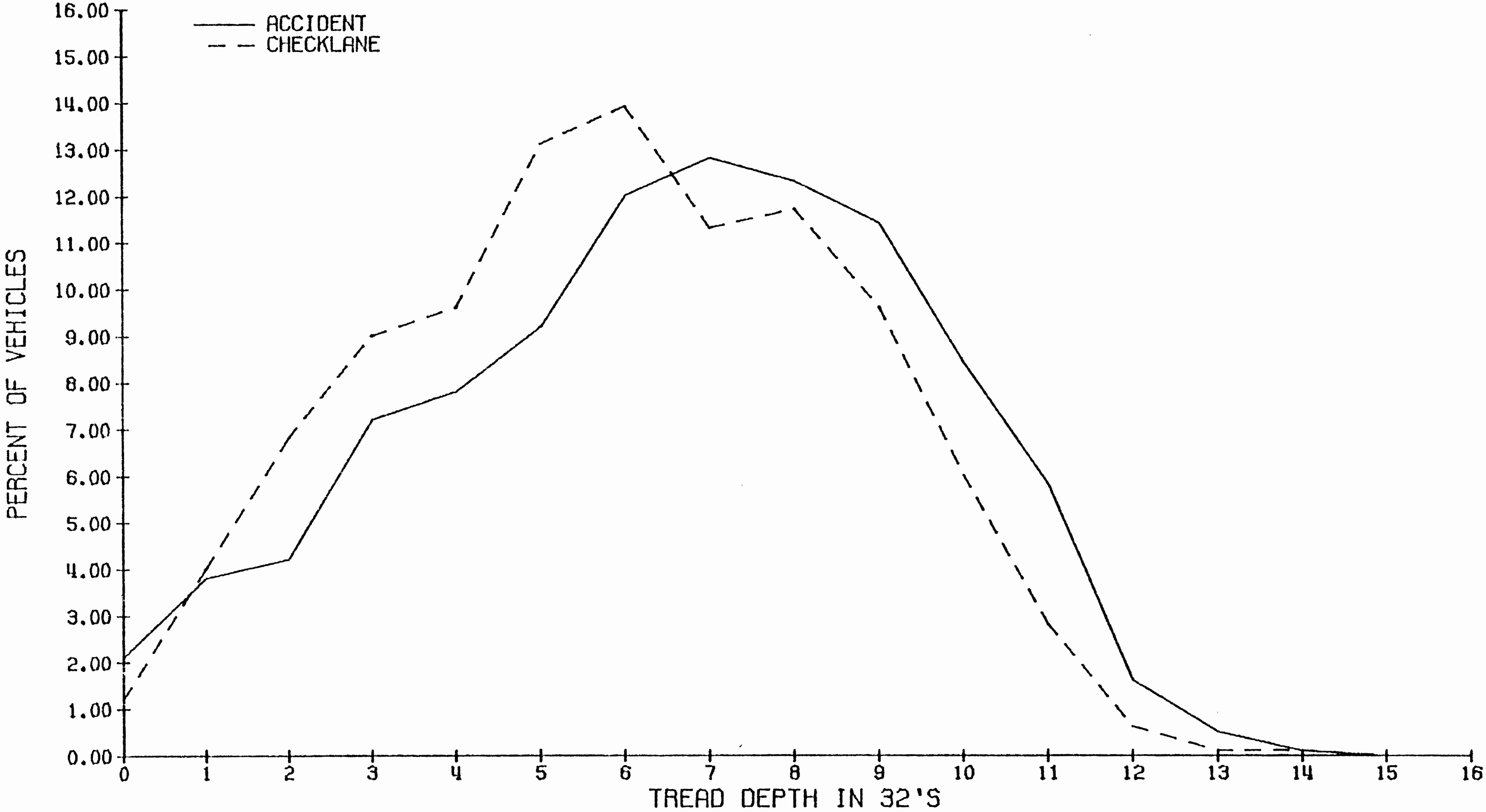

FIGURE 3
DISTRIBUTION OF MINIMUM TREAD DEPTH
ON EACH VEHICLE, 0-6 YEAR OLD VEHICLES

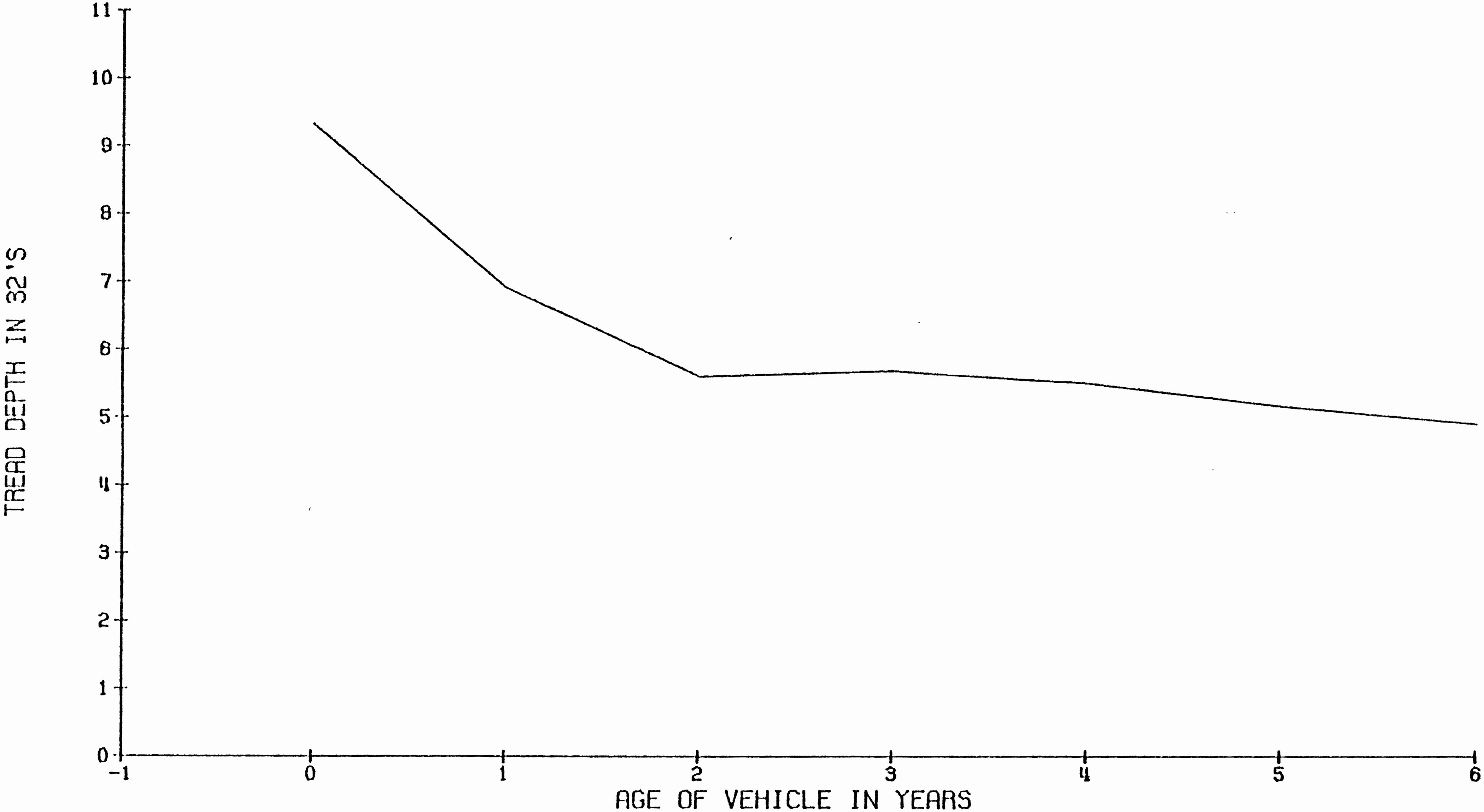

FIGURE 4
MEAN MINIMUM TREAD DEPTH BY VEHICLE AGE
COMBINED CHECKLANE AND ACCIDENT DATA

for which all four tires met the requirements given relative to the previous figure, 1042 vehicles in the checklane and 807 in the accident samples. Almost all observations made with regard to Figure 2 also apply to Figure 3. The difference in the two distributions is significant at the 0.000 level using Flora's technique. The mean minimum depth in the accident sample is 6.5 (32's) and 5.9 for the checklane sample. While the difference is significant (at the 0.0001 level using the Students test), it is small.

The proportion of accident-involved vehicles with minimum tread of 0-2/32 is 10.9% and 12.1% for the checklane sample, although the difference in the two proportions is not significant ($X^2=0.63$, d.f.=1).

The greater tread depths on tires of the accident-involved vehicles shown in Figure 2 are surprising, but can be explained in part by differences in the two samples. It was noted earlier that tread depth is correlated with vehicle age. Figure 4 indicates the mean of the minimum depth (of four tires) decreases with age, particularly in the first two years. The proportion of vehicles with at least one tire with a tread depth of 0-2/32 also increases with age, even more markedly than the mean. This is shown in Table 26.

Table 26

Proportion of Vehicles in the Combined Accident and Checklane Samples with a Minimum Mean Tread Depth 2/32 or less by Age.*

Age in Years	Proportion in Percent
0	0.8
1	5.2
2	12.0
3	14.2
4	15.5
5	17.3
6	23.6
Mean	11.4
Total N	1849

*Vehicles with snowtires have been excluded from the accident sample

The age of vehicles in the two samples is different. Table 27 shows that a greater proportion of the vehicles in the accident sample is less than two years old. The associations between sample (accident, checklane) and age, and between tread depth and age, suggest that comparisons of tread depth in the two samples could be confounded by vehicle age and that the comparisons should be controlled for the effects of age. Multivariate linear regressions were used to provide such control.

Table 27

Vehicle Age By Population

Age in Years	Proportion of vehicles of each age in percent for: Checklane	Accident*
0	14.3	20.3
1	16.9	22.0
2	18.5	18.1
3	19.3	18.1
4	15.7	13.0
5	9.7	7.9
6	5.6	0.6
Total %	100.0	100.0
N	1051	838

*Vehicles with snowtires have been excluded.

In the regressions to be discussed below for comparing tread depths in the accident sample with those in the checklane sample, tires on trucks in both samples, and snowtires on cars in the accident sample were excluded. Only vehicles in a common range of ages--0-5 years old--were included. The tread depths in the regressions are of the tire with the minimum tread on the vehicle (there were 1606 such vehicles in the two samples). Consequently, the basic observational unit is a vehicle. The regressions provide predicted values of a dependent variable Y (in this case tread depth) as a linear function of several dependent variables X_i,

$$Y = b_0 + b_1X_1 + b_2X_2 \ldots.$$

The least squares method selects the coefficients such that the sum of squares of the differences between the predicted and observed values of Y is minimized.

A regression of tread depth (in 32's) against sample (1=checklane, 2=accident) and age gives the results in Table 28.

Table 28

Least Squares Regression
by Tread Depth by Sample and Vehicle Age

R^2=0.136

Variable	Coefficient	Significance Level
Constant	8.225	---
Sample	0.132	0.32
Age	-0.647	0.00

These results indicate that after controlling for age, the difference in the two samples was not significant (sig. level=0.32), while the effect of age was, with each additional year of age, to reduce the mean tread depth by 0.65/32 inch. However, the conclusion must be tempered by the fact that the model only explained 14 percent of the variability in the data as indicated by the value of R^2. Nevertheless, the result is consistent with the observation that while the accident sample has more tread than the checklane sample, it also has more new cars which in general have more tread.

The regression using tread depth in 32's effectively examines differences in the means of the samples. Since the mean minimum tread depths are substantial, about 6/32, small differences in the means may have little influence on accident experiences. Therefore the remaining comparisons of tread depth will examine the proportions of the vehicles in each sample which have minimum tread depths of 0-2/32. For examining proportions, it is possible to use weighted least squares models.

Basically, the proportions used as the dependent variables are computed for the group of observations (vehicles) that fall in each of the population cells defined by the combinations of values of the independent variables. Each cell, i, has n observations with a cell proportion of p . In the weighted least squares, the variables are weighted for each cell by the square root of W_i, where

$$W_i = n_i/p_i(1-p_i),$$

resulting in a regression equation of the form:

$$Y_i(W_i) = B_0(W_i) + B_1(W_i) \quad X_{1i} + B_2(W_i) \quad X_{2i}$$

This weighting avoids problems associated with non-uniform variances in the cells.

The weighted least squares regression of the proportion of vehicles with a minimum tread depth of 0-2/32 against sample and vehicle age gives the information in Table 29. The coefficient for sample has a significance level of 0.324, indicating the difference in the samples may result from sampling and not represent true differences in the at-risk and accident populations.

The effects of confounding variables, such as vehicle age, is important. The apparent difference in tread depth of the accident and control samples shown in Figures 2 and 3 disappeared when vehicle age was included as a control variable. It is also possible for real differences to be marked or hidden by the effects of confounding variables. Therefore it is necessary to consider as many as possible control variables as the data will provide unless prior knowledge indicates they are irrelevant.

Model (body type) is also a candidate control variable. Table 30 gives the distribution of model in the two samples. Full sized cars occur about half as frequently in the accident sample. The four-level model variable for passenger cars results in 48 cells when crossed with sample (2 levels) and vehicle age (6 levels). This results in many empty or nearly empty cells with the quantity of data available. Hence a two-level model variable was used. Full sized and intermediate cars were pooled into level 1, while compacts and sub-compacts were pooled into level 2. The distribution given in Table 30 suggests this pairing.

Table 29

Weighted Least Squares Regression of Tread Depth less than 3/32 by Sample and Vehicle Age
$R^2=0.610$
Total Degrees of Freedom = 14

Variable	Coefficient	Significance Level
Constant	-0.0455	0.008
Sample*	0.0116	0.324
Age**	0.0361	0.000

*1=checklane sample, 2=accident sample
**The age variable used is the age of the vehicle plus one.

Table 30

Distribution of Model in Each Sample

Model	Distribution in Percent	
	Checklane	Accident
Full Size	38.1	21.8
Intermediate	28.0	20.4
Compact	14.7	22.5
Sub-Compact	10.2	23.4
Small Truck	8.9	11.9
Total	100.0	100.0

Table 31 substantiates the choice of the dichotomous model variable as a control since small cars have a greater incidence of little tread in both samples.

The weighted least squares regression using both vehicle age and the two-level model variable—generating 24 cells in all—is given in Table 32.

Table 31

Proportion of Cars with Minimum
Tread Depth of 0-2/32 in Percent by Sample and Model

Sample	Model	
	Large	Small
Checklane	9.35	14.80
Accident	7.97	12.75

Table 32

Weighted Least Squares Regression of Tread
Depth of 2/32 or Less by Sample, Age, and Model
$R^2=0.51$
Total Degrees of Freedom = 28

Variable	Coefficient	Significance Level
Constant	-0.0677	0.000
Sample	0.00493	0.464
Age	0.0345	0.000
Model	0.0252	0.017

This regression indicates that controlling on model as well as vehicle age also results in no significant difference in the proportion of cars with low tread in the two samples. However, this regression does not explain as much of the variability as does the regression in Table 29. Nevertheless, it strongly suggests that model is an important control variable since it is highly significant, at the 0.017 level.

The less adequate "fit" could have several reasons. The introduction of model increases the number of cells from 12 to 24, thereby increasing the variability. The high value of R^2 in Table 29 could in fact result from too much pooling of the data. An interaction between independent variables of the regression including model could also result in the low R^2, e.g., interactions between model, sample, and tread depth.

The possibility of the above interaction was examined by a regression of tread against sample, age, and two variables representing model. The two model variables were structured as shown in Table 33. The same data structure of 24 cells was used.

Table 33

Dummy Model Variables for Interaction

Sample	Model	Model Variable 1	Model Variable 2
Checklane	Large	1	0
	Small	-1	0
Accident	Large	0	1
	Small	0	-1

By using this variable structure the effect of model can be examined separately for each sample.

The regression results are shown in Table 34. There is a moderate interaction between model and sample. The effect of model is not significant in the checklane sample, but is in the accident sample. Furthermore the estimated effect of model (as given by the coefficients) is 1.7 times as great in the accident sample as in the checklane sample. Again, the effect of the sample itself on the proportion with low tread depths is not significant. However, the addition of the interaction terms has resulted in a 1% increase in the unexplained variability--R^2 has increased from 0.51 (Table 32) to 0.52.

Four different regressions have been presented which examine the differences in tread depth in the accident and control samples. The raw

Table 34

Weighted Least Squares Regression of Tread Depth
Less than 3/32 by Sample, Age, and Model with Interaction

R^2=0.52
Total Degrees of Freedom = 28

Variable	Coefficient	Significance Level
Constant	-0.0364	0.035
Sample	0.00970	0.337
Age	0.0342	0.000
Model 1 (checklane)	-0.00957	0.174
Model 2 (accident)	-0.0161	0.037

data shown in Figures 2 and 3 indicate there are differences in the two samples. However, these differences are primarily in the regions of substantial remaining tread where we would not expect the differences to be important. These apparent differences are probably the result of differences in the population of cars in the two samples rather than in the tread depths of accident and non-accident cars. Although the regression analyses do not explain a large proportion of the variability of tread depth within the samples, they all fail to detect any real differences between the samples either in the amount of remaining tread or in the proportion of vehicles with a mean tread depth on any one tire of 2/32 in. or less.

3.4.2 Mean Tread Depths in the Accident Sample. Data are collected on the depth of each groove of each tire. One measurement is made in each groove at a point not over a tread wear indicator. Six of the 4176 tires currently in the accident data set have nine grooves; the others have from two to eight grooves or are missing data on the number of grooves.[1] Of the 4105 with two to eight grooves, tread depth measurements were completed for 4042.

The parameter selected as a measure of the amount of tread on each tire

[1] One pickup had four snow tires with only one recorded. These four tires were deleted from all analyses of tread depth.

is the mean of the groove measurements. Since the number of grooves varies from 2 (on some snow tires) to 8, the means are based on 2 to 8 measurements. The comparisons to be presented for subsets of the accident-involved cars are based on cars rather than individual tires. In these cases, that tire which had the lowest mean tread depth was selected to represent the vehicle in the comparisons. This was done under the assumption that little tread would more likely be a causal accident factor than ample tread.

Admittedly this is a simplistic—although not unreasonable—view of the role of tread. The combination of tires with different tread depths can have subtle effects on the handling performance of a car, e.g., the understeer coefficient (even on dry pavement), but this is difficult to study with the existing data structure. The effects of tire-to-tire differentials in tread depth on accident involvement can best be studied through dependent vehicle parameters such as the understeer coefficient.[1]

The distribution of the mean depth for each of the four wheel positions is given in Table 35. Since the data set includes a small number of light trucks and vehicles with snow tires, the means exceed the depths that would be found on new passenger car tires with regular highway tread. The break is quite evident at depths of 14/32 and greater. The mode is at 9/32 for all tire positions. The depth for new passenger car tires is about 11/32-13/32.

The two right-hand columns give the distribution of the minimum mean depth on the car. The mode is at 7/32, while the median is between 6/32 and 7/32. The mean minimum depth is 6.8(32's).

The number and percentage of tires with tread depths of 2/32 or less is given for each wheel position in the bottom row. Of the 4042 tires in the table, 127 or 3% have 2/32 or less. In general, the tires with low tread appear singly; they are distributed over 87 (8.9%) of the vehicles.

The distributions of the minimum mean tread depths (given in the right-hand column of Table 35 for the entire accident sample) have been compared

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[1] Segel, L. and L. Johnson, Development of Techniques for Investigating Accident Causation, UM-HSRI-78-4, Highway Safety Research Institute, University of Michigan, January 1978.

Table 35

Distribution of Mean Tread Depth

Depth in 32's	Left Front		Right Front		Left Rear		Right Rear		Minimum Mean On Vehicle	
	N	%	N	%	N	%	N	%	N	%
0	2	0.2	6	0.6	4	0.4	3	0.3	11	1.1
1	9	0.9	7	0.7	7	0.7	13	1.3	28	2.9
2	21	2.1	21	2.1	19	1.9	13	1.3	48	4.9
3	26	2.6	43	4.2	26	2.6	25	2.5	63	6.5
4	51	5.0	50	4.9	41	4.1	41	4.1	72	7.4
5	62	6.1	54	5.3	48	4.8	49	4.9	95	9.7
6	97	9.6	91	9.0	81	8.0	82	8.1	109	11.2
7	124	12.4	119	11.7	87	8.6	101	10.0	128	13.1
8	126	12.4	128	12.6	121	12.0	116	11.5	110	11.3
9	150	14.8	148	14.6	159	15.8	151	15.0	108	11.1
10	133	13.1	131	12.9	125	12.4	132	13.1	77	7.9
11	113	11.2	123	12.1	149	14.8	133	13.2	79	8.1
12	55	5.4	48	4.7	59	5.8	56	5.6	23	2.4
13	20	2.0	21	2.1	27	2.7	35	3.5	8	0.8
14	7	0.7	9	0.9	23	2.3	22	2.2	4	0.4
15	5	0.5	4	0.4	16	1.6	16	1.6	4	0.4
16	3	0.3	3	0.3	7	0.7	5	0.5	2	0.2
17	4	0.4	2	0.2	4	0.4	3	0.3	3	0.3
18	2	0.2	2	0.2	1	0.1	4	0.4	1	0.1
19	1	0.1	0	0.0	3	0.3	2	0.2	1	0.1
20	0	0.0	3	0.3	1	0.1	0	0.0	1	0.1
21	1	0.1	0	0.0	1	0.1	2	0.2	0	0.0
22	1	0.1	0	0.0	0	0.0	1	0.1	0	0.0
Total	1013	100.0	1013	100.0	1009	100.0	1007	100.0	975	100.0
0-2	32	3.2	34	3.4	30	3.0	31	3.1	87	8.9

for specific subsets of the accident population. Subsets were selected either to (1) compare those groups that might be expected to have the greatest difference in incidence of "handling" accidents or, (2) compare those in which tread depth could be expected to play a role with those in which it is least likely to be a factor. Since the data thin out at the higher tread depths, cases with depths of 15/32 or greater were pooled, thus giving 16 levels of depth. Two tests were used. The Students-T test of means, and the Mann-Whitney (U) test of ranks. Both methods are appropriate and have their strengths and weaknesses. The means test is straightforward to interpret and simply tests for equality of means. However, it depends on the assumption of normality of the distributions. The Mann-Whitney test is distribution free, and tests for equality of ranks of scores (ordered variables). However, it is invalid if ties are frequent. With large data sets the difference in results of the two tests is small.

Table 36 gives the results for vehicles involved in several types of collision. The mean for those in single vehicle accidents (which might be expected to involve vehicle handling more frequently than other collisions) is lower than for those in two vehicle collisions. However, the difference is small and not statistically significant by either the mean test (sig. level = 0.16) or the Mann-Whitney test (sig. level = 0.18). The difference between the two most common subsets of two-vehicle collisions—head-on and and intersection--are greater than the difference between single and two-vehicle collisions. The difference is statistically significant at the 0.01 level by both tests. Vehicles in head-on and single-vehicle crashes have mean minimum tread depths which differ by only one-half of a 32nd, a difference which is not significant (sig. level = 0.10). The greatest difference is the comparison between head-on and intersection. This difference (1/32) is statistically significant at the 0.00 level using both tests. The reason for this difference and its implications have not been identified.

Table 36

Minimum Mean Tread Depth
by Type of Collision

Type of Collision	Mean (in 32.s)	N
Single Vehicle	6.74	404
Two-Vehicle	7.02	571
Head-On	6.21	110
Intersection	7.24	386

Table 37 gives the results of three comparisons of road surface conditions. Mean minimum tread depths are given for each subset along with significance levels for both tests.

Table 37

Minimum Mean Tread Depth

Comparison	Mean in 32's	Sig. Level
Dry vs. Others		
Dry	7.06	0.051 mean test
Others	6.66	0.057 Mann-Whitney
Dry vs. Wet		
Dry	7.06	0.041 mean test
Wet	6.57	0.051 Mann-Whitney
Wet vs. Ice/Snow		
Wet	6.57	0.37 mean test
Ice/Snow	6.78	0.51 Mann-Whitney

Vehicles in crashes on dry roads have marginally significantly different minimum tread depths than those on other surfaces (wet, icy, or snow covered). The comparison of dry surfaces with wet surfaces was made to "sharpen" the contrast. If tread, regardless of depth, is unable to cope with ice or packed snow, the former comparison would be "diluted." Almost identical results were obtained when ice/snow were removed. This suggests that there is little difference--in minimum mean tread depth--between vehicles in accidents on wet roads and those on roads covered by snow or ice. Indeed, the last comparison of Table 37 indicates this is the case.

Carrying this reasoning one step further, the wet-dry comparison could also be "diluted" if moderate tread is sufficient to provide braking and cornering forces with the most frequently encountered degrees of wetness. Since only a small proportion of the vehicles had little tread, under the above conditions small differences in mean tread depths could not be expected to result in different accident experience.

Consequently a wet-dry comparison was made using a dichotomous minimum tread depth variable. Vehicles with at least one tire with a mean depth of 0-2/32 were pooled, and compared with those with more tread. The result is shown in Table 38. Comparing wet and dry roads, the chi-square test of homogeneity gives X^2=6.6 with d.f.=1 and a significance level of 0.010. Thus we may conclude that vehicles with a tire with less than 3/32 mean tread depth are overrepresented in accidents on wet roads by nearly 2 to 1. The last column of Table 38 gives the results for vehicles involved on snow or ice. The results are midway between "dry" and "wet", and because of this (or the smaller number of cases) are not significantly different from either. This would suggest that while performance on wet surfaces is degraded by tread depths of less than 3/32 in, degradation on ice or snow--if it exists--is at a greater tread depth. Unfortunately, the small number of cars involved on ice or snow makes it difficult to examine dichotomies of tread depth with a more equal "split" because the variance of an estimated proportion increases as the proportion becomes closer to 0.5.

Table 38

Comparison of Wet and Dry
Surfaces with a Dichotomy
of Minimum Mean Tread Depths

Tread Depth	Dry	Wet	Snow/Ice
Up to 2/32	7.4%	13.2%	8.8%
Over 2/32	92.6%	86.8%	91.2%
Total %	100.0	100.0	100.0
N	583	220	155

3.4.3 <u>Tread Wear Patterns in the Accident Sample.</u> Since one depth measurement is made in each groove of a tire, the data are available to examine the pattern of tread wear, i.e., the pattern generated by differential wear across the surface of the tire in the lateral direction. The pattern itself may not be directly related to vehicle handling or accident causation. If it is, it would be through a complex relation between cornering or braking forces and tire pressure, load, lateral acceleration, carcass construction, etc. However, the wear pattern is directly related to tire pressure maintenance practices and suspension system geometry, particularly toe and camber. These factors, in turn, directly affect handling characteristics. Thus one might expect to find some association between wear patterns and accident experience, albeit indirect.

Unfortunately, the large amount of data generated by the individual groove measurements is difficult to categorize and analyze. One of the more conveniently obtained measures of the pattern is the range of groove depths on each tire. The distribution of ranges for front and rear tires is given in Table 39. Although front tires have a slightly lower range (the odds of a front tire having a lower range than a rear tire is 1.0007),[1] the difference is insignificant.

The range of groove depths is a rather crude measure of the wear pattern. A more descriptive procedure is provided by least squares fitting a second order equation to the groove depths given for each tire. This technique provides a predicted (or estimated) pattern defined completely by the three coefficients of the second order equation. Appendix C describes the procedure and results, and the derivation of the pattern characteristics that will be discussed here.

Two pattern characteristics will be discussed. One is the concavity or convexity of the pattern. Convex patterns are those that have more tread in the middle grooves than on either side, and are characteristic of continual underinflation. Concave patterns are those that have less tread in the middle than on either side, characteristic of continual overinflation. The amount of concavity or convexity is measured by the depth of the pattern, i.e., the maximum distance from a straight line joining the outside groove depth and the inner groove depth as shown in Figure C of Appendix C.

The second pattern characteristic to be discussed is lack of symmetry about the lateral center—more wear on one side than the other. This

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[1] The odds ratio and significance level were obtained by Flora's RIDITS technique. J.D. Flora, op cit.

Table 39

Tread Depth Range on Each Tire
(Maximum-Minimum Groove Depth)

Range in 32's	Front Tires N	Front Tires %	Rear Tires N	Rear Tires %
0	429	20.9	484	24.0
1	668	33.0	596	29.6
2	468	23.1	412	20.4
3	244	12.0	238	11.8
4	111	5.5	137	6.8
5	47	2.3	69	3.4
6	39	1.9	40	2.0
7	16	0.8	21	1.0
8	4	0.2	11	0.5
9	4	0.2	6	0.3
10	1	0.0	0	0.0
11	0	0.0	2	0.1
Total	2026	100.0	2016	100.0
≤2/32	1565	77.2	1492	74.0

pattern is usually characteristic of improper toe, but can be caused by incorrect camber.

Pattern Concavity/Convexity

The distribution (density function) of the depth of concavity/convexity is shown in Figure 5. Concave patterns are more common than convex patterns. This is surprising since it is characteristic of continued overinflation, while one might expect underinflation to be more common. The mode is at zero, which represents a linear pattern. Note that new passenger car tires have outside grooves about 2/32 deeper than middle grooves. Thus, a new tire would be concave with a pattern depth of 2/32. This may account for the skewness of Figure 5.

In the discussions of concavity/convexity to follow, the patterns have been trichotomized into groups that are concave, convex, and linear. The linear group has been expanded to include those with pattern depths of -1/32

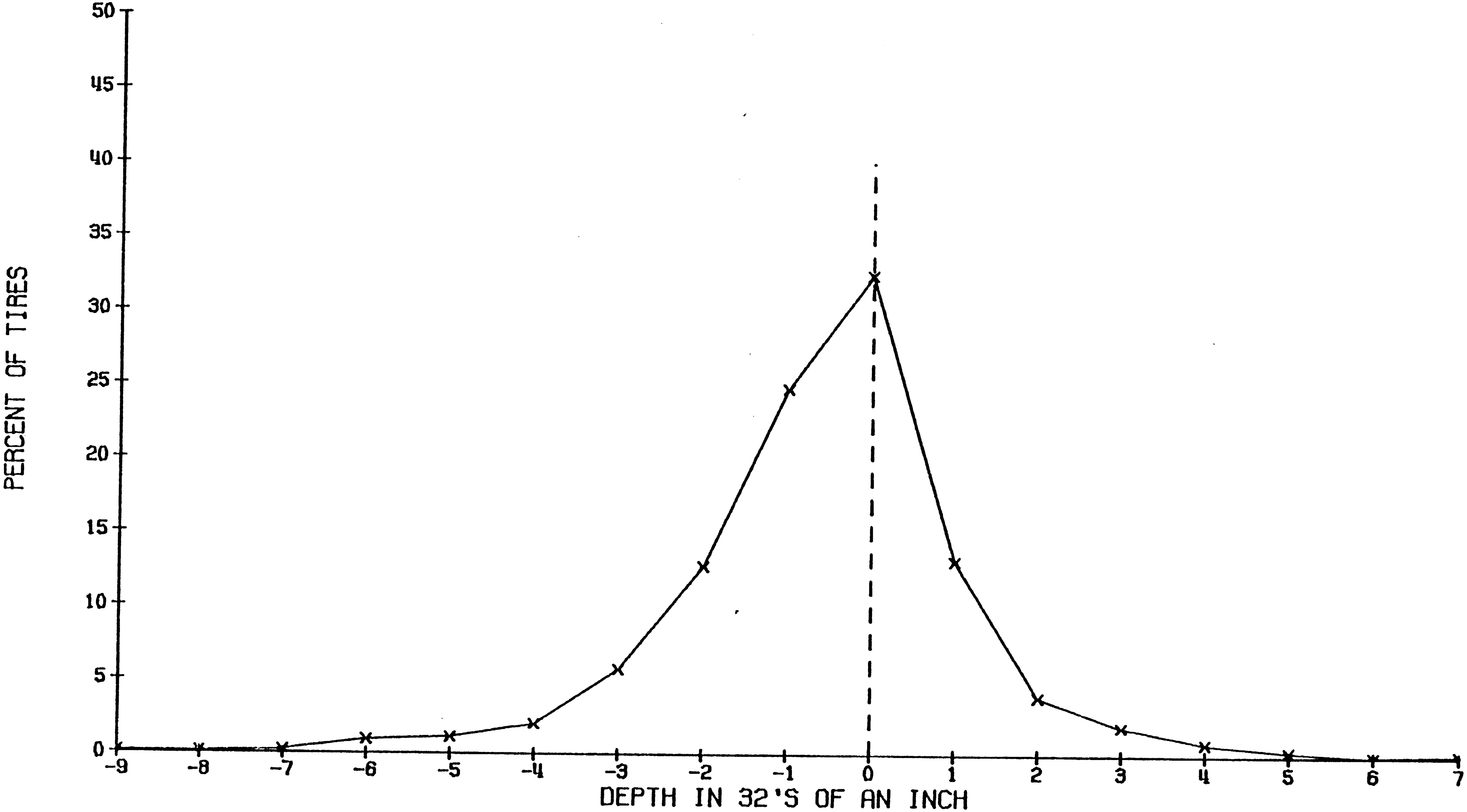

FIGURE 5
DEPTH OF TREAD WEAR PATTERN
OF TIRES IN ACCIDENTS
NEGATIVE VALUES INDICATE TREAD LOW IN CENTER

to +1/32 inch inclusive. This represents the resolution of depth measurements and is probably not an operationally significant departure from linear.

Pattern direction by wheel position is given in Table 40. The rear tires have a higher incidence of concave patterns, with fewer linear and convex patterns. The differences are statistically significant at the 0.000 level. The side to side differences are small.

Table 40

Tread Wear Pattern Direction
and Wheel Position

Position	Number of Tires and Row Percent		
	Direction		
	Concave	Linear	Convex
Left Front	270 27.5	551 56.1	162 16.5
Right Front	287 29.2	522 53.2	173 17.6
Left Rear	377 43.1	418 47.8	79 9.0
Right Rear	369 42.4	435 50.0	66 7.6

Table 41 gives the pattern direction by carcass type and this table is also significant at the 0.000 level. Radials have a high (66.6%) incidence of linear patterns, while both bias and belted-bias tires have a high incidence of concave patterns. Consistent with this, the radial tires also have a higher incidence of uniform (flat) patterns (29% for radials, 7% for belted-bias, and 9% for bias). Since the radials are a newer construction, one might expect the higher incidence of uniform and linear patterns on radials to result from less wear on these tires and hence, less opportunity to develop wear patterns. However, the mean groove depths (averaged over all grooves on all tires of each construction) differ little. They are 9.1 (32's) on the bias tires, 8.7 on belted-bias, and 9.2 on radials.

Table 41

Tread Wear Pattern Direction
and Carcass Type

Carcass Type	Number of Tires and Row Percent		
	Direction		
	Concave	Linear	Convex
Bias Ply	386 60.9	193 30.4	55 8.7
Belted-Bias Ply	459 52.5	274 31.3	142 16.2
Radial Ply	446 20.5	1448 66.6	279 12.8

Table 42 gives the pattern direction by tire aspect ratio. Only two ratios are common, 0.70 and 0.78. The differences in the distributions of 0.70 and 0.78 are not significant (X^2=0.8, d.f.=2). Tires with an aspect ratio of 0.60 are likely to have a convex patterns, significantly more frequently than for series 70 tires (X^2=11.8, sig level = 0.003). The distributions for other ratios differ, but are based on small numbers of cases.

Pattern directions by model type are given in Table 43. Passenger cars and small trucks are significantly different (X^2=33, d.f.=1) with essentially an interchange of the incidence of concave and linear patterns. This is not surprising since truck tires are more likely to be inflated for load capacity than for comfort or handling characteristics. Differences among the four passenger car models are also significant at the 0.000% level with X^2=48, d.f.=6. Subcompacts have the highest incidence of concave,

Table 42

Tread Wear Pattern Direction
and Tire Aspect Ratio

Aspect Ratio	Number of Tires and Row Percent		
	Direction		
	Concave	Linear	Convex
0.50	3 75.0	1 25.0	0
0.60	35 55.6	22 34.9	6 9.5
0.65	12 33.3	24 66.7	0
0.70	221 33.9	350 53.7	81 12.4
0.74	11 64.7	4 23.5	2 11.8
0.78	928 33.7	1456 52.9	366 13.3
0.80	21 43.8	20 41.7	7 14.6
0.88	54 54.5	36 36.4	9 9.1

while full size cars have the fewest. Conversely, full size cars have the greatest incidence of convex patterns and subcompacts the lowest. While these differences are statistically significant, they may not be operationally significant.

The pattern directions were also examined by inflation pressure. The tires used here were limited to load range B with no suspected loss of pressure during the accident. Table 44 gives the results of an ANOVA test of the means. The mean pressures do not differ significantly except between concave and linear. The Mann-Whitney test of ranks also indicates a

Table 43

Tread Wear Pattern Direction
and Model Type

Model Type	Number of Tires and Row Percent — Direction: Concave	Linear	Convex
Full size	234 28.1	468 56.1	132 15.8
Intermediate	236 30.1	448 57.2	99 12.6
Compact	325 37.6	411 47.5	129 14.9
Sub-compact	339 38.6	461 52.4	79 9.0
Total of above	1134 33.7	1788 53.2	439 13.1
Small trucks	165 49.1	130 38.7	40 12.2

difference between the concave and linear groups (with a level of significance of 0.04). However, the difference in means is so small—0.46 psi--that it is very doubtful if it is of any consequence.

Lack of a more pronounced association between pattern direction and inflation pressure is surprising since relative inflation pressure is one of the primary mechanisms of pattern generation. However, the pattern is a function of the history of inflation over the entire period of wear, rather than the pressure at a single point in time.

Pattern Asymmetry

The second characteristic of wear pattern examined is asymmetry of wear. Asymmetric wear is simply the loss of more tread from one side of a

Table 44

Means Test of Inflation Pressure
by Wear Pattern Direction

Load Range B tires with no suspected pressure loss		
Pattern Direction	Mean Pressure in PSI	Standard Deviation of the Mean
Concave	24.62	5.6
Linear	25.08	5.6
Convex	24.99	5.5

Between Group: F statistic = 2.2 Degrees of freedom = 2 Significance level = 0.12

tire than from the other. The derivation of this wear characteristic from the mathematical representation of the groove depth profile is discussed in Appendix C. Briefly, the asymmetry was classified into groups depending on whether they were worn more heavily on the outside, inside, flat (uniform depth), or were symmetrical but not flat. This was done by considering the location of the minimum depth of convex patterns, the maximum for concave patterns, or the sign of the slope of linear wear. The incidence of the asymmetry classifications for all tires in the accident data is presented in Table 45.[1] In this and subsequent tables the asymmetry will be classified by the location of maximum wear (minimum tread groove depth). Tires in the outside and inside categories include cases of convex or concave patterns with the axis of symmetry displaced laterally from the mid-point of the tire, and those with linear wear with a non-zero slope. In subsequent tables the tires with flat patterns will be aggregated with the symmetrical cases.

The distribution of the location of maximum wear is given for each wheel position in Table 46. Left-front tires are worn on the inside more

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[1] Table 45 and subsequent tables on asymmetry exclude 193 tires for which the tread depth data are not complete.

Table 45

Incidence of Tire Tread Wear Asymmetry

Location of Maximum Wear	Number of Tires	Percent
Outside	1012	26.8
Symmetrical	582	15.4
Inside	1421	37.7
Flat (uniform depth)	759	20.1
Missing Data	258	

frequently than right-front tires, and more frequently than they are on the outside. Right-front tires are worn on the inside and outside with equal frequency. The difference between right- and left-front tires is significant at the 0.0001 level (X^2=18.8, d.f.=2).

Table 46

Wear Pattern Asymmetry by Wheel Position

Number of Tires and Column Percent

Location of Maximum Wear	Position: Left Front	Right Front	Left Rear	Right Rear
Outside	253 25.6	329 33.3	226 25.1	204 22.8
Symmetrical	335 33.8	338 34.2	350 38.9	318 35.5
Inside	402 40.6	322 32.6	324 36.0	373 41.7

The difference in wear patterns on the two rear tires is statistically significant, but the magnitude of the difference is less than on the front tires. Similarly, the front tires as an aggregate have a distribution significantly different from that of the rear tires, but of a small magnitude.

Asymmetry by model type is given in Table 47. Differences in the table (5x3) are significant at the 0.0002 level with X^2=29.8 and 8 degrees of freedom. Compacts have the highest incidence of low tread on the outside, while small trucks have the highest incidence on the inside. Nearly equal proportions of all cars have symmetrical wear patterns, although trucks have substantially fewer.

Table 47

Wear Pattern Asymmetry by Model Type

Number of Tires and Column Percent

Location of Maximum Wear	Model: Full Size	Intermediate	Compact	Subcompact	Small Truck
Outside	203 24.2	209 26.3	209 24.1	258 28.7	130 36.0
Symmetrical	311 37.1	274 34.5	310 35.7	336 37.4	105 29.1
Inside	325 38.7	312 39.2	350 40.3	304 33.9	126 34.9

The distribution of asymmetry for dry road surfaces is compared to all other surface conditions (wet, snow, ice) in Table 48 for passenger cars only. The differences are small, but they are significant at the 0.04 level with X^2=6.5 and 2 degrees of freedom. The distribution for wet surfaces only is outside, 23.9%; symmetrical, 34.9%; inside, 41.2%. This distribution is not significantly different than for dry surfaces (X^2=2.2, d.f.=2). Thus, the significance in Table 48 is largely because of the winter accidents on snow or ice.

Table 48

Wear Pattern Asymmetry by Road Surface Condition
Passenger Cars

Location of Maximum Wear	Number of Tires and Column Percent — Surface: Dry	Other
Outside	557 26.5	318 24.6
Symmetrical	726 34.6	503 38.9
Inside	816 38.9	471 36.5

The associations of asymmetry with road surface coverings that are statistically significant are small, and it is not yet possible to identify them as causal accident factors.

The asymmetries of wear on tires of cars in one- and two-vehicle accidents are compared in Table 49. The differences are significant at the 0.0002 level (X^2=17.3, d.f.=2), with more tires with wear on the outside in single-vehicle accidents. Asymmetry is also significantly different among the types of two-vehicle collisions. This is shown in Table 50 for which X^2=28.3, d.f.=6. Vehicles involved in head-on or intersection accidents have a high incidence of maximum tread wear on the inside, while vehicles in rear-end collisions have a high incidence of symmetrical tread wear.

Table 49

Wear Pattern Asymmetry
by Number of Vehicles in Accident

Passenger Cars

Location of Maximum Wear	Number of Tires and Column Percent — Number of Vehicles in Accident: 1	2
Outside	404 28.6	475 23.9
Symmetrical	527 37.3	704 35.4
Inside	482 34.1	809 40.7

Table 50

Wear Pattern Asymmetry by Type of Collision for Two-Vehicle Accidents

Passenger Cars

Number of Tires and Column Percent

Location of Maximum Wear	Type of Collision			
	Head-on	Intersection (L and T)	Rear-end	Others
Outside	109 28.6	310 22.8	51 23.5	5 16.7
Symmetrical	118 31.0	484 35.6	98 45.2	4 13.3
Inside	154 40.4	566 41.6	68 31.3	21 70.0

APPENDIX A

Control Population Data Collection Form
with
Selected Univariate Percentages

HIGHWAY SAFETY RESEARCH INSTITUTE 6/76(2)

TIRE CONDITION SURVEY

POLICE FORM NUMBER ____________

CAR MODEL ____________

	RF	RR	LR	LF
TIRE TYPE (check one):				
UNKNOWN	0.3%	0.2%	0.6%	3.2%
BIAS PLY	16.3	16.3	16.4	15.6
BELTED BIAS PLY	50.8	51.6	50.8	48.8
RADIAL PLY	32.5	31.9	32.2	32.3
TIRE PRESSURE (PSI)	__ __	__ __	__ __	__ __
TREAD DEPTH (Center groove, 32nd's inch)	__ __	__ __	__ __	__ __
CHECK IF PRESENT:				
CUPPING	6.5	3.5	3.1	4.3
UNEVEN TREAD WEAR	7.6	5.1	4.1	5.8
BULGES OR BREAKS	1.1	0.5	0.3	0.8
TREAD SEPARATION	7.3	4.5	3.9	6.0

SIZE: RF ____________

RR ____________

LR ____________

LF ____________

APPENDIX B

Individual Case Summaries of Accident-Involved Vehicles with Radial Tires Mixed with Non-Radial Tires

(Unless otherwise indicated, all tires have regular highway tread)

Case HS 2180

1974 Dodge Charger 2-door sedan. Drinking driver fell asleep on a gentle curve in an urban area. Spun to left, sideways into a tree at right front door. Speed before impact 45 mph.

CDC = 03RPAW4, crush 23 in.

One occupant, alcohol noted.

Dry asphalt pavement at 2:19 am.

Tires:		Right	Left
Front -	Construction	Belted-Bias	Belted-Bias
	Size	F78-14	F70-14
	Tread Depth	5/32 in.	5/32 in.
	Inflation Pressure	26 psi	24 psi
Rear -	Construction	Radial	Radial
	Size	HR78-14	HR78-14
	Tread Depth	6/32 in.	5/32 in.
	Inflation Pressure	25 psi	26 psi

Case OK 2415

1974 Chevrolet Van 20. Single vehicle collision on US-10. Ran through a puddle. Slewed right over 5" curb, rolled to right, slid on right side, rolled down embankment onto left side, skidded on left side, rotated back on wheels.

CDC = OOLDA03 Prim. crush 7 in.
OORDA01 Sec. crush 3 in.

One occupant, no alcohol noted.

6 lane divided depressed expressway, concrete - no rain, but pavement puddled.

Tires:		Right	Left
Front -	Construction	Belted-Bias	Belted-Bias
	Size	unknown	unknown
	Tread Depth	5/32 in.	7/32 in.
	Inflation Pressure	28 psi	Deflated in crash
Rear -	Construction	Belted-Bias	Radial
	Size	L78-15	LR78-15
	Tread Depth	10/32 in.	2/32 in.
	Inflation Pressure	33 psi	26 psi

Case OK 2805

1973 Cadillac Calais, Head-on collision with a 1973 Chevy pickup. Cadillac driver said she went over the centerline because of ice, struck other vehicle head-on. Other vehicle was driving without lights (at 1:40 a.m. on a December morning). Neither driver drinking.

2 lane asphalt road, snow covered in moderate snowfall.

Speed - case vehicle 15 mph at impact.
other vehicle could not be located.

CDC = 12FREW1, crush 9 in.

Tires:		Right	Left
Front -	Construction	Radial	Belted-Bias
	Size	225-15	unknown
	Tread Depth	7/32 in.	10/32 in.
	Inflation Pressure	20 psi	20 psi
Rear -	Construction	Radial	Radial
	Size	225-15	225-15
	Tread Depth	7/32 in.	2/32 in.
	Inflation Pressure	20 psi	20 psi

Case HS 2272

1972 Buick Skylark 2-dr, H.T. Driver ran red light at intersection, struck in left side at "C" pillar. Driver & pass (unknown age, etc.) fled from scene. Speed before and at impact 26 mph.

CDC = 10LZEW3, crush 12 in.

Two occupants, asphalt pavement - slippery, snow covered at 4:40 p.m.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	GR70-14	GR70-14
	Tread Depth	4/32 in.	3/32 in.
	Inflation Pressure	unknown	22 psi
Rear -	Construction	Belted-Bias	Belted-Bias
	Size	H78-14	H78-14
	Tread Depth	4/32 in.	0/32 in.
	Inflation Pressure	Deflated in crash	21 psi

Case OK 2680

1973 Olds Toronado. Single vehicle collision. Driver went through a "T" intersection into a house. Told police brakes failed, but police tried them and said they worked OK. Driver also said accelerator stuck. Investigator could not check because of jammed hood.

Speed before impact 25, at impact 20 mph.

CDC = 12FDEW2 pri. house crush 18"
12FLMS1 sec. chain link fence

One occupant, no alcohol noted.

Road: 2 lane asphalt, dry, no precip.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	LR70-15	LR70-15
	Tread Depth	12/32 in.	12/32 in.
	Inflation Pressure	25 psi	25 psi
Rear -	Construction	Belted-Bias	Belted-Bias
	Size	J78-15	J78-15
	Tread Depth	4/32 in.	6/32 in.
	Inflation Pressure	21 psi	27 psi

Case HS 2407

1972 Mercury Monterey, 4-Door Sedan. Two vehicle collision on Michigan Avenue east of Ypsilanti. The case vehicle pulled out of a private drive, across the Eastbound lanes of Michigan, into the path of a Westbound Vega. Was struck in the left rear door and rear wheel area.

CDC=03-RZEW-2, crush 6 in.

One occupant, no alcohol noted.

5 lane pavement, dry, clear, daylight

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	HR 78-15	HR 78-15
	Tread Depth	5/32 in.	7/32 psi
	Inflation Pressure	32 psi	31 psi
Rear -	Construction	Radial	Bias (retread)
	Size	LR 78-15	H 78-15
	Tread Depth	6/32 in.	1/32 in.
	Inflation Pressure	unknown	15 psi

Case HS 2450

1974 Mercury Montego, 2-dr. hardtop. Two vehicle collision on Hamilton. Case vehicle entered an intersection from the north and was struck by a westbound Volkswagen Rabbit which ran a stop sign on an intersecting two-lane street.

CDC=10-LPEW-3 crush 11 in.

4 occupants,no alcohol noted on part of case vehicle driver.

4 lanes, asphalt - raining, night

Tires:		Right	Left
Front	- Construction	Bias	Bias
	Size	G 78-14	G 78-14
	Tread Depth	0/32 in.	0/32 in.
	Inflation Pressure	32 psi	33 psi
Rear	- Construction	Belted-Bias	Radial
	Size	G 78-14	FR 70-14
	Tread Depth	4/32 in.	5/32 in.
	Inflation Pressure	25 psi	15 psi

Case HS 2496

1974 AMC Gremlin. Single vehicle collision on Austin Road. Westbound on a rural road early in the morning. Drifted across the left lane, striking first a fence, then a barn.

CDC=03-RPEN-2 prim. crush 12 in.
12-FDEW-1 sec. crush 14 in.

1 occupant, alcohol noted.

2-lane asphalt, damp, dark.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	DR 78-14	DR 78-14
	Tread-Depth	8/32 in.	8/32 in.
	Inflation Pressure	45 psi	Deflated in crash
Rear -	Construction	Belted-Bias	Belted-Bias
	Size	E 70-14 (snow)	E 70-14 (snow)
	Tread Depth	14/32 in.	14/32 in.
	Inflation Pressure	24 psi	23 psi

Case HS 2517

1975 Ford Custom Van. Single vehicle collision. Driver fell asleep, ran off left side of southbound lanes of US-23 into the median.

CDC=12-FDEW-1 crush 1 in. (damage tie rod).

1 occupant, alcohol noted.

4 lanes, divided expressway, concrete, dry, dark.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	H 70-15	H 70-15
	Tread Depth	8/32 in.	8/32 in.
	Inflation Pressure	26 psi	unknown (deflated)
Rear -	Construction	Belted-Bias	Radial
	Size	H 78-15	H 70-15
	Tread-Depth	7/32 in.	5/32 in.
	Inflation Pressure	21 psi	34 psi

Case OK 2886

1975 Ford Granada 2-door hardtop. Single vehicle collision. Ran off right side of road, struck a tree in right front corner, then rolled onto roof.

CDC=01-FZEW-3 prim. crush 25 in. (tree)
00-TYHO-1 sec. crush 5 in.

2 occupants, both had been drinking.

2-lane, asphalt covered with snow or ice, dark.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	DR 78-14	DR 78-14
	Tread Depth	4/32 in.	5/32 in.
	Inflation Pressure	unknown (deflated in crash)	15 psi
Rear -	Construction	Bias	Bias
	Size	G 50-14 (snow)	G 50-14 (snow)
	Tread Depth	10/32 in.	10/32 in.
	Inflation Pressure	24 psi	23 psi

Case OK 2991

1973 Chevrolet Caprice Classic S/W. Two vehicle collision. Case vehicle turned left into right hand lane of 5-lane road from a parking lot driveway into path of another vehicle, and was struck in the right side (sideswipe).

CDC=04-RZES-2 crush 9 in. on right side.

4 occupants, no alcohol involved.
5 lane asphalt, raining, dark.

Tires:		Right	Left
Front -	Construction	Belted-Bias	Radial
	Size	L 78-15	LR 78-15
	Tread Depth	11/32 in.	5/32 in.
	Inflation Pressure	49 psi	29 psi
Rear -	Construction	Belted-Bias	Belted-Bias
	Size	G 70-15	G 70-15
	Tread Depth	10/32 in.	11/32 in.
	Inflation Pressure	26 psi	unknown (deflated in crash)

Case OK 2919

1976 Ford F-150 pickup. Two vehicle accident. Case vehicle ran a stop light and struck other vehicle which was completing a left turn.

CDC=10-FZEW-2 crush 14 in.

1 occupant, no alcohol involved.

5 lane asphalt, dry.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	230-15X	230-15X
	Tread Depth	10/32 in.	9/32 in.
	Inflation Pressure	25 psi	26 psi
Rear -	Construction	Belted-Bias	Belted-Bias
	Size	L 78-15 (snow)	L 78-15 (snow)
	Tread Depth	5/32 in.	10/32 in.
	Inflation Pressure	31 psi	25 psi

Case OK 2969

1974 Ford LTD 4-dr. Sedan. Single vehicle accident. Turning left from 5 lane highway into service station. Driver was blinded by sun (turning from South to East at 7:15 am in May) and struck light pole which was in middle of station drive.

CDC=12-FCEN-1 crush 5 in.

5 land asphalt, dry.

1 occupant, no alcohol involved.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	HR 78-15	HR 78-15
	Tread Depth	11/32 in.	8/32 in.
	Inflation Pressure	31 psi	31 psi
Rear -	Construction	Belted-Bias	Belted-Bias
	Size	G 78-15 (snow)	G 78-15 (snow)
	Tread Depth	9/32 in.	7/32 in.
	Inflation Pressure	25 psi	30 psi

Case OK 3022

1975 AMC Pacer. Single vehicle accident. Driver claims he was distracted by vehicle encroaching on his left, ran off road to right and struck wrought iron fence.

CDC=02-RFEN-1 crush 1 in.

1 occupant, no alcohol involved.

4 lane concrete, dry.

Tires:		Right	Left
Front -	Construction	Radial	Bias
	Size	DR 78-14	D 78-14
	Tread Depth	5/32 in.	9/32 in.
	Inflation Pressure	unknown (deflated in accident)	29 psi
Rear -	Construction	Radial	Radial
	Size	DR 78-14	DR 78-14
	Tread Depth	5/32 in.	6/32 in.
	Inflation Pressure	unknown (deflated in accident)	28 psi

Case OK 3035

1973 Chevrolet Monte Carlo single vehicle crash. Vehicle ran off road, to right and struck guardrail/bridge rail.

CDC=01-FREE-9 crush 98 in. (sideswipe).

6 lane (divided) concrete, dry.

1 occupant, alcohol involved.

Tires:		Right	Left
Front -	Construction	Radial	Belted-Bias
	Size	GR 70-15	H 78-15
	Tread Depth	8/32 in.	4/32 in.
	Inflation Pressure	unknown (deflated)	unknown (deflated)
Rear -	Construction	Radial	Radial
	Size	GR 70-15	GR 70-15
	Tread Depth	9/32 in.	10/32 in.
	Inflation Pressure	22 psi	unknown (deflated)

Case OK 3124

1973 Chevrolet Chevyvan 10. Two vehicle collision. In turning left, pulled out from stop sign and stopped in near lane while waiting for far lane to clear. Struck in left side.

CDC=09-LPEW-3 crush 18 in.

1 occupant, no alcohol involved.

2-lane concrete, dry.

Tires:		Right	Left
Front	- Construction	Radial	Radial
	Size	FR 78-14	FR 78-14
	Tread Depth	8/32 in.	7/32 in.
	Inflation Pressure	30 psi	unknown (deflated in accident)
Rear	- Construction	Bias	Bias
	Size	H 78-14	H 78-14
	Tread Depth	9/32 in.	9/32 in.
	Inflation Pressure	30 psi	unknown (deflated in accident)

Case OK 3198

1972 Chevrolet Sportvan 20. Single vehicle accident. Skidded to left across left lane into concrete bridge rail.

CDC=02-RYEN-4 crush 20 in.

2-lane, asphalt, covered with snow.

3 occupants, no alcohol involved.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	JR 70-15	JR 70-15
	Tread Depth	10/32 in.	10/32 in.
	Inflation Pressure	16 psi	21 psi
Rear -	Construction	Belted-Bias	Radial
	Size	H 78-15	JR 70-15
	Tread Depth	10/32 in.	10/32 in.
	Inflation Pressure	16 psi	21 psi

Case OK 3239

1976 Chevrolet Monte Carlo. Single vehicle accident. "Lost control" and ran off road to right into light pole.

CDC=10-LFEW-3 crush 20 in.

3 lane concrete ramp, covered with snow, dark.

1 occupant, no alcohol involved.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	GR 70-15	GR 70-15
	Tread Depth	7/32 in.	10/32 in.
	Inflation Pressure	36 psi	33 psi
Rear -	Construction	Radial	Belted-Bias
	Size	GR 70-15	unknown
	Tread Depth	6/32 in.	2/32 in.
	Inflation Pressure	unknown (deflated in accident)	29 psi

Case OK 3275

1975 Ford LTD 2-dr. Two vehicle collision. Vehicle proceeded through intersection on red stop light, struck other vehicle crossing with green light.

CDC=10-LFEW-3 prim. crush 17 in.
09-LZEW-1 sec. crush 7 in.

4 lane concrete, wet.

4 occupants, no alcohol involved.

Tires:		Right	Left
Front -	Construction	Belted-Bias	Belted-Bias
	Size	H 78-15	H 78-15
	Tread Depth	11/32 in.	10/32 in.
	Inflation Pressure	13 psi	21 psi
Rear -	Construction	Radial	Radial
	Size	HR 78-15	HR 78-15
	Tread Depth	9/32 in.	8/32 in.
	Inflation Pressure	24 psi	21 psi

Case OK 3322

1975 Pontiac Astre S/W. Single vehicle accident. Lost control on ice while changing lanes, ran off road to left and struck marker barrel with front left.

CDC=01-RFEN-2 crush 6 in.

4-lane, divided concrete, ice covered.

2 occupants, no alcohol noted.

Tires:		Right	Left
Front -	Construction	Radial	Bias
	Size	BR 78-13	B 78-13
	Tread Depth	5/32 in.	8/32 in.
	Inflation Pressure	30 psi	23 psi
Rear -	Construction	Bias	Bias
	Size	B 78-13	B 78-13
	Tread Depth	10/32 in.	9/32 in.
	Inflation Pressure	15 psi	13 psi

Case OK 3331

1972 Oldsmobile Toronado. Two vehicle collision. Vehicle was traveling on 8-lane divided artery and struck a vehicle that was turning from a drive on the right.

CDC=01-FDEW-1 crush 12 in.

One occupant who had been drinking.

8-lane divided asphalt, dry.

Tires:		Right	Left
Front -	Construction	Radial	Radial
	Size	225-15	225-15
	Tread Depth	7/32 in.	7/32 in.
	Inflation Pressure	22 psi	21 psi
Rear -	Construction	Bias	Radial
	Size	J 78-15	LR 78-15
	Tread Depth	10/32 in.	7/32 in.
	Inflation Pressure	25 psi	26 psi

APPENDIX C

Mathematical Representation of Tread Wear Patterns

The tread on each tire is described by a simple measurement of the depth of each groove in a location not over a wear indicator. This gives substantial data on each tire, sufficient to describe wear patterns. However, the fact that each tire is described by up to ten variables makes analysis cumbersome. The technique that was used to represent the wear pattern of each tire for analytical purposes is described below.

The wear pattern given by a depth measurement in each groove can be conceptualized in the framework of a cartesian coordinate system in which the groove number is the abscissa and the depth (in 32nds of an inch) is the ordinate.

These points can be represented—i.e., the pattern they describe can be characterized—by a curve (envelope) passing through them. The curve used in this study is the second order equation:

$$Y = a_0+a_1X+a_2X^2$$

where: Y = the estimated depth of groove X in 32's of an inch

X = the groove number ($1 \leq X \leq N$)

a_0, a_1, a_2 = constants unique to each tire

Groove 1 is the outside groove of the mounted tire and N is the number of grooves on the tread (the sidewall "grooves" of radial tires were not included in the data collection).

The constants a_0, a_1, and a_2 were determined by a least squares fit for each tire in the accident sample. The number of grooves on tires in the data set ranges from 2 (136 tires) to 9 (2 tires). The tires with 2 grooves are snow tires and 80% of them were on rear wheels. For the sake of simplicity only tires with 3 to 8 grooves were fit with the quadratic. Thus 1859 of the 2052 tires in the accident data file were "fit," with missing data for each coefficient for 193 tires.

An example is shown in Figure C1. The circled points are the depth of each groove—eight in this example—as measured in the field. Values of the constants for the least squares fit are:

$$a_0 = 7.321$$

$$a_1 = 2.262$$

$$a_2 = -0.333$$

The curve of predicted values given by these constants is the solid line of the figure. Other features of the figure will be explained later. For this tire the fit is excellent.

In general the second order function was successful in representing the profile (or pattern) of worn tires. The root-mean-square error (residuals) for all grooves of all 1859 tires was 0.0183 inches. Figure C2 gives the cumulative distribution of the maximum error for each tire. Thus 50% of the tires have maximum errors in the predicted pattern of 0.17/32 or less,[1] while 90% have maximum errors of 0.69/32 or less. Figures C3 and C4 give histograms of the computed values of a_0 and a_1 respectively, while Figure C5 gives the distribution of a_2.

It may be noted that a_1 can have large absolute values. These should not be interpreted as high slopes. The constant a_1 can be interpreted as a slope only when $a_2=0$, in which case the wear pattern is linear. If $a_2=0$, the predicted pattern is parabolic, and much of a_1 results from translation of the axis of the parabola away from the origin, usually to a location between the outside groove (X=1) and the inside groove (X=N).

Interpretation of the Mathematical Representation

The parabolic representation of tread wear patterns is convenient because only three parameters are required—rather than a variable number ranging up to eight—and because certain key features of the patterns can be readily determined. Two particular features are addressed in this study. One is the concavity or convexity of the pattern, the other is unsymmetrical wear.

The example shown in Figure C1 has higher tread in the center. As a result, the parabola fitting the pattern opens downward. Such a pattern will be denoted as convex, and exemplifies the classical pattern from under-

---

[1] This strange notation is used because the basic unit of measurement was 1/32 of an inch, and all computations are in terms of this basic unit.

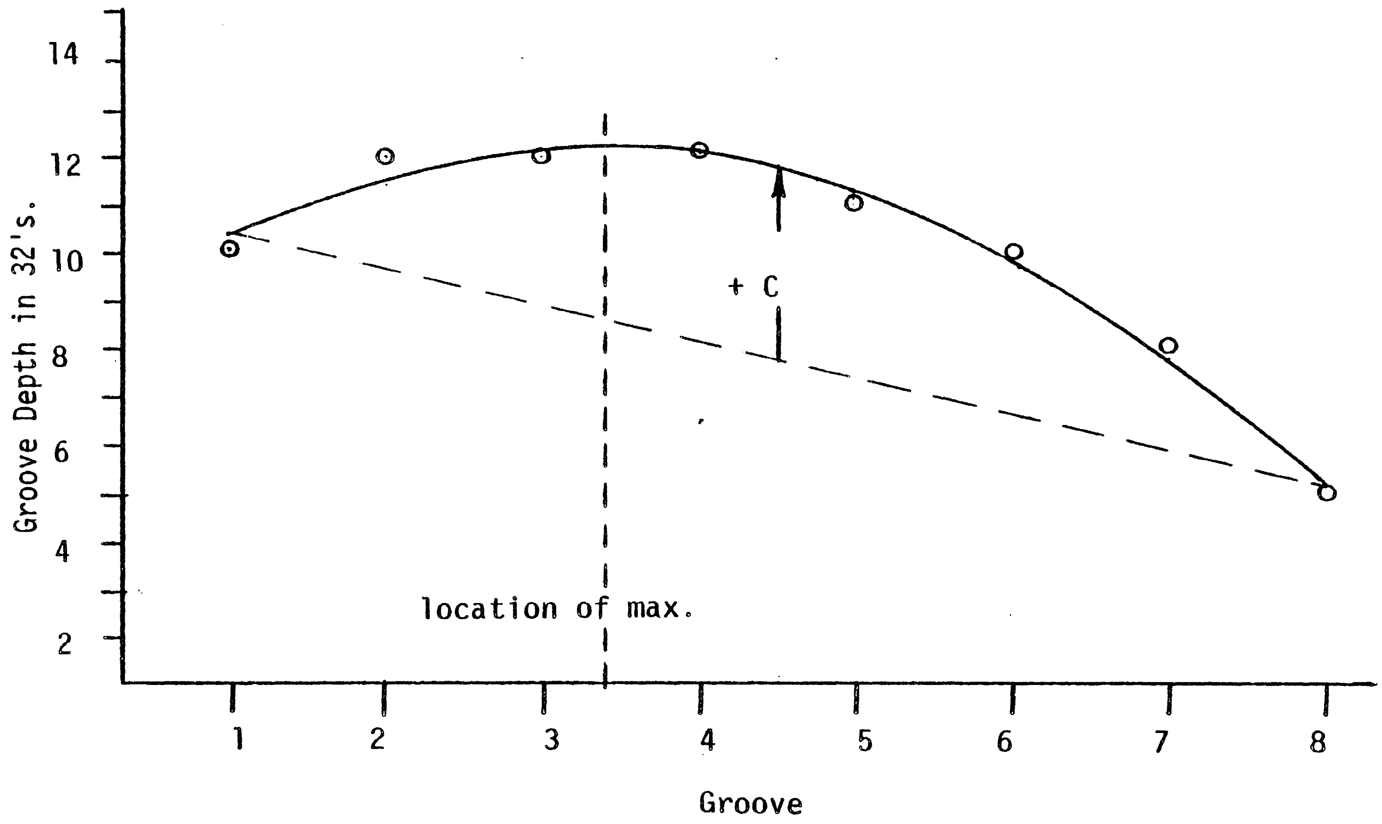


Figure C1

Sample Representation of a Tread Wear Pattern by a Second Order Curve

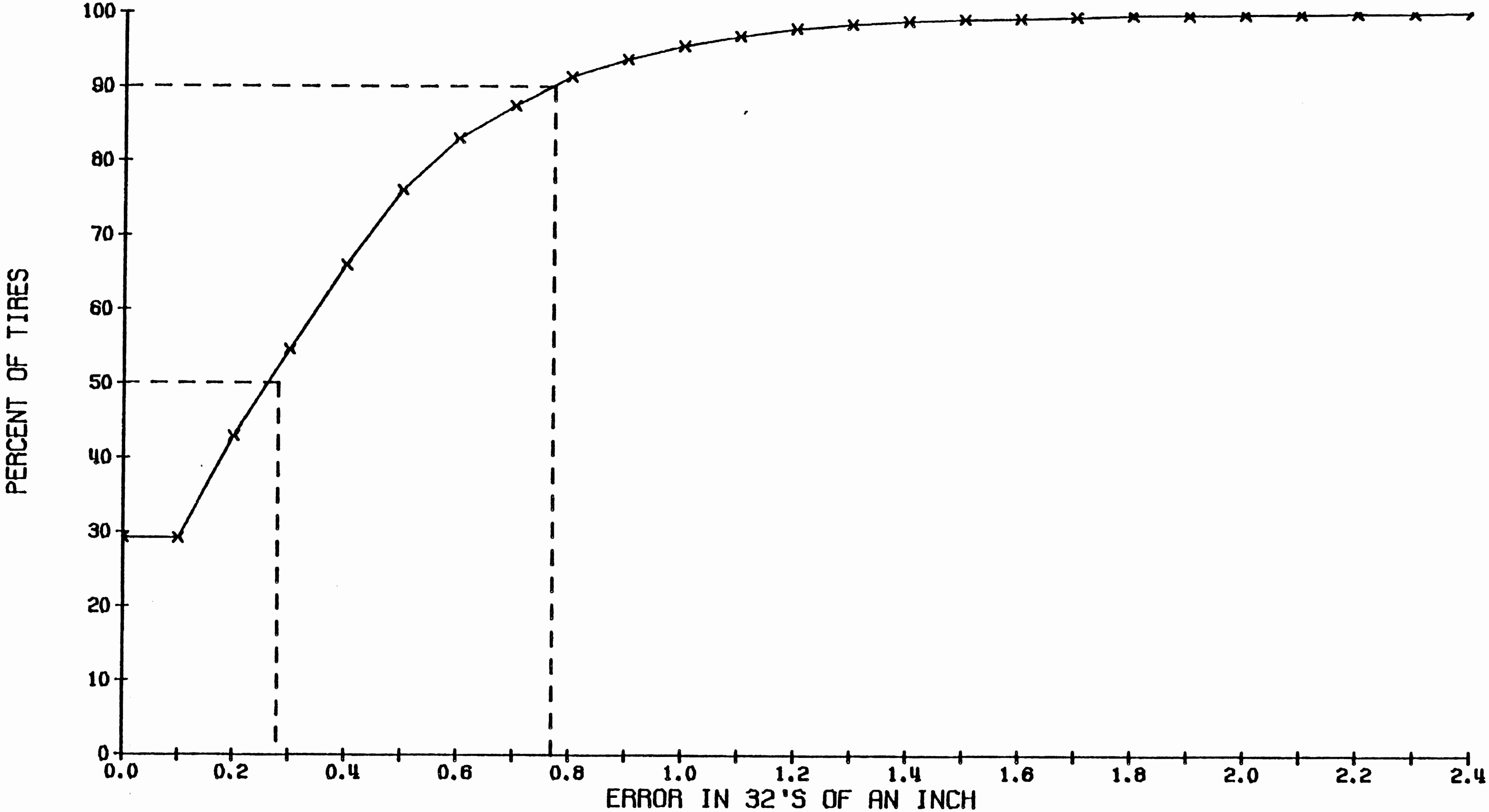


FIGURE C2
CUMULATIVE DISTRIBUTION OF THE MAXIMUM
DIFFERENCE BETWEEN OBSERVED AND PREDICTED
GROOVE DEPTH FOR EACH TIRE

Midpoint	Percent	Count for A0 (Each X=12)
-13.000	0.0	1 +X
. . .		
-9.0000	0.0	1 +X
-8.0000	0.0	1 +X
. . .		
-6.0000	0.0	1 +X
-5.0000	0.1	2 +X
-4.0000	0.2	9 +X
-3.0000	0.3	10 +X
-2.0000	0.5	19 +XX
-1.0000	0.4	16 +XX
0.	0.6	24 +XX
1.0000	1.2	47 +XXXX
2.0000	1.4	52 +XXXXX
3.0000	2.0	74 +XXXXXXX
4.0000	2.2	84 +XXXXXXX
5.0000	3.5	132 +XXXXXXXXXXX
6.0000	3.9	148 +XXXXXXXXXXXXX
7.0000	5.5	209 +XXXXXXXXXXXXXXXXXX
8.0000	6.1	232 +XXXXXXXXXXXXXXXXXXXX
9.0000	8.7	328 +XXXXXXXXXXXXXXXXXXXXXXXXXXXX
10.000	9.5	360 +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
11.000	11.1	418 +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
12.000	12.0	452 +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
13.000	8.3	312 +XXXXXXXXXXXXXXXXXXXXXXXXXX
14.000	6.9	261 +XXXXXXXXXXXXXXXXXXXXXX
15.000	5.6	211 +XXXXXXXXXXXXXXXXXX
16.000	3.6	134 +XXXXXXXXXXXX
17.000	2.4	90 +XXXXXXXX
18.000	1.1	40 +XXXX
19.000	0.8	31 +XXX
20.000	0.6	22 +XX
21.000	0.2	7 +X
22.000	0.2	8 +X
23.000	0.2	6 +X
24.000	0.2	7 +X
. . .		
26.000	0.1	3 +X
27.000	0.1	2 +X
28.000	0.1	2 +X
29.000	0.1	2 +X
30.000	0.1	3 +X
31.000	0.1	2 +X
32.000	0.0	1 +X
33.000	0.1	2 +X
. . .		
35.000	0.1	3 +X
36.000	0.1	2 +X
37.000	0.0	1 +X
. . .		
39.000	0.0	1 +X
. . .		
44.000	0.0	1 +X
Missing		402
Total		4176

Note: The width of each interval is 1.0.

Figure C3

Histogram of the Constant Term in the Second Order Equation for tread Pattern

Midpoint	Percent	Count for A1	(Each X=29)
-36.000	0.0	1	+X
. . .			
-30.000	0.0	1	+X
-29.000	0.1	2	+X
-28.000	0.0	1	+X
. . .			
-26.000	0.0	1	+X
-25.000	0.1	2	+X
-24.000	0.0	1	+X
. . .			
-21.000	0.1	2	+X
-20.000	0.1	3	+X
. . .			
-17.000	0.0	1	+X
-16.000	0.1	5	+X
. . .			
-14.000	0.1	2	+X
-13.000	0.2	6	+X
-12.000	0.4	14	+X
-11.000	0.1	3	+X
-10.000	0.2	7	+X
-9.0000	0.2	8	+X
-8.0000	0.4	15	+X
-7.0000	1.0	39	+XX
-6.0000	1.1	41	+XX
-5.0000	2.9	110	+XXXX
-4.0000	3.9	147	+XXXXXX
-3.0000	6.1	231	+XXXXXXXX
-2.0000	15.8	596	+XXXXXXXXXXXXXXXXXXXXX
-1.0000	16.7	632	+XXXXXXXXXXXXXXXXXXXXXX
0.	30.7	1159	+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1.0000	10.1	383	+XXXXXXXXXXXXXX
2.0000	4.7	179	+XXXXXXX
3.0000	3.0	113	+XXXX
4.0000	1.0	36	+XX
5.0000	0.4	14	+X
6.0000	0.3	10	+X
7.0000	0.0	1	+X
8.0000	0.1	3	+X
9.0000	0.0	1	+X
. . .			
11.000	0.0	1	+X
12.000	0.0	1	+X
. . .			
18.000	0.0	1	+X
. . .			
23.000	0.0	1	+X
Missing		402	
Total		4176	

Note: The width of each interval is 1.0.

Figure C4

Histogram of the coefficients of the First Order Term in the Equation for Tread Pattern

```
Midpoint    Percent  Count for A2    (each X=38)
-4.4000      0.1       2 +X
  . . .
-2.2000      0.1       2 +X
-2.0000      0.0       1 +X
-1.8000      0.0       1 +X
  . . .
-1.4000      0.0       1 +X
-1.2000      0.1       3 +X
-1.0000      0.2       7 +X
-.80000      0.5      18 +X
-.60000      0.7      25 +X
-.40000      5.0     187 +XXXXX
-.20000      9.8     369 +XXXXXXXXXX
 .0         39.4    1486 +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 .20000     19.9     750 +XXXXXXXXXXXXXXXXXXXX
 .40000      8.3     314 +XXXXXXXXX
 .60000      7.5     282 +XXXXXXXX
 .80000      2.7     102 +XXX
 1.0000      3.0     112 +XXX
 1.2000      0.6      24 +X
 1.4000      0.1       2 +X
 1.6000      0.6      24 +X
 1.8000      0.1       5 +X
 2.0000      0.3      11 +X
 2.2000      0.2       6 +X
 2.4000      0.0       1 +X
 2.6000      0.2       9 +X
 2.8000      0.1       2 +X
 3.0000      0.2       7 +X
  . . .
 3.6000      0.0       1 +X
  . . .
 4.0000      0.1       5 +X
  . . .
 4.6000      0.0       1 +X
  . . .
 5.0000      0.1       3 +X
  . . .
 5.6000      0.1       2 +X
  . . .
 6.0000      0.1       2 +X
  . . .
 6.6000      0.1       2 +X
  . . .
 7.0000      0.0       1 +X
  . . .
 7.6000      0.1       3 +X
  . . .
 9.0000      0.0       1 +X

 Missing            402
 Total             4176
```

Notes: The width of each interval is 0.2.

889 cases equal exactly zero. 597 additional cases range from -0.15 to +0.15

Figure C5

Histogram of the Coefficients of the Second Order Term in the Equation for Tread Pattern inflation. Convex patterns result in negative values of a_2, while positive values indicate concave patterns. A measure of the concavity/convexity is the depth of "dishing" shown by C in Figure C1, where C is the maximum distance from a straight line through the predicted depths of the outer two grooves and the parabola between the outer grooves. The sign of C is arbitrarily chosen to be positive when the pattern is convex.

$$C = -a_2(N-1)^2/4$$

and is 3.39 in the example shown. The location of C (groove number) is

$$\text{Groove}_C = (N+1)/2$$

which is the center of the tread.

In the analysis reported in Section 3.4.3, the patterns were treated as a trichotomy, those that are concave, convex, or linear. The linear group was expanded to include cases in which

$$-1/32 \leq C \leq 1/32$$

since the measurements of depth have a resolution of 1/32, and such small deviations from linearity are probably irrelevant.

The other pattern characteristic examined is its lateral symmetry. If $a_2 \neq 0$, indicating a parabola, the wear is symmetrical if the vertical axis of the parabola is located in the center of the tread. If the axis is off-center, the wear is greater on one side—the classical wear pattern of improper toe or camber. The axis of the parabola is located at the point of maximum or minimum tread depth given as a groove number by

$$G_{M/M} = -a_1/2a_2 \qquad a_2 \neq 0,$$

or as the proportion of the distance from groove 1 to the inner groove, N by

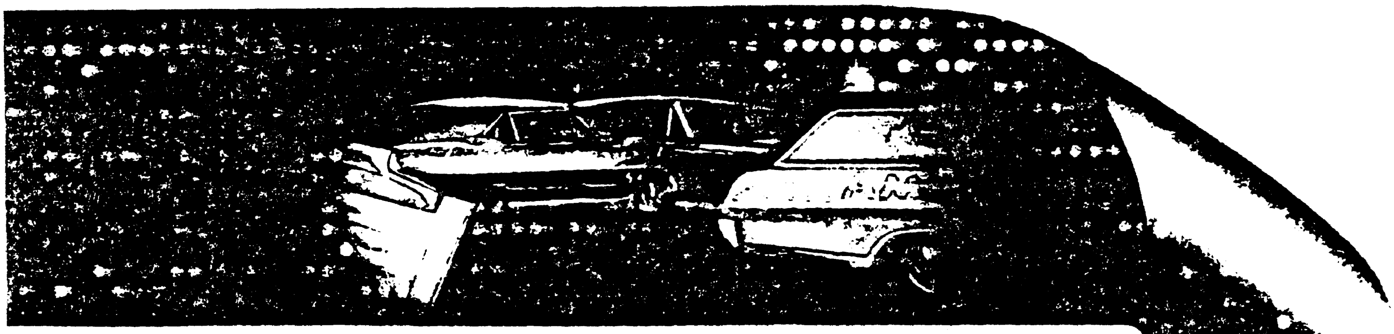
$$\text{Location of } G_{M/M} = -(a_1/2a_2+1)/(N-1) \qquad a_2 \neq 0$$

The location of the maximum or minimum—greater or less than 0.5—in combination with the sign of a_2 indicating whether a maximum or minimum—can be used to determine whether the inside or outside has lower tread.

If a_2=0, the pattern is linear. In this case the sign of the slope (a_1) indicates the side with the greater wear. If $a_2 \neq 0$ and the location of the maximum or minimum is at 0.5, the pattern is symmetrical. If both a_1=0 and $a_2=0$, the pattern is uniform (flat) and hence also symmetrical.

APPENDIX D

Data Collection Form



ANNOTATED

COLLISION PERFORMANCE and INJURY REPORT

REVISION 3

EDITION 1/76

VH/IC STUDY

4/76

Form 2/76

HIGHWAY SAFETY RESEARCH INSTITUTE
THE UNIVERSITY OF MICHIGAN

2/1

Card 5 0 (10)

VEHICLE HANDLING AND INJURY CAUSATION STUDY

* *

TEAM ____________________ INVESTIGATOR __ __ (12)

CASE NO. __ __-__ __ __ __ __ __-__ (2, 9) INVESTIGATION DATE __ __/__ __/__ __ (14) mo day yr

OTHER VEHICLE CASE NO. __ __-__ __ __ __ __ __-__ (20, 27)

* *

REPORTING POLICE DEPT. __ (28) POLICE REPORT NO. __ __ __ __ __ (29)

DATE OF ACCIDENT __ __/__ __/__ __ (34) mo day yr TIME OF ACCIDENT 24 hour clock __ __ __ __ (40)

* *

CASE VEHICLE ACTUALLY TOWED? (44)

( )1 YES ⟶ to: ____________
( )2 NO reason: ____________

OTHER VEHICLE ACTUALLY TOWED? (45)

( )1 YES ⟶ to: ____________
( )2 NO reason: ____________
( )3 NO OTHER VEHICLE

* *
* *

INVESTIGATION TERMINATED

I. Investigation Complete: (46)

a( )1 Data Complete
b( )2 Data Incomplete

II. Investigation Incomplete;

c( )3 No Data--case could not be investigated.
reason: ____________

d Case Did Not Meet Criteria.
Reason:
( )4 Not towed from scene
( )5 Not towed for damage
( )6 License plate no. incorrect
( )8 Other:____________

* *

SAMPLE RULE/PERIOD (47)
( ) 1 ( ) 3
( ) 2 ( ) 4

VEHICLE INSPECTED (48)
( )1 YES
( )2 NO

TOTAL CASE SLIDES __ __ (49)

KP DATE 51-56 57-58=0

Dup 1-9 Card 5 1

LEFT-FRONT WHEEL AND TIRE

WHEEL

WHEEL

INSPECTED 12 (1) Yes (2) No, why ______ (9) Unk

ORIGINAL EQUIPMENT 13 (1) Yes (2) No, describe ______ (9) Unk

DAMAGED 14 (2) No (1) Yes, describe ______ (9) Unk

TIRE

IDENTIFICATION

POSITION 15 (1) This Position (9) Unknown Position

INSPECTED 16 (1) Yes (2) No, why ______ (9) Unk

TREAD TYPE ___ 17

(1) Regular (3) Studded Snow (5) Reg/Chains (8) Other
(2) N/S Snow (4) Snow/Chains (6) Slick (9) Unknown

INTENDED USE ___ 18

(1) Pass. Car (3) Off Road (8) Other
(2) Light Truck (4) Trailer (9) Unknown

SIZE: 19 __ __ __ __ __ __ __ __ __ __ 28

BRAND ______ 29 __ __

MODEL ______ 32 __ __

DOT CODE* 35 __ __ __ __ __ __ __ __ __ __ __ __ 46

LOAD RANGE* ___ 47 MAXIMUM LOAD* 48 __ __ __ __ MAXIMUM PSI* 52 __ __

RETREAD 54 (2) No (1) Yes (9) Unk TUBE 55 (2) No (1) Yes (9) Unk

CONSTRUCTION

CARCASS TYPE 56 (1) Bias (2) Belted-Bias (3) Radial (8) Other (9) Unk

NO. TREAD PLIES* ___ 57 BELT MATERIAL ___ 58 ___ 59 0 60

NO. SIDEWALL PLIES* ___ 61 SIDEWALL MATERIAL ___ 62

UNKNOWN = 9

(0) None (2) Rayon (4) Polyester (8) Other
(1) Nylon (3) Fiberglass (5) Steel (9) Unk

Dup 1-9 Card 5 2

CONDITION

OUTER GROOVE TREAD DEPTH* NO. GROOVES* 73 __ __

14 __ __ : __ __ : __ __ : __ __ : __ __ : __ __ : __ __ : __ __ : __ __ : __ __ 33

UNKNOWN = 9's

CUPPING 34 (2) No (1) Yes (9) Unk

PRESSURE LOSS SUSPECTED 35

(1) None (2) Pre-crash (3) Crash
(4) Post-crash (8) Unknown time

PSI* 36 ___ ___

NUMBER OF SLIDES* ___ 38

DAMAGED 39 (2) No (1) Yes, describe ______ (9) Unk

DAMAGE CONTRIBUTORY TO ACCIDENT 40 ( )3 Not Damaged ( )2 No ( )1 Yes (9) Unk

* UNKNOWN = 9's

Dup 1-9 Card 5 3

2/76

RIGHT-FRONT WHEEL AND TIRE

WHEEL

WHEEL

INSPECTED 12 (1) Yes (2) No, why ____________________ (9)Unk

ORIGINAL EQUIPMENT 13 (1) Yes (2) No, describe ____________________ (9)Unk

DAMAGED 14 (2) No (1) Yes, describe ____________________ (9)Unk

TIRE

IDENTIFICATION

POSITION 15 (1) This Position (9) Unknown Position

INSPECTED 16 (1) Yes (2) No, why ____________________ (9)Unk

TREAD TYPE ___ 17

(1) Regular (3) Studded Snow (5) Reg/Chains (8) Other
(2) N/S Snow (4) Snow/Chains (6) Slick (9) Unknown

INTENDED USE ___ 18

(1) Pass. Car (3) Off Road (8) Other
(2) Light Truck (4) Trailer (9) Unknown

SIZE: 19 ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ 28

BRAND ____________________ 29 ___ ___ ___

MODEL ____________________ 32 ___ ___ ___

DOT CODE* 35 ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ 46

LOAD RANGE* ___ 47 MAXIMUM LOAD* 48 ___ ___ ___ ___ MAXIMUM PSI* 52 ___ ___

RETREAD 54 (2) No (1) Yes (9) Unk TUBE 55 (2) No (1) Yes (9) Unk

CONSTRUCTION

CARCASS TYPE 56 (1) Bias (2) Belted-Bias (3) Radial (8) Other (9) Unk

NO. TREAD PLIES* ___ 57 BELT MATERIAL ___ 58 ___ 59 0 60

NO. SIDEWALL PLIES* ___ 61 SIDEWALL MATERIAL ___ 62

UNKNOWN = 9

(0) None (2) Rayon (4) Polyester (8) Other
(1) Nylon (3) Fiberglass (5) Steel (9) Unk

Dup 1-9 Card 5 4

CONDITION

OUTER GROOVE

TREAD DEPTH* NO. GROOVES* 12 ___ ___

14 ___ ___ : ___ ___ : ___ ___ : ___ ___ : ___ ___ : ___ ___ : ___ ___ : ___ ___ : ___ ___ : ___ ___ 33

UNKNOWN = 9's

CUPPING 34 (2) No (1) Yes (9) Unk

PRESSURE LOSS SUSPECTED 35

(1) None (2) Pre-crash (3) Crash
(4) Post-crash (8) Unknown time

PSI* 36 ___ ___

NUMBER OF SLIDES* ___ 38

DAMAGED 39 (2) No (1) Yes, describe ____________________ (9)Unk

DAMAGE CONTRIBUTORY TO ACCIDENT 40 ( )3 Not Damaged ( )2 No ( )1 Yes (9)Unk

* UNKNOWN = 9's

Dup 1-9 Card 5 5

LEFT-REAR WHEEL AND TIRE

WHEEL

WHEEL

INSPECTED 12 (1) Yes (2) No, why ______ (9)Unk

ORIGINAL EQUIPMENT 13 (1) Yes (2) No, describe ______ (9)Unk

DAMAGED 14 (2) No (1) Yes, describe ______ (9)Unk

TIRE

IDENTIFICATION

POSITION 15 (1) This Position (9) Unknown Position

INSPECTED 16 (1) Yes (2) No, why ______ (9)Unk

TREAD TYPE ___ 17

(1) Regular (3) Studded Snow (5) Reg/Chains (8) Other
(2) N/S Snow (4) Snow/Chains (6) Slick (9) Unknown

INTENDED USE ___ 18

(1) Pass. Car (3) Off Road (8) Other
(2) Light Truck (4) Trailer (9) Unknown

SIZE: ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ 19–28

BRAND ______ ___ ___ ___ 29

MODEL ______ ___ ___ ___ 32

DOT CODE* ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ 35–46

LOAD RANGE* ___ 47 MAXIMUM LOAD* ___ ___ ___ ___ 48 MAXIMUM PSI* ___ ___ 52

RETREAD 54 (2) No (1) Yes (9) Unk TUBE 53 (2) No (1) Yes (9) Unk

CONSTRUCTION

CARCASS TYPE 56 (1) Bias (2) Belted-Bias (3) Radial (8) Other (9) Unk

NO. TREAD PLIES* ___ 57 BELT MATERIAL ___ 58 ___ 59 0 60

NO. SIDEWALL PLIES* ___ 61 SIDEWALL MATERIAL ___ 62

UNKNOWN = 9

(0) None (2) Rayon (4) Polyester (8) Other
(1) Nylon (3) Fiberglass (5) Steel (9) Unk

Dup 1-9 Card 5 6

CONDITION

OUTER GROOVE TREAD DEPTH* NO. GROOVES* ___ ___ 12

___ ___: ___ ___: ___ ___: ___ ___: ___ ___: ___ ___: ___ ___: ___ ___: ___ ___: ___ ___ 14–33

UNKNOWN = 9's

CUPPING 34 (2) No (1) Yes (9) Unk

PRESSURE LOSS SUSPECTED 35

(1) None (2) Pre-crash (3) Crash
(4) Post-crash (8) Unknown time

PSI* ___ ___ 36

NUMBER OF SLIDES* ___ 38

DAMAGED 39 (2) No (1) Yes, describe ______ (9)Unk

DAMAGE CONTRIBUTORY TO ACCIDENT 40 ( )3 Not Damaged ( )2 No ( )1 Yes (9)Unk

* UNKNOWN = 9's

Dup 1-9 Card 5 7

RIGHT-REAR WHEEL AND TIRE

WHEEL

WHEEL

INSPECTED 12 (1) Yes (2) No,why ______ (9)Unk

ORIGINAL EQUIPMENT 13 (1) Yes (2) No, describe ______ (9)Unk

DAMAGED 14 (2) No (1) Yes, describe ______ (9)Unk

TIRE

IDENTIFICATION

POSITION 15 (1) This Position (9) Unknown Position

INSPECTED 16 (1) Yes (2) No,why ______ (9)Unk

TREAD TYPE ___ 17

(1) Regular (3) Studded Snow (5) Reg/Chains (8) Other

(2) N/S Snow (4) Snow/Chains (6) Slick (9) Unknown

INTENDED USE ___ 18

(1) Pass. Car (3) Off Road (8) Other

(2) Light Truck (4) Trailer (9) Unknown

SIZE: 19 __ __ __ __ __ __ __ __ __ __ 28

BRAND ______ 29 __ __ __

MODEL ______ 32 __ __ __

DOT CODE* 35 __ __ __ __ __ __ __ __ __ __ __ __ 46

LOAD RANGE* ___ 47 MAXIMUM LOAD* 48 __ __ __ __ MAXIMUM PSI* 52 __ __

RETREAD 54 (2) No (1) Yes (9) Unk TUBE 55 (2) No (1) Yes (9) Unk

CONSTRUCTION

CARCASS TYPE 56 (1) Bias (2) Belted-Bias (3) Radial (8) Other (9) Unk

NO. TREAD PLIES* ___ 57

BELT MATERIAL 58 __ 59 __ 0 60

NO. SIDEWALL PLIES* ___ 61

SIDEWALL MATERIAL ___ 62

UNKNOWN = 9

(0) None (2) Rayon (4) Polyester (8) Other

(1) Nylon (3) Fiberglass (5) Steel (9) Unk

Dup 1-9 Card 5 8

CONDITION

OUTER GROOVE

TREAD DEPTH*

NO. GROOVES* ___ 72 ___

14 __ __ : __ __ : __ __ : __ __ : __ __ : __ __ : __ __ : __ __ : __ __ : __ __ 33

UNKNOWN = 9's

CUPPING 34 (2) No (1) Yes (9) Unk

PRESSURE LOSS SUSPECTED 35

(1) None (2) Pre-crash (3) Crash

(4) Post-crash (8) Unknown time

PSI* 36 ___ ___

NUMBER OF SLIDES* ___ 38

DAMAGED 39 (2) No (1) Yes,describe ______ (9)Unk

DAMAGE CONTRIBUTORY TO ACCIDENT 40 ( )3 Not Damaged ( )2 No ( )1 Yes ( )9 Unk

* UNKNOWN = 9's

ACCIDENT SCHEMATIC

CASE VEHICLE (A): ____________________ OTHER VEHICLE (B): ____________________

ACCIDENT DESCRIPTION: ____________________

NORTH

2/76

SUPPLEMENTARY DATA--VEHICLE

STEERING WHEEL

12
( ) 1 Original Equipment
( ) 9 Unknown
( ) 2 Non-O.E., describe_____
____

GLAZING OBSTRUCTIONS

13
( ) 2 None
( ) 9 Unknown
( ) 1 Yes, type and location ___
____

SUSPENSION MODIFICATIONS

14
( ) 2 None
( ) 9 Unknown
( ) 1 Yes, describe__________
____

FUEL LEVEL

15
( ) 1 Full ( ) 2 3/4 ( ) 3 1/2
( ) 4 1/4 ( ) 5 Empty ( ) 9 Unk

AIR CONDITIONING EQUIPPED

16
( ) 1 Yes
( ) 2 No
( ) 9 Unknown

CARGO

17
( ) 2 None
( ) 9 Unknown
( ) 1 Yes, describe location and estimate weight

____
____
____
____
____
____

PLACARD INFORMATION

Vehicle Capacity Weight (Maximum Load)

___ ___ ___ ___ LBS.
18 21

Vehicle Average, Minimum, or Light Load

___ ___ ___ ___ LBS.
26 29

Manufacturer's Recommended Tire Pressure at Capacity Weight (Maximum Load)

FRONT ___ ___ PSI
22

REAR ___ ___ PSI
24

Manufacturer's Recommended Tire Pressure at Average or Minimum Load

FRONT ___ ___ PSI
30

REAR ___ ___ PSI
32

RIGHT-FRONT SEATING SYSTEM

DAMAGE TO ADJUSTERS (0,1,2,3)	___ 34
TYPE OF DAMAGE (2) None (4) Chucking (5) Deformed and Released (6) Separated (8) Swivel Damage (0) Unknown	___ 35
LOCATION OF SEPARATION (3) Not Applicable (4) At Floor (5) At Adjuster (6) At Seat (0) Unknown	___ 36
HEAD RESTRAINTS (Right Front) Equipped (1,2,0) Removed Prior to Collision (1,2,3,0) Retained During Collision (1,2,3,0) Damaged (1,2,3,0) Occupant Contact (1,2,3,0)	___ 37 ___ 38 ___ 39 ___ 40 ___ 41
HEAD RESTRAINT ADJUSTMENT AT TIME OF COLLISION (3) Not Applicable, None (4) UP From Seat Top (5) Down on Seat Top (6) Integral (0) Unknown	___ 42
WAS THIS SEATING POSITION OCCUPIED? (1,2,0)	___ 43

CASE VEHICLE MALFUNCTION

(0) Unknown
(1) Malfunction definite
(2) No Malfunction
(4) Malfunction probable
(5) Malfunction possible
(6) Driver claimed malfunction- No investigation

	Code
(01) Brake System	___ 44
(02) Exhaust System	___
(03) Steering System	___
(04) Suspension System	___
(05) Tires	___
(06) Electrical System	___
(07) Throttle System	___
(08) Driver Controls	___
(09) Power Train	___
(10) Fuel System	___
(11) Visibility Items	___
(12) Other:___________	___
(13) Applicable, but Unknown	___

Primary Item Noted Above (01 to 13) from above (00) None (99) Unknown	___ 57 ___ 58
HAD ROUTINE MAINTENANCE BEEN PERFORMED (0,1,2)	___ 59

FORM VERSION NUMBER 3 (1) REPORT NUMBER __ __ __ __ __ __ __ __ (2 3 4 5 6 7 8 9) CARD NUMBER 0 1 (10 11) DATE OF COLLISION MO. __ __ (12 13) / DAY __ __ (14 15) / YR. __ __ (16 17) (99/99/99) Unknown	TIME OF COLLISION ______ AM PM DATE OF FIELD INVESTIGATION ______ INVESTIGATOR ______ CIRCLE PHOTO RECORDS MADE: SLIDES NEGATIVES POLAROIDS LOCATION WHERE VEHICLE WAS EVALUATED: ______ REPORT PREPARED BY ______	KEYPUNCH ONLY: DATE REC'D. PUNCHED VERIFIED

	PUNCH CODE	CARD COL.
LOCATION STATE: (FIPS Code)	— —	18-19
CITY, TOWNSHIP, ETC.: ______		
AREA (1) URBAN (2) RURAL (0) UNKNOWN	——	20
LOCALITY (1) MANUFACTURING OR INDUSTRIAL (2) SHOPPING OR BUSINESS (3) APARTMENTS (4) SCHOOL OR PLAYGROUND (5) RESIDENTIAL (6) FARM (7) UNDEVELOPED (0) UNKNOWN	——	21
ENVIRONMENTAL CONDITIONS LIMITED ACCESS HIGHWAY (1) YES (2) NO (0) UNKNOWN	——	22
ROAD TOTAL TRAFFIC LANES (1) 1-Lane (2) 2-Lane Case Vehicle (3) 3-Lane (4) 4 or More Lanes (5) 4 or More Lanes Divided (6) Parking Lot, Driveway (7) Other, e.g. RR Tracks, Ramps (0) Unknown	——	23
OTHER ROAD TOTAL TRAFFIC LANES (IF AT INTERSECTION) CHOOSE FROM ABOVE LIST OR (9) NOT APPLICABLE	——	24
TYPE OF ROAD SURFACE (1) Asphalt, Bituminous Concrete (2) CONCRETE (3) GRAVEL (4) MORE THAN ONE TYPE (5) OTHER: ______ (0) UNKNOWN	——	25

Case Vehicle ONLY	PUNCH CODE	CARD COL.
ROAD ALIGNMENT VERTICAL PLANE (1) LEVEL (2) CREST OF HILL (3) SLOPE- 2% grade (4) BOTTOM OF HILL (0) UNKNOWN	——	26
HORIZONTAL PLANE (1) STRAIGHT (2) CURVE (0) UNKNOWN	——	27
SURFACE COVERING (01) DRY WATER (02) DAMP (03) WET (04) PUDDLED (05) UNKNOWN AMOUNT SNOW (06) LOOSE (07) PACKED (08) CONDITION UNKNOWN (09) ICE (10) SLUSH (11) SPILLED GRAVEL (12) OTHER: ______ (00) UNKNOWN	— —	28-29
PRECIPITATION (1) NONE (2) RAIN (3) SNOW (4) HAIL (5) SLEET (6) OTHER: ______ (0) UNKNOWN	——	30
RATE OF PRECIPITATION (3) NOT APPLICABLE (4) LIGHT, MIST (5) MODERATE (6) HEAVY (0) UNKNOWN	——	31
SURFACE SLIPPERY (1) YES (2) NO (0) UNKNOWN	——	32

COLLISION DESCRIPTION

ENVIRONMENTAL CONDITIONS

POSSIBLE MECHANICAL MALFUNCTION

ENVIRONMENTAL CONDITIONS

	PUNCH CODE	CARD COL.
SPEED LIMIT (1) 5-25 MPH (2) 26-30 (3) 31-35 (4) 36-40 (5) 41-45 (6) 46-55 (7) 56-65 (8) 66-75 (9) OVER 75 MPH (0) UNKNOWN	____	33
ROAD DEFECTS (1) YES, TYPE UNKNOWN OR OTHER (2) NO (3) POTHOLE, BUCKLING, ROAD DISREPAIR (4) RAISED OR SUNKEN SEWER (5) RAISED OR SUNKEN RR GRADE CROSSING (6) DROP FROM ROAD TO SHOULDER (0) UNKNOWN	____	34
TEMPERATURE, °F (1) BELOW ZERO (2) 0-19 (3) 20-29 (4) 30-34 (5) 35-39 (6) 40-59 (7) 60-79 (8) 80-99 (9) 100 or over (0) UNKNOWN	____	35
CROSSWIND (1) NONE (2) LIGHT (3) STRONG (4) STRONG & GUSTY (0) UNKNOWN	____	36
TIME OF DAY (1) DAY (2) NIGHT (3) DUSK (4) DAWN (0) UNKNOWN	____	37
VISIBILITY LIMITATION (for accident) (1) None (2) Cloudy - Dark (3) Fog (4) Smoke (5) Windshield Condition (6) Glare (7) Other: ____________ (8) Rain (9) Snow (0) Unknown	____	38
VISIBILITY OBSTRUCTION (for accident) (1) None (2) Building (3) Sign (4) Bushes (5) Tree (6) Hill or Curve in Road (7) Other: ____________ (8) Vehicle in Transport (9) Parked Vehicle (0) Unknown	____	39

POSSIBLE MECHANICAL MALFUNCTION

INVESTIGATION OF THE POSSIBILITY OF MECHANICAL MALFUNCTION

THIS SECTION SHOULD BE FILLED OUT IF A MECHANICAL MALFUNCTION IS RECOGNIZED, OR SUSPECTED BY THE INVESTIGATOR OR WAS ALLEGED TO HAVE CONTRIBUTED TO THE ACCIDENT INVOLVING THIS VEHICLE. SUPPORT ANY ITEMS CHECKED OR NOTATED BY COMMENTS.

CHECK ITEMS INVOLVED:

- ☐ BRAKE SYSTEM
- ☐ EXHAUST SYSTEM
- ☐ STEERING SYSTEM
- ☐ SUSPENSION SYSTEM
- ☐ TIRES
- ☐ ELECTRICAL SYSTEM
- ☐ THROTTLE CONTROLS
- ☐ DRIVER CONTROLS
- ☐ POWER TRAIN
- ☐ FUEL SYSTEM
- ☐ VISIBILITY ITEMS
- ☐ OTHER: ____________

	PUNCH CODE	CARD COL.
NUMBER OF ITEMS INVOLVED	0	40
WAS COMMENT ABOUT MECHANICAL MALFUNCTION MADE BY ANY PERSON(s)? (1) YES (2) NO (0) UNKNOWN	0	41

IF "YES", GIVE COMMENT(s) AND NAME(s) AND ADDRESS(es) OF PERSON(s):

____

POSSIBLE MECHANICAL MALFUNCTION

COMMENTS AND OBSERVATIONS OF INVESTIGATOR ABOUT THE POSSIBILITY OF MECHANICAL MALFUNCTIONS:

INVESTIGATOR:

DATE OF INVESTIGATION:

DATE OF REPORT:

GENERAL INFORMATION

COLLISION CONFIGURATION (of case vehicle)	PUNCH CODE	CARD COL.
VEHICLE TO OBJECT (1,2,0)*	—	42
ROLLOVER (1,2,0)* (90° or more)	—	43
RAN OFF THE ROADWAY (1,2,0)* (Before first impact)	—	44
VEHICLE TO VEHICLE (1) Yes, Configuration unknown (2) No (3) Head-on (F to F) (4) Intersection type L (5) Side-swipe (6) Rear-impact (F and B) (7) Other: ________ (8) Intersection type T (0) Unknown	—	45
VEHICLE TO STOPPED VEHICLE (1,2,0)* (Either vehicle)	—	46
VEHICLE TO MOVING VEHICLE (1,2,0)*	—	47
OTHER CONFIGURATION (1,2,0)* (5) Non-Collision only (6) Vehicle-part to Vehicle (7) Vehicle to O.V. Trailer (8) Self-induced (9) Veh to Object to Veh	—	48
VEHICLES INVOLVED TOTAL NUMBER (INCLUDING CASE VEHICLE) In Accident (0) Unknown	—	49

OBJECTS CONTACTED

Enter Only Damage- or Injury-Producing Objects in Order of Contact

(02) None
(00) Unknown Object
(03) Other Automobile
(04) Ground (rollover only)
(05) Guardrail
(06) Bridge (rail)
(07) Sign
(08) Ditch
(09) Embankment (snowbank)
(10) Culvert
(11) Fence
(12) Pole or Tree
(13) Pedestrian
(14) Large Animal
(15) Motorcycle
(16) Large Truck--Type Unknown (see 20-25)
(17) Train
(18) Pedalcycle (bicycle+)
(19) Building
(20) Light/Pickup Truck, Small Van, Carryall
(22) Tractor without trailer
(23) Van delivery (walk-in/step van)
(24) Straight truck, motor home
(25) Tractor-trailer combination
(26) Multi-purpose vehicle (Jeep)
(28) Bus
(29) Trailer
(40) Object disengaging from other vehicle
(50) Hydrants, short posts, stumps
(51) Mailbox (rural), small posts/trees
(52) Pier, Pillar (e.g., bridge support)
(53) Retaining wall, abutment, Hiway fixtures
(54) Impact attenuator
(55) Breakaway Fixtures
(99) Other

PUNCH CODE	CARD COL.
— —	50-51
— —	52-53
— —	54-55
— —	56-57

CASE VEHICLE DRIVER'S ABILITY TO DRIVE IMPAIRED BY (CHOOSE NO MORE THAN TWO)	PUNCH CODE	CARD COL.
(00) UNKNOWN (02) NONE (03) DRINKING INVOLVED (Broad) (04) Drunk By Local Legal Standards (BAC given) (05) ASLEEP (06) FATIGUE (07) RECKLESSNESS (08) INATTENTION (09) LACK OF TRAINING (10) EMOTIONAL STATE (11) MEDICATION (12) Drugs (narcotic)	— —	58-59
(13) ILLNESS (or otherwise) (14) INFIRMITIES (15) PHYSICALLY HANDICAPPED (16) OTHER: ________	— —	60-61
SOURCE OF INFORMATION: ________		
TRAFFIC VIOLATION (EITHER DRIVER) (1) YES (2) NO (0) UNKNOWN DESCRIBE VIOLATION: ________ Citation need not be issued, but only indicated.	0	62
LEGAL ACTION WAS TRAFFIC VIOLATION CITATION ISSUED TO ANYONE? (1,2,0)* IF "YES", CIRCLE VIOLATOR: DRIVER OF CASE VEHICLE DRIVER OF OTHER VEHICLE PEDESTRIAN OTHER: ________	0	63
(Accident Point of View) TYPE OF LOSS PERSONAL INJURY (1,2,0)*	0	64
PROPERTY DAMAGE (1,2,0)*	0	65

*WHERE (1,2,0) IS INDICATED, USE 1 FOR YES
2 FOR NO
0 FOR UNKNOWN

COLLISION SKETCH

Based on Information From

1. Draw heavy lines to show highway detail at the location of collison.
2. Give name of streets and highways and US, State and Interstate Route numbers, if any.
3. Identify all objects in sketch. Case vehicle should always be labeled "A". Time sequence numbers may be added (e.g., A1, A2).
4. Include dimensions when possible.

INDICATE NORTH BY ARROW

COLLISION SKETCH

DESCRIBE COLLISION EVENTS

INFORMATION SOURCES:

REPORTED BY:
(Attach Police Report)

COMMENTS (Include 3rd vehicle speed estimate)

SPEEDS

CASE VEHICLE	PUNCH CODE	CARD COL.
ESTIMATED SPEED* (MPH)		
PRIOR TO IMPACT ESTIMATED BY:	___ ___ ___	66-68
At FIRST Impact ESTIMATED BY:	___ ___ ___	69-71

OTHER VEHICLE	PUNCH CODE	CARD COL.
ESTIMATED SPEED* (MPH)		
PRIOR TO IMPACT ESTIMATED BY:	___ ___ ___	72-74
At FIRST Impact ESTIMATED BY:	___ ___ ___	75-77

*IF SPEEDS ARE UNKNOWN, ENTER 999: (888) for Other Vehicle "not applicable"

END OF CARD 01

OTHER VEHICLE

NOTE: A complete analysis of this accident requires that a minimum amount of information be obtained on the other vehicle(s) involved. Therefore, the information on this page should be completed even though a separate long form may be filled out on these other vehicles.

DUPLICATE COLUMNS 1-9 FROM PRECEDING CARD 0 (10) 2 (11)

OTHER VEHICLE DESCRIPTION

VEHICLE IDENTIFICATION NUMBER

12	13	14	15	16	17	18	19	20	21	22	23	24

MAKE ____________________

MODEL ____________________

CODE TO BE INSERTED ___ ___ ___ ___ ___ (25 26 27 28 29)

MODEL YEAR 19 ___ ___ (30 31)

Shipping Weight (pounds) ___ ___ ___ ___ (32 33 34 35)

ODOMETER READING (IF OVER 100,000: USE 99 999) ___ ___ ___ ___ ___ (36 37 38 39 40)

BODY STYLE	PUNCH CODE	CARD COL.
(Code Sun Roof as 1 to 5, not 6) (1) 2-Door Hardtop (no upper B pillar) (2) 2-Door Sedan or Coupe (any upper B) (3) 4-Door Hardtop (4) 4-Door Sedan (5) Station Wagon or Pickup Car (6) Convertible - soft or hard shell (7) Van (not walk-in) (8) Truck (inc. pickups+carryalls) (9) Other (e.g. bus, jeep, train) (0) Unknown	___	41
NUMBER OF CYLINDERS OR ROTORS (Enter "0" if Unknown)	___	42
HIGH PERFORMANCE/AIR BAG EQUIPPED (0) No A/B: Unk if High Perf. (1) No A/B: High Performance (2) No A/B: Not High Perf. Air Bag Equipped (any engine) and: (4) Any Deployments (5) No Deployments (6) Deployment Unknown (9) Both High Performance and A/B Equipped Unknown	___	43
NUMBER OF OCCUPANTS	___ ___	44-45
VEHICLE LOADING (4) BELOW FULL RATED LOAD (5) NEAR FULL RATED LOAD (6) ABOVE FULL RATED LOAD (0) UNKNOWN	___	46

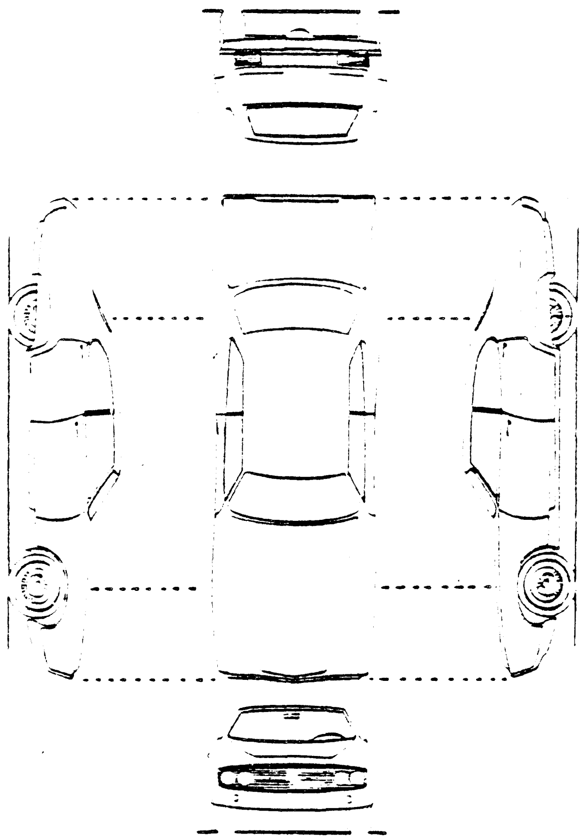
*WHERE (1,2,0) IS INDICATED, USE 1 FOR YES
2 FOR NO

DAMAGE INDEX (OTHER VEHICLE)

___ ___ - ___ ___ ___ ___ - ___
(47 48 49 50 51 52 53)

VEHICLE DAMAGE

(This space may be used to enter details and notes about the other vehicle. See page 9 for instructions.)



COMMENTS: ____________________

IF SEPARATE REPORT WAS MADE, GIVE REPORT NUMBER ____________________

END OF CARD 02

OTHER VEHICLE

CASE VEHICLE

DUPLICATE COLUMNS 1-9 FROM PRECEDING CARD 0 (10) 3 (11)

CASE VEHICLE DESCRIPTION

VEHICLE IDENTIFICATION NUMBER

12	13	14	15	16	17	18	19	20	21	22	23	24

MAKE ______ ______

MODEL ______

CODE TO BE INSERTED

__ __ __ __ __
25 26 27 28 29

MODEL YEAR 19 __ __ (30 31)

Shipping Weight (pounds) __ __ __ __ (32 33 34 35)

ODOMETER READING (IF OVER 100,000: USE 99 999) __ __ __ __ . __ (36 37 38 39 40)

BODY STYLE	PUNCH CODE	CARD COL.
(Code Sun Roof as 1 to 5, not 6) (1) 2-Door Hardtop (no upper B pillar) (2) 2-Door Sedan or Coupe (any upper B) (3) 4-Door Hardtop (4) 4-Door Sedan (5) Station Wagon or Pickup Car (6) Convertible - soft or hard shell (7) Van (not walk-in) (8) Truck (inc. pickups+carryalls) (9) Other (e.g. bus, jeep, train) (0) Unknown	___	41
BODY STRUCTURE (1) Body and Frame (2) Unitized (3) Integral-Stub Frame (4) Body and Platform-Frame (e.g.,VW bug) (9) Other: ______ (0) Unknown	___	42
NUMBER OF CYLINDERS OR ROTORS (Enter "0" if Unknown)	___	43
HIGH PERFORMANCE/AIR BAG EQUIPPED (0) No A/B; Unk if High Perf. (1) No A/B; High Performance (2) No A/B; Not High Perf. Air Bag Equipped (any engine) and: (4) Any Deployments (5) No Deployments (6) Deployment Unknown (9) Both High Performance and A/B Equipped Unknown	___	44
NUMBER OF OCCUPANTS (Enter 99 if unknown)	__ __	45-46

*WHERE (1,2,0) IS INDICATED, USE 1 FOR YES
2 FOR NO
0 FOR UNKNOWN

	PUNCH CODE	CARD COL.
VEHICLE LOADING (4) BELOW FULL RATED LOAD (5) NEAR FULL RATED LOAD (6) ABOVE FULL RATED LOAD (0) UNKNOWN	___	47
EQUIPMENT OPTIONS TRANSMISSION (4) AUTOMATIC + Semi Automatic (5) MANUAL (0) UNKNOWN	___	48
STEERING (4) POWER (5) MANUAL (0) UNKNOWN	___	49
BRAKES (4) POWER (5) MANUAL (0) UNKNOWN	___	50
BRAKES - TYPE (4) DRUM - ALL WHEELS (5) DISC - FRONT WHEELS (6) DISC - ALL WHEELS (0) UNKNOWN	___	51
BRAKE ANTI-LOCK DEVICE (2) NONE INSTALLED (4) TWO-WHEEL (5) FOUR-WHEEL (0) UNKNOWN	___	52
~~Top Position at Time of Collision~~ ~~(3) Solid Top - Not Applicable~~ ~~(4) Convertible Soft Top Up or Closed~~ ~~(5) Retracted Soft Top or Hard Shell Removed~~ ~~(6) Removable Hard Shell Installed~~ ~~(7) Sun Roof - Closed~~ ~~(8) Sun Roof - Open~~ ~~(0) Unknown~~	0	53

CASE VEHICLE REPAIR OR REPLACEMENT COST $ __ __ __ __ (54 55 56 57)
Unknown (9999)

CASE VEHICLE DAMAGE INDEX

PRIMARY DAMAGE __ __ - __ __ __ __ - __ (58 59 60 61 62 63 64)

SECONDARY DAMAGE __ __ - __ __ __ __ - __ (65 66 67 68 69 70 71)

Unknown or None (99-0000-0)

END OF CARD 03

EXTERIOR DAMAGE

DUPLICATE COLUMNS 1-9 FROM PRECEDING CARD	0	4
	10	11

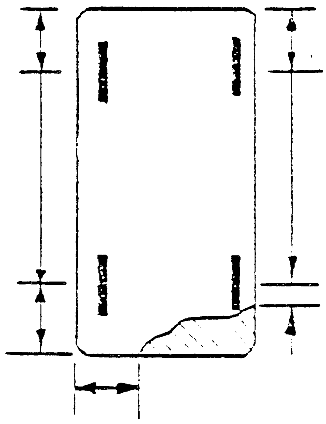
	PUNCH CODE	CARD COL.
SHEET METAL DAMAGE (Direct)		
FRONT (1,2,0)*	0	12
REAR (1,2,0)*	0	13
LEFT SIDE (1,2,0)*	0	14
RIGHT SIDE (1,2,0)*	0	15
ROOF (1,2,0)*	0	16
OTHER (1,2,0)*: ______	0	17
REMARKS: ______		

	PUNCH CODE	CARD COL.
SHEET METAL CRUSH (Direct)		
INSERT MAXIMUM CRUSH DIMENSION TO THE NEAREST INCH. DIMENSIONS MUST AGREE WITH DIAGRAMS ON FACING PAGE. (INSERT "99", IF UNKNOWN INSERT "98", IF 98 INCHES OR OVER)		
FRONT (INCHES)	__ __	18-19
REAR	__ __	20-21
LEFT SIDE	__ __	22-23
RIGHT SIDE	__ __	24-25
ROOF	__ __	26-27
OTHER:	__ __	28-29

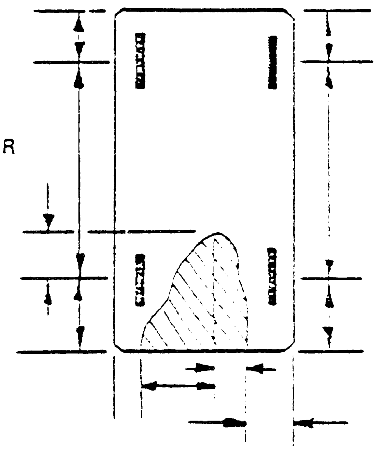
*WHERE (1,2,0) IS INDICATED, USE 1 FOR YES
2 FOR NO
0 FOR UNKNOWN

EXAMPLES.

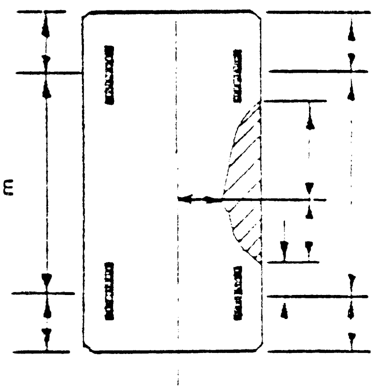
FRONT OR REAR



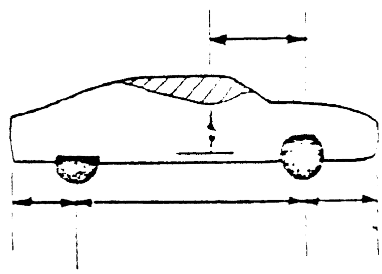
FRONT OR REAR



SIDE



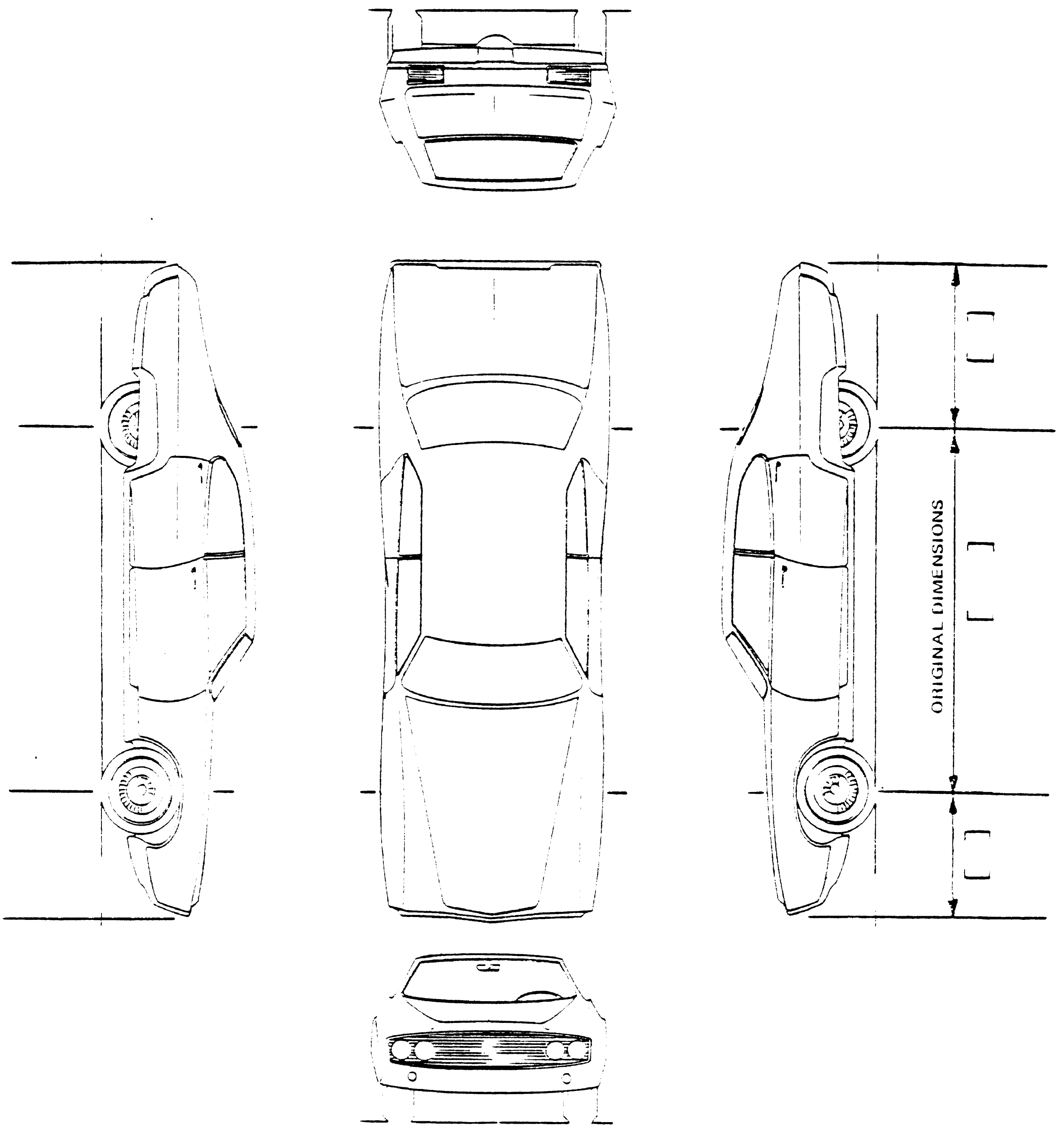
ROOF
(REFERENCE TO TOP OF DOOR SILL OR WINDOW SILL)



EXTERIOR DAMAGE

FIELD INVESTIGATOR INSTRUCTIONS:

1. Indicate crushed areas by outlining new perimeter of vehicle and shading the damaged areas on the large sketch below. Use as many sketches as ncessary to completely describe the damage.
2. Enter the dimensions on the sketch(es) measured to the point of maximum penetration by the object(s) contacted. Use the examples on the facing page as a guide.
3. Enter the three dimensions to the center of the wheels (wheelbase, front and rear overhangs) on both sides of the car.
4. Add other dimensions as necessary to completely describe the damage.



VEHICLE SKETCH

WHEELS AND TIRES

WHEELS	PUNCH CODE	CARD COL.
ORIGINAL EQUIPMENT TYPE		
FRONT (1,2,0)*	___	30
REAR (1,2,0)*	___	31
DAMAGED (1,2,0)*	___	32
DESCRIBE DAMAGE AND NON O.E. WHEELS ________________ ________________ ________________		
TIRES		
TREAD TYPE (4) REGULAR (5) NON-STUDDED SNOW (6) STUDDED SNOW (7) 'SLICK' (8) LEFT AND RIGHT SIDES DIFFERENT (9) OTHER: ________ (0) UNKNOWN		
FRONT	___	33
REAR	___	34
TREAD WEAR (4) LIGHT (5) MEDIUM (6) HEAVY (7) BALD (8) LEFT AND RIGHT SIDES DIFFERENT (9) OTHER: ________ (0) UNKNOWN		
FRONT	___	35
REAR	___	36
PROFILE (4) REGULAR 80,78 (5) WIDE OVAL 70,60,50 (6) LEFT AND RIGHT SIDES DIFFERENT (7) OTHER: ________ (0) UNKNOWN		
FRONT	___	37
REAR	___	38
CARCASS TYPE (4) BIAS PLY (5) BELTED-BIAS PLY (6) RADIAL PLY (7) LEFT AND RIGHT SIDES DIFFERENT (8) OTHER: ________ (0) UNKNOWN		
FRONT	___	39
REAR	___	40

TIRES (CONT'D.)

SIZE	FRONT	LEFT	________
		RIGHT	________
	REAR	LEFT	________
		RIGHT	________
MANUFACTURER	FRONT	LEFT	________
		RIGHT	________
	REAR	LEFT	________
		RIGHT	________
MODEL	FRONT	LEFT	________
		RIGHT	________
	REAR	LEFT	________
		RIGHT	________
CODE	FRONT	LEFT	________
		RIGHT	________
	REAR	LEFT	________
		RIGHT	________
LOAD RANGE	FRONT	LEFT	________
		RIGHT	________
	REAR	LEFT	________
		RIGHT	________

*WHERE (1,2,0) IS INDICATED, USE 1 FOR YES
2 FOR NO
0 FOR UNKNOWN

FRONT EXTERIOR

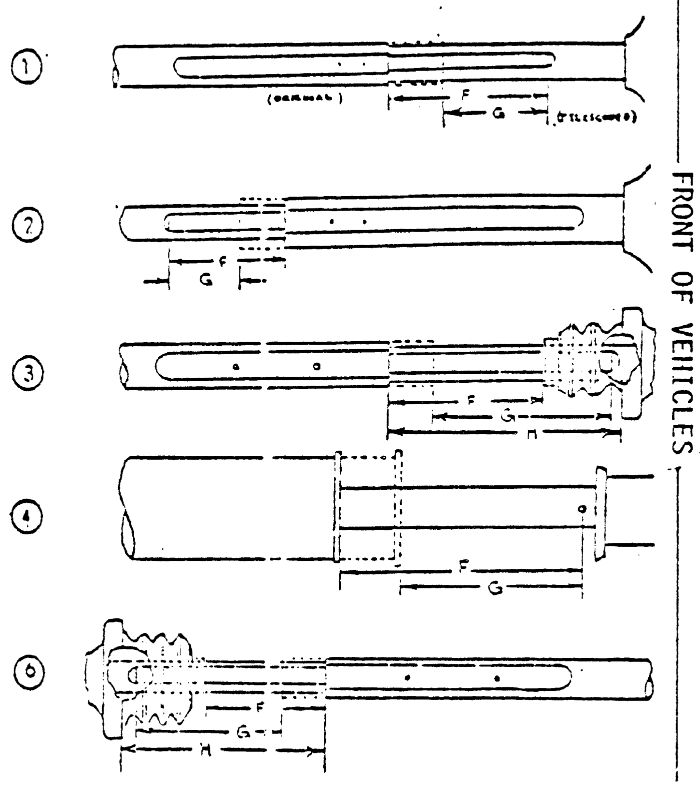
HOOD PERFORMANCE (FRONT OF VEHICLE)	PUNCH CODE	CARD COL.
HOOD LATCH(ES)		
RELEASED (1,2,3,0)*	___	41
DAMAGED (1,2,3,0)*	___	42
JAMMED (1,2,3,0)*	___	43
HOOD HINGES		
LEFT — DAMAGED (1,2,3,0)	___	44
LEFT — SEPARATED (1,2,3,4,5,0)**	___	45
RIGHT — DAMAGED (1,2,3,0)	___	46
RIGHT — SEPARATED (1,2,3,4,5,0)**	___	47
HOOD REMAINED ON VEHICLE (1,2,3,0)	___	48
REAR EDGE OF HOOD		
ELEVATED (1,2,3,0)	___	49
CONTACTED WINDSHIELD (1,2,3,0)	___	50
PENETRATED WINDSHIELD (1,2,3,0)*	___	51
OPTIONAL HOOD INSTALLED (1,2,3,0)	___	52
ENGINE OR TRANSMISSION MOUNT SEPARATION (1,2,3,4,5,0)	___	53
STEERING COLUMN FLEXIBLE COUPLING		
EQUIPPED (2) No; Yes: (1) Type Unknown, (6) Rag, (7) Pot, (8) Universal, (9) Other; (0) Unknown	___	54
SEPARATED (1,2,3,4,5,0)**	___	55
OTHER DAMAGE (1,2,3,0)*	___	56
DESCRIBE: ______________________		

*USE: 1=YES 2=NO 3=NOT APPLICABLE 0=UNKNOWN

**USE: 1=YES, TYPE UNKNOWN 2=NO 3=NOT APPLICABLE 4=PARTIAL SEPARATION 5=COMPLETE SEPARATION 0=UNKNOWN

ENGINE COMPARTMENT TELESCOPING UNIT

(SEE DRAWING ON PAGE 18 FOR LOCATION)



TYPE OF UNIT	PUNCH
(5) None Installed (1-6) See Sketch Above (8) Double U-Joint or Flexible Cable Joint (9) Others ________ (0) Unknown	___ 57
ORIGINAL LENGTH, (F) ________ TELESCOPED LENGTH, (G) ________ DIFFERENCE (F-G) ________ - (tolerance ± 0.5 in.) (777) Device Extended (888) Not Equipped, (999) Unknown (998) Compressed, Unknown Amount	___ ___ . ___ 58 59 60
	END OF CARD 04

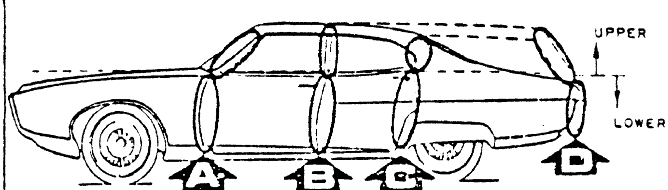
FIRE

DUPLICATE COLUMNS 1-9 FROM PRECEDING CARD 0 (10) 5 (11)

	PUNCH CODE	CARD COL.
FIRE (Accident Viewpoint) (1) Fire - time unknown (2) No Fire (4) Pre-Crash Fire Start (5) At-Crash Fire Start (6) Post-Crash Fire Start (0) Unknown	___	12
EXTENT OF FIRE (to Case Vehicle) (3) No Fire, Not Applicable (4) Minor - easily extinguished (5) Major (e.g., entire interior or engine) (0) Unknown	___	13
FIRE ORIGIN (in Case Vehicle) (3) No Fire, Not Applicable (4) Engine Compartment (5) Passenger Compartment (6) Luggage Compartment (7) Fuel Tank, lines, filler (8) Other:__________ (0) Unknown	___	14

NOTES ABOUT FIRE: ______________________

LEFT PILLARS



LEFT EXTERIOR

LEFT PILLARS		PUNCH CODE	CARD COL.
If left pillars were not damaged or separated or left roof side rail was not damaged or buckled, place a "1" in code column. Code remainder of column		0	15
A-PILLAR UPPER	DAMAGED (1,2,0)*	0	16
	SEPARATED (1,2,3,4,5,0)**	0	17
A-PILLAR LOWER	DAMAGED (1,2,0)*	0	18
	SEPARATED (1,2,3,4,5,0)**	0	19
B-PILLAR (Also Rear Pillar on Pick-Up Truck, Corvette, Camaro, Firebird) UPPER	DAMAGED (1,2,3,0)*	0	20
	SEPARATED (1,2,3,4,5,0)**	0	21
B-PILLAR LOWER	DAMAGED (1,2,0)*	0	22
	SEPARATED (1,2,3,4,5,0)**	0	23
C-PILLAR UPPER	DAMAGED (1,2,3,0)*	0	24
	SEPARATED (1,2,3,4,5,0)**	0	25
C-PILLAR LOWER	DAMAGED (1,2,3,0)*	0	26
	SEPARATED (1,2,3,4,5,0)**	0	27
D-PILLAR (Station Wagon & Limousine) UPPER	DAMAGED (1,2,3,0)*	0	28
	SEPARATED (1,2,3,4,5,0)**	0	29
D-PILLAR LOWER	DAMAGED (1,2,3,0)*	0	30
	SEPARATED (1,2,3,4,5,0)**	0	31

LEFT ROOF SIDE RAIL	PUNCH CODE	CARD COL.
DAMAGED (1,2,3,0)*	___	32
BUCKLED (1,2,3,0)*	___	33

*USE: 1-YES 2-NO 3-NOT APPLICABLE 0-UNKNOWN

**USE: 1-YES, TYPE UNKNOWN 2-NO 3-NOT APPLICABLE 4-PARTIAL SEPARATION 5-COMPLETE SEPARATION 0-UNKNOWN

LEFT EXTERIOR

SIDE STRUCTURE – LEFT SIDE	PUNCH CODE	CARD COL.
LEFT BODY MOUNT SEPARATION (1,2,3,0)* (3 – Unitized)	___	34
If door hinges and latches were not damaged and doors did not jam or open during collision, and continuity of the side structure was maintained, place a "1" in code column. Code remainder of column	___	35
DOOR LATCHES – LEFT FRONT – DAMAGED (1,2,3,0)*	___	36
DOOR LATCHES – LEFT FRONT – RELEASED (1,2,3,0)*	___	37
DOOR LATCHES – LEFT REAR – DAMAGED (1,2,3,0)*	___	38
DOOR LATCHES – LEFT REAR – RELEASED (1,2,3,0)*	___	39
DOOR HINGES – LEFT FRONT – DAMAGED (1,2,3,0)*	___	40
DOOR HINGES – LEFT FRONT – SEPARATED (1,2,3,4,5,0)**	___	41
DOOR HINGES – LEFT REAR – DAMAGED (1,2,3,0)*	___	42
DOOR HINGES – LEFT REAR – SEPARATED (1,2,3,4,5,0)**	___	43
CONTINUITY OF SIDE STRUCTURE MAINTAINED (1,2,3,0)*	___	44
i.e., Is Side Boundary Broken. Not restricted to vehicles with reinforced side structure.		
DOORS OPENED DURING COLLISION – LEFT – FRONT (1,2,0)*	___	45
DOORS OPENED DURING COLLISION – LEFT – REAR (1,2,3,0)*	___	46
DOORS JAMMED CLOSED – LEFT – FRONT (1,2,0)*	___	47
DOORS JAMMED CLOSED – LEFT – REAR (1,2,3,0)*	___	48

REAR EXTERIOR

FUEL TANK AND LINES	PUNCH CODE	CARD COL.
APPROXIMATE FUEL LEVEL AT TIME OF IMPACT (4) LESS THAN 1/2 (5) 1/2 OR MORE (0) UNKNOWN	___	49
TANK RETENTION (4) COMPLETE RETENTION (5) PARTIAL DISENGAGEMENT (6) COMPLETE DISENGAGEMENT (0) UNKNOWN	___	50
TANK DEFORMED (1,2,0)* includes neck	___	51
FUEL LEAKAGE PRESENT (1,2,0)* (2 → skip location of leaks)	___	52
LOCATION OF LEAKS – FROM THE TANK (1,2,3,0)*	___	53
LOCATION OF LEAKS – FROM THE NECK (1,2,3,0)*	___	54
LOCATION OF LEAKS – FROM THE LINES (1,2,3,0)*	___	55
TRAILER AND HITCH (1) Yes, Type Unknown (2) No hitch (3) Ball and Socket, Temporary Bumper (e.g., rental clamp-on) (4) Ball and Socket, Bumper only (e.g., light truck) (5) Ball and Socket - Frame Hitch (e.g., frame and bumper) (6) Equalizing, load distributing (7) Ring and Pintle (e.g., double tractor) (8) Fifth Wheel (e.g., semi) (9) Other (e.g., clevis and pin) (0) Unknown	___	56
TRAILER BEING TOWED (AT TIME OF COLLISION) (1) Yes, Type Unknown (2) No (hitch, no trailer) (3) Not Applicable (no hitch) (4) Travel Trailer/Camper (5) Mobile Home (6) Boat/Snowmobile/ATV Trailer (7) Rental/Cargo Trailer (8) Car (9) Other: ______________ (0) Unknown	___	57

*USE: 1=YES 2=NO 3=NOT APPLICABLE 0=UNKNOWN

**USE: 1=YES, TYPE UNKNOWN 2=NO 3=NOT APPLICABLE 4=PARTIAL SEPARATION 5=COMPLETE SEPARATION 0=UNKNOWN

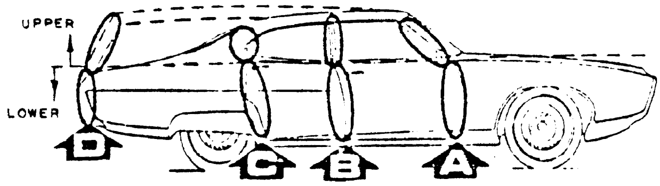
REAR EXTERIOR

	PUNCH CODE	CARD COL.
TAILGATE (HATCHBACK) PERFORMANCE Includes back doors of Vans		
LATCHES		
RELEASED (1,2,3,0)*	___	58
DAMAGED (1,2,3,0)*	___	59
LATCH OR TAILGATE JAMMED (1,2,3,0)*	___	60
HINGES OR TRACKS (CLAM SHELL)		
BOTTOM LEFT — DAMAGED (1,2,3,0)*	___	61
BOTTOM LEFT — SEPARATED (1,2,3,4,5,0)**	___	62
BOTTOM RIGHT — DAMAGED (1,2,3,0)*	___	63
BOTTOM RIGHT — SEPARATED (1,2,3,4,5,0)**	___	64
TOP LEFT — DAMAGED (1,2,3,0)*	___	65
TOP LEFT — SEPARATED (1,2,3,4,5,0)**	___	66
TOP RIGHT — DAMAGED (1,2,3,0)*	___	67
TOP RIGHT — SEPARATED (1,2,3,4,5,0)**	___	68
EQUIPPED WITH TWO-WAY TAILGATE (1,2,3,0)* (6) Disappearing Tailgate	___	69
TAILGATE ELECTRIC WINDOW OPERABLE (1,2,3,0)*	___	70
	END OF CARD 05	

DUPLICATE COLUMNS 1-9 FROM PRECEDING CARD 0 (10) 6 (11)

	PUNCH CODE	CARD COL.
TRUNK LID PERFORMANCE (REAR OF VEHICLE)		
LATCHES		
RELEASED (1,2,3,0)*	0	12
DAMAGED (1,2,3,0)*	0	13
LATCH OR LID JAMMED (1,2,3,0)*	0	14
HINGES		
LEFT — DAMAGED (1,2,3,0)*	0	15
LEFT — SEPARATED (1,2,3,4,5,0)**	0	16
RIGHT — DAMAGED (1,2,3,0)*	0	17
RIGHT — SEPARATED (1,2,3,4,5,0)**	0	18
TRUNK or PARTITIONED LUGGAGE AREA		
DAMAGED (1,2,3,0)	___	19
SPARE TIRE SEPARATION (1,2,3,4,0) (4) for spare tire not initially attached	___	20
TRUNK - PASSENGER COMPARTMENT PARTITION DAMAGE (1,2,3,0)*	___	21
BACKLIGHT HEADER (REAR WINDOW TOP FRAME)		
BACKLIGHT HEADER DAMAGED OR BUCKLED (1,2,3,0)* 3 — convertible	0	22

RIGHT PILLARS



*USE: 1-YES 2-NO 3-NOT APPLICABLE 0-UNKNOWN

**USE: 1-YES, TYPE UNKNOWN 2-NO 3-NOT APPLICABLE 4-PARTIAL SEPARATION 5-COMPLETE SEPARATION 0-UNKNOWN

RIGHT EXTERIOR

RIGHT PILLARS	PUNCH CODE	CARD COL.
If right pillars were not damaged or separated or right roof side rail was not damaged or buckled, place a "1" in code column. Code remainder of column	0	23
A-PILLARS		
UPPER — DAMAGED (1,2,0)*	0	24
UPPER — SEPARATED (1,2,3,4,5,0)**	0	25
LOWER — DAMAGED (1,2,0)*	0	26
LOWER — SEPARATED (1,2,3,4,5,0)**	0	27
B-PILLAR (ALSO REAR PILLAR ON PICK-UP TRUCK, CORVETTE, CAMARO, FIREBIRD)		
UPPER — DAMAGED (1,2,3,0)*	0	28
UPPER — SEPARATED (1,2,3,4,5,0)**	0	29
LOWER — DAMAGED (1,2,0)*	0	30
LOWER — SEPARATED (1,2,3,4,5,0)**	0	31
C-PILLAR		
UPPER — DAMAGED (1,2,3,0)*	0	32
UPPER — SEPARATED (1,2,3,4,5,0)**	0	33
LOWER — DAMAGED (1,2,3,0)*	0	34
LOWER — SEPARATED (1,2,3,4,5,0)**	0	35
D-PILLAR (STATION WAGON & LIMOUSINE)		
UPPER — DAMAGED (1,2,3,0)*	0	36
UPPER — SEPARATED (1,2,3,4,5,0)**	0	37
LOWER — DAMAGED (1,2,3.0)*	0	38
LOWER — SEPARATED (1,2,3,4,5,0)**	0	39
RIGHT ROOF SIDE RAIL		
DAMAGED (1,2,3,0)*	___	40
BUCKLED (1,2,3,0)*	___	41
WINDSHIELD HEADER		
DAMAGED OR BUCKLED (1,2,0)*	___	42

SIDE STRUCTURE – RIGHT SIDE	PUNCH CODE	CARD COL.
RIGHT BODY MOUNT SEPARATION (1,2,3,0)* — 3 = Unitized	___	43
If door hinges and latches were not damaged and doors did not jam or open during collision, and continuity of the side structure was maintained, place a "1" in code column. Code remainder of column	___	44
DOOR LATCHES		
RIGHT FRONT — DAMAGED (1,2,3,0)*	___	45
RIGHT FRONT — RELEASED (1,2,3,0)*	___	46
RIGHT REAR — DAMAGED (1,2,3,0)*	___	47
RIGHT REAR — RELEASED (1,2,3,0)*	___	48
DOOR HINGES		
RIGHT FRONT — DAMAGED (1,2,3,0)*	___	49
RIGHT FRONT — SEPARATED (1,2,3,4,5,0)**	___	50
RIGHT REAR (Hinge or track) — DAMAGED (1,2,3,0)*	___	51
RIGHT REAR (Hinge or track) — SEPARATED (1,2,3,4,5,0)**	___	52
CONTINUITY OF SIDE STRUCTURE MAINTAINED (1,2,3,0)* — i.e., Is Side Boundary Broken. Not restricted to vehicles with reinforced side structure.	___	53
DOORS OPENED DURING COLLISION		
RIGHT — FRONT (1,2,0)*	___	54
RIGHT — REAR (1,2,3,0)*	___	55
DOORS JAMMED CLOSED		
RIGHT — FRONT (1,2,0)*	___	56
RIGHT — REAR (1,2,3,0)*	___	57

RIGHT SIDE STRUCTURE

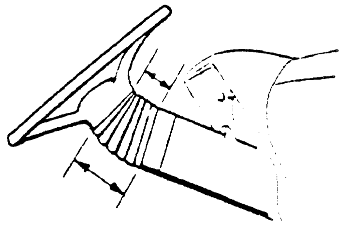
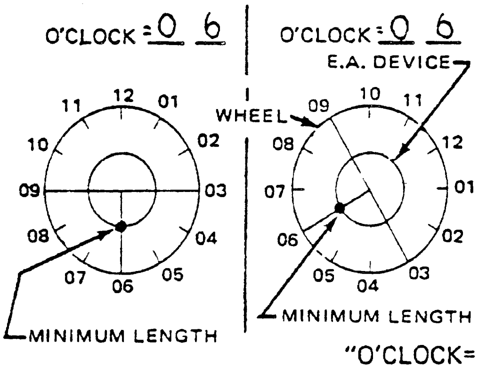
RIGHT PILLARS

*USE: 1-YES 2-NO 3-NOT APPLICABLE 0-UNKNOWN

**USE: 1-YES, TYPE UNKNOWN 2-NO 3-NOT APPLICABLE 4-PARTIAL SEPARATION 5-COMPLETE SEPARATION 0-UNKNOWN

STEERING WHEEL

STEERING WHEEL	PUNCH CODE	CARD COL.
TYPE GM only, others and unknown use (99).	9 9	58-59
NOTES ON NON-ORIGINAL EQUIPMENT STEERING WHEEL: ______ ______ ______		
STEERING WHEEL RIM DAMAGE (2) NONE (4) SLIGHTLY DEFORMED (5) SEVERELY BENT (6) BROKEN (0) UNKNOWN	____	60
OCCUPANT CONTACT (1,2,3,0)	____	61
STEERING WHEEL SPOKES NUMBER OF SPOKES (ENTER "O" IF UNKNOWN)	____	62
DAMAGE (2) NONE (4) SLIGHTLY DEFORMED (5) SEVERELY BENT (6) BROKEN (0) UNKNOWN	____	63
OCCUPANT CONTACT (1,2,3,0)	____	64
HORN RING, HORN BUTTON(S), OR SPOKE SHROUD OR DRIVER AIR BAG COVER DAMAGED (1,2,0)*	0	65
OCCUPANT CONTACT (1,2,3,0)	0	66

STEERING WHEEL ENERGY ABSORBING DEVICE	PUNCH CODE	CARD COL.
(SEE DRAWING ON PAGE 18 FOR LOCATION) EQUIPPED (1,2,0)*	____	67
ENERGY ABSORBING DEVICE FINAL POSITION MEASURE THE MINIMUM AND MAXIMUM OVERALL LENGTH OF THE ENERGY ABSORBING DEVICE (BETWEEN THE STEERING WHEEL AND STEERING COLUMN). ENTER THESE LENGTHS BELOW  MAX. = ____in.; MIN. = ____in. THE E.A. DEVICE ROTATES WITH THE STEERING WHEEL. WE WANT TO KNOW WHERE THIS MINIMUM LENGTH OCCURRED (AROUND THE CIRCUMFERENCE OF THE E.A. DEVICE) WITH RESPECT TO THE SPOKES. RECORD BELOW THE O'CLOCK POSITION AT WHICH THIS MINIMUM LENGTH WAS MEASURED. EXAMPLES  "O'CLOCK= (ENTER 00 IF UNKNOWN)	____ ____	68 69
ENERGY ABSORBING DEVICE COMPRESSION FOLLOWING TO BE FILLED IN BY ANALYSIS GROUP (ENTER 99.9 IF UNKNOWN) ORIGINAL LENGTH (H) ____ IN. DAMAGED MAX. LENGTH (X) ____ IN. DIFFERENCE (H-X) ____ IN.	8's for Not Equipped __ __.__	70 71 72
ORIGINAL LENGTH (H) ____ IN. DAMAGED MIN. LENGTH (Y) ____ IN. DIFFERENCE (H-Y) ____ IN.	__ __.__	73 74 75
DEVICE EXTENDED (4) X GREATER THAN H (5) X AND Y GREATER THAN H (6) NEITHER (0) UNKNOWN (8) NOT APPLICABLE	____	76
	END OF CARD 06	

*WHERE (1,2,0) OR (1,2,3,0) ARE INDICATED, USE 1 FOR YES 2 FOR NO 3 FOR NOT APPLICABLE 0 FOR UNKNOWN

STEERING WHEEL AND COLUMN

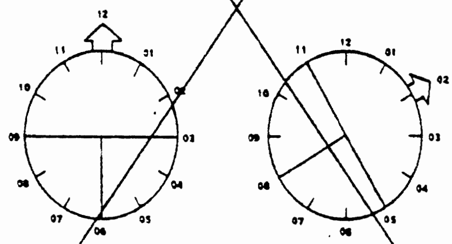
DUPLICATE COLUMNS 1-9 FROM PRECEDING CARD 0 (10) 7 (11)

STEERING WHEEL POSITION AT TIME OF COLLISION

	PUNCH CODE	CARD COL.
IN WHAT O'CLOCK POSITION WAS THE NORMAL TOP OF THE WHEEL POINTED WHEN THE COLLISION OCCURRED?		
O'CLOCK =	0 0	12-13

EXAMPLES

O'CLOCK = 1 2 O'CLOCK = 0 2



(NORMAL STRAIGHT AHEAD)

(00) UNKNOWN

Steering Wheel Pad or Air Bag

	PUNCH CODE	CARD COL.
S.W. Pad Equipped (1,2,0)* Steering Wheel Air Bag: (4) Deployment (5) Equipped-No Deployment (6) Deployment Unknown (9) Both Pad and Air Bag Unknown	___	14
S.W. Pad Deformed or Contact to Driver Air Bag(1,2,3,0)*	___	15

TILT FEATURE

	PUNCH CODE	CARD COL.
EQUIPPED (1,2,0)*	___	16
FINAL POSITION (3) NOT APPLICABLE (4) NORMAL (5) TILTED UP (6) TILTED DOWN (0) UNKNOWN	___	17

TELESCOPING FEATURE

	PUNCH CODE	CARD COL.
EQUIPPED (1,2,0)*	___	18
FINAL POSITION (3) NOT APPLICABLE (4) NORMAL (5) ABOVE NORMAL (6) BELOW NORMAL (0) UNKNOWN	___	19

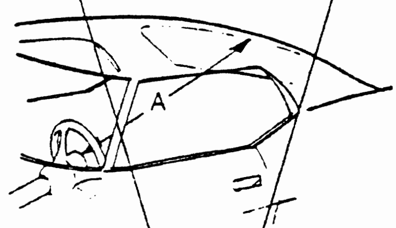
SWING-AWAY FEATURE

	PUNCH CODE	CARD COL.
EQUIPPED (1,2,0)*	___	20
FINAL POSITION (3) NOT APPLICABLE (4) NORMAL (5) RIGHT OF NORMAL (0) UNKNOWN	___	21

FINAL COLUMN POSITION

MEASURE THE DISTANCE FROM THE STEERING WHEEL CENTER TO THE TOP OF THE REAR WINDOW GLASS, DIRECTLY BEHIND THE HUB. ("A" IN SKETCH).

ENTER THIS DISTANCE IN BLANK "A".



A: ________ INCHES

COLUMN MOVEMENT

If top or rear window glass is displaced, then use (999)

(ENTER 99.9 IF UNKNOWN)

FROM A CORRESPONDING UNDAMAGED VEHICLE, MAKE A MEASUREMENT SIMILAR TO "A" ABOVE, AND RECORD IT IN BLANK "B". (PLACE TILT STEERING WHEEL IN MID-POSITION AND TELESCOPING COLUMNS IN FULL DOWN POSITION).

ORIGINAL DIMENSION (B) ________ IN.

DAMAGED VEHICLE DIMENSION (A) ________ IN.

DIFFERENCE |A-B| ________ 9 (22) 9 (23) . 9 (24)

tolerance ± 1.0

DIRECTION OF MOVEMENT

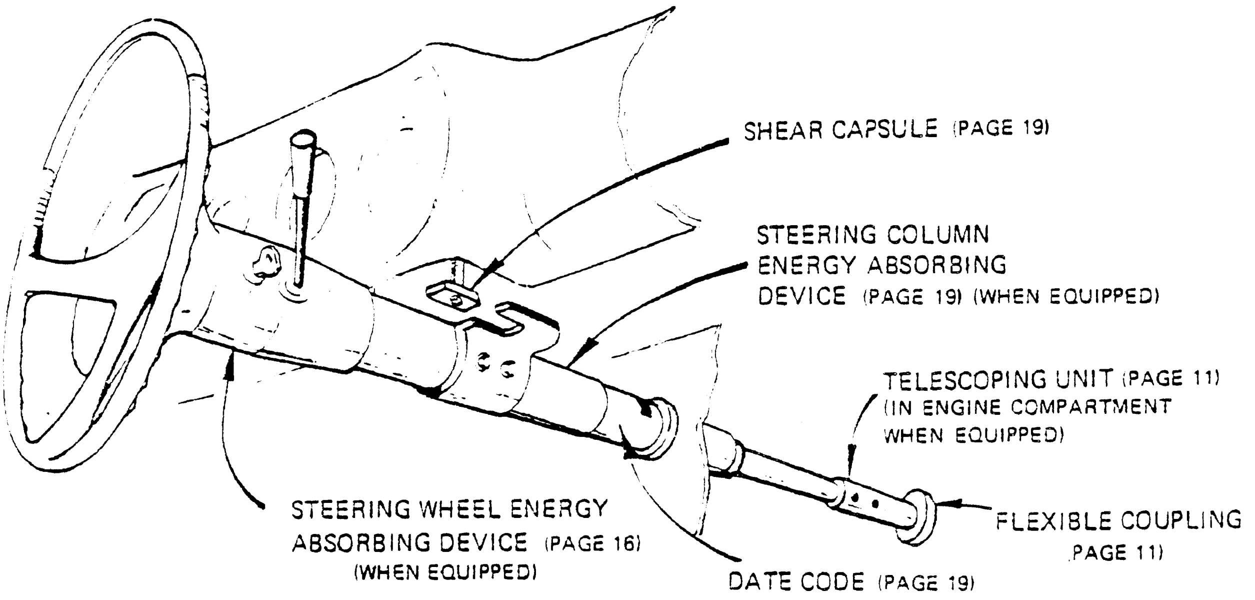
(4) FORWARD (A GREATER THAN B)
(5) REARWARD (A LESS THAN B)
(6) NEITHER
(0) UNKNOWN

0 (25)

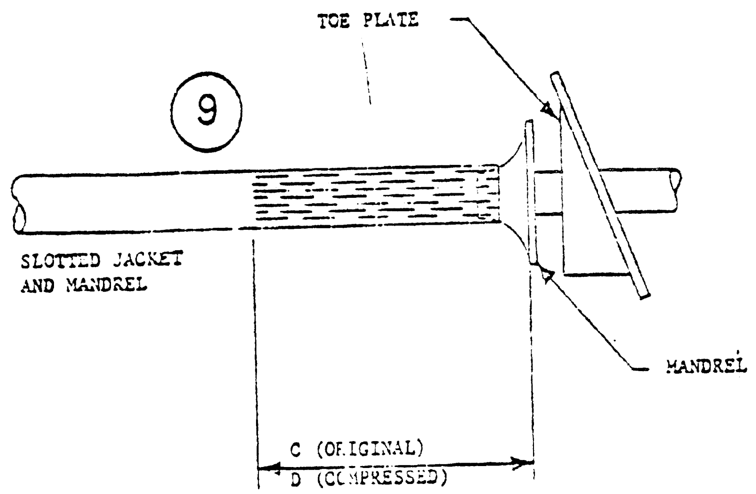
*WHERE (1,2,0) OR (1,2,3,0) ARE INDICATED, USE 1 FOR YES, 2 FOR NO, 3 FOR NOT APPLICABLE, 0 FOR UNKNOWN

STEERING WHEEL AND COLUMN

STEERING COLUMN (CONT'D.)

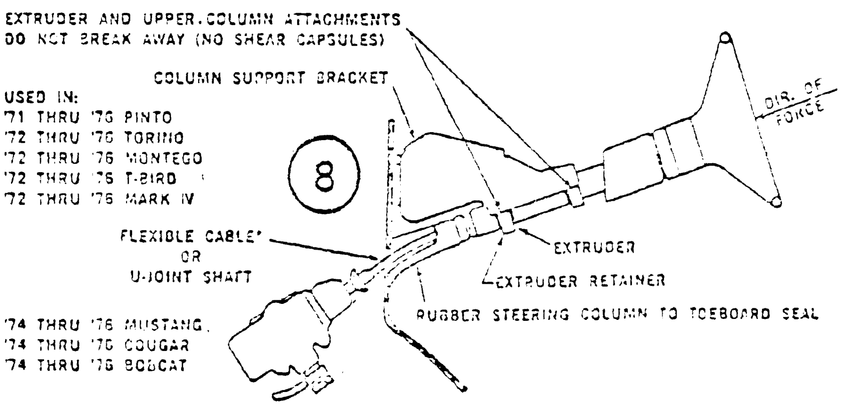


1974 CHRYSLER CORPORATION ENERGY ABSORBING STEERING COLUMN



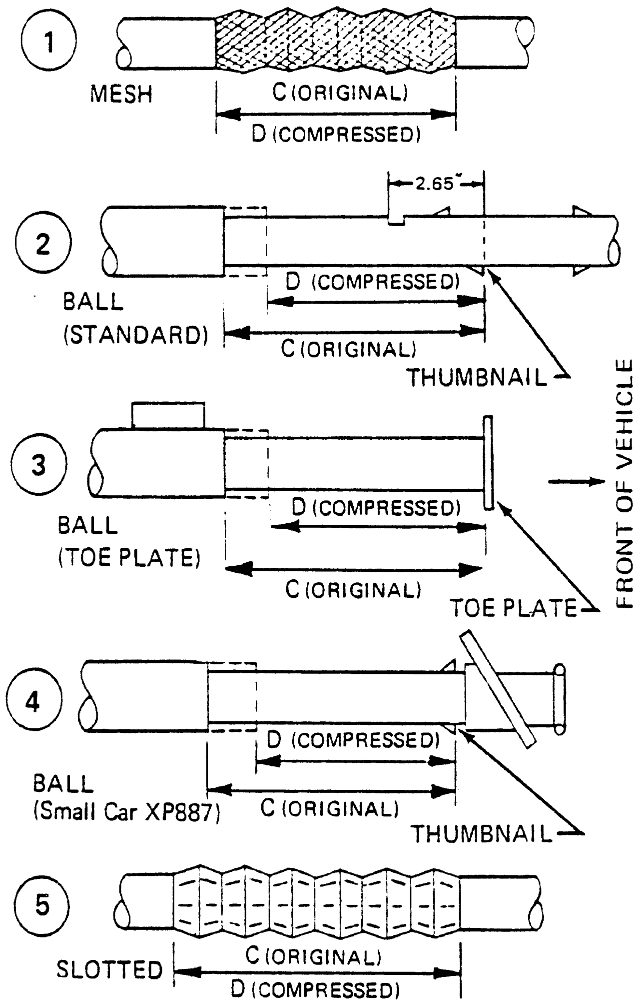
FORD ENERGY ABSORBING "MINI" COLUMN

(1971-76 PINTO; 1972-76 TORINO, MONTEGO, T-BIRD, MARK IV) AND
1975-76 BOBCAT; 1974-76 MUSTANG & COUGAR, AND 1975-76 GRANADA & MONARCH



STEERING COLUMN (CONT'D.)

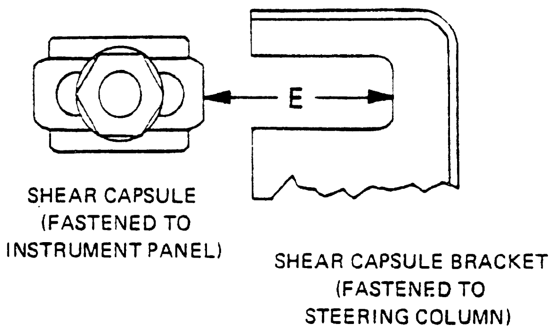
STEERING COLUMN ENERGY ABSORBING DEVICE SEE ALSO: page 18



STEERING COLUMN ENERGY ABSORBING DEVICE	PUNCH
TYPE OF DEVICE (7) Not Equipped (1) Mesh (2) Ball (Standard) (3) Ball (with Toe Plate) (4) Ball (Vega) (5) Slotted (6) Other:______ (e.g. Colt) (8) Ford Mini-Column (9) Chrysler Slotted Jacket and Mandrel (1974+) (0) Unknown	__ 26
(SEE DRAWING ON PAGE 18 FOR LOCATION)	
ORIGINAL LENGTH, (C) ______ COMPRESSED LENGTH, (D) ______ COMPRESSION, (C-D) ______ (777) Device Extended (888) Not Equipped, (999) Unknown (998) Compressed, Unknown Amount	__ __ . __ 27 28 29

SHEAR CAPSULE SEPARATION

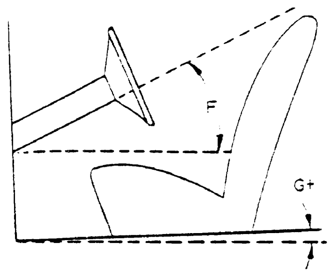
(SEE DRAWING ON PAGE 18 FOR LOCATION)



NOTE: WHEN CAPSULES HAVE SEPARATED IT MAY BE NECESSARY TO LIFT COLUMN ASSEMBLY INTO POSITION AGAINST INSTRUMENT PANEL BEFORE MEASURING.

	PUNCH
SHEAR CAPSULE SEPARATION (E) (888) Not Equipped, (999) Unknown (998) Separated, Unknown Amount	__ __ . __ 30 31 32

STEERING COLUMN VERTICAL ANGLE



MEASURE THE ANGLE THE STEERING COLUMN MAKES WITH THE HORIZONTAL ('F' IN DIAGRAM ABOVE), AND THE ANGLE THE DOOR SILL MAKES WITH THE HORIZONTAL ('G' IN DIAGRAM) AND ENTER THEM BELOW. ANGLES WHICH TILT DOWN TOWARD THE FRONT OF THE CAR ARE POSITIVE.

(NOTE: LIFT COLUMN INTO POSITION FOR MEASUREMENT)

F: ______ DEGREES; G: ______ DEGREES

COLUMN VERTICAL ROTATION	PUNCH
FINAL COLUMN POSITION COLUMN ANGLE (Relative to Ground) (F)____ VEHICLE ANGLE (G)____ COLUMN ANGLE (Relative to Vehicle) (F-G=H)____ FROM A CORRESPONDING UNDAMAGED VEHICLE, MAKE A MEASUREMENT SIMILAR TO "H" ABOVE AND RECORD IT IN BLANK "J" ORIGINAL DIMENSION (J)____ DAMAGED VEHICLE DIMENSION (H)____ COLUMN ROTATION (H-J)____ (ENTER 99 IF UNKNOWN) tolerance ± 1° 98 Rotated - Unknown amount	Either + or - __ __ 33 34

STEERING COLUMN

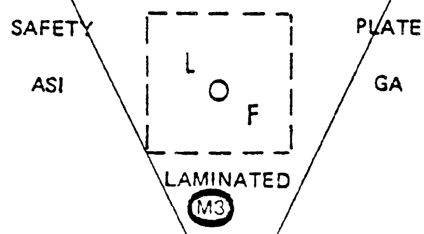
PASSENGER COMPARTMENT

GENERAL INFORMATION	PUNCH CODE	CARD COL.
PASSENGER COMPARTMENT REDUCED IN SIZE (1,2,0)*	____	35
EXTERNAL OBJECT INTRUSION (1,2,0)* DESCRIBE ON FOLD-OUT FLY-LEAF	____	36
INTERNAL LOOSE OBJECT (1,2,0)*	____	37
VERTICAL ROTATION OF INSTRUMENT PANEL (1,2,0)*	____	38
FIREWALL (COWL) DEFORMATION (1,2,0)*	____	39
FLOORPAN DEFORMATION (1,2,0)* (INCLUDING TOEPAN)	____	40
WINDSHIELD		
CRACKED (1,2,3,0)*	____	41
BROKEN (1,2,3,0)* (Plastic Interlayer Torn)	____	42
OCCUPANT CONTACT (1,2,3,0)*	____	43
CRACKED OR BROKEN BY OCCUPANT CONTACT (1,2,3,0)*	____	44
BOND SEPARATED (1,2,0)* (IF "YES", ESTIMATE PERCENT____)	____	45
~~WINDSHIELD CODE~~ (YY) ~~Unknown~~	Y Y	46-47

WINDSHIELD MARK

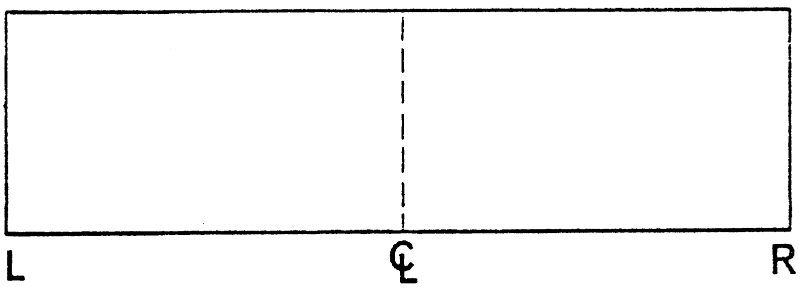
DRAW GLASS MANUFACTURER'S WINDSHIELD MARK WHICH IS LOCATED ALONG THE BOTTOM OF THE WINDSHIELD AT CENTER OR AT ONE CORNER.

EXAMPLE OF TYPICAL MARK:



MARK ON CASE VEHICLE:

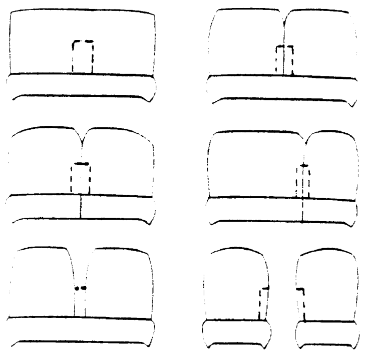
LOCATE AREA OF WINDSHIELD INTEREST OR DAMAGE WITH DIMENSIONS (VERTICAL & HORIZONTAL) ON THIS DIAGRAM OF THE WINDSHIELD AS VIEWED FROM INSIDE.



KEYPUNCH:
Col. 48-75=0
End of Card 07
Dup. 1-9 0/10 8/11
Col. 12-34=0

*WHERE (1,2,3,0) IS INDICATED, USE 1 FOR YES, 2 FOR NO, 3 FOR NOT APPLICABLE, 0 FOR UNKNOWN

PASSENGER COMPARTMENT (CONT'D.)

SEATS	PUNCH CODE	CARD COL.
TYPE OF FRONT SEAT		
(4) (7) (5) (8) (6) (9) 		
(0) UNKNOWN 3) Drivers Seat Only	—	35
FOLDING BACKS (1,2,0)*	—	36
DELUXE ACCESSORIES (1) Deluxe Accessories (2) None (4) Reclining Seatbacks (0) Unknown	—	37
TYPE OF SEAT ADJUSTERS Driver's Side (4) MANUAL (5) POWER (6) RIGID (7) OTHER: ____________ (0) UNKNOWN	—	38
TYPE OF SEAT ADJUSTMENT (3) NONE (NOT APPLICABLE) (4) 2-WAY (5) 4-WAY Driver's Side (6) 6-WAY (7) OTHER: ____________ (0) UNKNOWN (8) Swivel Seats	—	39
DAMAGE TO ADJUSTERS (1,2,0)* Include Rigid	—	40
TYPE OF DAMAGE TO ADJUSTERS (CHOOSE TWO: rank in order of severity) (2) None (4) Chucking (some free play) (5) Deformed (e.g. Released or Jammed) (6) Separated (0) Unknown (8) Swivel Damaged	— —	41 42
LOCATION OF SEPARATION (3) NOT APPLICABLE (4) AT FLOOR (5) AT ADJUSTER (6) AT SEAT (0) UNKNOWN	—	43

POSITION OF SEAT PRIOR TO CRASH	PUNCH CODE	CARD COL.
DRIVER'S SEAT (4) FORWARD (5) MIDDLE (6) REARWARD (0) UNKNOWN	—	44
RIGHT FRONT PASSENGER'S SEAT (3) NOT APPLICABLE (No Seat) (4) FORWARD (5) MIDDLE (6) REARWARD (0) UNKNOWN	code the same if bench seat —	45
DAMAGE TO FRONT SEAT		
BACKREST DAMAGE (1,2,0)*	—	46
CUSHION DAMAGE (1,2,0)*	—	47
CONTACTED BY REAR OCCUPANT (1,2,3,0)* 3 – If no rear occupant	—	48
SEAT CENTER ARMRESTS (FRONT)		
EQUIPPED (1,2,0)*	—	49
DAMAGED (1,2,3,0)*	—	50
HEAD RESTRAINTS (FRONT) Driver's Side		
EQUIPPED (1,2,0)*	—	51
REMOVED PRIOR TO COLLISION (1,2,3,0)* (3 – Integral)	—	52
RETAINED DURING COLLISION (,1,2,3,0)* (3 – Integral)	—	53
DAMAGED (1,2,3,0)*	—	54
OCCUPANT CONTACT (1,2,3,0)*	—	55
HEAD RESTRAINT ADJUSTMENT AT TIME OF COLLISION Driver's Side (3) Not Applicable, None (4) UP from seat top (5) DOWN on seat top (0) Unknown (6) Integral	—	56

SEATS

PASSENGER COMPARTMENT (CONT'D.)

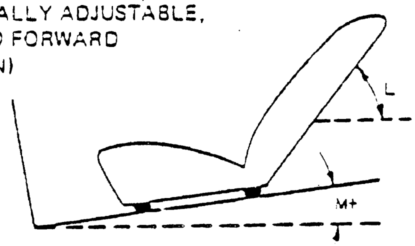
SEATS (CONT'D)

FRONT SEAT BACK LOCKS

		PUNCH CODE	CARD COL.
LEFT or center	EQUIPPED (1,2,3,0)*	___	57
	HELD (1,2,3,0)*	___	58
RIGHT	EQUIPPED (1,2,3,0)*	___	59
	HELD (1,2,3,0)*	___	60

FRONT SEAT BACK ANGLE

MEASURE THE FRONT SEAT BACK ANGLE AT THE LEFT AND RIGHT SEAT BACK FRAMES. (IF SEAT BACK ANGLE IS NORMALLY ADJUSTABLE, MOVE TO FORWARD POSITION)



MEASURE THE ANGLE THE SEAT BACK MAKES WITH HORIZONTAL (L IN DIAGRAM), AND THE ANGLE THE DOOR SILL MAKES WITH HORIZONTAL (M IN DIAGRAM) AND ENTER BELOW.

LEFT SIDE	RIGHT SIDE
L ____ DEG. M ____ DEG.	L ____ DEG. M ____ DEG.

SEAT BACK ROTATION

	DEGREES LEFT	DEGREES RIGHT	PUNCH CODE	CARD COL.
FINAL SEAT ANGLE (ENTER 99 IF UNKNOWN)				
SEAT ANGLE (L) (Relative to Ground)	___	___		
VEHICLE ANGLE (M)	___	___		
SEAT ANGLE (L-M=P) (Relative to Vehicle)	___	___		
FROM A CORRESPONDING UNDAMAGED VEHICLE, MAKE A MEASUREMENT SIMILAR TO "P" ABOVE AND RECORD IT IN BLANK "R" BELOW.				
ORIGINAL ANGLE (R)	___	___	(98) Rotated - Unknown amount	
DAMAGED SEAT ANGLE (P)	___	___		
DIFFERENCE (R-P)	___	___		
tolerance ±3°				
LEFT SEAT ANGLE DIFFERENCE			__ __	61-62
RIGHT SEAT ANGLE DIFFERENCE			__ __	63-64

TYPE OF REAR SEAT

(2) NO SEAT
(4) NON-FOLDING
(5) FOLDING
(0) UNKNOWN

PUNCH CODE	CARD COL.
___	65

END OF CARD 08

DUPLICATE COLUMNS 1-9 FROM PRECEDING CARD 0 (10) 9 (11)

DAMAGE TO REAR SEAT

	PUNCH CODE	CARD COL.
BACKREST DAMAGED OR LOOSENED (1,2,3,0)*	___	12
CUSHION DAMAGED OR LOOSENED (1,2,3,0)*	___	13

SEAT CENTER ARMRESTS (REAR)

	PUNCH CODE	CARD COL.
EQUIPPED (1,2,3,0)*	___	14
DAMAGED (1,2,3,0)*	___	15

REAR SEAT BACK LOCKS

		PUNCH CODE	CARD COL.
LEFT OR CENTER	EQUIPPED (1,2,3,0)*	___	16
	HELD (1,2,3,0)*	___	17
RIGHT	EQUIPPED (1,2,3,0)*	___	18
	HELD (1,2,3,0)*	___	19

THIRD SEAT

	PUNCH CODE	CARD COL.
EQUIPPED (1,2,0)*	___	20
BACKREST DAMAGED (1,2,3,0)*	___	21
CUSHION DAMAGED (1,2,3,0)*	___	22

BACKLIGHT (REAR WINDOW)

	PUNCH CODE	CARD COL.
DAMAGED (1,2,3,0)*	0	23
OCCUPANT CONTACT (1,2,3,0)*	0	24

BACKLIGHT HEADER

	PUNCH CODE	CARD COL.
DAMAGED (1,2,3,0)* convertible	0	25
OCCUPANT CONTACT (1,2,3,0)*	0	26

WINDOWS CLOSED AT TIME OF COLLISION (3=no window)

	PUNCH CODE	CARD COL.
LEFT FRONT (1,2,3,0)*	___	27
LEFT REAR (1,2,3,0)*	___	28
RIGHT FRONT (1,2,3,0)*	___	29
RIGHT REAR (1,2,3,0)*	___	30
BACKLIGHT (1,2,3,0)*	___	31
ALL SIDE WINDOWS OPERABLE AFTER COLLISION (1,2,3,0)*	___	32
POWER SIDE WINDOWS EQUIPPED (1,2,0)*	___	33

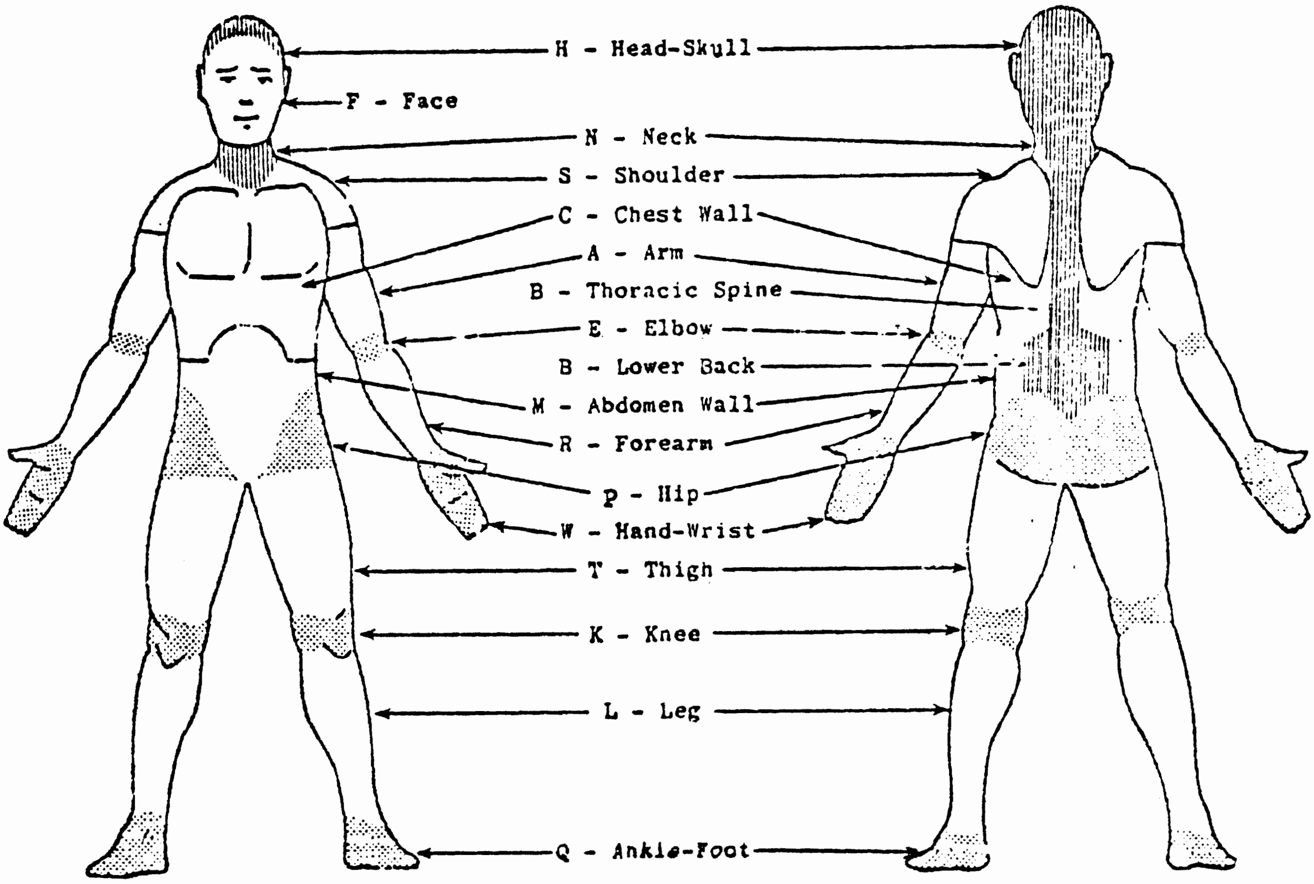
(PUT NOTES ON FOLD-OUT FLY-LEAF)

KEYPUNCH: Col. 34-59=0 End of Card 09
Dup 1-9 1 0 12-1=0 End of Card 10

*WHERE (1,2,0) OR (1,2,3,0) ARE INDICATED, USE 1 FOR YES, 2 FOR NO, 3 FOR NOT APPLICABLE, 0 FOR UNKNOWN

Case No. _ _-_ _ _ _ _ _-_

Occupant Position ________________



OCCUPANT INFORMATION

OCCUPANT

DUPLICATE COLUMNS 1-9 FROM PRECEDING CARD __/__ __/__ (10, 11)

	PUNCH CODE	CARD COL.
OCCUPANT NUMBER	__ __	12-13
SEAT LOCATION (3) EXTERNAL TO PASS. COMP. (e.g., bed of pickup) (4) FRONT (5) REAR (6) THIRD (7) OTHER: ____________ (0) UNKNOWN	__	
POSITION ON SEAT (3) EXTERNAL TO PASS. COMP. (4) LEFT (5) LEFT CENTER (6) CENTER (7) RIGHT CENTER (8) RIGHT (9) ALL (Lying on seat) (0) UNKNOWN	__	
POSTURE (1) SITTING ON SEAT (2) ON LAP OR IN ARMS (3) STANDING ON SEAT (4) STANDING ON FLOOR (5) IN BASSINET (6) IN CHILD SEAT (7) LYING ON SEAT (8) LYING OR SITTING ON FLOOR OR OTHER OBJECT (0) UNKNOWN	__	16
AGE YEARS, OR	__ __	17-18
MONTHS (INFANTS) to 24 months (ENTER "0"S IF UNKNOWN)	__ __	19-20
WEIGHT, LBS. (ENTER "0"S, IF UNKNOWN)	__ __ __	21-23
HEIGHT, INCHES (ENTER "0"S, IF UNKNOWN)	__ __	24-25
SEX (4) Male (5) Female (6) Large Animal (0) Unknown	__	26

RESTRAINT SYSTEM	PUNCH CODE	CARD COL.
LAP BELT		
EQUIPPED FOR THIS POSITION (1,2,0)*	__	27
WORN BY OCCUPANT (1,2,3,0)*	__	28
WORN CORRECTLY (1,2,3,0)*	__	29
LOCKING RETRACTOR (1,2,3,0)*	__	30
UPPER TORSO RESTRAINT Upper Torso Belt and/or Air Bag Equipped (1) No A/B & Upper Belt Equipped (2) No A/B & Upper Belt Not Equipped (0) No A/B & Upper Belt Unk if Equipped (4) A/B Equipped & Upper Belt Equipped (5) A/B Equipped & Upper Belt Not Equipped (6) A/B Equipped & Upper Belt Unk if Equipped (9) Both A/B & Upper Belt Unk if Equipped	__	31
Upper Torso Belt and/or Air Bag Used (1) No Deployment or No Bag; Upper Belt Worn (2) No Deployment or No Bag; Upper Belt Not Worn (3) No Deployment or No Bag; No Upper Belt (0) No Deployment or No Bag; Unknown if Worn (4) Deployment; Upper Belt Worn (5) Deployment; Upper Belt Not Worn (6) Deployment; No Upper Belt (7) Deployment; Upper Belt Unknown if Worn (9) Both Upper Torso Worn or Air Bag Deployed Unknown	__	32
WORN CORRECTLY (1,2,3,0)*	__	33
INERTIA REEL (1,2,3,0)*	__	34
LAP AND/OR UPPER TORSO RESTRAINT USAGE CODE	__ __	35-36
TYPE OF UPPER TORSO PESTRAINT USED (3) No Torso Restraint Used (4) 3-point (5) 4-point (6) Other (e.g. VW passive restraint system) (7) Air Bag Deployed & No Belts Used (8) Air Bag Deployed & Any Belts Used (9) Air Bag Deployed & Unknown Belt Use (0) Unknown	__	37
CHILD RESTRAINT SYSTEM: NOTE MAKE AND MODEL NUMBER ____________ ____________		
CHILD RESTRAINT CODE (99 none)	__ __	38-39
	__	40
	__	41

*WHERE (1,2,0) OR (1,2,3,0) ARE INDICATED, USE 1 FOR YES, 2 FOR NO, 3 FOR NOT APPLICABLE, 0 FOR UNKNOWN

OCCUPANT INFORMATION

EJECTION	PUNCH CODE	CARD COL.
DEGREE OF EJECTION (2) NONE (4) PARTIAL (5) COMPLETE (0) UNKNOWN	___	42
AREA OF EJECTION (3) NOT APPLICABLE (1) WINDOW, LEFT SIDE (2) " , RIGHT SIDE (4) " , REAR (5) DOOR, LEFT SIDE (6) " , RIGHT SIDE (7) TAILGATE (8) WINDSHIELD (9) ROOF OR OPEN CONVERTIBLE OR FROM EXTERNAL AREA (0) UNKNOWN	___	43
TREATMENT/MORTALITY (0) None (1) First Aid - On-scene or outpatient (2) Hospitalized - Observation under 24 Hours (3) Hospitalized - Significant Treatment or over 24 Hours (4) Fatal - Dead at Scene (5) Fatal - Dead on Arrival at Hospital (6) Fatal - Dead within 24 Hours (7) Fatal - Dead 24 hours to 1 year (8) Fatal - Time of Death Unknown (9) Unknown	___	44
OVERALL SEVERITY OF INJURIES (USE 1976 AIS) (00) NONE (01) MINOR (02) NON-DANGEROUS, MODERATE (03) NON-DANGEROUS, SEVERE (04) DANGEROUS, SERIOUS (05) DANGEROUS, CRITICAL (06) MAXIMUM, UNTREATABLE (98) INJURY UNKNOWN (99) INJURED, SEVERITY UNKNOWN	___ ___	45-46
	END OF CARD	

RECUPERATION AND TREATMENT FOR A PERIOD OF AT LEAST ONE DAY. "HELD FOR OBSERVATION ONLY" IS NOT CONSIDERED "HOSPITALIZED" IN THIS DEFINITION.

Dup 1-9 Card 8 0 (10) Dup 12-13 0 (14)

POSTURE (10) Sitting on Seat (11) Sitting on Seat in Abnormal Position (e.g., Feet on Dash, Sideways, Etc.) (12) Sitting on Console (20) On Lap or in Arms (30) Standing on Seat (40) Standing on Floor (47) Standing - External to Passenger Compartment (50) In Bassinet (60) In Child Seat (65) In Child Harness (70) Lying on Seat (80) Lying or Sitting on Passenger Floor (83) Lying or Sitting on Other Object in Passenger Compartment (85) On Station Wagon Cargo Floor or Fold Seat Back (87) Lying or Sitting - External to Passenger Compartment (98) Other: ________ (00) Unknown	___ ___ (16) 9 (17)
Occupant Alcohol Involvement/Test (0) Unknown (999).................. NO TEST (1) Alcohol Not Suspected (000)........... (2) Alcohol Indicated & No Test Requested (999). (3) Test Requested & Refused (999)............. (4) Reason Unknown & Alcohol Indicated (999)... (5) Charged DWI, Booked Drunk (999)................ (6) Fled Scene (999).......... BAC TESTED (8) Results Not Given (999)... (9) Results Reported (____)...	___ (18)
Occupant Blood Alcohol Level (MG%) (000) Had Not Been Drinking or Negative Test BAC=.000 . .. ____ Record Actual BAC (MG%).... (999) Tested but results Unknown or No Results.....	. ___ ___ ___ (19) (20) (21)
Occupant Alcohol Test (2) None YES: (1) Type Unknown (4) Urine (5) Spinal (6) Breath (7) Blood (8) Other: ________ (9) Several of Above (0) Unknown	___ (22)

k

SEAT BELT BUZZER/INTERLOCK EQUIPPED

23

(0) Unknown if Equipped

(1) Equipped, Type Unknown

(2) Not Equipped

(4) Non-Cycled Buzzer

(5) Ignition Interlock

(6) 4-second buzzer (post-interlock)

(9) Other:____________

SEAT BELT BUZZER OPERATIONAL

(0) Unknown if Operational

(1) Yes, Operational

24

(2) Not Operational, Reason Unknown

(3) Not Applicable, Not Equipped

System Inhibited by:

(4) Fastening Belts Together (Behind Occupant, Behind Seat, Under Seat, In Front of Seat, etc.)

(5) Disconnection, Removal, Intentional Destruction)

(6) Fixing in Pulled-Out Position (Knotted, Taped, Twisted, Folded Back, Tucked into Seat, Hooked To Upper Belt, etc.)

(7) Temporarily Fixing (Sitting on Belt, Holding onto Belt, Hook on Floor, etc.)

(8) Letting it Buzz

(9) Other: (Defective)

IGNITION INTERLOCK OPERATIONAL

(1,2,3,0)

25

PASSIVE RESTRAINT SYSTEM EQUIPPED

(2) No

YES:

26

(1) Type Unknown

(4) Air Bag

(5) Knee and Torso Restraint (e.g., VW)

(9) Other:____________

(0) Unknown

PASSIVE RESTRAINT SYSTEM ACTIVATED

27

(3) Not Applicable, None

(2) No

(1) Yes

(0) Unknown

C/28

INVESTIGATOR'S JUDGEMENT OF RESTRAINT SYSTEM EFFECTIVENESS

(0) Unknown

29

(1) Reduced Injury Severity

(2) Could Have Reduced Severity If Worn

(3) No Opinion

(4) Could Not Have Reduced Severity if Worn

(5) Did Not Reduce Severity

(6) Increased Severity

(7) Would Have Increased Severity if Worn

(8) More Restraints Would Have Reduced Severity

TREATMENT/MORTALITY

30

(00) None

(01) First Aid At Scene

(02) Treated at Hospital/Clinic but not Admitted

(03) Hospitalized (observation less than 24 hours)

(04) Hospitalized over 24 Hours or Significant Treatment

(05) Fatal--Dead at Scene

(06) Fatal--DOA

(07) Fatal--Dead within 24 Hours

(08) Fatal--Dead 24 hrs to 1 yr

(09) Fatal--Period Unknown

(99) Unknown

EMS CONTRIBUTORY TO SEVERITY

Due to delays and/or insufficient treatment on-scene or in transport?

32

(2) No

(1) Yes

(0) Unknown

(4) Exemplary Service

AUTOPSY PERFORMED

(3) Not Applicable/ Non-fatal

33

(1) Yes

(2) No

(0) Unknown

OVERALL POLICE INJURY SEVERITY (KABC)

(0) 0,D No Injury

(1) C Possible Injury

(2) B Non-incapacitating Injury ____ 34

(3) A Incapacitating Injury

(4) K Fatal

(9) Unknown

(5) Reported as Injured (severity not reported)

RESTRAINT SYSTEM CONDITION

Belts Operable (0,1,2,3) Lap ____ 35 Shoulder ____ 36

Belts or Fittings Damaged (0,1,2,3) Lap ____ 37 Shoulder ____ 38

Belts or Fittings Damaged by Occupant Loading (0,1,2,3) Lap ____ 39 Shoulder ____ 40

RESTRAINT USAGE

SOURCE OF INFORMATION:

Vehicle (0,1,2,3) ____ 41

Injury Data (0,1,2,3) ____ 42

Occupant (0,1,2,3) ____ 43

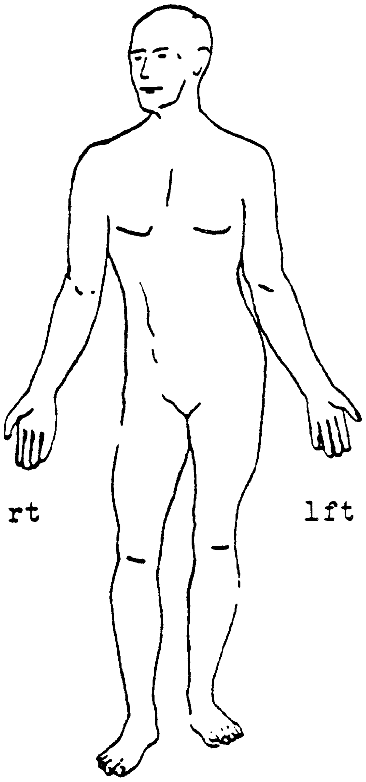
Other:____ (0,1,2,3) ____ 44

Restraint Usage Conclusion Lap ____ ____ 45 Shoulder ____ ____ 48

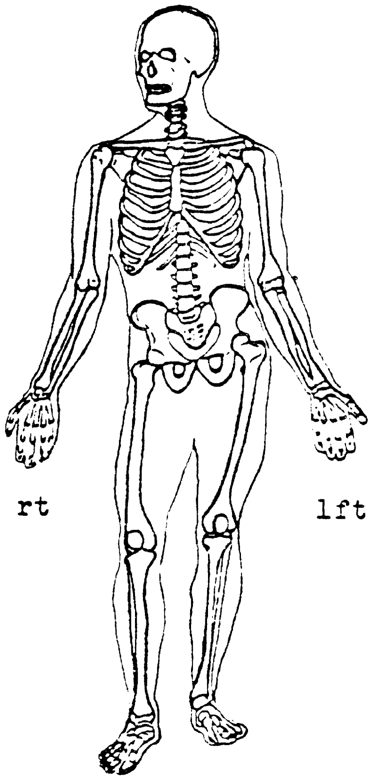
Yes		No
+3	Definite	-3
+2	Probable	-2
+1	Possible	-1
00	Unknown	00
99	Not Applicable	99

INDICATE LOCATION OF INJURIES, INCLUDING MAJOR BRUISES

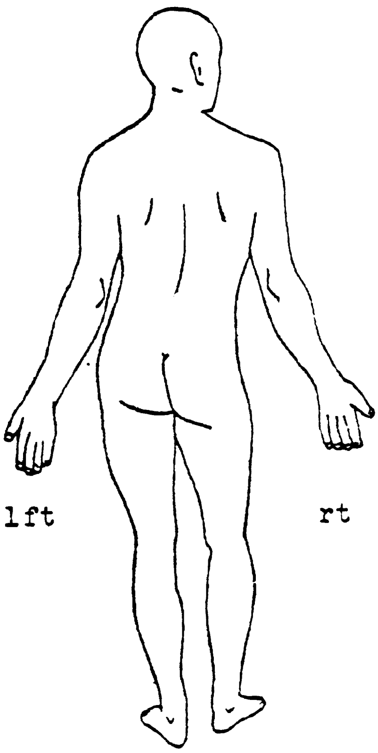
( ) NO INJURIES
( ) INJURED

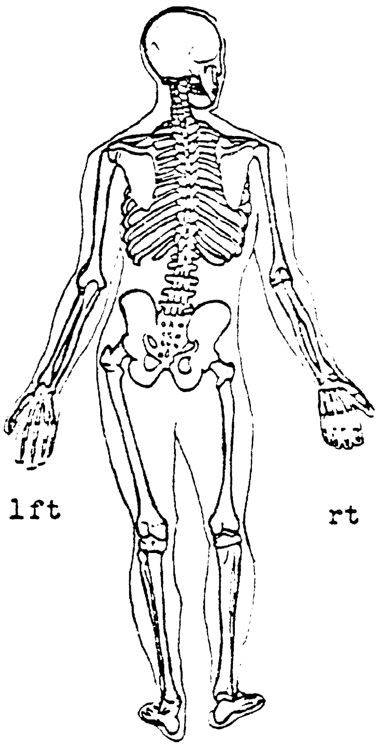


SOFT TISSUE INJURIES



SKELETAL INJURIES





X Rays: ________________________________

Other Tests: ____________________________

INJURY INFORMATION

2/76

BEST SOURCE OF INJURY INFCRMATION

49

( ) 1 Hospital/Doctor
( ) 2 Personal interview with occupant
( ) 3 Personal interview with other occupant
( ) 4 Other: ______________________

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*
*

END CARD 80

OCCUPANT INJURY CLASSIFICATION

	CARD NUMBER	OCCUPANT NO.	Place contacts in order of probability (horizontally). Start with most probable in col. 14-15. FOUR AREA(S) OF POSSIBLE CONTACT				PRIMARY OIC					ASSOCIATED OIC'S									
							BODY REGION	ASPECT	LESION	SYSTEM/ORGAN	SEVERITY	BODY REGION	ASPECT	LESION	SYSTEM/ORGAN	SEVERITY	BODY REGION	ASPECT	LESION	SYSTEM/ORGAN	SEVERITY
1-6	10-11	12-13	14-15	16-17	18-19	20-21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
DUPLICATE FROM PRECEDING CARD	81																				
	82																				
	83																				
	84																				
	85																				
	86																				
	87																				
	88																				
	89																				
	90																				
	91																				
	92																				
	93																				
	94																				
	95																				

NOTE areas of occupant contact.

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RESTRAINT DEVICE & USAGE

DEVICE STATUS

AT TIME OF COLLISION

	SOURCE USED	LAP BELT		SHOULDER BELT		OTHER DEVICE ①		CHILD SEAT	
EQUIPPED for this POSITION		11 1( ) Y 2( ) N 9( ) U	Original Equipment 12 1( ) Y 2( ) N 9( ) U	13 1( ) Y 2( ) N 9( ) U	Original Equipment 14 1( ) Y 2( ) N 9( ) U	15 1( ) Y 2( ) N 9( ) U	Original Equipment 16 1( ) Y 2( ) N 9( ) U	17 1( ) Y 2( ) N 9( ) U	Mfg: ____ Model: ____
BELTS OPERABLE		18 1( ) Y 2( ) N 9( ) U	Malfunction 19 1( ) ② Defeat 2( ) ③	20 1( ) Y 2( ) N 9( ) U	Malfunction 21 1( ) ② Defeat 2( ) ③	22 1( ) Y 2( ) N 9( ) U	Malfunction 23 1( ) ② Defeat 2( ) ③	24 1( ) Y 2( ) N 9( ) U	Malfunction 25 1( ) ② Defeat 2( ) ③
INTERLOCK BUZZER FUNCTIONAL		26 1( ) Y 2( ) N 9( ) U	Malfunction 27 1( ) ② Defeat 2( ) ③	28 1( ) Y 2( ) N 9( ) U	Malfunction 29 1( ) ② Defeat 2( ) ③	30 1( ) Y 2( ) N 9( ) U If ACRS --④	Malfunction 31 1( ) ② Defeat 2( ) ③		

DEVICE USAGE

		Response	Judgement	Response	Judgement	Resp	Deploy	Judge	Response	Judgement
VEHICLE	11 (1)Y (2)N (7)UA		12,13		14,15		16 1( ) Y 2( ) N 9( ) U	17,18		19,20
INJURY DATA	21 (1)Y (2)N (7)UA		22,23		24,25		26 1( ) Y 2( ) N 9( ) U	27,28		29,30
INTERVIEW OCCUPANT	31 (1)Y (2)N (7)UA	32 1( ) Y 2( ) N 6( ) NR	33,34	35 1( ) Y 2( ) N 6( ) NR	36,37	38 1( ) Y 2( ) N 6( ) NR	39 1( ) Y 2( ) N 9( ) U	40,41	42 1( ) Y 2( ) N 6( ) NR	43,44
INTERVIEW: ____	45 (1)Y (2)N (7)UA	46 1( ) Y 2( ) N 6( ) NR	47,48	49 1( ) Y 2( ) N 6( ) NR	50,51	52 1( ) Y 2( ) N 6( ) NR	53 1( ) Y 2( ) N 9( ) U	54,55	56 1( ) Y 2( ) N 6( ) NR	57,58
INTERVIEW: ____	59 (1)Y (2)N (7)UA	60 1( ) Y 2( ) N 6( ) NR	61,62	63 1( ) Y 2( ) N 6( ) NR	64,65	66 1( ) Y 2( ) N 6( ) NR	67 1( ) Y 2( ) N 9( ) U	68,69		
CONCLUSION			70,71		72,73		74 1( ) Y 2( ) N 9( ) U	75,76		77,78

YES		NO
+3	DEFINITE	-3
+2	PROBABLE	-2
+1	POSSIBLE	-1

00 UNKNOWN
99 NOT APPLICABLE

Y = YES
N = NO
U = UNKNOWN
NR = NO RESPONSE
UA = UNAVAILABLE

Response = Literal response of interviewee.
Judgement = Interviewer's best judgement of and confidence in interviewees response to question of restraint usage.

① Specify & describe device: ____________________

Describe irrespective of source. Source of Information

② Malfunction: ____________________

③ Defeat: ____________________

④ Summarize status of ACRS: ____________________