APPENDIX B

LETTER FROM JOHN VERSACE
FORD MOTOR COMPANY

February 6, 1975

Ford Motor Company

20000 Rotunda Drive
Dearborn, Michigan 48121 :
Mailing Address:
P.O. Box 2053
Dearborn, Michigan 48121

February 6, 1975

Mr. Howard P. Gates, Jr.
Economics & Science Planning
1200 18th Street, N.W.
Washington, D.C. 20036

Subject: OTA Automobile Collision Data Workshop

Dear Howard:

It did take some time in a very busy schedule to meet with you and to put our thoughts down, but we appreciate the opportunity to express our understanding of, and our position on the subject of accident data. In regard to societal costs: the Ford Motor Company submission to Docket 74-15 -- Advance Notice Concerning Higher Speed Protection Requirements -- contains some estimates of the additional consumption of resources entailed in trying to meet a high speed requirement.

It is difficult to determine all the ways in which inadequate accident data would lead to unnecessary expansion of costs, but we believe this one example will provide a general picture of the possible magnitude of such expense. I don't believe we conclude that raising the crash requirements is the wrong thing to do, but rather because the cost implications are so great nothing less than a commensurately significant analysis and determination of need –- which has not been done –- should precede any decision.

It is easy to lose sight of the fact that a good intention, or want, or objective gets converted, by means of a regulation, into very specific operational requirements and specifications which the manufacturer must meet, specifications which may have little to do in the last analysis with the intentions of the regulation. However, the regulation, in its specific detail, is often defended on the basis of its motivation rather than on what the particular requirements of the regulation are likely to actually accomplish. Specifically, in this case, if it is deemed desirable to provide better protection for those people who are in high speed crashes, then it may or may not follow that running an automobile into an immovable wall at 45 or 50 mph, and then comparing readings gotten on accelerometer in dummies against some mandated criterion level somehow validly signifies accomplishment of the societal goal which motivated the standard. The likelihood of gross erosion of relevance is probably nowhere better seen than in the accident avoidance series of standards, where little or no validation has been attempted.

A contrary argument is likely to be heard: that the need is so great we cannot wait for all the evidence to be in, that utterly adequate evidence will never be forthcoming, and thus we must act now. But such an argument seems to beg the question: for how can we know we must act now -- especially with some particular countermeasure -- if that determination depends on having adequate data? A variant on this argument is that it can do no harm and might do some good. But, without data there is no assurance that particular countermeasures will do no harm, and certainly a cost without a compensating benefit is a net harm.

I am attaching a copy of the Ford docket submission on the higher speed protection requirements proposal, but you will probably want to give special attention to the brief summary, "societal Cost Implications of Inadequate Accident Data," which puts forth the main points made there.

In addition, I am attaching an updated copy of the remarks which I made at the Workshop. They are essentially the same as the statement I read, but there have been some additional clarifications which I felt were appropriate in view of the discussions which took place at the meeting.

Sincerely,

John Versace

John Versace
Executive Engineer
Safety Research

Attachments

SOCIETAL COST IMPLICATIONS OF INADEQUATE ACCIDENT DATA

The demonstration of need for any safety standard must ultimately be established by accident data -- in all its forms -- if objective safety standard performance levels are to be achieved. If standard performance levels are established on a subjective basis, the possibility of very high societal cost with inadequate return for that cost is very real.

As an example of proposed performance levels which could have severe societal cost implications consider NHTSA's Advanced Notice of Proposed Rulemaking (ANPRM), Docket 74-15 Notice 1. This ANPRM proposes to increase frontal barrier crash requirements from 30 mph to 45/50 mph -- an increase in crash energy management requirements of 125 to 177% above that required today. The notice also proposes to implement the rule on September 30, 1980.

Ford Motor Company's response to this notice is attached. It presents the implications of implementing such a proposal in terms of increased car weight and car length. For example, to meet the frontal crash requirement alone, a 1974 Ford would be 500 pounds heavier and 16 inches longer; a 1974 Pinto would be 600 pounds heavier and 37 inches longer. Additional weight would be required to meet side and rear impact, roof crush, and fuel system crash requirements currently in being or presently proposed in other standards.

Weight increases of the magnitude discussed above imply completely re-designed cars -- not modifications to on-going designs. In addition to new metal structures, the added weight would require higher performance powertrain and running gear (brakes, suspensions> steering systems, etc.. . . .) which in turn would tend to weigh more. Ford Motor Company markets 16 domestically manufactured car lines built from eight separate body shell platforms. To completely redesign these platforms would involve staggering engineering and investment costs. Annual increased car purchase costs to consumers -- assuming such a gigantic task could be done at all -- would be on the order of billions of dollars annually.

Such a major weight increase in cars would have a two-fold effect on the consumption of energy. The fuel economy of vehicles would deteriorate and secondly, additional energy would be used to manufacture the added weight.

Fuel economy may be expected to decrease from the current average of 13.6 miles per gallon by about 10%. This represents an increase in fuel usage of 25 million barrels each year. Should this weight increase be applied to the entire vehicle population, the annual fuel economy penalty would be nearly 200 million barrels. In ten years gasoline purchase costs would be on the order of $5 billion more per year than 1975.

Adding this weight to 10 million new cars each year would increase manufactured material requirements by about 3 million tons annually. The gross effect of the vehicle weight increases would be to increase the demand for finished steel, steel castings and rubber for the auto industry by about 20%. The energy consumption for manufacturing this added material weight in 10 million new cars each year would approximate 130 trillion B.T.U's.

If all the cars on the road were at the higher weight levels, the total annual cost increase to consumers would be the sum of the annual cost of the decreased fuel economy (projected at $5 billion), PIUS the higher costs and energy associated with manufacturing the heavier vehicles (projected to be billions of dollars annually). This sustained annual societal cost impact could take place because of a regulation whose need has not been definitely or definitively established.

Ford Motor Company

The American Road
Dearborn, Michigan 48121

September 19, 1974

National Highway Traffic
Safety Administration
Docket Section -- Room 5108
400 Seventh Street, S. W.
Washington, D. C. 20590

Gentlemen:

Re: Advance Notice Concerning Higher Speed Protection Requirements (Docket 74-15: Notice 1)

Enclosed are Ford Motor Company's comments on the Administration's advance notice of proposed rulemaking to increase the frontal barrier crash requirements of Federal Motor Vehicle Safety Standard No. 208, Occupant Crash protection, to 45 or 50 mph effective September, 1980. Ford has also participated in the preparation of comments being submitted by the Motor Vehicle Manufacturers Association and respectfully requests that those comments be incorporated herein by reference.

The comments address the several areas of interest cited by the Administrator in the subject advanced notice of proposed rulemaking. It is appropriate, however, to highlight certain salient points on which the comments expand.

There is the apparent assumption that a 'manifold increase in lifesaving capability of occupant crash protection systems" can be demonstrated merely by increasing the velocity at which a test vehicle impacts a fixed barrier and having the recorded test results satisfy essentially arbitrary criteria.

As the Administration well knows, there are many unsettled questions and unresolved issues with regard to Standard 208 including the correlation of test device responses to those of humans, the subjectivity of test procedure, the questionable appropriateness of the criteria, etc. Barrier crash tests are not representative of actual traffic accidents. Meeting some requirement using a test device having a superficial resemblance to a 50th percentile male adult positioned in a normal seated position is no guarantee that human occupants will survive in actual collisions of apparent equivalent severity.

Despite the uncertainty associated with Standard No. 208, in an effort to aid the Administration in defining the potential effects of adopting requirements such as those in this proposal, Ford has conducted a theoretical study related only to front end impacts using a Simplified model and idealized assumptions as to restraint systems, structure behavior, etc. That study, as explained in the attached comments, convinces us that the results of the Administration's proposal would be to increase the weight of a vehicle with a Pinto size passenger compartment by about 600 pounds and that of a Ford size vehicle by between 500 and 900 pounds for a 50 mph barrier impact speed. Length increases of as much as 37 inches for the Pinto and 16 inches for the Ford would be required. Specific modifications would be dependent upon restraint systems parameters that are yet undeveloped.

It is obvious that vehicle weight increases of this magnitude will have a pronounced effect on vehicle cost. The engineering and investment costs necessary for major redesigns of all existing cars in a short time period of a few years might best be described as staggering. Based on our analysis to date, Ford would not be able to meet the proposed effective date of September, 1980.

These weight and length increase estimates are based on a simplified, idealized analytical study and we consider them the minimum changes required, if only the requirement for front end impact speed was increased. It is significant that these results are not greatly dissimilar to those that could be derived from an analysis of the vehicle designed and built under the Experimental Safety Vehicle programs. It is also significant to note that none of the full sized Experimental Safety Vehicles were successful in meeting the requirements during a 50 mile per hour barrier crash despite, in some cases, the somewhat exotic designs employed.

Ford believes that the increased speed requirement with its attendant cost and weight increases cannot be justified without an analysis of highway accident data showing that a safety need exists for the proposed increase. The accident impact speed data currently available with which to perform a benefit analysis of higher speed requirements are dependent on subjective human evaluation. Speed estimates in existing data files are thought to be unreliable because they are formed by witnesses or by accident investigators having varying degrees of experience.

The lack of a sound data base with which to evaluate the need for higher speed performance requirements further underscores the need for a large scale crash recorder program to evaluate the actual crash dynamics. The initial results of crash recorder analyses have indicated that impact speeds estimated by police and accident investigation teams are consistently higher than the speed change noted by the recorder.

Ford is currently engaged in a research project under DOT contract to define the performance parameters of a 3000 pound safety vehicle which will be practicable to manufacture in the mid 1980's. We believe this research will be of value in evaluating future motor vehicle safety needs in the area of higher speed protection. This project is scheduled for completion in April, 1975.

We, therefore, recommend that NHTSA's efforts in the area of higher speed occupant crash protection be concentrated on developing an accurate data base from which the Administration can determine,on an informed basis, the safety need, if any, for a barrier crash test and identify appropriate and practicable test speeds.

At the present time we can only conclude that adopting the proposal advanced in this notice would have the certain effect of increasing weight and vehicle size (with the attendant adverse effects on fuel and material consumption) and consumer cost. The amount of benefit to be gained is only speculative.

If we can be of further assistance in explaining our position, we will be available at the Administration's convenience.

"Respectfully submitted,

J. C. Eckhold
Director
Automotive Safety Office

bgw

Attachments

ATTACHMENT
September 19, 1974

HIGHER SPEED PROTECTION REQUIREMENTS
DOCKET 74-15; NOTICE 1

COMMENTS OF FORD MOTOR COMPANY

Ford Motor Company, with Offices at The American Road, Dearborn, Michigan 48121, as a manufacturers of motor vehicles, is commenting on the Advance Notice of Proposed Rulemaking concerning Higher Speed Protection Requirements published in the Federal Register on March 19, 1974 (39 Fed. Reg. 10273).

The Notice states that the Administration is considering amending Federal Motor Vehicle Safety Standard No. 208 (FMVSS 208) to include a 45 or 50 mph frontal crash requirement with a suggested effective date of Septmber 1, 1980.

In our evaluation of the Administration% proposal, we found we were impaled by the lack of adequate factual information. Analysis of the available accident data lead us to the conclusion that such data are not sufficiently reliable to assess safety need.

Review of the public record on FMVSS 208 did not disclose the existence of technology which would show that a practicable vehicle could be designed to meet the frontal impact requirements of that Standard at 50 mph. The domestic ESV's, including the one built by Ford, represent the most comprehensive attempts to comply with such a requirement and all of them failed in that endeavor.

Nonetheless, we have gained some insight into the problem and have prepared the following comments based in part on engineering judgment, relying heavily upon theoretical studies.

Technology

The Administration states in the Notice that based on research which is extensively documented in the Docket on FMVSS 208, it is of the opinion that technology has advanced to the point where protection can be offered in crashes equivalent to those into a fixed barrier at more than 40 mph. We have examined the public record concerning FMVSS 208 and have found no evidence that the Administration has ever conducted the complete test series required by FMVSS 208 even at 30 mph, much less at 45 or 50 mph.

<u>Technogy</u> (Cont'd)

None of the domestic experimental safety vehicles built under DOT contracts met the performance requirements of FMVSS 208 at 50 mph. These vehicles exceeded the 4000 pound weight objective by between 1000 and 2000 pounds. One such vehicle even used unconventional lightweight materials in an effort to minimize weights. These materials are generally impractical for high volume automotive use because of supply limitations, high cost and lack of adequate manufacturing technology.

More recent higher speed research by NHTSA contractors has concentrated on maintaining passenger compartment integrity independent of programs to develop restraint systems* Advanced structures have not been evaluated in combination with advanced restraint systems in a 50 mph fixed barrier impact test series which would otherwise conform to FMVSS 208 although the intent to do so has been expressed in requests for contract proposals issued by NHTSA.

This was noted by Dr. Patrick Miller of Calspan Corporation in his statement before the Senate Commerce committee on February 21, 1974. He stated that “although impressive structural performance has been demonstrated during frontal collisions, we have not yet developed restraint systems which could take advantage of these advances”.

Another problem which has not been adequately considered is the possibility of adverse consequences on occupants of vehicles designed for a 50 mph barrier impact when they are involved in lower speed impacts. The possibility exists that due to increase in vehicle stiffness the injury level in low speed collisions will Become worse.

Many of the crash tests have been conducted at test weights substantially less than that required by FMVSS 208. Under DOT Contract HS-257-2-461, ‘Frontal and Side Impact Crashworthiness-Compact Cars” the contractor conducted the crash test without any dummy occupants and with the vehicle weight 700 pounds under that required by FMVSS 208. The effect of added weight is to place even greater demands upon the vehicle structure and, thus, to produce substantially different results.

Further, our review of structural integrity research under NHTSA contracts indicates that these efforts have not been directed toward designs which are practicable in high volume production. The usefulness of the resultant designs for commercial marketing has been inadequate in most cases. For example, the domestic ESV's were five passenger sedans with the occupants tightly packaged while the exterior

Technology (Cont'd)

dimensions were equivalent to current vehicles capable of carrying six passengers. One NHTSA contractor raised the body of a Pinto six inches higher off the ground and moved the driver four inches into the rear passenger space. (DOT Contract HS-113-3-746, "Crashworthiness of Subcompact Vehicles")

We anticipate that the structural modifications introduced to meet the 50 mph fixed barrier impact requirement would aggravate any existing car to car impact compatibility problems. The stiffer frontal structure and greater mass would have an effect in frontal, rear and side impacts.

Size and Weight Effects

There is only minimal data and limited experience with vehicle designs needed to approach a 45 or 50 mph fixed barrier frontal impact requirement. Therefore, we have attempted to extrapolate data from existing cars to determine the size and weight effects of the Administration's proposal. The results of Ford's and other domestic ESV programs, along with additional Ford research, were used even though the ESV's did not meet the occupant protection requirements of FMVSS 208 at 50 mph and exceeded the vehicle weight objective by large margins.

The test data used as a basis for the engineering assumptions and projections were gleaned from recorded force and acceleration measurements upon various anthropometric test devices. Though such data was found to lack repeatability, it nevertheless was averaged and used for directional guidance.

Simplified analytical techniques were used along with assumed performance parameters for advanced restraint systems to derive an estimate of the size and weight increases necessary to meet the proposal.

For purposes of this analysis, the parameters for an advanced air bag system and an advanced belt restraint system were hypothesized to represent restraint systems which are not currently available but which may be possible by September, 1980.

The results of numerous barrier crash tests were examined to evaluate the performance of various experimental and production belt and air bag restraint systems. Values for effectiveness time, rate of deceleration onset, and equivalent uniform deceleration or "square wave" deceleration were then determined. The key criterion was the 60 g deceleration limit of FMVSS 208. We concluded that for an

<u>Size and Weight Effects</u> (Cont'd)

advanced belt restraint system, a deceleration curve with an effectiveness time of 20 milliseconds, a uniform onset rate of 1200 g/see, and a constant deceleration of 40 g's gave an idealized representation of the deceleration which could be produced on the chest of an anthropometric test device. For an air bag, the values of 40 milliseconds effectiveness time, 1500 g/see and 48 g's were determined. The deceleration levels represent the square wave that would simulate the average of the peaks and valleys of a dynamic curve in which the peaks would still remain under the 60 g limit of FMVSS 208. Onset rates and effectiveness times were chosen based on predicted future system performance capabilities.

The advanced belt system would include a crash sensor and a preloader device and possibly a load limiting webbing material. The advanced air bag system would require developing improvement to present systems to achieve effectiveness within 40 milliseconds.

The restraint system parameters were used with a simple mathematical model consisting of two point masses representing vehicle and occupant. Idealized occupant stopping distances were determined and then compared with the available vehicle crush and interior occupant space. The vehicle deceleration necessary to produce the assumed occupant deceleration was also computed.

The output of the simple mathematical m-cl thus gives an indication of the amount that a vehicle must be lengthened or stiffened to approach a 45 or 50 mph barrier impact requirement. The length and stiffness increases were used to determine weight effects using engineering judgment based on Ford experimental results and ESV experience, and a review of the ESV's designed by others.

One particular assumption included in the length calculations is that 65% of the added length will actually crush during impact. Deformed structure would occupy the remaining 35% of space. The frontal area occupied by relatively incompressible components such as the engine are considered unavailable for vehicle crush. However, the space occupied by the engine was also considered available for the deformed structure. For purposes of this analysis, length added to the vehicle was considered totally usable for computing crush distance up to the point where the 65% efficiency level was reached. After that point, 1.54 inches of vehicle length were added for each inch of crush length needed.

Size and Weight Effects (Cont'd)

The resultant length increases, stiffness, and weights are shown in Fig. 1 for a vehicle with a Ford size passenger compartment and Fig. 2 for one with a Pinto size passenger compartment.

The Ford size car with an advanced air bag system intended to meet a 50 mph impact level would be over 16 inches longer and an estimated 530 pounds heavier than the current Ford. The same car with an advanced belt restraint would only be 2.4 inches longer than the 1974 model but would be nearly 900 pounds heavier.

The Pinto size car with an advanced air bag system intended to meet the same 50 mph requirement would become 37 inches longer and an estimated 600 pounds heavier than the 1974 version. Under the assumptions for the advanced belt restraint, the Pinto would be 18 inches longer and 630 pounds heavier than the existing car.

Front end structural stiffness would have to be increased substantially for both cars with either restraint system.

Lesser, although dramatic, weight increases would result on both Ford and Pinto size vehicles as shown in Figures 1 and 2 if a 45 mph barrier impact goal were established.

These weight increases are estimates for meeting only frontal impact requirements. No provision has been made in this estimate for increased side, rear and roof structure which we anticipate would be necessary to meet the existing levels of such Standards as FMVSS 214, Side Door Strength, FMVSS 216, Roof Crush Resistance and FMVSS 301, Fuel System Integrity. Structual modifications would be necessary to withstand the increased static or dynamic test loads imposed as a result of the weight added to the vehicle to meet the increased frontal impact speed. The weight increase resulting from these side, rear and roof structural modifications would cause further changes to be made in the frontal structure to meet frontal requirements. These effects would be more pronounced on small cars under 3500 pounds curb weight due to the provisions regarding curb weight in FMVSS 214 and FMVSS 216. Neither is there provision in these weight estimates for revision or deletion of any other standards.

Size and Weight Effects (Cont'd)

The weight and length additions shown in Figures 1 and 2 were derived, in part, using simplified analytical techniques which do not fully consider the dynamic interactions of vehicle structure, restraint system and test device. They represent minimum levels of vehicle modification which we believe would be necessary to approach the frontal impact performance levels of FMVSS 208 at 45 and 50 mph. Restraint system performance parameters were chosen which we believe are possible by 1980, but do not represent any system which we currently have available. Vehicle structures with the necessary frontal crush characteristics would have to be developed. Objective, repeatable conformance demonstration procedures for FMVSS 208 have yet to be developed. We therefore consider these estimated weight and length increases to be minimum levels.

The weight increase shown in Fig. 1 includes that due to structural additions to meet the higher barrier speed requirement plus added weight to upgrade such areas as engine, brakes, suspension and steering. Weight estimates for these other systems were determined by increasing their weight in proportion to the increase in structural weight. This was done by determining the portion of total vehicle weight due to the other systems for several large size vehicles as shown in Fig. 3. The portion of total weight contributed by each system was found to remain fairly constant. The increased weight of these systems was computed by an iterative process based on the added structure weight. This process would add weight to the various supporting systems for each pound of crashworthiness structure added. We realize that in a practical sense weight additions occur in discrete increments.

A similar analysis was conducted for smaller size vehicles to determine the weight additions for a Pinto. (See Fig. 4) .

cost

We have not determined the cost effect of the proposal, but it is obvious that addition of this amount of weight will result in substantial vehicle cost increases. The engineering and investment cost to redesign all of our vehicles to attempt to meet a 45 or 50 mph requirement would be staggering.

Timing

The vehicle modifications required to meet a 45 or 50 mph barrier impact requirement are so extensive that we would be required to redesign all of our affected vehicles. After a final rule of this type is established, technology

Timing (Cont'd)

is available, and practicability is achieved, it would take approximately three years to redesign and retool a single car line family.

Ford normally cannot develop more than two totally redesigned car line families in the same model year due to manpower and facility limitations and available capacity within the tooling industry. It would require a total of four additional years to introduce new designs of all existing passenger car models. However, Ford has never before undertaken a task of this magnitude. Even this cycle is optimistic as it is unlikely the tooling industry could contain the magnitude of such programs if all domestic automobile manufacturers found it necessary to implement similar redesigns.

On the basis of our analysis to date, we could not meet a Septmber, 1980 effective date for all cars, even if the means of meeting the proposed requirements were fully developed. Due to the uncertainties that now exist, we cannot determine whether or not we can meet this date even on one car line.

A new car body and chassis design is produced for a minimum of three years and in many instances can exist for eight years before a major redesign. Therefore, the redesign program that would be required by the proposal would probably obsolete relatively new car lines before the end of their normal cycle with additional cost consequences.

The precise timing effects of the Administration's proposal have not been determined. Small cars would cease to exist as they are known today and large cars might well become impracticable due to increased size. We do not know what vehicle model mix the market would support if it is artificially constrained by a requirement which has such a pronounced effect on vehicle size.

Accident Data Analysis

Ford and others have previously noted the unreliable nature of reported accident speeds available for analysis. The source of data errors and some of the methods which have been used to adjust these data are shown in Exhibit I. Recent crash recorder results have confirmed that reported crash speeds are usually too high.

Accident Data Analysis (Cont'd)

Twenty accident cases involving vehicles equipped with crash recorders were summarized in SAE Paper 740566 by S. S. Teel et al[1] of the National Highway Traffic Safety Administration (NHTSA). The results of an analysis comparing each case vehicle's velocity change, as reported by the police and/or an accident investigation team, are summarized below. The impact speeds used in this analysis and their differences are contained in Exhibit II.

The accident cases in Teel's paper which contained the necessary information were used to construct a sample of the population of differences between velocity "changes estmated by an accident investigator and the velocity change experienced by the vehicle, as reflected by the crash recorder. The sample of 22 differences as tested for normality using the Kolmogorov-Smirnov test[2] and the hypothesis that the population of impact velocity change differences is normally distributed could not be rejected. Although our sample of accident cases is small, it indicates that the distribution of the difference in estimates is a bell-shaped curve centered at 14 mph (the sample mean) with an estimated standard deviation of 11.9 mph. Using these figures, we are 95% confident that ten percent of the reported impact speeds overestimate the true change in velocity by at least 35 mph while one-quarter of them overestimate the true change in velocity by at least 25 mph.

An interval which contains the true mean difference between the estimated and the recorded velocity change of a vehicle in an accident, with 99% confidence, was constructed using the Students-t distribution. This interval, 7.1 mph < Mean Difference < 21.4 mph, indicates that, on the average, accident investigators can be expected to overestimate accident impact speeds by from 7 to 21 mph. Our

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1 Teel, S. S., Pierce, S. J., and Lutkefedder, N. W., "Automotive Recorder Research --A Summary of Accident Data and Test Results", SAE 740566, 3rd International Conference on Occupant Protection, July, 1974.

2 Lilliefors, H. W., "On the Kolmogorov-Smirnov Test for Normality with Mean and Variance Unknown", JASA, June, 1967.

Accident Data Analysis (Cont'd)

accident sample also indicates that impact speeds can be overestimated by as much as 40 mph. These large overestimates do not depend on the magnitude of the crash recorder velocity change.

As an alternative statistical test, a nonparametric test, the Wilcoxon Matched-Paris Signed-Ranks Test, also indicates that estimated impact speeds from accident investigators are positively biased. Based on crash tests, Teel concludes that changes in velocity reported by crash recorders are accurate to within ± 2 mph. Therefore, as a conservative approach, the differences between the estimated and the recorded changes in velocity in Exhibit II were reduced by 5 mpht ad the Wilcoxon test was re-run to determine if the velocity differences could be due to the crash recorder accuracy. The results still indicate that impact speeds estimated by police and accident investigators are too high.

The lack of a sound data base with which to evaluate the need for higher speed performance requirements further underscores the need for a large scale crash recorder program to evaluate actual crash dynamics.

EXHIBIT I
September 19, 1974

THE TREATMENT OF RECORDED IMPACT SPEEDS

- A Summary-

Methods which have been used to deal with reported impact speeds from the ACIR accident case file are summarized below.

A. Cooke, Conrad H., "Safety Benefits of The Occupant Crash Protection Standard", January, 1971.

Cooke reduced all reported traveling speeds by 10 mph to obtain his estimated impact 'speeds.

B. Mela, Donald F., "A Source of Substantial Error In Estimating The Distribution of Traveling Speed For Accident-Involved Vehicles .*O ", DOT, Septmber 3, 1968.

Mr. Mela stated that, by using the estimated impact speeds to determine speed distributions, "the fraction of vehicles in the speed ranges 20-30 mph and 70-80 mph is overestimated by a factor of 3, and the fractions below 20 mph and above 80 mph are overestimated by a factor of 17". If this statement is true, then it suggests that some variable type of correction factor (and not a constant 10 mph as Cooke used) be applied to the estimated impact velocities in the ACIR file.

C. White, S. B., Nelson, C., "Some Effects of Measurement Errors in Estimating Involvement Rate as a Function of Deviation from Mean Traffic Speed", Journal of Safety Research, Volume 2, June, 1970.

White and Nelson show that even if errors in estimation are non-systematic, an overestimate of high-speed frequency would be found. That is because any error of measurement always serves to inflate the variance of the distribution of reported values, regardless of the nature of the data. Thus, reported variance (i.e., the mean-square deviation from the mean) is equal to the sum of "true)' variance and "error" variance. White and Nelson point this out, in suggesting that high speed estimates would tend to be exaggerated. They state that "errors in estimating speeds of accident-involved vehicles causes the involvement rate, when plotted as a function of the speed deviation, to be U-shaped -- overestimated for large derivations (from the mean) and underestimated for small deviations”. White and Nelson refer to traveling, not impact, speed, but the principle is the same in either case.

D. Grush, E. S., Henson, S. E., and Ritterling, O. R., ‘Restraint System Effectiveness”, Report No. S-71-40, Ford Motor Company, September 21, 1971.

In this report, ACIR impact speeds were converted to barrier-equivalent velocities. The following factors were considered in the conversion: the estimated relative closing speed; the weight differential; a center of gravity adjustment; and an accident location adjustment. A second method of obtaining the barrier-equivalent value for each accident-involved vehicle was based on photographs of the vehicle damage and the study showed that this latter method produces better results.

E. Mason, R. R., D. W. Whitcomb, "The Evaluation of Accident Impact Speed”, CAL Report No. YB-3109-V-1, August, 1972.

This report presents several formulas, one for each type of vehicle impact, which can be used to estimate a vehicle% impact speed. It provides some insight into how Calspan <u>may</u> estimate impact speeds.

EXHIBIT II
September 19, 1974

IMPACT VELOCITY CHANGES

Recorder Number	Crash Recorder Velocity Change (mph)	Accident Investigator Estimated Velocity Change (mph)	Difference (mph)
1086	20	60 +	+ 40
485	15	50	+ 35
485	15	50 to 60	+ 35
642	10	30 ,	+ 20
322	5	25	+ 20
335	6	25 to 30	+ 19
641	13	30	+ 17
694	9	25	+ 16
596	10	25	+ 15
596	10	24 to 26	+ 15
596	10	25	+ 15
641	13	25 to 35	+ 12
642	10	22 to 25	+ 12
306	19	30	+ 11
463	19	30	+ 11
463	19	30	+ 11
485	15	25	+ 10
25	18	25 to 35	+ 7
352	15	22	+ 7
463	19	20	+ 1
94	11	5 to 8	- 6
352	15	5	- 10

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Reference: Teel, S. S., Place, S. J. and Lutkefedder, N. W., "Automotive Recorder Research -- A Summary of Accident Data and Test Results", SAE 740566, 3rd International Conference on Occupant Protection, July, 1974.

FORD

SUMMARY: LENGTH AND WEIGHT INCREMENTAL EFFECTS FOR FRONTAL IMPACT

SPEED	RESTRAINT SYSTEM TYPE	AVERAGE g's S.W.E. 1/	WHEELBASE LENGTH INCREASE 2/	VEHICLE WEIGHT Additions (LBS.) STRUCTURE	RESTRAINT SYSTEM	BUMPER SYSTEM	ENGINE SYSTEM	DRIVELINE SUSPENSION AND BRAKES	FUEL SYSTEM INCLUDING FUEL	STEERING SYSTEM	TOTAL WEIGHT INCREASE	CURB WEIGHT (LBS	INCREMENT OVER BASE (%)	FMVSS 208 TEST WEIGHT (LBS)
30	Production	11.3	◁— Base —▷									4400	Base	5600
45	A	19.3	6.0	182	20	21	53	69	6	7	358	4759	8%	5958
45	B	22.5	0	283	20	31	81	104	9	10	538	4938	12%	6138
50	A	19.6	16.2	282	20	31	80	104	9	10	536	4936	12%	6136
50	B	26.0	2.4	483	20	52	134	172	14	17	892	5292	20%	6492

Restraint Type A: Air bag - 40 msec. effectiveness - 1500 g/ sec. onset - 48g max.

Restraint Type B: Seat belt with sensor and preloader - 20 msec. effectiveness - 1200 g/SeC. onset - 40g max.

1/ Square Wave Equivalent of vehicle deceleration pulse based on impact speed and total crush distance.

2/ Crush length increases in excess of 5 inches are adjusted by a 65% efficiency factor

Figure 1
September 19, 1974

PINTO

SUMMAR EN TH AND WEIGHT NCREMENTAL TS FO FRON AL MP

SPEED	RESTRAINT SYSTEM TYPE	AVERAGE g's S.W.E. 1/	LENGTH INCREASE 2/ 3/	VEHICLE WEIGHT ADDITIONS (LBS.)								CURB WEIGHT (LBS.)	INCREMENT OVER BASE (%)	FMVSS 208 TEST WEIGHT (LBS.)
				STRUCTURE	RESTRAINT SYSTEM	BUMPER SYSTEM	ENGINE SYSTEM	DRIVELINE SUSPENSION AND BRAKES	FUEL SYSTEM INCLUDING FUEL	STEERING SYSTEM	TOTAL WEIGHT INCREASE			
30	Production	14.4	←				Base				→	2457	Base	3300
45	A	18.4	23.5	188	20	23	57	83	8	7	386	2843	16%	3686
45	B	25.0	5.7	227	20	27	69	99	10	8	460	2917	19%	3760
50	A	18.9	37.2	305	20	36	89	130	13	10	603	3060	25%	3903
50	B	24.7	18.0	319	20	37	94	136	13	11	630	3087	26%	3930

Restraint Type A: Air bag - 40 msec. effectiveness - 1500 g/sec. onset - 48g max.

Restraint Type B: Seat belt with sensor and preloader - 20 msec. effectiveness - 1200 g/sec. onset - 40g max.

1/ Square Wave Equivalent of vehicle deceleration pulse based on impact speed and total crush distance.

2/ Crush length increases in excess of 5 inches are adjusted by a 55% efficiency factor

3/ 2.8 inches can be added to front overhang without wheelbase increase (19° minimum approach angle). (wheelbase increase is 2.8 inches less than length increase)

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Figure 3

WEIGHT OF VARIOUS VEHICLE SYSTEMS
AS A PERCENTAGE OF TOTAL WEIGHT

	RSV*	TORINO	FORD	LINCOLN	AVERAGE
Curb Weight:	3000	4030	4398	5373	
Percentage of Curb Weight:					
Bumper Systems	6.0%	1 5.9%	5.4%	5.6%	5.8%
Engine	15.6%	14.2%	15.8%	15 0%	15.0%
Suspension Driveline Brakes	21.3%	19.8%	18.5%	17.5%	19.3%
Fuel System:	To maintain the current Ford vehicle range fuel system weight should be increased at-the rate-of .01415 lb. per lb. of added vehicle weight. The fuel tank weight is approximately 17% of the total fuel system weight.				1.6%
Steering	2.0%	1.5%	2.3%	1.8%	1.9%
TOTAL:	**46.5%**	**43.0%**	**43.6%**	**41.5%**	**43.6%**

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*RSV figures are an average of 10 Unitized vehicles with curb weights from 2000 to 3300 lbs.

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Figure 4

WEIGHT OF VARIOUS VEHICLE SYSTEMS AS A PERCENTAGE OF TOTAL WEIGHT

	PINTO	MUSTANG	MAVERICK	GRANADA	AVERAGE
Curb Weight:	2457	2753	2831	331.9	
Percentage of Curb Weight:					
Bumpers	6.1%	N. A.	6.0%	5.7%	5.9%
Engine	14• 0%	14. 6%	14• 996	15• 9%	14• 9%
Suspension Driveline Brakes	21• 3%	21• 7%	22• 1%	21• 3%	21. 6%
Fuel System:	To maintain the current Pinto vehicle range fuel system weight should be increased at the rate of .01415 lb. per lb. of added vehicle weight. The fuel tank weight is approximately 17% of the total fuel system weight.				2.0%
Steering	1.7%	1.5%	2.0%	1.7%	1.7%
TOTAL:	45.1%		47.0%	46.6%	46.1%