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THE USE OF ACCIDENT DATA IN THE NHTSA STANDARDS ENFORCEMENT PROGRAM

Final Report
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by
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16. Abstract

The present usage of accident data in connection with selection of vehicles for compliance testing is studied, and recommendations are made for changes in this usage. Recommended actions include assignment of analytical personnel to the processing of data for this purpose, addition of several new data elements in the MDAI collection process, expansion of the MDAI program, and certain use of police-reported accident data.

Specific examples of analysis of accident data relevant to Standards 105 and 207 are given.

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I. INTRODUCTION

This is the final report on a study conducted by the University of Michigan's Highway Safety Research Institute concerning the use of accident data in the NHTSA Standards Compliance program. The work was conducted in response to the needs expressed in the NHTSA contract, the work statement of which is included herein as Appendix A.

This HSRI report describes how NHTSA currently uses accident data in selecting vehicles for compliance testing, and recommends immediate and long-term changes in the present program. Section II of this report presents a summary of activities and findings as they relate to task statements included in the NHTSA contract. Section III describes present operations within NHTSA concerned with acquiring accident data, processing it, and using the results in the vehicle selection process. Section IV discusses problems and shortcomings of the present operations. Section V discusses recommended changes and their likely costs and benefits.

II. FINDINGS AND CONCLUSIONS

The individual tasks of this study and a brief summary of the findings and conclusions are given here.

> Task 1: Critically review how OSE now uses accident data, and recommend improvements in use of current data as well as uses of data not currently used.

Currently there is relatively little analysis of either the MDAI data or of other accident data directed toward the needs of the Office of Standards Enforcement. OSE personnel have made a real attempt to use what information they have been given, but they are not satisfied that accident data can be very useful to them. We recommend fuller use of analytic techniques to process the accident data (as opposed to simple case listings), closer and more frequent technical communication between OSE and OAIDA personnel on problem definition, and perhaps 12 man-months of analyst time per year devoted to this area.

> Task 2: For each Safety Standard, specify the accident data items needed, and discuss the deficiencies in content, quantity, quality, and format of accident data OSE is currently receiving.

Tables of the Federal Motor Vehicle Safety Standards in Appendix B provide lists of accident data items presently used by OSE, data items present and of potential value which have not been used, and data items judged to be of value which are not collected or not coded at this time. The format used for presenting accident information to OSE provides relatively raw information. Recommendations for analyzing and processing the accident data into a more usable form are presented in Section V.

Task 3: Determine the capability of current data collection and processing programs of OAIDA to remedy the deficiencies.

On a standard-by-standard basis, specify changes that would be required, and estimate the approximate costs of changes in case selection, collection procedures and forms, reports, and the manner in which the information could best be given to OSE.

In the past OAIDA has responded to an annual request from OSE for information to assist in the vehicle selection process. Little or no analytical effort was devoted to the problem at other times of the year. Personnel currently assigned to OAIDA have the capability to develop more useful forms of information, but they have not been able to put the required time on this program. We have noted a number of untapped sources of accident information-several add-on files of MDAI data, several police accident report files--which could be addressed with respect to many of the standards. Further, there are a number of information items in the present CPIR file which could be searched fruitfully. None of these would require any great expenditure other than an increased allocation of time to this job.

Specific changes which may involve expenditure of funds are discussed in detail in Section V of this report. These include adding data elements to those currently reported by investigators, some changes in the coding and computer storage of the information, an order-of-magnitude increase in the number of MDAI cases investigated, and a continuing communication between OSE and OAIDA regarding needs and data capabilities.

Task 4: Using Safety Standards 105 and 207 as examples, develop and present the actual forms, checklists, and procedures that can be used by

OAIDA's Accident Investigation and Information Systems divisions and by the Office of Standards Enforcement.

An accident investigation form incorporating supplementary questions for all appropriate standards has been prepared and is attached as Appendix C. Two examples of analytical procedures which could be developed to put the raw accident data into a more useful form are presented in Appendix D. One of these uses police-reported data, and is pertinent to Standard #105; the other uses MDAI data and is pertinent to Standard #207.

Task 5: Develop a method to identify the critical vehicles for each safety standard.

The general method recommended is to perform an analysis of the accident data which results in a list ordered by the decreasing likelihood of that vehicle's failing to pass a standards test. The methods of Appendix D are examples of this process. The interpretation of such lists, and the conversion of such information into a demerit score, is discussed in Section V.

Task 6: Develop a method to determine which standards are the most critical and should be selected for enforcement testing.

One interpretation of this task could require a complete cost/benefit analysis of the entire set of standards--leading to a determination of which standards violations are most likely to cause accidents or increase injuries. This is beyond the scope of the present effort.

A second interpretation could be that OSE's task is to select those vehicles (and standards) which are most likely to exhibit violations, and the methods developed here are intended to do just that. Accident data is but one input to the selection process, and experience to date has not made it a primary one. While it is not clear from the work presented here that more effort will make it more useful, there is at least some hope. The demerit assignment model presented in Section V is intended to provide a mechanism for that process.

The General Accounting Office had suggested strongly in its report, For Safer Motor Vehicles, More Effective Efforts Need to Insure Compliance with Federal Safety Standards, that more use should be made of accident records in the selection of vehicles for the standards enforcement process. The authors of that report noted that there had been little use of the data up to that time, and that a great deal of money was being spent in accident investigation, and they discussed a few examples of accident results which deserved consideration by those doing the vehicle selection. They did not, however, perform a very deep analysis of the data--and their examples of supposed usefulness turned out to be less positive than first observation indicated they would be. At the conclusion of the present study it is still not clear to the authors how much value the accident data will have in this application, but it is asserted that more effort--particularly in the development of methods to draw inferences from the accident data--can produce more worthwhile results.

Accidents on the highways, unfortunately for the standards test personnel, just don't happen the way we would like them to. Few vehicles crash into solid walls at exactly 30 miles per hour, and when they do they are usually at some undesired angle of impact, and often include a rotational component. Even when crashes meet the speed and angle requirements, the forces are very difficult to measure. For example, the force on a windshield which has separated depends on the mass of the occupant's head, how he was sitting, and many other factors--

none of which can be measured with great precision after the fact.

There may be some flagrant violations of the safety standards which could be directly observed by accident investigators. Certainly a part of the accident investigation curriculum should be devoted to a discussion of the standards, the needs of the Office of Standards Enforcement, and standards testing methods, so that trained observers could report such violations promptly and accurately.

In addition, however, there are a number of analytical things which can be done with present accident data which should at least set in order the likelihood that particular vehicles will fail in a test of a particular standard. A problem with the present MDAI data is that, since useful statistical analyses can be performed only with relatively large groups of data, information about accident involvement must often be aggregated over more than one model (by year, make, body size, etc.). This problem is evident in the example in Appendix D regarding seat separation in crashes. If NHTSA expects to have the results of such analyses identify individual makes and models, there will have to be a large increase in the number of cases reported. Even so, statistics being what they are, vehicles which seldom occur in the total vehicle population (e.g., Imperials, or perhaps the entire American Motors Line) may never produce enough data to permit such precise make/model identification.

It follows from this that the Office of Standards Enforcement should be able to accept data in aggregated form. For example, if the accident data show that all Ford passenger cars (as compared with other manufacturers' cars) are more likely to fail in a brake test, there should be some way of adding weight (demerits) to the Ford products considered for selection.

Police-level accident information is generally quite limited in its detail but extensive in its quantity. Police reports also vary in their detail. Some police accident data files include a variety of component items on the contributing causes of the accident. These refer to brakes, lights, windshield wipers, tires, steering, defrosters, etc. Vehicle makes and models are identified in some police files in great detail, in others only by manufacturer's name. But the data have been collected at considerable expense by the police, are available for analysis, and deserve to be tried.

Finally, for trucks, buses, and probably for multipurpose passenger vehicles, there will often not be enough MDAI information even in an expanded program for meaningful statistical analysis. A consequence of this is that OSE will have to continue to rely primarily on anecdotal information--individual case reports which describe the events of the crash and comment on the applicability of the standard. The data processing system can assist in identifying cases to be looked at, but in the end the user will have to do some hard reading.

Perhaps the most important single conclusion of this study is that the Office of Accident Investigation and Data Analysis is by definition a service organization for other activities within the NHTSA, and its service must be more than a mere handing over of raw information it has acquired from elsewhere. With regard to the needs of OSE, OAIDA should identify a person with the ability to understand OSE's engineering problems and selection needs, the inventiveness to understand, interpret, and analyze the accident data into a form useful to OSE, and the talent to sell the results to OSE as a customer. More data elements, more cases, and the collection of additional kinds of raw information will be used only if this interpretive function is well performed.

III. CURRENT USE OF ACCIDENT DATA IN THE STANDARDS COMPLIANCE PROGRAM

A. Specification of Data to be Collected

One of the stated purposes of the Multi-disciplinary accident investigation (MDAI) program is to provide information to the Office of Standards Enforcement regarding possible non-compliance with the several Federal Motor Vehicle Safety Standards (FMVSS). Information collected by the various MDAI teams includes a detailed written account of the accident, numerous photographs, and preparation of several specific data reporting forms. Of particular interest among the latter are a modified Collision Performance Investigation Report (CPIR), also known as the "General Motors Long Form," and a Vehicle Condition and Maintenance Report (VCMR). The CPIR form has been in constant use since 1969, and the VCMR has been in use since 1972. For each investigated vehicle these reports are completed and forwarded to the sponsor for further processing.

These primary reporting forms have been developed over a period of many years, initially by the industry but with some modification by the NHTSA. They include a number of items of information pertinent to the needs of the Office of Standards Enforcement (OSE).

In addition to the MDAI effort, most police accident-reporting systems include some information on the vehicle inadequacies noted in police accident investigations. While these are far less detailed than are the MDAI reports, they represent a larger body of data and are, in general, available to the NHTSA from several sources.

B. Data Collection

The MDAI programs are conducted by teams of investigators located throughout the United States. The number and purpose of these teams has varied from time to time, but over the past five years there have been about 20 such teams in operation, each producing from 20 to 100 reports per year. In addition, the Motor Vehicle Manufacturer's Association has sponsored investigations of accidents involving relatively new cars manufactured by their member companies. These reports are forwarded to the MVMA, but the compatible data (i.e., the CPIR-form information) are added to the total set of digital information obtained from the MDAI operations. There are now somewhat more than 5000 reports of crashed vehicles available in the digital files. Each is backed up by a written report detailing the investigator's observations and opinions.

The selection of cases in the present MDAI operations is not random. It is, in fact, biased in several ways, so that it is not generally possible to consider the sum as being representative of any definable population. This shortcoming will be discussed later.

C. Data Processing

The digital files of the reported information are prepared after the cases are received by their respective sponsors, and the NHTSA maintains access to this filed information. With respect to the needs of OSE, the Office of Accident Information and Data Analysis (OAIDA) produces tabulations of data from these files upon request from OSE. For the past three years OSE has made an annual request for a search of information pertinent to their vehicle selection process, supplemented by occasional requests for information during the year. The normal form of information output has been a listing of cases which correspond to some chosen bit of information--e.g., all cases in which the windshield bond separated in a frontal collision--along with other information which may roughly indicate standards compliance (e.g., impact speed, type of collision, make/model of vehicle, etc.).

For the 1974 model year the primary indicator variables used to select from the files are shown in Table 1.

The 13 vehicle standards shown in that table are not the only ones for which existing MDAI variables could be studied with reference to standards compliance. Of the 45 standards, accident data can be used in assessing criticality or selecting vehicles in 28 of them, and is of doubtful utility with respect to the other 17 standards. A summary of the standards is shown in Section IV, along with a brief assessment of the applicability of accident data. The table identifies 15 standards for which the accident data have not been used but might be.

D. Costs

The present cost of operations directly associated with analysis of data for OSE is minimal. Several members of the OAIDA staff maintain occasional contact with OSE personnel throughout the year to provide them with specific case reports likely to be of interest, and to respond to requests for listings of data. But the aggregate effort in OAIDA in direct support of OSE needs is on the order of a man-month each year. The present data collection operations must be viewed as being partly in support of the OSE needs. There is no convenient way to show what portion of the total accident investigation costs might be allocated to the OSE needs, but if it were 10% this would be a substantial sum (perhaps $200,000 per year). In that sense, the present effort allotted to processing and analyzing the data for OSE seems much too low.

Table 1: Indicator variables used in OSE search of the MDAI files for 1974 model year.

Standard #	Short Title	CPIR Variable No.*	CPIR Variable Description	Codes
103	Defogging	37	Visibility limitation?	Yes, No
104	Wiping/Washing	37	Visibility limitation?	Yes, No
105	Brake Systems (cars)	41	Brake system malfunction?	Yes, No
122	Motorcycle Brakes	41	Brake system malfunction?	Yes, No
202	Head Restraints	414	Head restraint damaged?	Yes, No
204	Steering column rearward displacement	329	Steering Col. EA Compression	inches
207	Seat Attachments	207	Seat adjustor damage?	Yes, No
210	Seat Belt Anchorages	--	(No variable available)	
212	Windshield Mountings	342	Bond separation	Yes, No
214	Side door strength	170/171	Left (right) crush	inches
215	Exterior Protection (5 mph bumper)	168/169	Front (rear) crush	inches
216	Roof Crush Resistance	172	Roof crush	inches
301	Fuel System	239	Fuel leakage present	Yes, No

* See, for fuller description, CPIR Codebook dated October, 1973.

E. OSE Procedures

Vehicles identified by study of the data-set lists as being possibly non-compliant are listed by make and model and tabulated for addition to the selection model currently in use by OSE. This selection model permits a weighted sum of inputs from last year's test data, design analyses, defect reports, and accident information to be computed with respect to each of several standards.

The accident data weighting consists of adding one or two demerit points to a given vehicle's score if the accident information indicates a possible non-compliance. The judgment of non-compliance is not arbitrary, but is based on a reasoned inspection of the lists of accidents. The weighting system presently scores 1 point if the vehicle has been reported in 1 to 5 collisions, 2 points if more than 5. While the number of reported involvements is obviously a function of the market penetration, the system currently in use automatically compensates by permitting a higher weight for either a high accident rate for a low-volume vehicle or a modest accident rate for a high-volume vehicle.

OSE personnel have become well informed about the types of information obtained in the accident investigations, and have formulated their questions generally in terms of variables identified in the digital MDAI files. They have supplemented the computer printouts with direct reading of individual in-depth reports as they felt it was necessary.

Under a separate contract, OSE is automating its selection weighting system. It is our understanding that this modification will provide for some flexibility in assigning weights, better detail in vehicle identification, and the capability to adjust the selection analysis procedures more readily. It should also permit more automatic input of information resulting from accident investigations, if the accident data can be put into the proper form.

IV. PROBLEMS RELATING TO CURRENT POLICIES AND PROCEDURES

A. Data Specification

The present variables in the multidisciplinary accident investigation files are deficient in content--i.e., they do not relate well enough to the standards, and in many cases there are no coded data items relevant to particular standards. The deficiencies come about from a combination of factors: items of information which would be useful are not reported by the investigation teams; items of information are reported (e.g., in the text of the report) but are never digitally coded for easy identification; items of potentially useful information are digitally coded but are not presently used. Also, in the design of the coding structure, some information items are grouped so that the reports must be searched individually to identify particular circumstances. For example, visibility problems are coded as a "yes-no" entry, and the user must search the yesses by reading to determine whether the problem involved a wiper, defroster, cracked or dirty windshield, etc.

The basic MDAI data file is concerned almost entirely with passenger cars, although it contains a few light trucks. The file structure is not appropriate for vehicles with anything other than four tires; thus data on large trucks, motorcycles, buses, and pedestrians are not present. A supplementary file contains a limited amount of information on these cases, but it has not been used to date in support of the OSE efforts. Additionally, there is a relatively recent compilation (in digital form) of an MDAI supplementary report on vehicle condition and maintenance factors. Certain information of potential value to OSE is contained in this, but it has not been used to date.

As discussed in Section V, the utility of the information depends largely on the method of analysis. It is difficult to judge whether a particular item of information--properly processed and analyzed--will assist in identifying out-of-compliance vehicles without actually trying it. However, it is possible to identify the information items currently available which are most likely to succeed, and to suggest new or more detailed information which may be of value.

Table 2 lists the present Vehicle Safety Standards, the data items (from the MDAI file) which have been used in OSE studies, additional data items present (in the MDAI file, the VCMR file, and the TBMP file) which may be of value, and a notation of the need for additional information. The new information requirements are specified in more detail in Appendix B, in which each standard is treated separately.

B. Data Collection, Processing, Transmission

The quantity of MDAI case reports in a single year is too small to permit much meaningful statistical analysis with regard to the vehicle selection process. The present case studies are not representative of a definable population. The speed with which cases are acquired and processed is too slow to provide current-model-year information to the OSE. The present processing method is inefficient, in that it forces much of the analytical effort onto the user when it could better be performed by the supplier. These points will be discussed in more detail.

The current MDAI program produces less than a thousand in-depth case reports per year. For a very popular car model--e.g., the Ford Mustang--we would expect about 60 cases per year. For the Cadillac (all

Table 2. Standards vs. MDAI Data

Standard Number	Standard Title	Presently Used MDAI Information	Available Unused MDAI Information	Need for New MDAI Information (See Appendix B)
101	Controls	none	none	No
102	Shift, start, etc.	none	none	No
103	Defogging	37	none	Yes
104	Wiping/Washing	37	none	Yes
105	Brakes	41,132-134,74,75	541,(255-259*)	Yes
106	Brake hose	none	41,541(258*)	Yes
107	Reflections	none	none	No
108	Lamps	none	541,(263,264)	Yes
109	Tires, Passenger cars	none	178,(221-244*)	Yes
110	Tire placard	none	none	No
111	Mirrors	none	none	No
112	Headlamp concealment devices	none	none	Yes
113	Hood latch	none	none	Yes
114	Theft protection	none	none	No
115	VIN	none	none	No
116	Brake fluids	none	41,541,(255-258*)	No
117	Retreads	none	none	No

* These variables are contained in the Vehicle Condition and Maintenance Report (VCMR) File

Table 2 Continued

118	Power windows	none	none	No
119	Tires, Non-passenger Cars	none	none	No
121	Air brakes	none	(35**)	Yes
122	Motorcycle brakes	none	(35**)	Yes
123	Motorcycle control	none	none	No
124	Accelerator controls	none	none	Yes
125	Warning device	none	none	No
126	Truck-camper	none	none	No
201	Interior protection	none	none	Yes
202	Head restraint	none	411-416	Yes
203	Steering column	none	312,314,315,316, 329,330,328	No
204	Rearward displacement of column	306,329	327	No
205	Glazing materials	none	339, 340,436,453, 461,479,487, others	No
206	Door latches	none	201-303, 223-230, 605	No
207	Seat anchor	401,402	398,399,400,403,404 405,421,422	No
208	Occupant crash protection	none	belt usage and injury information	Yes
209	Seat belt assemblies	none	belt types, usage and injury information	Yes
210	Seat belt assemblies	none	same as above	Yes

** These variables are contained in the Truck, Bus, Motorcycle & Pedestrian (TBMP) File.

Table 2 continued

211	Hub caps, etc.	none	none	No
212	Windshield mounting	none	342	Yes
213	Child seats	none	602, injury data	Yes
214	Side door strength	170,171, injury, speed, information		Yes
215	Exterior protection	75,168,169,182,265, 246	other damage information	Yes
216	Roof crush	172,270,275,278,283, 203,207,212,215		No
217	Bus window retention	none	(50,57**)	Yes
218	Motorcycle helmet	none	(50**)	Yes
301	Fuel tanks, etc.	201,237,239,240,241, 242	238,236	Yes
302	Flammability of interior mat'ls.	none	199,200	Yes

** These variables are contained in the Truck, Bus, Motorcycle & Pedestrian File.

models) we might expect about 12. For all American Motors passenger cars we might expect 30. Each of these will be distributed over a number of types of crashes (frontal, rear, side) and a number of severities (minor to severe), so that it seems unlikely that there will be many cases which occur with dynamics which approximate the requirements of any particular standard. With the four or five years of accident reports now stored in digital form, some analysis is possible. But even in this it is necessary to group cars by several model years, body styles, etc.

The present case selection method does not arrive at a sample which permits inferences to be drawn directly to the national population, or, in fact, any larger population. Biases in the present data are largely unknown; it is possible, for example, that all Ford products are under-represented in severe collisions, as compared with all General Motors products. One could not, then, compare Ford and General Motors products directly for, say, evidence of such dynamic characteristics as steering column compression, sheet metal crush, windshield retention, etc. This limitation of the data can be partly overcome by use of analytic methods which account for variations in crash severity, but the simplest and most direct uses of data are obviated.

In-depth accident reports in the past have taken a relatively circuitous route to their final resting place. The requirement for much detailed information on the drivers as well as the cars lengthens the investigation, the full reports take time to prepare, and the delay in getting these into a useful digital form has made the process even longer. Adding to this the fact that new cars enter the driving population slowly, beginning in about September of each year, it is clear that there will be very little new-model accident data available to the user.

The type of processing which has been applied to the data by OAIDA personnel in the past has been inefficient, in that it forces upon the user analysis tasks which could and should have been done by the analyst and the computer. This seems to have occurred for two reasons: The users have in general been more comfortable with unprocessed information (even though they recognize the effort they must apply), and the supplier has not had sufficient technical effort available to perform the more sophisticated analyses. Specifically the usual mode of processing has consisted of preparing tabulations of cases which lie in a certain class (e.g., all cars in crashes for which the gas tank was not retained), along with other information such as the speed of the crash, type of collision, make/model, etc. The user has been left to determine whether the failure should have occurred under the circumstances listed in the data. Such questions could be formulated in such a way as to let the computer/analyst combination come up with an ordered list of, e.g., the likelihood of dropping a gas tank.

C. Application of Data within Standards Compliance Program

OSE personnel tend to view the accident report information on a case-by-case basis, as opposed to a collection of data available for analysis. This results, at least in part, from the present method of data presentation. The problem it creates is that the OSE staff member must perform an analysis on the spot to determine whether this car might have failed in a compliance test. In effect he is computing roughly and with too little information an estimate of the equivalent barrier speed or other dynamic measure to permit him to judge the value of the case. The process of individual analysis and counting of cases by the OSE staff is difficult and inefficient.

Data printouts supplied to OSE contain case identification information along with a vehicle make/model code. But the code is not easily translated into the unique make/model codes required in the selection process, and must frequently be supplemented by a complete reading of the case--a time-consuming process.

The demerit scale for "previous tests and unknown performance" ranges from one to twenty points, giving enough weight to ensure selection of vehicles which failed compliance tests or exhibited marginal performance in the past. The scale of demerits currently used for accident information is limited to values 0, 1, or 2, depending on the number of cases for which appropriate accident information was available. While the accident demerit scale may never be applied, it should provide a weight sufficient to ensure testing if the accident information is strong enough to support such a conclusion.

The present three-point scale for accident demerits is not sensitive enough to account for gradations in the available data. While this is only a slight problem with the present data and analysis methods, it will become a greater problem with an increase in the number of cases and in the sophistication of analytic methods.

The selection model currently in use by OSE effectively requires identification of each vehicle by make and model designation, i.e., the accident data must be in this form before it can be used at all. Accident-related information, on the other hand, frequently is grouped in classes of vehicles--all "Chevrolets," all General Motors B Bodies, all foreign-manufactured passenger cars, etc.--and cannot be usefully broken down into individual makes and models. This occurs sometimes because the numbers are so small as to require grouped data for statistical analysis, and sometimes because the original source of the data has failed to identify the vehicles in enough detail. In either case, the present OSE methods do not provide for data of this sort to be used, and this is a shortcoming.

D. Intercommunications

In this study we are addressing the problems of using accident data in the selection of vehicles for tests in a standards enforcement program. The users of the information, then, are the staff members of the office of Standards Enforcement. The producers of the information are the accident investigators and the OAIDA staff members who compile and process the data about the accidents. While there has been some direct communication between the two NHTSA units, it has been limited mainly to a once-a-year request for a search of the data relative to the new year's selection process, and a formal response to this request. Continuing communications over the year have been too limited to provide OAIDA a full understanding of the selection problems or provide OSE a full understanding of the data potentials. In short, while a communications channel exists, it has not been broad enough nor used enough.

V. RECOMMENDED CHANGES

A. Changes in the Specification of Accident Data

The present data collection forms used by the MDAI teams have resulted from a series of steps. The CPIR or GM Longform served as a starting point beginning in about 1969. This has been supplemented by several specific forms prepared by the OAIDA and other offices. Specifically there is a detailed reporting form for motorcycle accidents, one for trucks and buses, and add-on forms for damage analysis, occupant analysis, and pre-crash condition. In addition, several other elements of information are routinely reported by investigators, but many of these are not in a readily codable form and thus do not appear directly in computer files. Among these, for example, are brief descriptions that relate the accident report to the NHTSA nine-cell matrix (pre-crash human, post-crash vehicle, etc.).

With all of this material, there are still some potentially useful data elements which might be added to meet the needs of the Office of Standards Enforcement. These have been detailed for each standard in Appendix B, and the new variables listed there are recommended for inclusion in the MDAI program. These new variables are specified in a somewhat speculative manner--i.e., they may or may not prove useful. Further, they have not been fully evaluated with respect to the difficulty of collection, and some may turn out to be inappropriate in the field. For example, some knowledge of whether a head restraint had been properly adjusted for the occupant using it might be useful, but a full consideration of this would require information about the occupant's seated height--a factor not readily determined in the field. In time it would be appropriate for these data items to be added in the proper sequence in a fuller accident report, but for the present they are presented in a suggested temporary form in Appendix C.

B. Changes in the Data Collection Program

The quantity of accident reports in the MDAI program must be expanded by a factor of ten or more if analyses by make and model are to provide statistically useful results. This point is supported by two examples in Appendix D of this report. The present rate of input will not be adequate. The exact number of cases to be acquired per year is debatable, but ten to twenty thousand would be necessary to provide 100 to 200 cars in, say, the Cadillac line.

A sampling scheme should be developed so that the data collected are in fact representative of some larger population of accidents, as is currently being done in the NHTSA's restraint system evaluation program. And for the purposes of the Office of Standards Enforcement, emphasis should be placed on new models. If OSE were the only customer for the data, there would be little value in conducting investigations of older vehicles at all. But the entire program should be expected to support more than one need.

Such a program would probably require more accident investigation teams. Both these teams and the present ones, however, should receive more specific training in the needs of OSE. In this connection we recommend a curriculum element in the accident investigators' course to present a discussion of the vehicle standards, the detailed test requirements for them, and the methods of tests employed by the OSE. This should be supported by a written report which lies somewhere in between the full standards publication (which is difficult reading) and the widely distributed short form of the standard.*

MDAI teams should be encouraged to report any suspected flagrant violation of a standard. This has been done in the past, and program managers have observed that the investigators are sometimes overzealous, do not understand the standards well enough, and are likely to err on the side of reporting deviations which are not really there. Nevertheless, MDAI reports can be judged in a calmer atmosphere by NHTSA personnel in the light of more complete information. A "mailgram" format might well be provided to the teams to place some importance on this type of report. The argument that teams might report with insufficient evidence should be countered with training and information rather than with ignoring this source of information.

Police-level accident information has the advantage of being voluminous, but it has the disadvantage of containing little detail. An example of the use of police-level data in the study of brake system performance by make and model is given in Appendix D. Police reports vary in their detail. In some jurisdictions, these reports identify brakes, lights, windshield wipers, defrosters, head and tail lights, tires, and steering. While the precision of the data is poor, the reports can be searched cheaply and easily and should at least be tried.

One accident data acquisition method available to NHTSA seems to be most appropriate to new standards and to the rapid input of information on new-model cars. This is the police bi-level approach, which can be operated as a supplement to the normal police report--usually in

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* See, for example, "Standards" folder published by U.S. Dept. of Transportation, NHTSA, revised June, 1972.

a limited area and for a short period of time. Bi-level operations need careful planning and well-controlled (managed) implementation. But one could, for example, ask for a short supplementary report on crash fuel leakage of all 1976 passenger cars in several large states for two months in the fall of 1975. Several thousand reports over a two-month period, processed expeditiously, would serve to identify any likely problems in compliance with the new Standard 301. The techniques for setting up such bi-level studies have been documented in a recent Indiana University study, and would serve as the basis for this. But planning should begin long in advance, with direct input from OSE personnel regarding the measures they would like to see, and the detail with which they want vehicle identification and other factors reported.

C. Changes in Accident Data Processing and Transmission.

A number of specific changes are recommended here. Some are merely changes in procedure, and if there is a cost involved it is a small, one-time expense. Other recommendations involve changes of larger magnitude, and an estimate will be made of the expected costs of these changes.

Accident investigators routinely list the applicable standards in their writing of in-depth reports. Unfortunately, they include references to standards which demonstrated their effectiveness, those which did not, and sometimes comments on why a standard did not apply. As a result, this information has never been coded into the digital file. Identification of case studies in which the investigator had any indication of non-compliance would permit the user to read the cases of most interest to him. For example, the accident form item could look like this:

Standard #	Definitely out of Compliance	Probably	Possibly
XXX		X	

The OAIDA should continue to develop analytic methods applicable to the vehicle selection problem. While this is expected to be a continuing function, it should build up a library of techniques over time which could be repeatably employed--e.g., each year or each time an update is made to the data. In general, the present data must be analyzed with respect to auxiliary information which defines the severity of the crash, and the schemes for doing this will depend on the specific problem. General Motors Corporation analysts* have developed methods for defining the equivalent barrier speed for each crash-involved vehicle to permit a more direct comparison with the standards. Carlson, at HSRI, developed a regression model by using information in the accident reports to account for variations in crash dynamics. Simpler methods involve sorting the existing data on simple variables such as impact speed, vehicle damage index, or inches of crush. All of these serve the same purpose--and some or all of these methods are necessary in the drawing of inferences from the present MDAI data. NHTSA should have a continuing in-house effort devoted to developing methods of analysis, and in conducting analyses pertinent to user groups such as OSE. The cost (relative to OSE's needs) would be small compared to the costs of the present field investigation program. One-half to one man-year of effort per year would be a large increase from the present allocation. Anything less would be too little.

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* See, for example, "Crash related and occupant related factors in determining occupant injury". J. Marquardt paper presented at the February 1974 Society of Automotive Engineers Meeting held in Cobo Hall, Detroit, Michigan.

Accident information processing, in a statistical sense,often requires grouping of information across common characteristics. While it is possible to define for investigation a set as limited as "all 1973 Chevrolet Impala 4-door sedans," many characteristics of this vehicle may be shared by other full-sized Chevrolets, or by other full-sized General Motors products. If it possible to define those vehicles with a common suspension system design, a common windshield mounting system, or a common door latch mechanism, more statisticsl power can be achieved by such groupings. It follows from this that the results of the analysis can then only be stated in terms of the group at hand. This imposes certain constraints on the user (as discussed in Appendix D). But the NHTSA analysts who address these problems should always consider grouping for common characteristics an appropriate method, and should seek the assistance of the OSE staff in defining the groups.

The present MDAI accident data files code vehicle make and model in a variety of ways, including the Vehicle Identification Number, a five-digit code which refers to the manufacturer, division, body size, and body style (convertible, four-door sedan, etc.). None of these identification methods, however, directly duplicates the system currently in use within NHTSA in both the OSE and the Office of Vehicle Defects. For their purposes a five-character code has been defined which identifies the manufacturer, the individual make, and the model, essentially by its advertised name--e.g., General Motors-Chevrolet-Chevelle-Nomad. At present the conversion of accident data out put to meet the needs of OSE requires considerable hand work. It is suggested that those responsible for coding vehicle identification into the digital accident data files be instructed to incorporate the OSE codes directly into the system, so that accident data output can be used more conveniently. In most cases there is enough information in the digital files to perform the necessary translations, although some table lookup material will have to be prepared.

The case-by-case method of analysis can be supplemented or indeed superseded by statistical analysis when there are enough cases available. But there are types of vehicles for which large quantities of data will be impossible to obtain. This is particularly true of large trucks and of passenger cars with low production volumes. The listing of cases which has been done in the past should be continued, but the analyst should filter as much of the case material as possible before presenting the results to OSE. Data-set lists which have been furnished to OSE in response to requests could be further defined to increase the likelihood of a case being of interest by such techniques as limiting the selection to certain speed ranges, certain collision configurations, etc. While this has been done, OSE staff members have had to do a moderate amount of hand work in further sorting work which could have been accomplished by the computer.

Timing of the analytic work is of some importance. OSE currently needs information leading to the selection of vehicles for test in about January of each year. There is a desire to make the selection even earlier. But, as noted above, few in-depth accident reports on new-model vehicles are available by January, let alone any deeper evaluation efforts. For the January selection (excepting perhaps the results of the bi-level kind of operations discussed above) accident information will be based on vehicles produced the preceding year or earlier. This suggests that if a package of analytic techniques is to be employed periodically with the latest information, it should be employed in the fall--leading to information for the selection model by November.

Appendix D presents two sample analyses of accident data performed to define vehicles most appropriate for tests. The development of methods for these analyses is somewhat time-consuming, both in thinking about what to do, and in a trial-and-error approach to a solution. But once such a method is developed it can be applied again rather quickly. The analysis of MDAI data with respect to seat separation (Appendix D)--once it was developed--was run with a one-hour session at a computer terminal, followed by another hour of hand computation and a couple of hours of writing into final form. Similarly, the Texas data could be processed in less than a day's time if standardized procedures were followed. The development of methodology should be a relatively continuous process, with the expectation that the methods most likely to be useful would be placed in a bank for application at the appropriate time. A solid month of application of such techniques should lead to some evaluation of most of the standards, based on, say, September's data, in time to be of value in the selection process.

D. Changes in the Application of Data to the Selection of Standards and Vehicles for Enforcement Testing.

The present demerit model used by the Office of Standards Enforcement is a relatively straightforward, albeit somewhat arbitrary, method of combining information from several sources to provide a basis for decision on vehicle selection for standards testing. It has demonstrated its usefulness, in that selected vehicles seem to fail more frequently than might be expected by chance.

The present system of adding accident demerits to the vehicle selection model has both a limited range (0, 1, or 2) and a maximum value which is small relative to the current number of demerits necessary to ensure the selection of the vehicle for test. With past data this model may have been appropriate, but if more processed accident information is available, or more cases of the type used to date, the scale needs expansion.

It should be possible for accident information to demonstrate with high probability that a particular vehicle will fail on a compliance test, although this may seldom occur. Thus there should be a maximum number of accident demerits which would ensure selection--or at least rate the vehicle in the range of others being selected. On the other hand, a three-point scale may be all the detail that could be justified in the light of uncertainties in the accident data. One possible addition would be a negative demerit assignment for a vehicle which had demonstrated its proficiency in passing a standards test by its accident involvement. The demerit assignment system, and a computer mechanism for working with it, is now being further developed by another contractor. It is our understanding that it will be somewhat flexible, and that it will permit variation in demerit weighting at the option of the user. With that in mind a usable scheme is described here.

A possible demerit scoring system for accident information might be based on the following concept:

Condition	Demerits
The data indicate with near certainty that this vehicle will fail the test for this standard.	Assign enough demerits to assure selection-- if 10 is the needed number, give it 10.
The data indicate that this vehicle might not pass the test.	Assign perhaps 5 demerits.
The data do not suggest anything negative or positive.	Assign 0 demerits.
The data indicate that this vehicle could not possibly fail the test.	Assign -5 demerits.

It would be possible to draw a finer division for the "might not pass" level if the data would support that precision, but for the moment we will proceed with the four-point scale. Appendix D presents an analysis of brake failure data (from police reports), giving a weighted failure rate number for each of about 60 vehicle makes and models. The method used, the source of the data, and other limitations would force the analyst to judge that there was no certainty that the high scorers would fail any brake test, though perhaps the significantly low scorers might be accepted as rather unlikely to fail. We might weigh the value of the analysis in our minds, and assign a maximum value of 5 demerits to the top 10%, none to the middle 80%, and perhaps -5 to the bottom 10%. This arbitrary judgment must be made with respect to each analysis, and it should be made as a result of considerable discussion and a reasonable understanding of both the data and the requirements of the standard. Each such analysis, then, should conclude with some recommendation regarding the weighting to be assigned to the resulting information, and it should, in general, follow the rules suggested here.

The present selection model is strictly additive--i.e., 1 point for a defect is added to 2 points for accidents, and these are then added to 4 points for "never tested before," yielding a total of 7. What should be done with the results of several accident analyses which would assign different numbers of demerits to the same vehicle? Straight addition would be too dependent upon the number of studies conducted, and any more complex arrangement (say, some sort of geometric addition) seems too sophisticated to be justified. We suggest recording only the maximum value resulting from any single analysis, but keeping a separate count of the number of positive entries.

The accident demerit arrangement currently in use weights the result in two ways. If a particular vehicle has a large number of "acceptable" accidents, it will receive more demerits. But the large number of acceptable accidents can occur because the vehicle has only a few (total) accidents but performs very badly, or because it performs reasonably well but has many reported accidents likely because of high sales volume. The method suggested in this section for assigning demerits for the accident information would not, in general, satisfy the second function--that of accounting for market penetration of a particular make/model. The other inputs to the selection model (last year's results, defect data, design analyses) also do not account for sales volume, and it is suggested that this function also be dropped from the accident demerits and added to the model in some other way. The implicit payoff for finding and fixing a departure from standard on a high-volume car is greater than the same finding in a low-volume car. But sales volume data is available external to the accident data and would better be applied separately to the selection model.

E. Summary of Recommended Changes and Estimated Costs

For the purposes of the Office of Standards Enforcement, the expected benefits of implementing the recommendations of this study would be an increased likelihood of selecting vehicles for test which will exhibit compliance deviations. It has not been possible in this study to estimate the increase in effectiveness of selection. But it is clear that unless more effort is applied to processing and analysis of data, the accident data will not be of much value. So the penalty of not doing something will be that things will not get any better.

The recommendations given in Section V have been restated in brief form in Table 3, along with an estimate of the cost of implementing them. Costs have been estimated with some thought, but will, of course, depend on factors not presently known. For example, we have estimated that a bi-level police data-collection effort might cost $50,000 (including the data collection, processing, and completion of any necessary reports)--but it is easy to visualize a specific program of this type costing as little as $10,000 or much more than the $50,000. Estimates given, then, should certainly be reviewed; but they are thought at this writing to be reasonable.

In the lists in the table, the recommendations are grouped according to their importance in three degrees--essential, important, and useful. Within each group they have been ordered by increasing cost.

Table 3

RECOMMENDATIONS AND COSTS

Essential Recommendations	Costs	Comments
A. Include make/model codes in data files.	$5,000 one-time expenditure	This implies identification of vehicle in data files.
B. Add new data items for specific standards	$7,000 annually	Increases number of standards for which data can be analyzed.
C. Increase emphasis on statistical analysis.	$70,000 annually	These recommendations represent a man-year of analysis per year, plus additional computer time and slightly increased data taking per case. They allow for consideration of a larger number of standards, and more accurate determination of compliance likelihood. Demerit flexibility reduces chances of selection errors.
D. Provide continuing program to develop statistical methods.		
E. Change demerit system, with flexibility based on analysis results.		
F. Use presently available (but previously unused)data items for specific standards.		

Important Recommendations	Costs	Comments
G. Provide analysis results in concentrated effort early each fall.	*	This allows for timely use of most current data.

H.	Emphasize grouping of data by common vehicle characteristics.	*	Improved statistical significance of broad problem indicators will result.
I.	Remove weighting of "market penetration" from accident-related demerits; apply such weighting to total demerits.	*	Vehicle and standard selection will be influenced more by compliance problems rather than sales volume.
J.	Add variables on compliance likelihood for each standard.	$1,000	These variables will provide a quick, initial insight into potential compliance problems.
K.	Use existing motorcycle, truck and bus data files.	$1,000	Immediate improvement will be possible in consideration of vehicles other than passenger cars.
L.	Use existing police accident data.	$15,000	Large number of cases in police data will allow greater significance in distributions of demerits.
M.	Develop reference manual for field investigators.	$20,000**	The manual will aid investigators in improved data quality.
N.	Expand MDAI program, including more cases, more teams with larger population representation, and more emphasis on new vehicles.	$3,000,000	Increased data quality will improve significance of statistical results. Better national representation will minimize biases. New-vehicle emphasis will enhance predictive qualities of selection process.

* No additional costs.

** A one-time cost only, i.e., not annual.

Useful Recommendations

O. Continue case listing for trucks, low-sales cars, etc., but with improved data grouping.	*	This will allow in-depth analysis where case frequencies are too low for statistical studies.
P. Improve team training regarding compliance program and quick reporting of unique violations.	$2,000	Data quality will improve and early awareness of new problems will be possible.
Q. Initiate special police bi-level reporting programs.	$50,000	When new problems are identified, data can be obtained quickly to support final additions to vehicle selection list.

APPENDIX A

STUDY TASKS

1. The contractor will review critically the way that the Office of Standards Enforcement now uses accident data and will make recommendations (a) for improvements in the use of currently available accident data and (b) for the use of accident data that may be made available after implementation of recommendations derived under tasks 2, 3, 4, 5, and 6.

2. For each Federal Motor Vehicle Safety Standard, specify the accident data items needed to carry out adequately the methods recommended under task 1. Compare these with the accident data currently available to OSE and discuss the principal deficiencies in content, quantity, quality, and format of the accident data that OSE is receiving.

3. Determine the capability of current accident data collection and processing programs in the Office of Accident Investigation and Data Analysis (OAIDA) to remedy the deficiencies.

   On a standard-by-standard basis, specify the changes that would be required, and estimate the approximate costs of the changes. The review should consider how cases are selected for investigation, data collection procedures and forms, the manner in which the reports are submitted to OAIDA and OAIDA's processing and retrieval capabilities, and the manner in which the information could best be given to OSE.

4. Using FMVSS #105 and FMVSS #207 as examples, develop and present the actual forms, checklists and the detailed designation of procedures that can be used by members of OAIDA's Accident Investigation and Information Systems Divisions and by the Office of Standards Enforcement.

5. Develop a method to identify the critical vehicles for each FMVSS.

6. Develop a method to determine which standards are the most critical and should be selected for enforcement testing.

APPENDIX B

MDAI DATA ITEMS APPLICABLE TO 29 SAFETY STANDARDS

This appendix contains, first, a list of the 16 safety standards for which no MDAI data items are particularly applicable, followed by a treatment of the other 29 safety standards in terms of what relevant data items are currently available, what items are currently used, and what additional data items need to be collected.

STANDARDS FOR WHICH NO SPECIFIC DATA ITEMS ARE DEFINED

Number	Name
101	Control Location, Identification, and Illumination
107	Reflecting Surfaces
110	Tire Selection and Rims
111	Rearview Mirrors
112	Headlight Concealment Devices
113	Hood Latch Systems
114	Theft Protection
115	Vehicle Identification Number
116	Motor Vehicle Brake Fluids
117	Retreaded Pneumatic Tires
118	Power-Operated Window Systems
123	Motorcycle Controls and Displays
125	Warning Devices
126	Truck-Campter Loading
211	Wheel Nuts, Wheel Discs, and Hub Caps
218	Motorcycle Helmets

STANDARD #102

Transmission Shift Level Sequence, Starter Interlock, and Transmission Braking Effect

REQUIREMENT: Braking shall be provided by downshifting in automatic transmissions.

CURRENTLY AVAILABLE DATA: Drive Train Defects, V255 (VCMR)
Power Train Defects, V44 (CPIR)

CURRENTLY USED DATA: None

NEEDED DATA: Indication by driver (or other evidence) of whether or not downshifting provided braking effect when attempted prior to the accident.

STANDARD #103

Windshield Defrosting and Defogging Systems

REQUIREMENT: The system shall defrost and defog the windshield over a certain area in a specified time period.

CURRENTLY AVAILABLE DATA: Visibility Limitation, V37 (CPIR)
Visibility Item Malfunction, V51 (CPIR)

CURRENTLY USED DATA: Visibility Item Malfunction, V51 (CPIR)

NEEDED DATA: Was there a windshield visibility problem due to inadequate defrosting or defogging?

Did the defrosting/defogging system malfunction?

STANDARD #104

Windshield Wiping and
Washing Systems

REQUIREMENT: The system shall wipe the windshield over a certain area.

CURRENTLY AVAILABLE DATA: Visibility Limitation, V37 (CPIR)
Visibility Item Malfunction, V51 (CPIR)
Condition of Wiper Blades, V270-271 (VCMR)
Equipped with Anti-Wind Lift Device, V272-273 (VCMR)
Condition of Windshield, V292 (VCMR)

CURRENTLY USED DATA: Visibility Item Malfunction, V51 (CPIR)

NEEDED DATA: Was there a windshield visibility problem due to inadequate wiping?

Did the wiping/washing system malfunction?

STANDARD #105

Hydraulic Brake Systems

REQUIREMENT: The brakes shall be capable of stopping the vehicle from certain speeds within certain distances and under a variety of conditions. Residual braking must be provided in case of failure of service brake. Other requirements for warning lights and parking brake performance.

CURRENTLY AVAILABLE DATA: Brake System Malfunction, V41 (CPIR)
Type of Brakes, V132-133 (CPIR)
Anti-Lock Device, V134, (CPIR)
Primary Error--Lack of Brakes, V541-542 (CPIR)
Did Pedal Retain Pressure After Accident, V261 (VCMR)
Any Leakage of Brake Components? V259 (VCMR)
Were brakes used in Attempt to Avoid Accident?, V545-546 (CPIR)

CURRENTLY USED DATA: Brake System Malfunction, V41 (CPIR)
Type of Brakes, V132-133 (CPIR)
Anti-Lock Device, V134 (CPIR)

NEEDED DATA: Did the brakes seem to malfunction prior to the crash? (Driver Opinion)

Did the brakes respond to a normal degree? (Driver Opinion)

Was there any evidence of imbalance in the braking system?

Were the brakes wet?

STANDARD #106

Brake Hoses

REQUIREMENTS: The hoses shall not break under certain pressures, temperatures, and corrosion conditions.

CURRENTLY AVAILABLE DATA: Brake System Malfunction, V41 (CPIR)
Primary Error--Lack of Brakes, V541-542 (CPIR)
Leakage in the Brake System, V259 (VCMR)

CURRENTLY USED DATA: None

NEEDED DATA: Same as for #105

STANDARD #108

Lamps, Reflective Devices, and
Associated Equipment

REQUIREMENT: Vehicles shall have certain lamps with specified candlepower.

CURRENTLY AVAILABLE DATA: Primary Error--Lack of Lights, V541-542 (CPIR)
Headlights, Parking Lights On, V263-264 (VCMR)

CURRENTLY USED DATA: None

NEEDED DATA: Any evidence of lamp failure prior to collision?

Did lighting system limitations contribute to the accident cause?

STANDARD #109

New Pneumatic Tires,
Passenger Cars

REQUIREMENT: The tires shall withstand specified loads and endurance tests.

CURRENTLY AVAILABLE DATA:
- Tire Malfunction, V45 (CPIR)
- Tread Wear, V178 (CPIR)
- Tread Depth, V222-225 (VCMR)
- Inflation Pressure, V226-229 (VCMR)
- Irregular Wear, V234-237 (VCMR)
- Precrash Tire Defects, V242-245 (VCMR)
- Odometer Mileage*

CURRENTLY USED DATA: None

NEEDED DATA:
- Direct Recording of Blowout
- Skid (by type)
- Were tires on car original or replacement?

*NOTE: While for older cars it will be impossible to infer tire mileage from odometer readings, this can be done for most new (i.e., less than 2-year-old) passenger cars.

STANDARD #119

New Pneumatic Tires,
Non-passenger Cars

(See remarks for Standard #109)

STANDARD #121

Air Brake Systems*

REQUIREMENT: The braking system shall provide specified stopping distances and other peformance.

CURRENTLY AVAILABLE DATA: Brake System Malfunction, V35 (TBMP)
Type of Brakes (Reported in the Truck Long Form)

CURRENTLY USED DATA: Standard Not Yet in Effect

NEEDED DATA: Slippery switch installed? Position?

Did truck skid from its travel lane as a result of braking?

Did any wheel lock up (evidence of skid)?

Did any components burst?

- Hoses
- Steel Lines
- Fittings, Valves
- Reservoirs

Record reading of air pressure gauage after collision?

Ask driver if brake warning horn sounded.

Did service brake stop-lamps operate after collision?

*This standard is not yet in effect, and measurements taken in connection with accidents involving trucks not constructed to the standard would not be very useful to OSE's need. The suggestions given here should be applied in the future as trucks built to the standard appear on the highways.

STANDARD #122

Motorcycle Brake System

REQUIREMENT: Specified stopping distance, and certain other performance factors.

CURRENTLY AVAILABLE DATA: Brake System Malfunction, V35 (TBMP)

*CURRENTLY USED DATA: Brake System Malfunction, V41 (CPIR)

NEEDED DATA: Any braking problems? (Driver Opinion)

Evidence of braking with both wheels.

Straight line stop, or not.

Did brakes operate after collision?

Were brakes wet?

*NOTE: Data on motorcycle braking malfunctions were requested by OSE for a search of the present CPIR file. No motorcycles are included in that file at present. The TBMP file does include data on the few motorcycles for which in-depth investigations have been conducted.

STANDARD #124

Accelerator Control Systems

REQUIREMENT: The throttle shall return to idle when force is removed.

CURRENTLY AVAILABLE DATA: Throttle Control Malfunction, V47 (CPIR)

CURRENTLY USED DATA: None

NEEDED DATA: Did the throttle stick prior to the accident?

STANDARD #201

Occupant Protection in
Interior Impact

REQUIREMENT: Padding on certain panel areas, seat backs, sunvisors and armrests; interior doors must remain closed under certain loads.

CURRENTLY AVAILABLE DATA: Head Injury, V609-614 (CPIR)
Area Contacted, V344, V501 (CPIR)
Speed, V74-81 (CPIR)

CURRENTLY USED DATA: None

NEEDED DATA: Did interior doors (e.g., glove box) open as a result of the collision?

STANDARD #202

Head Restraints

REQUIREMENT: The restraint shall withstand specified loads, and limit rearward displacement of the head during forward accelerations.

CURRENTLY AVAILABLE DATA: Driver Head Restraint Damage, V411-414 (CPIR)
Driver Head Restraint Contact, V415 (CPIR)
Head and Neck Injury (V609-616)

CURRENTLY USED DATA: None*

NEEDED DATA: Right front passenger head restraint damage.
Right front passenger head restraint contact.
Was headrest bent.
Was headrest detached or broken.
Was headrest properly adjusted for the occupant.

*Information on this item was requested by OSE for the 1974 model year, but no variables were specified in the documents available to us.

STANDARD #203

Impact Protection for the Driver
From the Steering Control System

REQUIREMENT: The steering column shall not impact the chest with more than a specified force.

CURRENTLY AVAILABLE DATA: EA Column Compression, V329,330 (CPIR)
Chest, Neck, Face Injury, V611-624 (CPIR)
Steering Assembly Contacted, V306,309 (CPIR)
Steering Wheel EA Device Performance, V312-317

CURRENTLY USED DATA: None

NEEDED DATA: No new requirements.

STANDARD #204

Steering Column Rearward Displacement

REQUIREMENT: The steering column shall not move rearward more than a certain amount in a specified forward collision.

CURRENTLY AVAILABLE DATA: Amount of Rearward Motion, V326 (CPIR)
Chest, Neck, Face Injury, V623-628 (CPIR)
Steering Assembly Contacted, V306, V309 (CPIR)

CURRENTLY USED DATA: Steering Wheel Rim Contact, V306 (CPIR)
Steering Column Energy-Absorbing Compression*

NEEDED DATA: No new requirements.

*Judged not appropriate for rearward displacement problem.

STANDARD #205

Glazing Materials

REQUIREMENT: The glass shall meet ASI standards of shatter resistance and penetration resistance.

CURRENTLY AVAILABLE DATA: Windshield Cracked, Broken, Occupant Contact, V338-341 (CPIR)
Window Damage, Contact, V435, 436, 452, 453, 460, 461, 478, 479, 486, 487 (CPIR)
Laceration Due to Glass Contact, V611-633 (CPIR)
Ejection Through Window, V604-605 (CPIR)

CURRENTLY USED DATA: None

NEEDED DATA: No new requirements.

STANDARD #206

Door Locks and Door Retention Components

REQUIREMENT: Door latches and hinges shall not separate under specified loads.

CURRENTLY AVAILABLE DATA: Door Latch Release, V223-226 (CPIR) 291-294
Door Hinge Separation, V227-230 (CPIR) 295-298
Door Opened During Collision, V232-233 (CPIR) 300-301
Ejection Through Door, V605 (CPIR)

CURRENTLY USED DATA: None

NEEDED DATA: No new requirements.

STANDARD #207

Seating Systems

REQUIREMENT: Seats, seat backs, adjusters, and anchorages shall withstand specified forces.

CURRENTLY AVAILABLE DATA: Seat Adjuster Damage, V400-402 (CPIR)
Seat Separation Location, V403 (CPIR)
Seat Backrest Damage, V406 (CPIR)
Seat Back Lock Held, V417-420 (CPIR)
Seat Angle Difference, V421,422 (CPIR)

CURRENTLY USED DATA: Seat Adjuster Damage, V401-402 (CPIR)

NEEDED DATA: No new requirements.

STANDARD #208

Occupant Crash Protection

REQUIREMENT: Vehicles shall have passenger restraints that limit body accelerations to certain levels under specified crash conditions.

CURRENTLY AVAILABLE DATA: Lap, Torso Belts Worn, V592, 596 (CPIR)
Belts Worn Correctly, V593, 597 (CPIR)
Type of Restraints Worn, V599 (CPIR)
Injury Severity, V600 (CPIR)

CURRENTLY USED DATA: None

NEEDED DATA: Airbag deployment information when available.

STANDARD #209

Seat Belt Assemblies

REQUIREMENT: Assemblies and components shall withstand specified forces, abrasion, corrosion, and other effects.

CURRENTLY AVAILABLE DATA:
- Lap, Torso Restraints Worn, V592, 596 (CPIR)
- Restraint System Malfunction or Separation (Variable #18 in occupant supplement file)
- Lap Belt Locking Retractor, V594 (CPIR)
- Upper Torso Inertia Reel, V598 (CPIR)

CURRENTLY USED DATA: None

NEEDED DATA: No new requirements.

STANDARD #210

Seat Belt Assembly Anchorage

REQUIREMENT: Anchorages shall withstand specified forces.

CURRENTLY AVAILABLE DATA: Same as for Standard #209

CURRENTLY USED DATA: None*

NEEDED DATA: Did anchorage deform or rip out?

*Data requested for 1974 model tests, but no variable specified.

STANDARD #212

Windshield Mounting

REQUIREMENT: Windshield mountings must retain certain amounts of windshield perhiphery in longitudinal collision of specified speed.

CURRENTLY AVAILABLE DATA: Windshield Bond Separation, V342 (CPIR)
Windshield Occupant Contact, V340 (CPIR)

CURRENTLY USED DATA: None*

NEEDED DATA: The percent of windshield separation is reported by the investigation teams, but has not been coded into the digital files. It should be added.

*Data were requested for the 1974 studies, but no variable numbers were specified. Unspecified data were used for the 1973 tests.

STANDARD #213

Child Seating Systems

REQUIREMENT: The seat shall not deform more than a certain amount under a specified forward load.

CURRENTLY AVAILABLE DATA:
- Type of Child Seat, V602 (CPIR)
- Restraint System Usage, V599 (CPIR)
- Injury Severity, V600 (CPIR)
- Areas Contacted, V607-635 (CPIR)

CURRENTLY USED DATA: None

NEEDED DATA:
- Child ejected from seat.
- Child seat separation from anchorages.
- Child seat harness/belt used.
- Child seat anchored by adult lap belt.
- Child seat failaure, came apart.

STANDARD #214

Side Door Strength

REQUIREMENT: Doors shall not deflect more than certain amounts under specified lateral loads.

CURRENTLY AVAILABLE DATA: Injury from Contact with Interior of Door, V607-635 (CPIR)
Side Door Beam Present (Variable #54, Damage Analysis Supplement)
Direct Door Damage (V55-58, Damage Analysis Supplement)
Inches of Crush, V59-62 (Damage Analysis Supplement)
Beam Involvement, V63-66 (Damage Analysis Supplement)

CURRENTLY USED DATA: Side Sheet Metal Crush, V164, 165 (CPIR)
Injury and Speed Data (CPIR)

NEEDED DATA: No new requirements.

STANDARD #215

Exterior Protection

REQUIREMENT: Vehicles involved in front or rear impacts of certain speeds shall maintain normal operations of lamps, hood, trunk, doors, fuel and cooling systems, exhaust system, propulsion, suspension, steering, and braking.

CURRENTLY AVAILABLE DATA: Front-end or Rear-end Collision, V145 (CPIR)
Speed of Impact, V75 (CPIR)
Tailgate and Trunklid Damage, V246-7, 259-60 (CPIR)
Door Hinge Damage, V295-298 (CPIR)

CURRENTLY USED DATA: Speed of Impact, V75 (CPIR)
Front and Rear Sheet Metal Crush, V162-3 (CPIR)
Hood Latch Damage, V181-183 (CPIR)
Tailgate and Trunklid Damage, V246-7, 259-60 (CPIR)

NEEDED DATA:* Did the following systems remain normally operable?

Fuel	Suspension
Cooling	Steering
Exhaust	Braking
Propulsion	

Damage to Lamps?

Did doors, hood, and trunk operate normally?

*Needed far more than new data elements for consideration of this standard will be more cases. Present practice in the MDAI program emphasizes severe collisions, or at least vehicles damaged enough to require towing. Unless there is a change in the selection rules there are not likely to be many cases collected which are pertinent to this standard.

STANDARD #216

Roof Crush Resistance

REQUIREMENT: The roof shall not crush more than a certain amount when loaded with a specified downward force.

CURRENTLY AVAILABLE DATA: Roof Sheet Metal Crush, Inches, V172 (CPIR)
Upper Pillar Damage (A,B,C,D), V203, 204, 207, 208, 211, 212, 215, 216, 270, 271, 274, 275, 278, 279, 282, 283 (CPIR)

CURRENTLY USED DATA: Roof Sheet Metal Crush, V172 (CPIR)
Upper Pillar Damage (as above)

NEEDED DATA: No new requirements.

STANDARD #217

Bus Window Retention and
Release

REQUIREMENT: Bus side windows shall be retained under specified forces on the glass, and exit window shall operate after application of such forces.

CURRENTLY AVAILABLE DATA:* Number Ejected, V57 (TBMP)

CURRENTLY USED DATA: None

NEEDED DATA: Window not retained.
Occupant contact with window.
Ejection through window.
Exit window fails to operate.

NOTE: Some additional items of information are reported in the truck/bus longform, but with little detail.

STANDARD #301

Fuel Tanks, Fuel Tank Filler
Pipes, and Fuel Tank Connections

REQUIREMENT: After vehicle impact at a specified speed, there shall be no leakage greater than a certain amount from tanks, filler pipes, or connections.

CURRENTLY AVAILABLE DATA:
- Fuel Level at Impact, V236 (CPIR)
- Fuel Tank Retention, V237 (CPIR)
- Fuel Tank Deformed, V238 (CPIR)
- Fuel Leakage Present, V239 (CPIR)
- Fuel Leak from Tank, V240 (CPIR)
- Fuel Leak from Neck, V241 (CPIR)
- Fuel Leak from Line, V242 (CPIR)

CURRENTLY USED DATA:
- Origin of Fire, V201 (CPIR)
- Fuel Tank Retention, V237 (CPIR)
- Fuel Leakage Presnet, V239 (CPIR)
- Fuel Leak from Tank, V240 (CPIR)
- Fuel Leak from Neck, V241 (CPIR)
- Fuel Leak from Line, V242 (CPIR)

NEEDED DATA: Rate of fuel leakage after impact.

STANDARD #302

Flammability of Interior Materials

REQUIREMENT: Certain portions of interior components shall not burn faster than a specified rate.

CURRENTLY AVAILABLE DATA: Origin of Fire, V201 (CPIR)
Extent of Fire, V200 (CPIR)

CURRENTLY USED DATA: None

NEEDED DATA: Was fire sustained by interior materials, as opposed to fuel?

Was burning rate of interior materials judged to be faster than permitted by the standard?

APPENDIX C

RECOMMENDED SUPPLEMENTAL ACCIDENT INVESTIGATION FORM

The field data recording form suggested here contains 51 variables relating to 19 of the safety standards. While similar items have been grouped together here and identified by the number of the standard to which they apply, they should ultimately (if adopted) be placed within existing field forms in such a way as to make the investigators' task most quick and easy.

Some of the data items shown here require observation of the accident scene, some require an interview with the driver or witnesses, and most require direct observation of the crashed vehicle (although not necessarily on-scene). There is, of course, a tradeoff between the number of cases investigated and the difficulty of investigation. That has not been considered here. However, those responsible for the accident investigation programs will have to consider that as they consider adoption of these new data elements.

SUPPLEMENTAL ACCIDENT DATA
RELATING TO VEHICLE STANDARDS

	Code	Column
(S 102) DOWNSHIFTING PROVIDED BRAKING EFFECT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	12
(S 103) WINDSHIELD VISIBILITY PROBLEM DUE TO INADEQUATE DEFROSTING OR DEFOGGING (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	13
(S 103) MALFUNCTION OF DEFROSTING/ DEFOGGING SYSTEM (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	14
(S 104) WINDSHIELD VISIBILITY PROBLEM DUE TO INADEQUATE WIPING (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	15
(S 104) MALFUNCTION OF WIPING/ WASHING SYSTEM (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	16
(S 105) MALFUNCTION OF BRAKES PRIOR TO CRASH (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	17

	Code	Column
(S 105) BRAKES RESPONDED NORMALLY (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	18
(S 105) EVIDENCE OF IMBALANCE IN THE BRAKING SYSTEM (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	19
(S 105) WET BRAKES (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	20
(S 108) EVIDENCE OF LAMP FAILURE PRIOR TO COLLISION (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	21
(S 108) LIGHTING SYSTEM LIMITATIONS CONTRIBUTED TO THE ACCIDENT CAUSE (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	22
(S 109) BLOWOUT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	23

	Code	Column
(S 109) TYPE OF SKID (1) NO SKID (2) STRAIGHT (3) CLOCKWISE (4) COUNTERCLOCKWISE (5) UNKNOWN	--	24
(S 109) TIRES ON CAR ORIGINAL OR REPLACEMENT (0) ALL ORIGINAL TIRES (1-8) NUMBER OF REPLACEMENT TIRES (9) UNKNOWN	--	25
(S 124) THROTTLE STUCK PRIOR TO ACCIDENT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	26
(S 201) DOOR OPENED IN ACCIDENT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	27
(S 202) RIGHT FRONT PASSENGER HEAD RESTRAINT DAMAGE (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	28
(S 202) RIGHT FRONT PASSENGER CONTACT WITH HEAD RESTRAINT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	29

	Code	Column
(S 202) TYPE OF DAMAGE - DRIVER HEAD RESTRAINT (1) BENT (2) DETACHED (3) BROKEN (4) NOT APPLICABLE (5) UNKNOWN	--	30
(S 202) TYPE OF DAMAGE - RIGHT FRONT HEAD RESTRAINT (1) BENT (2) DETACHED (3) BROKEN (4) NOT APPLICABLE (5) UNKNOWN	--	31
(S 202) PROPER ADJUSTMENT - DRIVER HEAD RESTRAINT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	32
(S 202) PROPER ADJUSTMENT - RIGHT FRONT HEAD RESTRAINT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	33
(S 208) DRIVER'S SIDE AIR BAG DEPLOYMENT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	34
(S 208) RIGHT AIR BAG DEPLOYMENT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	35

	Code	Column
(S 210) DRIVER SEAT BELT ANCHOR DEFORMED OR RIPPED OUT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	36
(S 210) RIGHT FRONT SEAT BELT ANCHOR DEFORMED OR RIPPED OUT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	37
(S 212) PERCENT WINDSHIELD BOND SEPARATION (998) NOT APPLICABLE (999) UNKNOWN	--	38, 39,40
(S 213) CHILD EJECTED FROM CHILD SEAT (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	41
(S 213) CHILD SEAT SEPARATED FROM ANCHORAGES (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	42
(S 213) ANCHORAGE OF CHILD SEAT (1) SPECIAL HARNESS OR BELT (2) ADULT LAP BELT (3) OTHER (4) NONE (5) NOT APPLICABLE (6) UNKNOWN	--	43

	Code	Column
(S 213) CHILD SEAT FAILED OR CAME APART (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	44
(S 215) FOLLOWING SYSTEMS REMAINED NORMALLY OPERABLE AFTER COLLISION (L) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN		
FUEL	--	45
COOLING	--	46
EXHAUST	--	47
PROPULSION	--	48
SUSPENSION	--	49
STEERING	--	50
BRAKES	--	51
LAMPS	--	52
DOORS	--	53
HOOD	--	54
TRUNK	--	55
(S 217) ANY BUS WINDOW NOT RETAINED (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	56
(S 217) OCCUPANT CONTACT WITH ANY WINDOW NOT RETAINED (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	57
(S 217) OCCUPANT EJECTED THROUGH WINDOW (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	58

	Code	Column
(S 217) EXIT WINDOW OPERATION AFTER COLLISION (1) AT LEAST ONE FAILS TO OPERATE (2) ALL OPERATE (3) NOT APPLICABLE (4) UNKNOWN	--	59
(S 301) RATE OF FUEL LEAKAGE AFTER IMPACT (1) LESS THAN ONE OUNCE PER MINUTE (2) ABOUT ONE OUNCE PER MINUTE (3) MORE THAN ONE OUNCE PER MINUTE (4) NO LEAKAGE (5) UNKNOWN	--	60
(S 302) FIRE SUSTAINED BY INTERIOR MATERIALS RATHER THAN BY FUEL (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	61
(S 302) BURNING RATE OF INTERIOR MATERIALS JUDGED TO BE FASTER THAN PERMITTED BY THE STANDARD (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	62

FOR TRUCKS OR BUSES WITH AIR BRAKES

	Code	Column
(S 121) SLIPPERY SWITCH INSTALLED FOR AIR BRAKE SYSTEM (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	63
(S 121) TRUCK SKIDDED FROM ITS TRAVEL LANE AS A RESULT OF BRAKING (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	64
(S 121) POSITION OF SLIPPERY SWITCH (1) ON (2) OFF (3) NOT APPLICABLE (4) UNKNOWN	--	65
(S 121) LOCK-UP OF ANY WHEEL (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	66
(S 121) AIR BRAKE COMPONENTS BURST (1) HOSES (2) STEEL LINES (3) FITTINGS, VALVES (4) RESERVOIRS (5) NONE (6) UNKNOWN	--	67
(S 121) READING OF AIR PRESSURE GAUGE (psi) AFTER COLLISION (998) NOT APPLICABLE (999) UNKNOWN	--	68, 69,70

	Code	Column
(S 121) DRIVER'S OPINION OF WHETHER BRAKE WARNING HORN SOUNDED (1) YES (2) NO (3) DON'T KNOW (4) NOT APPLICABLE (5) UNKNOWN	--	71
(S 121) SERVICE BRAKE STOP-LAMPS OPERATED AFTER COLLISION (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	72

FOR MOTORCYCLES

	Code	Column
(S 122) BRAKING PROBLEM (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	73
(S 122) EVIDENCE OF BRAKING WITH BOTH WHEELS (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	74
(S 122) MOTORCYCLE ACHIEVED A STRAIGHT-LINE STOP (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	75
(S 122) BRAKES OPERATED AFTER COLLISION (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	76
(S 122) BRAKES WET (1) YES (2) NO (3) NOT APPLICABLE (4) UNKNOWN	--	77

APPENDIX D

EXAMPLES OF ANALYTIC PROCEDURES RELATING TO FMVSS 105 and 207

While the request for proposal for this program specifically stated that the report should not contain a lot of philosophy, there is a need to present a brief philosophical discussion of the relationship between accident data and compliance testing. Physically the laboratory testing of vehicles for compliance with standards is a rather precise process. Forces are defined in magnitude and point of application to permit both the manufacturer and the government to conduct repeatable and comparable tests. For example, the forces to be applied to car seats in testing to standard #207 (seat retention) are given with appropriate precision in the standard and in the test procedures documents.

In accidents, however, it is seldom possible to arrive at more than a general description of the forces involved. It is true that many seats separate from their mountings during collisions, some of these in relatively minor crashes. Yet the actual forces involved depend on the location and masses of the occupants, the direction of the collision,the presence of other materials (e.g., luggage) in the car, etc. Not infrequently damage is imparted to a vehicle after the collision in the process of extrication or towing, so that the observed damage may not be directly related to the collision itself.

Nevertheless, the purpose of the standard was to minimize the incidence of some undesirable factor (in this case the seat separating from its mounting) in collisions. Unless there is some radical deviation from the manufacturing standard it seems unlikely that the accident investigator will be able to conclude directly that a violation has occurred. Such radical departures do occur--e.g., in the case of the Opel windshield--and it is appropriate that the investigators be trained to look for these. Lesser indications of non-compliance may, however, be detected in aggregated data, and it is for this purpose that the detailed reporting of the results of crashes is of value.

Now here is a sort of quandary. The vehicle standards test personnel tend to think of the problem in very specific terms--a force is applied, something gives more than it is supposed to, and the vehicle is not in compliance. The accident investigator sees some distorted metal part which is related to the standard (a crushed side door, or roof, a seat which has left its track), but he can provide only a rough estimate of the forces involved. Is there any way out?

We present in this section two examples of the analysis of accident data which are intended to demonstrate that a combination of appropriate data collection and subsequent analysis can provide information which will increase the likelihood of appropriate selection by the Standards Enforcement Office. It will not often be in the form of "Here is a vehicle which will surely fail the test," but rather in the form of a listing of vehicles in decreasing order of their likelihood of failing. The information will sometimes be in aggregate form rather than associated with a particular make and model--i.e., it may apply to all Ford intermediates either because the data were collected in that way or because there are too few cases to permit finer definition. And the standards enforcers will have to learn to use data in such aggregated form or not to use it at all.

With this introduction, we proceed with the two examples. The first is an analysis of police-reported data taken from the state of Texas and is concerned with brake system performance. The second is an analysis of data from the MDAI program, and is concerned with seat separation. The methods are not unique to these two problems, but they also do not represent an exhaustive set of methods for studying the compliance problem. They are given as examples which, if taken as a starting point, should lead to better identification of vehicles for enforcement selection.

The Use of Mass Accident Data in a Study of Compliance with FMVSS #105.

Many police accident reports provide a space for noting the presence of vehicle defects as "causative factors" in connection with an accident. While some reporting agencies group these into a general category such as "vehicle defect indicated," others separate into individual component parts. In the State of Texas a separate notation is made by the reporting officer when he believes that some brake malfunction has been at least partly responsible for a collision. It is clear that the reporting officer does not have in mind the elements of Standard #105 when he makes such a report--he probably never heard of it. He is more likely dependent on his own observations that the vehicle skidded out of its lane, that the brakes were wet, that a hydraulic line parted, or on the driver's claim that "my brakes didn't work." Nevertheless, we can infer some correlation between his report and performance with respect to the standard in a general sense, and study of the incidence of reported failures by vehicle make and model may illuminate the problem.

The purpose of this section of the report is to present a procedure for the analysis of police-reported accident information. In a simple display of the relative frequency of brake "failure" by car make/model some differences are apparent. For example, the Corvair shows up with a high brake failure rate relative to the Pinto, but it seems likely that this could come about simply because there are no new Corvairs (old cars have more brake problems), and there are no old Pintos.

In order to look at the data more critically, then, we should devise a method to take out the effect of vehicle age. The frequency of reported brake problems in passenger car collisions in Texas in the year 1971 varies substantially with the age of the vehicle--ranging from .123% for 1971-72 models to 0.95% for 1966 models. For cars 10 years old the involvement of "bad brakes" rises to nearly 5%. In this analysis we restrict ourselves to cars six years old or less, and we will weight the data in such a way as to minimize the effect of an older car failing, and raise the effect of a new car failing. Weighting factors were defined which were inversely proportional to the actual incidence of brake failure by model year--e.g., if a 1971 car has a brake failure in connection with an accident, we will weight that incident 7.7 times more than we would if the same model were a 1966 car. The weights actually used in this analysis were multiplied by a factor of ten for convenience.

With this adjustment model in hand, data from the State of Texas for 1971 has been analyzed and is displayed in Table D-2. The make/model codes are those assigned by the state, and although do not exactly duplicate those conventionally used by OSE, are reasonably clear. The second column gives the total number of "defective brakes" reported in the state for that model during the year. The third column gives that number weighted by the numbers from Table D-1--e.g., multiplied by 77 if it were a 1971 car, etc. The fourth column displays the total number of cars of that make/model involved in accidents in a 5% sample of accidents in the state that year. The fifth presents the unweighted proportions--it may be read directly as the frequency of brake failure for that make. And the last column displays the weighted proportions. The weighted proportions have no direct numerical value as they have been presented, but may be set down in order to observe the relative frequency of brake failure (adjusted for vehicle age).

Table D-1. Brake defects reported in accidents in Texas, 1971. The column entitled "prop." shows the proportion of all cars of that make (model years 1966-72) which exhibited brake problems (as reported by police) in accidents in Texas in that year. The column entitled "Wtd. Prop." shows that proportion weighted according to the schedule shown in the text. This weights "failures" in recent car models about 7.5 times more heavily than it does in six=year-old cars.

Make of Car	Number Brake Defects	Weighted Number	5% Total Population of Accident Involved Vehicles	Proportion with Brake Defects	Weighted Proportion
Buick Electra	25	514	224	.00558	.1147
Buick Lesabre, Wildcat	27	606	336	.00402	.0902
Buick Riviera	8	104	91	.00417	.0571
Buick Skylark/Special	15	536	271	.00277	.0989
Buick (other)	8	231	165	.00242	.0700
Cadillac	12	402	339	.00177	.0593
Full size Chevrolet	126	2797	1893	.00333	.0739
Chevy II/Nova	23	706	339	.00339	.1041
Camaro	38	1139	392	.00485	.1450
Chevelle	82	2202	772	.00531	.1426
Corvair	5	66	18	.0139	.1833
Corvette	2	20	45	.00222	.0222
Monte Carlo	4	191	116	.00172	.0823
Vega	4	303	65	.00308	.2331
Chevrolet (other)	42	899	439	.00478	.1024
Chrysler	21	429	274	.00383	.0783
Datsun	3	70	117	.00128	.0299
Dodge Charger	17	543	144	.00590	.1885
Dodge Coronet	24	514	235	.00511	.1094
Dodge Dart	26	577	186	.00699	.1551
Dodge Polara	16	450	97	.00825	.2319
Dodge (other)	16	523	230	.00348	.1137
Fiat	7	260	43	.00814	.3023

Ford Custom	41	898	238	.00861	.1887
Ford Fairlane	45	978	316	.00712	.1547
Ford Falcon/Futura	15	356	150	.00500	.1187
Ford Galaxie	95	1991	693	.00685	.1437
Ford LTD	26	681	414	.00314	.0822
Ford Maverick	19	923	286	.00332	.1614
Ford Mustang	117	2639	788	.00742	.1674
Ford Pinto	2	154	103	.00097	.0500
Ford Thunderbird	23	365	86	.01337	.2122
Ford Torino	23	1003	236	.00487	.2125
Ford (other)	56	1199	444	.00631	.1350
Lincoln	17	455	106	.00802	.2146
Mercury Comet	10	122	83	.00602	.0735
Mercury Cougar	20	568	138	.00725	.2058
Mercury Marquis	2	121	71	.00141	.0852
Mercury Montclair	4	46	15	.01333	.1533
Mercury Monterey	17	380	55	.01545	.3455
Mercury (other)	23	501	185	.00622	.1354
Olds Cutlass, F-85, 442	24	545	458	.00262	.0595
Olds 88	32	686	322	.00497	.1065
Toronado	5	50	37	.00676	.0676
Olds (98 & other)	39	860	301	.00648	.1429
Opel	26	812	141	.00922	.2879
Plymouth (Belv., Duster)	19	520	243	.00391	.1070
Plymouth Fury	55	1383	543	.00506	.1273
Plymouth Sat., Val.	17	380	227	.00374	.0837
Plymouth (GTX & other)	37	1223	280	.00611	.2184
Pontiac (Bonn., Cat., Ex)	66	1147	568	.00581	.1010
Pontiac Firebird	6	150	112	.00268	.0670
Pontiac Grand Prix	17	480	164	.00518	.1463
Pontiac GTO/Tempest	35	731	329	.00532	.1111
Pontiac (other)	16	374	194	.00412	.0964
Ambassador	9	241	61	.00738	.1975
AMC (other)	37	1099	268	.00690	.2050
Toyota	17	753	205	.00414	.1837
Volkswagen (bug)	93	2266	572	.00813	.1981
Volkswagen (other)	25	532	217	.00576	.1225
Volvo	2	52	27	.00370	.0963
Small European Cars	18	544	94	.00957	.2894

Some of the high values in that column obviously appear as a result of chance and a small sample size. No statistical tests have been applied here, although one could judge which high values might be discarded on the basis of some statistical test. Those vehicles which score more than .2000 in the weighted proportion include Vega, Dodge Polara, Fiat, Thunderbird, Torino, Lincoln, Cougar, Mercury Monterey, Opel, one model of the Plymouth (GTX & other), and the grouping of "Small European Cars" which includes MG, Renault, Austin-Healy, etc., all of which occurred with too low a frequency to consider them alone.

Of these the Vega and Fiat may be discounted for their small sample size, but the others might well be considered candidates for further examination. At the other end of the scale the Cadillac, the Chrysler, all of the Oldsmobiles, etc. exhibit few brake problems.

Further analysis of this data is possible. One could retrieve the few specific accident reports for the newer cars in the "high" cells, and read those for a fuller understanding of the defects. And it would be possible to combine several years of data to get a stronger set of information for the most recent model years.

The analysis presented here represents perhaps a week of effort for an analyst--including his solving the problems of locating the right data, making the necessary computer runs, devising a model to account for (in this case) the age effect, and writing up the results. It is intended that such information could be used by OSE as a weighting factor to be applied to its selection model--perhaps by increasing the weight for Standard #105 for those vehicles at the top of the list.

The point of the presentation here is that similar analyses are possible for other sets of data, and for other standards. Tire failures for new cars (where the tire make/model can be directly associated with the car) could be studied. Some states note non-working or deficient defrosters, wipers, etc. We have not made any detailed tabulation of other sources of data, but NHTSA has compiled lists of data elements in all of the state accident data files which could be addressed with these sorts of questions.

Vehicle identification in police files varies from none to a full explanation of the Vehicle Identification Number. The Texas data presented here should be viewed as one of the more detailed in this respect. In some states it will only be possible to identify the manufacturing corporation, and in others perhaps only a difference in the size of the car. But several analyses which identified a consistent problem with an identifiable subset of cars should provide enough information to suggest weighting those in the test selection process.

The Use of CPIR Data in a RIDIT Analysis Associated with a Study of Compliance with FMVSS 207

FMVSS #207 sets requirements for the performance of car seat anchorages. In tests, the seat is subjected to a force of 20 times its own weight in a longitudinal direction (either forward or backward) and the seat must not separate from its mounting. In addition, a moment of 3300 inch-pounds (measured from the H-point) is applied to the seat back (rearward force for a front-facing seat).

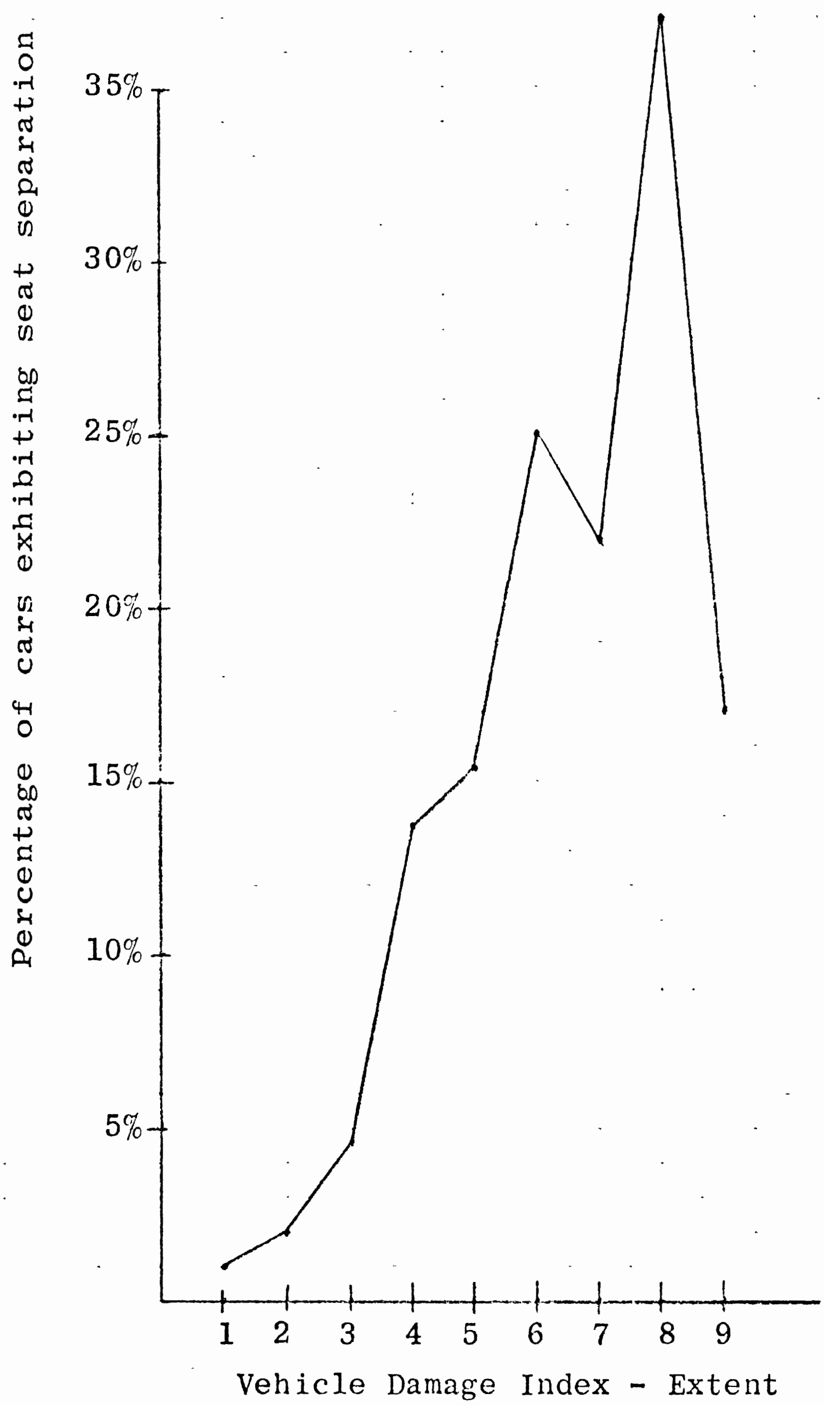
While these performance measures were chosen to represent some real-life forces which may occur in accidents, accidents unfortunately do not provide the precision of measurement necessary to determine compliance with the standard. Numerous seat tracks do separate in collisions, their frequency increasing in general with increasing collision severity. Figure D-1 shows (for the current CPIR files of passenger cars) the frequency of seat track separation as a function of the vehicle damage index extent. The trend is clear, although the reason for the small percentage at VDI=9 is not. VDI=9 is a fairly rare event (there are only 37 cars with or without seat separation in this cell). Perhaps these cars are so badly damaged that the investigator could not determine seat track separation.

In any case, we might argue that a force of 20 times the seat's weight could have been applied in any of these cases, but that it seems least likely in the VDI=1 case, and reasonably understandable at the level of VDI=5 and above.

The item of data used for the present analysis is a derived dichotomous variable, "Seat separation, yes or no." It is derived by taking variable 403 of the present CPIR file, which details the location of seat separation (track, floor, etc.) and collapses it into a two-level variable. Filtering on this

Figure D-1

Percentage of Passenger Cars Exhibiting Seat Separation in Crashes, by Severity of Crash. Data taken from CPIR file, 1974.



DAMAGE INDEX	ALL CARS	1970 MODELS	LIGHT CARS	HEAVY CARS	GM CARS	FORD	MUSTANG
1	4	2	1	2	0	2	0
2	26	7	13	5	6	11	1
3	46	8	21	8	11	14	4
4	51	12	8	7	11	22	8
5	30	10	1	11	6	13	4
6+	47	10	6	17	22	15	2

Table D-2: Damage index distribution for selected groups of cars with seat separation.

DAMAGE INDEX	ALL CARS	1970 MODELS	LIGHT CARS	HEAVY CARS	GM CARS	FORD	MUSTANG
1	725	203	131	232	303	223	
2	1368	403	255	441	611	484	
3	953	262	185	261	385	315	
4	377	116	53	112	159	134	
5	177	56	29	65	72	62	
6+	196	48	33	63	93	58	

Table D-3: Damage index distribution for selected groups of cars (all cars in present CPIR file).

classes are significantly "worse" than the average. The Vega sample size was too small for significance.

Of course the VW-Datsun and 1500-2500 lb. groups are highly correlated, as are perhaps the Vega/low weight groups.

This particular analysis depends upon the parent distributions (i.e., the distribution of VDI for all cars in a subclass) not being different from the reference distribution. For example, of the 686 crashed cars in the weight class of 1500-2500 pounds, 50 experienced seat separation. The RIDIT analysis can be applied to test the difference in the severity of all 1500-2500 lb. cars to that of all cars of all weights. These data are as follows:

VDI	ALL	1500-2500 lbs.
1	730	132
2	1387	258
3	988	189
4	402	56
5	185	30
6+	218	36

RIDIT = .51
ODDS = 1.05
SIG = .31

The odds ratio of 1.05 indicates that the light cars were in a slightly less severe set of crashes than the reference group, but that the difference is not significant. While it is not appropriate to state that the two crash distributions were "the same," it is appropriate to say that the data do not support the hypothesis that they are different. With this in mind, we may compare the results of the same two groups for crashes involving seat separation. As shown in Table D-4, the odds that the lightweight group was in a less severe set of crashes are 2.02:1, and variable, we can determine the frequency of seat track separation for the entire set of cars in the file, and then separately for a number of subsets of the data. A summary of this information is shown in Table D-2. The entire population of passenger cars in the CPIR file, divided into the same groups, is shown in Table D-3. The RIDIT test may be applied to determine whether any two distributions (across the VDI) differ, and in which direction. Perhaps the most useful output of the RIDIT test is the "odds ratio" which gives, in this case, the odds that a vehicle selected at random from one (a comparison) distribution will be damaged less severely than one selected from the other (reference) distribution. In this analysis, the reference distribution will in general be a total population, and the comparison group will be a sub-class of that.

Several statistics are presented in Table D-4 comparing (1) the Vega against all General Motors cars; (2) all 1500-2500 lb. cars against the total population of passenger cars; (3,4) the same for 2500-3500 lb. and 3500-4500 lb. cars; (5) all Chevrolets against the total population; all (6) Pontiacs; (7) Fords; (8) Plymouths; and (10) Vegas against the total population. Note that the Vega is presented twice-once with reference to all General Motors cars, and once with reference to the whole population. The next to last column (9) of Table D-4 is for Volkswagens and Datsuns grouped together (it would be possible to separate them, but in the particular run made for this study they were combined).

Looking at the Odds Ratio row, it can be seen that the Vega (in either comparison), the group of 1500-2500 lb. cars, and the VW-Datsuns all have an odds ratio greater than one. This means that they are more likely to have seat separation at lower degrees of impact (as measured by the VDI) than the reference group. Of these four, however, only the VW-Datsun and the 1500-2500 lb.

the significance level is .0001 (i.e., there is a very low probability that this could have occurred by chance).

We conclude, then, that the lightweight group exhibits seat separation in crashes at a lower (crash) severity than does the reference group, and place it in a position of greater desirability for testing.

The reason for any particular vehicle exhibiting seat separation at lower damage indices is not clear from the aggregated data. It may well be that the vehicle would still pass the present standards, and that the observations were the result of some special design feature (like a stiff rear end in the VW). It is possible, also, that a particular vehicle could be identified as high in seat separation because a small number of these vehicles were in a type of accident conducive to this. Finally, the number of vehicles (in accidents) necessary to establish a significant difference from the reference group is a function of the difference—i.e., if a vehicle had a tendency to break the seat track in very low-severity collisions, a half-dozen collisions might be enough to draw and defend a conclusion. On the other hand, if a vehicle were very close to average, several hundred cases would be necessary to define the difference (which then would be significant but small).

In Table D-4, the Pontiac is shown to be better than average (i.e., the odds ratio = .54) with a significance level of about 7%. There is a total of 296 crash-involved Pontiacs, and 12 with seat separation. Using this as an example, we suggest that something on the order of 300 cases of a given car type would be appropriate for this kind of analysis.

The present MDAI program will achieve this number of cases only for a few of the most popular passenger cars-perhaps full-size and intermediate Chevrolets and Fords. In the present data,

Table D-4

	All with seat separation vs. all	Vega vs. all GM	1500-2500 # vs. all separation	2500-3500 # vs. all separation	3500-4500 # vs. all separation	Chevrolet vs. all separation	Pontiac vs. all separation	Ford vs. all separation	Plymouth vs. all separation	VW and Datsun vs. all separation	Vega vs. all separation
Probability that a car selected from the comparison population is damaged to the same (VDI) level as one selected from the reference population	.15	.17	.20	.21	.20	.22	.21	.21	.20	.19	.20
Probability that it is damaged less severely	.70	.14	.23	.43	.48	.50	.55	.41	.46	.21	.17
Probability that it is damaged more severely	.15	.70	.57	.36	.33	.28	.25	.38	.33	.61	.61
RIDIT value	.22	.78	.67	.46	.43	.39	.35	.48	.43	.70	.71
The "Odds ration"--i.e., the odds that a car selected at random from the comparison population will be less severely damaged than one in the reference population	.29	3.54	2.02	.87	.74	.64	.54	.94	.77	2.33	2.56

Table D-4 continued

The standard deviation of the probabilities	.04	.33	.09	.07	.09	.12	.17	.08	.13	.13	.32
Significance level of the difference	.0000	.09	.0001	.32	.0977	.0579	.0719	.6967	.3170	.0025	.18
Number with seat separation		3	50	90	50	27	12	63	20	20	3
Total number		128	686	1696	1174	899	296	1026	345	88	128

then, this sort of analysis would have to be applied to aggregated classes of vehicles (e.g., all General Motors cars of a given body size, or all Japanese-manufactured passenger cars).

Note that the present MDAI data is made up largely of data provided by the MVMA under their sponsored accident investigation programs, and that the NHTSA portion of the data would presently be even less adequate. While it may be difficult to justify a large increase in the number of MDAI-reported cases solely on the basis of the needs of the Office of Standards Enforcement, it is clear that an increase by a factor of ten or more is needed to get enough data to permit the kind of analysis shown here to be done with respect to specific makes and models of passenger cars.

The data for this analysis resulted from a set of 19 tables drawn from the CPIR file in a single pass at a cost of approximately $10.00 and in a one-hour session at a computer terminal. More of the identifiable groups of cars are not significantly different in seat separation from the average. The RIDIT computation was done on a programmable desk calculator, although it can be done in a reasonable time without programming. Using the program, it took approximately one minute for each computation—perhaps a half hour to prepare the information shown in Table D-4. In Table D-5 are listed the number of cars in the file, the odds ratio, and the significance levels for the 24 groups tested. For only seven groups was there enough data to yield significance at the 10% level or better, and these may be ordered by the decreasing odds ratio into (1) VW/Datsun, (2) 1500-2500 lb. cars (3) All Lincoln/Mercury division cars, (4) 3500-4500 lb. cars, (5) All Chevrolets, (6) All luxury cars, and (7) All Pontiacs. The last are "better than average," and the first two "worse."

Given a larger set of data, this sort of analysis could be performed on a car-by-car and model-year-by-model-year basis.

For many models there are not enough reported accidents now (in the MDAI files) to justify this kind of analysis at present.

Table D-5

RIDIT Results for 24 Groups of Cars Tested for Seat Separation

Number of cases in file	Class	Odds-Ratio	Signif. Level	
1121	1970 models	1.0032	.9858	(relative to all pass. cars)
1151	1971 models	1.2573	.2012	
717	1972 models	1.2214	.5529	
701	15-25k#	2.0240	.0001	
1735	25-35k#	.8687	.3249	
1211	35-45k#	.7423	.0977*	
899	All Chevrolets	.6402	.0579	
216	All Olds	.6988	.4492	
296	All Pontiac	.5357	.0719	
1026	All Ford	.9384	.6967	
345	All Plymouth	.7658	.3170	
88	VW/Datsun	2.3333	.0025	
57	Opel	1.7701	.2012	
133	All AMC	2.3804	.0427	
277	All Lincoln/ Mercury	1.1618	.0315	
137	All "Luxury" Cars	.58	.35	
427	Int. GM	.6568	.1971	(relative to all GM cars)
486	Full-size GM	.7230	.3203	
114	Pony GM	17.6666*	.1141	
170	Compact GM	.8317	.6816	
128	Mini GM	3.5405	.0924	
223	Inter Ford	.3928	.4252	(relative to all Ford cars)
324	Full-size Ford	.8443	.5391	
195	Pony Ford	1.2272	.6689	
272	Compact Ford	.9441	.8429	
157	Mini Ford	2.2195	.1152	

* only one car in this category exhibited seat track separating, this at VDI = 2.