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DEPARTMENT OF TRANSPORTATION  
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION  
[49 CFR Part 571]

DOCKET NO. 2-6; NOTICE 4  
PROPOSED MOTOR VEHICLE SAFETY STANDARD

ROOF INTRUSION PROTECTION FOR PASSENGER CARS

Automobile Manufacturers Association, Inc.

April 5, 1971

Docket No. 2-6; Notice 4

Roof Intrusion Protection for Passenger Cars

The Automobile Manufacturers Association, Inc. (AMA) submits the following comments in response to the Administration's notice of proposed rule making on Docket No. 2-6; Notice 4, Roof Intrusion Protection for Passenger Cars (36 Fed. Reg. 166, January 6, 1971).

The Administration implies a safety need for roof structure minimum performance based on field accident data. AMA has reviewed the research report<sup>1</sup> filed in the public docket that apparently was used in drafting the preamble. AMA has also reviewed other data sources which have tried to relate actual field deformation of vehicle top structures to actual occupant injuries and fatalities. AMA can find no

<sup>1</sup>"Estimating the Effects of Crash Phase Injury Counter-Measures," Travelers Research Corp., U. S. Department of Transportation, Contract No. FH-11-7228.

Shortly before the due date for comments, the Administration placed in the docket a copy of a draft final report (Contract No. FH-11-7549) dated March 5, 1971, entitled "Crashworthiness of Vehicle Structures - Passenger Car Roof Structures Program" from Lockheed-Georgia Company. AMA has not had sufficient opportunity to analyze this report in preparing these comments and, due to its late filing, wishes to reserve the right to comment on the report at a later date.

causal relationship between the amount of roof deformation and the injury status of the occupants in field accidents.

Attachment A hereto is a tabulation of degree of occupant injury versus observed roof deformation. This table demonstrates that major deformation can occur with little or no injury; and fatal injuries can occur with no deformation. It has been pointed out that any apparent correlation between collapse and injury:

"... does not necessarily mean that the roof collapse was the immediate cause of the increased injury; it may be that large amounts of roof collapse are an indication of large collision forces which would have led to serious injury anyway. From the cases examined in this study, it appears that if the roof collapse is so great that the weight of the car can be transmitted to the occupant's head through the seat, then very serious crushing injuries occur. If, however, the roof provides enough interior space so that the vehicle load is not transferred to the occupant then the amount of roof collapse is probably not critical, i.e., the head injuries are due to direct impact and are not due to the displacement of the roof as such."<sup>2</sup>

The Administration's research report<sup>3</sup> attributes approximately 3% of fatalities to contact with the top structures in

<sup>2</sup>G. M. MacKay and I. D. Tampen, "Field Studies of Rollover Performance," 1970 International Automobile Safety Conference Compendium, page 975, SAE Paper No. 700417.

<sup>3</sup>"Estimating the Effects of Crash Phase Injury Counter-Measures," Travelers Research Corp., page 3, U. S. Dept. of Transportation, Contract No. FH-11-7228.

rollover-type accidents. However, the reference suggests that if the individual were "properly restrained"<sup>4</sup> the level of fatalities allegedly could be reduced to approximately 1.5% or 700 deaths, based on 1969 accident data. Even these 700 deaths would not necessarily be eliminated if there were no roof intrusion since occupants do not remain in an upright position and might impact other vehicle interior surfaces.<sup>5</sup> Therefore, it is not possible to identify the precise number of cases of serious injury or death attributable to roof deformation or any precise safety gain which would be attained by the elimination of roof deformation.

Indeed, the Administration's assertion that "the benefits of occupant restraint are negated if the passenger compartment collapses" is an unsupportable overstatement, based on a recent Society of Automotive Engineers, Inc. (SAE) report.<sup>6</sup>

<sup>4</sup>"Estimating the Effects of Crash Phase Injury Counter-Measures," Travelers Research Corp., page 4, U. S. Dept. of Transportation, Contract No. FH-11-7228.

<sup>5</sup>Reference rollover scenes from the film "Unrestrained Flying Objects," available from the General Motors film library, 1968.

<sup>6</sup>W. O. Nelson, "Lap-Shoulder Restraint Effectiveness in the United States," SAE Automotive Engineering Congress, Detroit, Michigan, January 11-15, 1971, Paper No. 710077 (see especially case nos. 1, 2, 4 and 5).

In summary, in the absence of data to the contrary, AMA suggests that occupant injury by impact with a highly deformed roof structure may well be more directly a function of large collision forces in severe rollover accidents rather than of roof deformation per se.

AMA therefore questions whether there is a safety need for a standard on static roof strength that is not correlated with occupant injury. However, if the Administration insists that a standard on roof strength be issued, the total roof strength should be evaluated by appropriate measurement of deformation over a relatively large area of the roof. A laboratory-type roof crush test procedure has been under development for several years. This test procedure reflects the expert opinions of many automotive engineers and has been adopted by the SAE in Recommended Practice J374. Therefore, AMA requests that any proposed standard not arbitrarily change existing and appropriate test procedures.

AMA recommends the following changes in the proposed standard. Deletions are shown by cross-hatching and additions by underlining the new language.

Roof Inrtusion Protection  
Strength--Passenger Cars

S1. Scope THIS STANDARD SPECIFIES STRENGTH REQUIREMENTS UNDER COMPRESSIVE FORCES SUCH AS THOSE LIKELY TO BE EXPERIENCED IN A ROLL-OVER ACCIDENT FOR THE FORWARD PORTION OF THE PASSENGER COMPARTMENT Purpose and scope. This standard specifies strength requirements for passenger car top structures to reduce the effects of roof deformation during rollover accidents.

S2. Purpose THE PURPOSE OF THIS STANDARD IS TO REDUCE DEATHS AND INJURIES AND TO MINIMIZE THE RISK OF INJURY TO THE PASSENGER COMPARTMENT IN ROLL-OVER ACCIDENTS

COMMENT: AMA has changed the Title, Scope and Purpose to eliminate the inference that there is a necessary correlation between roof deformation and occupant injury. AMA also is recommending a test procedure which evaluates the strength of the total roof structure system and not just the forward section. The subsequent paragraph section numbers should be changed in accordance with deletion of S2.

S3. Requirements. A test device as described in S4 shall not move more than 3 \_\_\_ inches, measured in accordance with S5.4, when it is used to apply a force of  $1 \frac{1}{2}$  \_\_\_ times the empty curb weight of the vehicle, or 3,000 \_\_\_ pounds,

S3. (cont.)

whichever is less, to ~~each~~ one side of a vehicle's roof in accordance with the procedures of S6.5.

COMMENT: The 5-inch limit and the 12 by 12-inch test device in the test procedure overemphasize the performance of the windshield pillar and do not allow an adequate evaluation of the top structure performing as a system. Participation of center and rear roof pillars which can contribute to roof stability during rollover would not be evaluated with this limited deformation.

Attachment B indicates a geometric relationship which defines front body pillar displacements for typical passenger cars which will permit a total roof system strength evaluation. This information suggests the "A" pillar deformation dimensions at which rear roof pillar and front end sheet metal contribution to total roof strength can be evaluated for the size classes of vehicles listed in the chart.

AMA requests that the Administration adopt curb weight in place of some new definition. This weight term is presently used in other standards and is technically defined.

AMA has changed the requirement for testing each side of a vehicle to testing only one side for the reasons stated in the comments on S6.5.

AMA has not considered and has no recommendations to submit on what the appropriate force requirements or other values should be. Accordingly, AMA has simply struck those values and left blanks in the proposed standard. AMA member companies may have individual comments on what values would be appropriate.

S34. Test device. The test device is a rigid, unyielding block with its lower surface formed as a flat rectangle 12 inches x 72 inches. On a side the padding is a uniform depth of 2 inches. The padding surface is of such a stiffness that when the center of the padded surface is statically depressed 2 inches by a rigid disc 4 inches in diameter, the resistance offered by the padding is between 675 and 725 pounds. the deflection of the surface shall not exceed one-tenth inch under a 5,000 pound load.

COMMENT: SAE has developed a laboratory test procedure for roof structure strength, SAE Recommended Practice J374, December 1968, Passenger Car Roof Crush Test Procedure. This procedure, under which manufacturers now have some experience, provides that a 12-inch by 72-inch platen be pushed against the roof structure at prescribed locations and angles.

The Administration's proposal in contrast specifies a 12-inch by 12-inch platen covered with 2 inches of padding and positioned at a different angle, a device which does not allow the evaluation of the top structure as a complete system since the load is much more concentrated. In keeping with the recommendations that SAE J374 be used, we recommend that padding not be added to the lower surface of the test device.

The language has been changed to provide an objective definition of the term "rigid, unyielding" when applied to the test device.

S~~6~~5.1 Place the sills or the chassis frame of the vehicle on a rigid horizontal surface, and fix the vehicle ~~XXXXXX~~ in position. ~~AND CLOSE AND LOCK ALL DOORS~~ All exterior doors shall be fully latched. All fixed glass shall be installed and all movable glass shall be in its closed position.

COMMENT: The above changes have been made to eliminate test condition ambiguity.

Because lateral, fore or aft vehicle movement would affect the test results, it is necessary to define "rigidity" within certain specific tolerances. Accordingly, AMA recommends that if such a standard is adopted, it contain specific tolerances for fixing the vehicle during the test.

AMA's proposed change regarding the doors is to make it clear that doors must be fully latched (primary position) since a door could be considered closed and could even be locked in the secondary latch position. AMA does not believe that locking of the doors would have any effect on test results.

The status of the glass is defined to assure adequate control of potential test variables.

S~~6~~5.2 Orient the test device as shown in Figure 1, so that its lower surface--

- (a) Is at a forward (side view) angle of ~~XXX~~  $5^{\circ} \pm 1^{\circ}$  below the horizontal;
- (b) Is at a lateral (front view) outboard angle of  $25^{\circ} \pm 1^{\circ}$  below the horizontal;

## S5.2 (cont.)

(c) Has two edges parallel to the vertical plane through the vehicle's longitudinal centerline; and

(d) ~~At its center, it extends to the surface of the vehicle.~~ Extends not less than 8 nor more than 10 inches forward of the rearmost point on the windshield daylight opening. The point of tangency between the test device and the roof must be positioned to coincide with the longitudinal centerline of the test device lower surface.

COMMENT: As noted in the comments to section S5 (S4 of AMA's rewrite), AMA requests that the Administration adopt the 12-inch by 72-inch load device defined in SAE Recommended Practice J374. Over two years of test experience with this device could be retained as useful information if the change mentioned above was adopted.

Comments on S4 (S3 of AMA's rewrite), Requirements, suggest establishing a roof system structural evaluation. This intent supports using 5° for the side view platen angle consistent with Recommended Practice SAE J374. Using the 12-inch by 72-inch load device, the provisions of S5.2(d) are then modified to assure adequate overlap of the load device with the roof structure. Consistent with these changes, Figure 1 is modified as shown in Attachment C.

S5.3 Apply force in a downward direction perpendicular to the ~~roof~~ lower surface of the test device at a rate of not more than ~~two~~ one-half inch per second until reaching

## S5.3 (cont.)

a force of  $\lambda \lambda/2$  \_\_\_\_\_ times the ~~empty~~ curb weight of the tested vehicle or  $3/000$  \_\_\_\_\_ pounds, whichever is less. The test must be completed within 120 seconds. Guide the test device so that throughout the test it moves in a straight line with its rigid lower surface oriented as shown in Figure 1.

COMMENT: Most loading devices are designed to operate at a constant rate of displacement rather than a constant rate of force. Due to the nature of vehicle structure, which may experience rapid changes in force level as it picks up additional "hard" structure below the exterior surface, controlling force rate requires additional test equipment and complication without rational basis. The same controlled displacement rate and test completion time limit recommended by AMA have been accepted in the test procedure defined in FMVSS No. 214, Side Door Strength, and are a method of ensuring the essentially static character of the test. The proposed performance values have been deleted and curb weight has been substituted for empty weight for the reasons stated in the comments on S4 (S3 of AMA's rewrite).

Figure 1 would be changed as shown in Attachment C.

*S5.3 Repeat the test on the other front corner of the roof of the vehicle.*

COMMENT: AMA objects to this provision on the following grounds:

(1) Test and accident survey experience indicates that in most cases roof structure damage is distributed to only one side of the roof in an actual rollover situation. Attachment D supports this position.

## 56.5 (cont.)

(2) Since the upper car structure is symmetrical, it makes no difference which side of the roof is selected for testing.

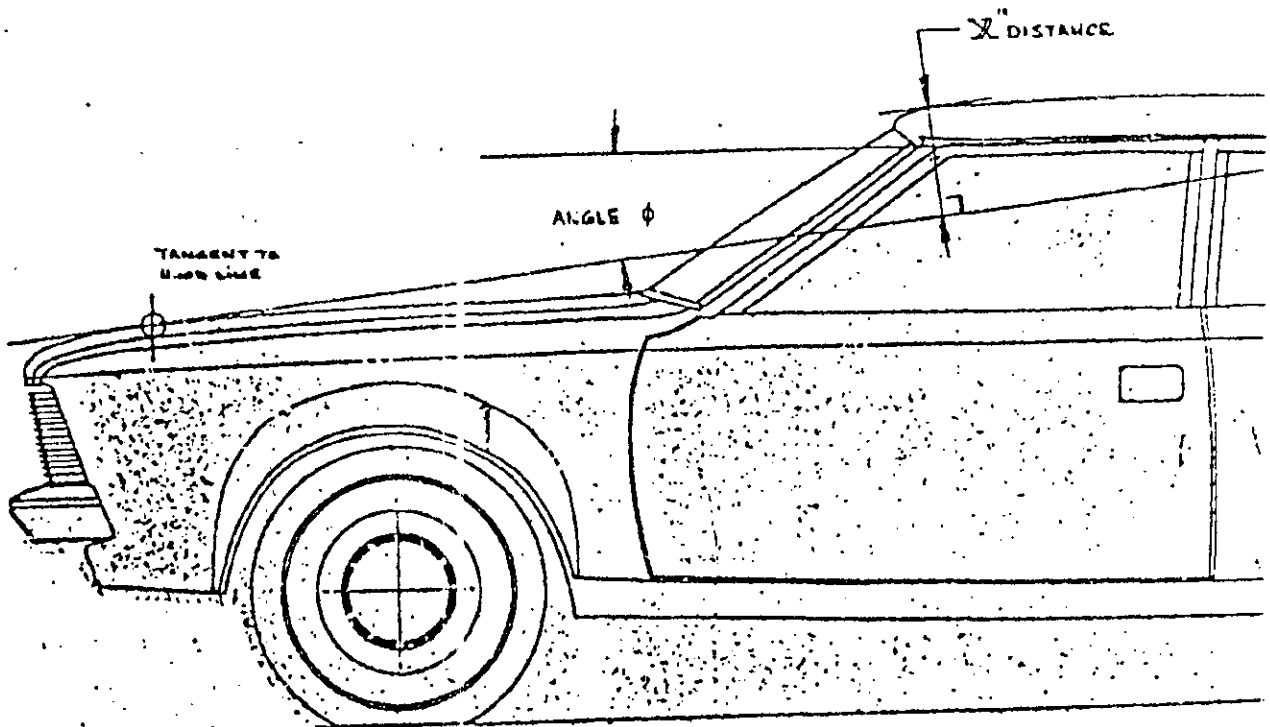
(3) However, it is very questionable whether repeatable or reliable results can be obtained by testing both sides of the same roof structure system. This follows from the fact that consistent material deformation in the vicinity of the second test cannot be assured after an initial destructive test on the first side.

ATTACHMENT A

INJURY LEVEL WITH ROOF DEFORMATION OVER OCCUPANT  
 (Restrained and Unrestrained Occupants Non Ejected)

No. of Accident Cases	Injury Level of Occupant	Range of Roof Deformation Over Occupant, Inches	No. of Cases with Roof Deformation of 5" and Greater
71	None	0 to 20"	25
26	Minor	0 to 20"	30
31	Non-Dangerous	0 to 20"	13
3	Dangerous	4 to 18"	2
4	Fatal	0 to 18"	3

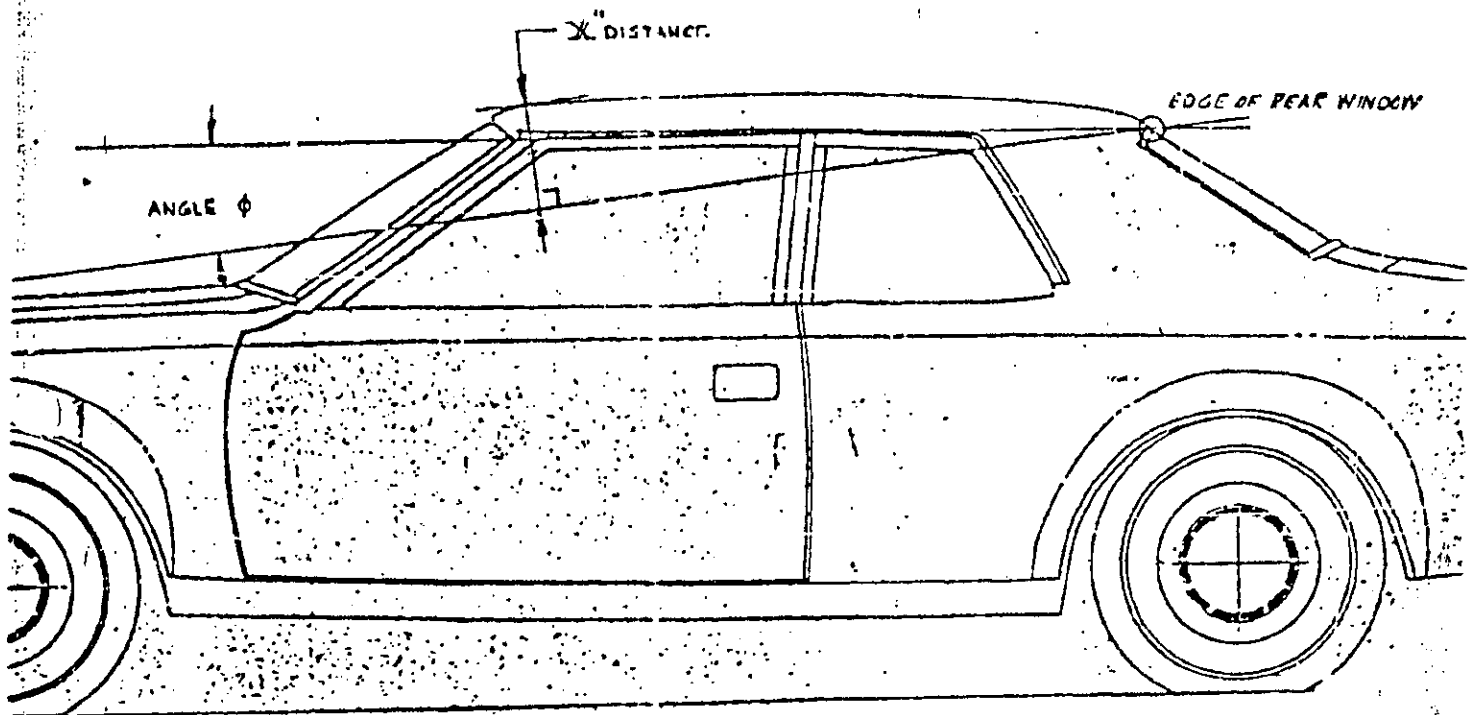
References: General Motors report (30203) - "Roof Crush and Injury in Rollover Accidents"



LOAD DEVICE DISPLACEMENT AND ANGLE TO ENSURE ROOF STRUCTURE SYST

DOMESTIC U.S. VEHICLE SIZE CATEGORY	DISPLACEMENT*
	RANGE $X$ , Distance (inches)
SUB-COMPACT	6.5 to 10.8
COMPACT	5.5 to 10.5
INTERMEDIATE	5.3 to 11.9
STANDARD	5.4 to 10.5

\* See above drawing for definition



ROOF DISPLACEMENT AND ANGLE TO ENSURE ROOF STRUCTURE SYSTEM EVALUATION		
C U.S. SIZE CATEGORY	DISPLACEMENT*	ANGLE*
	RANGE X, Distance (inches)	RANGE phi (degrees)
PACT	6.5 to 10.8	6.0 to 9.5
	5.5 to 10.5	5.5 to 9.0
DIATE	5.3 to 11.9	4.5 to 9.0
	5.4 to 10.5	5.0 to 10.0

drawing for definition

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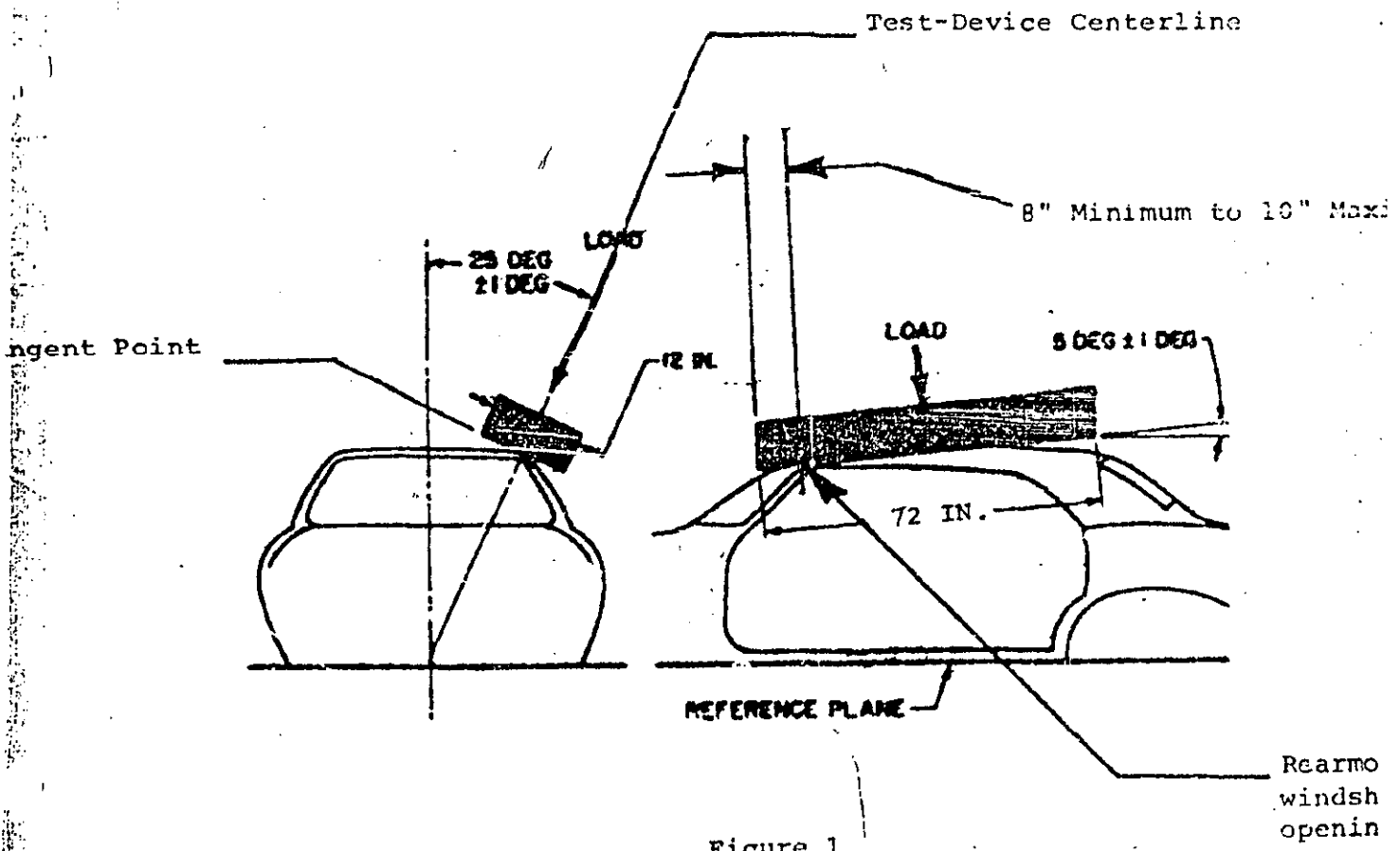


Figure 1

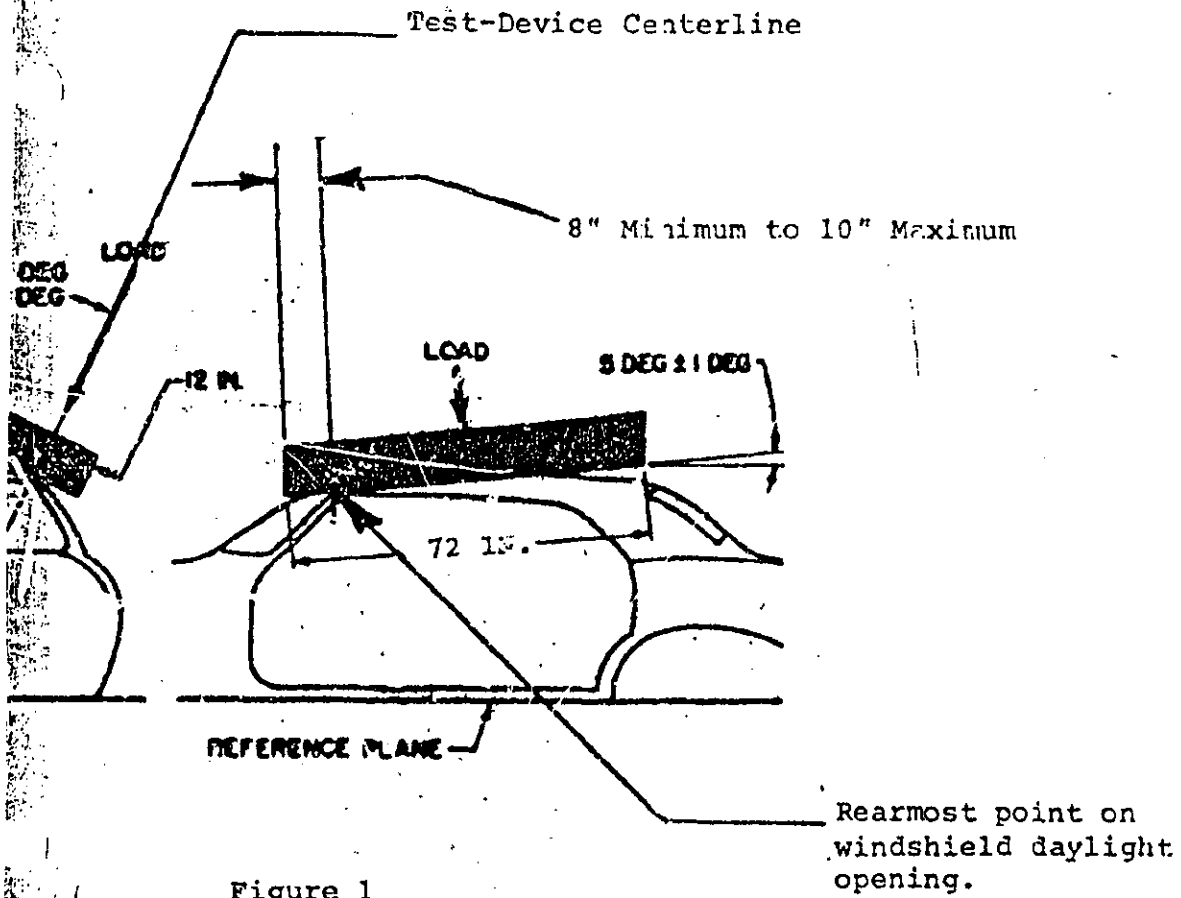


Figure 1

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ATTACHMENT C

ROOF DAMAGE DISTRIBUTION DURING ROLLOVER\*

DAMAGE CATEGORY	NO. OF CASES	% OF TOTAL
CASES WITH IMPACT AND DAMAGE ON ONE SIDE	83	
CASES WITH IMPACT AND DAMAGE ON ONE SIDE PLUS INDUCED DAMAGE ON OTHER SIDE	42	
SUBTOTAL-DIRECT IMPACT DAMAGE TO ONE SIDE	125	
CASES WITH IMPACT AND DAMAGE DISTRIBUTED ON BOTH SIDES	33	
SUBTOTAL-DIRECT IMPACT DAMAGE TO BOTH SIDES	33	
TOTAL CASES	158	

\*General Motors report (30203) - "Roof Crush and Injury in Rollover Accidents"

DURING ROLLOVER\*

SES      % OF TOTAL CASES

52

27

79

21

21

100

of Crush and

02-06-N04-011-04

ATTACHMENT D