

**General Motors
Documents Showing
Knowledge
of
Roof Crush Risks**

1966 Meeting Held to Review Energy Absorption Work Being Conducted at GM

Report No. PG-21773

~~We are presently in trouble with the "A" or~~ *Number 1*

~~Number 1~~ *Perhaps it should have a steep slope*

Report No. PG-21773

FOREWORD

On May 15, 1966, a meeting was held to review energy absorption work currently being conducted within General Motors.

The following people were in attendance:

G. Bailey	Buick Motor Division
D. H. Stratton	Chevrolet Motor Division
E. DeFusco	Chevrolet Motor Division
R. G. Khotan	Chevrolet Motor Division
V. D. Valade	Chevrolet Motor Division
J. Anderson	Defense Research Laboratories
A. Rydquist	Defense Research Laboratories
K. R. Vincent	Defense Research Laboratories
H. A. Wilcox	Defense Research Laboratories
T. M. Fisher	Engineering Staff
O. K. Kelley	Engineering Staff
L. C. Lundstrom	Engineering Staff
K. A. Stonex	Engineering Staff
F. J. Wittchell	Engineering Staff
D. Clark	Fisher Body Division
P. C. Skeels	Proving Ground
D. L. Venetrate	Proving Ground
R. A. Wilson	Proving Ground
J. P. Danforth	Research Laboratories
C. W. Good	Research Laboratories
L. Johnson	Research Laboratories
W. F. King	Research Laboratories
D. E. Martin	Research Laboratories
W. M. Spreitzer	Research Laboratories
G. Bennett	Styling Staff
L. L. Rowson	Styling Staff
K. B. Kelly	Styling Staff
P. Kyriopoulos	Styling Staff
B. Martens	Styling Staff
R. McLean	Styling Staff
A. J. Sobey	Styling Staff

**L.C. Lundstrom, Director,
Automotive Safety Engineering,
General Motors:**

**“We are presently in trouble
with the “A” or Number 1
pillar.”**

1969 Study Shows Harm to A-pillar, Occupant Heads from Roof Crush

Excerpts from Safety Analysis by GM Engineer Ben Parr, 1969

a weak one. When the vehicle is dropped from its inverted position and contacts the ground, the left upper "A" pillar is deformed to an imaginary straight line between the left upper "C" pillar and the left front fender (Figure 7). If the vehicle is dropped from a high enough height, for example 24 inches, most "A" pillars, regardless of their structural properties, will deform to this same imaginary straight line. By this analysis, it could be shown that a structurally weak "A" pillar experiences the same roof deformation as a stronger one. A good requirement to correct this condition might be to state, for example, that every part of the upper "A" pillar must remain outside this imaginary straight line when the vehicle is dropped from a height of 18 inches.

Exhibit 9, page 20, lists the degree of head injury by overall rollover accident severity and clearly indicates that higher degrees of roof collapse result in higher degrees of head injury. This is particularly true in the dangerous and fatal injury categories. In rollovers with only moderate roof damage, 1.2% of the occupants received fatal head injuries. In rollovers with extremely severe roof damage, 14.1% of the occupants received fatal head injuries.

“Progress in Areas of Public Concern,” General Motors Paper, 1971

Many of our engineers working on passive restraints have spent a great deal of time trying to make use of the air cushion to prevent ejection from the car during rollover accidents. Field surveys show that the chief cause of death in a rollover comes from passenger ejection through broken side windows.

GENERAL MOTORS CORPORATION

PROGRESS
IN AREAS OF
PUBLIC CONCERN

GM PROving GROUND
MILFORD, MICHIGAN
February, 1971

**General Motors Admits that
the Chief Cause of Death in
Rollovers is Occupant Ejection
through Broken Side Windows**

1971 NHTSB Proposed Roof Crush Rule

166

PROPOSED RULE MA.

02-06-N04

National Highway Safety Bureau
[49 CFR Part 571]

[Docket No. 2-8; Notice 4]

ROOF INTRUSION PROTECTION FOR PASSENGER CARS

Proposed Motor Vehicle Safety Standard

The purpose of this notice is to propose a motor vehicle safety standard that would establish minimum strength requirements for a passenger car roof to reduce the likelihood of roof collapse in a rollover accident. An advance notice of rule making on the general subject of intrusion from exterior impact, including roof intrusion, was published on October 13, 1967 (32 F.R. 14273; Docket No. 2-6).

The strength of a vehicle's roof has an evident bearing on the integrity of the passenger compartment in a rollover-type accident and consequently on the safety of the occupants. When applied to 1969 accident data, the analysis developed in a recent study indicates that approximately 1,400 motor vehicle occupants were killed in that year by impact with roof structure in rollover accidents. Roof intrusion would have been sufficient in many of the cases for the roof to have struck the head of a properly restrained occupant. The benefits of occupant restraint are negated if the passenger compartment collapses in this fashion, and it is therefore important that minimum roof strength requirements be established.

The proposed standard would establish requirements for the forward portion of the roof. This is the area of the roof most likely to sustain severe damage, particularly for front-engine passenger cars. In addition, the front seats are more frequently occupied than the rear seats, and tend to be more dangerous in a crash.

The resistance of the roof to intrusion is determined by a static test, in which a force of 1½ times the empty weight of the vehicle or 5,000 pounds, whichever is less, is gradually applied to the roof in the vicinity of the "A" pillar. The force is applied by a flat test device at a 25° roll angle and 10° pitch angle to simulate the direction of forces that can be encountered in a rollover. During the test, the roof may show no more than 5 inches of intrusion, as measured by the movement of the test device.

Proposed effective date: January 1, 1973.

In consideration of the above, it is proposed that a standard on roof intrusion protection be issued as set forth below. Comments are invited on the proposal, particularly on the lead time required for compliance. Comments should identify the docket number and be submitted to: Docket Section, National Highway Safety Bureau, Room 4223, 400 Seventh Street SW, Washington, DC 20591. It is requested, but not required, that 10 copies be submitted.

All comments received before the close of business on April 5, 1971, will be con-

sidered, and will be available for examination in the Rules Docket at the above address both before and after the closing date. To the extent possible, comments filed after the above date will also be considered by the Bureau. However, the rule making action may proceed at any time after that date, and comments received after the closing date and too late for consideration in regard to the action will be treated as suggestions for future rule making. The Bureau will continue to file relevant material, as it becomes available, in the docket after the closing date, and it is recommended that interested persons continue to examine the docket for new materials.

This notice of proposed rule making is issued under the authority of sections 105 and 119 of the National Traffic and Motor Vehicle Safety Act of 1966, 15 U.S.C. 1392, 1407, and the delegations of authority at 49 CFR 1.51 (35 F.R. 4955) and 49 CFR 501.8 (35 F.R. 11126).

Issued on December 23, 1970.

RODOLFO A. DIAZ,
Acting Associate Director,
Motor Vehicle Programs.

§ 571.21 Federal motor vehicle safety standards.

ROOF INTRUSION PROTECTION—PASSENGER CARS

S1. *Scope.* This standard establishes strength requirements, under compressive forces such as those likely to be experienced in a rollover accident, for the forward portion of the passenger compartment roof.

S2. *Purpose.* The purpose of this standard is to reduce deaths and injuries due to the intrusion of the roof into the passenger compartment in rollover accidents.

S3. *Application.* This standard applies to passenger cars.

S4. *Requirements.* A test device as described in S3, shall not move more than 5 inches, measured in accordance with

S6.4, when it is used to apply a force of 1½ times the empty weight of the vehicle or 5,000 pounds, whichever is less, to each side of a vehicle's roof in accordance with the procedures of S6.

S5. *Test device.* The test device is a rigid, unyielding block with its lower surface formed as a flat square 12 inches on a side, and padded to a uniform depth of 2 inches. The padding is of such a stiffness that when the center of the padded surface is statically depressed 1 inch by a rigid disc 4 inches in diameter, the resistance offered by the padding is between 675 and 725 pounds.

S6. *Test procedures.* Each vehicle shall meet the requirements of S4, when tested in accordance with the following procedure:

S6.1 Place the sills or the chassis frame of the vehicle on a rigid horizontal surface, fix the vehicle rigidly in position, and close and lock all doors.

S6.2 Orient the test device as shown in Figure 1, so that its lower surface—

(a) Is at a forward (side view) angle of 10° below the horizontal;

(b) Is at a lateral (front view) outboard angle of 25° below the horizontal;

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

(d) At its center, is tangent to the surface of the vehicle.

S6.3 Apply force in a downward direction perpendicular to the rigid lower surface of the test device at a rate of not more than 200 pounds per second until reaching a force of 1½ times the empty weight of the tested vehicle or 5,600 pounds, whichever is less. 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.

S6.4 Measure the distance that the test device moves, i.e., the distance between the location of the rigid portion of

the test device and the original force level is reached and its original location.

S6.5 Repeat the test on the other front corner of the roof of the vehicle.

Agency's initial proposal suggests a two-sided test:

“Repeat test on the other front corner of the roof of the vehicle.”

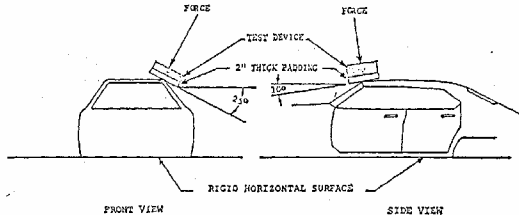


FIGURE 1

(F.R. Doc. 71-7; Filed, Jan. 5, 1971; 6:45 a.m.)

**GM Tests
7 vehicles
on
2nd Side in
1971: 6 fail**

SUBJECT:

**Bodies - Static Roof Intrusion Tests -
1970 and 1971 F, H, A, X, and E Styles**

FORWARD:

The Research Testing Laboratory was asked to conduct static roof intrusion tests in accordance with the proposed roof intrusion requirement (Docket 2-6 Notice 4) issued on December 28, 1970.

--

The following bodies were tested:

- 1. 1971 Chevrolet 8-47 Production Body**
- 2. 1971 Chevrolet W-11, Pilot Body**
- 3. 1970 Pontiac 1-81 Production Body**
- 4. 1971 Chevrolet X-27 Production Body**
- 5. 1970 Oldsmobile B-37 Production Body**
- 6. 1971 Pontiac B-45 Pilot Body**

CONCLUSIONS:

All the bodies tested failed to meet the requirements of the proposed roof intrusion requirement (Docket 2-6 Notice 4) except the X-21 body that passed.

GM Proving Ground Occupant Protection

RECEIVED: 8/23/83 1:53PM; FAXPHS LLC; #693; PAGE 3

26/23/2803 14:18 3236515511

MARDIROSSIAN ASSOCIA

PAGE 03

PRODUCED BY GENERAL MOTORS CORPORATION

GM

ENGINEERING REPORT

General Motors Proving Ground

REPORT NO. PG-41695

PROJECT NO.

DATE 22 August 1981

OCCUPANT PROTECTION SYSTEM GUIDE FOR PROVING GROUND TEST OPERATIONS

ABSTRACT

This report reviews currently defined occupant protection systems recommended for on-road vehicle test operations at the Milford and Mesa Proving Grounds. Acceptable vehicle roll bar and roll cage design guidelines are reviewed.

SUMMARY

An occupant protection system guide has been developed as a means of defining and matching a recommended level of occupant protection with vehicle type and test operation as agreed upon by Traffic Safety and division and staff supervisory personnel.

Roll bar and roll cage design guidelines are reviewed to aid test operations personnel in the construction and use of acceptable structures.

Approval for variations in recommended level and type of occupant protection should be obtained from Traffic Safety personnel prior to testing.

GM
R
E
S
T
R
I
C
T
E
D

Following a death of one of its drivers in 1976 unplanned rollover crash on GM proving ground, GM establishes protective criteria for its professional testing drivers.

004727

DISTRIBUTION: See list at end of report.

AUTHOR: *T. G. Wingblad*
T. G. Wingblad, Sr. Proj. Engr.

APPROVED: *A. H. Kelly*
A. H. Kelly, Manager
PG Facilities & Operations

GENERAL MOTORS ENGINEERING STAFF

PG-41695
PURSUANT TO PROTECTIVE ORDER

PRODUCED BY GMC IN PENNY SHIPLER VS GMC

PRODUCED BY GM IN JOANNE BARKER V GM

28037

GM Proving Ground Occupant Protection

OCCUPANT PROTECTION SYSTEM GUIDE - GM PROVING GROUNDS TEST OPERATIONS

Attachment 2

Recommended Level of Protection (Safety Equipment)

- A - Production Type Restraint System
- B - Production Type Restraint System + Helmet
- C - Production Type Restraint System + Helmet + Roll Bar
- D - 4-5 Point Belts + Helmet + Roll Bar + Side Net
- E - 4-5 Point Belts + Helmet + Roll Bar + Side Net + Safety Seat
- F - 4-5 Point Belts + Helmet + Roll Cage + Side Net + Safety Seat + Fuel Cell
- Consult Traffic Safety

Test Operation Speed Range (km/h)	Most Passenger Cars (Geometric Stability > 1.30)			Most Light Duty Trucks & Vans Up to B including C-20 & G-30 Series (Geo. Stab. Range 1.10-1.29)			Most H. D. Trucks & Special Use Vehicles (Geometric Stability < 1.10)		
	Production, ¹ Tested Pilot, Tested Proto	Untested ² Proto or Mod. Prod.	Hybrids ³	Production, ¹ Tested Pilot, Tested Proto	Untested ² Proto or Mod. Prod.	Hybrids ³	Production, ¹ Tested Pilot, Tested Proto	Untested ² Proto or Mod. Prod.	Hybrids ³
Lane Changes 0-88	A	A	A	A	A	A	C	D	D
Lane Changes 88-100	B	B	B	B	B	C	D	E	E
Lane Changes 100-130	B	B	D	B	B	D	.	.	.
Limit Handling High "G" Schedule 40-56	B	B	B	B	B	B	.	C	C
Limit Handling (Engineering Side Road or Closed Facility) 40-88	B	B	C	C	C	C	.	.	.
Limit Handling (VOTA or Closed Facility) 88-130	F	F	F	F	F	F	.	.	.
Special Tests									

In rollover-prone SUVs, GM requires drivers to wear helmets and roll bars installed in vehicles, even for simple lane change maneuvers.

1 - Vehicles that comply with Federal Motor Vehicle Safety Standards listed on Attachment 6
 2 - Vehicles designed to meet FMVSS requirements but with uncompleted certification
 3 - Vehicles with unconventional designs and/or nonproduction-like parts or fabrication
 NOTE: See Attachments 9-15 for vehicle and test operation definitions.

V IN JOANNE BARKER V GM
 PRODUCED BY GMC IN PENNY SHIPLEN VS GMC
 ATTORNEY GENERAL