Document retrieval information

Date: May 1986 Report No: OR8

Keywords

Barrier test, bull-bar, forward control vehicle, frontal impact, safety, structure, vehicle

Abstract

The report describes a series of nine barrier crash tests performed on behalf of the Federal Office of Road Safety to investigate frontal impacts on forward-control vehicles, or vans.

Existing safety requirements for vans and current frontal impact protection standards in Australia and overseas are discussed as a background to the test programme. Two of these standards, Australian Design Rule (ADR) 10B and United Nations' Economic Commission for Europe (ECE) Regulation 33 were assessed in detail to help determine their suitability as a standard to be applied to vans. The report also considers the effect of bull-bars on occupant protection. Additional data gathered in the course of testing is presented but the relevance of these results to van safety is not discussed.

The report concludes that the application of ADR 10B and ECE Regulation 33 will result in an improvement in the occupant safety of vans in a frontal impact. However, as a further stage, both these standards may be made more effective for vans if some of their test parameters are reviewed.

Note

This report is disseminated in the interest of information exchange and to assist in the development of vehicle safety standards.

Australian Design Rule 10 B means Australian Design Rule for Motor Vehicle Safety 10 B for Steering Columns and United Nations' ECE Regulation 33 means United Nations Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts done at Geneva on 20 March 1958 Addendum 32: Regulation No 33 to be annexed to the Agreement. "Uniform Provisions Concerning the Approval of Vehicles with the Regard to the Behaviour of the Structure of the Impacted Vehicle in a Head-on Collision"

ISSN 0158-3077
ISBN 0 644 05053 5

Printed in Australia by Watson Ferguson & Co. Brisbane

Department of Transport
Federal Office of Road Safety

FRONTAL IMPACT ON FORWARD CONTROL VEHICLES

Australian Government Publishing Service
Canberra 1986

SUMMARY

The Federal Office of Road Safety has given high priority to research to help the development of safety standards for forward-control vehicles, or vans.

The report describes a series of nine barrier crash tests performed on behalf of the Federal Office of Road Safety to investigate frontal impacts on these vehicles.

In 1984, the Australian Transport Advisory Council endorsed a package of safety requirements to be applied to passenger vans. The intent of the package was to require passenger vans to provide the same general level of safety currently provided by conventional passenger cars. Ministers agreed that some form of frontal impact protection was required but considered that more work was needed to determine the most effective standard.

Existing safety requirements for vans and current frontal impact protection standards in Australia and overseas are discussed as a background to the test programme. Two of these standards, Australian Design Rule (ADR) 10B and United Nations' ECE Regulation 33 were assessed in detail to help determine their suitability as a standard to be applied to vans. The report also considers the effect of bull-bars on occupant protection. Additional data gathered in the course of testing is presented but the relevance of these results to van safety is not discussed.

The report concludes that the application of ADR 10B and ECE Regulation 33 will result in an improvement in the occupant safety of vans in a frontal impact. However, as a further stage, both these standards may be made more effective for vans if some of their test parameters are reviewed.

ACKNOWLEDGEMENTS

The Federal Office of Road Safety wish to thank the following organisations and individuals for help given during the course of the project:

Telecom Australia for the supply of test vehicles which provided an impetus to the project.

Ford Motor Company of Australia Ltd, and in particular Mr Ron Hayes, for providing advice on the testing and giving full co-operation at every stage of the project.

Toyota Motor Corporation for the provision of test vehicles and technical advice.

Volkswagen Australia Pty Limited for the supply of information on their test work.

Australian Institute of Sport, and in particular Dr Bruce Mason, for the use of film analysis equipment.

The Director of the Federal Office of Road Safety wishes to thank staff from the Office who were involved in this project.

CONTENTS

INTRODUCTION

The need for improvement in the occupant safety provided by forward-control vehicles, or vans, was identified by ATAC Ministers in 1983. At that time, it had become apparent that these vehicles were being used increasingly for family transport. In 1984, it was agreed that a number of additional passenger car ADRs would be applied to passenger vans from 1986. Ministers also identified areas, including frontal impact protection, in which further work was needed.

The Federal Minister for Transport has given high priority to research to help the development of standards in this area. During 1985, nine barrier crash tests were performed on behalf of the Federal Office of Road Safety to investigate frontal impacts on these vehicles. This work was to complement recent crash studies for which partial funding was also provided by the Federal Government.

This report describes the test programme against a background of the existing regulatory situation. The relevance to this class of vehicle of a number of current standards is also assessed.

REVIEW OF VAN SAFETY

Development of safety standards

In recent years, the use of light forward-control vehicles as a means of family transport has increased significantly. Most of these passenger vans are derived from commercial vehicle designs, or are in fact modifications of actual goods vehicles. Hence the safety standards applied to these vehicles have also been derived from commercial vehicle standards which, in Australia, tend to be less stringent than passenger car standards. In 1983, work was started to develop safety requirements for these passenger vans that were more appropriate to this changed pattern of usage.

In February 1984, the Australian Transport Advisory Council (ATAC) endorsed a package of safety requirements for passenger vans. A new category of "forward-control passenger vehicle" was created and most of the existing Australian Design Rules for Motor Vehicle Safety (ADRs) then applicable to passenger cars were applied to this category and to small omnibuses. Implementation dates for these ADRs range from 1 January 1985 to 1 January 1988 depending on the amount of vehicle development possibly required.

Forward-control passenger vehicles of up to eight seats were previously classified as multi-purpose passenger vehicles so already complied with many passenger car ADRs. However, forward-control passenger vehicles of nine seats were previously classified as omnibuses which, owing to their generally larger size and different operational needs, were not required to meet the same ADRs as passenger cars. ATAC agreed that these larger forward-control passenger vehicles and smaller omnibuses, with up to 12 seats and under 3.5 tonnes gross vehicle mass, should comply with the same ADRs as the smaller forward-control passenger vehicles but with additional leadtime for any necessary vehicle changes and recertification.

The endorsed package of safety requirements identified those ADRs which could be applied to these passenger vans without significant change to the rules and which would lead to an improvement in overall safety. There remains, however, a number of additional passenger car ADRs which have not yet been applied to these vehicles. These rules cover such areas as frontal impact protection, side door strength, instrument panels and braking. In most of these cases, the need for a Rule was clearly identified but the equivalent passenger car Rule could not be applied without extensive revision or, at the very least, validation to prove the effectiveness of the Rule when applied to vans.

Existing frontal impact protection standards

To allow quick implementation of a Rule for frontal impact protection it would be desirable to adopt a standard that has been agreed to and is in use, if not for vans, then for some other category of vehicle. This would not only reduce development time for the Rule itself but should also minimise vehicle development and certification time through the adoption of known procedures. This approach is also consistent with ATAC policy of harmonising with international standards.

Steering system requirements

The frontal impact protection requirements in Australia for passenger cars are covered by ADR 10B-Steering columns. ADR 10B contains two basic requirements. One specifies that, during a perpendicular barrier test at 48 km/h, the maximum rearward intrusion of the steering column shall not exceed 127mm. The second part specifies that the force exerted by the steering system when impacted at 6.7m/s (24.1 km/h) by a 34 kg body block representing the torso of an unrestrained driver shall not exceed 11.11 kN. This Rule is currently applied to conventional passenger cars and their derivatives. The two parts of this Rule address two of the basic principles of occupant protection: preservation of occupant survival space and impact attenuation. However, they do so only in respect of the one component which, in conventional passenger cars, had been identified as the cause of greatest injuries.

There are a number of national and international requirements that are very similar to ADR 10B:

United Nations' Economic Commission for Europe (ECE) Regulation 12.02

European Economic Community (EEC) Directive 74/297/EEC

United States of America Federal Motor Vehicle Safety Standard (FMVSS) 204

These apply the same barrier test criterion but at a test speed of 48.3 km/h. Steering system impact requirements are the same in the ADR,ECE,EEC and FMVSS systems but in the case of the USA the standard (FMVSS 203) is separate. ECE 12.02, however, also allows a head impact test in lieu of the body impact test.

Like ADR 10B, both the ECE and EEC requirements apply to passenger cars but exclude forward-control vehicles. FMVSS 203 and 204 apply to vehicles up to 10000 lbs gross vehicle weight rating, except walk-in vans. In addition, forward control vehicles are granted exemption from the test requirements of FMVSS 203 if they are fitted with a Type 2 (lap and sash) seat belt.

FMVSS 204 allows the same exemption to forward-control vehicles of over 4000 lb unladen weight. The exact definition of "walk-in van" is not clear but in the Preamble to Amendments to FMVSS 204 (1979) this vehicle type is described as "the 'step-van' city delivery type of vehicle that permits a person to enter the vehicle without stooping". If such terminology only covers goods vehicles then clearly vehicles defined in Australia as forward-control passenger vehicles would not be exempt from the standard. However, in requesting the exemption for walk-in vans, manufacturers noted that steering column installation angles in these vehicles are of the order of 55-60 degrees compared with 30 degrees in conventional trucks. In granting the exemption NHTSA agreed that this driver/steering configuration would probably render the Standard ineffective. This comment is relevant to this study as most forward-control vehicles examined in the course of this project had steering column installation angles of approximately 55 degrees.

Occupant survival space

A number of other international standards provide alternative parameters for occupant protection in a frontal impact. ECE Regulation 33 -- Behaviour of the impacted vehicle in a head-on collision -- involves a similar barrier test to ECE Regulation 12 (and therefore to ADR 10B), however, the intent of the regulation is to provide an adequate total occupant survival space rather than just to limit steering column movement. Pass criteria are based on static, post-test measurement of vehicle dimensions so simple measurement methods are feasible. The dimensions measured are roof height, footwell width and seating reference point to instrument board and toeboard lengths. Like ECE Regulation 12, ECE Regulation 33 exempts forward-control vehicles. Furthermore, though the regulation has been adopted by a number of parties to the ECE agreement, none requires vehicles to meet it or any equivalent standard.

Truck cab strength

ECE Regulation 29 -- Protection of the occupants of the cab of a commercial vehicle -- simulates a frontal crash by impacting the cab of a truck with a 1500 kg pendulum. The pendulum strikes the cab square across the front, with the lower edge of the pendulum at least 550 mm below the vehicle's seating reference point and with a direction of impact parallel to the longitudinal axis of the vehicle. Impact energy, for light vehicles, is at least 29400 Nm. By comparison, a frontal, perpendicular barrier collision at 48 km/h involving a 1300 kg vehicle results in an energy dissipation of approximately 120000 Nm. However, as the pendulum will not engage the whole height of a light van, the crush produced may be more severe than the ratio of energies suggests. This Regulation requires the preservation of sufficient occupant space to allow the accommodation of a specified manikin without contact between the manikin and non-resilient parts.

Global tests

FMVSS 208 -- Occupant crash protection -- applies to all passenger cars, multi-purpose passenger vehicles, trucks and buses. However, forward-control vehicles need only meet the seat belt fitment requirements of this standard and not the barrier test requirements. The barrier test involves more sophisticated equipment than ADR 10B or its equivalents. The standard sets limits on the loads and accelerations experienced by an instrumented anthropomorphic dummy over a range of frontal barrier impacts from perpendicular to 30 degrees to the perpendicular. The injury criteria that are required to be met are based on head and thorax accelerations and femur loads during the impact. The ECE Group of Experts on the Construction of Vehicles has agreed to a Draft Proposal for a Regulation based on a similar but not identical test.

Other impacts

It should be noted that all the impact tests described above require an impact, perpendicular or oblique, across the entire width of the vehicle. Other impact types, such as a pole impact, vehicle-to-vehicle collision, or a partial offset barrier test in which the vehicle contacts a barrier across only part of the vehicle front, though perhaps more representative of certain crash situations, will not be considered in this study as the poorer repeatability of these tests renders them less useful for regulatory purposes.

Van crash studies

To determine whether any of the standards discussed above are likely to be effective in improving the safety of forward-control vehicles, it is necessary to examine the patterns of injury experienced by the occupants of these vehicles in real crashes. In addition, an examination of the vehicle structural deformation in these crashes will allow a determination of the most representative impact type. Once an impact type has been selected from the fairly restricted range feasible for a regulatory test, the test parameters and pass criteria can be determined. These should reflect the types of injuries being experienced in real crashes in order that application of the standard will lead to an improvement in overall safety.

Until recently, the data on crashes involving forward-control vehicles has bee. scanty. The main reason for this was the lack of an identified vehicle cat.gory for which to collect such data. As a result, most historical data is grouped with panel vans, light commercial vehicles and omnibuses. Only a proportion of these are the vehicles which are of interest to this particular study. Furthermore, the size of the proportion is not known accurately.

O'Day and Kaplan (1979), using 1977 data from the U.S. Fatal Accident Reporting System, found that vans [not necessarily forward-control] had an accident involvement rate approximately equal to that of cars. However, their fatality rate was lower. The authors of this study surmised that this lower rate was probably due to a greater exposure in urban areas, resulting in lower-speed crashes.

A number of crash studies in Australia have recently been completed or are in progress. Paix, Gibson and McLean (1985) examined historical data from the Motor Accidents Board in Victoria to compare the safety of forward-control vehicles with that of conventional passenger cars. In addition, these authors undertook a study of crashes involving light forward-control vans to determine in more detail the types of injuries experienced. The study found that van occupants injured in frontal crashes were more likely to have sustained leg injury than were car occupants. Consequently, the report recommended that: "all light forward-control vehicles should be required to meet the same form of frontal impact requirements as conventional passenger cars but with added requirements on the allowable intrusion of components mounted in the dashboard area of the vehicle."

On the subject of crashworthiness testing, Burger (1983) and Pohl and Kolms (1977) have described the development and testing by Volkswagen AG of a number of their forward-control models. Testing of a number of van makes has also been carried out at the Allianz Centre for Technology in West Germany as reported by ADAC (1984) and Commercial Motor (1984); this test programme involved 40% partial offset barrier collisions.

PROJECT DESCRIPTION

Aims

The barrier tests described in this report were undertaken to determine the structural behaviour of a range of van types in a standard barrier collision. Through the examination, in these tests, of a number of regulatory parameters, the effectiveness of various standards when applied to forward-control vehicles can be estimated. In particular, tests involving relatively simple procedures and equipment were studied as these standards are the ones that are likely to involve least cost and time in implementation. The rules studied in detail were ADR 10B and ECE Regulation 33.

The second aim of the project, based on this information, was to develop recommendations for frontal impact protection requirements that will be relevant to the injuries being experienced by occupants of vans. If ADR 10B and ECE Regulation 33 are found to be insufficient then alternative requirements will need to be developed retaining the simplicity of these rules. More complex standards such as FMVSS 208 were not considered in this study. A rule such as this could be introduced as a later stage of development should the need for increased representivity be demonstrated.

Other occupant protection Rules that have now been applied to vans but that were originally developed in the light of passenger car experience were also examined in the study. These results, including vehicle deceleration, seat belt loading, and seat performance are presented in this report but not discussed in detail. Assessment of their relevance to the performance criteria specified in ADRs delete etc requires further analysis.

The project also sought to examine the effect on occupant safety of the fitment of auxiliary front end structures above the bumper (commonly known as bull-bars).

Choice of test vehicles

Nine barrier tests were carried out in a programme that examined seven different models. They were selected to provide a range of structural types and to encompass the sizes of vehicles commonly used as passenger vans.

Telecom Australia provided three identical used vehicles. The tests carried out on these vehicles enabled an estimate to be made of test repeatability. In addition, the fitment of a bull-bar to one of these vehicles gave some indication of the effect of such a structure.

Additional new and used vehicles were selected to supplement these vehicles. These were obtained from a vehicle manufacturer, the Department of Local Government and Administrative Services and also purchased through normal commercial channels. Table 1 gives a brief specification for each test vehicle.

Table 1: Test vehicle specifications

Test no.	Date of manufacture	Unladen mass (kg)	Gross vehicle mass (kg)	Wheelbase (mm)	Seating capacity
F82	1981	710	1350	1840	3
F83	1982	1340	2395	2405	3
F84	1982	1164	2105	2200	3
F85	1985	1285	2075	2235	8
F86	1985	1463	2300	2350	9
F87	1985	1305	1960	2155	8
F88	1982	1164	2105	2200	3
F89	1985	1120	2120	2100	6
F90	1982	1164	2105	2200	3

Vehicle preparation

Before preparation for testing, all vehicles were stripped of interior fittings to allow the measurement of the position, and hence subsequent deformation, of a variety of interior features including those relevant to the assessment of ADR 10B and ECE Regulation 33. Vehicle interiors were then rebuilt to include all items likely to influence front occupant protection.

Vehicles were painted to improve photographic resolution -- white inside and outside and a variety of colours for the various components underneath. Datum markers were fitted to the vehicle exterior at known positions to allow measurement of vehicle crush.

Instrumentation fitted to each vehicle consisted of two Endevco 2262-200 accelerometers, two load-cells and a camera. One accelerometer was mounted at each end of the main bulkhead supporting the rear of the front seats, close to the base of each B-pillar as shown in Figure 1. These accelerometers were uni-axial and orientated so that accelerations in the fore and aft direction were measured. Two load cells were fitted to the passenger seat belt to measure belt tension during the test. One was fitted to the sash portion and one to the lap portion of the belt, each close to the outboard seat belt anchorages. One high speed camera was fitted behind the driver's seat with a field of view centred on the area of the front passenger's knee. Floodlights were fitted to the driver's door and the vehicle roof to provide illumination of the vehicle interior.

To enable photographic analysis of steering column movement, all vehicles were fitted with a bracket to allow the centreline of the steering shaft to be visible from outside the vehicle. Similar analysis of conventional passenger cars is possible without such devices as the steering system can be viewed directly through apertures cut in the front doors. **However, for this project** it was assumed that crush of the doors would be significant so it was important to maintain their structural integrity. Three designs of brackets were used during the test programme, these can be seen in the test photographs included in the Appendices. The bracket used initially, though very light, suffered from the fact that it rotated as the front wheels were deflected sideways during impact. From test F85, vehicles were fitted with a larger bracket which was designed to be unaffected by rotation of the steering shaft. This bracket weighed about 1.5 kg and was used in conjunction with a stripped steering wheel and column assembly to compensate for this added mass. An additional advantage offered by the use of this bracket was the availability of redundant points for film analysis: the targets applied to the bracket formed a radial array of lines intersecting at the end of the steering shaft. This arrangement allows for a duplication of analysis with resulting improvements in accuracy. A third design of bracket was used in one test, F89, to reduce the mass added to the steering column. This bracket, being simply a tube with threaded end fitting to accept the steering shaft, weighed 400 g. Though unaffected by steering rotation, this bracket did not provide the redundancy of target points provided by the second bracket used.

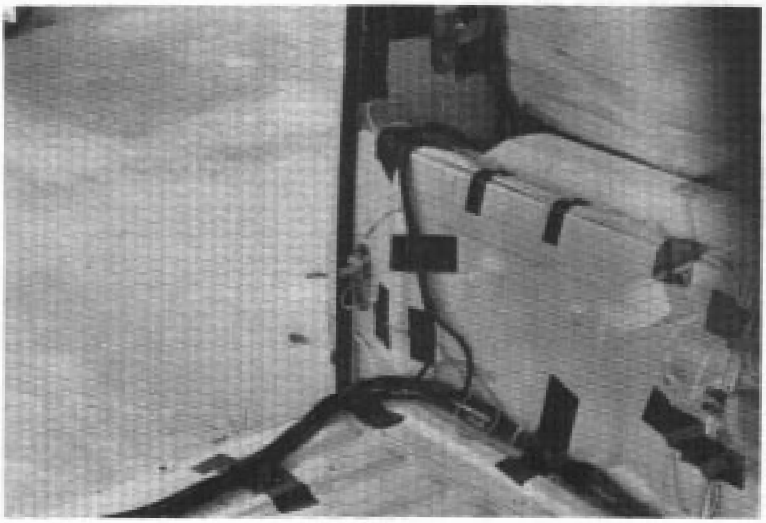

Figure 1: Installation of vehicle accelerometers to the outboard edge of bulkhead at front of cargo space.

A scale strip was fitted to the vehicle roof, to provide a scale for film analysis in the plane of the steering wheel. This strip was attached to the vehicle so that slip at one end could occur and hence not affect the vehicle crush during the test. Also attached to this strip was a flash unit wired through a switch on the front bumper bar to indicate precisely the moment of impact.

After the fitment of the items described above and of other test equipment such as a system to abort the test in the event of a malfunction, the vehicle mass was adjusted to the unladen mass by the addition of ballast or the removal of non-critical items such as rear seats. Unladen mass is the mass with all fluids and 90% of maximum fuel capacity but with no allowance for occupants or luggage. However test F82, using the smallest vehicle of the series, could not meet this target because insufficient material could be removed to compensate for the test equipment fitted without affecting the representivity of the vehicle structure. Vehicle mass distribution was approximately equivalent to manufacturer's specifications. Vehicle test mass was increased from the unladen mass by the addition of an Alderson 50th percentile VIP dummy which was installed in the front passenger seat for all tests.

Test procedure

All tests were conducted at the Ford Motor Company of Australia's proving ground and were carried out in accordance with the Society of Automotive Engineers Recommended Practice J850 -- Barrier Collision Tests. Vehicles were towed to the required impact velocity then released to impact on a rigid, plywood-faced barrier. All tests involved an impact with the barrier perpendicular to the direction of travel of the vehicle. Impact speeds for the tests ranged from 48.9 km/h to 51.7 km/h.

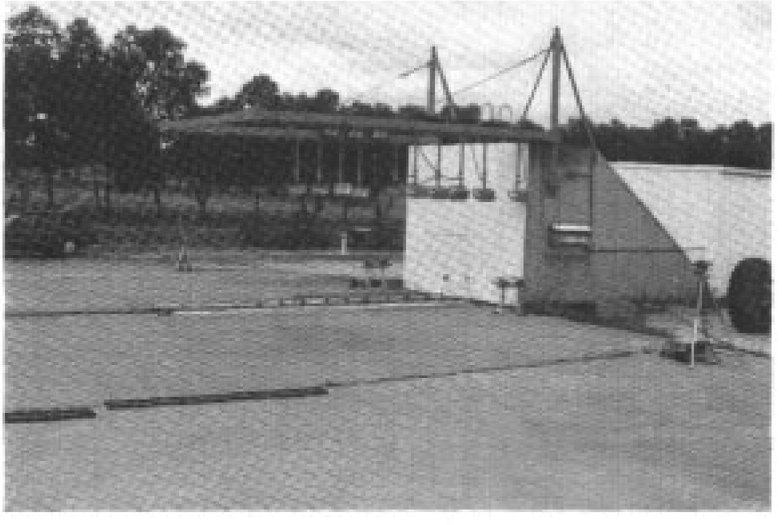

Figure 2: Barrier test site showing 200 tonne concrete barrier. Approach track, along which test vehicle is towed, extends approximately 100 metres to the left.

The anthropomorphic dummy installed in the front outboard passenger seating position for each test was used to investigate general occupant kinematics and to assess seat and seat belt loadings during the impact. Dummies were not instrumented. Dummy set-up was as shown in Figure 3. Dummies were positioned in the centre of the seat with hands placed lightly on the seat cushion with palms against the thighs. Legs were positioned symmetrically about the dummy centreline with the outer edges of the knees approximately 360 mm apart. Feet were removed to prevent damage to the dummy in the event that footwell space was crushed. Removal of the feet would also prevent unrepresentative stiffening of the vehicle structure if such crush occurred. To maintain correct leg attitude the ankles were placed on a block of polystyrene foam.

Figure 3: Vehicle interior before testing.

Six high speed cameras operating at approximately 1000 frames per second were used to record the test. Disposition of cameras varied, but generally consisted of one or two cameras on each side to record a general view and for use in the analysis of ADR 10B performance, one or two cameras underneath the vehicle to record the relative movement of various components and one camera on-board, as mentioned above, to record interior deformation and dummy behaviour.

Following the test, each vehicle was measured to determine static deformations and the high speed film was analysed to assess performance to ADR 10B.

RESULTS

Detailed results for each test are contained in Appendices A to I. A summary and discussion of the results are presented below.

Australian Design Rule 10B -- Steering columns

The extent of rearward intrusion of the top of the steering shaft for all test vehicles during and after the impact is shown in Table 2. This table includes the peak displacement measured during the impact and the corrected displacement making allowance for varying impact speed. ADR 10B requires that this corrected figure be less than 127 mm. The correction factor, as specified in ADR 10B, is $(48/v)^2$ where v is the impact speed in km/h. This factor varies slightly from that used in ECE Regulation 12 and other similar standards in which the numerator is 48.3 km/h. Hence the corrected results relating to these standards will be approximately 1% greater than those tabulated. However, ECE Regulation 12 also allows correction of the result if the test mass of the vehicle is greater than that required by the Regulation. This correction would tend to reduce the intrusion for tests F82 and F85 in which the test mass was slightly greater than the specified unladen mass. Dummy mass is not considered when determining this correction factor.

Also shown in the table below are the static displacements measured after each test. Graphs showing column intrusion-v-time during each test are included in the detailed results for each vehicle contained in the Appendices.

Table 2: Rearwards intrusion of the top of the steering shaft. Dynamic intrusion is the maximum during the impact measured photographically; static intrusion is measured after the test by direct means.

Test no.	Impact speed (km/h)	Dynamic intrusion (mm)	Corrected dynamic intrusion (mm)	Static intrusion (mm)
F82	48.9	see text	-	331
F83	49.7	193	180	175
F84	49.9	198	183	136
F85	49.3	83	79	48
F86	50.8	see text	-	213
F87	51.0	499	442	420
F88	50.5	134	121	85
F89	51.7	96	83	49
F90	51.7	257	221	173

It was not possible to obtain any figures for maximum dynamic intrusion for two of the tests. In test F82, the displacement of the steering column was such that, within 40 milleseconds of impact, the entire steering system and attached photographic targets had dropped below the level of the waistrail and so were not visible to any external high speed camera. In test F86, test equipment failure resulted in the bracket for the photographic targets breaking free from the steering shaft. This failure was in no way related to the design or construction of the vehicle itself. A rough estimate of the dynamic intrusion for these vehicles may be made by comparing their static displacement results with the results obtained in the other tests of the series.

ECE Regulation 33 -- Behaviour of the structure of the impacted vehicle in a head-on collision

ECE Regulation 33 requires that, after the barrier impact, a number of internal dimensions shall be greater than specified values. Two of these, the transverse width of the footwell and roof height were met comfortably by all vehicles tested. Exact results for these parameters can be derived from the detail static measurements tabulated in the Appendices. Table 3 below shows the performance of all the test vehicles to two other requirements of the ECE Regulation. The former of these, instrument panel distance, refers to the horizontal distance from the seating reference point to the rearmost point on the instrument panel that is also, transversely, within 150 mm of the seating position centreline. The second dimension, toeboard distance, refers to the horizontal distance from the seating reference point to a point at the front of the occupant compartment at the same height as the brake pedal. For these measurements, experimentally derived H-points were used rather than specified seating reference points. **The dimensions given in the table below are both** absolute and corrected for impact speed and test mass, as specified in the ECE Regulation. The correction factor is $(48.3/v)^2 \times (m_0/m)$ where

v = vehicle impact speed
m = vehicle test mass
m_0 = specified unladen mass

This correction factor is applied to the measured deformation and not to the remaining survival space dimensions as the Regulation might be interpreted to require.

Table 3: Occupant survival space. Instrument panel and toeboard distances were measured horizontally from the seating reference point to respectively the rearmost point on the instrument panel and the foremost point in the passenger space at foot height.

	Instrument panel distance (mm)		Corrected instrument panel distance (mm)		Toeboard distance (mm)		Corrected toeboard distance (mm)	
ECE requirement	-		>450		-		>650	
Test no.	Driver	Passenger	Driver	Passenger	Driver	Passenger	Driver	Passeng
F82	see text		-	-	498	516	517	534
F83	476	509	486	518	716	726	732	741
F84	420	412	442	435	786	732	802	750
F85	607	616	610	619	845	874	859	886
F86	438	485	465	507	643	646	683	686
F87	161	228	208	275	533	553	580	598
F88	491	480	501	492	812	770	831	791
F89	522	556	532	566	907	837	927	865
F90	396	379	421	408	738	708	776	747

It should be noted that the results for the passenger side were affected to a varying extent by the presence of the test dummy. There was evidence in most tests, particularly those with severe intrusion of the occupant space, that structural deformation of the vehicle had been caused by the dummy's legs.

In test F82, the instrument board dimension could not be determined because the entire instrument board assembly became detached from the vehicle structure and was extensively crushed by the test dummy.

ECE Regulation 33 includes additional requirements, the assessment of which is more qualitative than the measurement of dimensions reported above. Clause 5.7 requires that: "after the test, no rigid component in the passenger compartment shall constitute a risk of serious injury to the vehicle's occupants". The force of this clause is dependent very much on interpretation. In a number of the vehicles tested, the intrusion of the occupant space by a number of components was subjectively more severe than the intrusion measured to determine compliance with the first part of the rule as shown in Table 3. In particular, the intrusion of the steering column, brake master cylinder and pedals could in some tests be interpreted as being sufficient to prevent compliance with Clause 5.7 despite the fact that the dimensional requirements were met. Figures 4, 5 and 6 illustrate the post-test positions of these and other components in a number of tests.

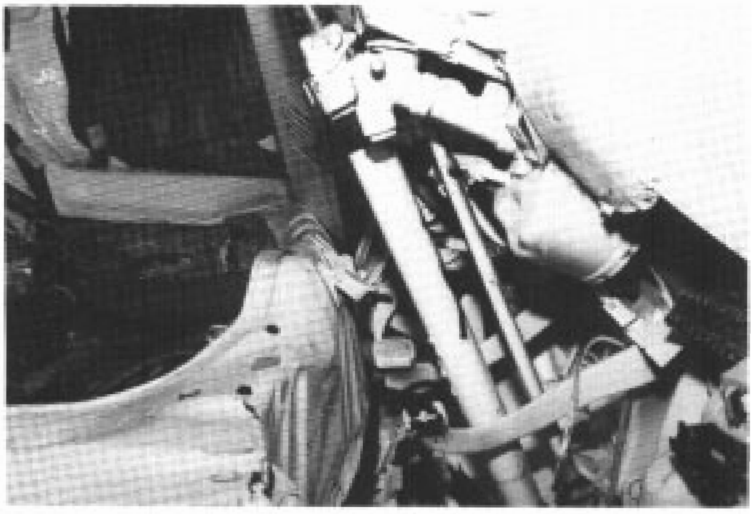

Figure 4: Intrusion of components into driver's leg space. To improve access, seat has been removed from its supporting structure on left hand side of picture.

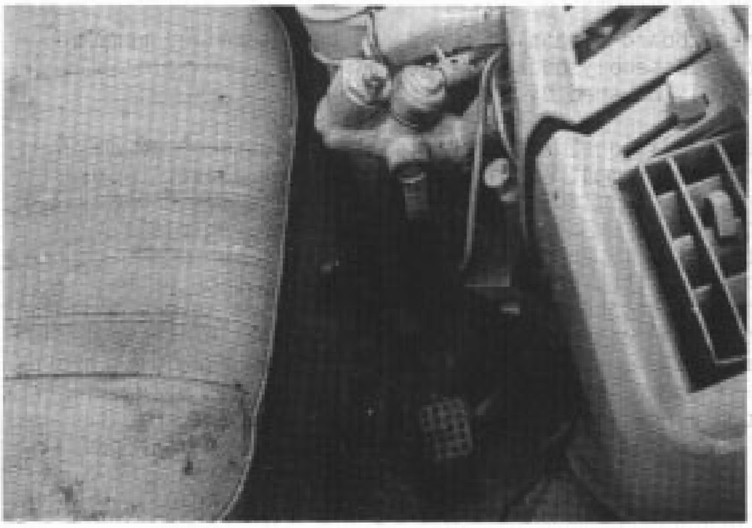

Figure 5: Intrusion of brake master cylinder into driver's right knee space.

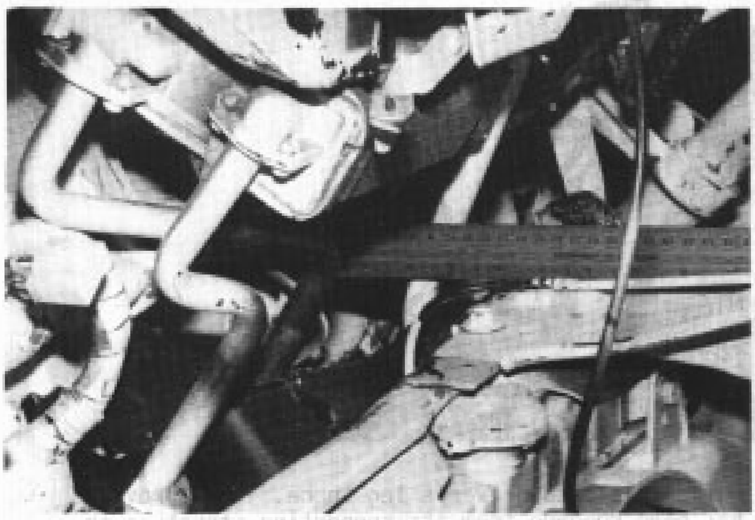

Figure 6: Centre passenger foot space. Scale indicates the reduction in usable space arising from the presence of heater and other components.

Another requirement of the ECE Regulation is that all the vehicle's doors remain closed during the impact and, after the test, a sufficient number can be opened without the use of tools to allow access to all occupants. All vehicles tested passed the first part of this requirement. Table 4 indicates which doors could be opened by hand after each test and hence comply with the second part of this requirement.

Table 4: Post test access without the use of tools

Test no	Right front	Left front	Right rear	Left rear	Rear
F82	No	No	Yes	Yes	Yes
F83	No	No	(1)	Yes	Yes
F84	No	No	(1)	Yes	Yes
F85	Yes	Yes	(1)	Yes	Yes
F86	No	No	(1)	Yes	Yes
F87	Yes (2)	Yes (2)	(1)	Yes	Yes
F88	No	No	(1)	Yes	Yes
F89	Yes (3)	Yes (3)	(1)	Yes	Yes
F90	No	No	(1)	Yes	Yes

Note: (1) No door in this location
(2) Latch mechanism not functioning but could be released by hand by reaching between inner and outer door panels.
(3) Force required to open doors increased above pre-test condition to 180-200 newtons.

In the cases in which the front doors could not be opened, the overall determination of compliance with the Regulation will depend on whether it is considered that front occupants could be expected to leave, or be removed from, the vehicle through the side or rear doors.

Vehicle crush

Overall structural deformation of the test vehicles was measured at points along each side of the vehicle identified before each test at 250 mm intervals. The post-test positions of these points are given in the Appendices.

The total crush measured ranged from 335 mm to 571 mm. In all vehicles tested, virtually all the crush was forward of the B-pillars with only minor creasing of body panels aft of that position.

In general, the primary area of energy absorption during impact appeared to be the longitudinal box-section members which were part of a separate chassis in some of the vehicles tested, or part of the body monocoque in others. There was some variation in the geometry of these members which are shown in the under-side pre- and post-test photographs included in the Appendices.

In all vehicles tested, engine movement played little part in the overall crash performance of the vehicle structure. Engine movement relative to the body was forward during the impact, with little contribution to energy absorption or distortion of the occupant space. This engine movement led to the propellor shaft becoming detached from the rear end of the gearbox so the drivetrain also contributed little to energy absorption.

Occupant compartment acceleration

The acceleration experienced by the occupant compartment is important in determining adequate occupant protection measures. The shape and magnitude of the acceleration pulse not only will affect the performance of the occupant restraint system but will also be a factor in determining the required strength of hardware such as seat anchorages and seat belt anchorages.

The accelerations measured near the base of each B-pillar in each vehicle are shown in the Appendices.

Seat belt loads

The anthropomorphic test dummy installed in the front outboard passenger seat in each vehicle was restrained by the standard seat belt supplied with each vehicle. In all cases, the belt used was a conventional three-point assembly incorporating an emergency locking retractor. During each test, seat belt loads were measured in the torso and lap parts of the belt, between the dummy and each outboard anchorages. Loads near the inboard anchorage were not measured because difficulties in fitting load transducers to the inboard section of belt or stalk without affecting the representivity of the seat belts and anchorages used.

The loads measured in each test are shown in the Appendices. In summary, peak torso belt loads ranged from 5.0 kN to 9.3 kN and peak lap belt loads ranged from 1.8 kN to 10.9 kN. The low lap belt loads experienced in some tests indicate that significant restraint of the lower part of the dummy was provided by femur loading arising from impact with the vehicle interior.

No seat belt failures were experienced during testing. All belt reels locked and all buckles could be released after the test without excessive force. In three of the vehicles the reels were found to be jammed after the test. Webbing in all cases showed visible signs of having stretched. In particular the webbing in the area of the B-pillar running loop showed signs of severe stress, with the webbing material often folded over and fused.

Seat belt anchorages showed no signs of failure. In a number of tests, there was distortion of the B-pillar running loop but this was not excessive. Displacement measurements for seat belt anchorages can be found in the Appendices.

Seat performance

Seats were positioned in the middle of the fore and aft adjustment range. For tests F82 to F85, the trim was stripped from the driver's seat squab to provide an adequate field of view for the on-board camera. The mass of trim removed was replaced on the seat frame at approximately the centre of gravity of the squab. Hence, for these tests, the dynamic behaviour of the seats approximated that of a fully trimmed seat. For subsequent tests, the entire squab frame was removed to improve the camera view. The seat base was retained for these tests to allow for interaction with the steering column. In some cases this was considerable as shown in Figure 7. In none of the tests was there any indication of failure of seat anchorages or separation of the adjustment mechanism.

Figure 7: Under-side of driver's seat showing distortion caused by rearward movement of steering column.

The passenger seat experienced different loading conditions because it was occupied by the test dummy. Again there were no instances of failure of anchorages or adjustment mechanism although not all the vehicles tested had adjustable seats in this position.

Some distortion of the seat base/engine cover assembly was apparent in most tests, this assembly experiencing seat belt loadings as well as seat loadings.

In tests F84, F88 and F90 there was some forward rotation of the seat squab. In these vehicles, the squab is secured to a cargo restraint frame bolted between the B-pillars near the top of the seat squab. Distortion of the brackets securing this frame to the B-pillars allowed a 30 mm forward movement of the top of the seat squab. In test F85, the seat squab experienced a rearward rotation of approximately 20^{0}.

Rear seats were fitted to vehicles in tests F85, F86, F87 and F89. No failures or observable distortion were witnessed in tests F85 and F87. In test F89, the test abort brake system was inadequately restrained in the load space and impacted the rear of the seat. The resulting distortion, as shown in Figure 8, should not be attributed to any weakness in the seat as it undoubtedly experienced a far greater load than any of the other rear seats tested. In test F86, the squab latching mechanism released, allowing the squab to move to a horizontal position.

Figure 8: Distortion of seat caused by impact of test equipment on rear seat back.

Windscreen retention

The windscreen was retained within its frame during four of the tests. In these tests, the amount of windscreen periphery retained ranged from 60% to 90%. It may be noted that FMVSS 212 requires retention of 75% of the periphery during a similar impact.

Occupant Space

Figures 9 to 17, below, show the overall crush of the occupant compartment for each test. The dashed line shows the pre-test position of instrument panel, steering system, toeboard etc with respect to the front seating position. The position of these components after the impact is indicated by the solid line. Particular points highlighted are the seating reference point denoted by the larger markers and the pre- and post-test positions of the steering column end denoted by the smaller markers.

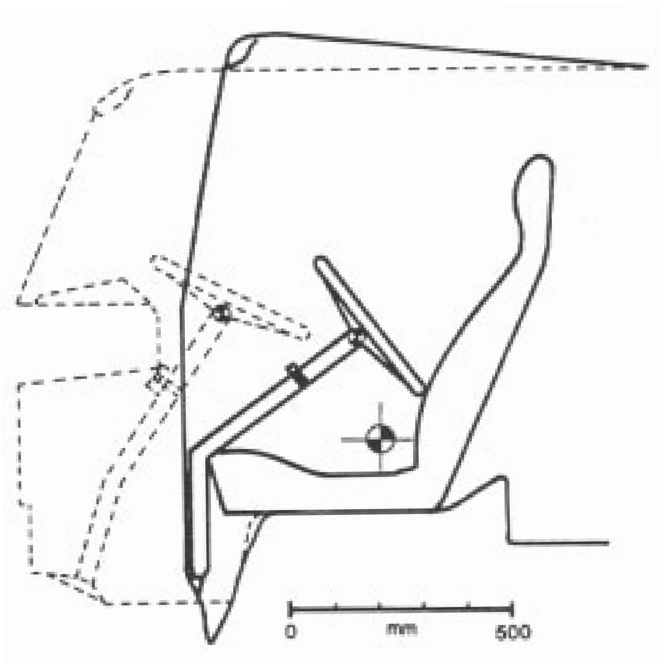

Figure 9: Static deformation of vehicle interior - Test F82

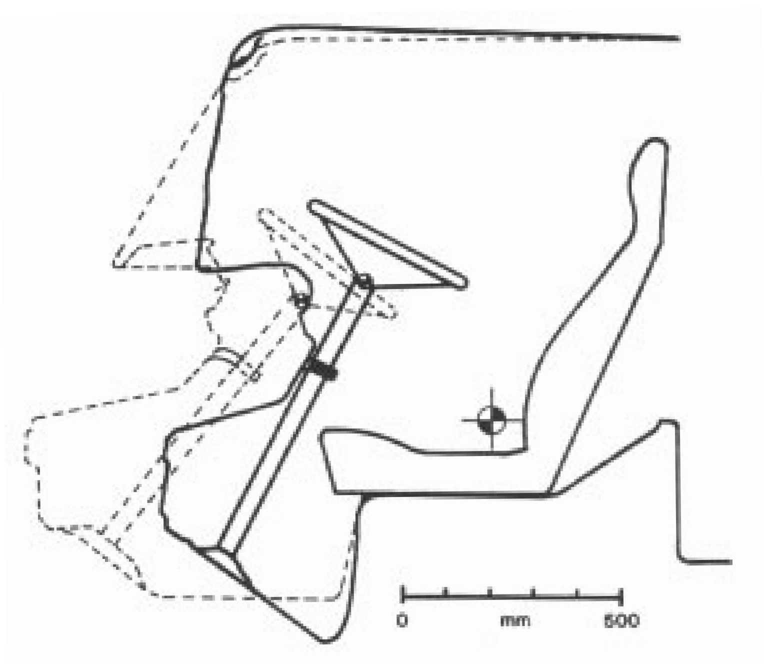

Figure 10: Static deformation of vehicle interior - Test F83

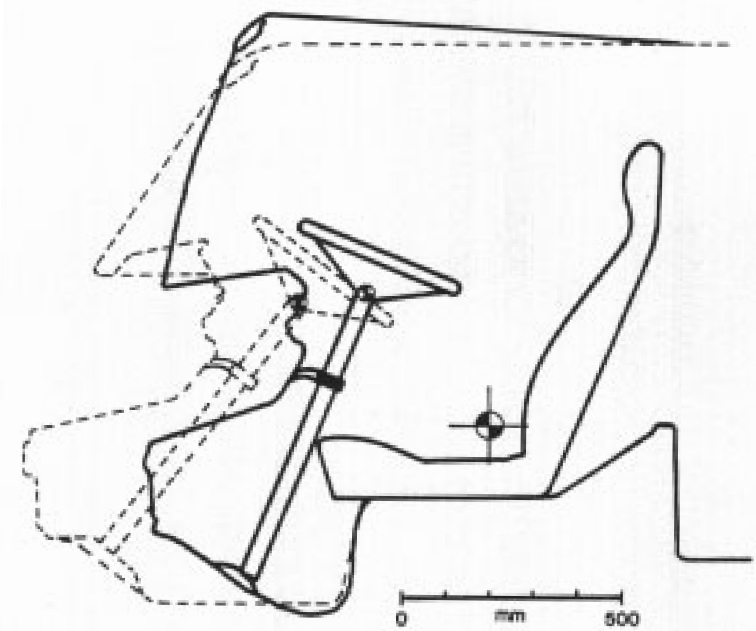

Figure 11: Static deformation of vehicle interior - Test F84

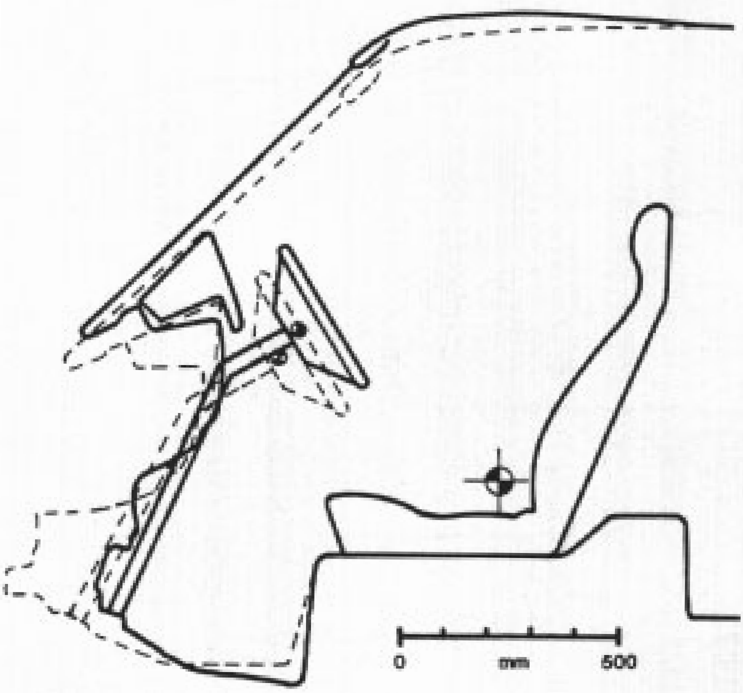

Figure 12: Static deformation of vehicle interior - Test F85

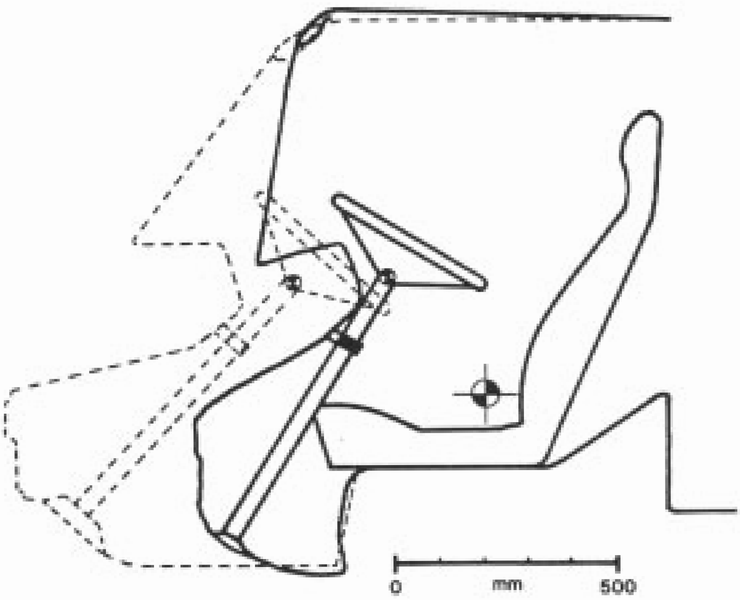

Figure 13: Static deformation of vehicle interior - Test F86

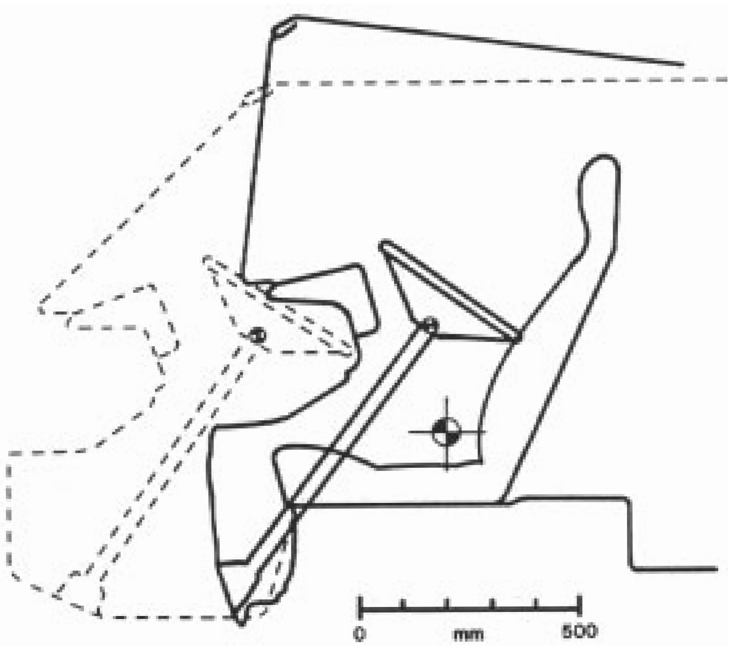

Figure 14: Static deformation of vehicle interior - Test F87

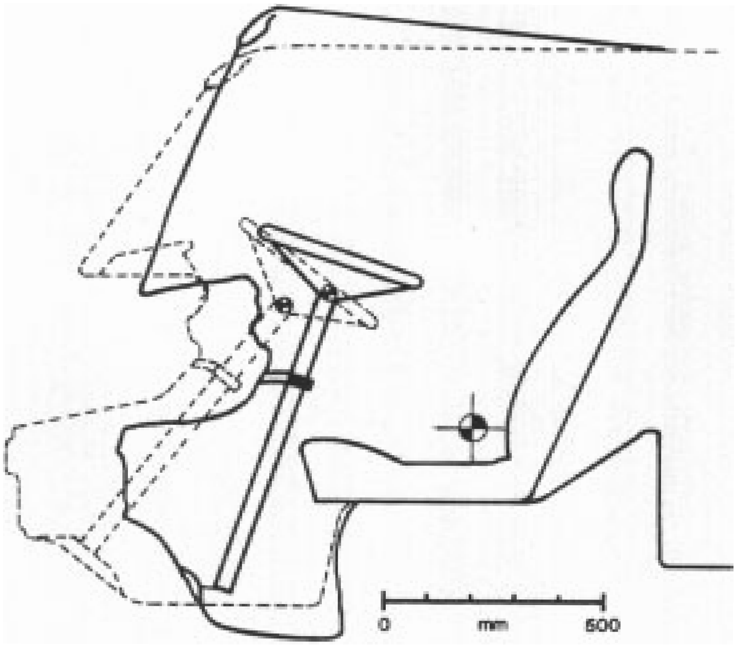

Figure 15: Static deformation of vehicle interior - Test F88

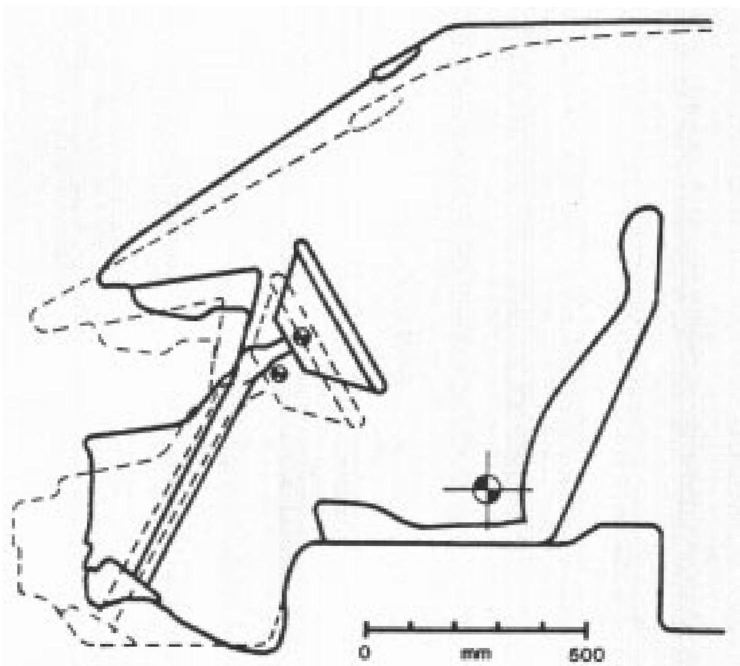

Figure 16: Static deformation of vehicle interior - Test F89

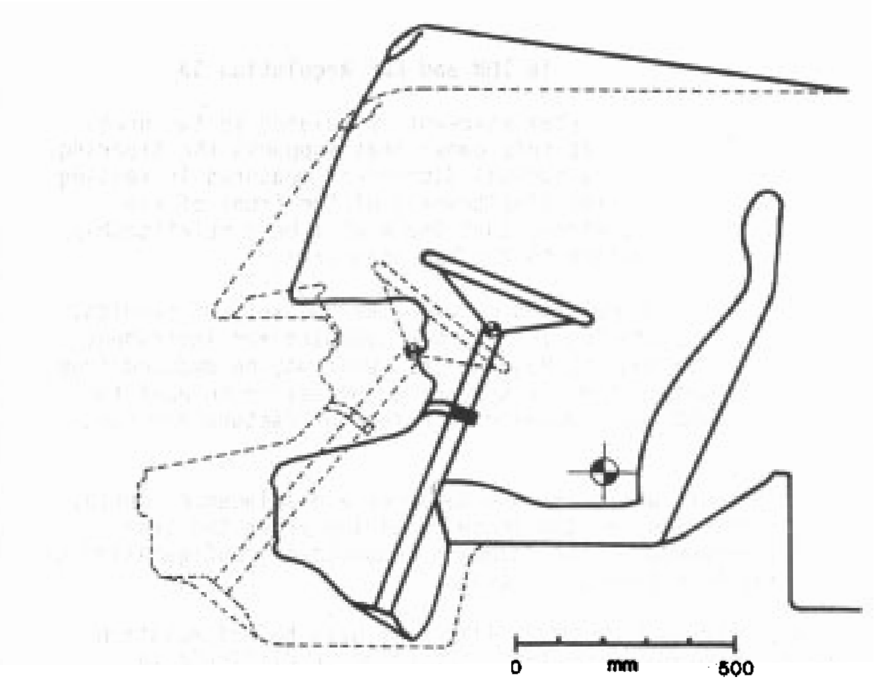

Figure 17: Static deformation of vehicle interior - Test F90

DISCUSSION

Correlation between Australian Design Rule 10B and ECE Regulation 33

In the vehicles tested the steering system movement is related to the gross deformation of the front panel as it is this panel that supports the steering column bracketry. Similarly, the longitudinal dimensions measured in testing to ECE Regulation 33 also depend on the displacement of the front of the vehicle. It is to be expected, therefore, that there will be a relationship between the results obtained in testing to the two standards.

Figure 18 shows graphically the correlation between the two sets of results. Steering column displacement is plotted against the toeboard and instrument board distances as specified in the ECE Regulation. What may be deduced from this data is that, for the vans tested, it appears to be easier to meet the ECE Regulation than to meet ADR 10B. However, a number of factors may have exaggerated this difference.

First, it should be noted that, while the ADR measures a displacement during the test, the ECE Regulation measures the space remaining after the test. Hence only the ECE result depends on the occupant compartment configuration of the undeformed vehicle and this obviously varies.

Secondly, the presence of the test dummy is likely to have helped maintain occupant survival space. The amount of this distortion is difficult to estimate but may be of the order of 50 mm to 75mm in some cases. However, this effect was greatest in the vehicles which experienced the largest deformations. These vehicles did not meet the requirement even with the help of the test dummy.

Thirdly, the ECE Regulation contains some additional requirements more qualitative than those plotted above. As mentioned in the Results section the interpretation put on these requirements is likely to affect whether some of the the vehicles tested would pass the Regulation overall. This factor is discussed in more detail in a later section.

Despite these factors, a number of conclusions might be drawn from the comparison of results. It might be argued that ADR 10B may provide sufficient protection on its own, however, ADR 10B does not ensure adequate post crash leg room in this type of vehicle. If the ADR is applied then the application of the ECE Regulation is likely to be achieved at little additional cost because one test can be used to demonstrate compliance with the two standards. In addition, the cases in which the ECE compliance cannot be achieved with little extra cost are likely to be the cases in which the benefits are the greatest.

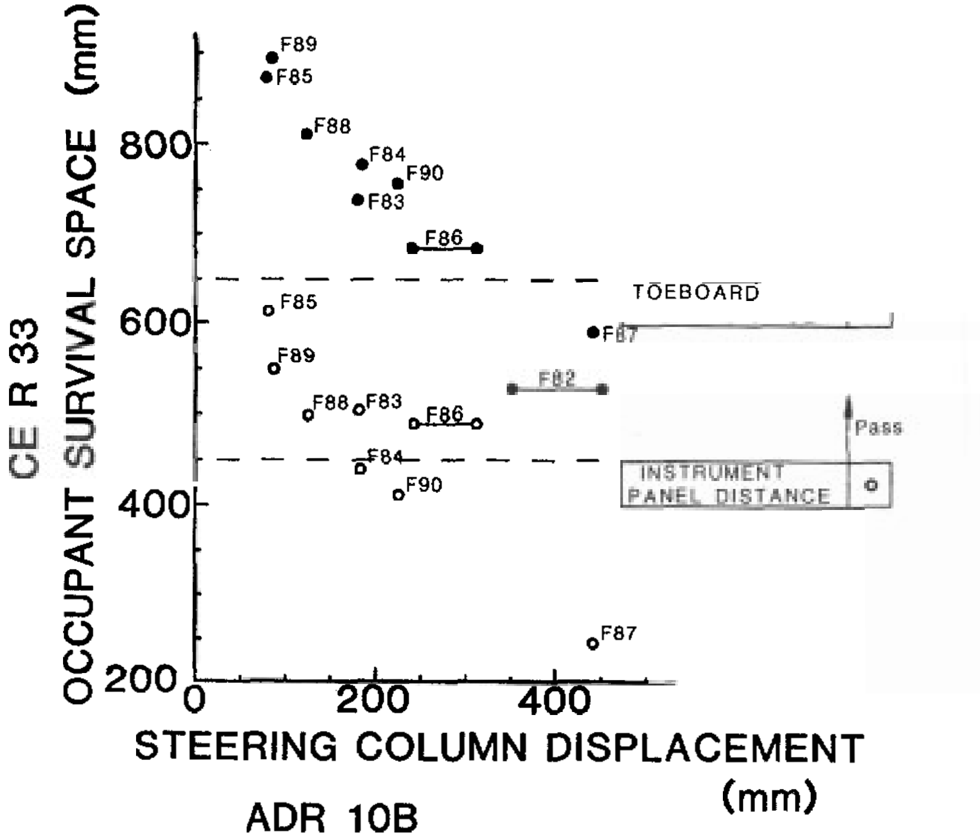

Figure 18: Comparison of ADR 10B and ECE Regulation 33 results. Required minimum dimensions for compliance with Clauses 5.2 and 5.3 of ECE Regulation 33 are shown as horizontal dashed lines. Compliance with Clause 10B.2.2 of ADR 10B is achieved if the steering column displacement is less than 127 mm. Steering column displacements for tests F82 and F86 are shown as a range in which it is estimated that the maximum dynamic displacement lies.

However, as discussed earlier in this report, the choice of standards should also consider the likely effectiveness of each standard in the areas that have been demonstrated to cause the most injuries.

Effectiveness of ADR 10B

A number of the vehicles tested failed the ADR requirement by a large margin (up to 250 percent). These large intrusions of the steering system resulted from gross distortion of the entire front of the vehicle. As an indication of the amount of intrusion measured, in a number of tests the lower portion of the steering wheel rim was displaced to a position above the base of the seat back. Such intrusion, if experienced in a real crash, would be considered life-threatening unless the steering system was sufficiently soft.

Hence the application of ADR 10B to these vehicles is likely to produce considerable benefit. For the vehicles which come closer to meeting the ADR obviously the benefits will be less. However, compliance could be achieved in these cases with less change to vehicle structure.

The application of ADR 10B is likely to result in vehicles that are stiffer. There may be some concern that the acceleration levels experienced in the occupant compartment may therefore become unacceptably high. In general, the vans tested showed high peak levels of acceleration. It is possible, however, that increased overall stiffness can be achieved without necessarily increasing the peak levels observed. In any case, the effect of crash acceleration is likely to become a significant factor only when occupant compartment intrusion ceases to be the major cause of injury. It is clear that most of the vans tested do not yet approach this level of crashworthiness.

The impact test requirement in ADR 10B was developed to provide some protection for an unrestrained driver in a conventional passenger car. Though some form of force-limiting requirement is desirable, it is not clear whether the test specified in ADR 10B will be the most effective for vans. In the case of a passenger car, the load exerted by the steering system is borne by the rib cage, hopefully over a fairly large area. In the case of a van, with a steering column angle nearer the vertical, the load is likely to be concentrated over the lower portion of the steering wheel rim. It is also probable that this load will be applied to soft tissue below the driver's ribs. An appropriate load limit for this situation may be different from that in the ADR.

The wearing of a seat belt by the driver will also result in an impact that is different from the current ADR test procedure. In the 02 series of amendments to ECE Regulation 12 this difference has been recognised in the inclusion of an optional head impact test procedure.

Though the test procedure and load limits specified in the current ADR do not appear to be optimal, there are no obvious safety penalties that would arise from their application.

Effectiveness of ECE Regulation 33

Many of the comments made in discussions the effectiveness of ADR 10B are also applicable when analysing the probable effectiveness of ECE Regulation 33. The same gross deformation that causes large steering system intrusion also results in an unacceptable reduction in the survival space parameters specified in the ECE Regulation. It is therefore likely that the engineering required to ensure compliance with ADR 10B will also result in an improvement in performance measured by ECE Regulation 33.

The bias towards leg injuries observed in the investigations of van crashes indicates that a standard such as this ECE Regulation should be more effective than ADR 10B in reducing injuries. Although the engineering solutions to the problems posed by the two standards are similar, the ECE Regulation does require a certain minimum size of occupant space. As an illustration the smallest vehicle of the test series was only marginally within the parameters set by the Regulation even before it was impacted. Obviously, in this particular case, the design changes required to meet ADR 10B might not be sufficient to ensure adequate occupant survival space measured by the ECE Regulation.

There appear to be a number of limitations in the requirements of the Regulation that relate both to its application to vans and its incorporation in the ADR certification system. It may seem that the occupant space dimensions specified in the Regulation should ensure adequate survival space without consideration of the vehicle type tested. However, it should be noted that, just as ADR 10B assumes a certain occupant/steering system relationship, the ECE Regulation is presumably based on the seating position found in conventional passenger cars. In such vehicles, intrusion of the toeboard will usually result in a displacement along the occupant's tibia. This movement can be accommodated to some extent by rotation of hip and knee joints. On the other hand, typical seating posture in a van may result in similar intrusion trapping the feet and tibia. Further investigation of the relative postures of occupants of the the different types of vehicles will help determine whether the dimensions specified in ECE Regulation 33 are appropriate to vans. Nevertheless, as with ADR 10B, there are no apparent safety penalties that would arise from the application of existing limits.

Approval of compliance with ECE Regulations is given after a test is witnessed by the administering authority. Although uniform interpretation of subjective requirements is required, compliance with such requirements can be assessed by the witnessing officer. The same is not applicable in the case of ADR certification as tests are witnessed only occasionally, as an audit of manufacturers' procedures. Ideally therefore, any requirement in an ADR should incorporate exact, objective parameters to enable the manufacturer to certify that his vehicle does comply. In the case of the ECE Regulation some requirements are currently expressed subjectively. ECE requirements will cover the allowable intrusion of such items as the brake master cylinders, handbrake, pedals and the lower part of the steering system on the driver's side of the vehicle and the parcel tray, heater ducting and pipework on the passenger's side.

One approach would be to use an occupant space envelope to ensure that sufficient occupant space remains after a barrier crash test to accommodate a complete test manikin. This global approach should overcome problems of interpretation and has the additional advantage that the use of a jointed manikin will cater for different seating postures.

Bull bars

A comparison of the results of tests F84, F88 and F90 allows observations to be made on the effect of fitment of a bull-bar on occupant safety. The vehicles tested in these three tests were identical models with the exception of a steel bull-bar fitted to vehicle F88. A comparison of the results obtained for tests F84 and F90 indicates the variation arising from unidentified experimental effects. Some of the improvement observed in test F88 might also be attributable to these effects. Hence the influence of the bull-bar cannot be determined precisely but it is probable that the bull-bar contributed to the improved vehicle performance observed in this test. It should be noted that the margin of compliance with ADR 10B demonstrated in this test may not be sufficient to give assurance that all identical vehicles would comply. Nevertheless, the test result demonstrates that significant improvements are possible from relatively simple engineering changes.

In determining the effectiveness of bull-bars in general a number of factors should be noted. Only one design was tested and a large number of commercially available assemblies are weaker than the one tested. In addition, the effectiveness of the bull-bar has been observed in only one impact type. Against this limited data must be weighed data such as that reported by Chiam and Tomas (1980) who demonstrated the pedestrian hazard caused by bull-bar fitment.

CONCLUSIONS

1. The application of ADR10B/ECE Regulation 12, and ECE Regulation 33 would result in a significant improvement in the occupant survival space provided by forward-control vehicles in a frontal barrier impact.

2. A review of these standards would lead to further occupant protection. The following areas should be examined as a second stage:

2.1 The impact test in ADR 10B should also cater for an occupant, possibly wearing a seat belt, in a vehicle with a steering column angle more vertical than that of conventional passenger cars. The test criteria required to ensure an acceptable level of injury should be reviewed for this case in which the impact with the driver's torso may be quite different in its nature and location.

2.2 The occupant space criteria of ECE Regulation 33 could be further improved for the case of a van occupant in view of different seating posture compared with a conventional passenger car.

2.3 An ADR based on ECE Regulation 33 will not be fully effective until objective interpretations are developed for existing subjective requirements, in particular that relating to the injury risk arising from rigid components.

3. Further investigation is required to determine whether the measured vehicle B-pillar accelerations, which were higher than presumed in current safety standards, need to be taken into account in future standards for forward-control vehicles.

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APPENDIX A

TEST REPORT

Test Order No.	T6749
Date of Order	1.5.85
Program No.	505
System No.	00.00
Date of Test	31.5.85

Subject: Evaluation - Barrier crash F82

Vehicle description:

Vehicle #:	ST 90 717268	
Engine	I4	
Transmission:	4 speed floorshift manual	
Steering column:	Non-adjustable	
Wheels & tyres:	Steel, 145 SR 12	
Actual test mass	Frt	470
	Rr	331
	Total	801 Kg

Procedure:

1. The test was conducted in accordance with SAE Recommended Procedure J850 - Barrier Collision Tests.

2. The weight of the vehicle was reduced to as close as possible to the kerb mass of 710 kg without structurally altering the vehicle. Actual achieved mass 728 kg. The 73 kg test dummy was then fitted to the vehicle to achieve the actual test mass.

Results:

The dynamic displacement of the steering column could not be determined as column rotation caused the targets to disappear below the door sill line.

An indication of the dynamic displacement is available by viewing the onboard camera film which shows the steering wheel rim moving rearward to the plane of the seat back. This seat has moved forward approximately 100 mm.

Figure A1 shows the load-v-time traces of the front passenger lap and sash seat belts. Figure A2 shows the deceleration-v-time traces of the left and right "B" pillar bases.

Static pre- and post-test measurements are shown below. The internal vehicle datum is the rear edge of the front seat rear crossmember. Positive displacement is horizontally rearwards or vertically upwards.

Figures A3 to A16 are pre- and post-test photographs of the vehicle.

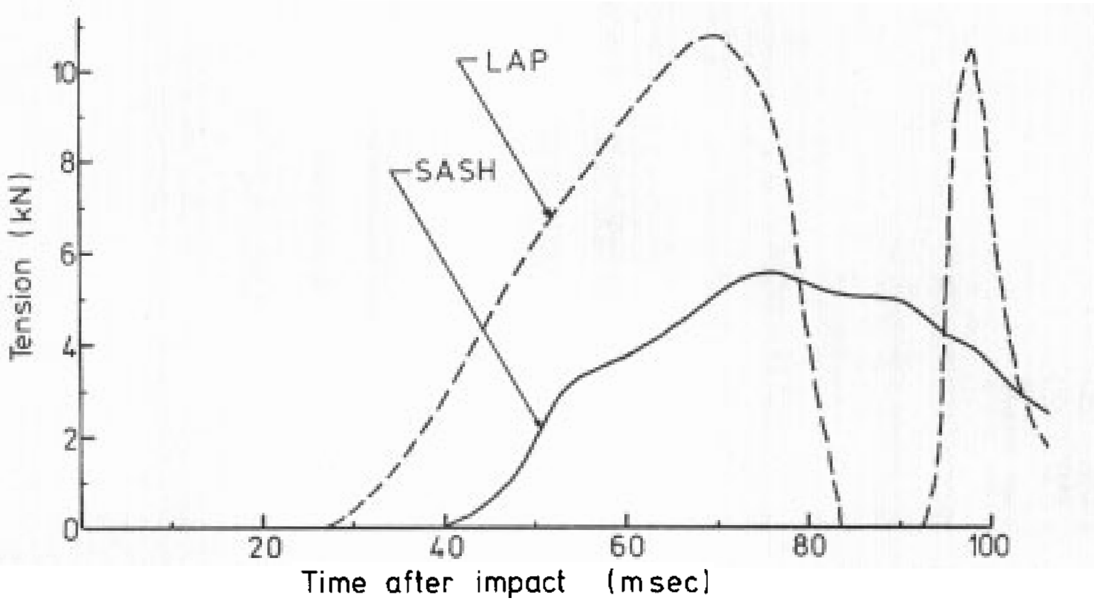


Figure A1: Test F82, Front outboard passenger seat belt loads during impact (100 Hz filtering)

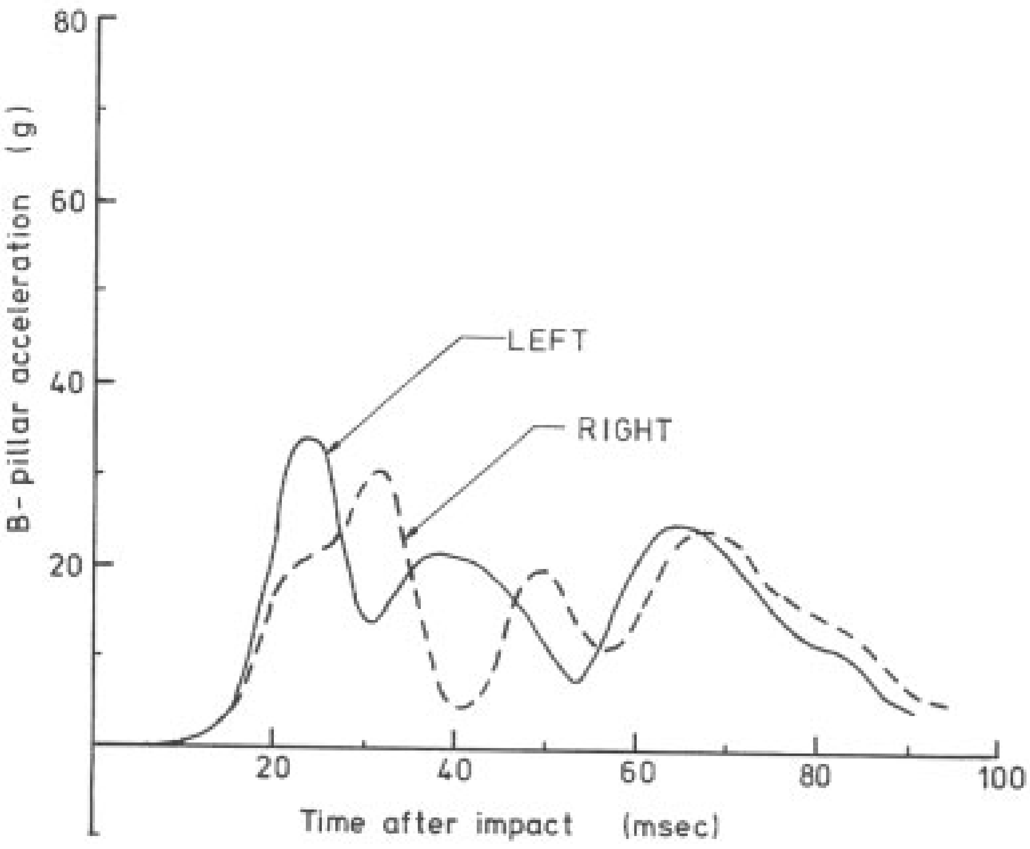


Figure A2: Test F82, Occupant compartment acceleration during impact (100 Hz filtering)

Figure A3: Test F82, Front-quarter view of vehicle -- pre-test

Figure A4: Test F82, Front-quarter view of vehicle -- post-test

Figure A5: Test F82, Right hand side view of vehicle -- pre-test

Figure A6: Test F82, Right hand side view of vehicle -- post-test

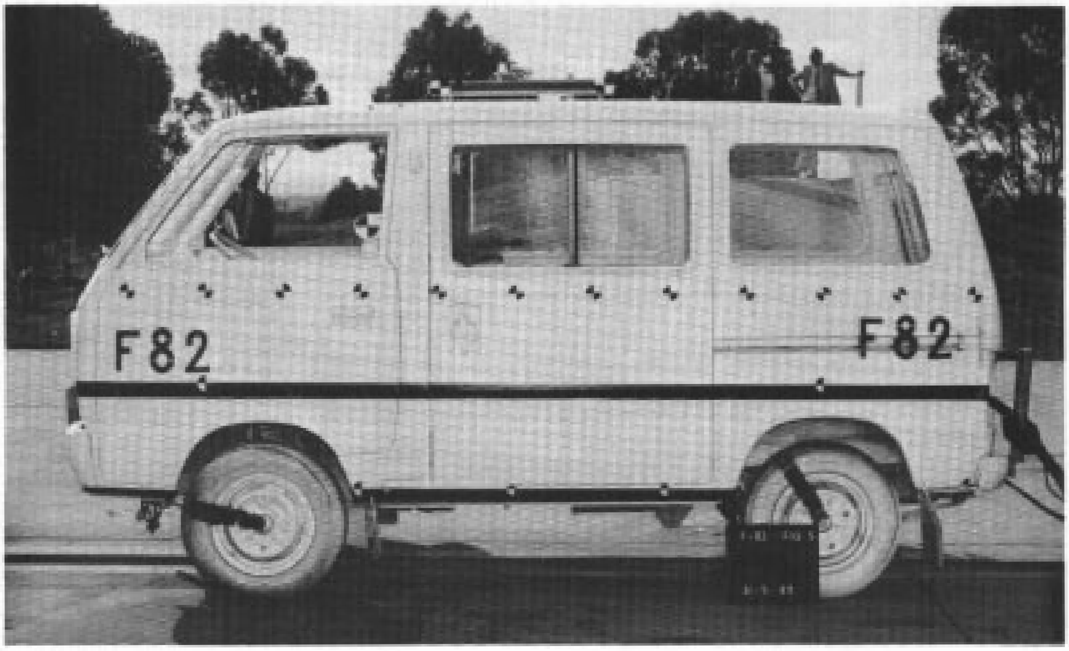


Figure A7: Test F82, Left hand side view of vehicle -- pre-test

Figure A8: Test F82, Left hand side view of vehicle -- post-test

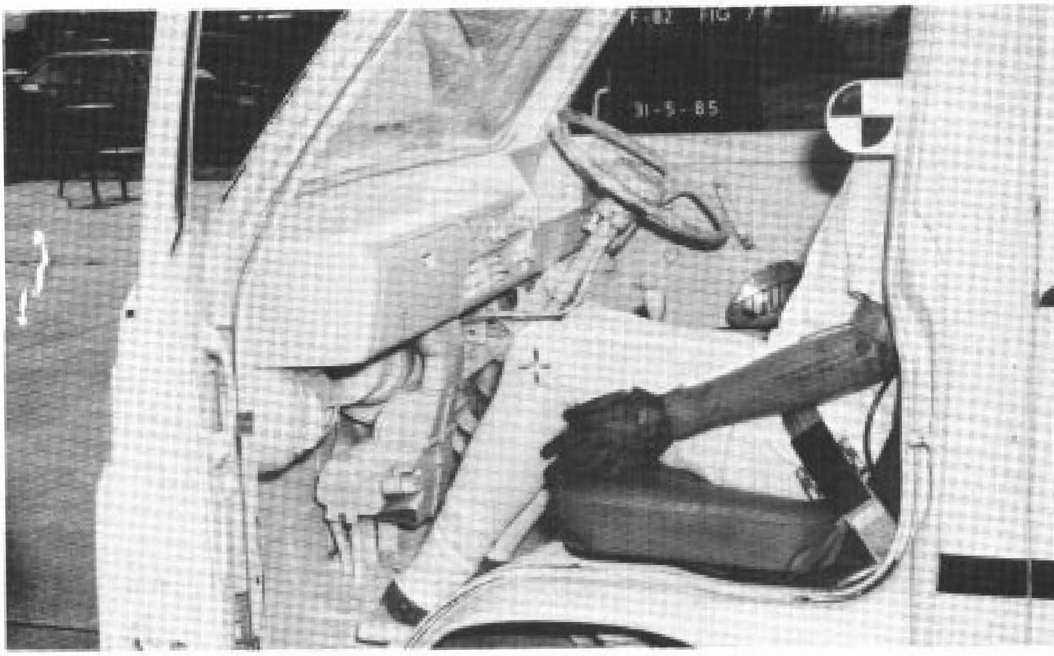


Figure A9: Test F82, Occupant compartment interior -- pre-test

Figure A10: Test F82, Occupant compartment interior -- post-test

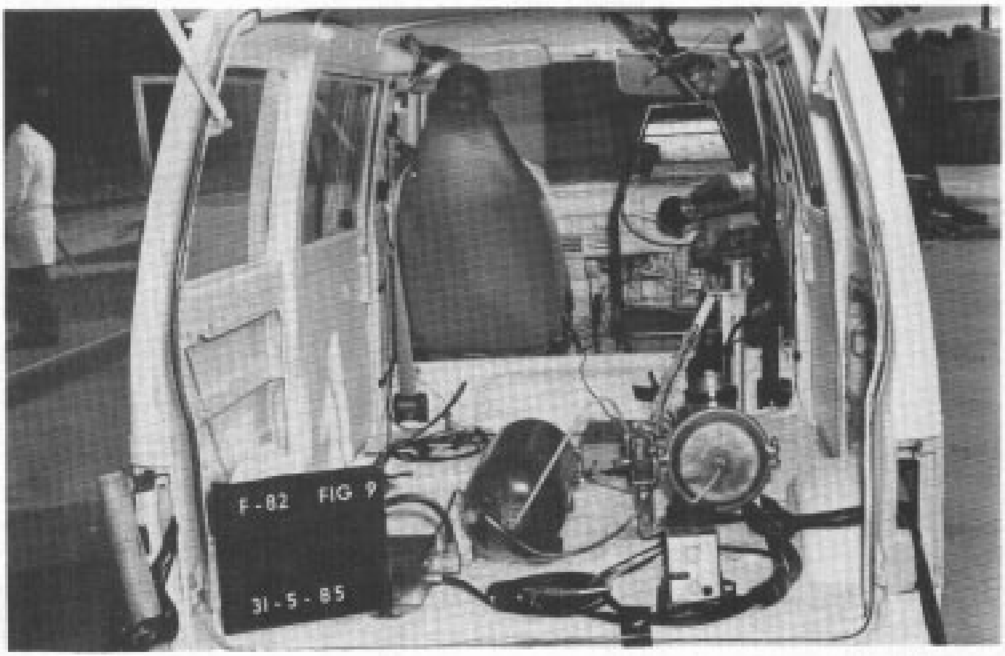


Figure A11: Test F82, Rear view of vehicle interior -- pre-test. Auxilliary brake components for test abort system are visible in the foreground

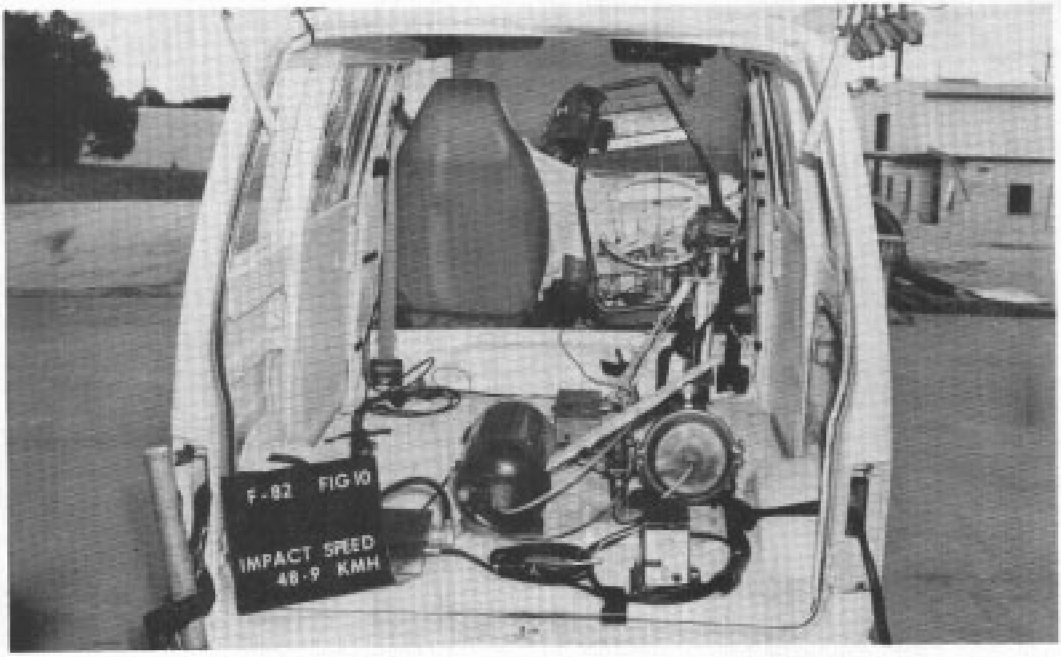


Figure A12: Test F82, Rear view of vehicle interior -- post-test

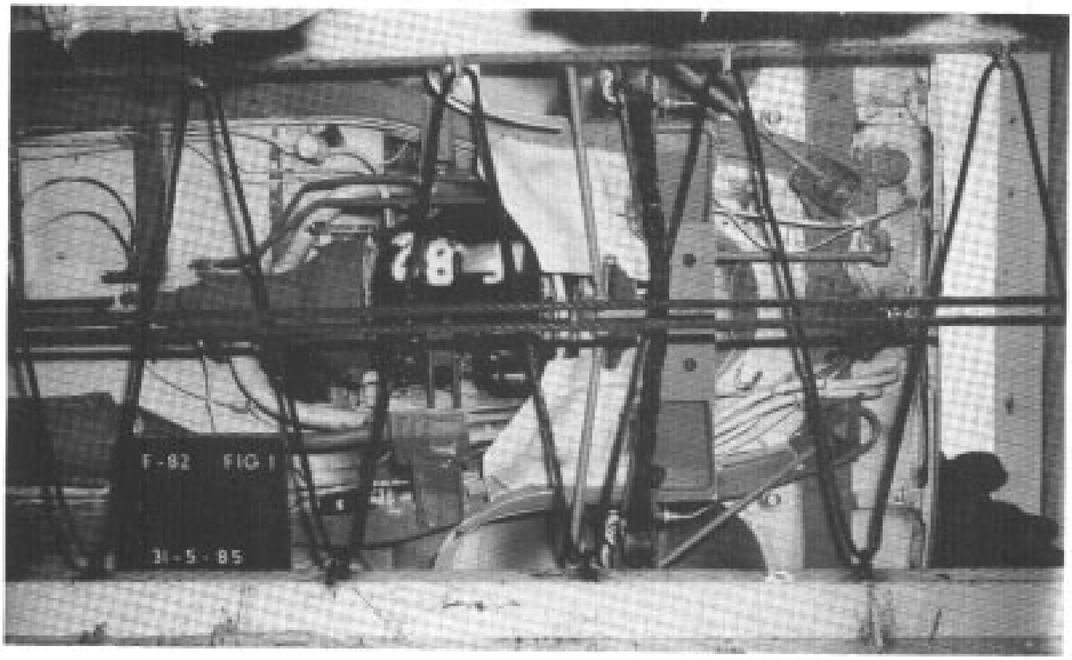


Figure A13: Test F82, Underside view of front of vehicle -- pre-test

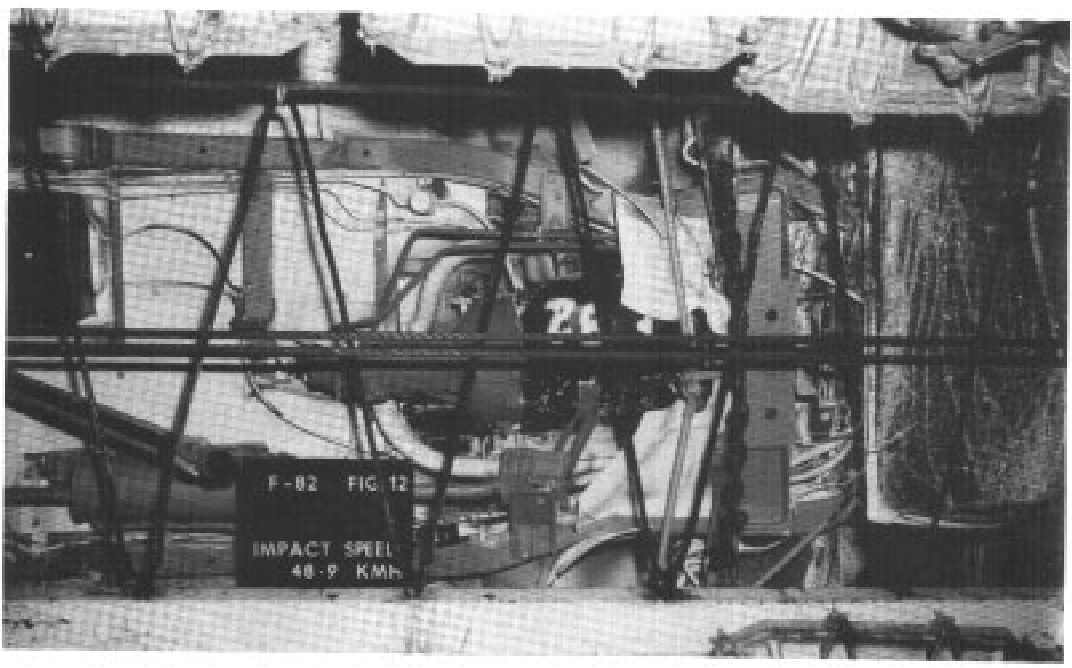


Figure A14: Test F82, Underside view of front of vehicle -- post-test

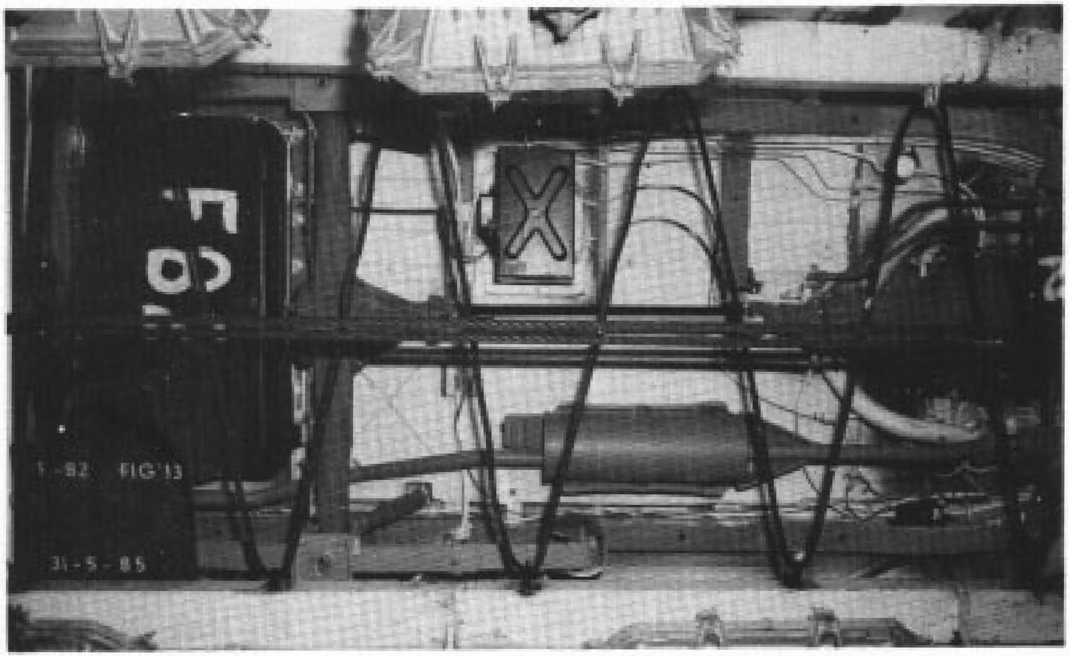


Figure A15: Test F82, Underside view of rear of vehicle -- pre-test

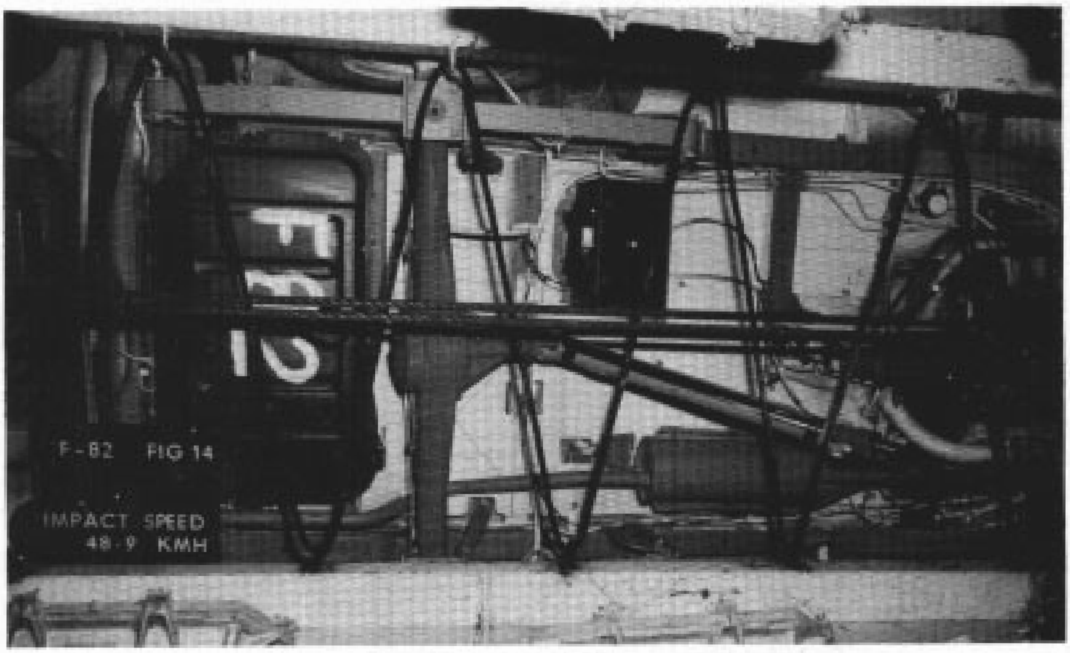


Figure A16: Test F82, Underside view of rear of vehicle -- post-test

F82

MEASUREMENT POINT DESCRIPTION		PRE TEST Horiz	PRE TEST Vert	POST TEST Horiz	POST TEST Vert	DISPLACEMENT Horiz	DISPLACEMENT Vert
Dash panel features							
	Right	779	424	-	-	-	-
	Binnacle	727	390	-	-	-	-
	Centre	817	407	-	-	-	-
	Left	795	559	-	-	-	-
Dash panel mount screw holes							
	Right	1000	470	683	457	317	-13
	Centre	1022	457	706	441	316	-16
	Left	1004	476	716	476	288	0
Headlight vent screws							
	Right	940	140	566	165	374	25
	Left	943	127	604	137	339	10
Front panel at height of brake pedal		1092	-50	703	-406	389	-356
Pedal bracket bolts to body							
	Right	970	292	631	282	339	-10
	Left	970	292	633	273	337	-19
Column to pedal bracket bolts							
	Right	786	254	459	212	327	-42
	Left	786	229	459	197	327	-32
Column upper bracket holes							
	Right	675	318	338	266	357	-56
	Left	680	356	-	-	-	-
Base of column		953	-178	-	-	-	-
Column nut		624	419	293	356	331	-63
Column angle		54^{o}		47^{o}		7^{o}	
Front panel on vehicle centreline		1112	30	728	57	384	27
Screw on left side of heater case		1102	75	727	32	375	-43
Top of suspension struts							
	Right	457	-35	467	-115	-10	-80
	Left	460	-35	450	-115	10	-80
Engine		255	-100	346	-135	-91	-35
Left hand drive column pressing		987	-165	675	-318	312	-153
Sunvisor screws							
	Right	618	916	610	950	8	34
	Left	615	917	585	945	30	28
Floor lengths	Right	518	-	180	-	338	-
	Centre	535	-	130	-	405	-
	Left	520	-	200	-	320	-
Width between flanges at "A" pillar base		1205	-	1230	-	25	-
Seat belt anchorages							
Drivers seat belt							
	Outer lap	36	0	36	0	0	0
	Buckle	19	0	26	0	-7	0
	Upper "B" pillar	-25	765	30	765	-55	0
Inertia reel (from rear floor)		0	45	0	45	0	0

Passenger seat belt						
Outer lap	36	0	38	0	-2	
Buckle	19	0	26	0	-7	
Upper "B" pillar	-25	765	32	751	-57	-1
Inertia reel (from rear floor)	0	45	0	46	0	
Seat mount crossmembers						
Length at right suspension tower	552	-	580	-	-28	-
Length at left suspension tower	548	-	552	-	-4	-
Length at right of centre plate	550	-	580	-	-30	-
Length at left of centre plate	549	-	590	-	-41	-
Floor to roof heights						
Right	-	939	-	1124	-	18
Centre	-	960	-	1100	-	14
Left	-	939	-	1130	-	19
"H" point at rearmost position	205	110	-	-	-	-
"H" point at mid position	247	113	-	-	-	-
Column to datum 2 (direct distance)	2375	-	2040	-	335	-
Front of vehicle to "B" pillar target						
Right	1015	-	-	-	-	-
Left	1014	-	-	-	-	-
Longitudinal distance column to "B" pillar						
Right	432	-	-	-	-	-
Left	430	-	-	-	-	-
Transverse distance column to "B" pillar						
Right	273	-	-	-	-	-
Left	894	-	-	-	-	-
Column to vehicle centreline	288	-	-	-	-	-
Rebound distance						
Centre	-	-	425	-	-	-

Body side targets		**Horiz Right**	**Horiz Left**	**Horiz Right**	**Hor Lef**
	250	90	50	160	20
	500	308	253	192	24
	750	550	500	200	25
	1000	770	740	230	26
	1250	865	900	385	35
	1500	1110	1150	390	35
	1750	1360	1400	390	35
	2000	1610	1650	390	35
	2250	1860	1900	390	35
	2500	2110	2150	390	35
	2750	2360	2150	390	35
	3000	2610	2650	390	35

APPENDIX B

TEST REPORT

Test Order No.	T6748
Date of Order	1.5.85
Program No.	505
System No.	00.00
Date of Test	2.6.85

Subject: Evaluation - Barrier crash F83

Vehicle description:

Vehicle #:	D of HC D11E233	
Engine	2.2 litre I4 diesel	
Transmission:	5 Speed column manual	
Steering column:	Non-adjustable	
Wheels & tyres:	Steel, Frt 165R15C Rr 145R12	
Actual test mass	Frt	827
	Rr	584
	Total	1411 Kg

Procedure:

1. The test was conducted in accordance with SAE Recommended Procedure J850 - Barrier Collision Tests.

2. The vehicle was weighted to the required test mass of 1340 kg. The 71 kg test dummy was then fitted to the vehicle to achieve the actual test mass of 1411 kg.

Results:

Dynamic steering column intrusion was analysed using the right main camera. The two sets of data were analysed to give the dynamic intrusion of the target 250 mm above the end of the steering column and the target 150 mm above the end of the steering column.

Both targets are directly in line with the steering column shaft. By determining the difference between the two targets, mulyiplying this difference by 1.5 and adding to or subtracting from the 150 mm target the dynamic intrusion of the steering column is determined. 1.5 is the ratio of the distance from the 150 mm target to the steering column end and to the 250 mm target.

The maximum derived steering shaft end intrusion is 193 mm at 49.7 km/h. When corrected back to 48 km/h the derived intrusion is 180 mm.

Figure B1 shows the dynamic movements (vertically and horizontally) of the derived position of the steering shaft end.

Figure B2 shows the load-v-time traces of the front passenger lap and sash seat belt loads. Figure B3 shows the deceleration-v-time traces of the left and right "B" pillar bases.

Static pre- and post-test measurements are shown below. The internal vehicle datum is 1280 mm rearward of the front wall of the load carrying space, 3 mm above floor level. Positive displacement is horizontally rearwards or vertically upwards.

Figures B4 to B17 are pre- and post-test photographs of the vehicle.

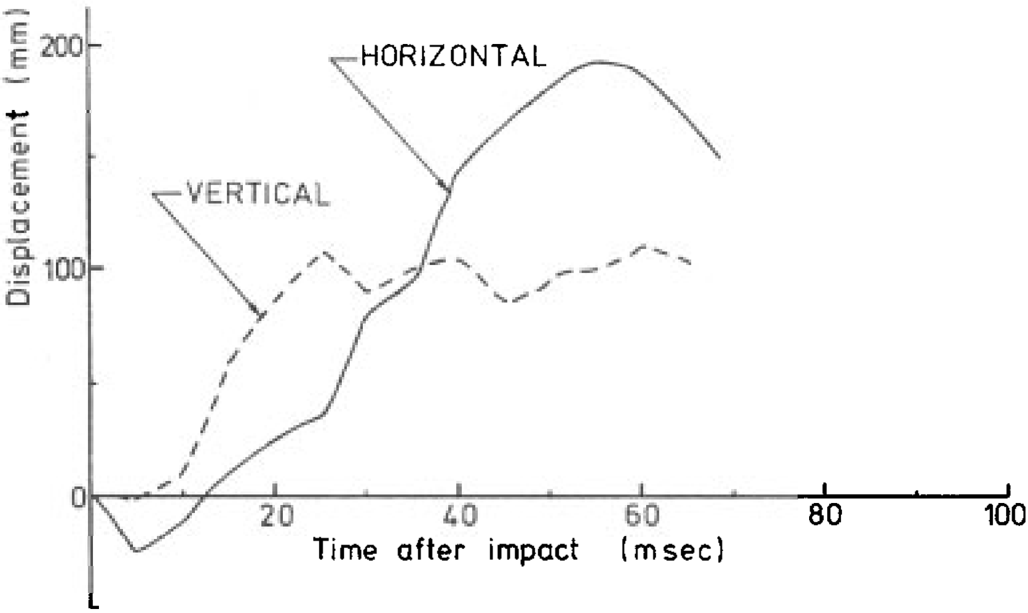


Figure B1: Test F83, Steering column intrusion during impact. Displacements shown are relative to the vehicle's B-pillar

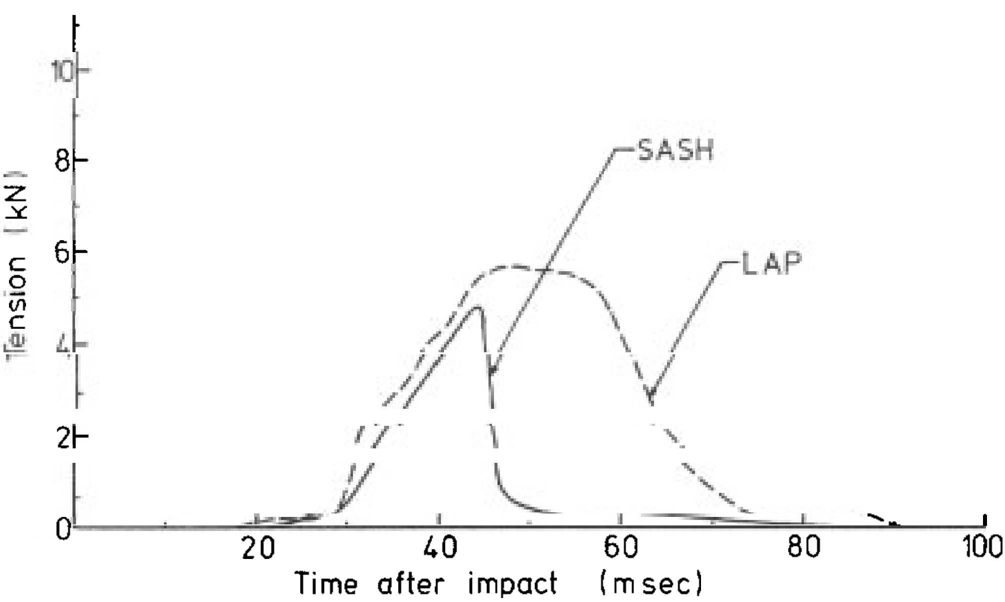


Figure B2: Test F83, Front outboard passenger seat belt loads during impact

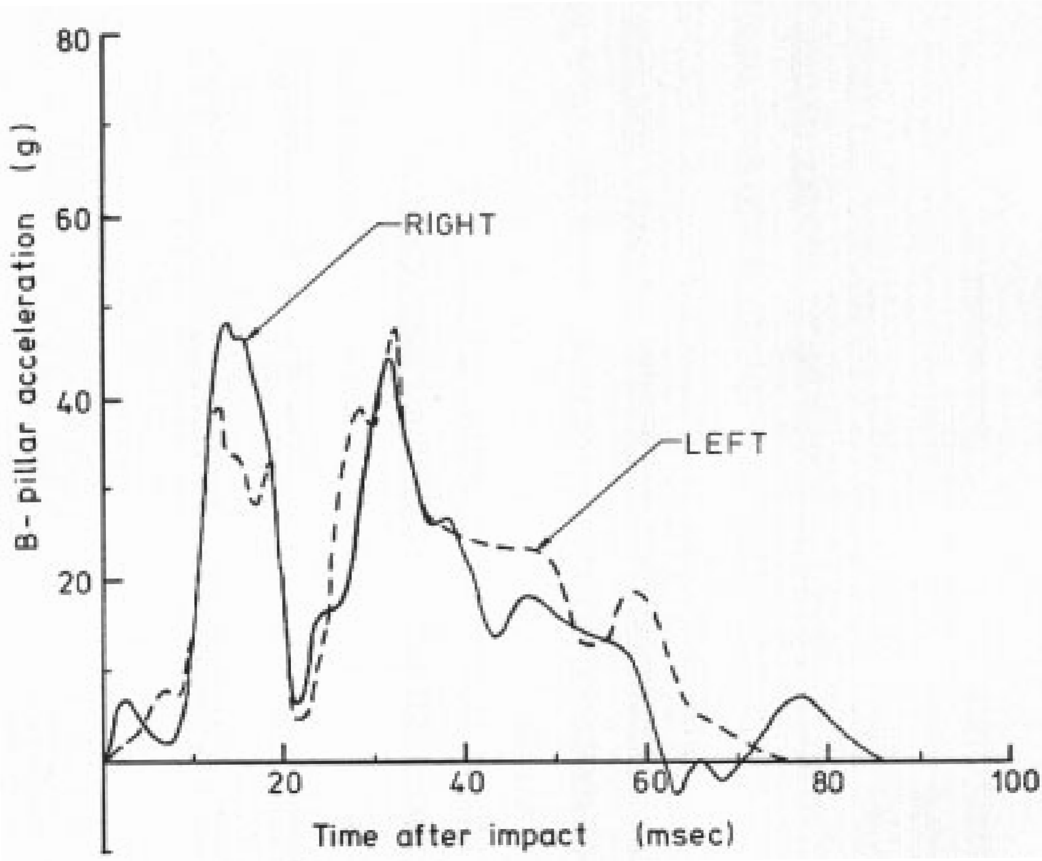


Figure B3: Test F83, Occupant compartment acceleration during impact

Figure B4: Test F83, Front-quarter view of vehicle -- pre-test

Figure B5: Test F83, Front-quarter view of vehicle -- post-test

Figure B6: Test F83, Right hand side view of vehicle -- pre-test

Figure B7: Test F83, Right hand side view of vehicle -- post-test

Figure B8: Test F83, Left hand side view of vehicle -- pre-test

Figure B9: Test F83, Left hand side view of vehicle -- post test

Figure B10: Test F83, Occupant compartment interior -- pre-test

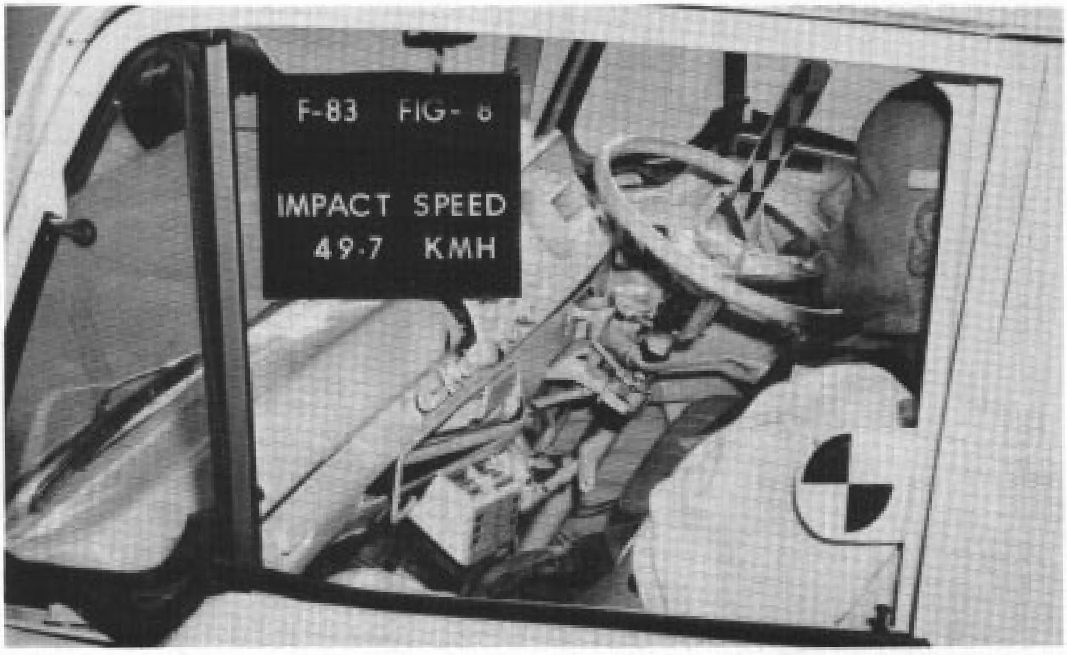


Figure B11: Test F83, Occupant compartment interior -- post-test

Figure B12: Test F83, Rear view of vehicle interior -- pre-test. Auxilliary brake components for test abort system are visible in the foreground

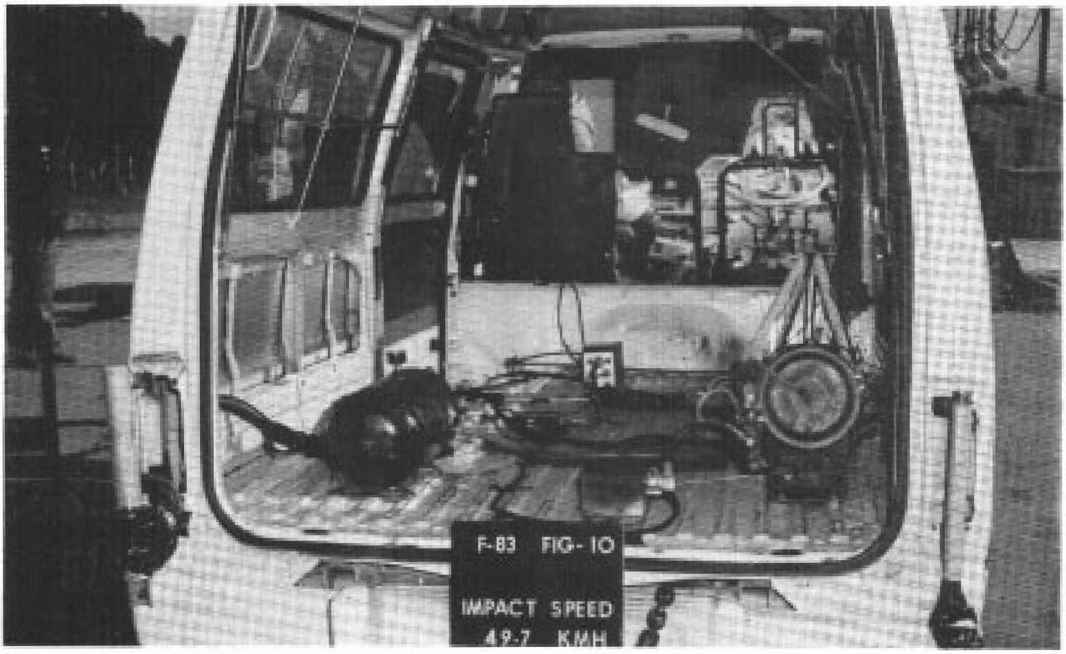


Figure B13: Test F83, Rear view of vehicle interior -- post-test

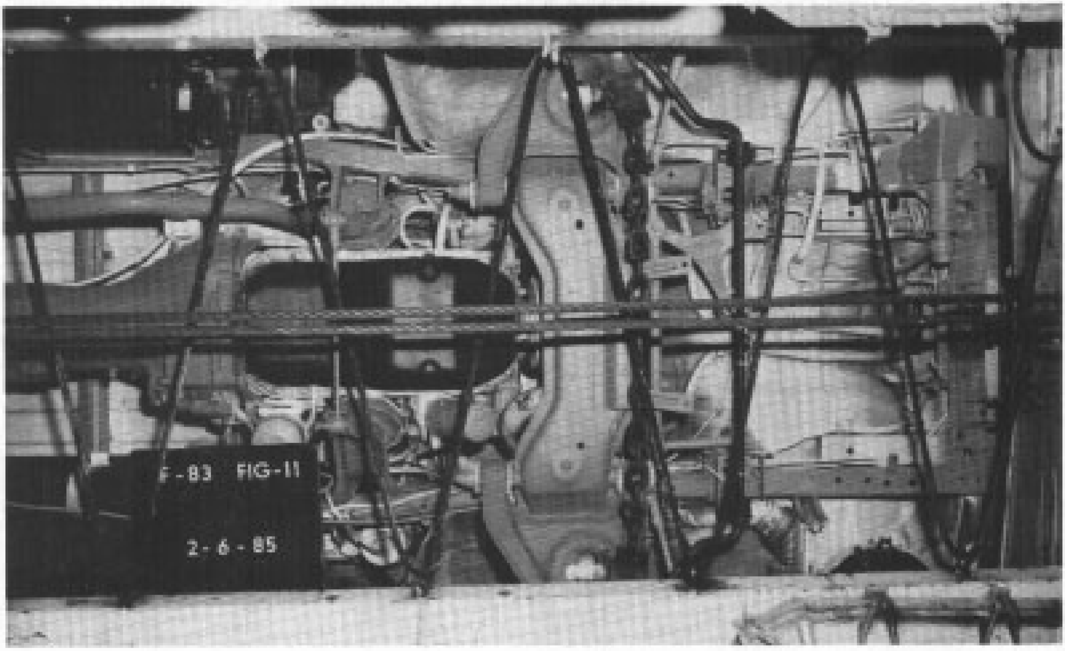


Figure B14: Test F83, Underside view of front of vehicle -- pre-test

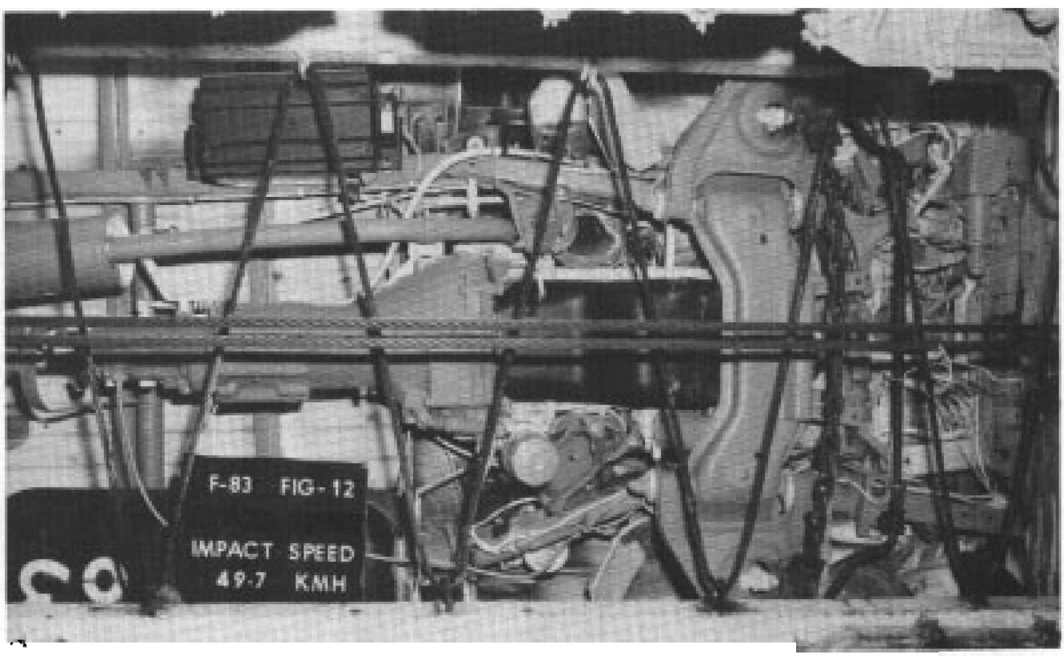


Figure B15: Test F83, Underside view of front of vehicle -- post-test

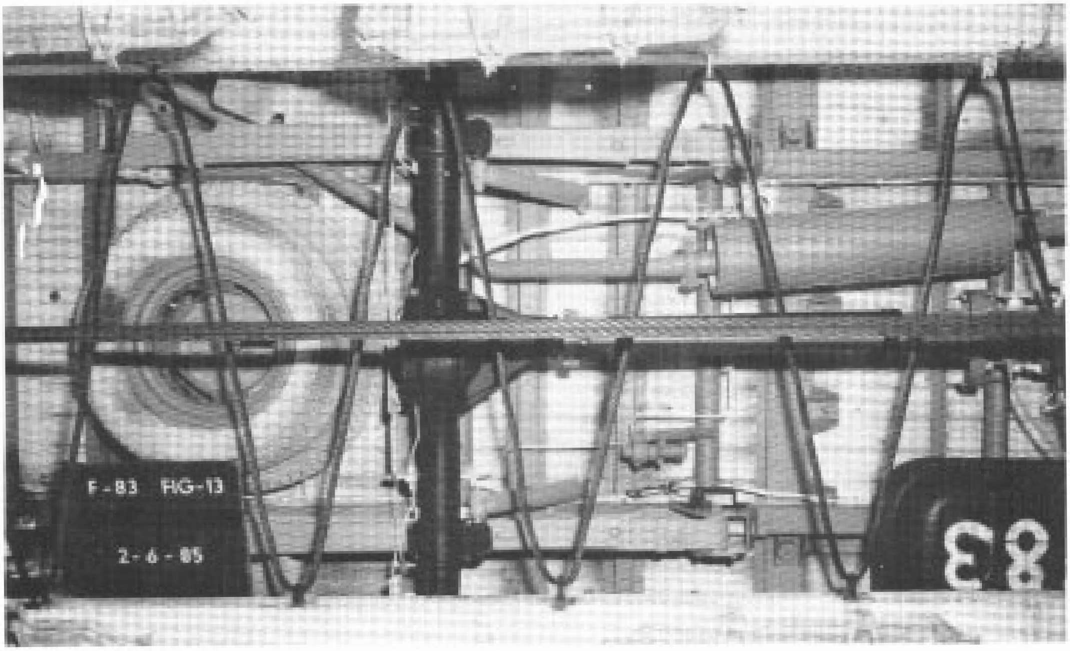


Figure B16: Test F83, Underside view of rear of vehicle -- pre-test

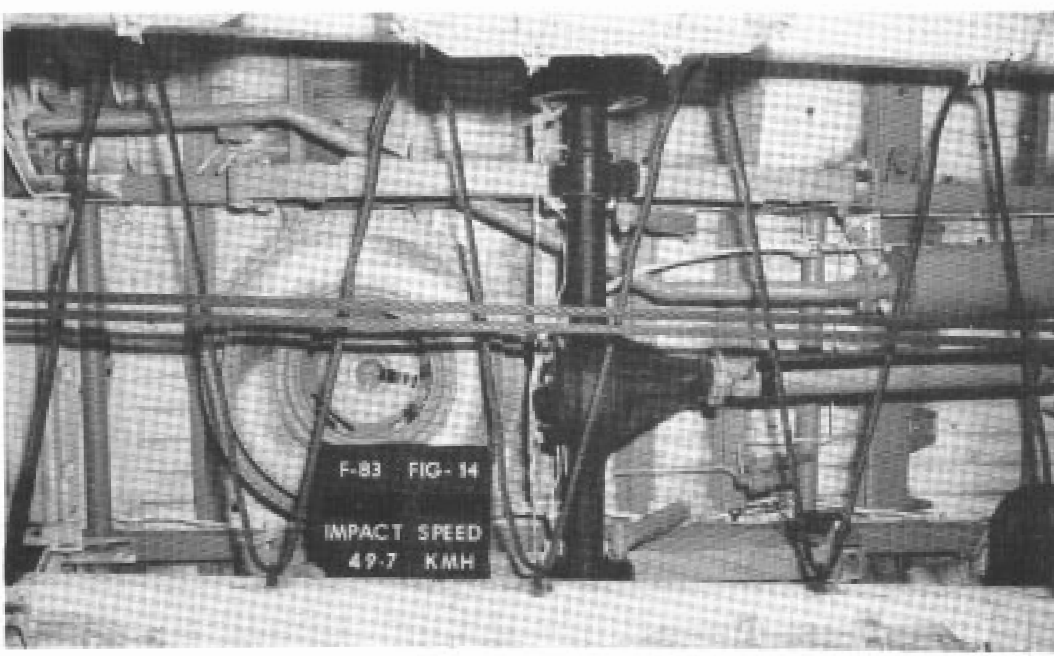


Figure B17: Test F83, Underside view of rear of vehicle -- post-test

F83

MEASUREMENT POINT DESCRIPTION		PRE TEST Horiz	PRE TEST Vert	POST TEST Horiz	POST TEST Vert	DISPLACEMENT Horiz	DISPLACEMENT Vert
Dash panel features							
	Right	2290	394	2140	470	150	76
	Binnacle	2305	394	2127	527	178	133
	Centre	2325	406	2163	527	162	121
	Left	2314	406	2160	500	154	94
Upper dash panel screws							
	Right	2487	533	2375	584	112	51
	Centre	2545	547	2398	533	147	-14
	Left	2496	546	2353	517	143	-29
Headlight holes							
	Right	2602	114	2337	150	265	36
	Left	2608	127	2343	140	265	13
Front panel at height of brake pedal		2644	-51	2367	64	277	115
Pedal bracket bolts to body							
	Right	2655	279	2418	280	237	1
	Left	2655	279	2410	245	240	-39
Column to pedal bracket bolts							
	Right	2265	305	2047	410	218	105
	Left	2265	305	2050	420	215	115
Base of steering column		2495	-114	2238	-152	257	-38
Steering column nut		2100	483	1925	590	175	107
Steering column angle		55^o		61^o		4^o	
LHD steering column pressing		2516	-25	2330	-37	186	-12
Wiper motor mount bolt		2660	267	2380	310	280	43
Front panel ridge							
	Right	2750	127	2428	140	322	13
	Left	2735	152	2413	152	322	0
Engine		1616	158	1665	127	-49	-31
Seat belt anchorages							
Drivers seat belt							
	Outer lap	1550	114	1545	114	5	0
	Buckle	1620	215	1625	203	-5	-12
	Upper "B" pillar	1432	838	1430	835	2	-3
	Inertia reel	1247	197	1255	203	-8	6
Centre seat belt							
	Right	1422	228	1428	220	-6	-8
	Left	1422	228	1428	220	-6	-8
Passenger seat belt							
	Outer lap	1558	102	1550	130	8	28
	Buckle	1558	184	1555	180	3	-4
	Upper "B" pillar	1430	838	1430	850	0	12
	Inertia reel	1332	330	1340	343	-8	13
Seat anchorages							
Drivers seat							
	Right rear	1420	220	1430	220	-10	-
	Left rear	1420	220	1430	220	-10	-
Passengers seat							
	Right rear	1400	265	1400	265	-	-

	Left rear	1400	265	1400	265	-	-
Front of both seats clipped down							
Sunvisor screws	Right	2147	1028	2120	1040	27	12
	Left	2146	1028	2155	1080	-9	52
"H" point at rearmost position		1651	254	-	-	-	-
"H" point at 50% track travel		1677	257	-	-	-	-
Brake pedal		2312	-51	2133	119	179	170
Width between "A" pillars		1372		1370		2	
Floor to roof heights							
	Right	-	1147	-	1167	-	20
	Centre	-	1125	-	1165	-	40
	Left	-	1133	-	1150	-	17
Floor lengths	Right	520	-	320	-	200	-
	Left	520	-	330	-	190	-
Steering column to datum 3 (direct)		3632	-	3473	-	159	-
Front of vehicle to "B" pillar							
	Right	1248	-	840	-	408	-
	Left	1282	-	858	-	424	-
Transverse distance column to "B" pillar							
	Right	306	-	-	-	-	-
	Left	1045	-	-	-	-	-
Longitudinal distance column to "B" pillar							
	Right	470	-	-	-	-	-
	Left	460	-	-	-	-	-
Column to vehicle centreline		360	-	-	-	-	-
Rebound	Right	-	-	180	-	-	-
	Left	-	-	120	-	-	-
Camera to barrier centreline							
	Right	10700	-	-	-	-	-
	Left	10400	-	-	-	-	-

Body side targets	Horiz Right	Horiz Left	Horiz Right	Horiz Left
250	55	60	195	190
500	195	215	305	285
750	438	456	312	294
1000	690	708	310	292
1250	944	958	306	292
1500	1154	1160	346	340
1750	1395	1406	355	344
2000	1641	1656	359	344
2250	1890	1906	360	344
2500	2137	2156	363	344
2750	2387	2406	363	344
3000	2637	2656	363	344
3250	2887	2906	363	344
3500	3137	3156	363	344
3750	3387	3406	363	344
4000	3637	3656	363	344
4250	3887	3906	363	344

APPENDIX C

TEST REPORT

Test Order No.	T6750
Date of Order	1.5.85
Program No.	505
System No.	00.00
Date of Test	15.6.85

Subject: Evaluation - Barrier crash F84

Vehicle description:

Vehicle #:	SB 3M038ND 08002053	
Engine	1.6 litre I4	
Transmission:	4 Speed column manual	
Steering column:	Non-adjustable	
Wheels & tyres:	Steel, 175 R14 LT	
Actual test mass	Frt	732
	Rr	504
	Total	1236 Kg

Procedure:

1. The test was conducted in accordance with SAE Recommended Procedure J850 - Barrier Collision Tests.

2. The vehicle was weighted to the required test mass of 1164 kg. The 72 kg test dummy was then fitted to the vehicle to achieve the actual test mass of 1236 kg.

Results:

Dynamic steering column intrusion was analysed using the right main camera. The two sets of data were analysed to give the dynamic intrusion of the target 250 mm above the end of the steering column and the target 150 mm above the end of the steering column.

Both targets are directly in line with the steering column shaft. By determining the difference between the two targets, mulyiplying this difference by 1.5 and adding to or subtracting from the 150 mm target the dynamic intrusion of the steering column is determined. 1.5 is the ratio of the distance from the 150 mm target to the steering column end and to the 250 mm target.

The maximum derived steering shaft end intrusion is 198 mm at 49.9 km/h. When corrected back to 48 km/h the derived intrusion is 183 mm.

Figure C1 shows the dynamic movements (vertically and horizontally) of the derived position of the steering shaft end.

Figure C2 shows the load-v-time traces of the front passenger lap and sash seat belt loads. Figure C3 shows the deceleration-v-time traces of the left and right "B" pillar bases.

Static pre- and post-test measurements are shown below. The internal vehicle datum is horizontally, the line between chassis mounting bolts approximately 1.1 m rearwards of the bulkhead at the front of the load space; vertically, the floor of the load space. Positive displacement is horizontally rearwards or vertically upwards.

Figures C4 to C17 are pre- and post-test photographs of the vehicle.

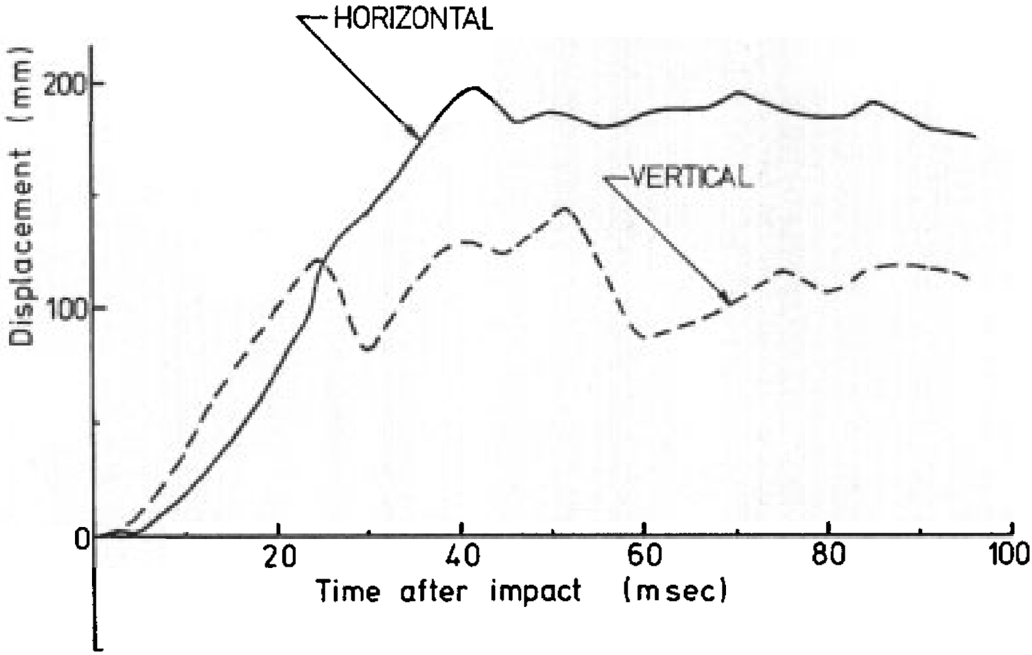


Figure C1: Test F84, Steering column intrusion during impact. Displacements shown are relative to the vehicle's B-pillar

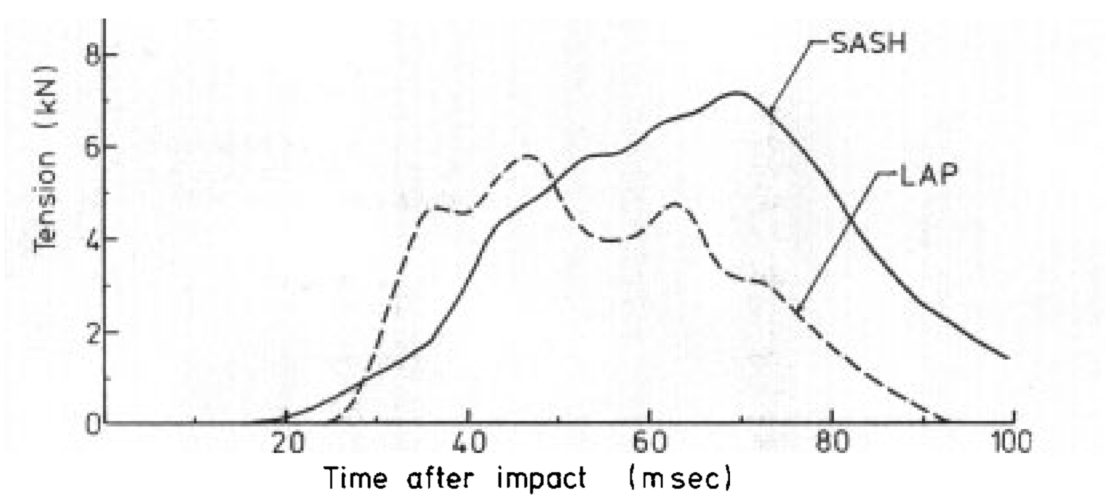


Figure C2: Test F84, Front outboard passenger seat belt loads during impact

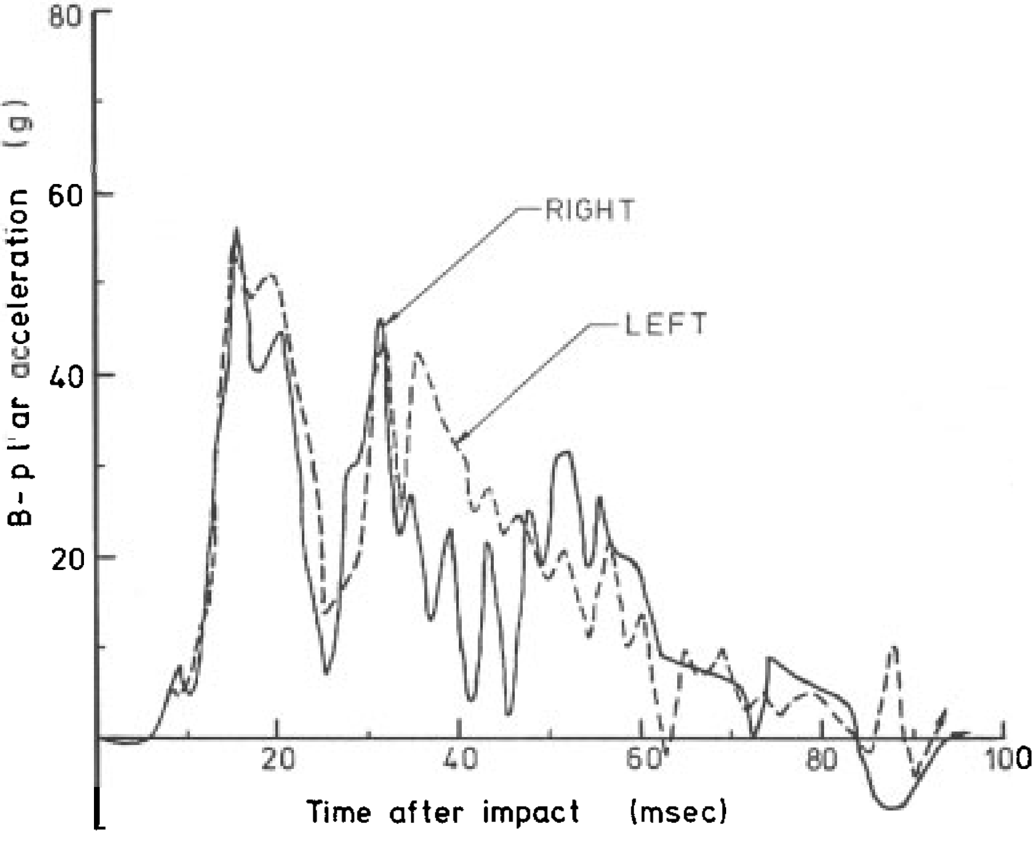


Figure C3: Test F84, Occupant compartment acceleration during impact

Figure C4: Test F84, Front-quarter view of vehicle -- pre-test

Figure C5: Test F84, Front-quarter view of vehicle -- post-test

Figure C6: Test F84, Right hand side view of vehicle -- pre-test

Figure C7: Test F84, Right hand side view of vehicle -- post-test

Figure C8: Test F84, Left hand side view of vehicle -- pre-test

Figure C9: Test F84, Left hand side view of vehicle -- post-test

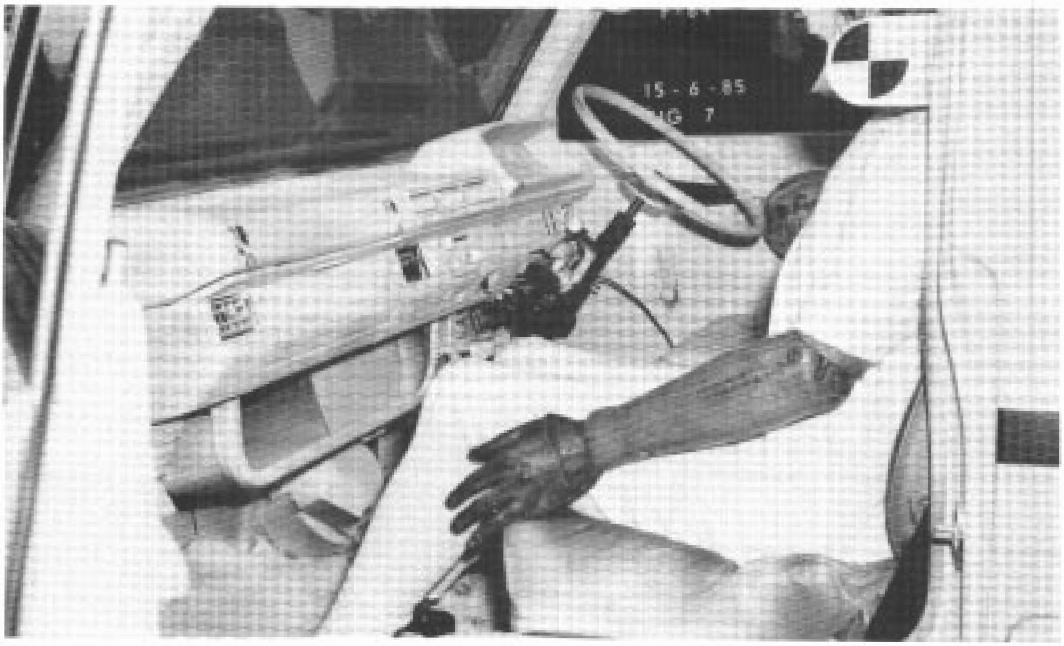


Figure C10: Test F84, Occupant compartment interior -- pre-test

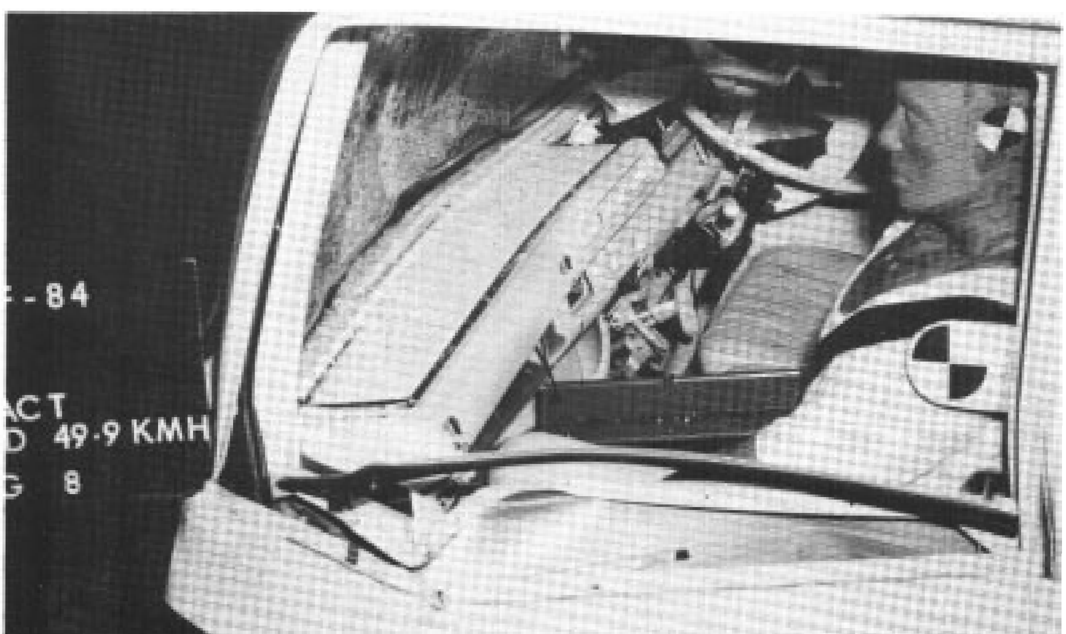


Figure C11: Test F84, Occupant compartment interior -- post-test

Figure C12: Test F84, Rear view of vehicle interior -- pre-test. Auxilliary brake components for test abort system are visible in the foreground

Figure C13: Test F84, Rear view of vehicle interior -- post-test

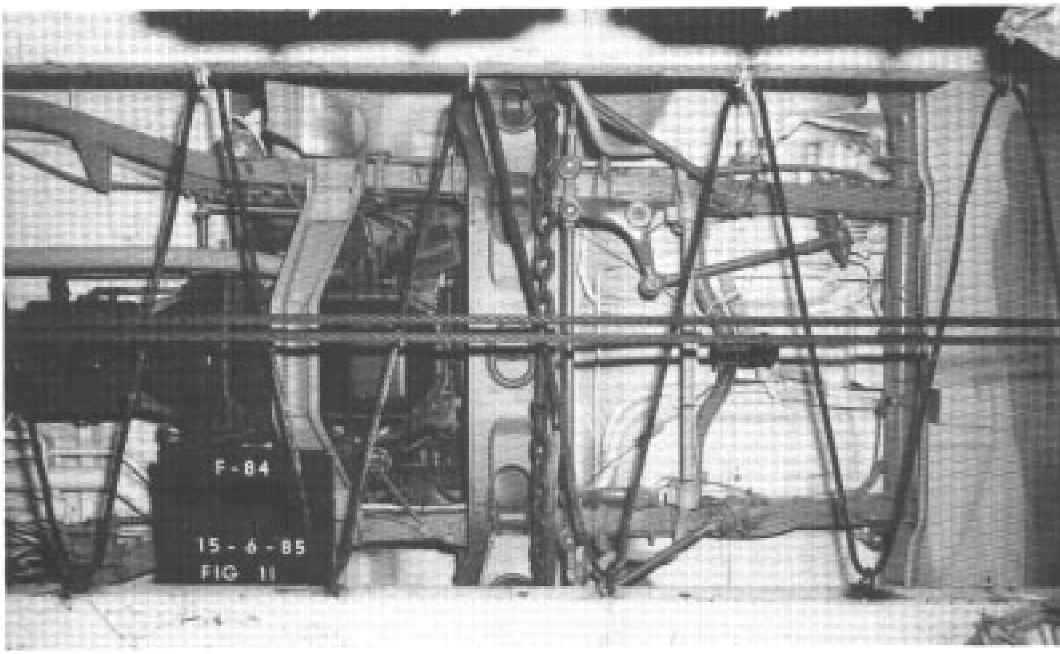


Figure C14: Test F84, Underside view of front of vehicle -- pre-test

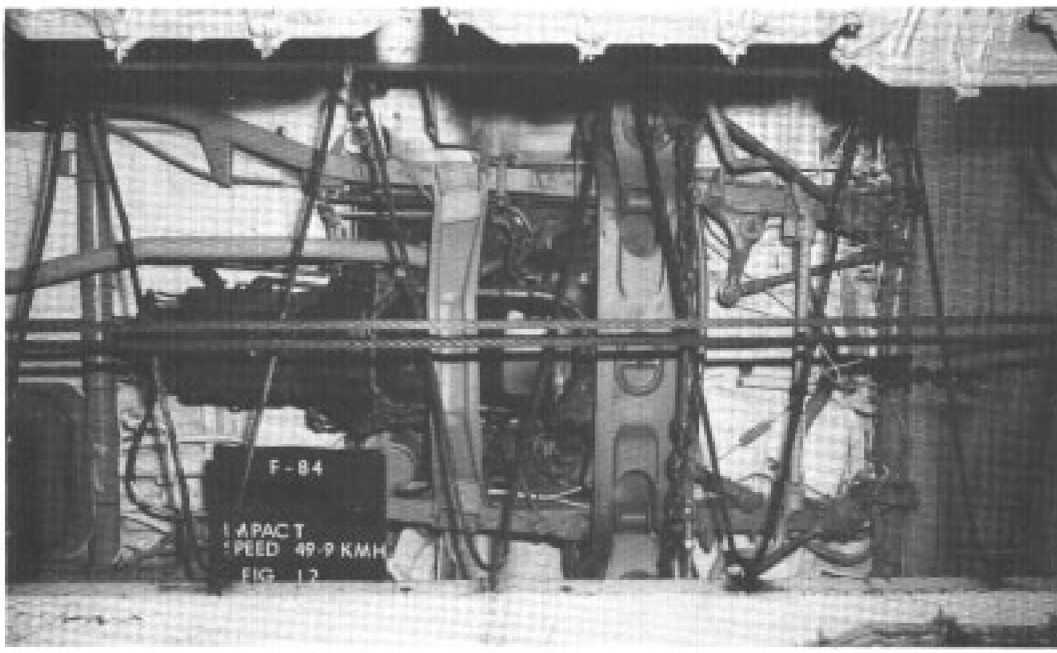


Figure C15: Test F84, Underside view of front of vehicle -- post-test

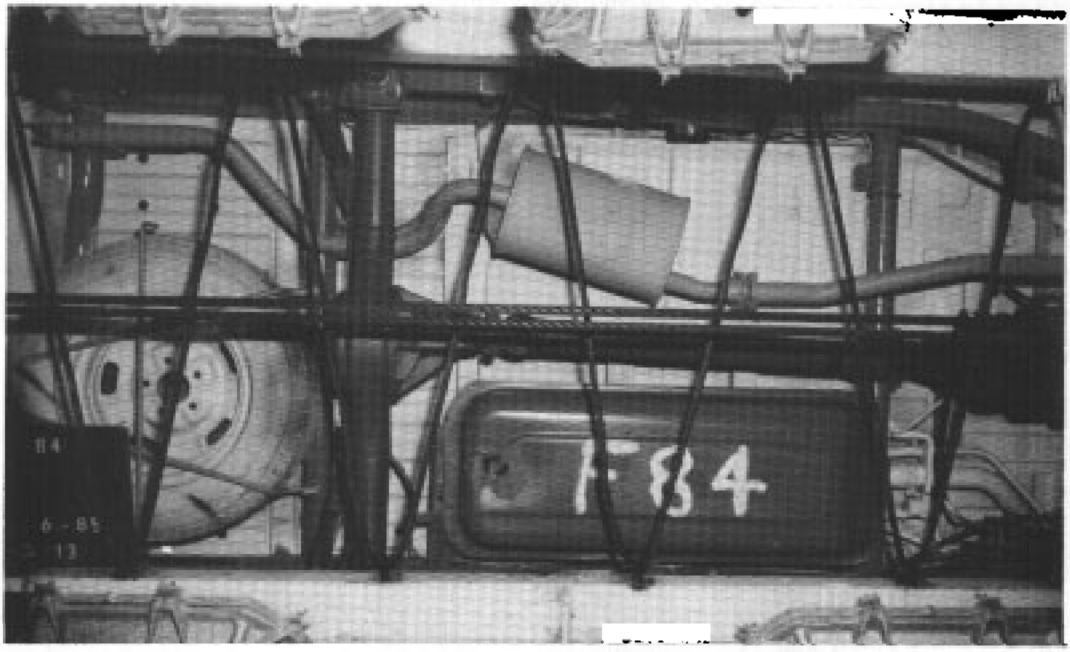


Figure C16: Test F84, Underside view of rear of vehicle -- pre-test

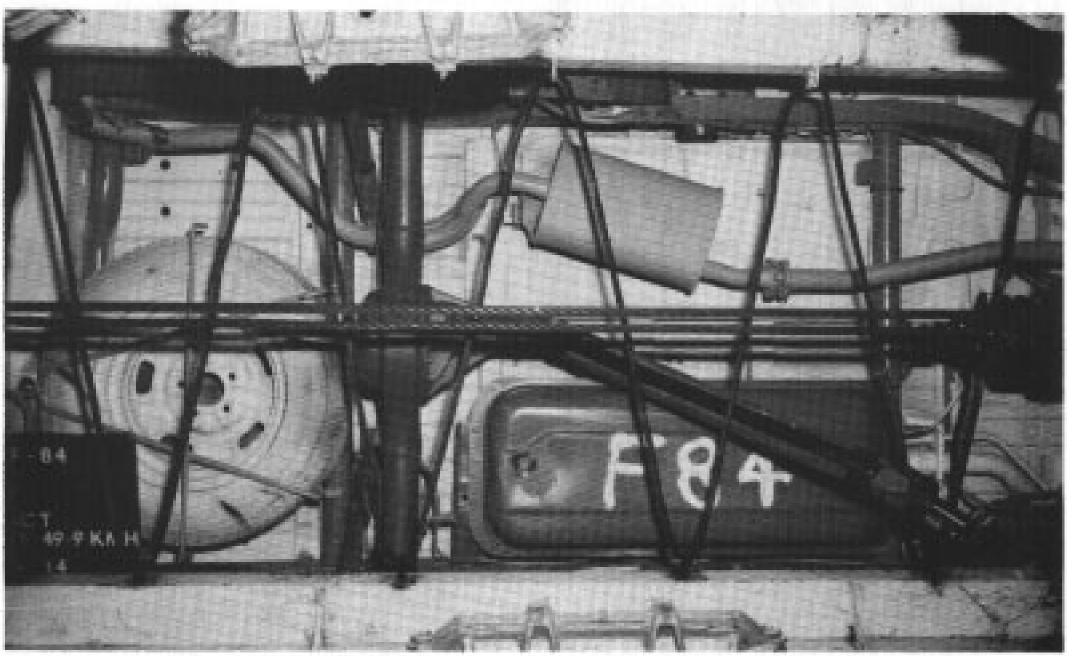


Figure C17: Test F84, Underside view of rear of vehicle -- post-test

F84

MEASUREMENT POINT DESCRIPTION		PRE TEST Horiz	PRE TEST Vert	POST TEST Horiz	POST TEST Vert	DISPLACEMENT Horiz	DISPLACEMENT Vert
Dash panel features							
Rearmost Point							
	Right	2111	609	1921	623	190	14
	Centre	2128	594	1934	615	194	21
	Left	2129	588	1932	595	197	7
Dash mounting screw	Right	2140	573	1947	618	193	45
Dash metal structure	Left	2161	590	1969	606	192	16
Head light mount screw							
	Left	2404	313	2120	314	284	3
Front panel at height of brake pedal							
	Right	2537	35	2287	116	250	81
	Left	2533	85	2252	108	281	23
Steering column lower bracket							
	Right	2415	46	2115	18	300	-28
	Left	2340	6	2081	-58	259	-64
Steering column nut		1931	604	1775	623	156	21
Steering column upper bracket bolt							
	Right	2091	431	1865	444	226	11
	Left	2091	431	1863	449	228	18
Engine (tappet cover bolt)		1446	211	1461	195	-15	-16
Seat belt anchorages							
Drivers seat							
	Outer lap	1411	173	1389	172	22	-1
	Upper	1140	908	1128	902	12	-6
	Inertia reel	1236	392	1216	392	20	0
Outboard passenger							
	Outer lap	1405	173	1386	172	19	-1
	Upper	1140	908	1128	907	12	-1
	Inertia reel	1234	392	1215	391	19	-1
Seat anchorages							
Drivers seat							
	Right front	1818	146	1789	154	29	8
	Right rear	1451	139	1429	143	22	4
	Left front	1735	142	1712	135	23	-7
	Left rear	1551	146	1525	142	26	4
Passengers seat							
	Front right	1855	169	1824	185	31	16
	Front left	1845	120	1813	146	32	-26
	Rear left	1127	300	1107	300	20	0
	Rear centre	1127	300	1107	300	20	0
	Rear right	1127	300	1107	299	20	1
LH sunvisor mount		2019	1106	1990	1196	29	86
RH sunvisor mount		2030	1109	1995	1217	35	108
Rear vision mirror mount		2031	1109	2000	1210	31	101
H point							
	Driver	1501	313	-	-	-	-
	Passenger	1520	313	-	-	-	-
Width between A pillars		1478	-	-	-	-	-

Floor to roof height at H point							
	Driver	-	1041	-	1077	-	30
	Passenger	-	1041	-	1070	-	29
Length of foot well at Centreline							
	Passenger	680	-	385	-	295	-
	Driver	600	-	360	-	240	-
Brake pedal to bulkhead		380	-	167	-	213	-
Clutch pedal to bulkhead		375	-	130	-	245	-
Front of vehicle to B pillar							
	Left	1500	-	1220	-	280	-
	Right	1500	-	1206	-	294	-
Steering column		440	-	325	-	115	-
Rebound							
	Right	-	-	400	-	-	-
	Left	-	-	410	-	-	-

Body side targets			**Horiz Right**	**Horiz Left**	**Horiz Right**	**Horiz Left**
	250		56	107	194	143
	500		271	313	229	182
	750		521	555	229	195
	1000		771	794	229	206
	1250		1016	1039	234	211
	1500		1206	1225	294	275
	1750		1456	1475	294	275
	2000		1706	1725	294	275
	2250		1956	1975	294	275
	2500		2206	2225	294	275
	2750		2453	2475	297	275
	3000		2703	2725	297	275
	3250		2953	2975	297	275
	3500		3203	3225	297	275
	3750		3453	3475	297	275

APPENDIX D

TEST REPORT

Test Order No.	T6754
Date of Order	1.5.85
Program No.	505
System No.	00.00
Date of Test	20.6.85

Subject: Evaluation - Barrier crash F85

Vehicle description:

Vehicle #:	YR 21-0023142	
Engine	2.0 litre I4	
Transmission:	5 Speed floorshift manual	
Steering column:	Tilt-adjustable	
Wheels & tyres:	Steel, 185/70SR14	
Actual test mass	Frt	845
	Rr	538
	Total	1383 Kg

Procedure:

1. The test was conducted in accordance with SAE Recommended Procedure J850 - Barrier Collision Tests.

2. The vehicle was weighted to the required test mass of 1285 kg and 31 kg of water was added to the fuel tank. The 68 kg test dummy was then fitted to the vehicle to achieve the actual test mass of 1383 kg.

Results:

Dynamic steering column intrusion was analysed using the right main camera. This camera was knocked prior to test and therefore analysis of the first 15 milliseconds could not be achieved using standard methods. The roof reference strip was also obscured which required using the door mounted targets as the scale of reference strip. This required a correction of 3% in the raw data.

The two sets of date were analysed to give the dynamic intrusion of the target 300 mm above the end of the steering column shaft and the target 150 mm above the end of the steering column shaft. The 300mm and 150mm target are directly in line with the steering column shaft. By determining the difference between the two targets and adding to or subtracting from the 150 mm target position, the position of the steering shaft is determined.

Two methods were used to determine column movement during the first 15 milleseconds. One used the left main camera with appropriate corrections for the increased depth of field, the other used the right main camera but use the reference target on the door rather than one of the "B" pillar which was not visible. During this time, the steering shaft intrusion was 10mm forward.

The derived column shaft intrusion from 15 milliseconds after impact was 90 mm. This value is increased by 3% to 93 mm.

The minus 10 mm intrusion measured from the left main camera is added to this figure to give a maximum actual intrusion of 83 mm at the impact speed of 49.3 Km/h. When corrected back to 48.0 km/h the dynamic rearward longitudinal intrusion of the end of the steering column shaft was 79 mm. Bearing in mind the errors introduced by the problems discussed above an estimated error for this figure is ± 10 mm.

Figure D1 shows the dynamic movements (vertically and horizontally) and the derived position of the steering shaft end.

Figure D2 shows the load-v-time traces of the front passenger lap and sash seat belt loads. Figure D3 shows the deceleration-v-time traces of the left and right "B" pillar bases.

Static pre- and post-test measurements are shown below. The internal vehicle datum is 20 mm forward of the seatbelt floor anchorages for the second row of seats and 3 mm above floor level. Positive displacement is horizontally rearwards or vertically upwards.

Figures D4 to D17 are pre- and post-test photographs of the vehicle.

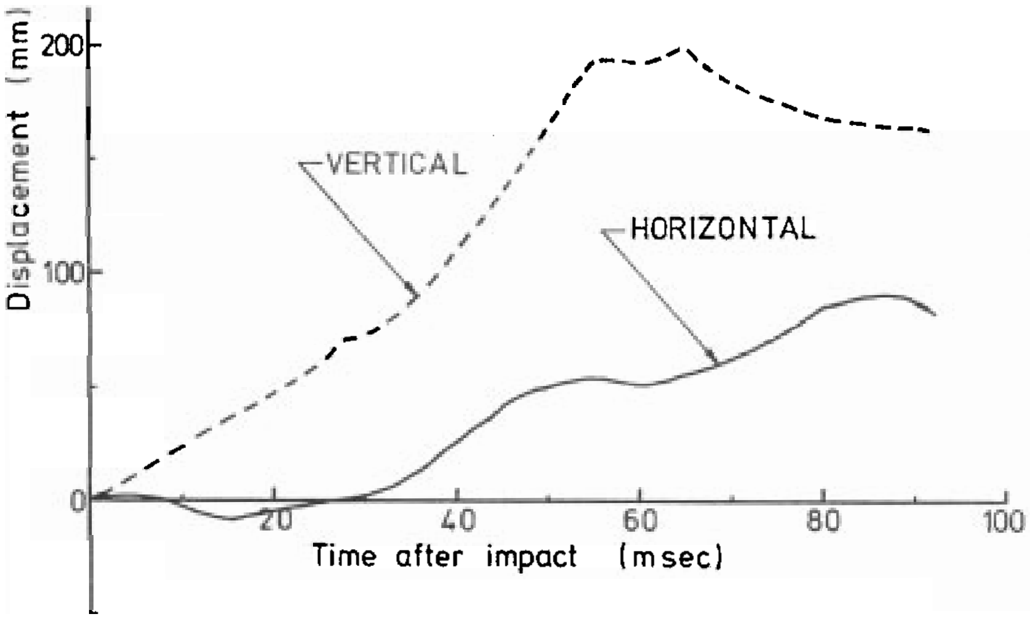


Figure D1: Test F85, Steering column intrusion during impact. Displacements shown are relative to the vehicle's B-pillar

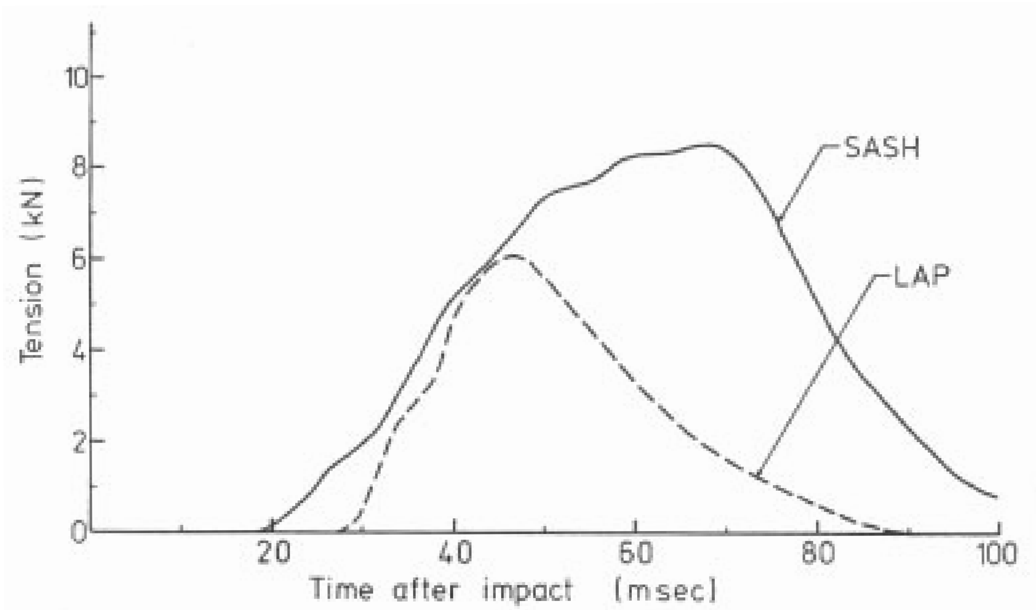


Figure D2: Test F85, Front outboard passenger seat belt loads during impact

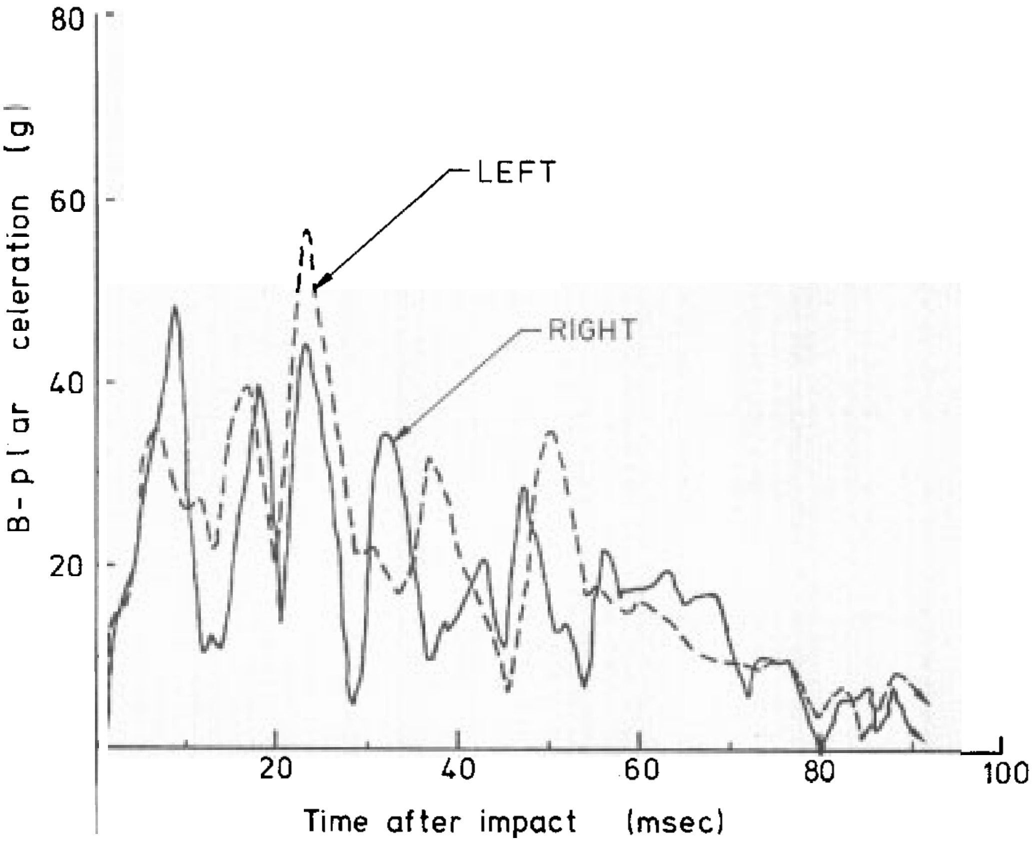


Figure D3: Test F85, Occupant compartment acceleration during impact

Figure D4: Test F85, Front-quarter view of vehicle -- pre-test

Figure D5: Test F85, Front-quarter view of vehicle -- post-test

Figure D6: Test F85, Right hand side view of vehicle -- pre-test

Figure D7: Test F85, Right hand side view of vehicle -- post-test

Figure D8: Test F85, Left hand side view of vehicle -- pre-test

Figure D9: Test F85, Left hand side view of vehicle -- post-test

Figure D10: Test F85, Occupant compartment interior -- pre-test

Figure D11: Test F85, Occupant compartment interior -- post-test

Figure D12: Test F85, Rear view of vehicle interior -- pre-test. Auxilliary brake components for test abort system are visible in the foreground

Figure D13: Test F85, Rear view of vehicle interior -- post-test

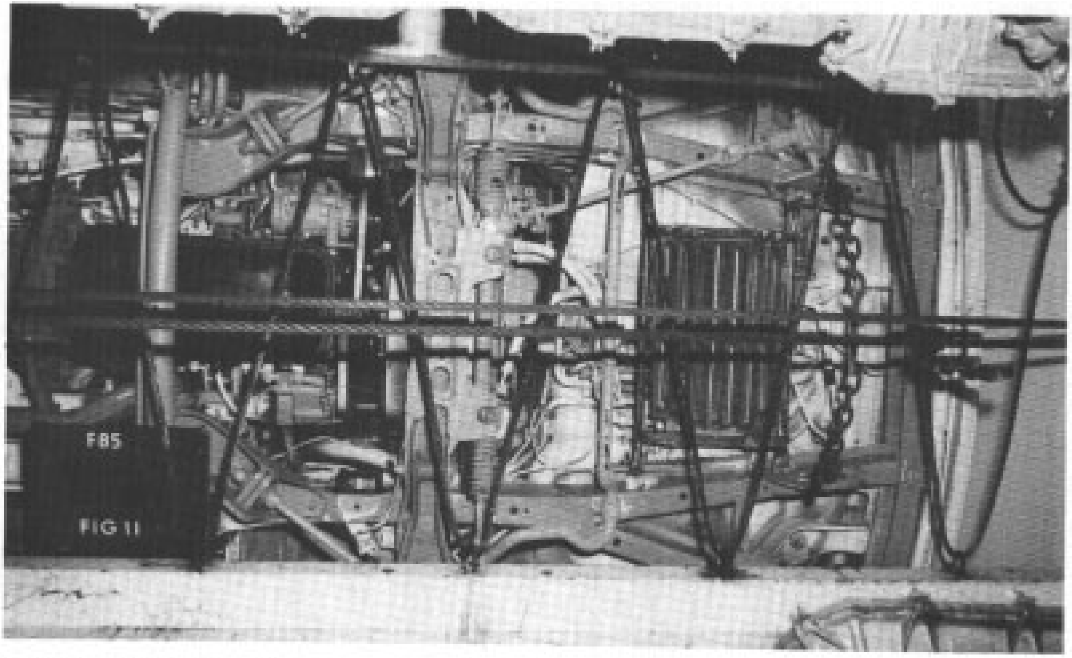


Figure D14: Test F85, Underside view of front of vehicle -- pre-test

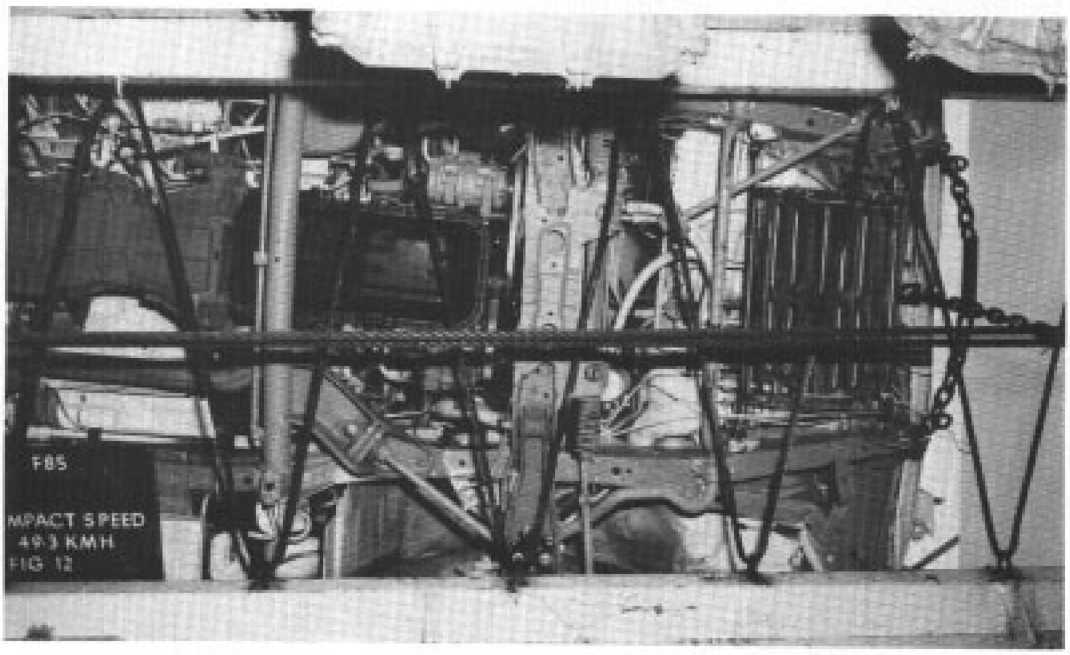


Figure D15: Test F85, Underside view of front of vehicle -- post-test

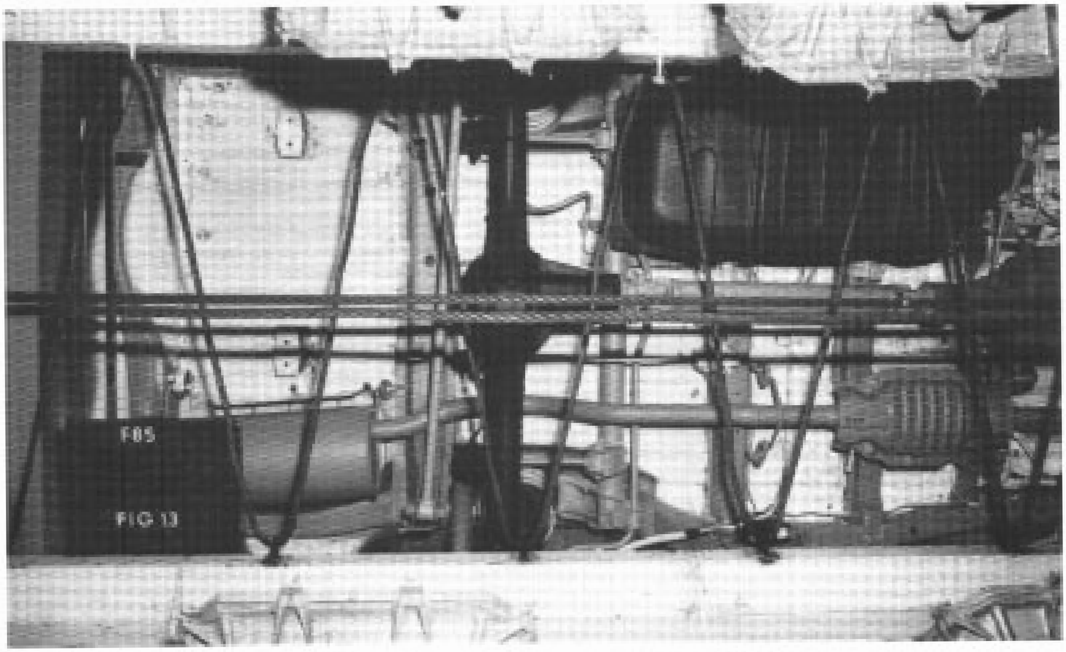


Figure D16: Test F85, Underside view of rear of vehicle -- pre-test

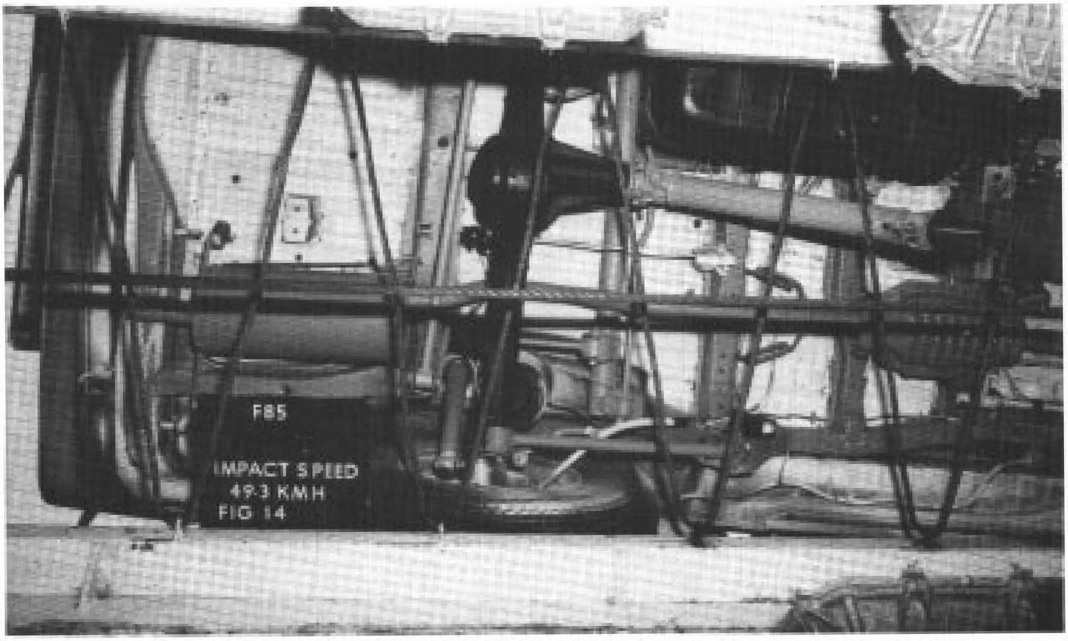


Figure D17: Test F85, Underside view of rear of vehicle -- post-test

F85

MEASUREMENT POINT DESCRIPTION		PRE TEST Horiz	PRE TEST Vert	POST TEST Horiz	POST TEST Vert	DISPLACEMENT Horiz	DISPLACEMENT Vert
Dash panel features							
	Right	2136	560	2081	745	55	185
	Binnacle	2112	727	2130	900	-18	173
	Centre	2140	507	2090	625	50	118
	Left	2150	559	2119	635	31	76
Dash panel mount screw holes upper							
	1 Right	2380	644	2335	640	45	-4
	2	2440	650	2387	642	53	-8
	3 Centre	2455	650	2412	660	10	43
	4	2437	647	2390	660	47	13
	5 Left	2373	634	2348	650	25	16
Headlight holes							
	Right	2505	221	2333	285	172	64
	Left	2534	173	2357	220	177	47
Front panel at height of brake pedal		2539	148	2319	179	220	31
Pedal bracket bolts (to body)							
	Right	2409	566	2379	335	30	-231
	Left	2440	573	2420	370	20	-203
Column to pedal bracket bolts							
	Right	2326	313	2225	380	101	67
	Left	2324	313	2225	380	99	67
Steering column upper bracket bolts							
	Right	2139	460	2085	531	54	71
	Left	2140	460	2084	531	56	71
Steering column floor mount bolts							
	Right	2416	3	2335	10	81	7
	Left	2463	18	2365	20	98	2
Steering column nut		1976	610	1928	657	48	65
LHD steering column pressing		2372	-15	2329	-65	43	-50
Screws on either side of heater case							
	Right	2569	126	2298	190	271	64
	Left	2569	126	2292	175	277	49
Seat belt anchorages							
Drivers seat belt							
	Outer lap	1394	150	1397	167	-3	17
	Buckle	1493	200	1510	200	-17	0
	Upper "B" pillar	1127	674	1145	865	-18	-9
	Inertia reel	1090	390	1115	390	-25	0
Passenger seat belt							
	Outer lap	1398	191	1406	150	-8	41
	Buckle	1460	210	1509	275	-49	65
	Upper "B" pillar	1126	870	1178	865	-52	-5
	Inertia reel	1070	370	1110	400	-40	30
Seat anchorages							
Driver's seat							
	Front right	815	180	807	150	8	-30
	Front left	867	195	882	135	-15	-60
	Rear right	430	170	421	160	9	-10

	Rear left	520	170	527	135	-7	-35
Passenger's seat							
	Front right	880	215	870	132	10	-83
	Front left	785	185	805	207	-20	22
	Rear right	481	180	495	205	-14	25
	Rear left	440	160	435	205	5	45
Sunvisor screws							
	Right	1794	1200	1805	1158	-11	-42
	Left	1800	1180	1810	1160	-10	-20
H Point		1474	321	-	-	-	-
H Point to pedal		793	-	430	-	363	-
H Point to instrument panel		555	-	-	-	-	-
Width between "A" pillars		1403	-	1417	-	14	-
Floor lengths							
	Right	621	-	395	105	226	105
	Centre	600	-	360	35	240	35
	Left	617	-	420	190	197	190
Floor to roof heights, H Point plane							
	Right	-	972	-	1050	-	78
	Centre	-	890		960	-	70
	Left		950		1025	-	75
Steering column to datum 2 (direct distance)		3065	-	3043		22	-
Front of vehicle to "B" pillar target							
	Right	1647		1303	-	344	-
	Left	1636	-	1289	-	347	-
Front of vehicle to "C" pillar target							
	Right	2909	-	2564	-	345	
Transverse distance column to **"B" pillar target**							
	Right	260	-	-	-	-	-
	Left	950	-	-	-	-	-
Longitudinal distance column to "B" pillar target							
	Right	520	-			-	-
	Left	530	-		-	-	
Column to vehicle centreline		400	-			-	-
Tranverse distance camera to barrier line							
	Right	10500	-	-		-	-
	Left	10900	-	-	-	-	-
Rebound distance							
	Right	-	-	1390	-	-	-
	Left	-	-	1320		-	-

Body side targets		Horiz Right	Horiz Left	Horiz Right	Hori Left
	250	125	143	125	107
	500	170	220	330	280
	750	444	440	306	310
	1000	694	689	306	311
	1250	944	939	306	311
	1500	1197	1188	303	312
	1750	1420	1414	330	336
	2000	1663	1661	337	339
	2250	1914	1913	336	337
	2500	2164	2163	336	337
	2750	2414	2415	336	335
	3000	2665	2660	335	340
	3250	2915	2914	335	336
	3500	3165	3164	335	336
	3750	3415	3412	335	338
	4000	3665	3663	335	337

APPENDIX E

TEST REPORT

Test Order No.	T6794
Date of Order	1.5.85
Program No.	505
System No.	00.00
Date of Test	4.7.85

Subject: Evaluation - Barrier crash F86

Vehicle description:

Vehicle #:	JAB WFR 111 F4 317630	
Engine	1.8 Litre I4	
Transmission:	5 Speed column Manual	
Steering Column:	Non-Adjustable	
Wheels & Tyres:	Steel, 185SR15	
Actual Test Mass	Frt	859
	Rr	676
	Total	1535 kg

Procedure:

1. The test was conducted in accordance with SAE Recommended Procedure J850 - Barrier Collision Tests.

2. The vehicle was weighted to the required test mass of 1463 kg. The 72 kg test dummy was then fitted to the vehicle to achieve the actual test mass of 1535 kg.

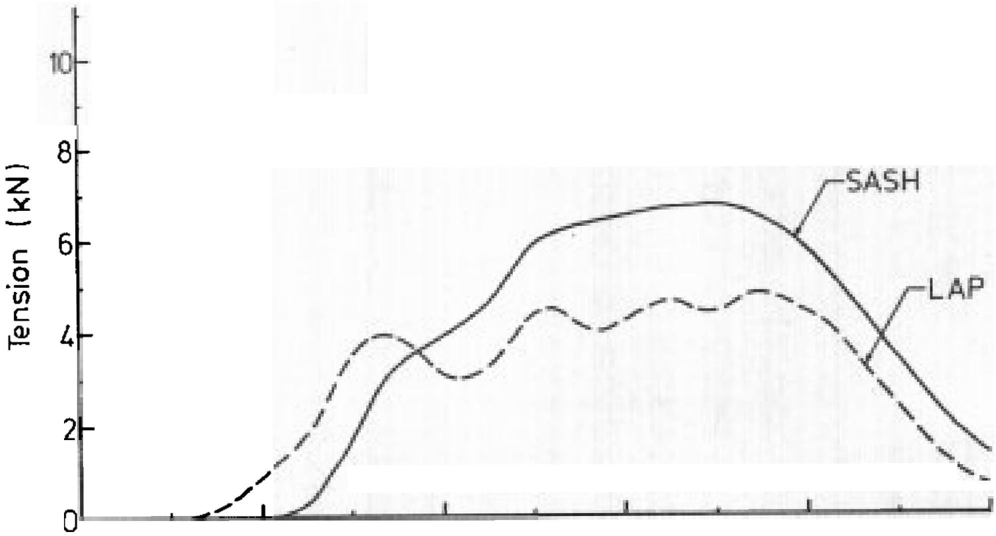
Results:

The dynamic displacement of the steering column could not be determined as the target array attached to the end of the steering column was dislodged on impact. This negated any possibility of analysing the film.

Figure E1 shows the load-v-time traces of the front passenger lap and sash seat belt loads.Figure E2 shows the deceleration-v-time traces of the left and right "B" pillar bases.

Static pre- and post-test measurements are shown below. The internal vehicle datum is 20 mm forward of the seat belt anchorages for the second row of seats and 3 mm above floor level. Positive displacement is horizontally rearwards or vertically upwards.

Figures E3 to E16 are pre- and post-test photographs of the vehicle.


10
8
6
4
2
0
Tension (kN)
SASH
LAP

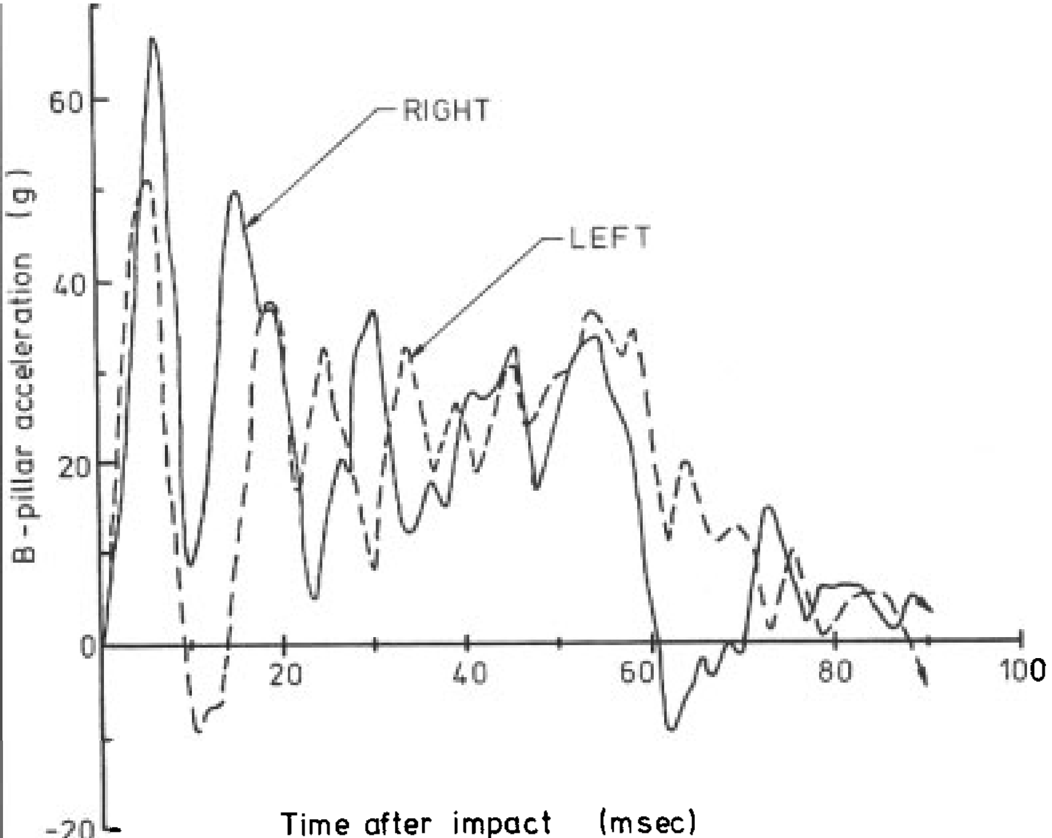


Figure E2: Test F86, Occupant compartment acceleration during impact

Figure E3: Test F86, Front-quarter view of vehicle -- pre-test

Figure E4: Test F86, Front-quarter view of vehicle -- post-test

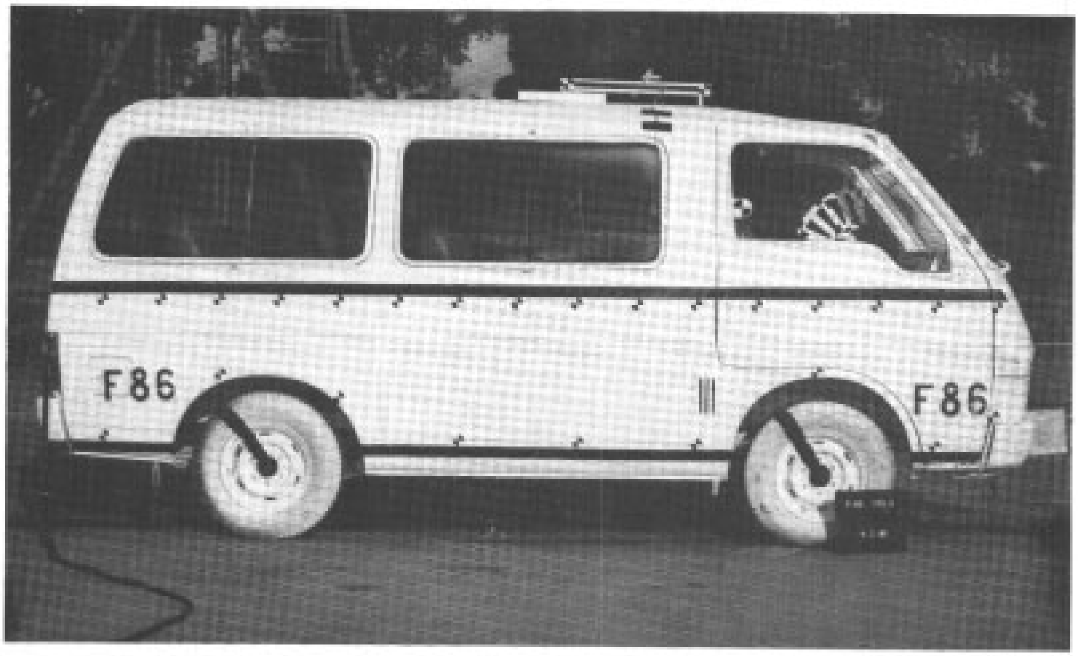


Figure E5: Test F86, Right hand side view of vehicle -- pre-test

Figure E6: Test F86, Right hand side view of vehicle -- post-test

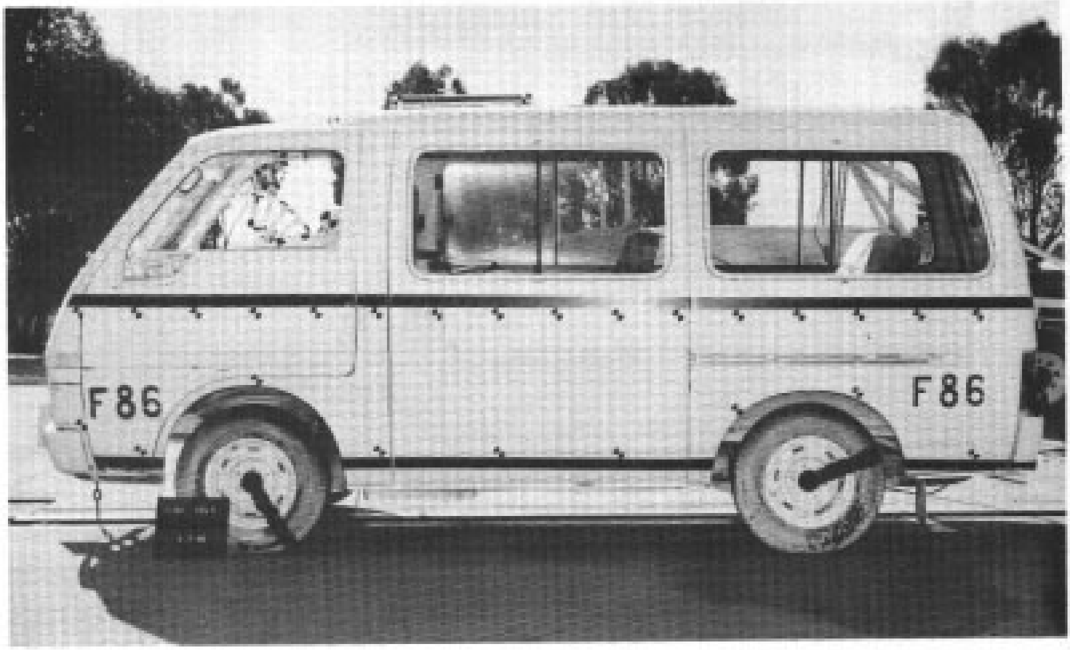


Figure E7: Test F86, Left hand side view of vehicle -- pre-test

Figure E8: Test F86, Left hand side view of vehicle -- post-test

Figure E9: Test F86, Occupant compartment interior -- pre-test

Figure E10: Test F86, Occupant compartment interior -- post-test

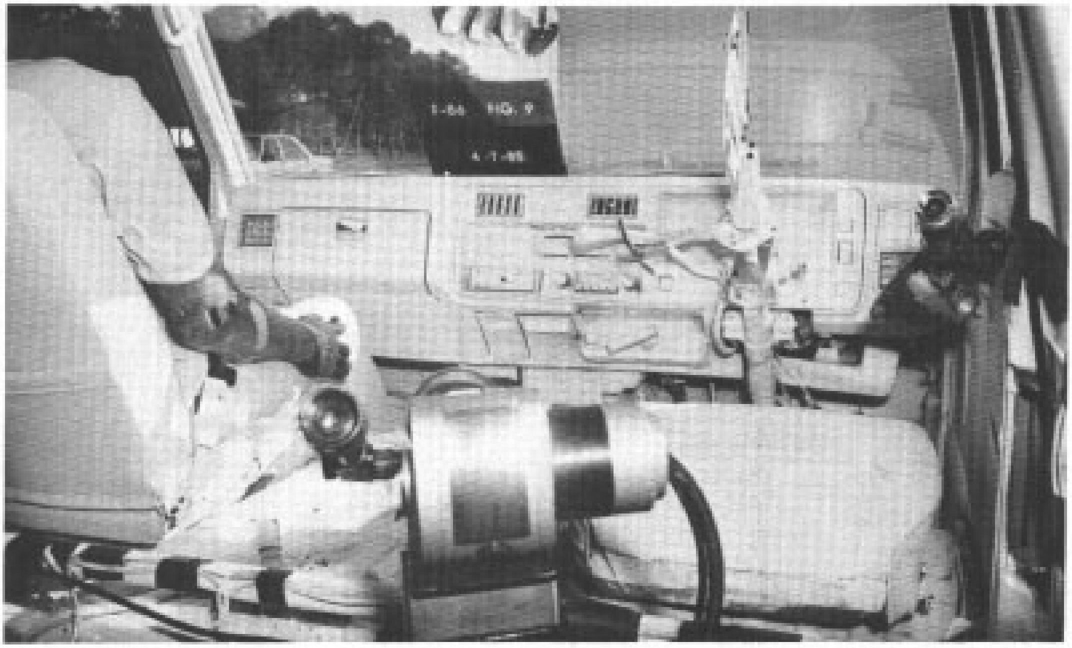


Figure E11: Test F86, Occupant compartment interior viewed from the rear -- pre-test

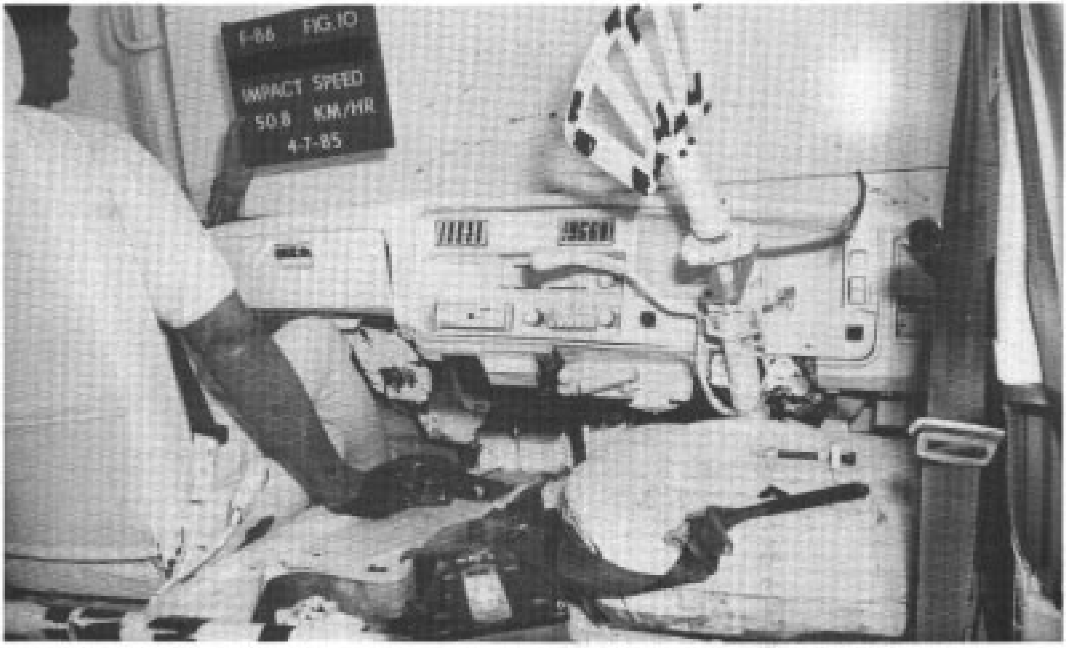


Figure E12: Test F86, Occupant compartment interior viewed from the rear -- post-test

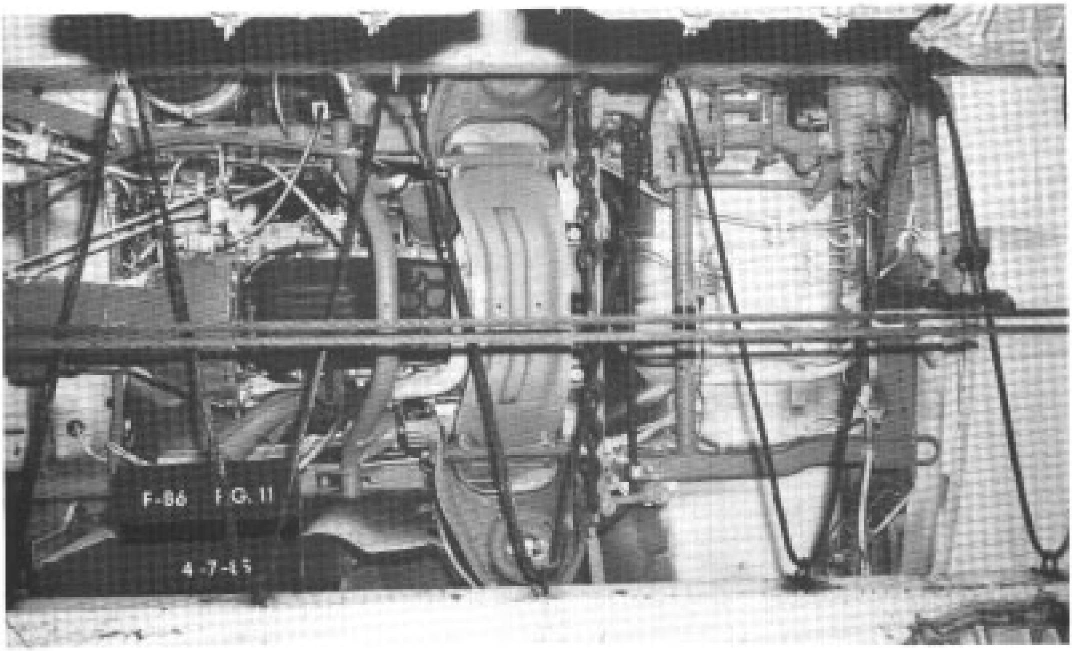


Figure E13: Test F86, Underside view of front of vehicle -- pre-test

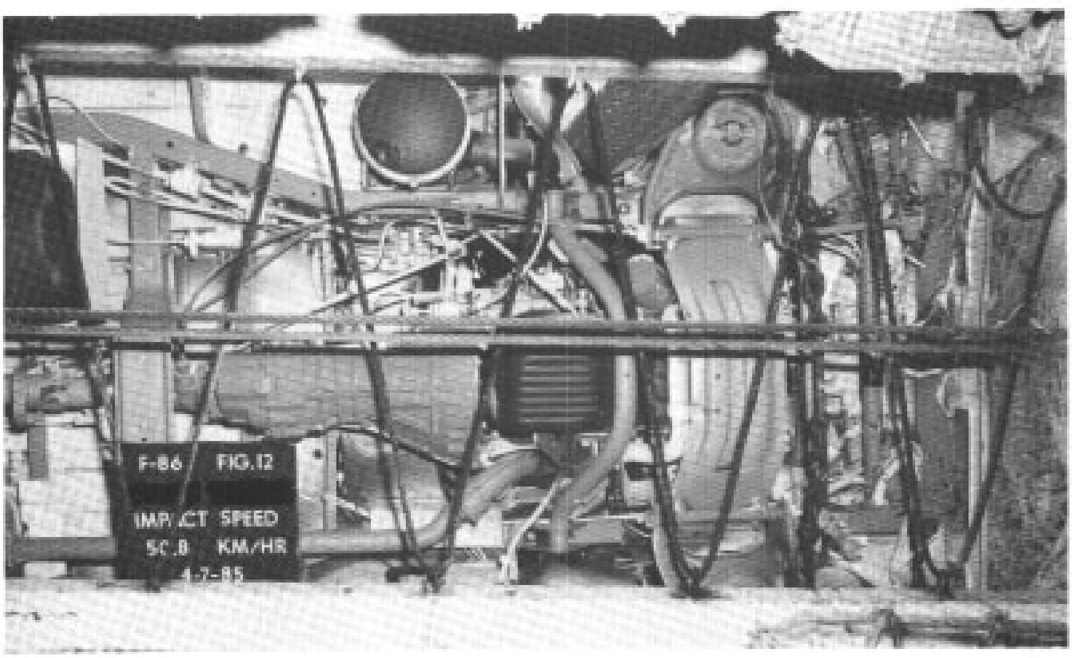


Figure E14: Test F86, Underside view of front of vehicle -- post-test

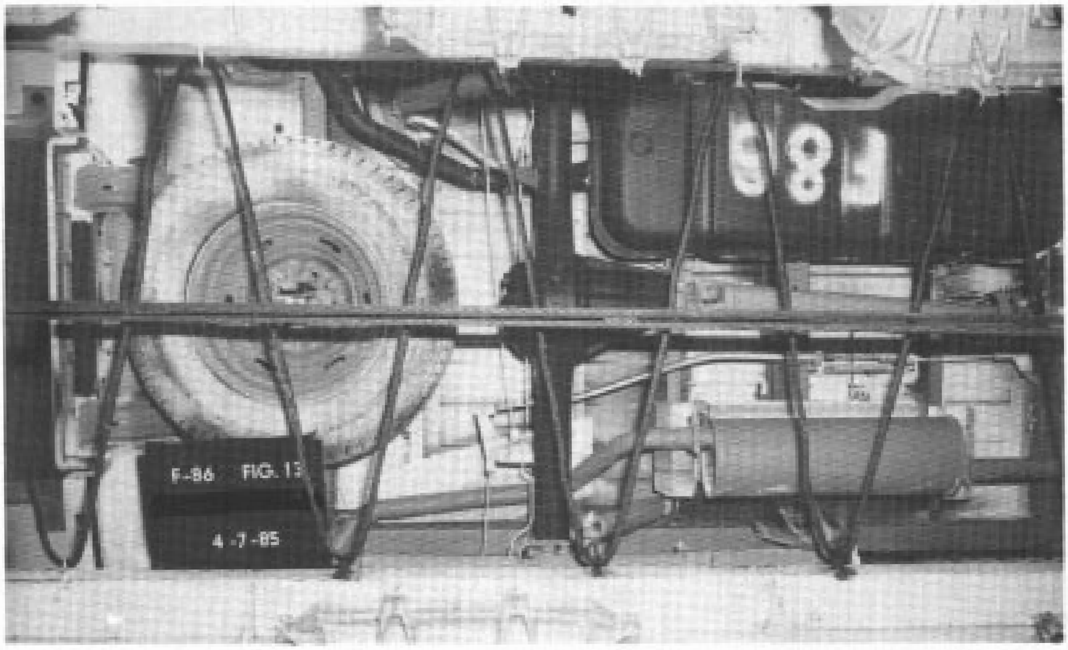


Figure E15: Test F86, Underside view of rear of vehicle -- pre-test

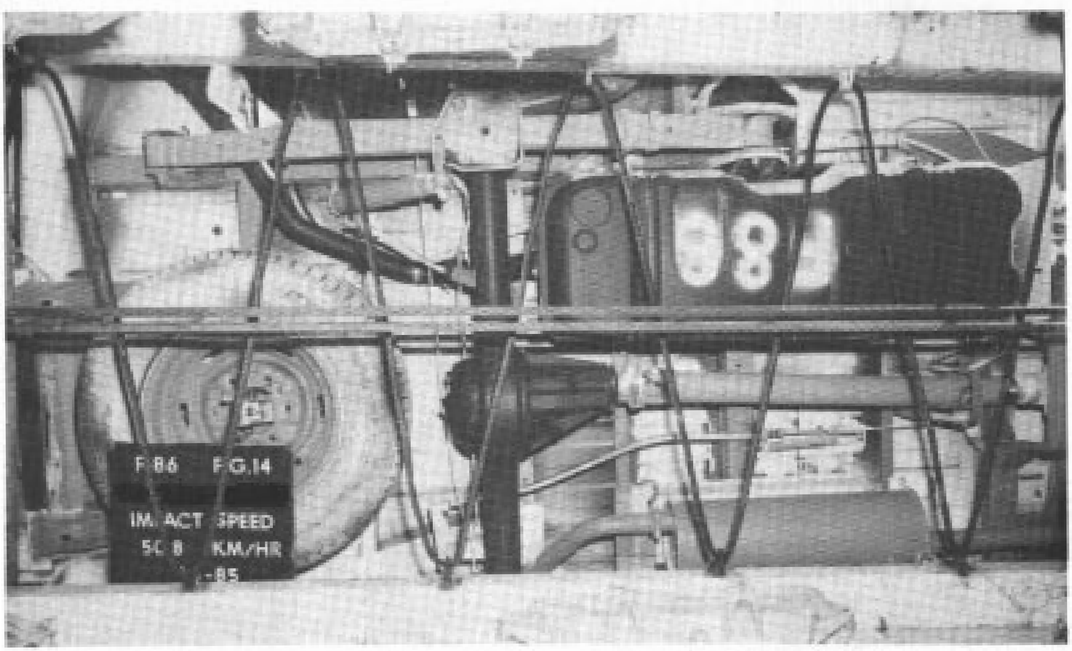


Figure E16: Test F86, Underside view of rear of vehicle -- post-test

F86

MEASUREMENT POINT DESCRIPTION		PRE TEST Horiz	PRE TEST Vert	POST TEST Horiz	POST TEST Vert	DISPLACEMENT Horiz	DISPLACEMENT Vert
Dash panel features							
	Right	2072	706	1973	692	279	-14
	Centre	2072	706	1856	753	216	47
	Left	2072	706	1840	683	232	-23
Upper dash panel mount screw holes							
	Right	2293	616	2002	559	291	-57
	2	2334	616	2040	572	294	-44
	3 Centre	2345	621	2063	585	282	-36
	4	2338	612	2063	580	275	-32
	5 Left	2297	612	2055	567	242	-45
Lower mount bolts							
	Right	2229	475	1944	447	285	-28
	Left	2245	474	2008	421	237	-53
Front panel features - dimples							
	Right	2437	290	2047	230	390	-60
	Right of Centre	2482	267	2076	235	406	-32
	Left of Centre	2488	242	2049	235	439	-7
	Left	2438	270	2093	218	345	-52
Access panel left side of vehicle		2478	278	2065	234	413	-44
Heater housing lower bolts							
	Right	2280	91	-	-	-	-
	Left	2280	91	-	-	-	-
Front panel at height of brake pedal		2415	196	1998	141	417	-55
Brake pedal		2130	194	1825	150	305	-44
Engine		1410	223	1455	225	-45	-2
Pedal bracket bolts to body							
	Upper	2329	608	2025	561	304	-47
	Lower	2427	208	2077	140	350	-68
Column to pedal bracket bolts							
	Right	1982	454	1717	493	265	39
	Left	1984	454	1733	492	251	38
Column floor mount bolts							
	Right	2297	115	1971	58	326	-57
	Left	2269	107	1947	40	322	-67
Column nut		1786	652	1573	704	213	52
Seat belt anchorages							
Drivers seat belt							
	Outer lap	1191	205	1181	214	10	9
	Buckle	1159	308	1192	290	-33	-18
	Upper "B" pillar	1028	1005	1018	1005	10	0
	Inertia reel	1065	432	1056	432	9	0
Centre seat belt							
	Right	1205	312	1230	295	-25	-17
	Left	1198	308	1192	290	6	-18
Passenger seat belt							
	Outer lap	1186	210	1192	225	-6	15
	Buckle	1148	300	1145	290	3	-10
	Upper "B" pillar	1028	1000	1066	995	-38	-5
	Inertia reel	1065	425	1084	425	-19	0

Seat anchorages							
Drivers seat							
	Front right	1732	255	1724	243	8	-12
	Rear right	1397	230	1392	233	5	3
Left side of seat slide only							
Passengers seat							
	Front right	1780	225	1778	202	2	-23
	Front left	1780	225	1769	146	11	-79
Rear right slide only							
	Rear left	1334	220	1341	220	-7	0
Sunvisor screws							
	Right	1785	1210	1790	1227	-5	17
	Left	1782	1210	1812	1225	-30	15
H Point		1355	390	-	-	-	-
H Point to brake pedal		755	-	450	-	305	-
H Point to dash panel		590	-	310	-	280	-
Width between A Pillars		1446	-	1492	-	46	-
Floor lengths							
	Right	540	-	240	-	300	-
	Centre	585	-	-	-	-	-
	Left	530		222		308	
Floor to roof heights, H point plane							
	Right	-	940	-	942	-	2
	Centre	-	987	-	1035	-	52
	Left	-	940	-	962	-	22
Steering column to datum 2 (direct distance)		3201	-	2985	-	216	-
Front of vehicle to "B" pillar target							
	Right	1338	-	881	-	457	-
	Left	1311	-	881	-	330	-
Transverse distance column to "B" pillar							
	Right	314	-	-	-	-	-
	Left	1130	-	-	-	-	-
Longitudinal distance column to "B" pillar							
	Right	463	-	-	-	-	-
	Left	504	-	-	-	-	-
Column to vehicle centreline Rebound distance		400	-	-	-	-	-
	Right	-	-	250	-	-	-
	Left	-	-	185	-	-	-
Transverse distance camera to Barrier centreline							
	Right	10450	-	-	-	-	-
	Left	11720	-	-	-	-	-

Body side targets	Horiz Right	Horiz Left	Horiz Right	Horiz Left
250	0	0	250	250
500	146	136	354	364
750	394	385	356	365
1000	644	635	356	365
1250	892	884	358	366
1500	1070	1100	430	400
1750	1344	1356	406	394
2000	1594	1600	406	400
2250	1844	1847	406	403
2500	2094	2097	406	403
2750	2344	2347	406	403
3000	2594	2597	406	403
3250	2844	2847	406	403
3500	3094	3097	406	403
3750	3344	3347	406	403
4000	3594	3597	406	403

APPENDIX F

TEST REPORT

Test Order No.	T6793
Date of Order	1.5.85
Program No.	505
System No.	00.00
Date of Test	7.7.85

Subject: Evaluation - Barrier crash F87

Vehicle description:

Vehicle #:	SG MDFP 45533	
Engine	1.8 litre I4	
Transmission:	5 speed floorshift manual	
Steering column:	Non-adjustable	
Wheels & tyres:	Steel, 165 R14 LT	
Actual test mass	Frt	784
	Rr	593
	Total	1377 kg

Procedure:

1. The test was conducted in accordance with SAE Recommended Procedure J850 - Barrier Collision Tests.
2. The vehicle was weighted to the required test mass of 1305 kg. The 72 kg test dummy was then fitted to the vehicle to achieve the actual test mass of 1377 kg.

Results:

Dynamic steering column intrusion was analysed using the right main camera. The two sets of data were analysed to give the dynamic intrusion of the target 300 mm above the end of the steering column and the target 150 mm above the end of the steering column.

Both targets are directly in line with the steering column end. By determining the difference between the two targets and adding to or subtracting from the 150 mm target the dynamic intrusion of the steering column is determined.

The maximum derived steering shaft end intrusion is 499 mm at 51.0 km/h. When corrected back to 48 km/h the derived intrusion is 442 mm.

Figure F1 shows the dynamic movements (vertically and horizontally) of the derived position of the steering shaft end.

Figure F2 shows the load-v-time traces of the front passenger lap and sash seat belt loads.Figure F3 shows the deceleration-v-time traces of the left and right "B" pillar bases.

Static pre- and post-test measurements are shown below. The internal vehicle datum is 20 mm forward of the seat belt anchorages for the second row of seats and 3 mm above floor level. Positive displacement is horizontally rearward or vertically upwards.

Figures F4 to F17 are pre- and post-test photographs of the vehicle.

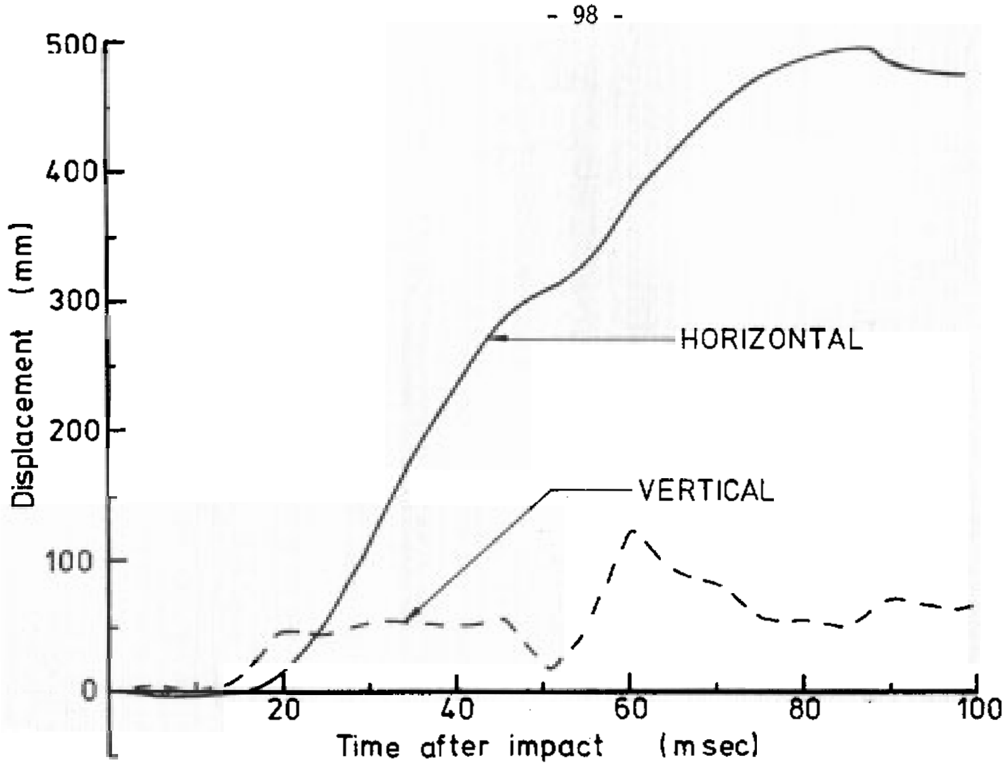


Figure F1: Test F87, Steering column intrusion during impact. Displacements shown are relative to the vehicle's B-pillar

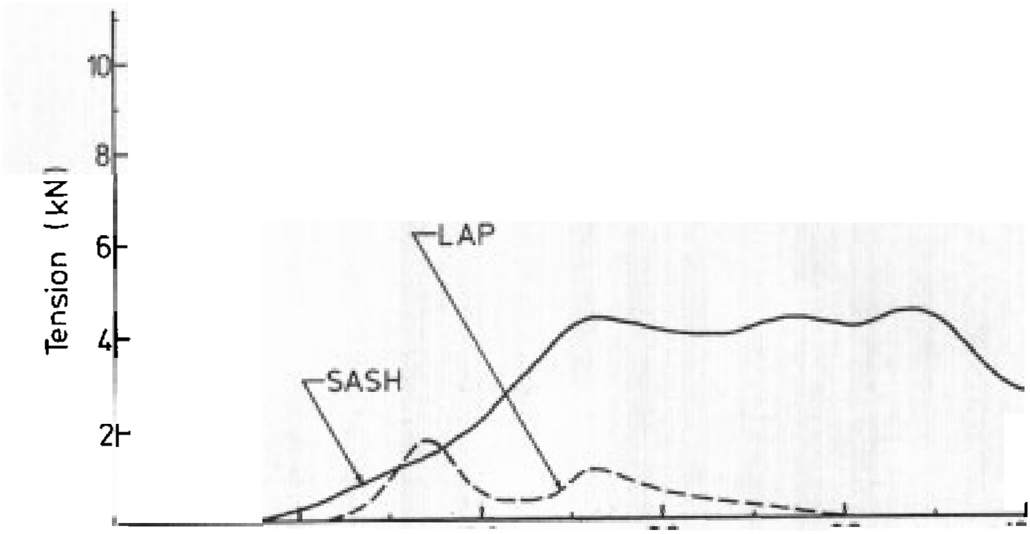


Figure F2: Test F87, Front outboard passenger seat belt loads during impact

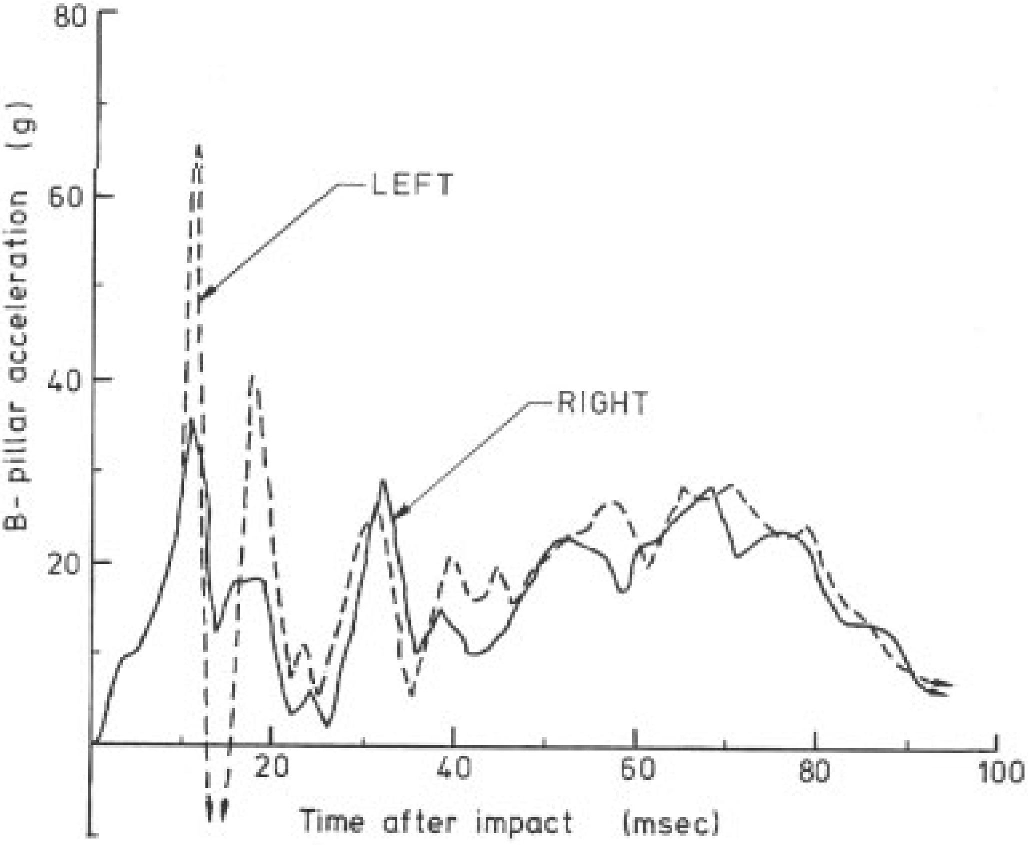


Figure F3: Test F87, Occupant compartment acceleration during impact.

Figure F4: Test F87, Front-quarter view of vehicle -- pre-test

Figure F5: Test F87, Front-quarter view of vehicle -- post-test

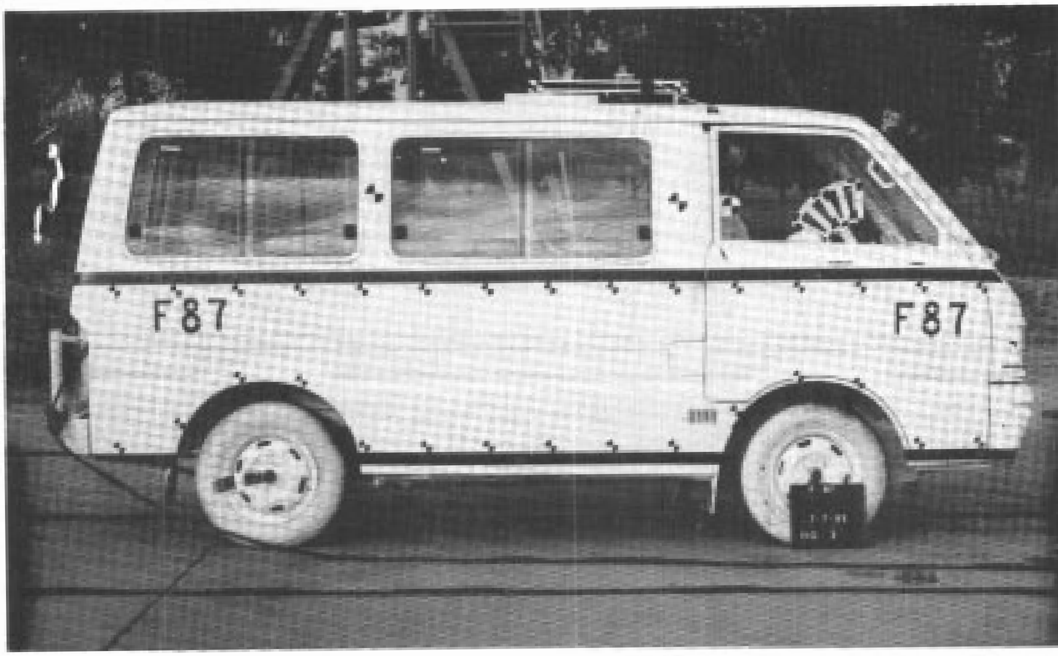


Figure F6: Test F87, Right hand side view of vehicle -- pre-test

Figure F7: Test F87, Right hand side view of vehicle -- post-test

Figure F8: Test F87, Left hand side view of vehicle -- pre-test

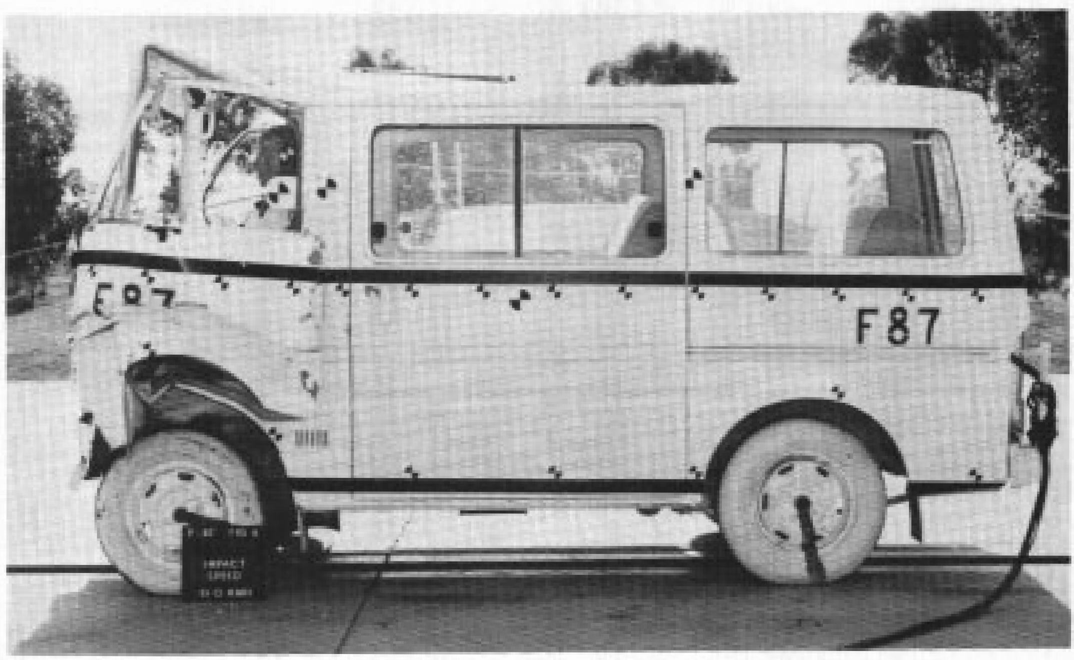


Figure F9: Test F87, Left hand side view of vehicle -- post-test

Figure F10: Test F87, Occupant compartment interior -- pre-test

Figure F11: Test F87, Occupant compartment interior -- post-test

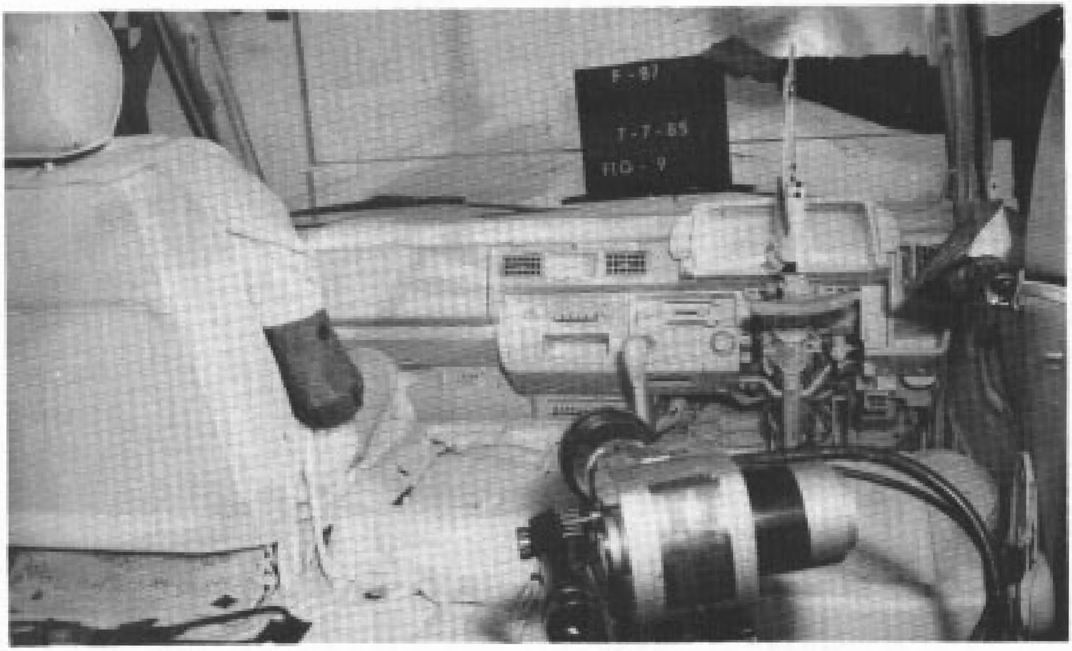


Figure F12: Test F87, Occupant compartment interior viewed from the rear -- pre-test

Figure F13: Test F87, Occupant compartment interior viewed from the rear -- post-test

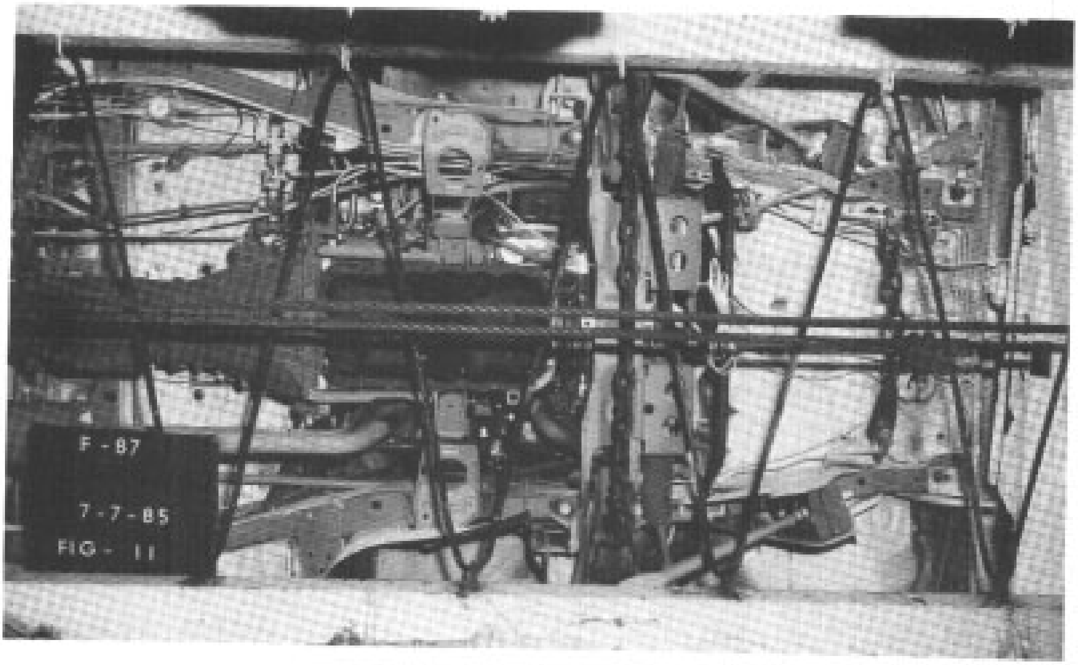


Figure F14: Test F87, Underside view of front of vehicle -- pre-test

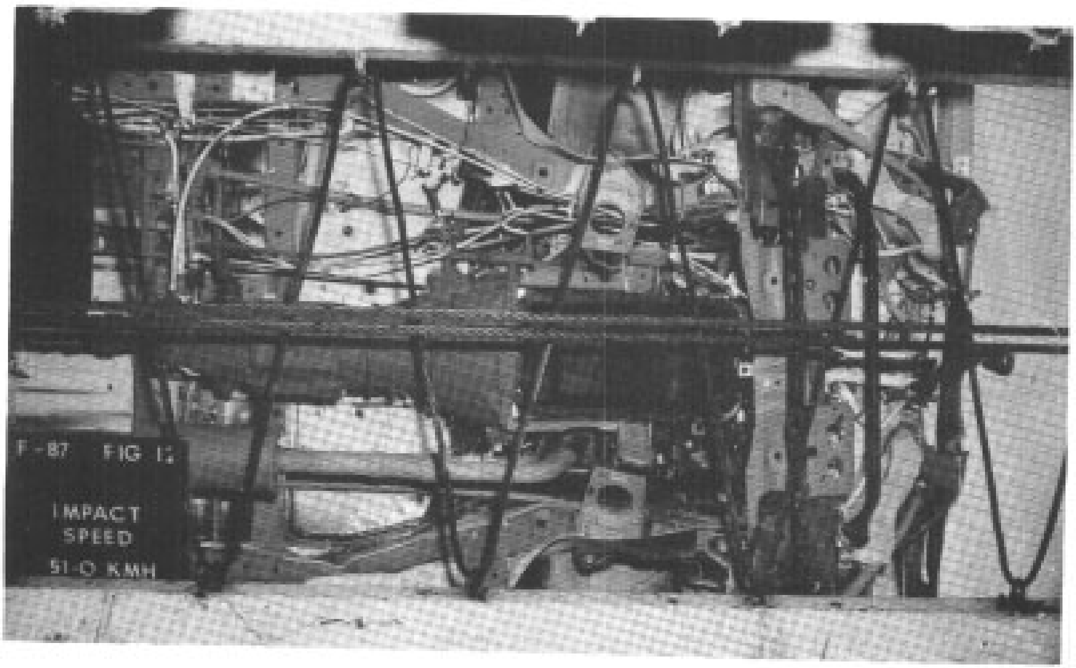


Figure F15: Test F87, Underside view of front of vehicle -- post-test

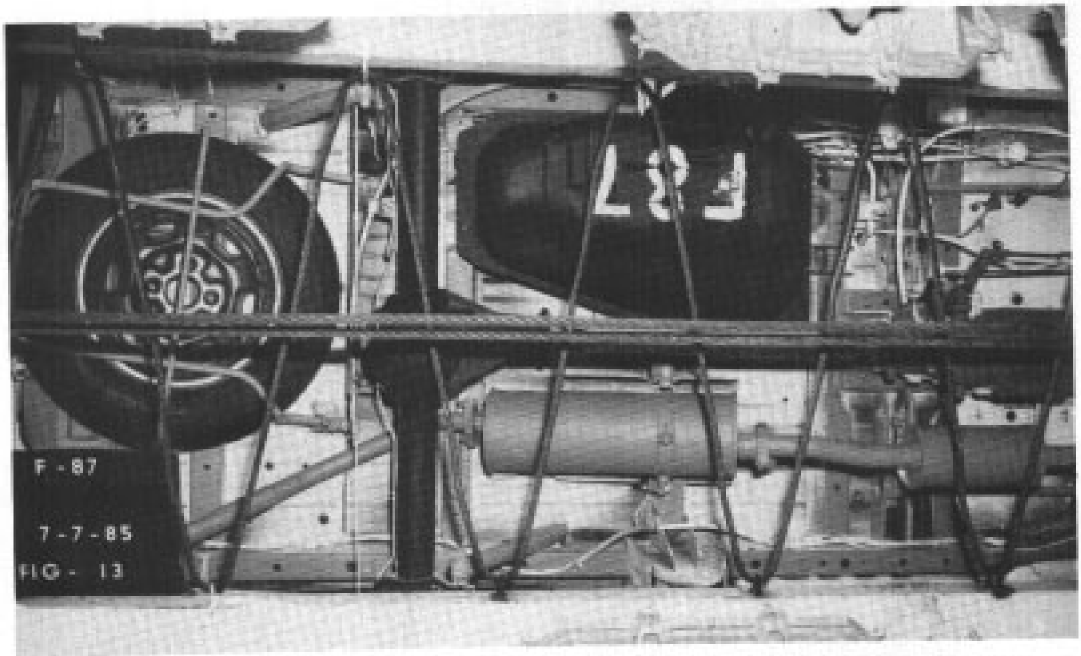


Figure F16: Test F87, Underside view of rear of vehicle -- pre-test

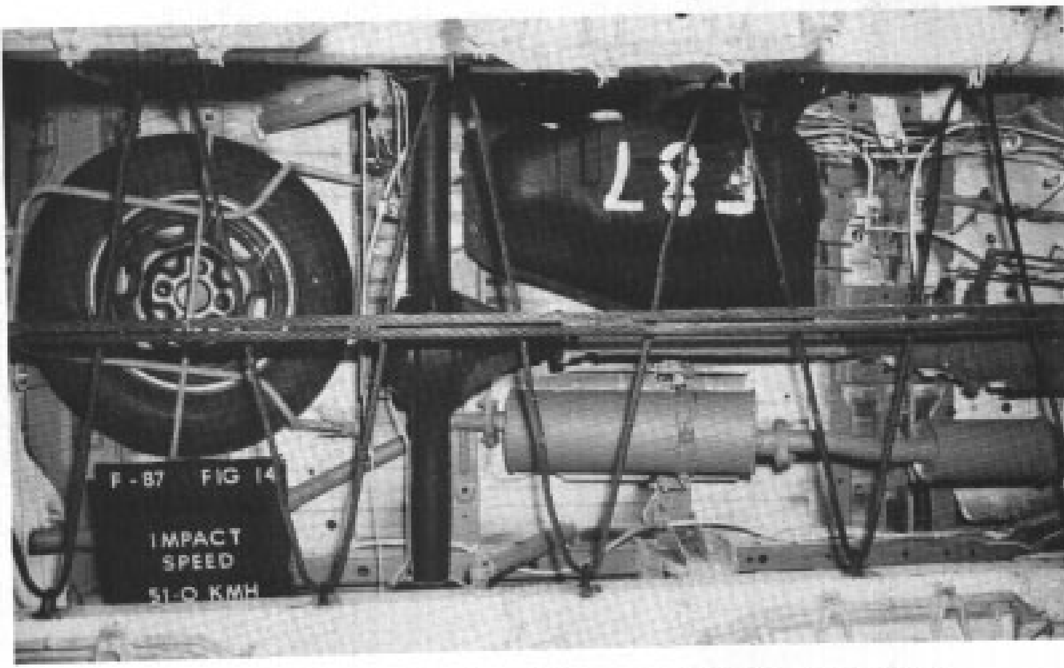


Figure F17: Test F87, Underside view of rear of vehicle -- post-test

F87

MEASUREMENT POINT DESCRIPTION			PRE TEST Horiz	PRE TEST Vert	POST TEST Horiz	POST TEST Vert	DISPLACEMENT Horiz	DISPLACEMENT Vert
Dash panel features								
	Right		2115	579	1648	625	467	56
	Binnacle		2048	541	1588	645	460	104
	Centre		2110	580	1655	661	455	81
	Left		2102	590	1683	666	419	76
Upper dash panel screws								
	Right		2334	588	1907	611	427	23
	Centre		2311	608	1888	718	423	110
	Left		2335	575	1916	665	419	90
Lower dash panel bolts								
	Right		2178	322	1743	351	435	29
	Left		2247	306	1809	410	438	104
Headlight pressings								
	Right		2415	120	1944	146	471	26
	Left		2415	134	1898	165	517	31
Front panel features								
	Right of centre		2551	270	1990	326	561	56
	Left of centre		2548	285	1983	336	565	51
	Brake block mount	Right	2459	153	1905	230	554	77
		Left	2456	145	1903	179	553	34
	Left dash panel brace		2347	128	1913	150	434	22
LHD steering column pressing			2275	85	-	-	-	-
Panel at height of brake pedal			2420	100	1960	183	460	83
Pedal brackets bolts to body								
	Upper		3338	540	1788	600	550	60
	Lower		2389	50	1907	62	482	12
Column to pedal bracket bolts								
	Right		2035	393	1584	450	451	57
	Left		2027	405	1580	450	447	45
Column to floor bolts								
	Right		2241	-32	1878	-23	363	9
	Left		2241	-32	-	-	-	-
Column nut			1879	597	1459	620	429	23
Column angle			56^0		54^0		2^0	
Engine			1375	214	1412	170	-37	-44
Seat belt anchorages								
Drivers seat belt								
	Outer lap		1341	194	1334	190	7	-4
	Buckle		1350	286	1377	258	-27	-28
	Upper "B" pillar		1113	921	1120	909	-7	-12
	Inertia Reel		1120	295	1111	299	9	4
Passenger seat belt								
	Outer lap		1352	184	1355	154	-3	-30
	Buckle		1255	304	1260	283	-5	-21
	Upper "B" pillar		1096	914	1110	927	-16	13
	Inertia reel		1114	288	1104	295	10	7

Seat anchorages						
Drivers seat						
Front right	1781	180	1764	104	17	-76
Front left	1790	162	1786	73	4	-89
Rear right	1456	184	1439	175	17	-9
Rear left	1445	183	1428	134	17	49
Passenger Seat						
Rear right	981	212	979	211	2	-1
Rear centre	981	210	976	203	5	-7
Rear left	982	215	976	203	6	-12
Front of seat is held by clips						
Sunvisor screws						
Right	1855	1130	1802	1289	53	159
Left	1855	1140	1788	1295	67	155
H Point	1427	370	-	-	-	-
H Point to pedal	755	-	300	-	455	-
H Point to Instrument panel	595	-	70	-	525	-
Width between A pillars	1378	-	1385	-	7	-
Floor lengths						
Right	583	-	120	-	463	-
Centre	610	-	135	-	465	-
Left	530	-	90	-	440	-
Floor to roof heights a H point line						
Right	-	930	-	1037	-	107
Centre	-	925	-	1030	-	105
Left	-	930	-	1007	-	77
Steering column to datum (direct distance)						
Right	3105	-	2684	-	421	-
Front of vehicle to B pillar target						
Right	1292	-	685	-	607	-
Left	1290	-	708	-	582	-
Transverse distance column to B pillar						
Right	282	-	-	-	-	-
Left	1113	-	-	-	-	-
Longitudinal distance column to B pillar						
Right	495	-	-	-	-	-
Left	450	-	-	-	-	-
Column to vehicle centreline	400	-	-	-	-	-
Rebound distance						
Right	-	-	904	-	-	-
Left	-	-	873	-	-	-
Transverse distance came to barrier centreline						
Right	10350	-	-	-	-	-
Left	10700	-	-	-	-	-

Body side targets		Horiz Right	Horiz Left	Horiz Right	Horiz Left
	250	0	11	250	239
	500	30	117	470	383
	750	257	332	493	418
	1000	502	576	498	424
	1250	735	811	515	439
	1500	927	921	573	579
	1750	1075	1166	675	584
	2000	1426	1416	574	584
	2250	1676	1668	574	582
	2500	1926	1917	574	583
	2750	2175	2173	575	577
	3000	2428	2423	572	577
	3250	2678	2673	572	577
	3500	2930	2923	570	577
	3750	3179	3173	571	577

APPENDIX G

TEST REPORT

Test Order No.	T6751
Date of Order	1.5.85
Program No.	505
System No.	00.00
Date of Test	19.7.85

Subject: Evaluation - Barrier crash F88

Vehicle description:

Vehicle #:	SB 3M038ND 08002057	
Engine	1.6 litre I4	
Transmission:	4 Speed column manual	
Steering column:	Non-adjustable	
Wheels & Tyres:	Steel, 175 R14 LT	
Actual test mass	Frt	747
	Rr	487
	Total	1234 kg

Procedure:

1. The test was conducted in accordance with SAE Recommended Procedure J850 - Barrier Collision Tests.

2. The vehicle was weighted to the required test mass of 1162 kg. The 72 kg test dummy was then fitted to the vehicle to achieve the actual test mass of 1236 kg.

Results:

Dynamic steering column intrusion was analysed using the right main camera. The two sets of data were analysed to give the dynamic intrusion of the target 300 mm above the end of the steering column and the target 150 mm above the end of the steering column.

Both targets are directly in line with the steering column shaft. By determining the difference between the two targets and adding to or subtracting from the 150 mm target the dynamic intrusion of the steering column is determined.

The maximum derived steering shaft end intrusion is 134 mm at 50.5 km/h. When corrected back to 48 km/h the derived intrusion is 121 mm.

Figure G1 shows the dynamic movements (vertically and horizontally) of the derived position of the steering shaft end.

Figure G2 shows the load-v-time traces of the front passenger lap and sash seat belt loads.Figure G3 shows the deceleration-v-time traces of the left and right "B" pillar bases.

Static pre- and post-test measurements are shown below. The internal vehicle datum is horizontally, the line between chassis mounting bolts approximately 1.1 m rearwards of the bulkhead at the front of the load space; vertically, the floor of the load space. Positive displacement is horizontally rearwards or vertically upwards.

Figures G4 to G17 are pre- and post-test photographs of the vehicle.

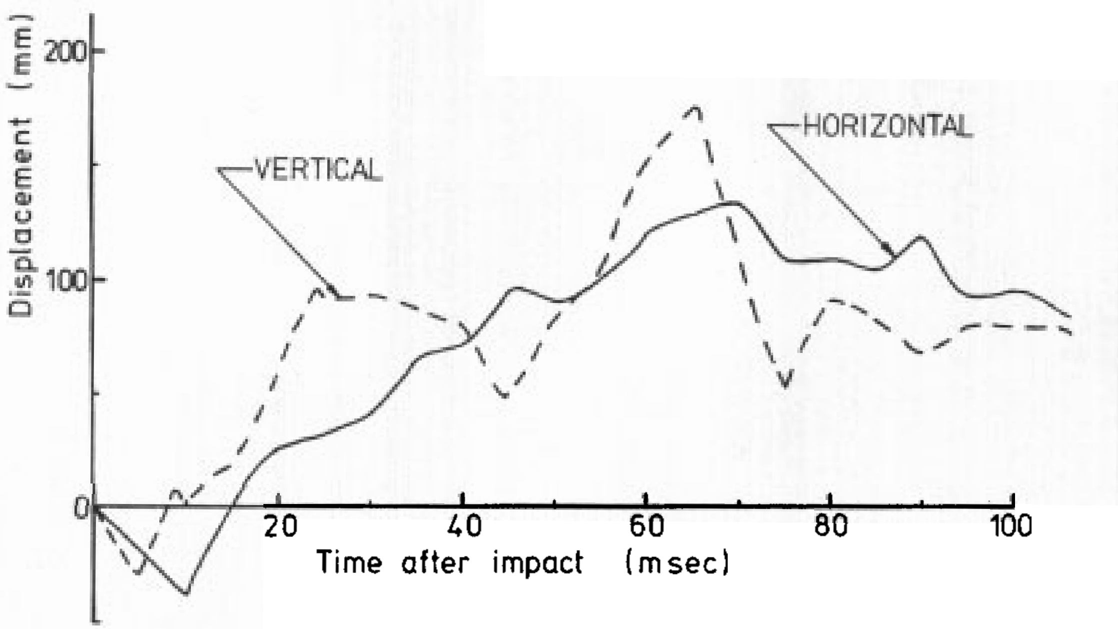


Figure G1: Test F88, Steering column intrusion during impact. Displacements shown are relative to the vehicle's B-pillar

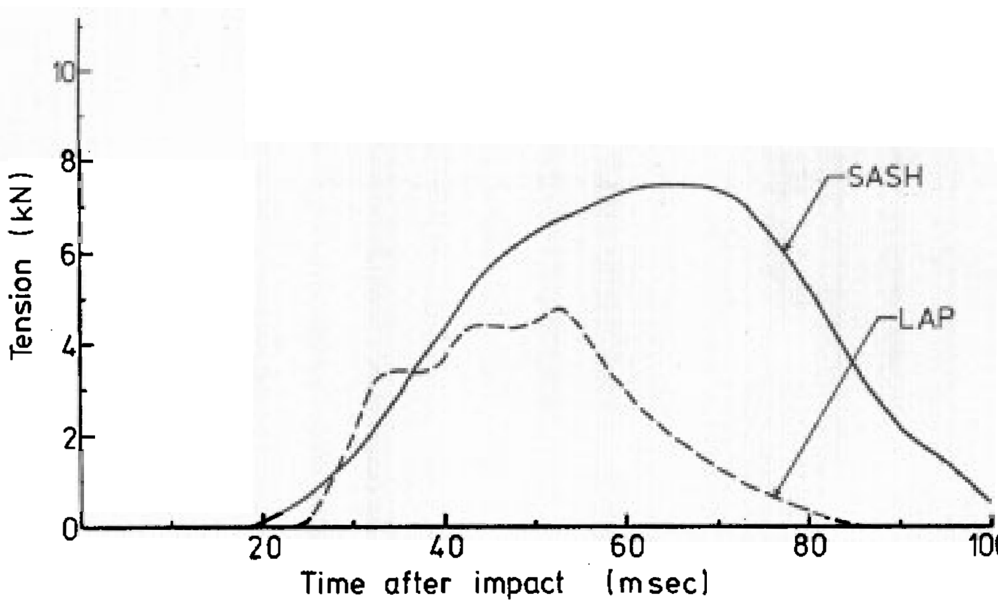


Figure G2: Test F88, Front outboard passenger seat belt loads during impact

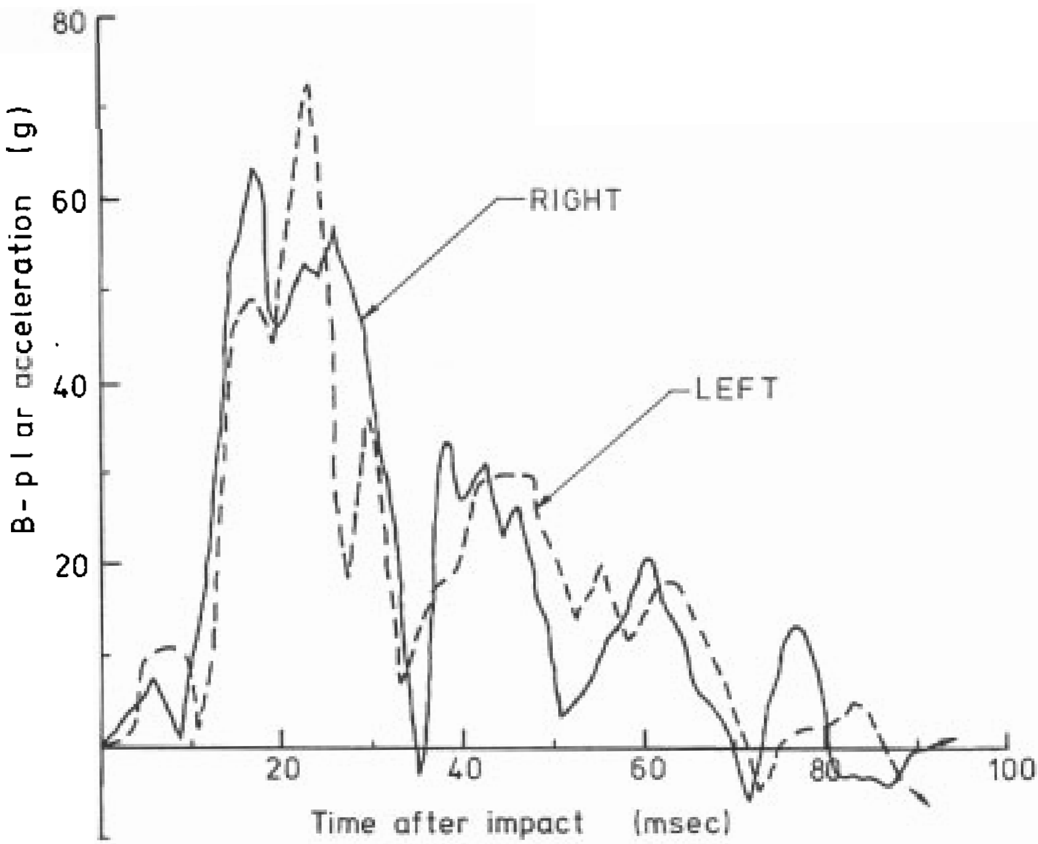


Figure G3: Test F88, Occupant compartment acceleration during impact

Figure G4: Test F88, Front-quarter view of vehicle -- pre-test

Figure G5: Test F88, Front-quarter view of vehicle -- post-test

Figure G6: Test F88, Right hand side view of vehicle -- pre-test

Figure G7: Test F88, Right hand side view of vehicle -- post-test

Figure G8: Test F88, Left hand side view of vehicle -- pre-test

Figure G9: Test F88, Left hand side view of vehicle -- post-test

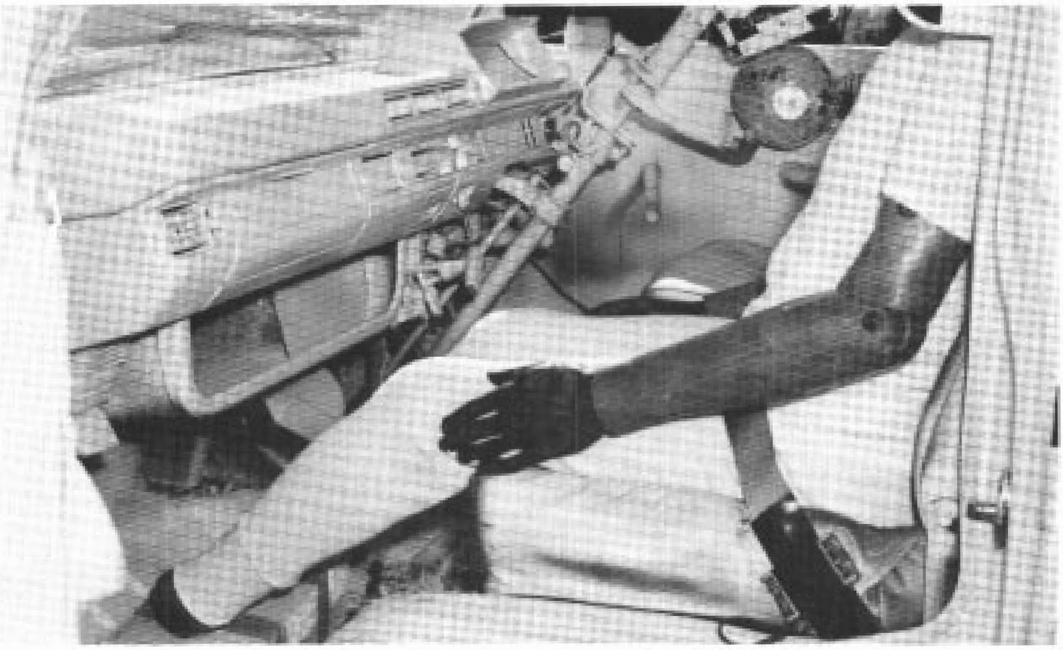


Figure G10: Test F88, Occupant compartment interior -- pre-test

Figure G11: Test F88, Occupant compartment interior -- post-test

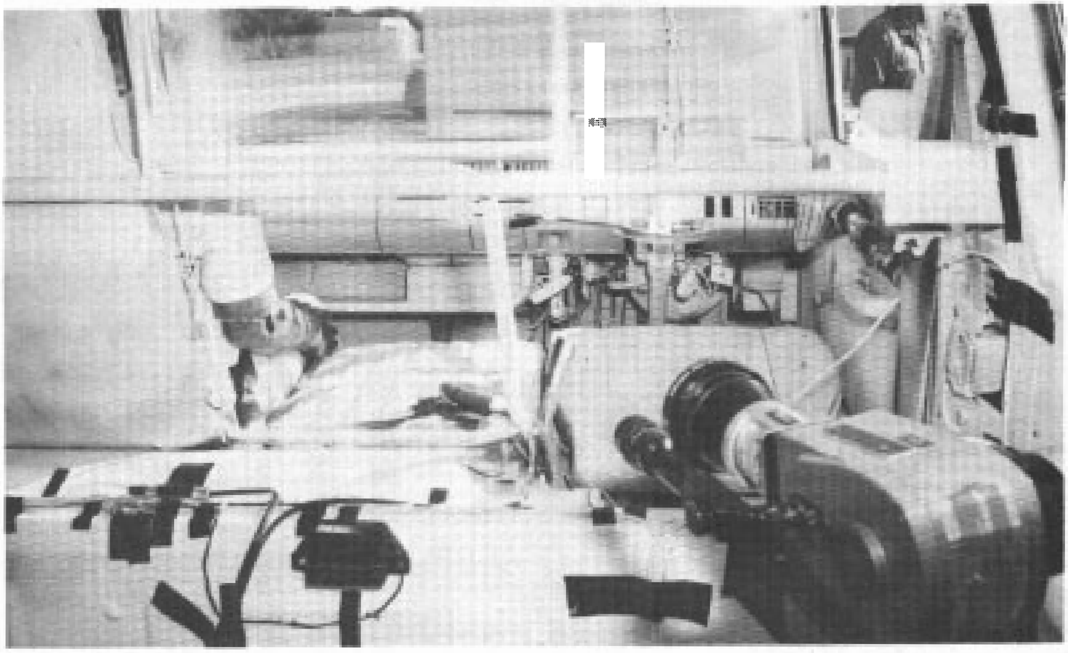


Figure G12: Test F88, Occupant compartment interior viewed from the rear -- pre-test

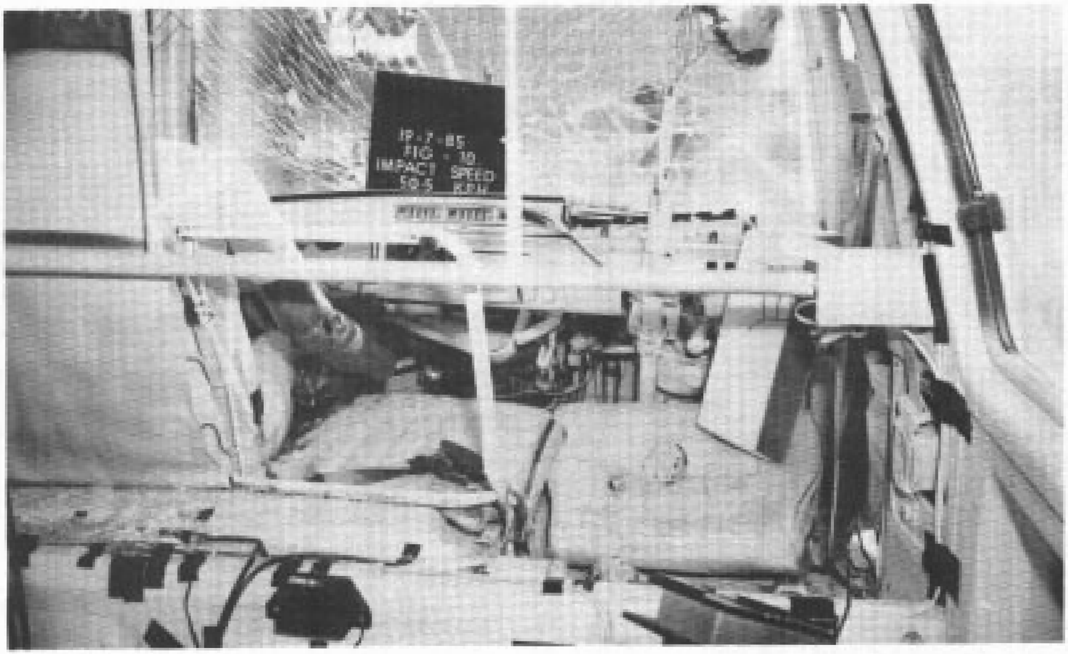


Figure G13: Test F88, Occupant compartment interior viewed from the rear -- post-test

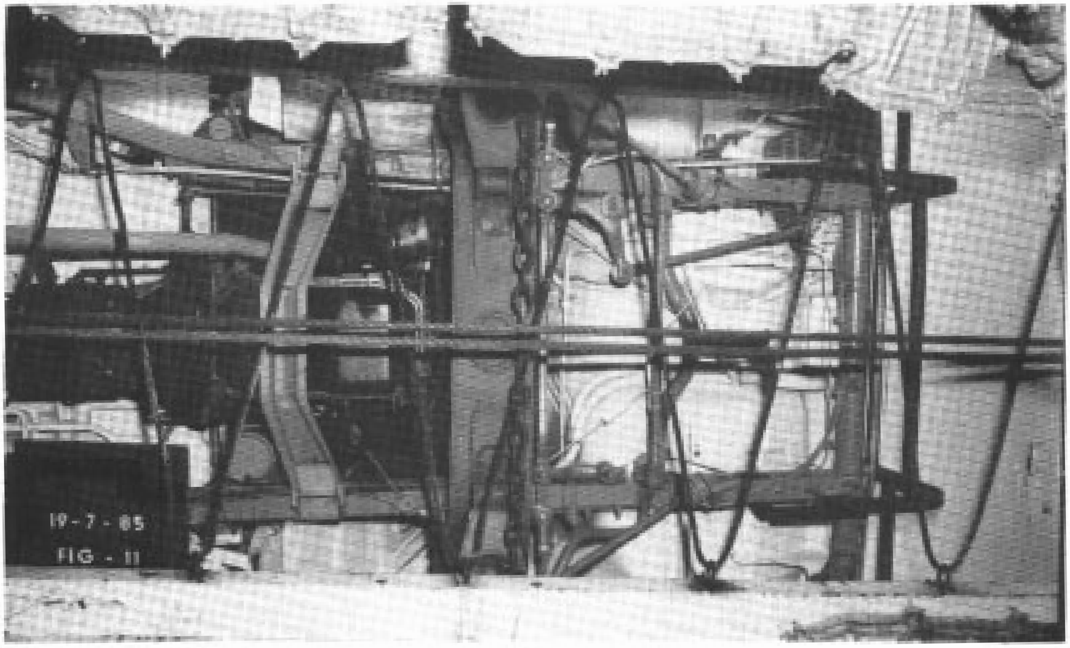


Figure G14: Test F88, Underside view of front of vehicle -- pre-test

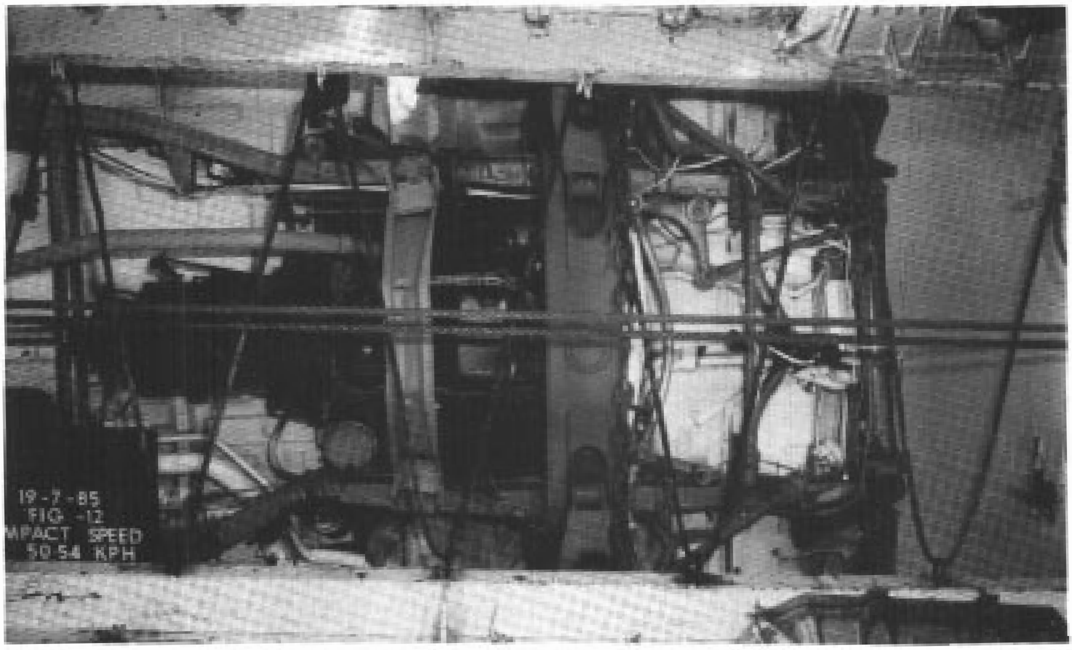


Figure G15: Test F88, Underside view of front of vehicle -- post-test

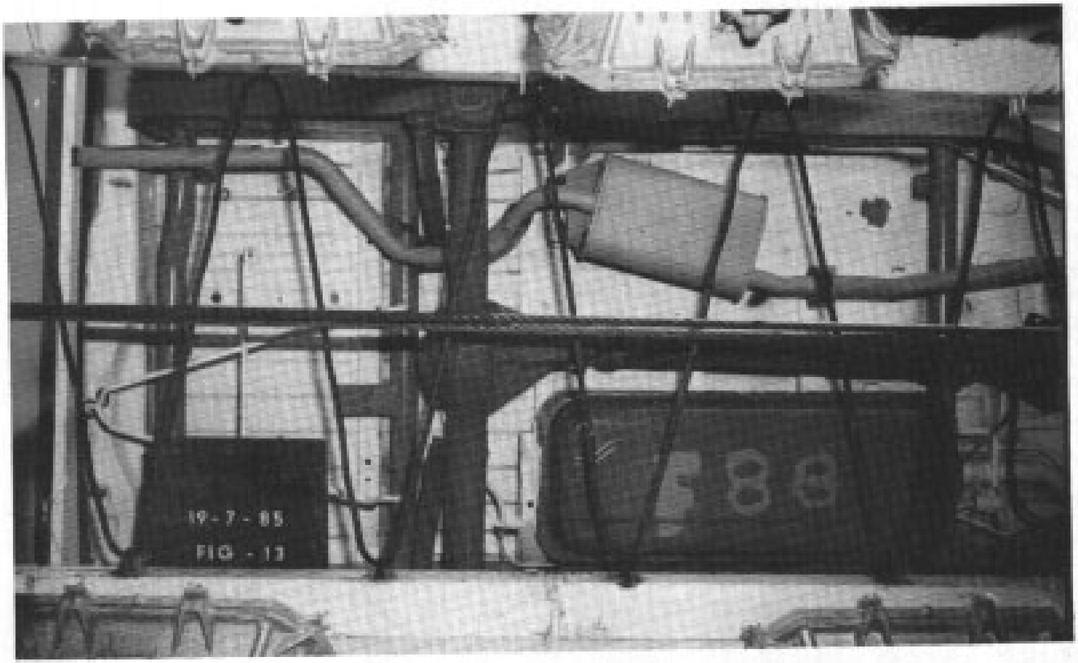


Figure G16: Test F88, Underside view of rear of vehicle -- pre-test

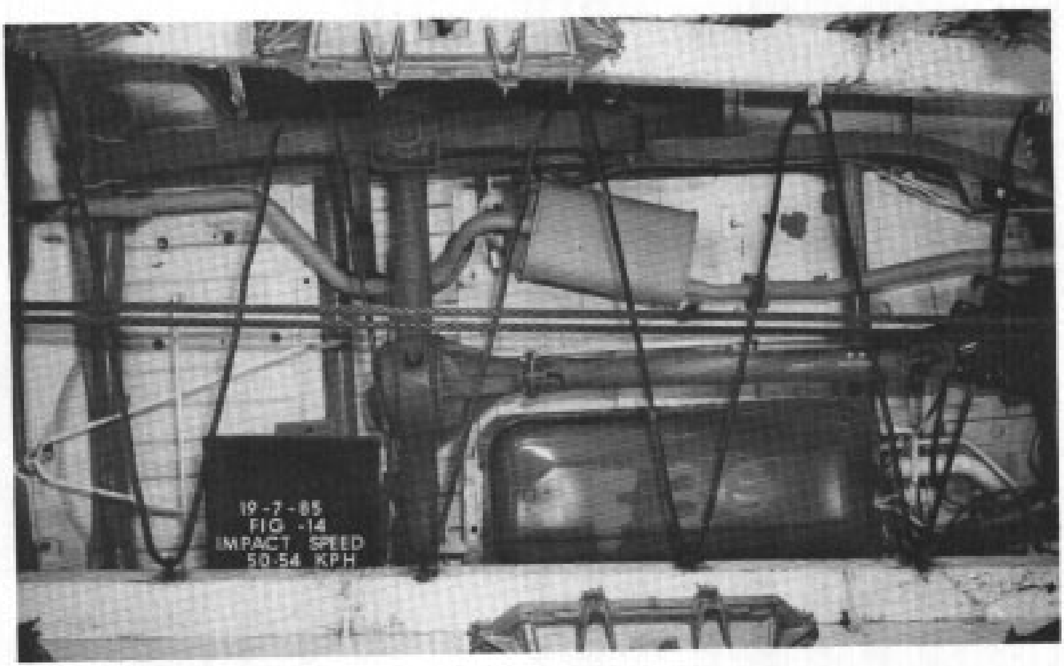


Figure G17: Test F88, Underside view of rear of vehicle -- post-test

F88

MEASUREMENT POINT DESCRIPTION		PRE TEST Horiz	PRE TEST Vert	POST TEST Horiz	POST TEST Vert	DISPLACEMENT Horiz	DISPLACEMENT Vert
Dash panel features							
Rearmost point							
	Right	2111	609	1992	634	119	25
	Centre	2128	594	2004	635	124	41
	Left	2129	588	2000	615	129	27
Dash mounting screw							
	Right	2140	573	2020	628	120	55
Dash metal structure							
	Left	2161	590	2037	624	124	34
Head light mount screw							
	Left	2404	313	2180	311	224	-2
Front panel of height of brake pedal							
	Right	2537	35	2313	45	224	10
	Left	2533	85	2291	121	246	36
Steering column lower bracket							
	Right	2415	46	2126	45	289	-1
	Left	2340	-6	2076	-30	264	-36
Steering column nut		1931	604	1752	655	179	51
Steering column upper bracket bolt							
	Right	2091	431	1858	457	233	26
	Left	2091	431	1856	457	235	26
Engine (tappet cover bolt)		1446	211	1457	205	-11	-6
Seat belt anchorages							
Drivers seat							
	Outer lap	1411	173	1405	169	6	-4
	Upper	1140	908	1150	898	-10	-10
	Inertia reel	1236	392	1235	386	1	-6
Outboard passenger							
	Outer lap	1405	173	1409	172	-4	-1
	Upper	1140	908	1157	900	-17	-8
	Inertia reel	1234	392	1241	387	-7	-5
Seat anchorages							
Drivers seat							
	Right front	1818	146	1812	150	6	4
	Right rear	1451	139	1453	141	-2	2
Passengers seat							
	Front right	1855	169	1849	181	-6	12
	Front left	1845	120	1853	155	-8	35
	Rear left	1127	300	1134	295	7	-5
	Rear centre	1127	300	1134	295	7	-5
	Rear right	1127	300	1134	295	7	-5
LH sun visor mount		2019	1106	2026	1184	-7	78
RH sun visor mount		2030	1109	2024	1191	6	82
Rear vision mirror mount		2031	1109	2035	1190	-4	81
H point							
	Driver	1501	313	-	-	-	-
	Passenger	1520	313	-	-	-	-
Width between A pillars		1478	-	-	-	-	-
Floor to roof height at H point							

Driver	-	1041	-	1062	-	2
Passenger	-	1041	-	1062	-	2
Length of foot well at centreline of seating position						
Passenger	680	-	415	-	265	-
Driver	600	-	380	-	220	-
Brake pedal to bulkhead	380	-	200	-	180	-
Clutch pedal to bulkhead	375	-	158	-	217	-
Front of vehicle to B pillar						
Left	1500	-	1151	-	349	-
Right	1500	-	1123	-	377	-
Steering column Rebound	3010	-	2925	-	85	-
Right	-	-	366	-	-	-
Left	-	-	310	-	-	-

Body side targets		**Horiz Right**	**Horiz Left**	**Horiz Right**	**Hor Lef**
	250	70	70	180	18
	500	177	170	323	33
	750	420	415	330	33
	1000	668	665	332	33
	1250	918	914	332	33
	1500	1151	1123	349	3
	1750	1401	1373	349	3
	2000	1651	1623	349	3
	2250	1901	1873	349	3
	2500	2151	2123	349	3
	2750	2401	2373	349	3
	3000	2651	2623	349	3
	3250	2901	2873	349	3
	3500	3151	3123	349	3
	3750	2401	3373	349	3
Overall length		3729	3718		

APPENDIX H

TEST REPORT

Test order no.	T6753
Date of order	1.5.85
Program no.	505
System no.	00.00
Date of test	26.10.85

Subject: Evaluation - Barrier crash F89

Vehicle description:

Vehicle no.	KM36-0000033	
Engine	1.6 litre I4	
Transmission	4 Speed column manual	
Steering column	Non-adjustable	
Wheels & tyres:	Steel, 165 R14	
Actual test mass	Frt	703
	Rr	488
	Total	1191 kg

Procedure:

1. The test was conducted in accordance with SAE Recommended Procedure J850 - Barrier Collision Tests.

2. The vehicle was weighted to the required test mass of 1120 kg. The 71 kg test dummy was then fitted to the vehicle to achieve the actual test mass of 1191 kg.

Results:

Dynamic steering column intrusion was analysed using the right main camera. Two sets of data were analysed to give the dynamic intrusion of the target 300 mm above the end of the steering column and the target 150 mm above the end of the steering column.

Both targets are directly in line with the steering column end. By determining the difference between the two targets and adding to or subtracting from the 150 mm target the dynamic intrusion of the steering column is determined.

The maximum derived steering shaft end intrusion is 96 mm at 51.7 km/h. When corrected back to 48 km/h the derived intrusion is 83 mm.

Figure H1 shows the dynamic movements (vertically and horizontally) of the derived position of the steering shaft end.

Figure H2 shows the load-v-time traces of the front passenger lap and sash seat belt loads. Figure H3 shows the deceleration-v-time traces of the left and right "B" pillar bases.

Static pre and post test measurements are shown below. The internal vehicle datum is 1 m rearward of the front edge of the load carrying area and 3 mm above floor level. Positive displacement is horizontally rearwards or vertically upwards.

Figures H4 to H17 are pre- and post- test photographs of the vehicle.

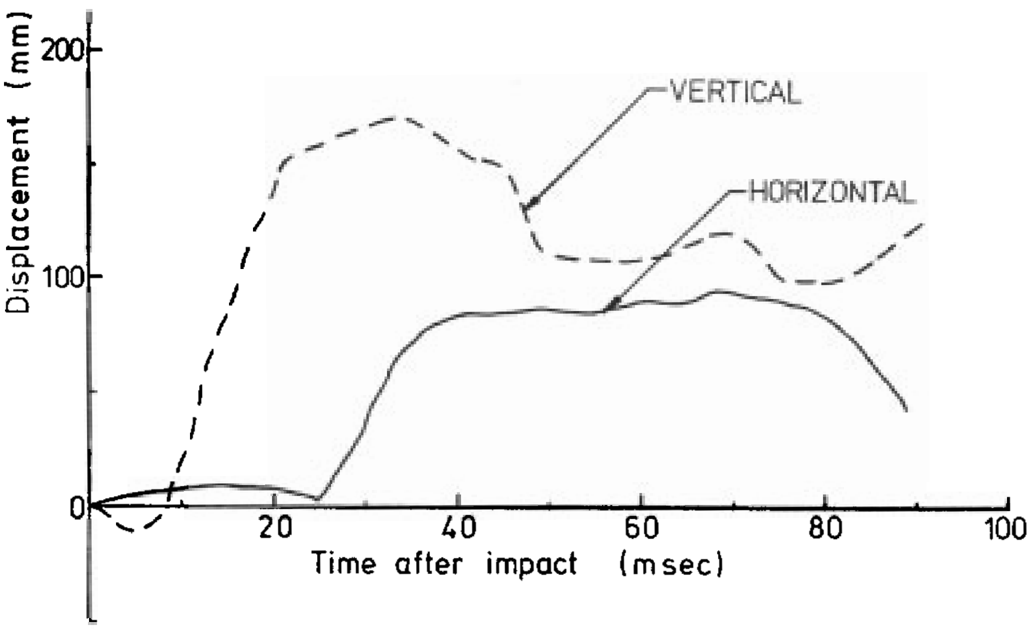


Figure H1: Test F89, Steering column intrusion during impact. Displacements shown are relative to the vehicle's B-pillar

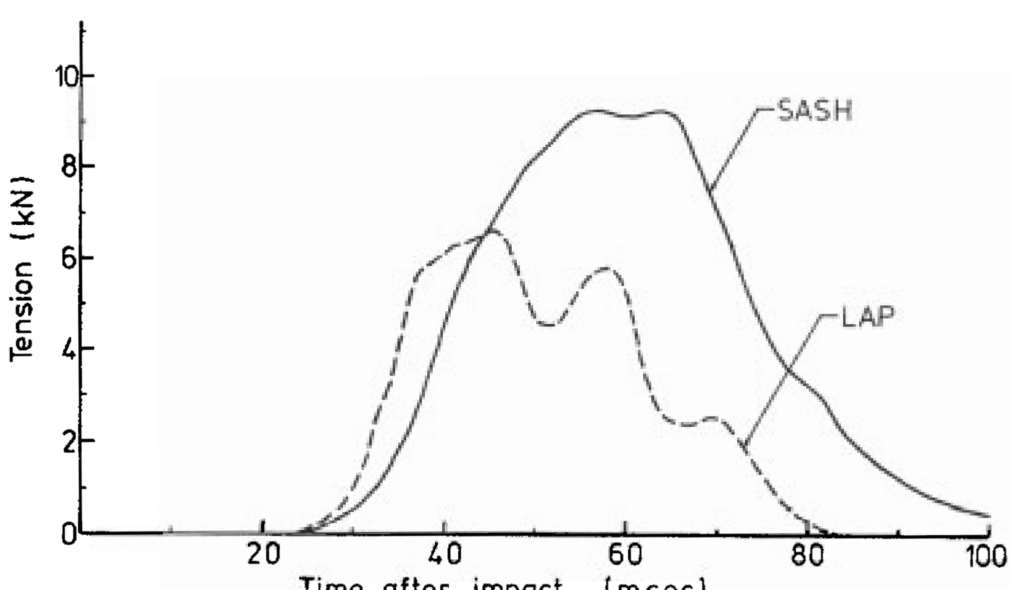


Figure H2: Test F89, Front outboard passenger seat belt loads during impact

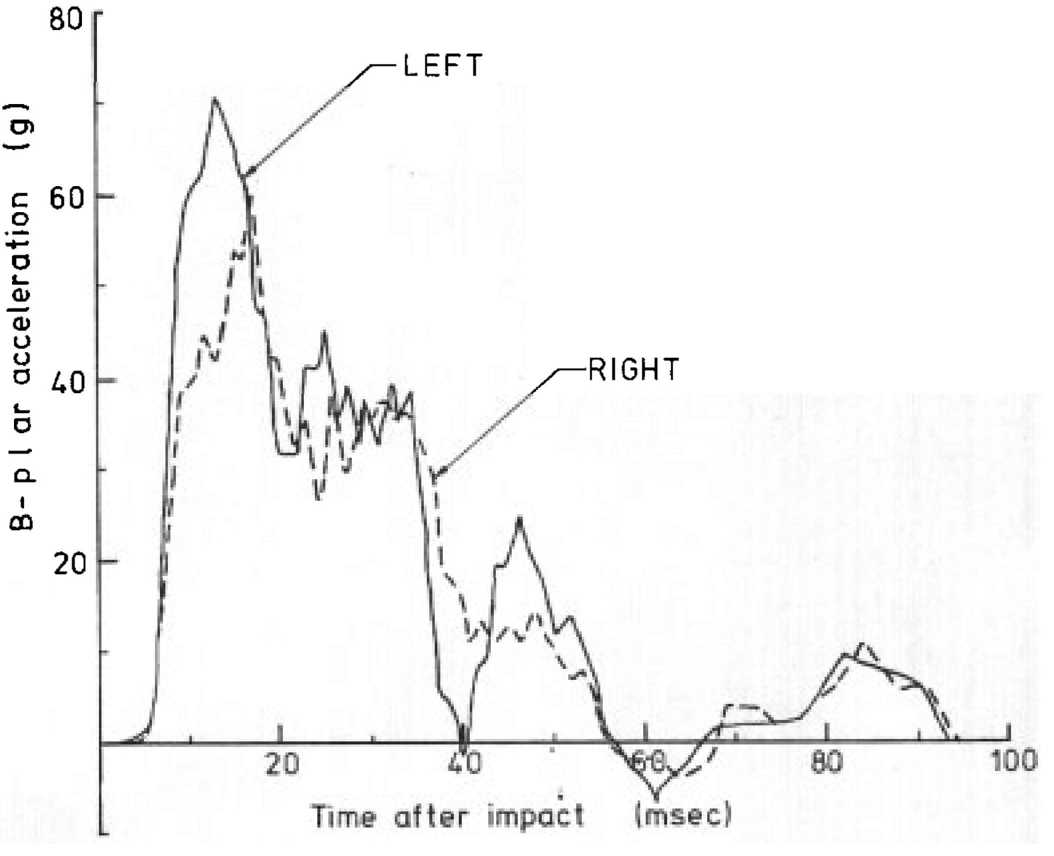


Figure H3: Test F89, Occupant compartment acceleration during impact

Figure H4: Test F89, Front-quarter view of vehicle -- pre-test

Figure H5: Test F89, Front-quarter view of vehicle -- post-test

Figure H6: Test F89, Right hand side view of vehicle -- pre-test

Figure H7: Test F89, Right hand side view of vehicle -- post-test

Figure H8: Test F89, Left hand side view of vehicle -- pre-test

Figure H9: Test F89, Left hand side view of vehicle -- post-test

Figure H10: Test F89, Occupant compartment interior -- pre-test

Figure H11: Test F89, Occupant compartment interior -- post-test

Figure H12: Test F89, Occupant compartment interior viewed from the rear -- pre-test

Figure H13: Test F89, Occupant compartment interior viewed from the rear -- post-test

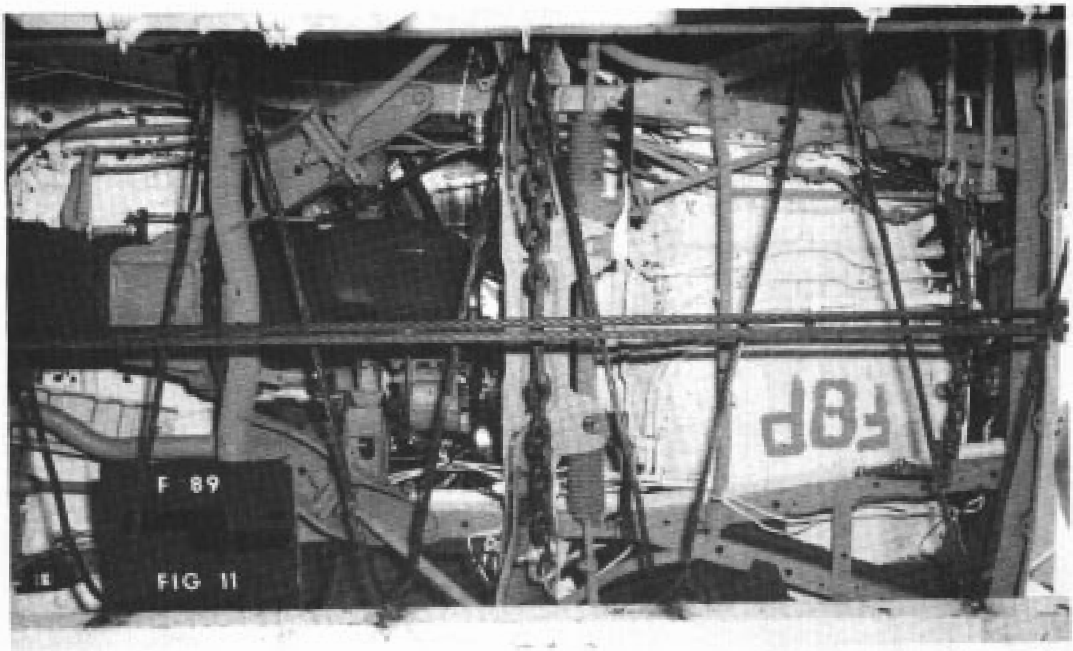


Figure H14: Test F89, Underside view of front of vehicle -- pre-test

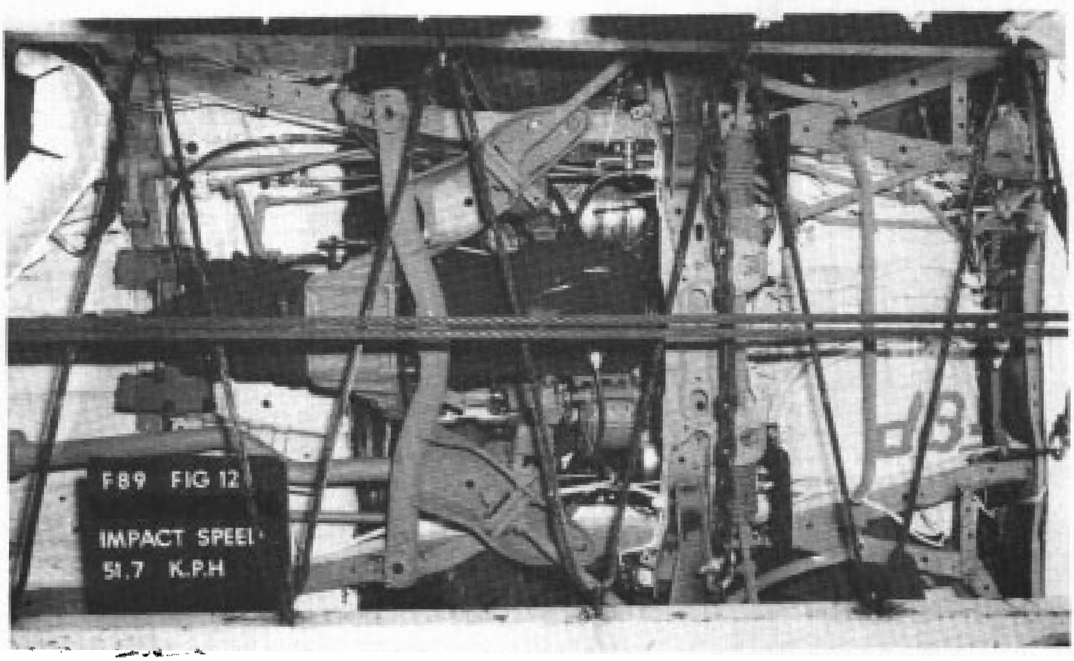


Figure H15: Test F89, Underside view of front of vehicle -- post-test

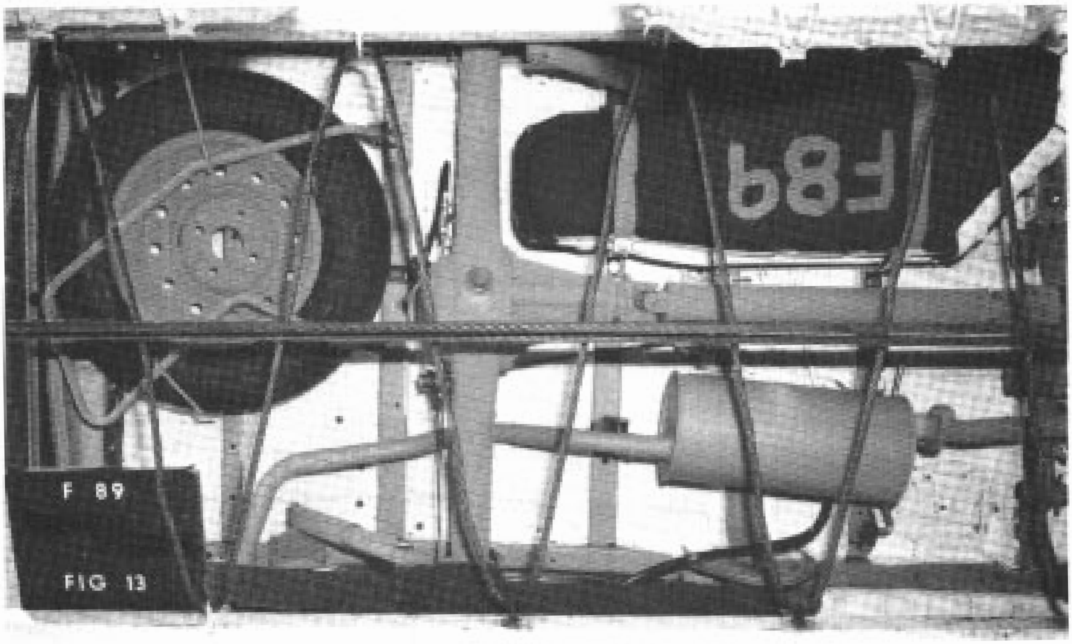


Figure H16: Test F89, Underside view of rear of vehicle -- pre-test

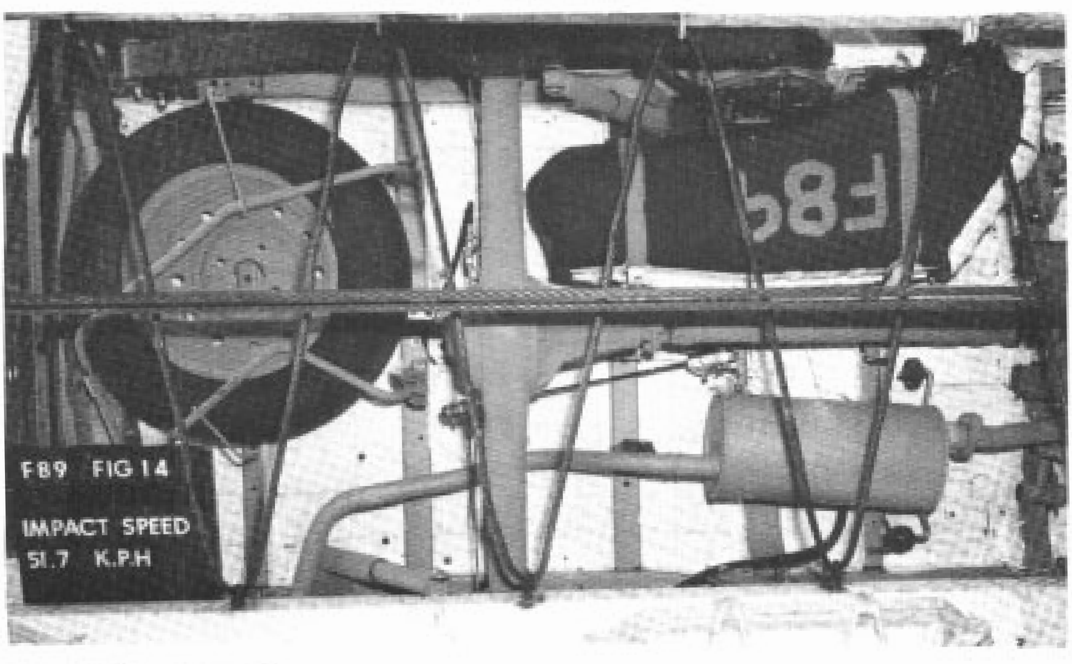


Figure H17: Test F89, Underside view of rear of vehicle -- post-test

F89

MEASUREMENT POINT DESCRIPTION		PRE TEST Horiz	PRE TEST Vert	POST TEST Horiz	POST TEST Vert	DISPLACEME[NT] Horiz	DISPLACEME[NT] Vert
Dash panel features							
	Right	2014	585	1936	650	78	65
	Binnacle	1989	700	1910	760	79	60
	Centre	2020	585	1942	653	78	68
	Left	2022	585	1945	656	77	71
Upper dash panel screws							
	Right	2372	562	2300	600	72	38
		2418	562	2314	620	104	58
	Centre	2424	562	2321	620	103	58
		2421	562	2328	620	93	58
	Left	2368	562	2310	612	58	50
Lower dash panel bolts							
	Right	2236	305	2142	350	96	45
	Left	2220	345	2173	362	47	17
Headlight holes							
	Right	2348	253	2216	310	132	57
	Left	2354	258	2203	315	151	57
Front panel features - ridge pressing							
	Right	2540	400	2364	465	176	6
	Left	2542	400	2364	475	178	7
LHD steering column pressing		2325	-42				
Brake pedal		2204	100	2059	180	145	8
Panel at height of brake pedal		2449	100	2295	130	154	3
Pedal brackets bolts to body							
	Upper	2410	530	2315	590	95	6
	Lower	2405	70	2280	147	125	7
Column to pedal bracket bolts							
	Right	2052	425	1981	460	71	3
	Left	2053	425	1983	460	70	3
Column to floor bolts							
	Foremost	2300	-11	2222	103	78	11
	Rearmost	2217	-45	2132	30	85	7
Column nut		1862	536	1813	620	49	8
Column angle			30^{o}		29^{o}		1
Engine		1371	180	1478	140	-107	-4
Seat belt anchorages							
Drivers seat belt							
	Outer lap	1323	140	1335	120	-12	-2
	Buckle	1323	183	1331	140	-8	-4
	Upper B pillar	1130	875	1131	870	-1	-
	Inertia reel	1125	395	1133	385	8	-1
Passenger seat belt							
	Outer lap	1341	153	1355	152	-14	-
	Buckle	1375	225	1433	435	-58	21
	Upper B pillar	1115	877	1132	870	-17	-
	Inertia reel	1108	375	1130	377	-22	

Seat anchorages

Drivers seat							
	Front right	1637	180	1648	170	-11	-10
	Rear right	1372	130	1383	110	-11	-20
Seat slide on inner edge							
Passenger seat							
	Front right	1708	210	1765	225	-57	15
	Front left	1720	140	1760	140	-40	0
	Rear right	1348	235	1420	290	-72	55
	Rear left	1590	280	1620	171	-30	-89
Sunvisor screws							
	Right	1650	1110	1678	990	-28	-120
	Left	1647	1115	1657	925	-10	-190
H Point - rearmost		1388	274	-	-	-	-
H point to pedal		800	-	-	-	-	-
H point to instrument panel		600	-	-	-	-	-
Width between A pillars		1335	-	1380	-	55	
Floor lengths							
	Right	580	-	455	-	125	-
	Centre	540	-	390	-	150	-
	Left	585	-	390	-	195	-
Floor to roof heights at H point plane							
	Right	-	1065	-	1055	-	-10
	Centre	-	1010	-	1000	-	-10
	Left	-	1020	-	1060	-	40
Steering column to datum (direct distance)		2910	-	2845	-	65	-
Front of vehicle to B pillar target							
	Right	1525	-	-	-	-	-
	Left	1535	-	-	-	-	-
Transverse distance column to B pillar							
	Right	350	-	-	-	-	-
	Left	960	-	-	-	-	-
Longitudinal distance column to B pillar							
	Right	760	-	-	-	-	-
	Left	750	-	-	-	-	-
Column to vehicle centreline		380	-	-	-	-	-
Rebound distance							
	Centre	350	-	-	-	-	-
Transverse distance camera to barrier centreline							
	Right	9550	-	-	-	-	-
	Left	9500	-	-	-	-	-
Door opening efforts (newtons)							
	Right						187
	Left						200

Body side targets		Horiz Right	Horiz Left	Horiz Right	Hori Left
	250	93	82	157	168
	500	320	319	180	181
	750	563	569	187	181
	1000	814	819	186	181
	1250	1063	1070	187	180
	1500	1271	1275	229	225
	1750	1525	1531	225	219
	2000	1772	1779	228	221
	2250	2023	2028	227	222
	2500	2272	2278	228	222
	2750	2522	2528	228	222
	3000	2772	2777	228	222
	3250	3023	3028	227	222
	3500	3273	3277	227	223
	3750	3523	3526	227	224

APPENDIX I

TEST REPORT

Test Order No.	T6752
Date of Order	1.5.85
Program No.	505
System No.	00.00
Date of Test	30/11/85

Subject: Evaluation - Barrier crash F90

Vehicle description:

Vehicle #:	SB 3M038ND 08002073
Engine	1.6 litre I4
Transmission:	4 Speed column manual
Steering column:	Non-adjustable
Wheels & tyres:	Steel, 175 R14 LT
Actual test mass	Frt 725
	Rr 511
	Total 1236 kg

Procedure:

1. The test was conducted in accordance with SAE Recommended Procedure J850 - Barrier Collision Tests.

2. The vehicle was weighted to the required test mass of 1165 kg. The 71 kg test dummy was then fitted to the vehicle to achieve the actual test mass of 1236 kg.

Results:

Dynamic steering column intrusion was analysed using the right main camera. Two sets of data were analysed to give the dynamic intrusion of the target 300 mm above the end of the steering column and the target 150 mm above the end of the steering column.

Both targets are directly in line with the steering column end. By determining the difference between the two targets and adding to or subtracting from the 150 mm target the dynamic intrusion of the steering column is determined.

When conducting the test, the front door glass shattered, obscuring the view of the 150 mm target from 35 msec to 95 msec after impact. The position of this target during this time period is an estimate based on the shape and position of target array. The maximum derived steering shaft intrusion, prior to 35 milliseconds, is 188 mm at 51.7 km/h. The maximum derived steering shaft intrusion, after 95 milliseconds, is 203 mm at 51.7 km/h. When corrected back to 48 km/h the derived intrusion is 175 mm. The maximum estimated derived steering shaft intrusion is 257 mm at 51.7 km/h. When corrected back to 48 km/h the estimated derived steering shaft intrusion is 221 mm. The static intrusion is 173 mm. The rebound was measured as 200 mm right side and 275 mm left side.

Figure I1 shows the dynamic movements (vertically and horizontally) of the derived position of the steering shaft end.

Figure I2 shows the load-v-time traces of the front passenger lap and sash seat belt loads. Figure I3 shows the deceleration-v-time traces of the left and right "B" pillar bases.

Figures I4 to I16 are pre- and post- test photographs of the vehicle.

Static pre- and post-test measurements are shown below. The internal vehicle datum is horizontally, the line between chassis mounting bolts approximately 1.1 m rearwards of the bulkhead at the front of the load space; vertically, the floor of the load space. **Positive displacement is horizontally rearwards** or vertically upwards.

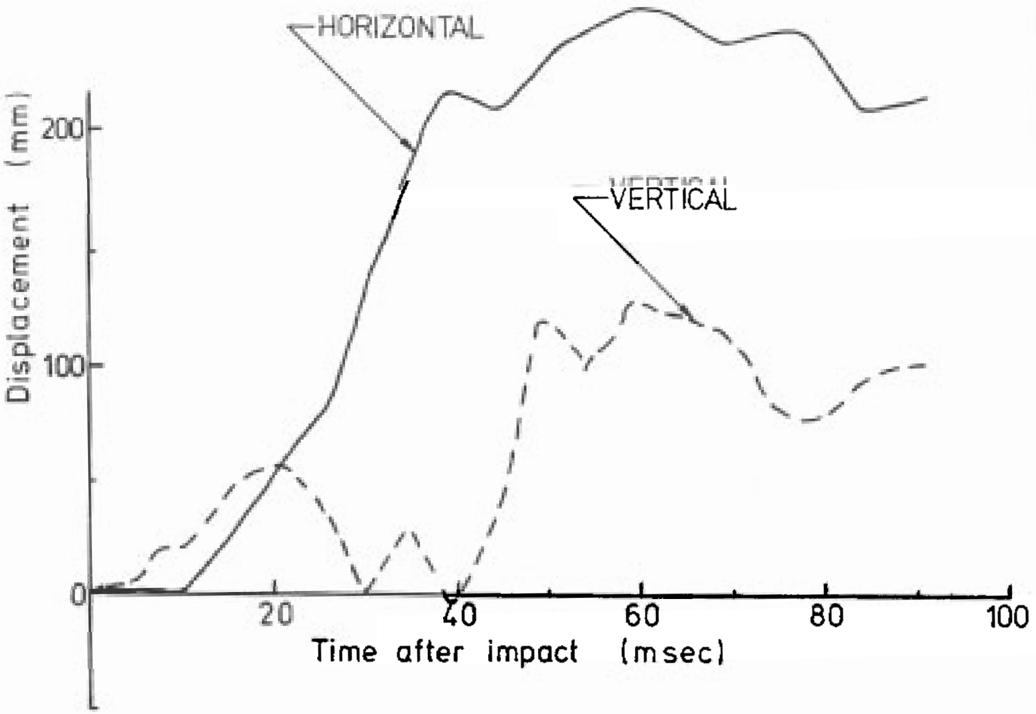


Figure I1: Test F90, Steering column intrusion during impact. Displacements shown are relative to the vehicle's B-pillar

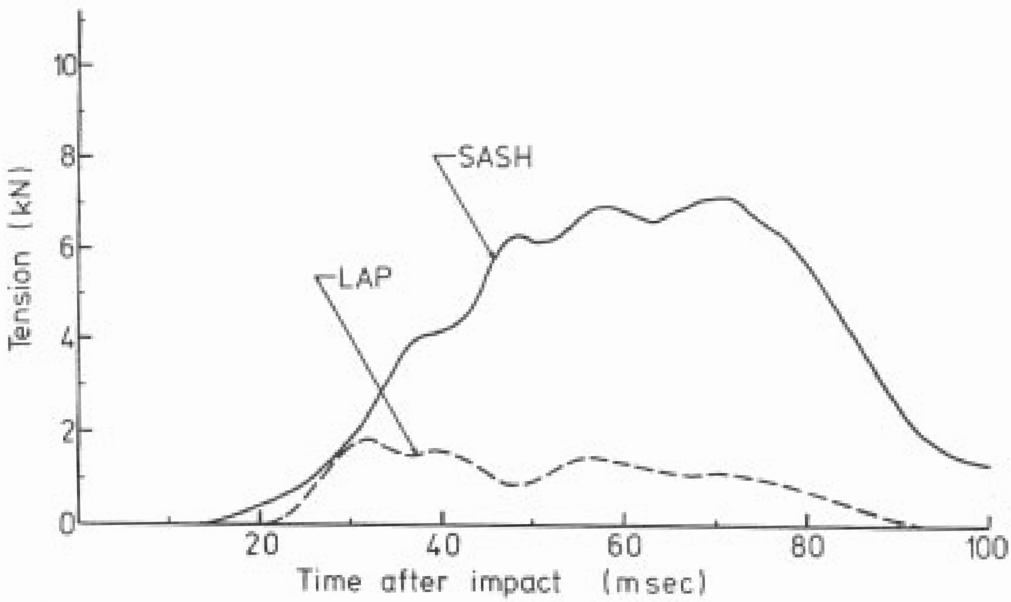


Figure I2: Test F90, Front outboard passenger seat belt loads during impact

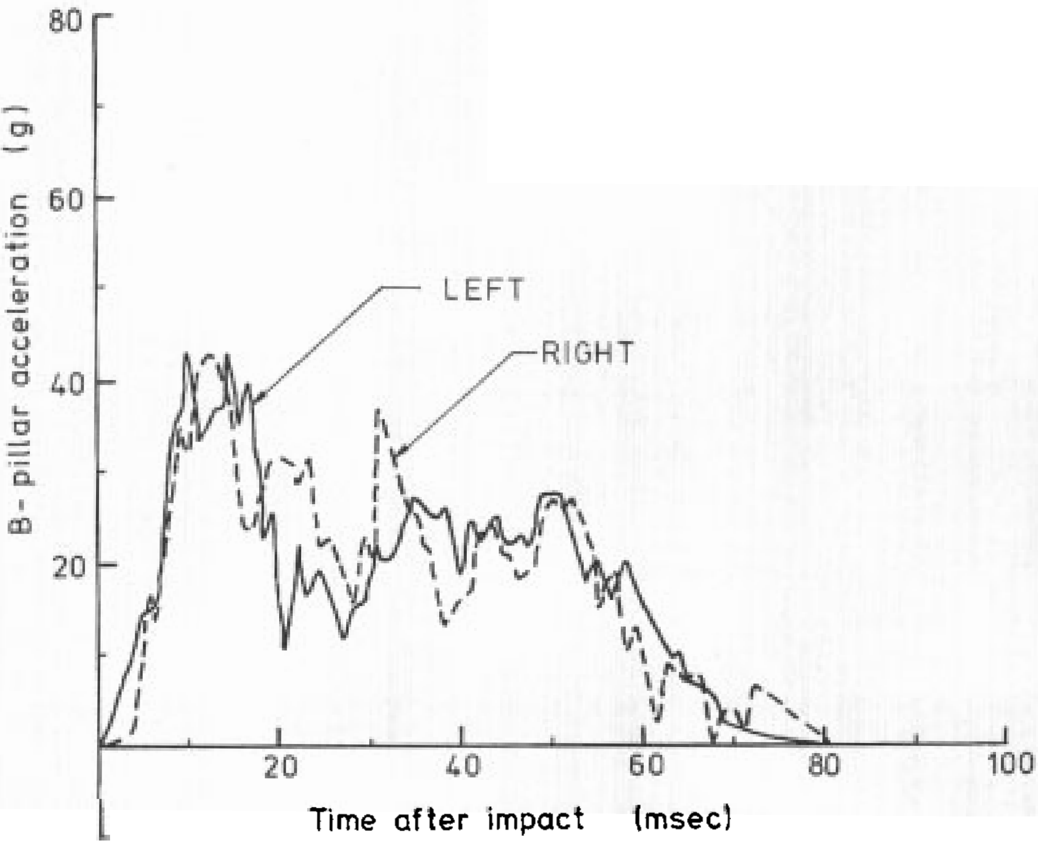


Figure I3: Test F90, Occupant compartment acceleration during impact

Figure I4: Test F90, Front-quarter view of vehicle -- pre-test

Figure I5: Test F90, Front-quarter view of vehicle -- post-test

Figure I6: Test F90, Right hand side view of vehicle -- pre-test

Figure I7: Test F90, Right hand side view of vehicle -- post-test

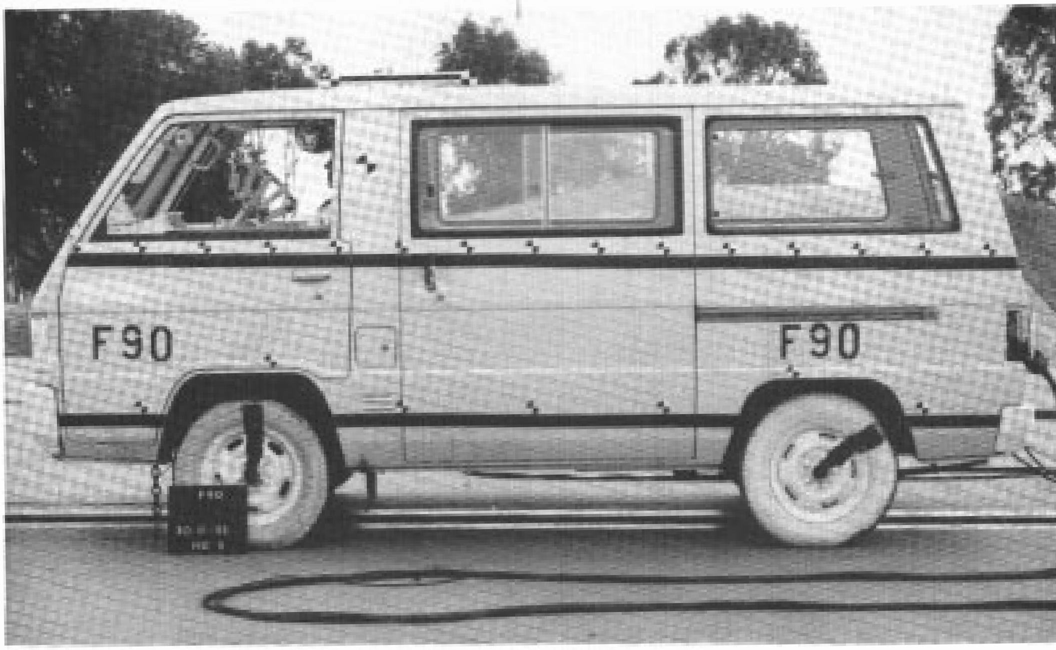


Figure I8: Test F90, Left hand side view of vehicle -- pre-test

Figure I9: Test F90, Left hand side view of vehicle -- post-test

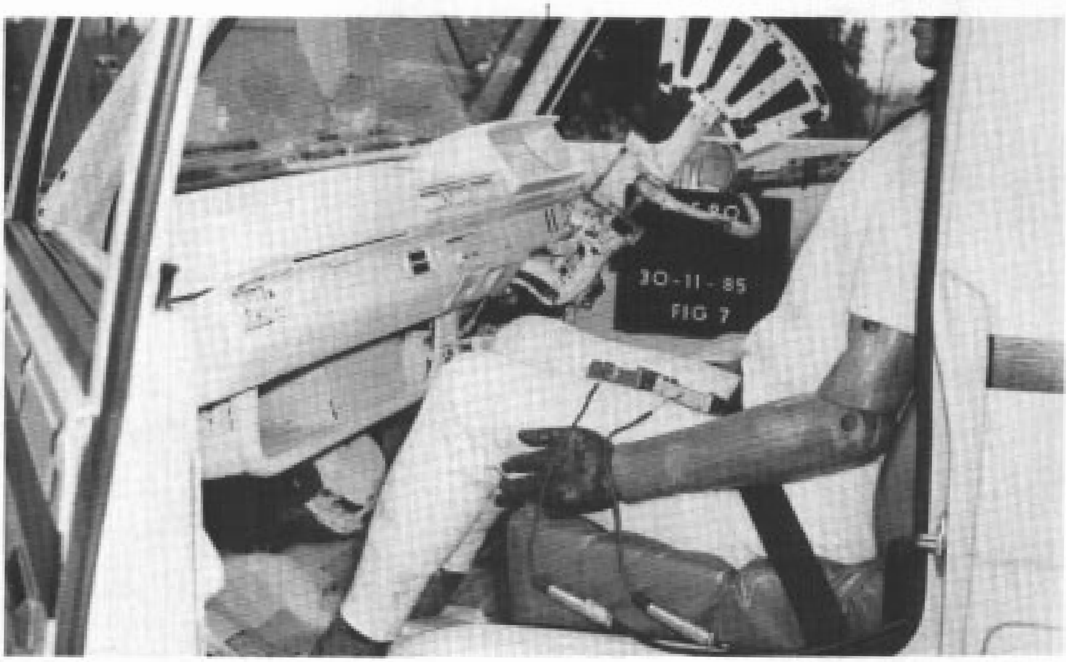


Figure I10: Test F90, Occupant compartment interior -- pre-test

Figure I11: Test F90, Occupant compartment interior -- post-test

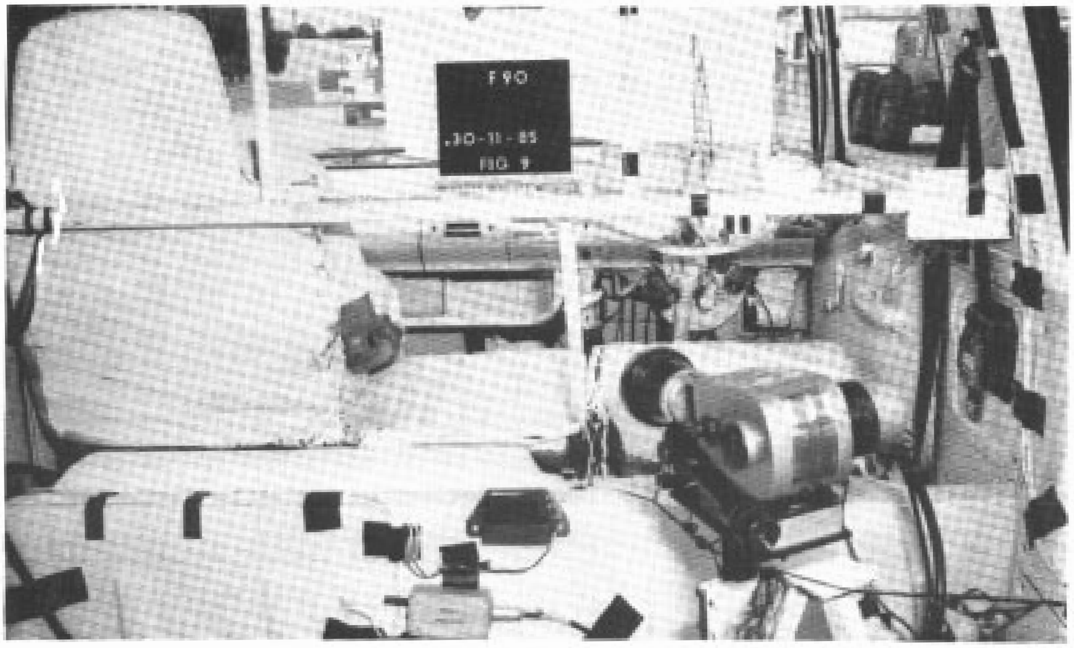


Figure I12: Test F90, Occupant compartment interior viewed from the rear -- pre-test

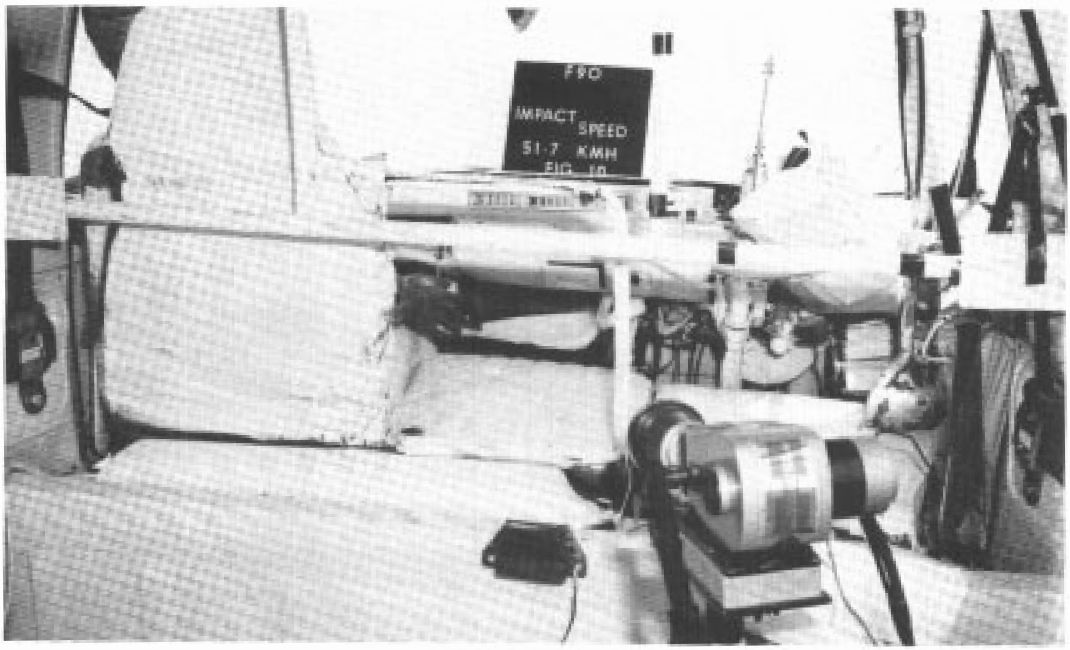


Figure I13: Test F90, Occupant compartment interior viewed from the rear -- post-test

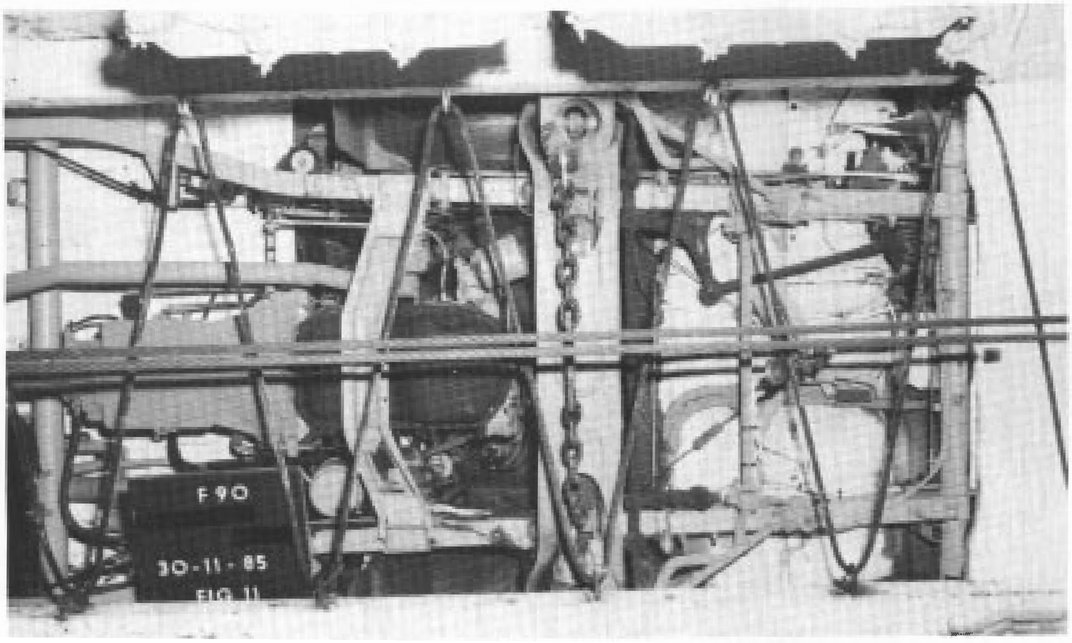


Figure I14: Test F90, Underside view of front of vehicle -- pre-test

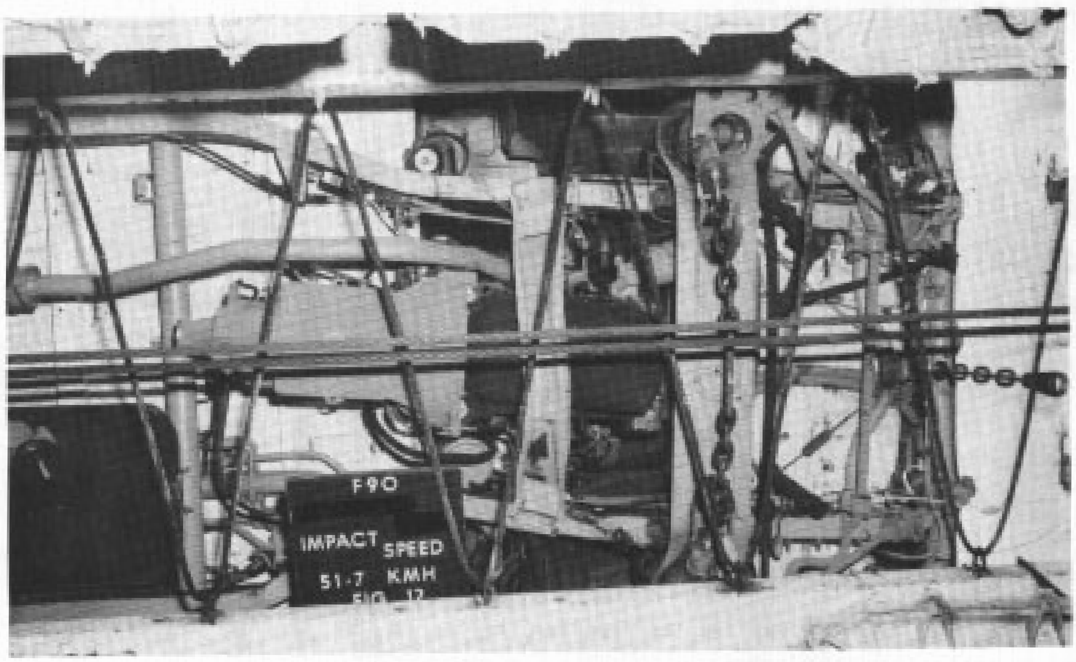


Figure I15: Test F90, Underside view of front of vehicle -- post-test

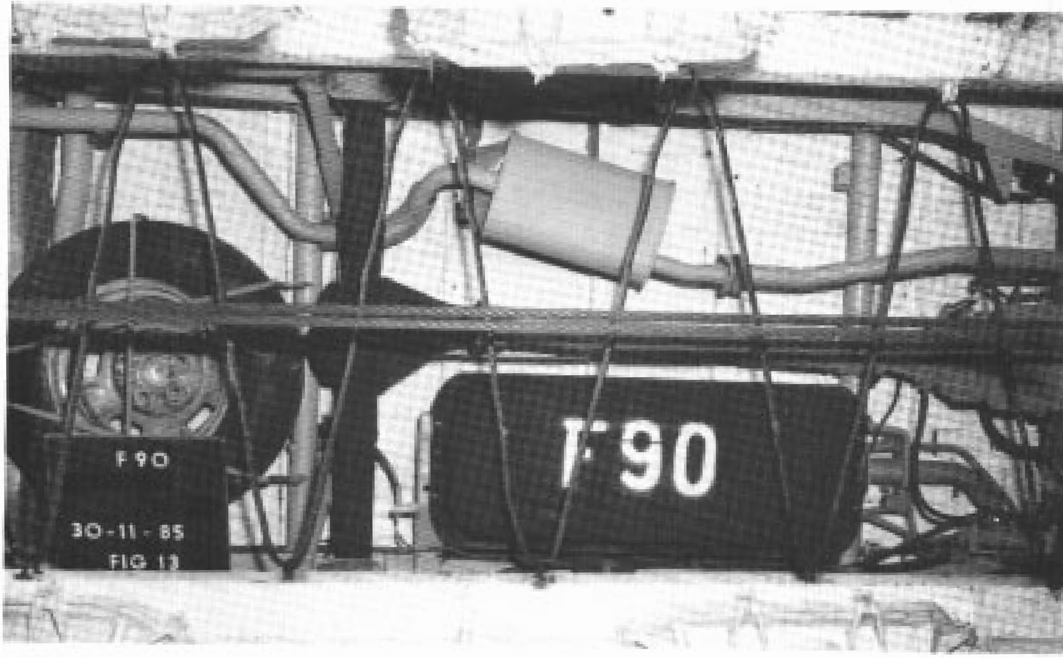


Figure I16: Test F90, Underside view of rear of vehicle -- pre-test

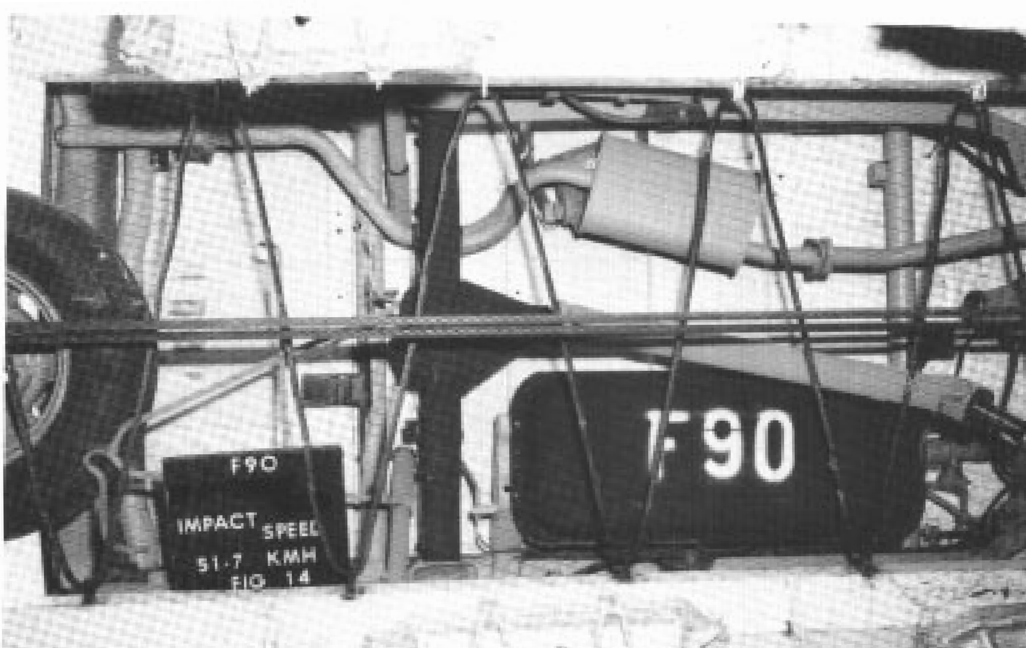


Figure I17: Test F90, Underside view of rear of vehicle -- post-test

F90

MEASUREMENT POINT DESCRIPTION		PRE TEST Horiz	PRE TEST Vert	POST TEST Horiz	POST TEST Vert	DISPLACEME Horiz	DISPLACEME Vert
Dash panel features							
Rearmost point	Right	2111	609	1897	652	214	43
	Centre	2128	594	1914	634	214	40
	Left	2129	588	1899	638	230	50
Dash mounting screw	Right	2140	573	1935	643	205	70
Dash metal structure	Left	2161	590	1948	645	212	55
Head light mount screw	Left	2404	313	2095	336	309	23
Front panel at height of brake pedal	Right	2537	35	2239	152	298	117
	Left	2533	85	2228	132	305	47
Steering column lower bracket	Right	2415	50	2122	55	293	5
	Left	2340	10	2072	-20	268	-30
Steering column nut		1931	604	1748	665	183	61
Steering column upper bracket bolt	Right	2091	431	1854	467	237	36
	Left	2091	431	1852	467	239	36
Engine (tappet cover bolt)		1446	211	1449	216	3	5
Seat belt anchorages							
Drivers seat	Outer lap	1411	173	1406	175	5	2
	Upper	1140	908	1136	907	4	-1
	Inertia Reel	1236	392	1232	401	4	9
Outboard passenger	Outer lap	1405	173	1404	176	1	3
	Upper	1140	908	1132	904	8	-4
	Inertia reel	1234	392	1232	389	2	-3
Seat anchorages							
Drivers seat	Right front	1818	146	1817	144	1	-2
	Right rear	1451	139	1456	152	5	13
Passengers seat	Front right	1855	169	1845	210	10	41
	Front left	1845	120	1845	194	0	74
	Rear left	1127	300	1121	308	6	8
	Rear centre	1127	300	1123	308	4	8
	Rear right	1127	300	1124	307	3	7
LH sun visor mount		2019	1106	2000	1232	19	126
RH sun visor mount		2030	1109	2001	1240	29	131
Rear vison mirror mount		2031	1109	1997	1243	34	134
H point	Driver	1501	313	-	-	-	-
	Passenger	1520	313	-	-	-	-
Width between A pillars		1478	-	1510	-	32	-
Floor to roof height at H point	Driver	-	1041	-	1035	-	-6
	Passenger	-	1041	-	1076	-	35

Length of footwell at centreline of seating position								
Passenger	680	-	345	-	335	-		
Driver	600	-	310	-	290	-		
Brake pedal to bulkhead	380	-	120	-	260	-		
Clutch pedal to bulkhead	375	-	90	-	285	-		
Front of vehicle to B pillar								
Left	1500	-	1159	-	341	-		
Right	1500	-	1185	-	315	-		

Body side targets		**Horiz Right**	**Horiz Left**	**Horiz Right**	**Horiz Left**
	0	52	0	52	0
	250	170	85	80	165
	500	322	280	178	220
	750	566	518	184	232
	1000	798	768	202	232
	1250	1047	1018	203	232
	1500	1211	1185	289	315
	1750	1455	1435	295	315
	2000	1705	1684	295	316
	2250	1955	1934	295	316
	2500	2205	2184	295	316
	2750	2455	2434	295	316
	3000	2705	2684	295	316
	3250	2955	2934	295	316
	3500	3205	3184	295	316