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Ref: S/04325

SPECIAL REPORT: SR2008/003

Dynamic sled testing of the 'Tummy Shield' cushion (test details and results)

Client: Tummy Shield Company

Client's reference: [REDACTED]

Test item: 'Tummy Shield' cushion.

Date of tests: 1st October 2008.

Prepared by: [REDACTED]
Project Co-ordinator.

Date: 31 Oct 2008

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Project Officer.

Date: 31 Oct 2008

Issued by: [REDACTED]
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The tests, calibrations and/or measurements covered by this document are traceable to national standards of measurement.

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Introduction

This research and development test program was requested by [REDACTED] to assess the dynamic test performance of the 'Tummy Shield' cushion.

The 'Tummy Shield' cushion primarily consists of a section of foam moulded onto a steel plate incorporating a metal guide (hook). It is designed to help reduce the risks of women and foetuses from motor vehicle injury during pregnancy by altering the geometry of the lap section of a conventional three-point seatbelt. The cushion (shown below) is placed on a vehicle seat and secured by means of a webbing strap and buckle at the back of the seat. The occupant sits on the cushion and wears the seatbelt as normal. The middle portion of the lap belt is then placed under the hook while adjusting any slack in the seatbelt.

[REDACTED] requested two dynamic sled tests to be conducted to enable a direct comparison. The tests both involved the use of a restrained test dummy in a passenger vehicle seat which was subjected to a frontal impact deceleration of approximately 28 g. The first test was a control test and the second test was fitted with the 'Tummy Shield' cushion.

This report documents the details of these tests and the results obtained. The data acquired and high-speed video of the test were provided to the client for analysis, to assess the dynamic performance and determine likelihood of injury to the occupant.

A previous test program conducted for [REDACTED] on a prototype cushion is documented in Crashlab report SR2007/005. Crashlab does not make any representations or warranty as to the adequacy, completeness or appropriateness of testing conducted on the 'Tummy Shield' cushion. In particular there are concerns of occupant entrapment in an emergency situation were the lap belt has to be unthreaded from under the hook. There is also the potential of misuse where the cushion may not be adequately secured, for instance in a rear seating position, which may have the potential to compromise the seating position of the occupant or becoming a projectile in a collision. These concerns are not within the scope of this program.



Cushion placed on a vehicle seat



Cushion fitted under test dummy

Test methodology

The test method involved mounting a vehicle seat to the test sled which was then subjected to a frontal impact deceleration of approximately 28 g. The first test (# S080327) involved the test dummy restrained by a three-point seatbelt in the vehicle seat. The second test (# S080328) was similar and involved the 'Tummy Shield' cushion fitted under the test dummy with the lap section of the seatbelt directed under the hook.

The test methods and specifications were carried out in accordance with the instructions provided and as requested by the client [REDACTED], whom was present for the testing.

Sled calibration

Crashlab's Monterey horizontal crash simulator (sled) was used to produce the simulated vehicle impact. The sled was calibrated using rigid ballast to represent the mass of the test seat, dummy and restraint system. The ballast was removed during the actual test to maintain a nominal test mass.

Sled test pulse

The dynamic impact simulation requested was based on ADR 4/03 Seatbelts. This requires a velocity change of not less than 49 km/h and a forward deceleration achieved within 30 ms of between 24 and 34 g, and must maintain this deceleration for not less than 20 ms. The sled calibration pulse (# S080325) is contained in Appendix B.

Photography

Two stationary high-speed cameras were used to record the dynamic impact. The cameras were positioned at 90° side (1000fps) and overhead (500fps) with respect to the direction of impact.

Test dummy

A Hybrid III 5th percentile female anthropomorphic test device (ATD) was used as the restrained occupant on the vehicle seat. This dummy is specified under Title 49 CFR Part 572 Subpart O - Hybrid III 5th percentile female test dummy. This part describes the anthropomorphic test devices that are to be used for motor vehicle safety standard compliance testing of motor vehicles and motor vehicle equipment. The dummy positioning was based on Subpart O of Part 572 and was instrumented to acquire biomechanical injury data during the test as specified in Table 1.

Location	Description	Channels
Head	Triaxial accelerometer	Gx, Gy, Gz
Neck	Six-axis upper neck load cell	Fx, Fy, Fz, Mx, My, Mz
Thorax	Triaxial accelerometer Chest Displacement Potentiometer	Gx, Gy, Gz Dx
Pelvis	Triaxial accelerometer	Gx, Gy, Gz
Femur	Six-axis femur load cell	Fx, Fy, Fz, Mx, My, Mz (one per leg)

Table 1 – Hybrid III 5th percentile female ATD instrumentation

Vehicle seat

A 2000 Mazda 626 front passenger seat was supplied for testing by the client. The seat was mounted to the test sled using specifically made mounting brackets to simulate those to be used in an actual vehicle. This seat was used for both tests.

The settings and measurements for the seat are as follows:

- seat runner was adjusted in the mid fore-aft position,
- head restraint was adjusted in the lowermost position,
- seat back angle adjusted to 15° (as nominated by the client) achieved using the H-point machine specified in SAE J826 (APR80) setup for a 5th percentile female test dummy,
- footrest angle was 44.9° and located 800 mm forward from the seat datum point[†].

The seat did not incorporate any other adjustments.

[†] The seat datum point is referenced from the vehicle seat's anchorage mount (rear left bolt-hole mount) as shown in photograph 1 in Appendix C.

Vehicle seat and dummy adjustments

The vehicle seat and test dummy adjustments are specified in Table 3.

Test number		S080327	S080328
Vehicle seat adjustments	fore-aft position	mid	mid
	headrest	lowermost	lowermost
	seat back angle ^a	15.5°	15.5°
Test dummy adjustments	pelvic angle	18.3°	19.4°
	head angle x-axis ^b	0.2°	0.3°
	head angle y-axis	0.3°	0.4°
	knee to knee centre	160 mm	163 mm

Table 3 - Vehicle seat and test dummy adjustments

^a The seat back angle obtained was the closest adjustment possible to the 15° angle specified.

^b Head level adjusted using the neck bracket set at 7° (extension).

Seatbelt restraint system

An inertia reel lap and sash (three-point) seatbelt with rigid buckle was used to restrain the test dummy. The seatbelt was mounted using specifically made mounting brackets to simulate those to be used in an actual vehicle. The seatbelt buckle which was designed to mount directly to the vehicle seat was mounted as close as practical to its intended mount using a rigid anchor mount. This was intended to ensure that there is no direct deformation of the seat from loading of the buckle anchorage. A new seatbelt was used for each test.

Webbing force transducers were used to record the lap and sash loads of the seatbelt. The coordinates for the seatbelt anchorages are specified in Table 4 and the test specimen details are specified in Appendix A.

Anchorage	x-axis	y-axis	z-axis
Lap inner (buckle)	100	498	-142
Lap outer	-71	-25	-6
Retractor	-71	-35	-6
Shoulder	-78	-26	-819

Dimensions in millimetres and measured from the seat datum point (refer to footnote on page 4)

The vehicle coordinate system as specified in SAE J211-1 (DEC2003) was used:

Positive x-axis is directed forward relative to the direction of the vehicle seat.

Positive y-axis is directed away from the vehicle seat's left to its right.

Positive z-axis is directed downward.

Table 4 - seatbelt anchorage coordinates

Test results

The test observations are specified in Table 5. The data traces and photographs are provided in Appendix B and C respectively.

Test No.	Component	Comments
S080327	Vehicle seat	<p>Inspection revealed no apparent deformation of the seat anchorages and the adjustment systems remained locked in position.</p> <p>The seat revealed some minor deformation of the metal panel under seat pan.</p>
	Seatbelt	<p>The dummy was effectively restrained in the vehicle seat by the seatbelt with no apparent deformation of the belt anchorages.</p> <p>The seatbelt revealed partial separation of the spring cover on retractor assembly, deformation of rigid plate on buckle assembly, and abrasion of webbing.</p> <p>The seatbelt buckle was capable of manual release.</p>
	'Tummy shield' Cushion	n/a
S080328	Vehicle seat	<p><i>The deformation of the metal panel under the seat pan from the first test was repaired before this test to obtain as near as possible similar profile.</i></p> <p>Inspection revealed no apparent deformation of the seat anchorages and the adjustment systems remained locked in position.</p> <p>The seat revealed some minor deformation of the metal panel under seat pan.</p>
	Seatbelt	<p>The dummy was effectively restrained in the vehicle seat by the seatbelt with no apparent deformation of the belt anchorages.</p> <p>The seatbelt revealed partial separation of the spring cover on retractor assembly, deformation of rigid plate on buckle assembly, and abrasion of webbing.</p> <p>The seatbelt buckle was capable of manual release. The lap section of the belt needed to be unthreaded from under the hook to allow removal of the dummy (occupant).</p>
	'Tummy shield' Cushion	<p>No damage was visible to the cushion or hook.</p> <p>The retention strap securing the cushion revealed tearing and fraying of webbing.</p>

Table 5 - Test observations

'Tummy Shield' cushion



Photograph 9
'Tummy shield' cushion



Photograph 10
Cushion with cover removed



Photograph 11
Hook detail on cushion



Photograph 12
Metal plate inside cushion

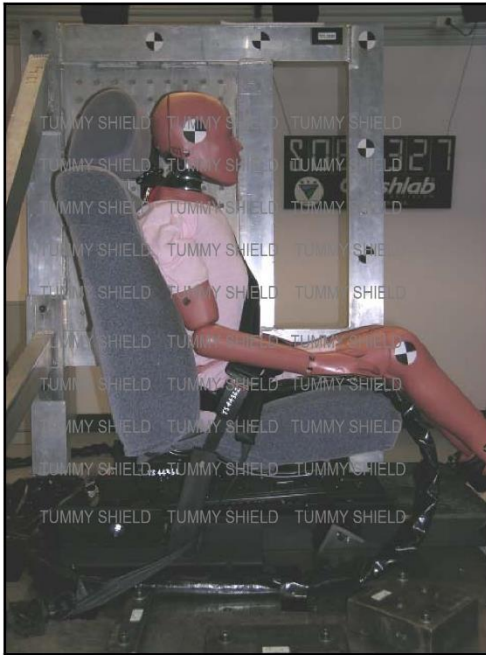


Photograph 13
Cushion retention strap fastened to vehicle seat

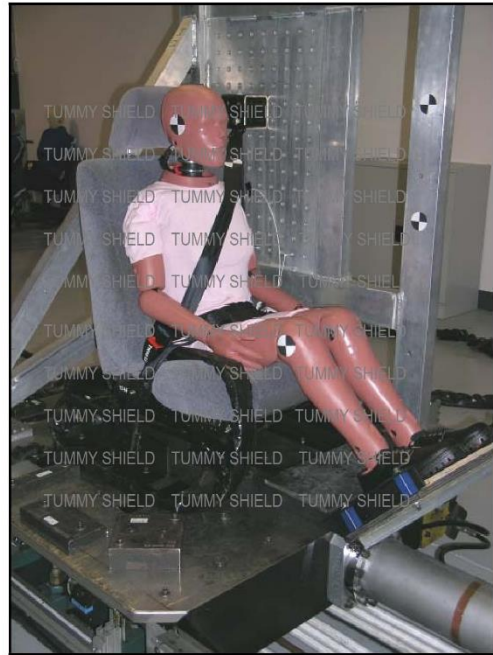


Photograph 14
Detail of three-bar buckle on cushion strap

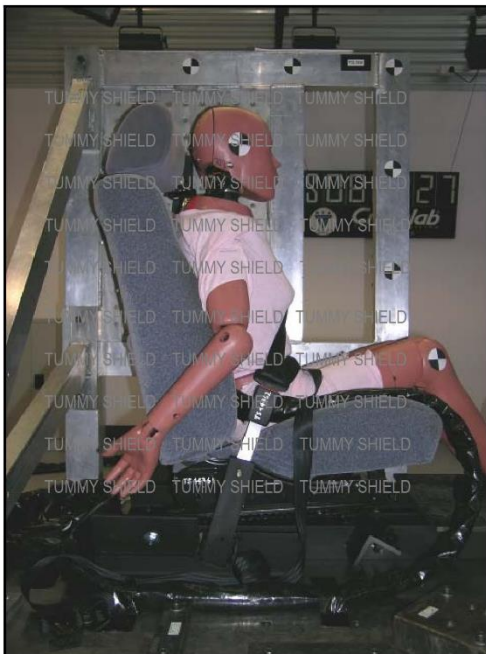
S080327



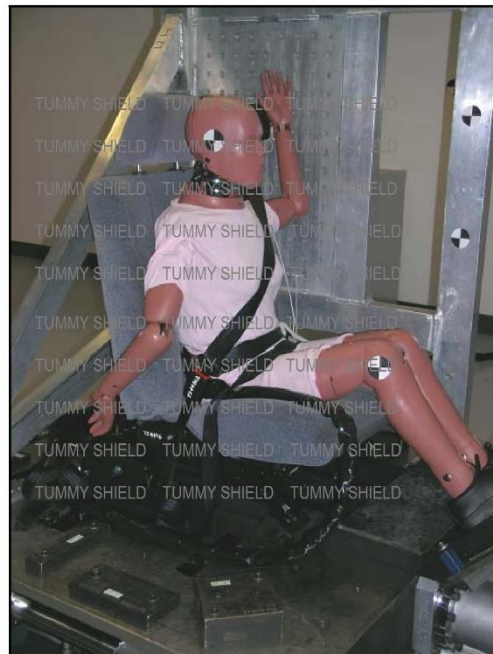
Photograph 15
S080327 Pre-test



Photograph 16
S080327 Pre-test

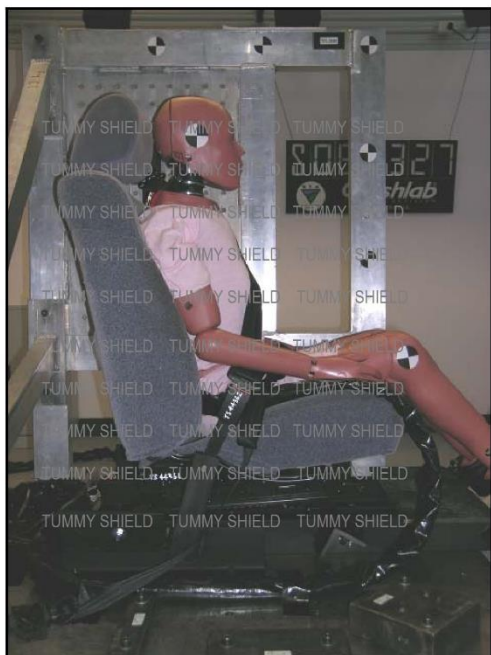


Photograph 17
S080327 Post-test

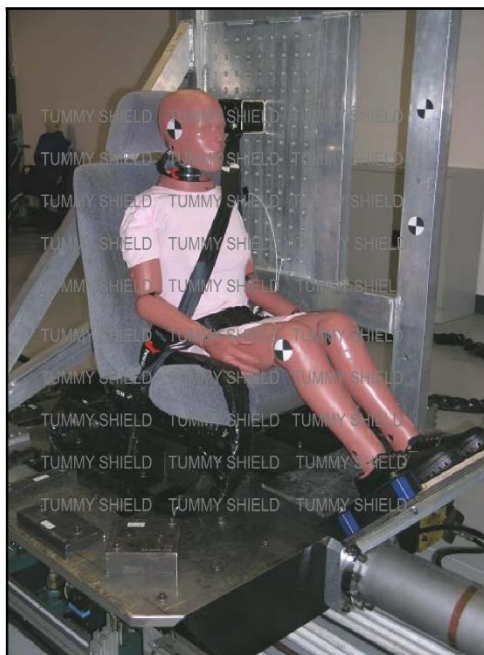


Photograph 18
S080327 Post-test

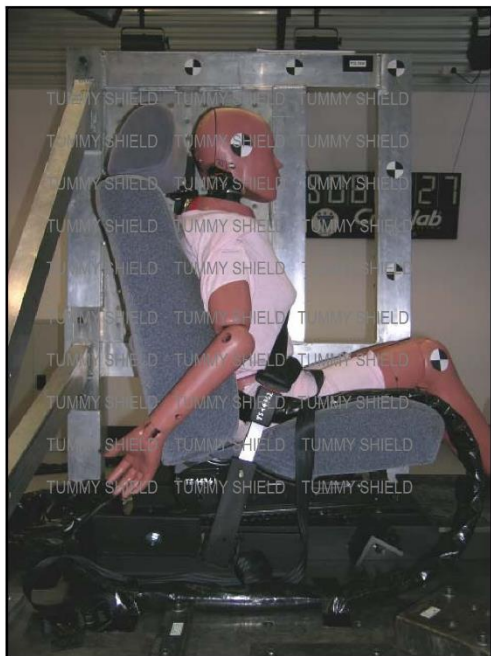
S080327



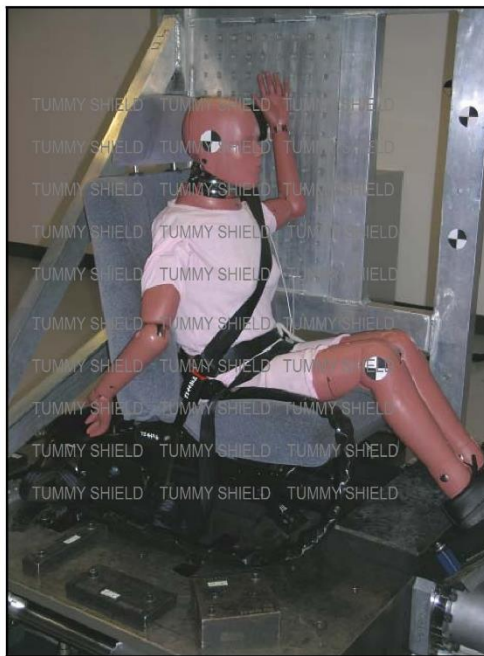
Photograph 15
S080327 Pre-test



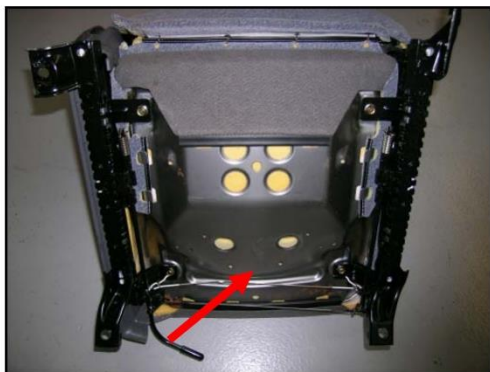
Photograph 16
S080327 Pre-test



Photograph 17
S080327 Post-test



Photograph 18
S080327 Post-test



Photograph 19 - S080327 Post-test
Minor deformation of metal panel under seat pan



Photograph 20 - S080327 Post-test
Abrasion of seatbelt webbing through sash guide



Photograph 21 - S080327 Post-test
Partial separation of spring cover on seatbelt retractor



Photograph 22 - S080327 Post-test
Detail of spring cover assembly



Photograph 23 - S080327 Post-test
Deformation rigid buckle on seatbelt assembly



Photograph 24 - S080327 Post-test
Detail of rigid buckle