

Sled Impact Test

**PR 1505**

**Product Design Group, Inc.**

**Frontal Impact of a Taco Tuesday Bentley Wheelchair  
Secured by a Surrogate Four-Point, Strap-Type Tiedown  
and Loaded with a Hybrid III Midsize-Male ATD  
Restrained by a Three-Point Belt Comprised of a  
Commercial Wheelchair-Anchored Lap Belt and a Surrogate Shoulder Belt**

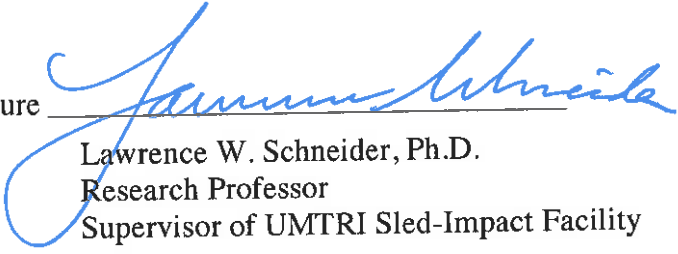
Tested in accordance with Annex A of  
ISO 7176-19 (2008): *Wheeled Mobility Devices for Use in Motor Vehicles*

Test Date: April 29, 2015

Submitted to:  
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## ACKNOWLEDGMENT AND DATA USE RESTRICTION

This test was sponsored by Product Design Group, Inc. of Vancouver and was conducted in accordance with procedures set forth in Annex A of ISO 7176-19 (2008): *Wheeled Mobility Devices for Use in Motor Vehicles*. The wheelchair's performance has been measured and evaluated according to the criteria in 5.2 of ISO 7176-19. Advertisements and marketing literature should refer to the requirements and provisions of ISO 7176-19, but should not refer to the University of Michigan or the University of Michigan Transportation Research Institute (UMTRI). Requests for copies of this report, test film, and video should be directed to the test sponsor.

## TEST METHODS

This frontal-impact test was conducted on the UMTRI impact sled in accordance with Annex A of ISO 7176-19. The sled operates on the rebound principle, achieving the desired change in velocity by reversing direction during the impact event. The sled crash pulse is trapezoidal in shape and is reported as an average deceleration level in *g*. The sled velocity is monitored immediately before and after impact.

Data generated during the test were digitized live using a TDAS onboard data acquisition system. All signals were filtered to the requirements of SAE J-211. The photo documentation consisted of high-speed (1000-frames/sec) digital video from right and right-rear side views of the impact event. A strobe flash and simultaneous voltage pulse record and synchronize the onset of impact deceleration on video and transducer signals.

## TEST SETUP

The Taco Tuesday Bentley wheelchair was placed on the sled platform facing forward and secured using the surrogate four-point, strap-type tiedown specified in Annex D of ANSI/RESNA WC-4:2012, Section 19 (WC19). The front tiedown straps were hooked to the securement points provided on the wheelchair base frame and the rear tiedown straps were hooked to the securement points provided on the seat frame.

The wheelchair was loaded with a Hybrid III midsize-male anthropomorphic test device (ATD) that was restrained by a three-point belt comprised of a Q'Straint wheelchair-anchored lap belt (part number Q2-6322) and a surrogate shoulder belt. Standard metal connectors at the ends of the lap belt were inserted through the seat bight opening and attached to shoulder bolts on the rear securement-point brackets just below the back-support/seat junctions on the sides of the wheelchair. The shoulder-belt upper anchorage was attached to a rigid structure on the sled platform at a position above and behind the ATD's shoulder that simulated a typical vehicle sidewall anchor point. The lower end of the shoulder belt was attached to the pin-bushing anchorage on a length of webbing sewn onto the right half of the lap belt just below the buckle receptacle near the right hip of the ATD. The pelvic belt was tightened to fit snugly over the ATD pelvic region. The shoulder belt was tightened snugly across the ATD chest with a 75-mm block between the belt and ATD, and the block was removed prior to the test.

The test was conducted using 48-kph (30-mph) and 20-g average impact conditions to determine the frontal-impact response of the wheelchair and compliance with performance criteria in section 5.2 of ISO 7176-19. The following table provides further details about the test equipment and setup.

## SUMMARY OF TEST SETUP AND PRE-TEST MEASUREMENTS

<b>GENERAL TEST INFORMATION</b> Test number Test date Wheelchair type Wheelchair tiedown Occupant restraint Anthropomorphic Test Dummy (ATD) Wheelchair orientation Sled platform Desired impact velocity ( $\Delta V$ ) Desired average sled deceleration	PR 1505 April 29, 2015 Taco Tuesday Bentley wheelchair Surrogate four-point, strap-type tiedown 3-point belt with a commercial WC-anchored lap belt Hybrid III midsize-male @ 79.5 kg (175 lb) Forward facing Rigid steel plate 48 kph (30 mph) 20 g
<b>WHEELCHAIR TIEDOWN</b> Front-to-rear anchor-point distance Rear tiedowns Lateral distance between anchor points Angle wrt horizontal Angle wrt to wheelchair center plane Anchor point to rear-wheel hub Length (anchor point to securement point) Front tiedowns Lateral distance between anchor points Angle wrt horizontal Angle wrt to wheelchair center plane Length (anchor point to securement point)	1295 mm (51.0 in)  343 mm (13.5 in) 40 degrees 0 degrees 356 mm (14.0 in) 495 mm (19.5 in)  737 mm (29.0 in) 19 degrees 12 degrees 546 mm (21.5 in)
<b>OCCUPANT RESTRAINT</b> Shoulder belt upper anchor point location Behind ATD shoulder Above ATD shoulder Above sled platform Left of wheelchair centerline Angle of pelvic belt wrt to horizontal Angle of shoulder-belt Projected frontal view wrt horizontal Projected lateral view wrt horizontal	305 mm (12.0 in) 178 mm (7.0 in) 1232 mm (48.5 in) 305 mm (12.0 in) 64 degrees  50 degrees, measured on ATD torso 30 degrees, measured above ATD shoulder
<b>FOOTSTRAP POSITIONING</b> Above ATD knee center In front of ATD knee center	51 mm (2.0 in) 483 mm (19.0 in)
<b>ATD POSITIONING</b> Shoulder height above sled platform H-point height above sled platform	1054 mm (41.5 in) 616 mm (24.3 in)
<b>WHEELCHAIR</b> Weight Wheelbase Seatback angle wrt vertical Seatback height (with headrest) Seatpan angle wrt horizontal Seat surface height from floor @ SB junction Seatpan length	40.9 kg (90 lb) 432 mm (17.0 in) 20 degrees 813 mm (32.0 in) 5 degrees 495 mm (19.5 in) 432 mm (17.0 in)
<b>POSTURAL SUPPORT DEVICES USED</b>	Head, foot and arm supports

## TEST RESULTS

The Taco Tuesday Bentley wheelchair was effectively secured during frontal-impact loading and the ATD was effectively restrained from forward and rearward excursions by the three-point belt with commercial wheelchair-anchored lap belt and wheelchair back support, respectively. The wheelchair was in an upright position at the completion of the test and the ATD was in the seat with the torso upright. The locking mechanism of the tilt seating system did not release or fail during the test. The maximum forward excursion of point P on the wheelchair seating system was 86 mm, which is below the ISO 7176-19 excursion limit of 200 mm. The plastic housing that covers the front wheel axles broke on the left wheel and cracked on the right wheel, but plastic joining the axles to the tires served as backup support components, so these cracks are not considered test failures. After the test, there was little observable deformation and no failure or separation of any securement points. The wheelchair was released from the tiedown system and the ATD was released from the wheelchair without the use of tools.

Peak forward excursion of the ATD's head was approximately 448 mm and peak forward knee excursion was about 282 mm, which are below the ISO 7176-19 limits of 650 mm and 375 mm, respectively. The ATD's head traveled 355 mm rearward from its initial position during the rebound from frontal-impact loading, which is below the ISO 7176-19 limit of 450 mm. The average post-test ATD H-point height did not change from the average pre-test height.

The results of this test show that the Taco Tuesday Bentley wheelchair with a wheelchair-anchored lap belt *meets* all of the performance criteria for wheelchair dynamic strength specified in 5.2 of ISO 7176-19. The following tables summarize the test results and compliance with ISO 7176-19.

## SUMMARY OF TEST RESULTS

<b>GENERAL TEST INFORMATION</b> Test number Actual impact velocity ( $\Delta V$ ) Actual average sled deceleration level Actual peak sled deceleration level Total time of deceleration over 20 g Total time of deceleration over 15 g Deceleration pulse duration	PR 1505 48 kph (30.2 mph) 20.6 g 23.5 g 30.7 ms 61.0 ms 80.9 ms
<b>ATD MEASUREMENTS</b> Peak resultant head acceleration Peak resultant chest acceleration Head Injury Criterion (15 ms) Maximum forward head excursion <sup>†</sup> Maximum forward knee excursion <sup>††</sup> Maximum rearward head excursion <sup>††</sup> Average post-test H-pt ht above sled platform	66 g 42 g 274 448 mm (17.7 in) 282 mm (11.1 in) 355 mm (14.0 in) 617 mm (24.3 in) 0% change
<b>TIEDOWN LOADS</b> Peak left-rear tiedown strap force Peak right-rear tiedown strap force	16707 N (3756 lb) 18691 N (4202 lb)
<b>BELT LOADS AND PELVIC BELT ANGLE</b> Peak left pelvic-belt load Peak shoulder-belt load	9092 N (2044 lb) 9986 N (2245 lb)
<b>WHEELCHAIR MEASUREMENTS<sup>††</sup></b> Maximum forward wheelchair excursion at Point P* Maximum forward excursion of front-wheel hub Maximum forward excursion of rear-wheel hub	86 mm (3.4 in) 63 mm (2.5 in) 75 mm (2.9 in)

<sup>†</sup>The forward head excursion is the total forward change in position of the leading edge of the head, measured at the initial position prior to impact and at the time of maximum forward head travel.

<sup>††</sup>Excursions reported are the total horizontal change in the position of the affixed targets relative to the sled platform from just prior to impact to the time of maximum forward or rearward excursion.

\*Point P is a seating reference point located 50 mm above and 50 mm in front of the junction of the seatback and seat cushion planes.

**SUMMARY OF PERFORMANCE TO ISO 7176-19 (2008)  
SLED TEST PR 1505**

Requirement		Observed Performance	
ISO 7176-19 Clause	Description	Description	Pass/Fail
5.2.1a	Forward excursion of Point P < 200 mm	86 mm	Pass
	Forward knee excursion < 375 mm	282 mm	Pass
	Forward head excursion < 650 mm	448 mm	Pass
	Rearward head excursion < 450 mm	355 mm	Pass
5.2.1b	Ratio of ATD knee excursion to Point P excursion must exceed 1.1.	N/A – a WC-anchored lap-belt restraint was used.	N/A
5.2.1c	Batteries must be within WC footprint	N/A	N/A
	Batteries cannot move into the WC user's space.	N/A	N/A
5.2.2a	WC must be upright and on test platform and the ATD must be in WC seat with torso leaning not more than 45° in any direction	The WC was upright on test platform and the ATD was seated in WC with the torso upright at the end of the test.	Pass
5.2.2b	WC securement points cannot show signs of material failure	There was no sign of securement point failure.	Pass
5.2.2c	Detached hardware cannot exceed 100 g	Seatbelt buckle cover that detached was < 100 g.	Pass
5.2.2d	WC must not have sharp edges with potential for occupant contact	There were no sharp edges with potential for occupant contact.	Pass
5.2.2e	Primary load-carrying components shall not show visible signs of structural failure unless there is a backup system to provide support	The plastic surrounding the front wheel axles cracked but additional plastic served as backup support.	Pass
5.2.2f	Locking mechanisms of tilt-in-space seat adjusters shall not show signs of failure	The locking mechanism of the tilt seating did not show signs of failure.	Pass
5.2.2g	Removal of ATD from WC shall not require use of tools	No tools were required.	Pass
5.2.2h	Release of WC from tiedown system shall not require use of tools	No tools were required.	Pass
5.2.2i	Post-test height of ATD H-point shall not be more than 20% lower than pretest height	Average H-point height did not change from the average pre-test height.	Pass
5.2.2j	WC cannot cause partial or complete failure of the webbing of the surrogate WTORS	There was no partial or complete failure of surrogate WTORS webbing.	Pass

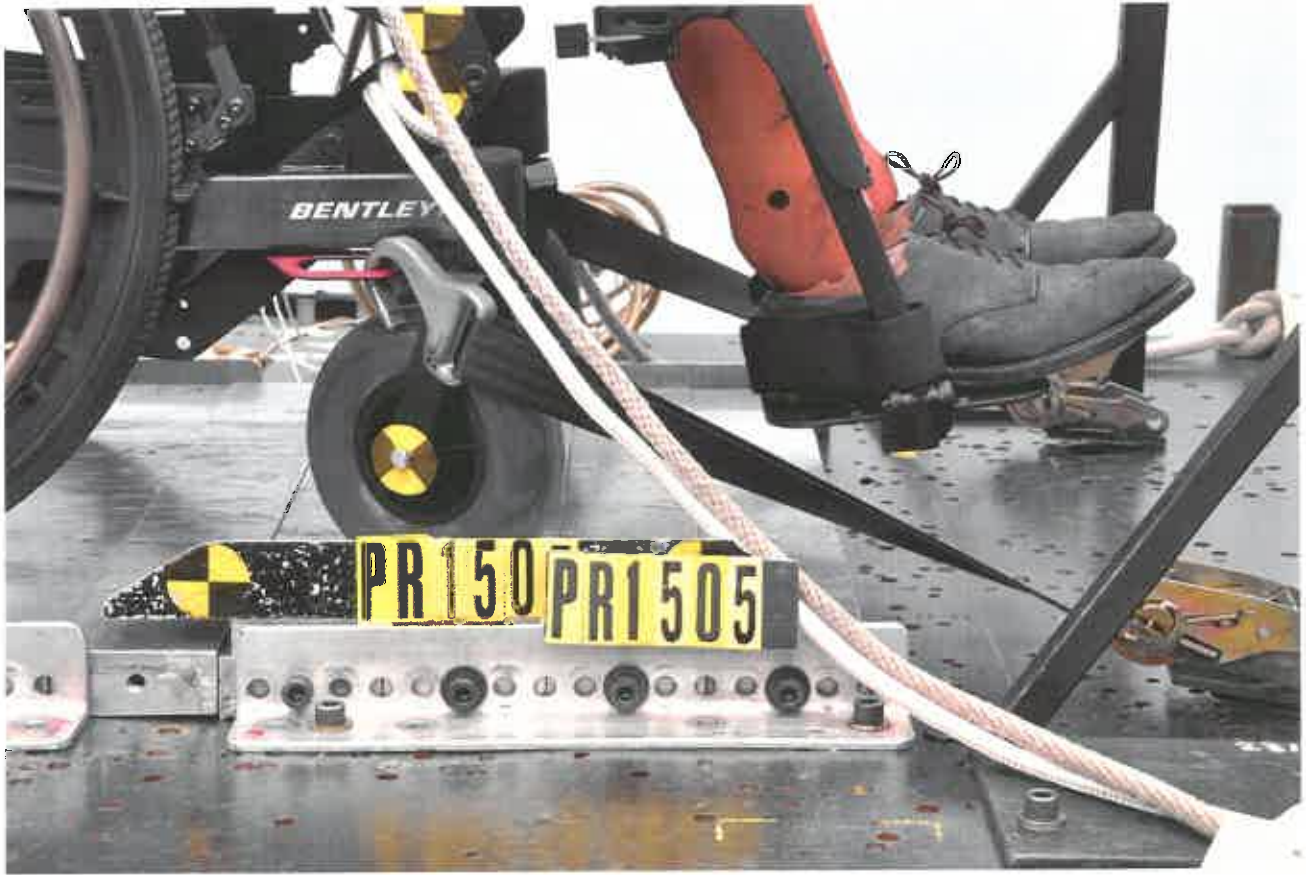
Note: WC = wheelchair, N/A = not applicable



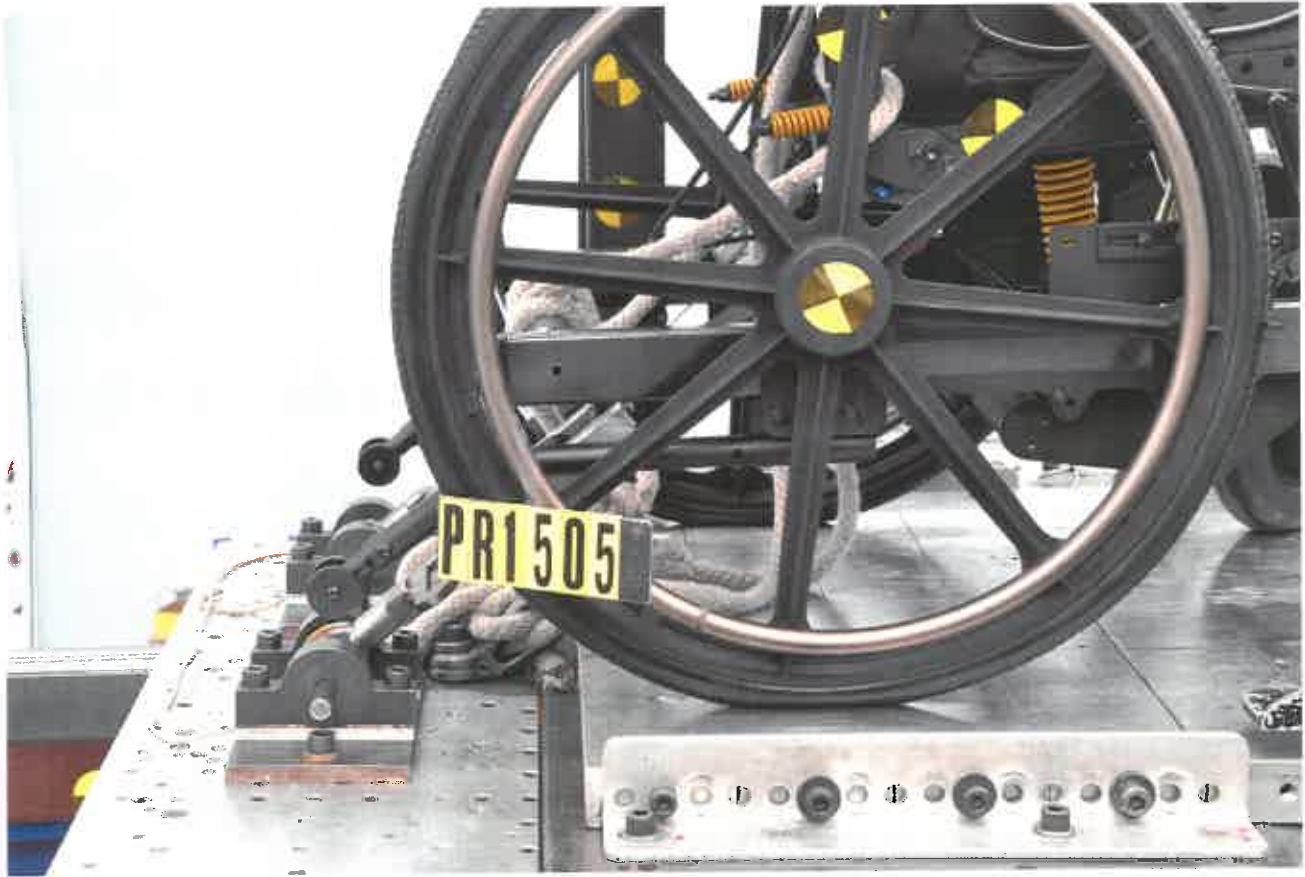
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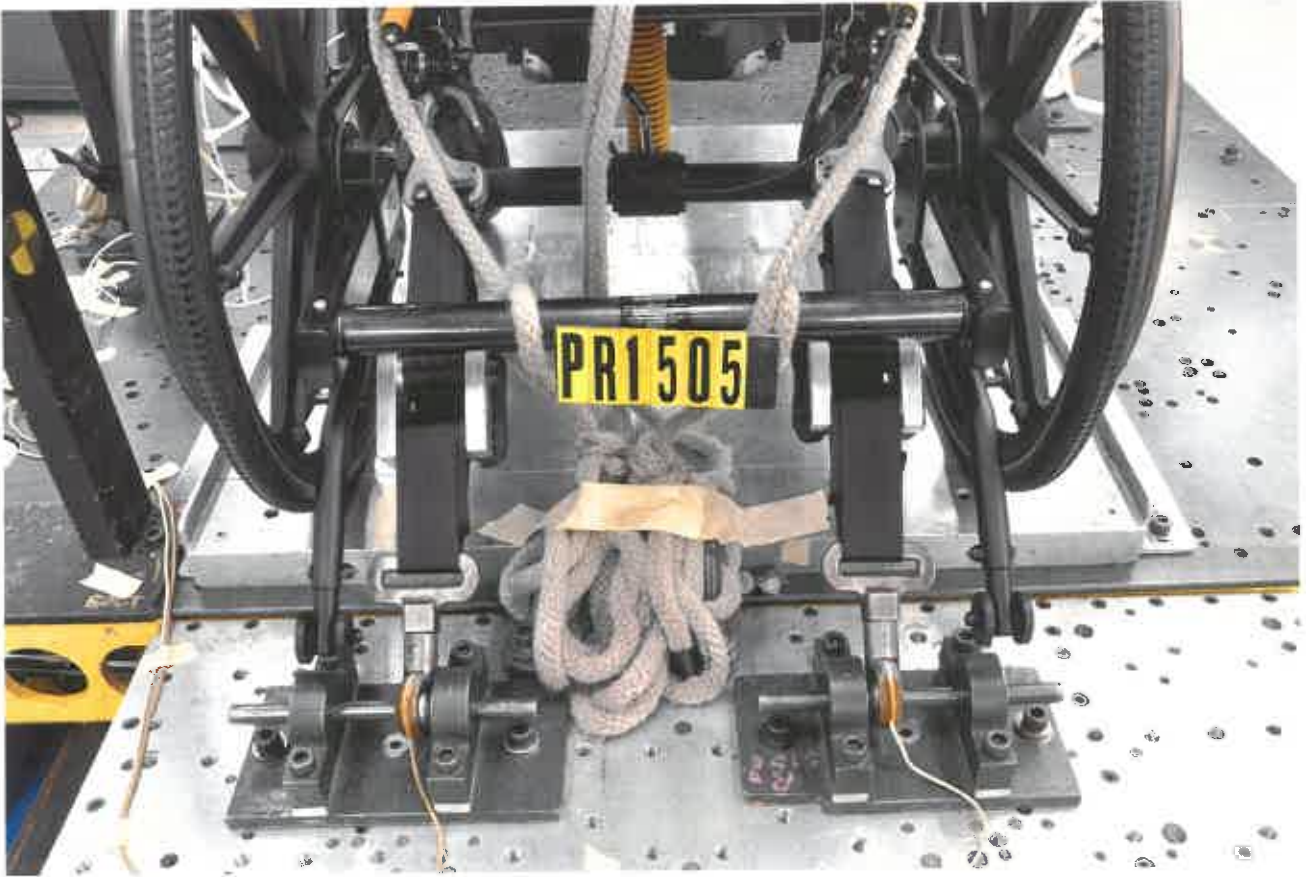


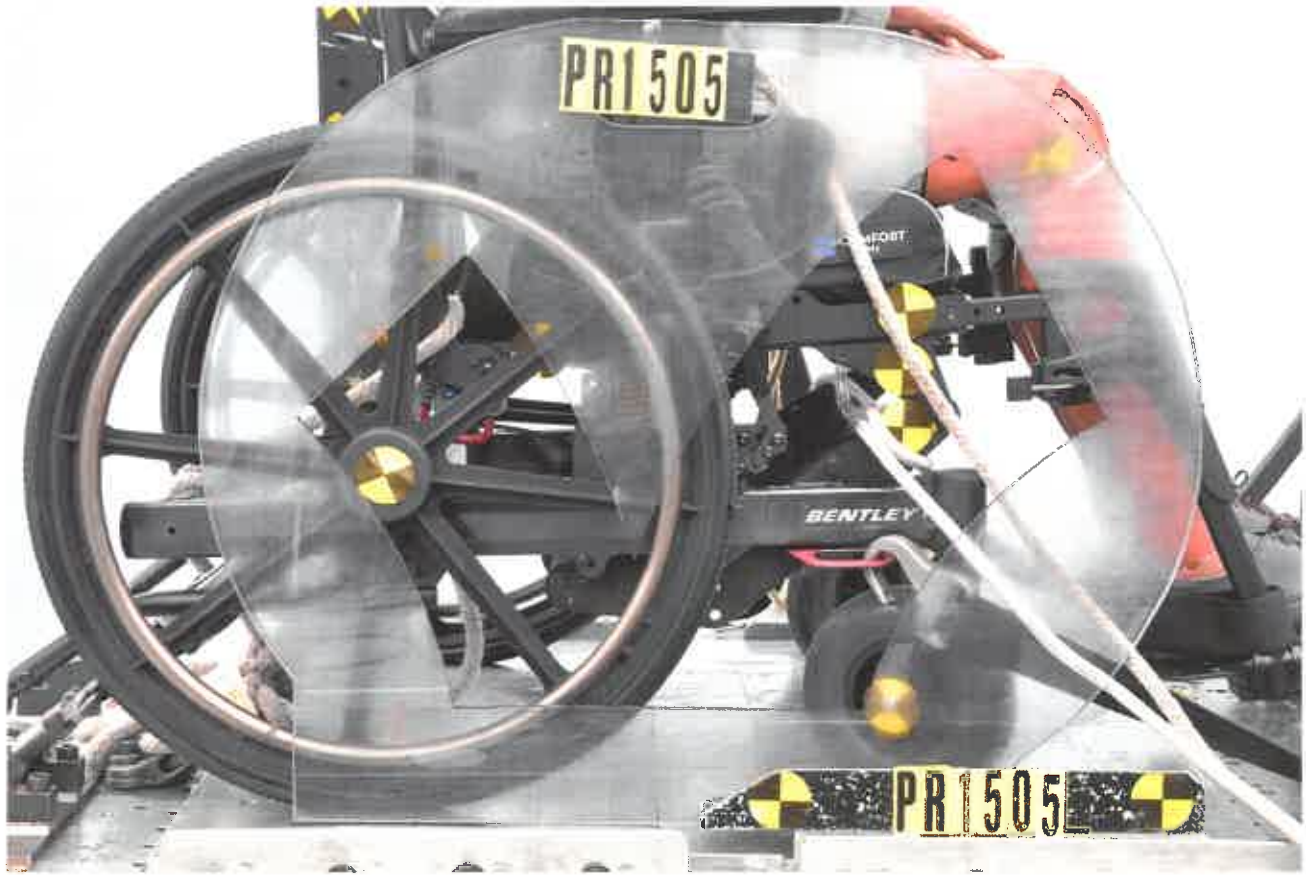














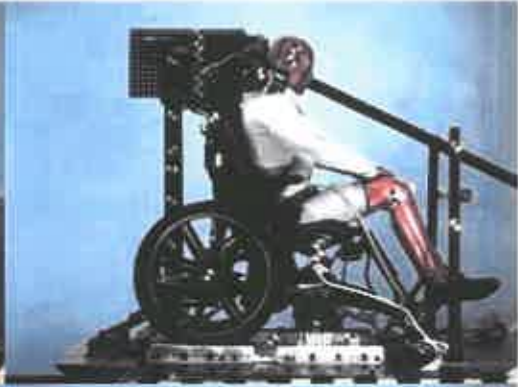
**TEST AND POST-TEST PHOTOS**

# PR1505

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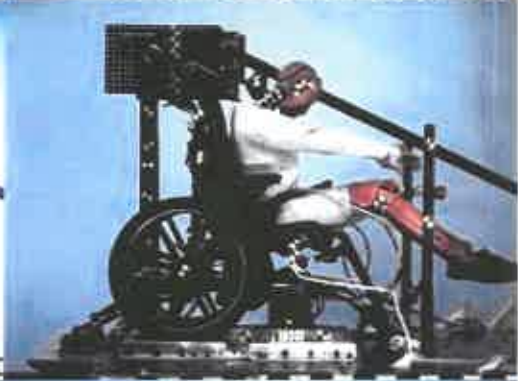
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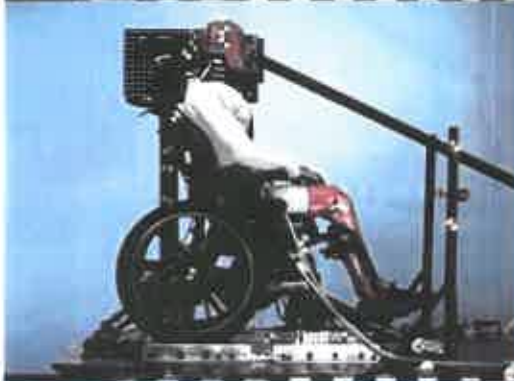
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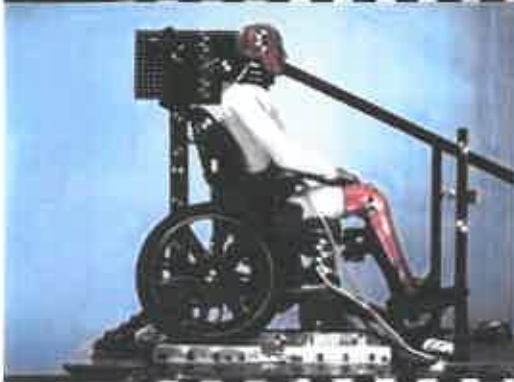
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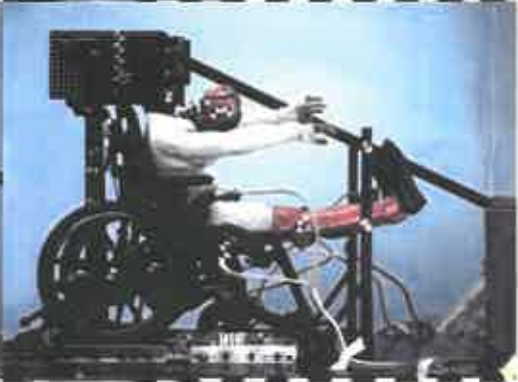
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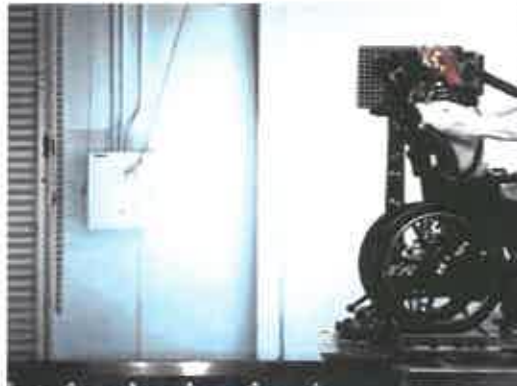


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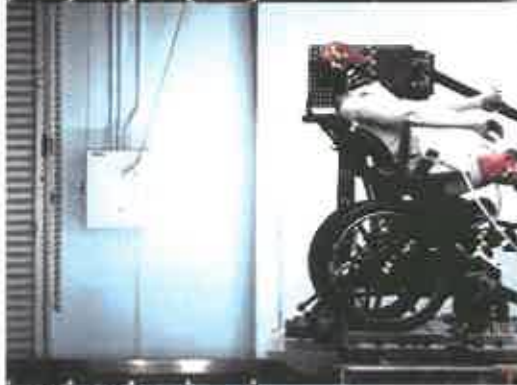
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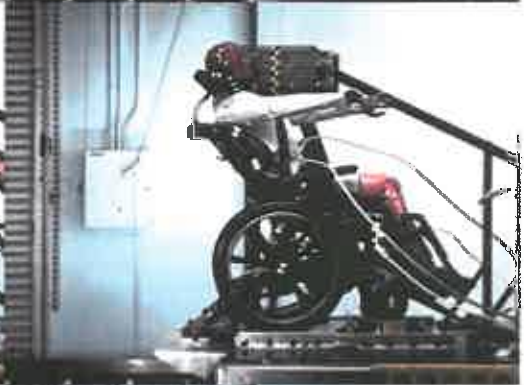
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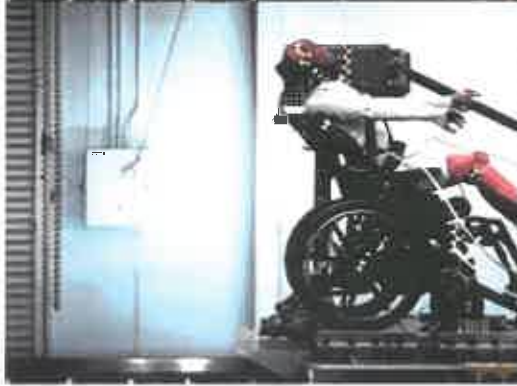
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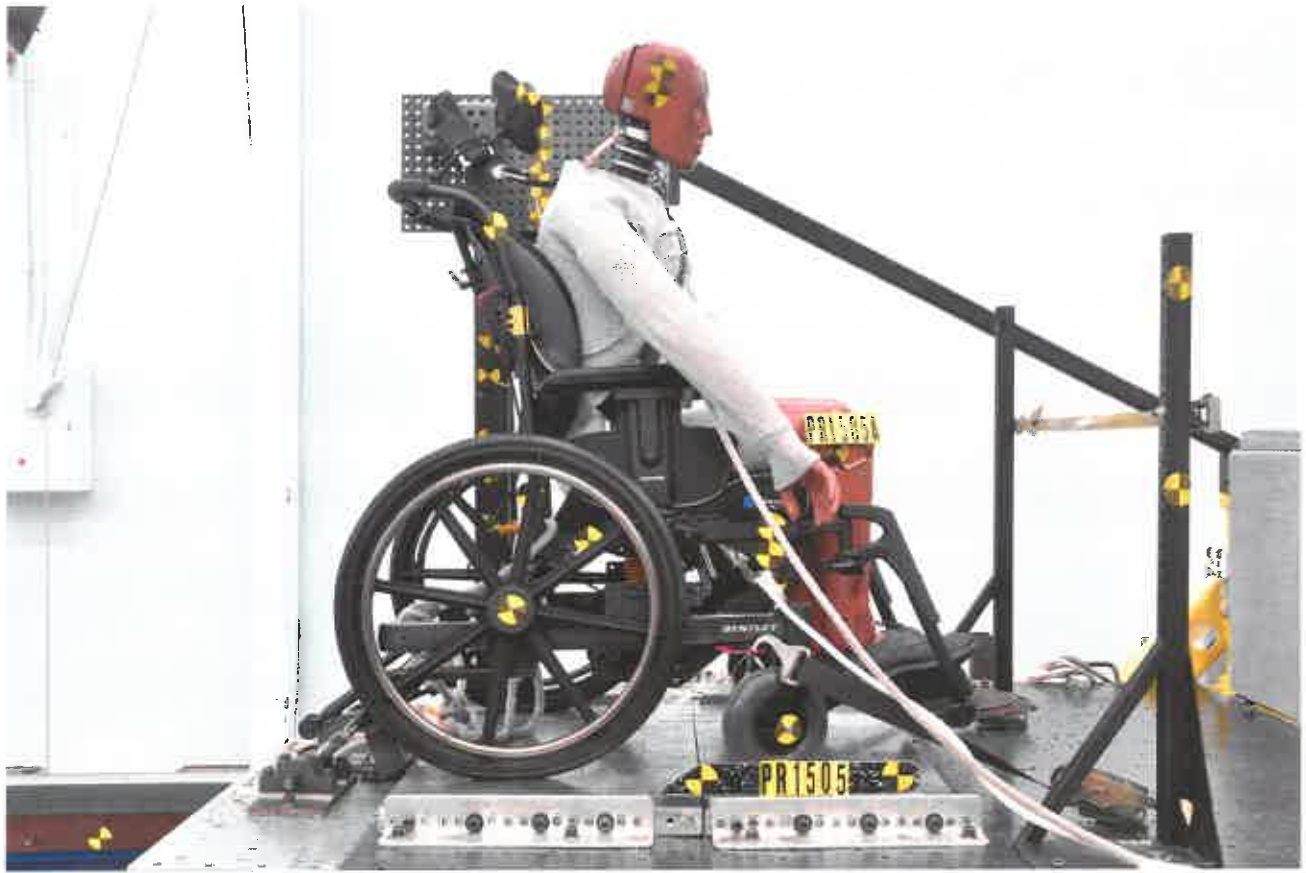
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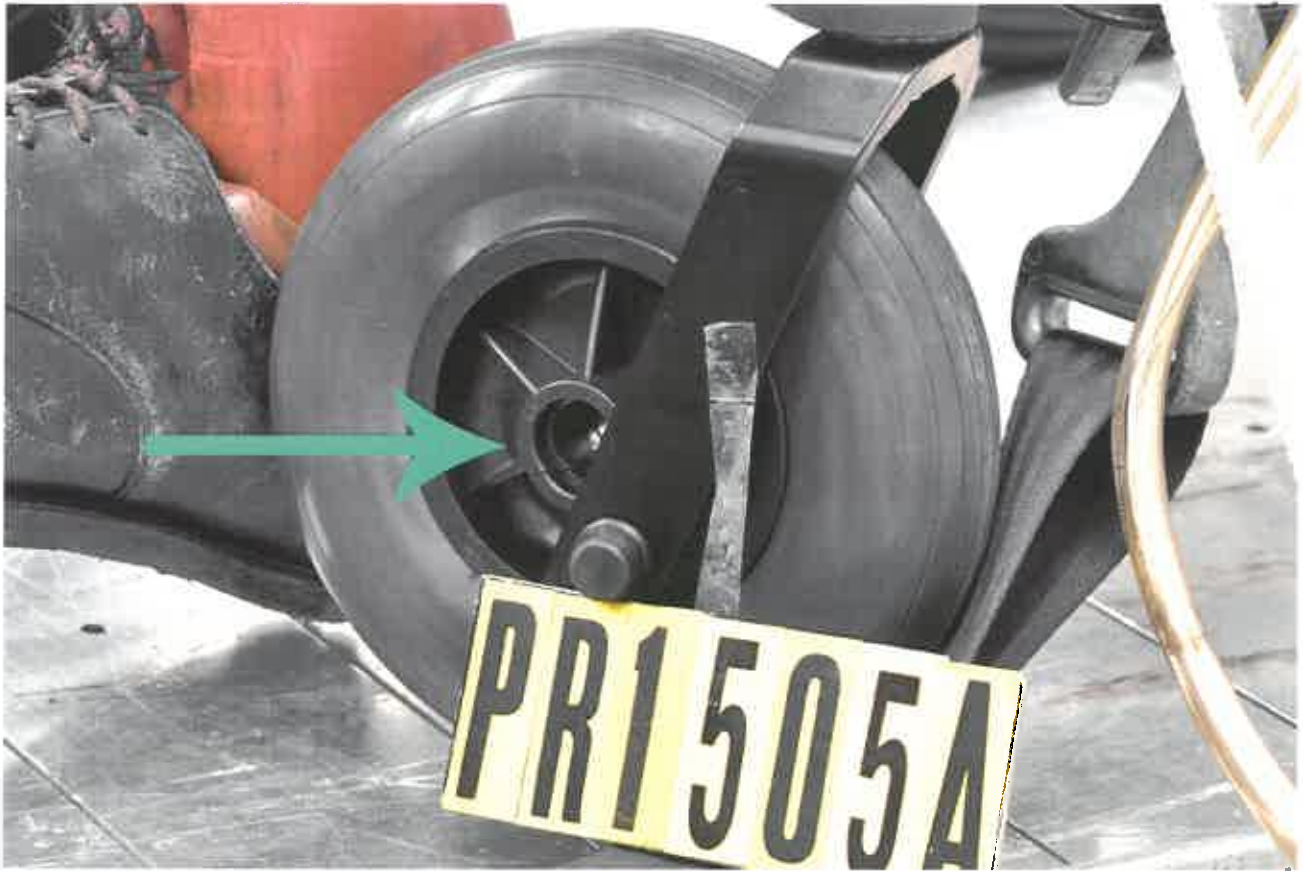












## **TEST SIGNALS**

**UMTRI****Results****PR1505**

Nominal = 30 mph/ 20 g

Pressures: 141.8/1076

Actual[P] = 48.7 km/h (30.2 mph) (71.4%) Plateau Avg.= -20.6 G; Peak = -23.5 G

Dummy: Hybrid III 50th Male (77.7 kg)

Buck Weight: 2227

Buck: steel plate, extension, risers, footstraps

PDG Taco Tuesday Bentley wheelchair

Tested with SWTORS, Commercial WC-anchored lap belt

**Sled Summary**

Sled Pulse Duration = 80.9 ms

Efficiency =  $V_{out} / V_{in} = 20.3 / 28.4 = 71.4\%$ 

Sled Plateau Average Level = -20.6 G

Sled Delta V = 48.7 kph (30.2 mph)

Sled Decel Peak = -23.5 G

Stopping Dist. (est) = .583 m

Total time under -20.0 G was 30.7 ms

Continuous time under -15.0 G was 61.0 ms

**Head Acceleration**

X -44.3 g @ 108 ms

52.8 g @ 175 ms

Y -39.5 g @ 224 ms

7.2 g @ 98 ms

Z -5.3 g @ 52 ms

62.2 g @ 53 ms

Resultant

Peak: 66.2 g @ 53 ms

H.I.C. (UN) = 711.9

From 45.4 to 119.3 ms

H.I.C. (36) = 526.7

From 77.4 to 113.4 ms

H.I.C. (15) = 274.3

From 85.1 to 100.1 ms

**Chest Acceleration**

X -39.7 g @ 74 ms

3.5 g @ 289 ms

Y -5.3 g @ 182 ms

8.8 g @ 96 ms

Z -18.5 g @ 95 ms

12.0 g @ 51 ms

Resultant

Peak: 41.6 g @ 72 ms

3.0 ms Clipped Peak = 41.5G

From: 71.8 to 74.8 ms

Total time over 60 G was 0.0 ms

**Belt and Tiedown Loads**

Lap Belt Load -4.8 N (-1.1 lb) @ 8 ms

9091.0 N (2043.7 lb) @ 72 ms

Shoulder Belt Load -25.0 N (-5.6 lb) @ 151 ms

9987.4 N (2245.3 lb) @ 79 ms

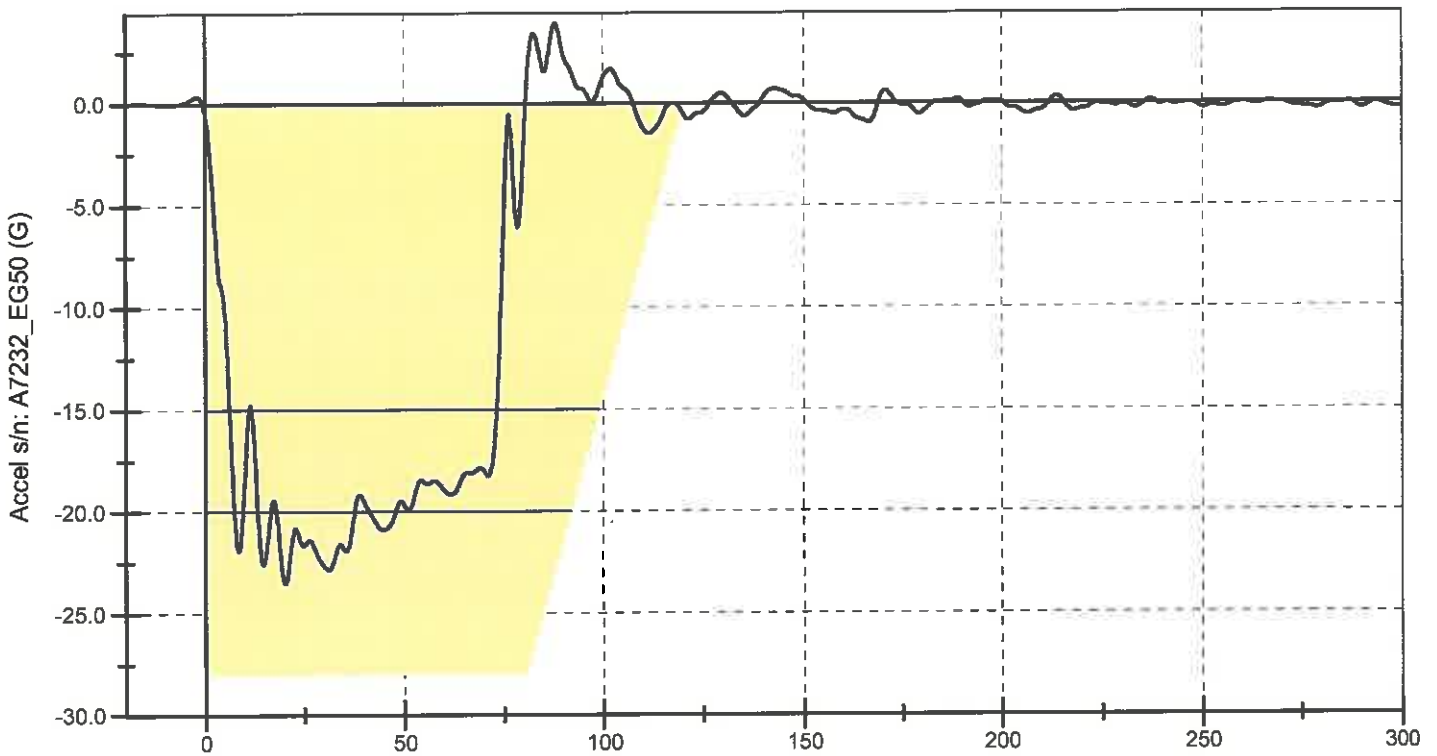
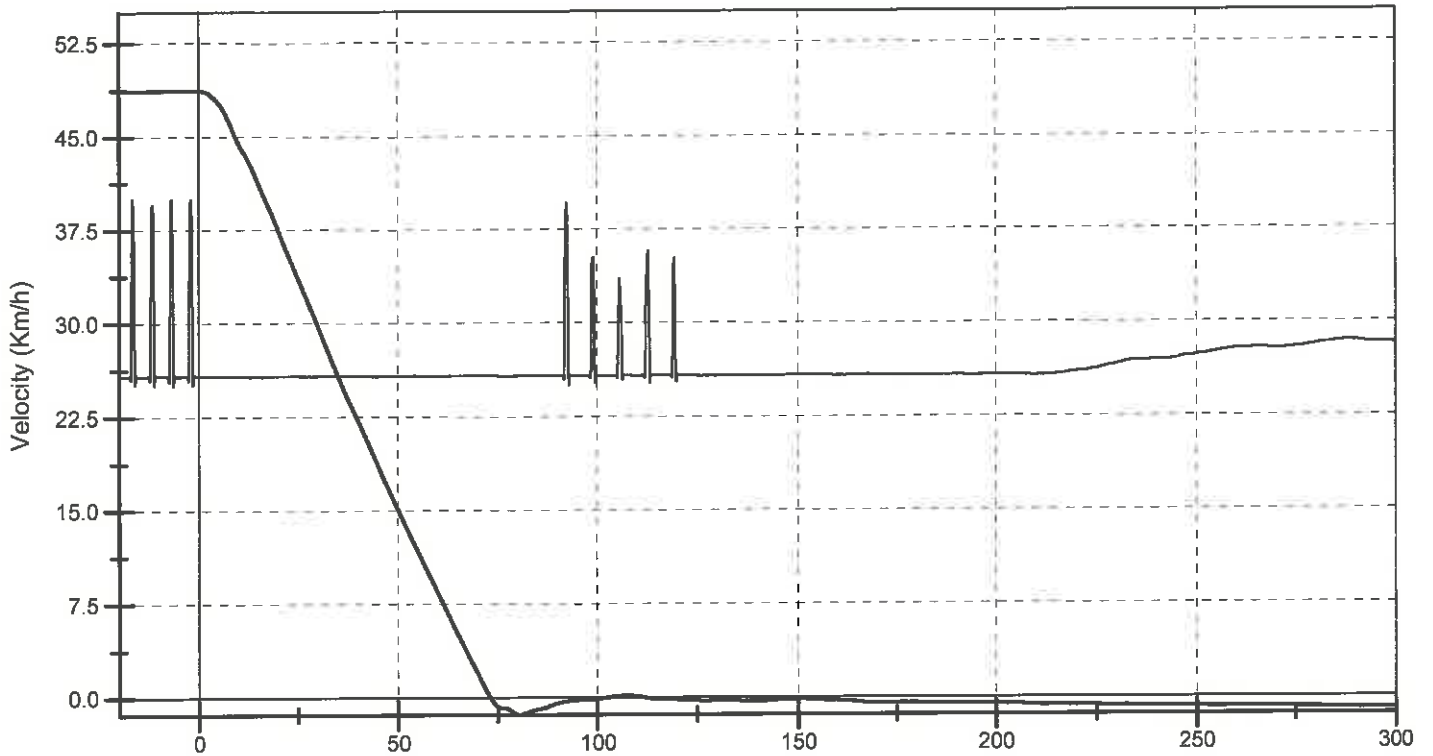
Left Rear Tiedown Load -710.2 N (-159.7 lb) @ 249 ms

16705.4 N (3755.5 lb) @ 76 ms

Right Rear Tiedown ... -722.8 N (-162.5 lb) @ 124 ms

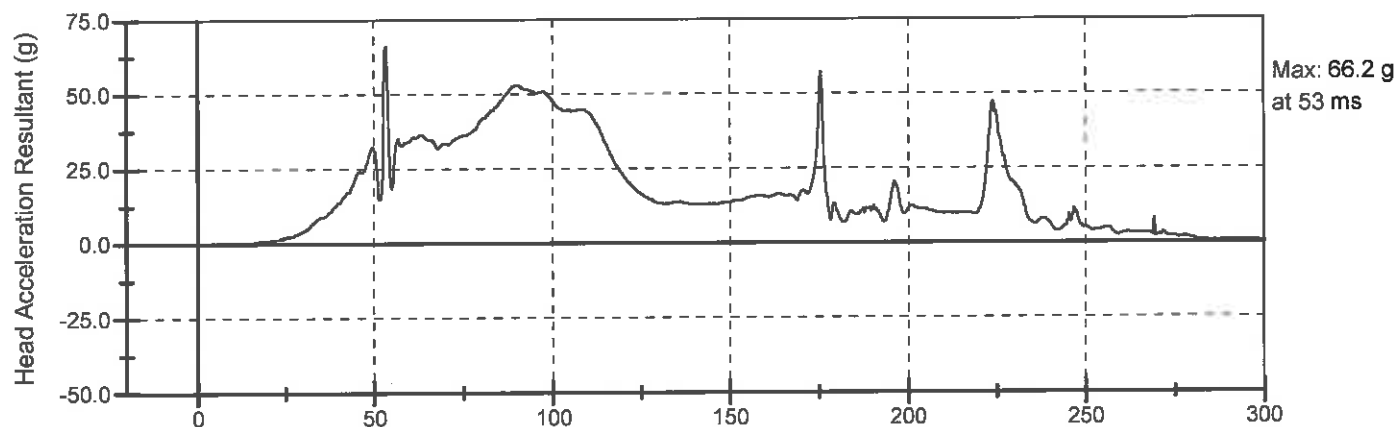
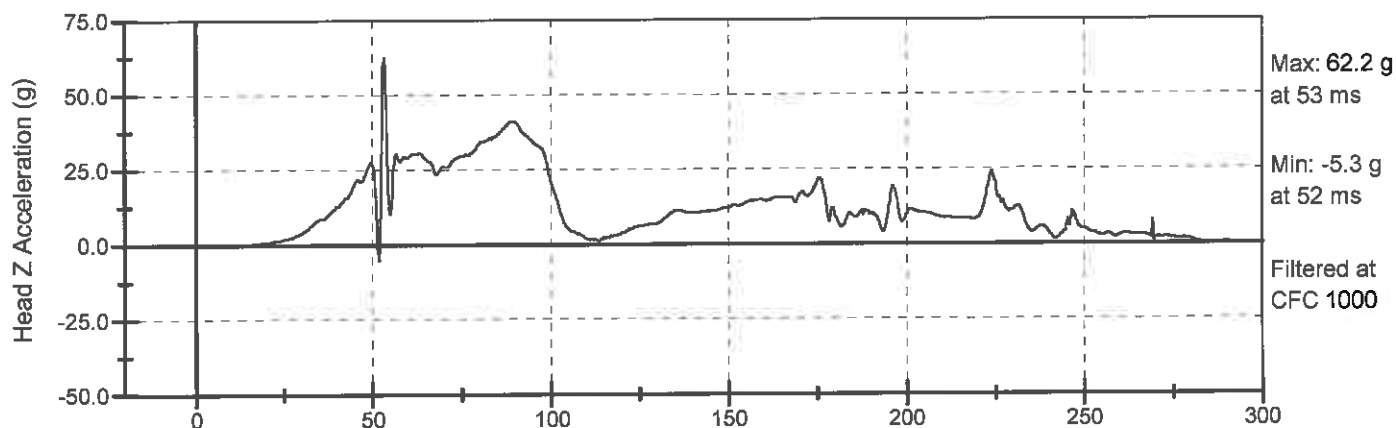
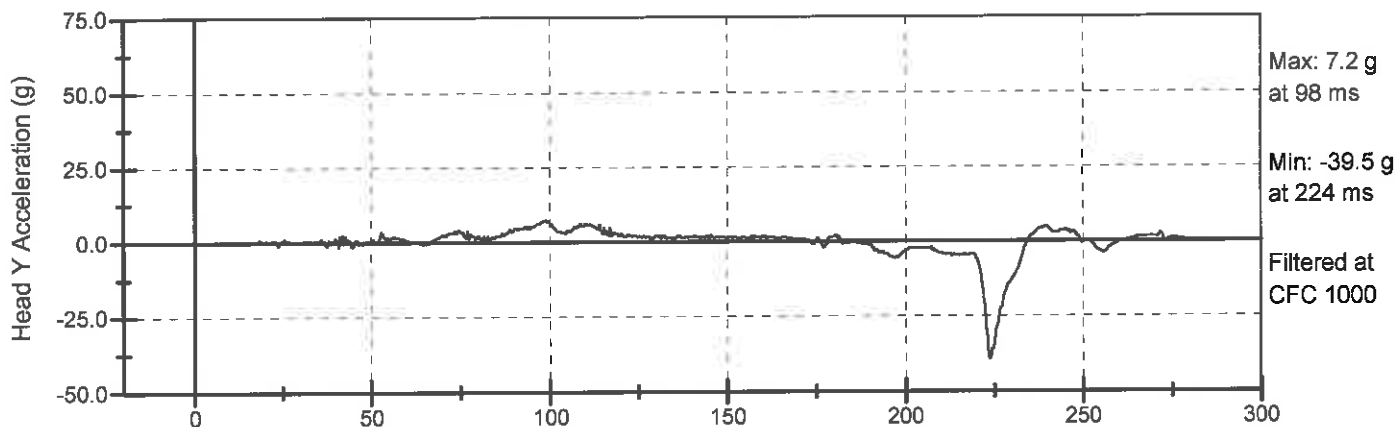
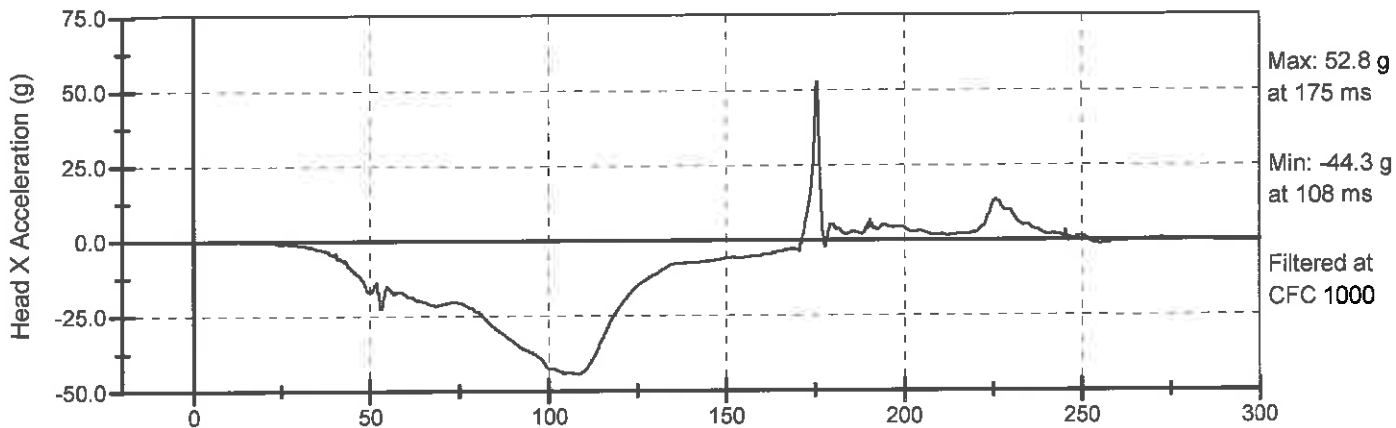
18693.1 N (4202.4 lb) @ 76 ms

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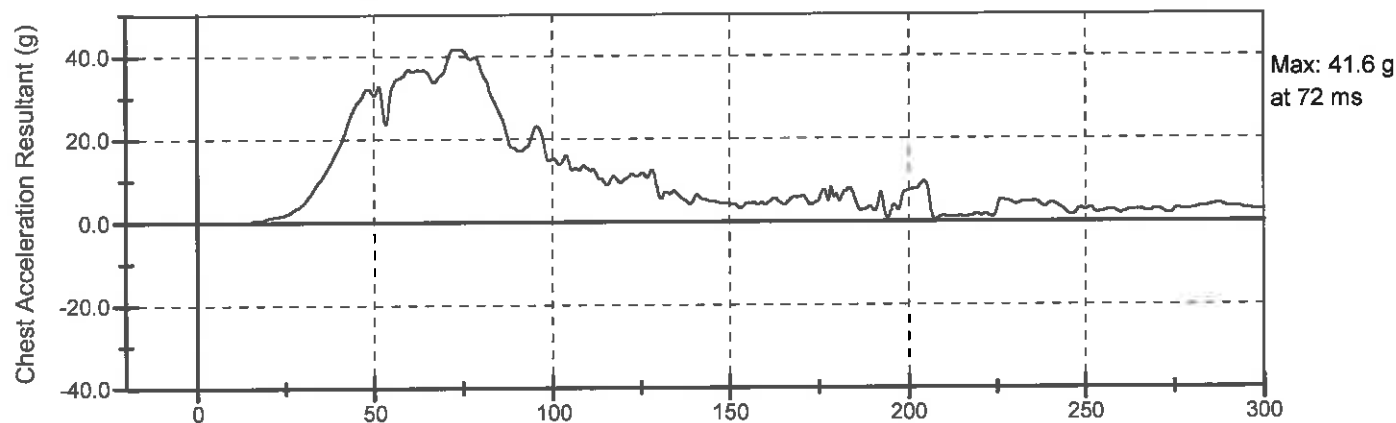
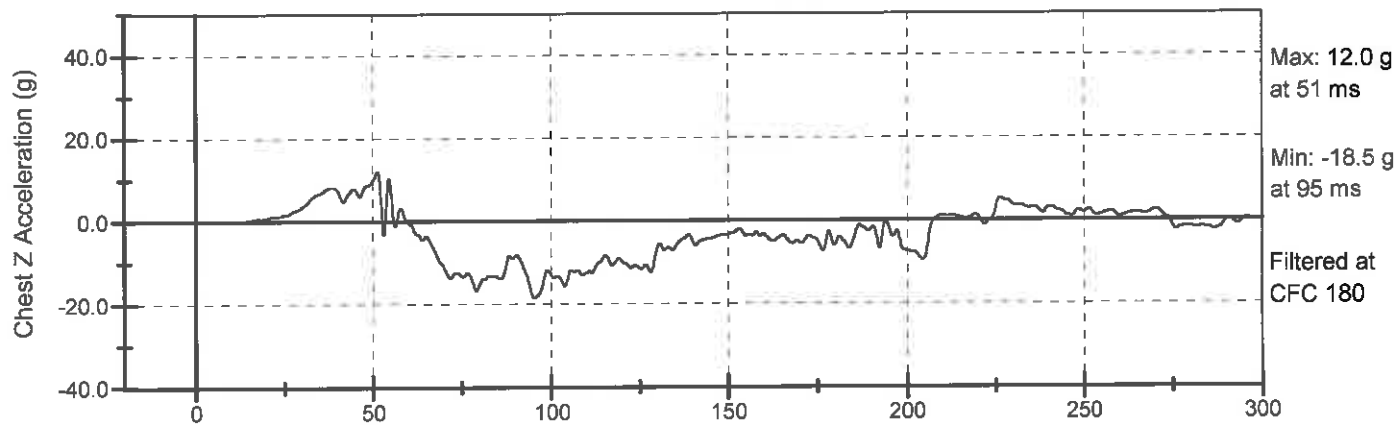
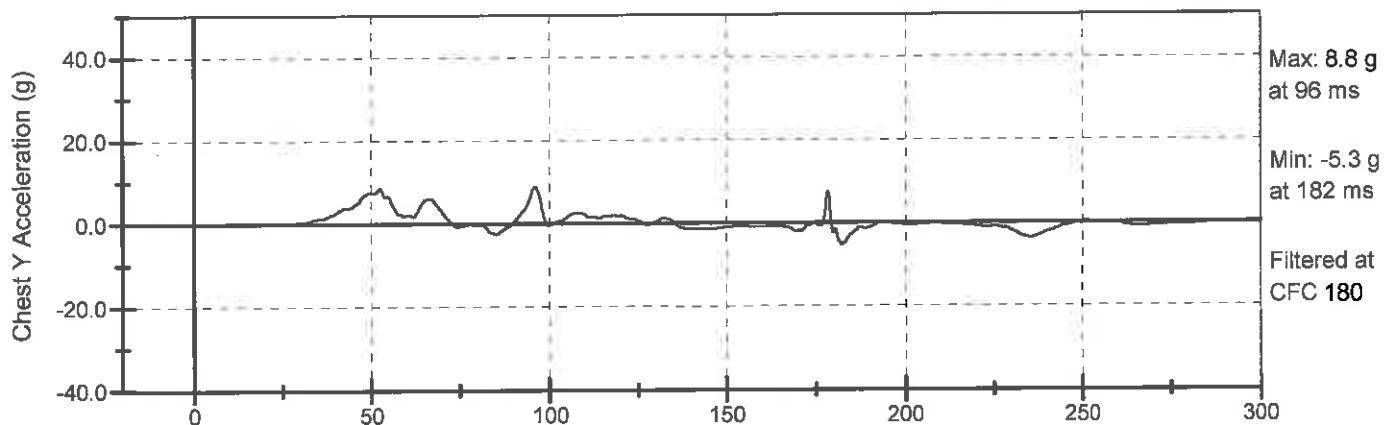
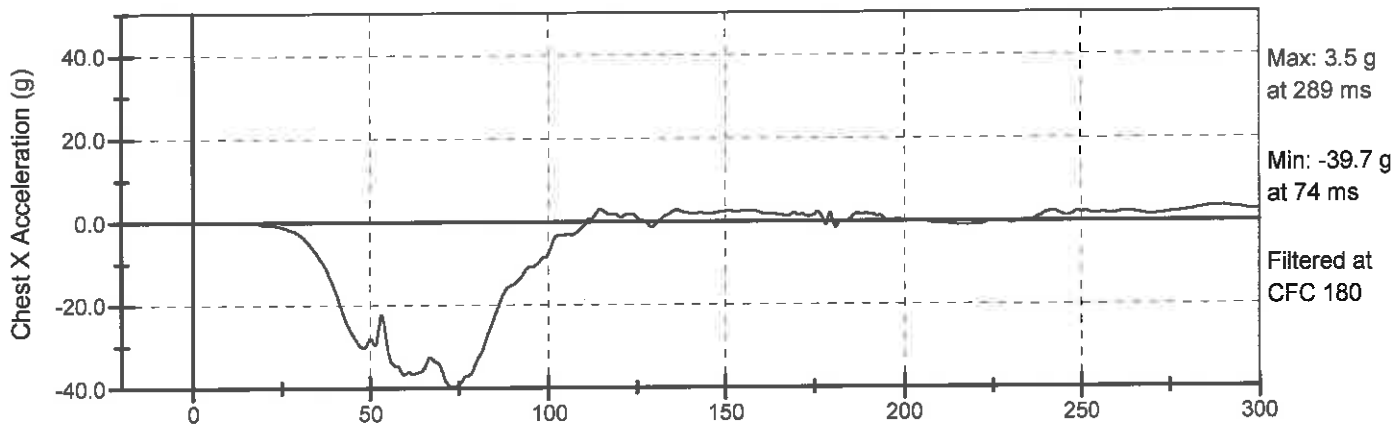
Continuous time under -15.0 G was 61.0 ms  
Total time under -20.0 G was 30.7 ms  
Sled Decel Peak = -23.5 G  
Sled Plateau Average Level = -20.6 G  
Sled Pulse Duration = 80.9 ms

Stopping Dist. (est) = .583 m  
Sled Delta V = 48.7 kph (30.2 mph)  
Efficiency =  $V_{out} / V_{in} = 20.3 / 28.4 = 71.4\%$



H.I.C. (15) = 274.3  
H.I.C. (36) = 526.7  
H.I.C. (UN) = 711.9

From: 85.1 to 100.1 ms  
From: 77.4 to 113.4 ms  
From: 45.4 to 119.3 ms



Total time over 60 G was 0.0 ms  
3.0 ms Clipped Peak = 41.5G

From: 71.8 to 74.8 ms

