

Sled Impact Test

**HG 1301**

**Hoggi, GmbH**

**Frontal Impact of a Hoggi SWINGBO-VTi Manual Wheelchair  
Secured by a Surrogate Four-Point, Strap-Type Tiedown  
and Loaded with a Hybrid III Small Female ATD Weighted to 130 lb  
Restrained by a Surrogate Three-Point Belt with Wheelchair-Anchored Lap Belt**

Tested in accordance with Annex A of  
RESNA WC-4:2012: Section 19, *Wheelchairs Used as Seats in Motor Vehicles*  
and ISO 7176-19 (2008): *Wheeled Mobility Devices for Use in Motor Vehicles*

Test Date: June 24, 2013

Submitted to:  
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## **ACKNOWLEDGMENT AND DATA USE RESTRICTION**

This test was sponsored by Hoggi of Ransbach-Baumbach, Germany, and was conducted in accordance with procedures set forth in Annex A of RESNA WC-4:2012: Section 19, *Wheelchairs Used as Seats in Motor Vehicles*, hereafter referred to as WC19, and ISO 7176-19 (2008): *Wheeled Mobility Devices for Use in Motor Vehicles*. The wheelchair's performance has been measured and evaluated according to the performance criteria of 5.3.2 of WC19 and 5.2 of ISO 7176-19. Advertisements and marketing literature should refer to the requirements and provisions of WC19 and 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 WC19 and 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 Hoggi SWINGBO-VTi manual wheelchair was placed on the sled platform facing forward, and secured using the surrogate four-point, strap-type tiedown specified in Annex D of WC19 and Annex E of 7176-19. The front and rear tiedown straps were hooked to the securement points provided on the frame of the wheelchair.

The wheelchair was loaded with a Hybrid III small female anthropomorphic test device (ATD) weighted to 130 lb that was restrained by a surrogate three-point belt with wheelchair-anchored lap belt\*. The left end of the lap belt was attached to a pin-bushing anchorage on the rear securement-point bracket just below and behind the seat/back-support junction on the left side of the wheelchair, while the right side of the lap belt and the lower portion of the shoulder belt formed a continuous loop through a triangular connector attached to a pin-bushing anchorage on the rear securement-point bracket just below and behind the seat/back-support junction on the right side of the wheelchair. Both sides of the lap belt were routed on the inside of the wheelchair frame and inserted in the gap between the back support and seat cushion before connecting to the pin-bushing anchorages. A three-bar clip held the lap and shoulder belt together near the right hip of the ATD. The upper anchorage of the shoulder belt was bolted to a rigid fixture that simulated the geometry of a typical vehicle sidewall anchor point. The pelvic belt was tightened to fit snugly over the ATD's pelvic region. The shoulder belt was tightened snugly across the ATD's chest with a 75-mm block between the belt and ATD, and the 75-mm 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 WC19 and ISO 7176-19. The following table provides further details about the test equipment and setup.

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\* Compliance with WC19 requires testing with a commercial wheelchair-anchored lap belt provided by the wheelchair manufacturer.

## SUMMARY OF TEST SETUP AND PRE-TEST MEASUREMENTS

<p><b>GENERAL TEST INFORMATION</b></p> <p>Test number Test date Wheelchair type Wheelchair tiedown Occupant restraint</p> <p>Anthropomorphic Test Dummy (ATD) Wheelchair orientation Sled platform Desired impact velocity (<math>\Delta V</math>) Desired average sled deceleration</p>	<p>HG 1301 June 24, 2013 Hoggi SWINGBO-VTi manual wheelchair Surrogate four-point, strap-type tiedown Surrogate three-point belt with WC-anchored lap belt Hybrid III small female @ 58.6 kg (130 lb) Forward facing Rigid steel plate 48 kph (30 mph) 20 g</p>
<p><b>WHEELCHAIR TIEDOWN</b></p> <p>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)</p>	<p>1283 mm (50.5 in)  406 mm (16.0 in) 38 degrees 0 degrees 533 mm (21.0 in) 495 mm (19.5 in)  699 mm (27.5 in) 38 degrees 13 degrees 629 mm (24.8 in)</p>
<p><b>OCCUPANT RESTRAINT</b></p> <p>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</p>	<p>305 mm (12.0 in) 178 mm (7.0 in) 1118 mm (44.0 in) 305 mm (12.0 in) 45 degrees  59 degrees, measured on ATD torso 30 degrees, measured above ATD shoulder</p>
<p><b>FOOTSTRAPS POSITIONING</b></p> <p>In front of ATD knee center Above ATD knee center</p>	<p>419 mm (16.5 in) 25 mm (1.0 in)</p>
<p><b>ATD POSITIONING</b></p> <p>Shoulder height above sled platform H-point height above sled platform</p>	<p>940 mm (37.0 in) 521 mm (20.5 in)</p>
<p><b>WHEELCHAIR</b></p> <p>Weight Wheelbase Seatback angle wrt vertical Seatback height (with headrest) Seatpan angle wrt horizontal Seat surface height from floor @ SB junction Seatpan length</p>	<p>19.1 kg (42 lb) 394 mm (15.5 in) 11 degrees 749 mm (29.5 in) 12 degrees 419 mm (16.5 in) 381 mm (15.0 in)</p>
<p><b>POSTURAL SUPPORT DEVICES USED</b></p>	<p>Foot supports                      Head support</p>

## TEST RESULTS

The Hoggi SWINGBO-VTi manual 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 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 leaning approximately 5° to the left. The maximum forward excursion of point P on the wheelchair seating system was 59 mm, which is below the WC19 and ISO 7176-19 excursion limit of 200 mm. After the test, there was no observable deformation, failure or separation of the securement points.

Peak forward excursion of the ATD's head was approximately 421 mm and peak forward knee excursion was about 126 mm, which are below the WC19 and ISO 7176-19 limits of 550 mm and 375 mm, respectively. The ATD's head traveled 380 mm rearward from its initial position during the test, which is below the WC19 and ISO 7176-19 limit of 400 mm. The average post-test ATD H-point height decreased by 9% from the pre-test height, which is below the limit of 20%.

The results of this test show that the Hoggi SWINGBO-VTi manual wheelchair with surrogate wheelchair-anchored three-point belt *meets* all of the performance criteria for wheelchair dynamic strength specified in 5.3.2 of RESNA WC-4:2012, Section 19 and in 5.2 of ISO 7176-19. The following tables summarize the test results and compliance with WC19 and 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	HG 1301 50 kph (30.5 mph) 20.4 ms 23.5 ms 31.7 ms 65.8 ms 79.0 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	82 g 45 g 714 421 mm (16.6 in) 126 mm (4.9 in) 380 mm (15.0 in) 476 mm (18.8 in) 9% change
<b>TIEDOWN LOADS</b> Peak left-rear tiedown strap force Peak right-rear tiedown strap force	9337 N (2099 lb) 13020 N (2927 lb)
<b>BELT LOADS AND PELVIC BELT ANGLE</b> Peak left pelvic-belt load Peak shoulder-belt load	5195 N (1168 lb) 10226 N (2299 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	59 mm (2.3 in) 47 mm (1.9 in) 39 mm (1.5 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 CRITERIA IN RESNA WC-4:2012: SECTION 19  
SLED TEST HG 1301**

Requirement		Observed Performance	
WC19 Clause	Description	Description	Pass/Fail
5.3.2a	Structural components of the WC securement points shall not completely fail	There were no signs of securement-point failure.	Pass
5.3.2b	Deformation of WC securement points must not prevent disengagement of hook	No securement-point deformation was observed.	Pass
5.3.2c	WC upright and on test platform	The WC was upright on the test platform.	Pass
5.3.2d	ATD must be in WC seat with torso leaning not more than 45°	The ATD torso was leaning 5° to the left.	Pass
5.3.2e	Detached hardware cannot exceed 150 g	No hardware with mass exceeding 150 g completely detached.	Pass
5.3.2f	WC must not have sharp edges with potential for occupant contact	There were no sharp edges with potential for occupant contact.	Pass
5.3.2g	Primary load-carrying components cannot completely fail, unless there is a backup mechanism that does not fail	No primary load-carrying components completely failed.	Pass
5.3.2h	Forward excursion of Point P < 200 mm	59 mm	Pass
	Forward knee excursion < 375 mm	126 mm	Pass
	Forward head excursion < 550 mm	421 mm	Pass
	Rearward head excursion < 400 mm	380 mm	Pass
5.3.2i	Ratio of ATD knee excursion to Point P excursion must exceed 1.1.	N/A – a WC-integrated lap-belt restraint was used.	N/A
5.3.2j	Locking mechanisms of tilt seating cannot release or completely fail.	The locking mechanism of tilt seating did not release or completely fail.	Pass
5.3.2k	Post-test height of ATD H-point shall be ≥ 20% of pretest height	Average H-point height decreased by 9%.	Pass
5.3.2l	Seating system cannot break free from WC at any attachment point.	The seating system remained attached at all points.	Pass
5.3.2mi	Batteries must be within WC footprint	N/A	N/A
5.3.2mii	Batteries must remain attached to battery compartment	N/A	N/A
5.3.2miii	Batteries cannot move into the WC user's space.	N/A	N/A
5.3.2n	WC cannot cause complete failure of the surrogate WTORS.	There were no WTORS failures.	Pass
5.3.2o	Tiedown hooks of WTORS shall remain engaged with WC securement points.	Tiedown hooks remained engaged.	Pass
5.3.2p	WC-anchored belt restraints shall not detach or completely fail.	No failures of the belt restraints.	Pass

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

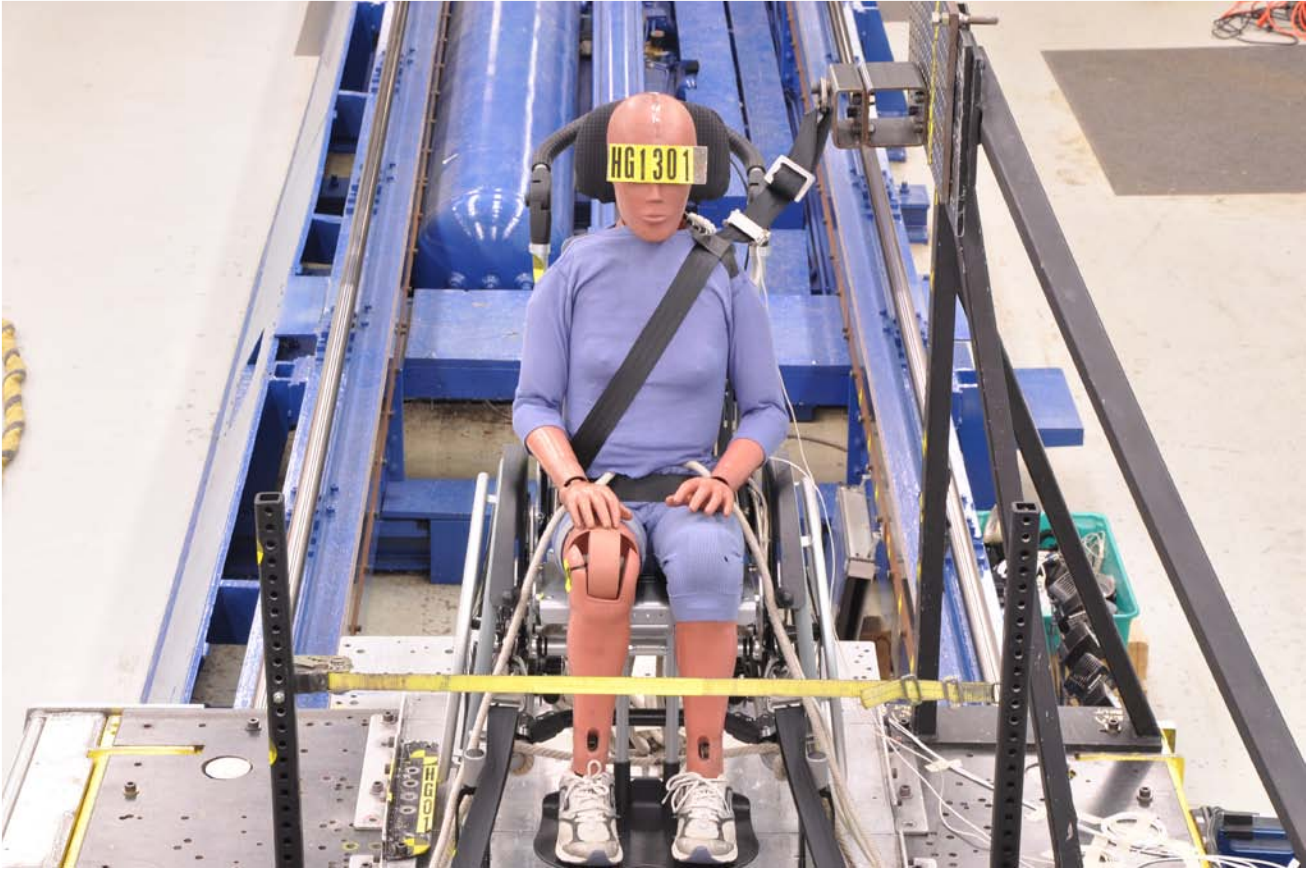


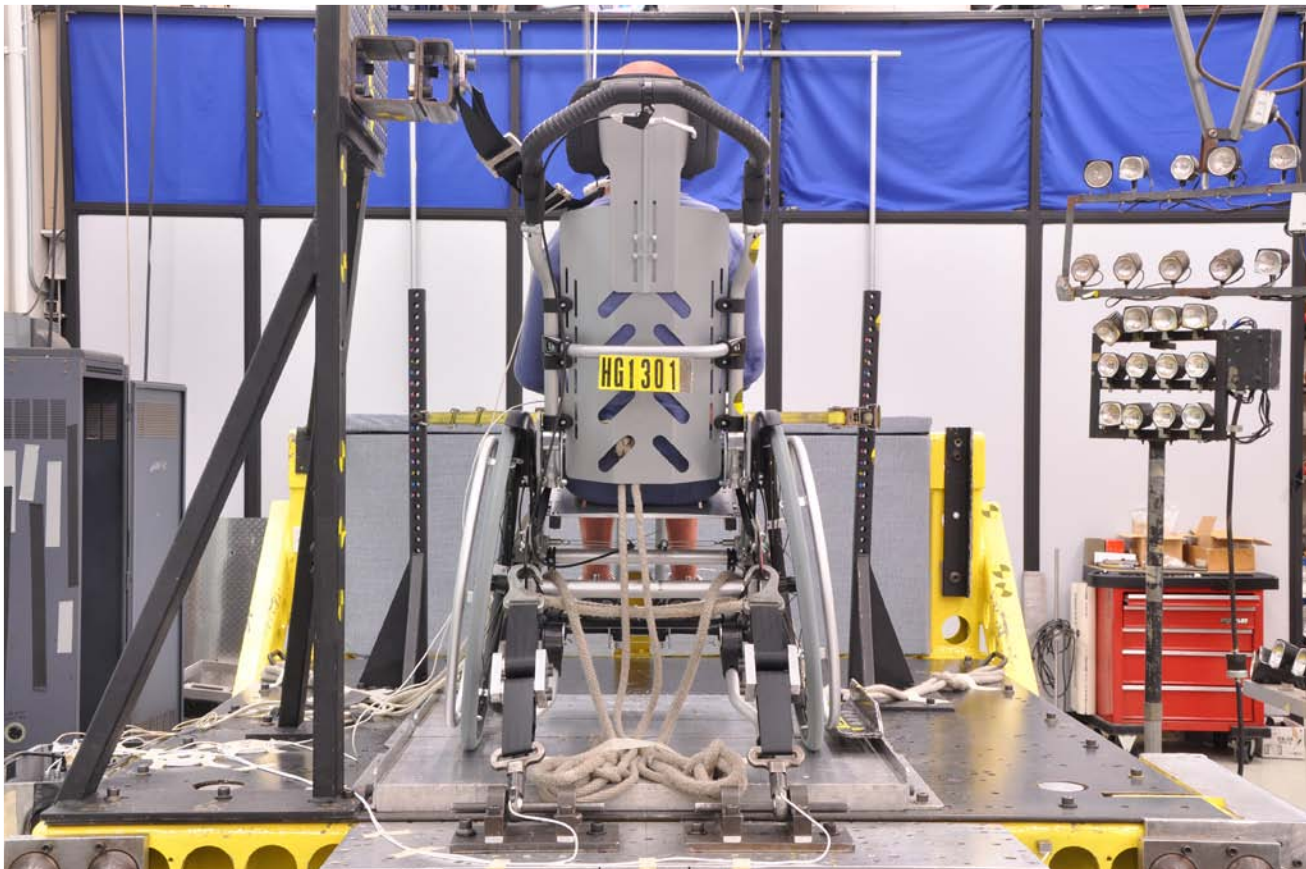
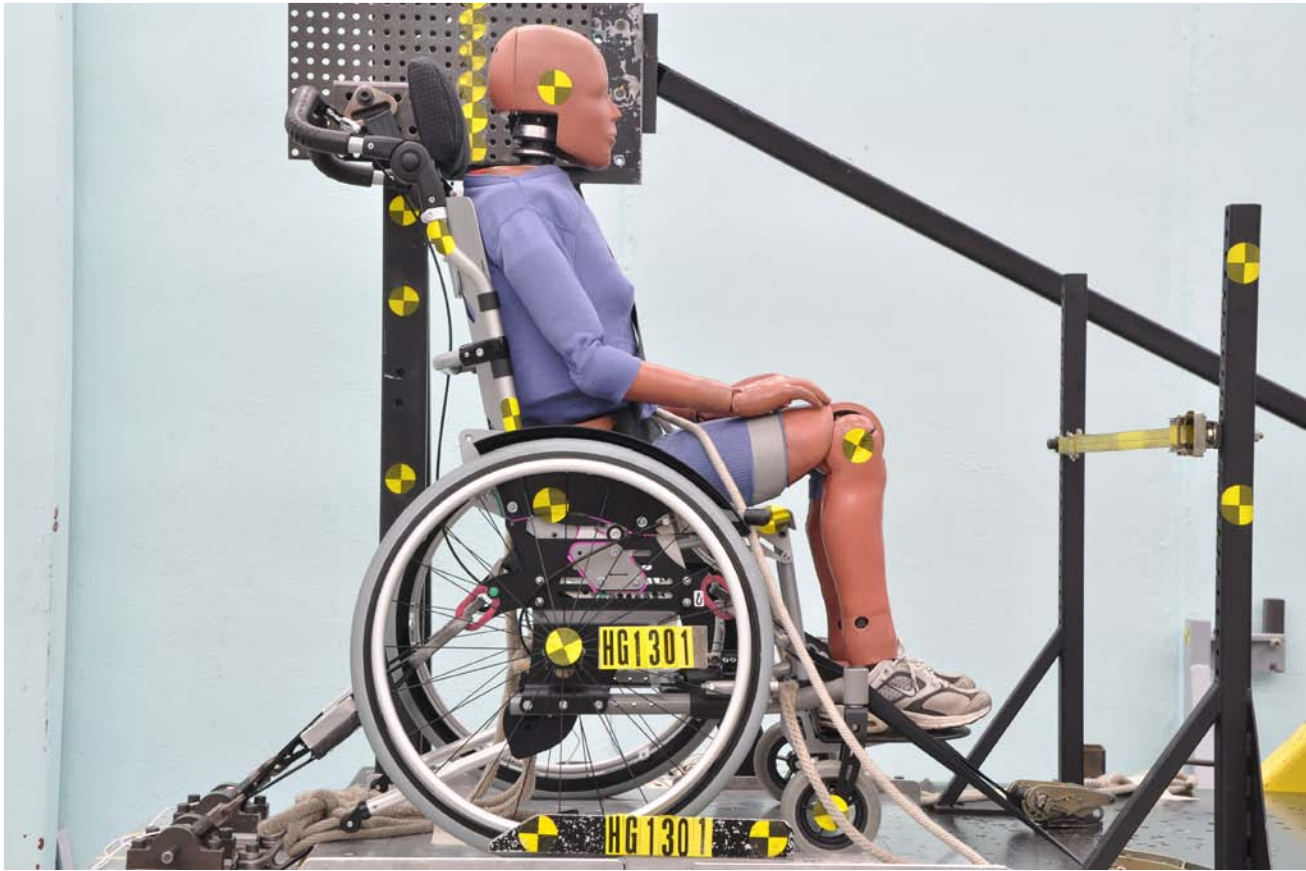
**SUMMARY OF WHEELCHAIR PERFORMANCE TO ISO 7176-19 (2008)  
SLED TEST HG 1301**

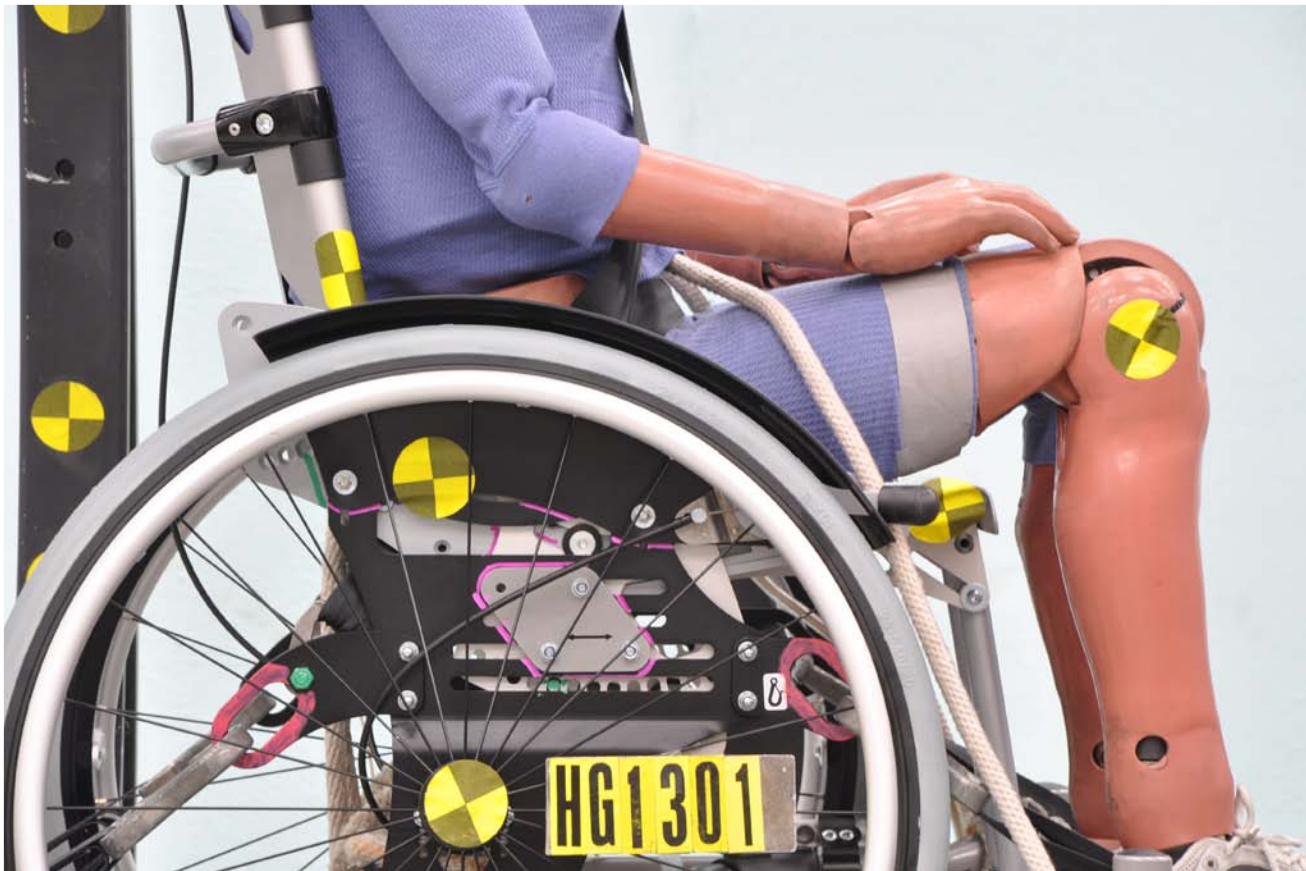
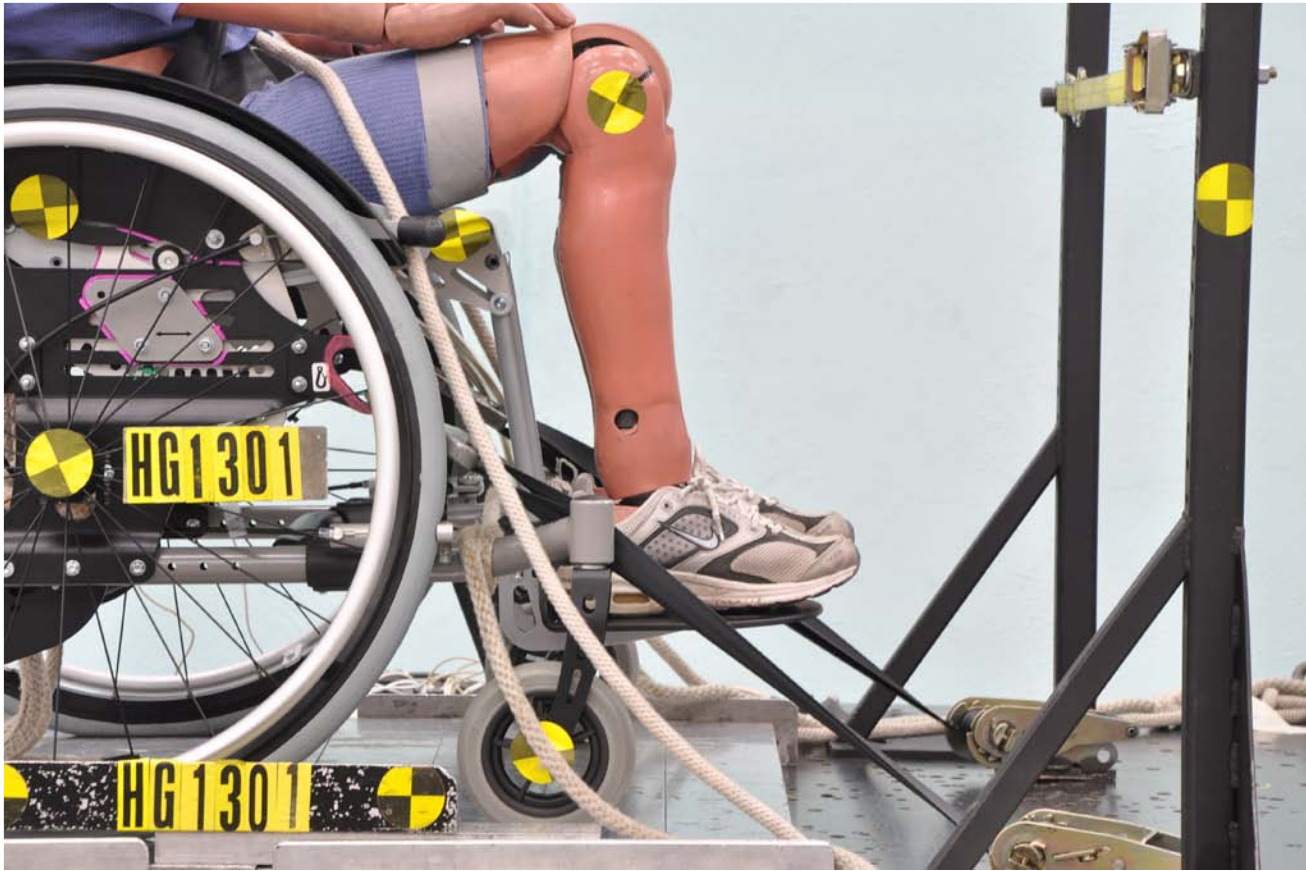
Requirement		Observed Performance	
ISO 7176-19 Clause	Description	Description	Pass/Fail
5.2.1a	Forward excursion of Point P < 200 mm	59 mm	Pass
	Forward knee excursion < 375 mm	126 mm	Pass
	Forward head excursion < 550 mm	421 mm	Pass
	Rearward head excursion < 400 mm	380 mm	Pass
5.2.1b	Ratio of ATD knee excursion to Point P excursion must exceed 1.1.	N/A – a WC-integrated 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 torso leaning 5° to the left.	Pass
5.2.2b	WC securement points cannot show signs of material failure	There were no signs of securement point failure.	Pass
5.2.2c	Detached hardware cannot exceed 100 g	No hardware detached.	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	No primary load-carrying components showed signs of failure.	Pass
5.2.2f	Locking mechanisms of tilt-in-space seat adjusters shall not show signs of failure	The locking mechanism of 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	The average post-test H-point height decreased by 9%.	Pass
5.2.2j	WC cannot cause partial or complete failure of the webbing of the surrogate WTORS	No surrogate WTORS failed.	Pass

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

**PRE-TEST PHOTOS**















**TEST AND POST-TEST PHOTOS**

# HG1301

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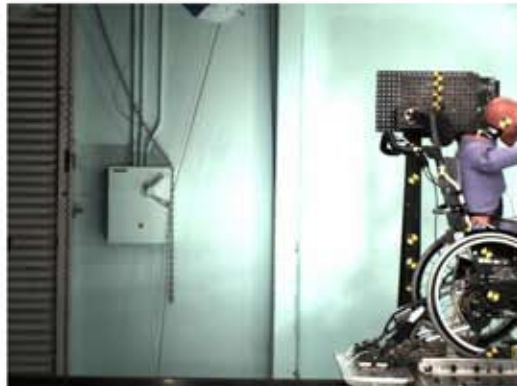


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# HG1301

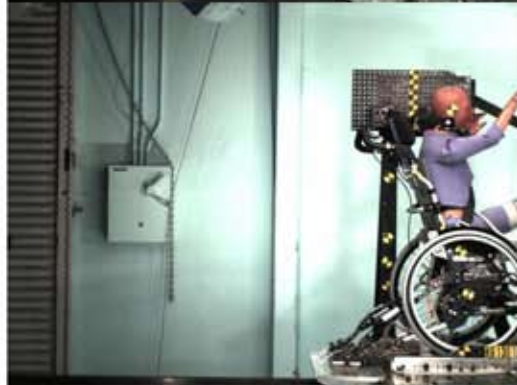
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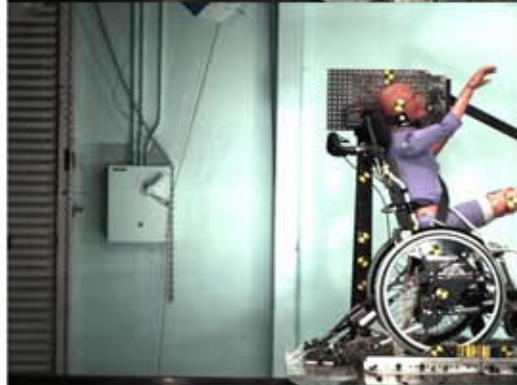
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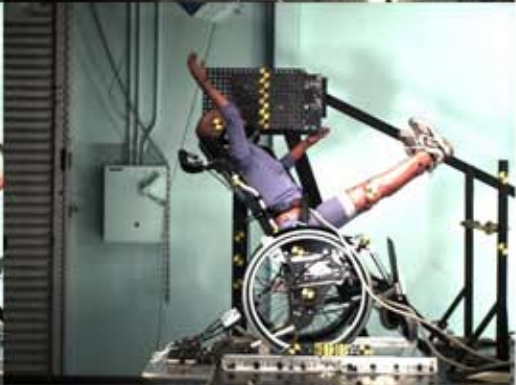
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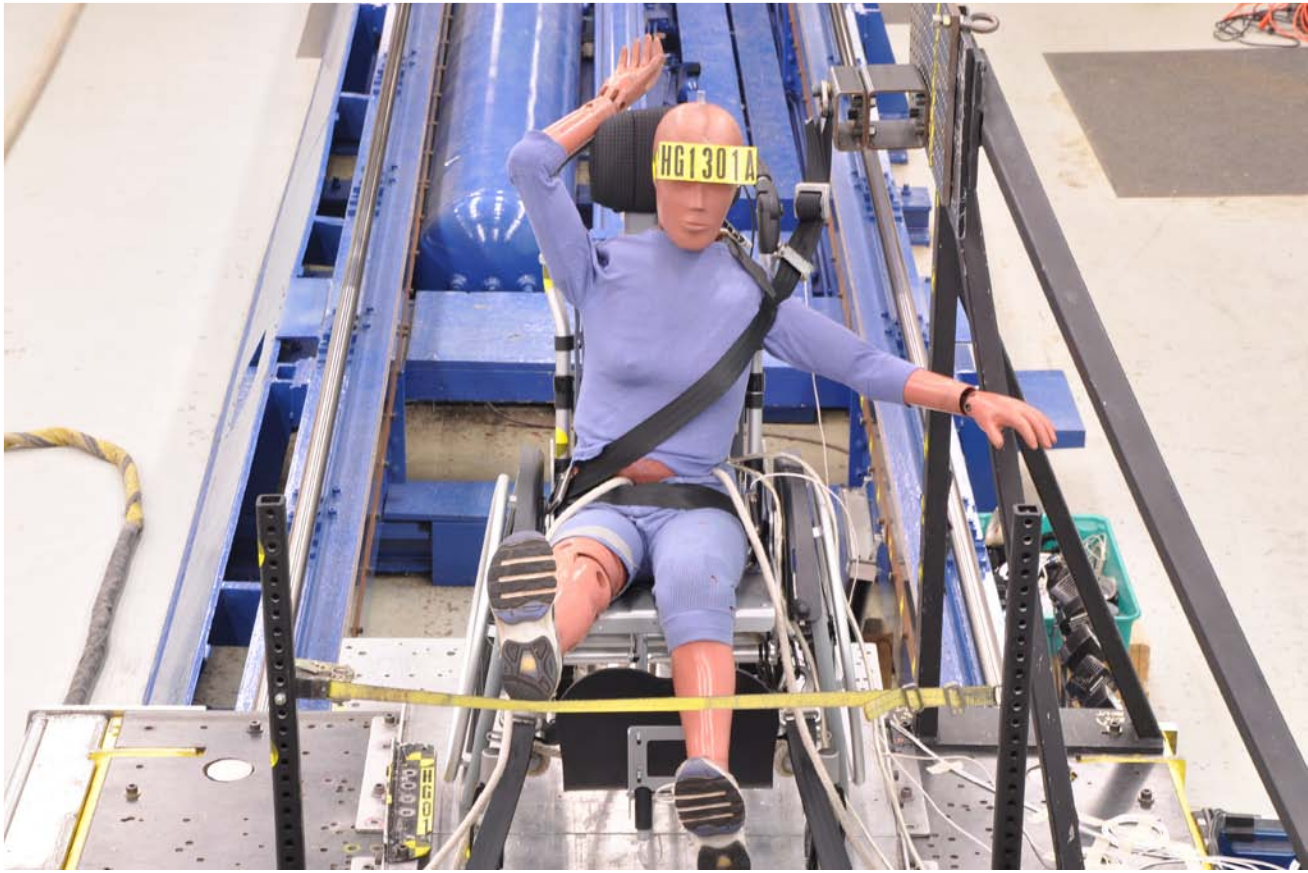


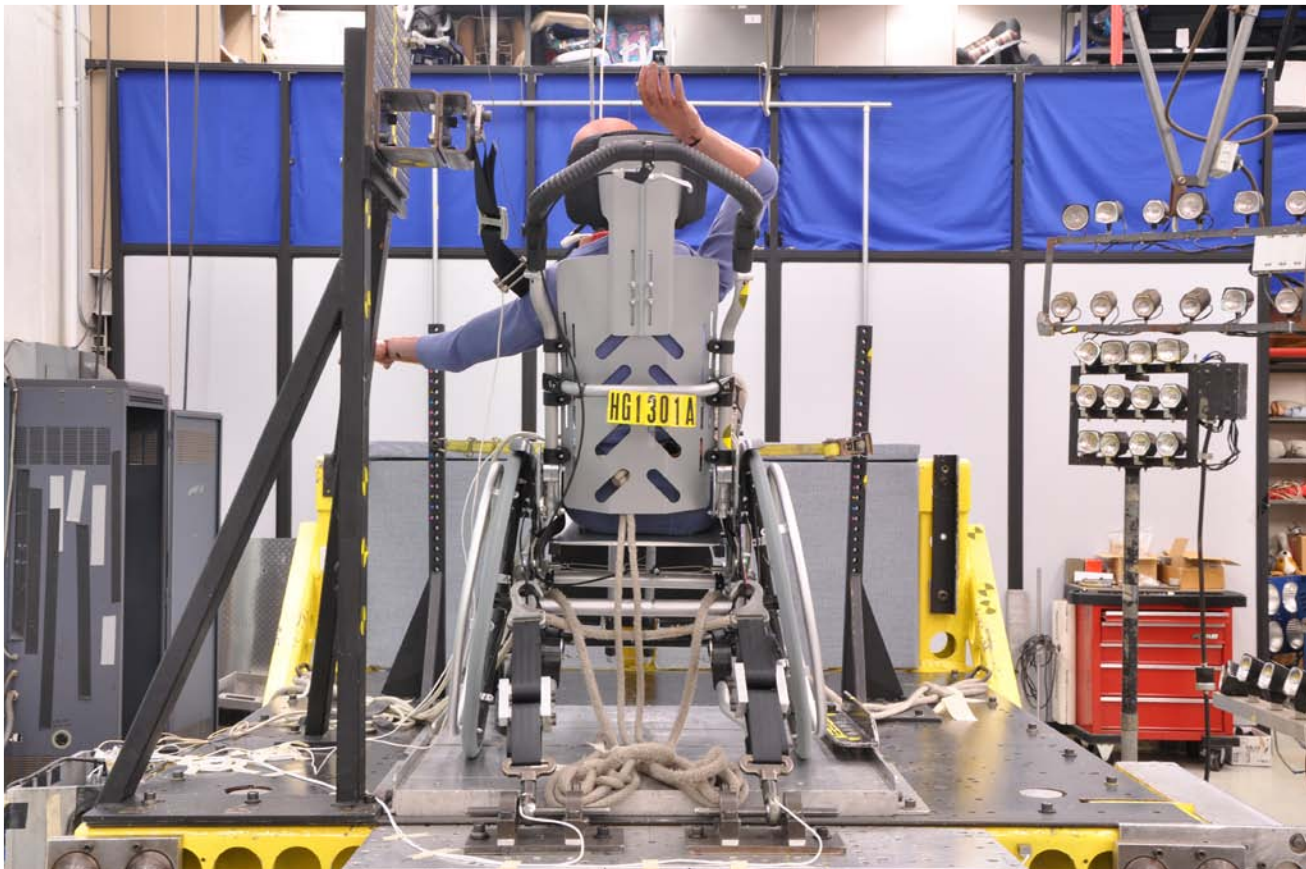
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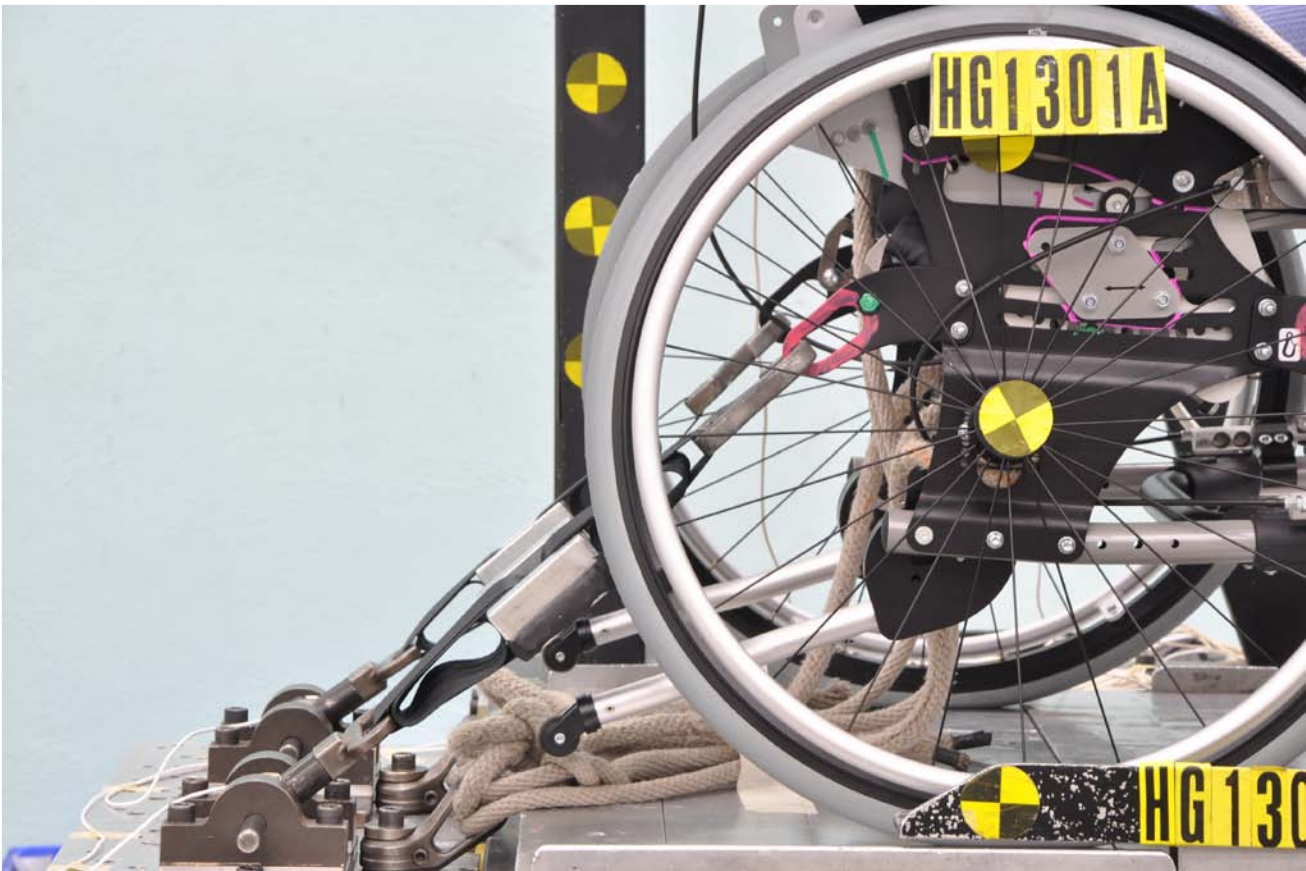
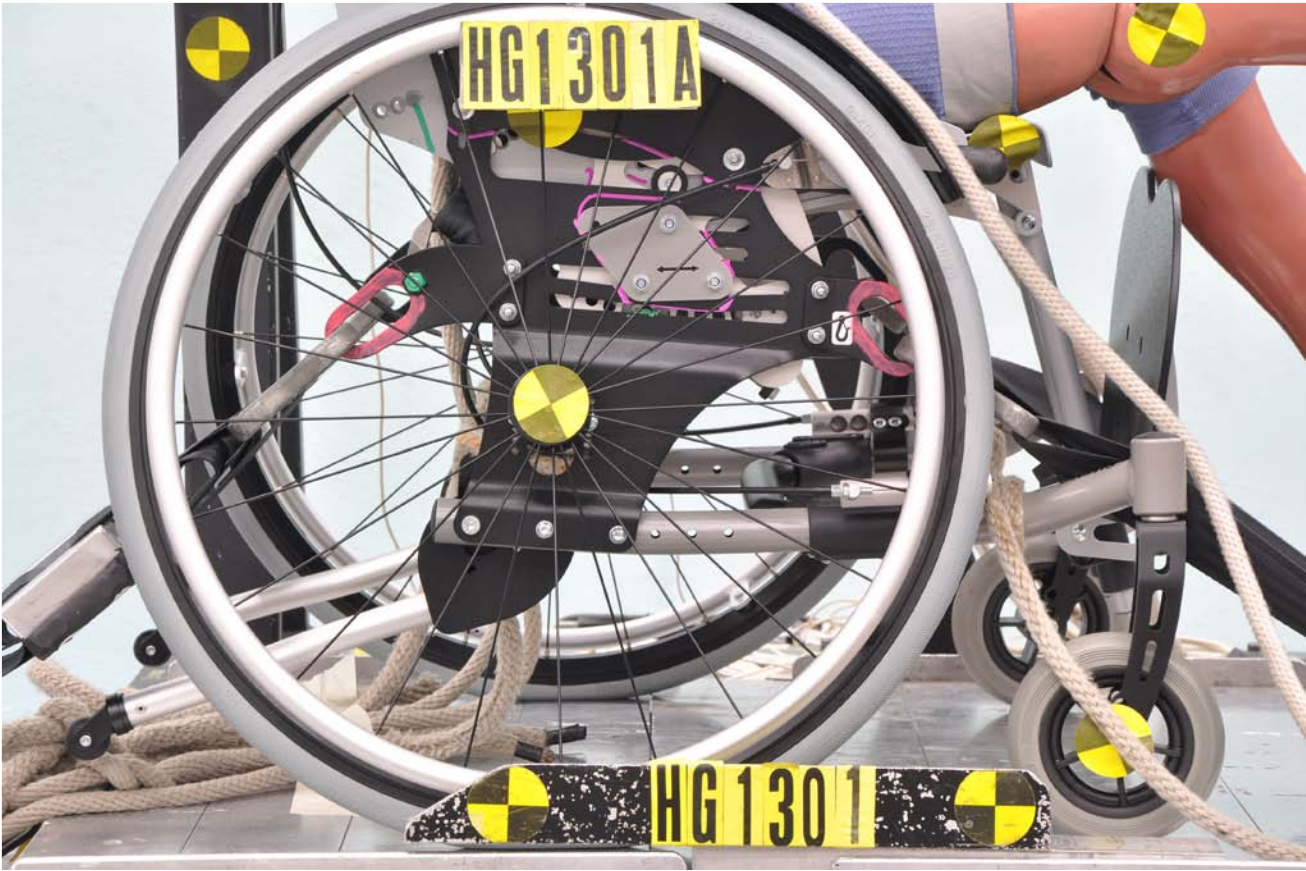
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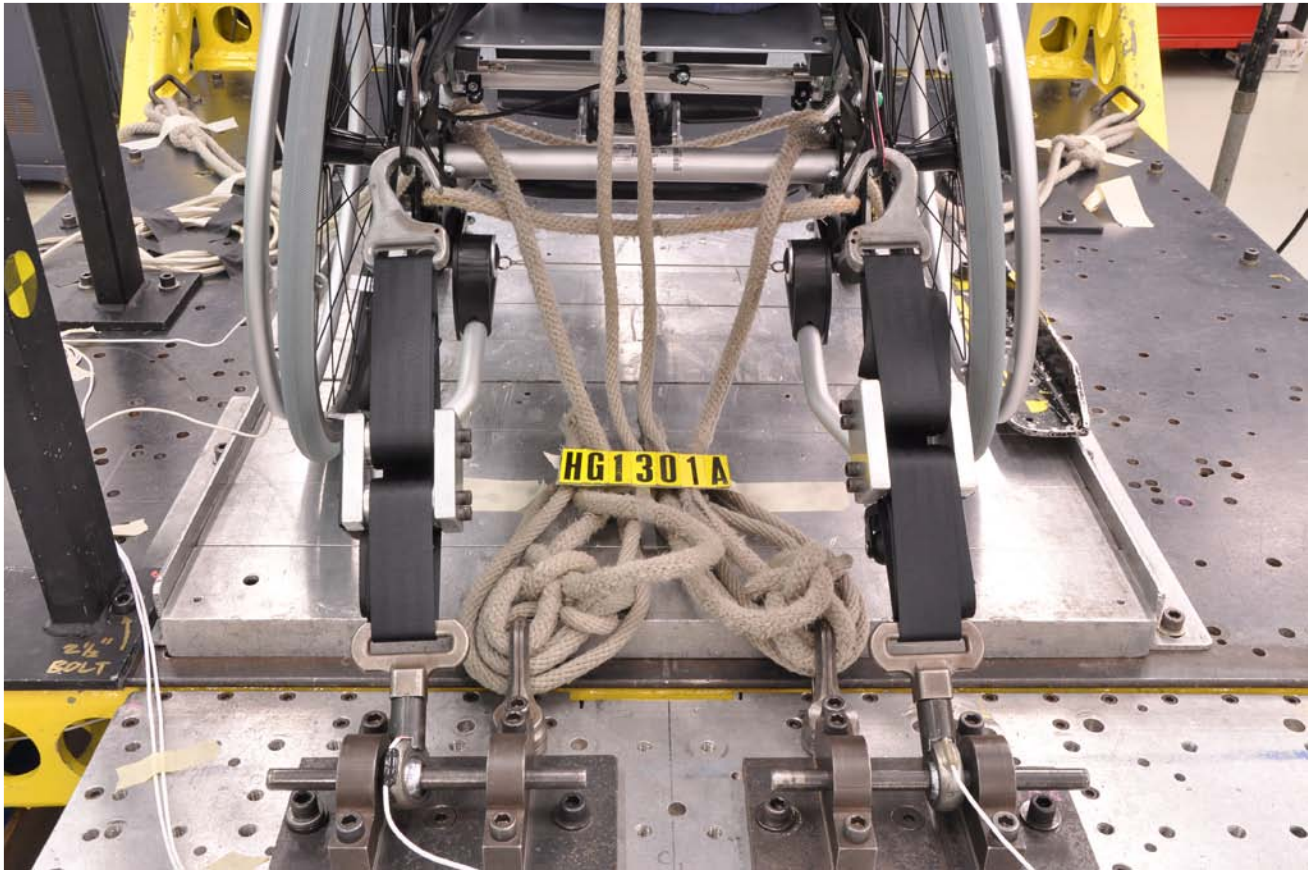






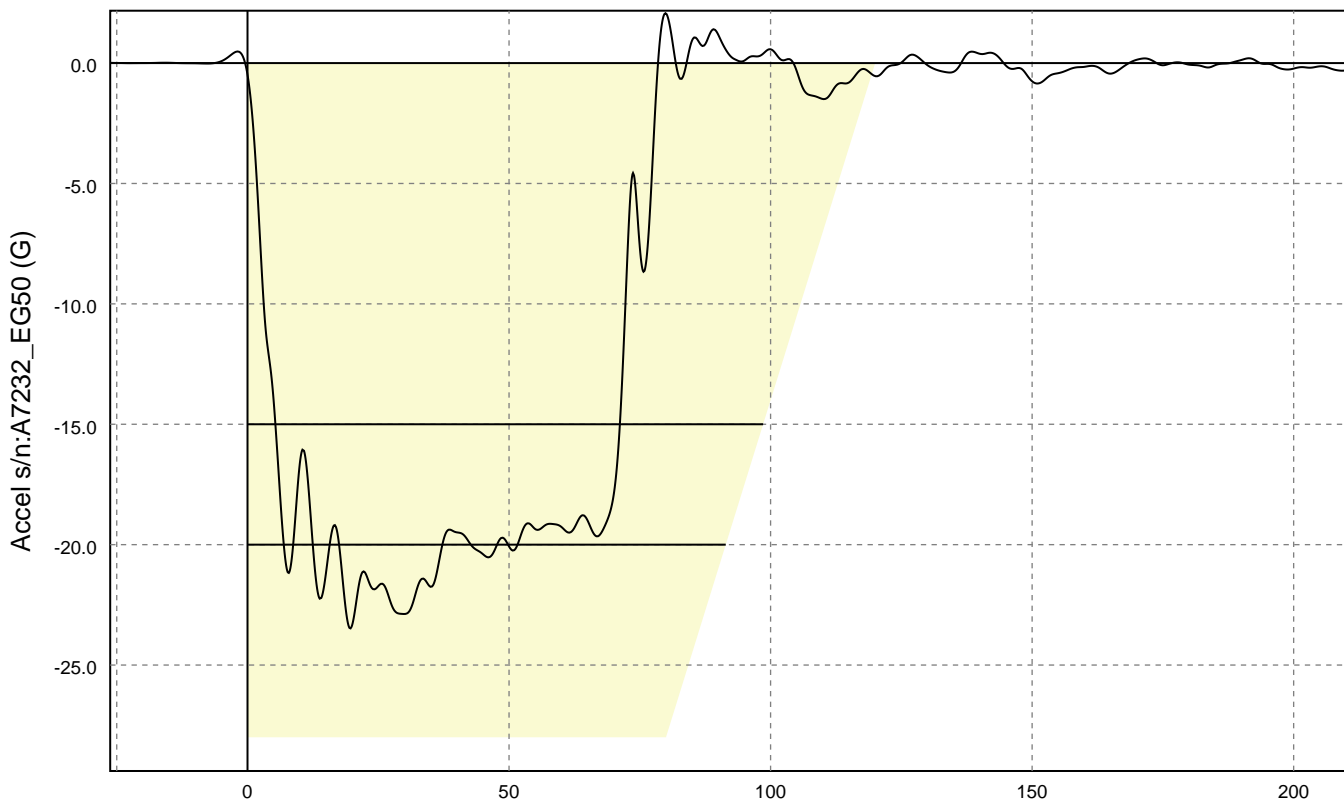
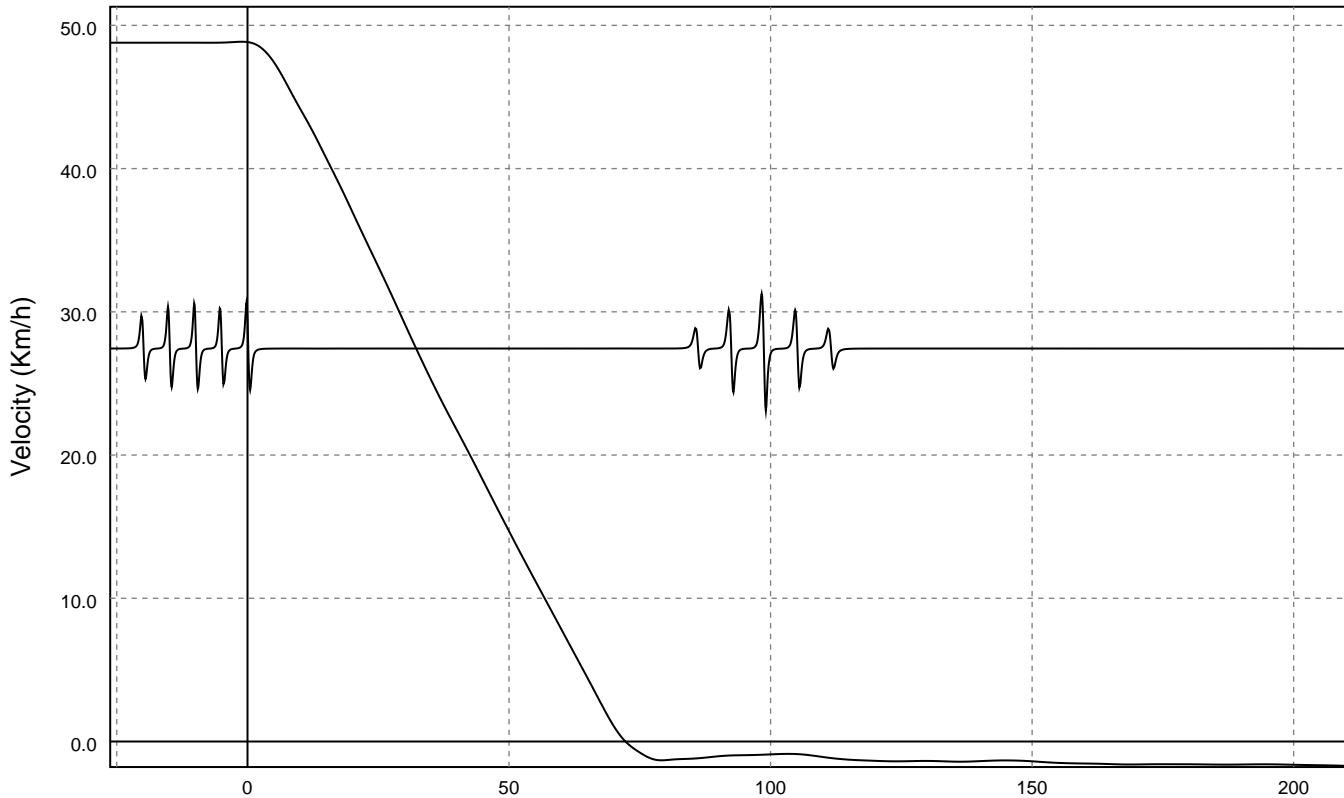






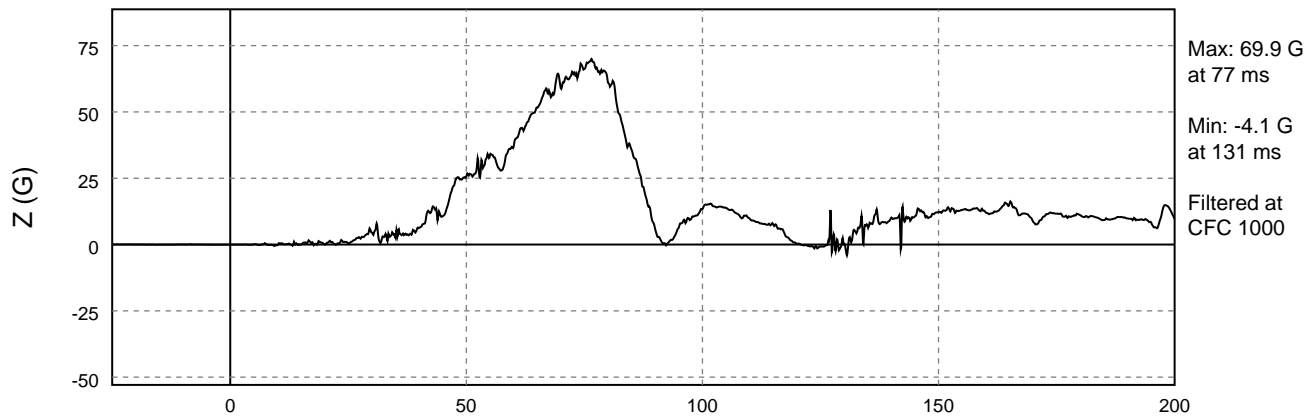
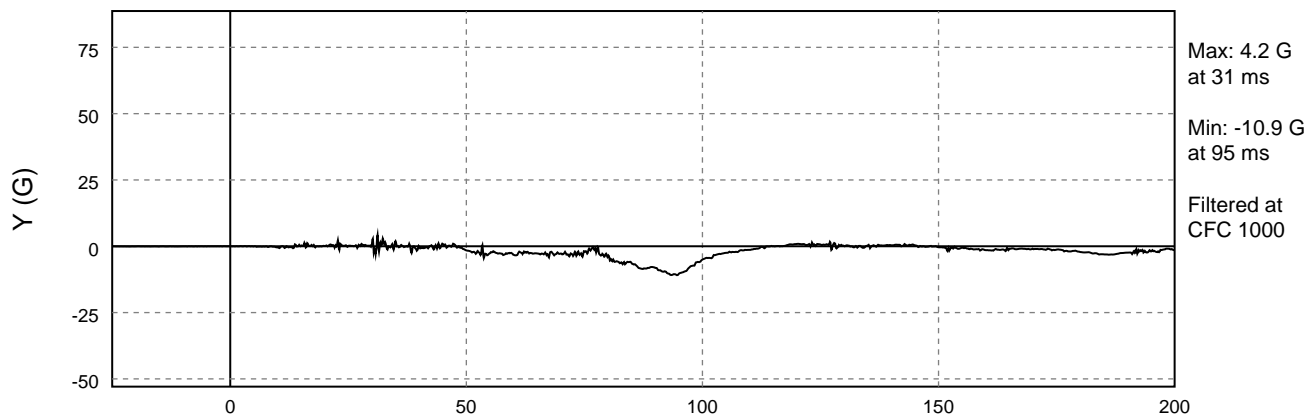
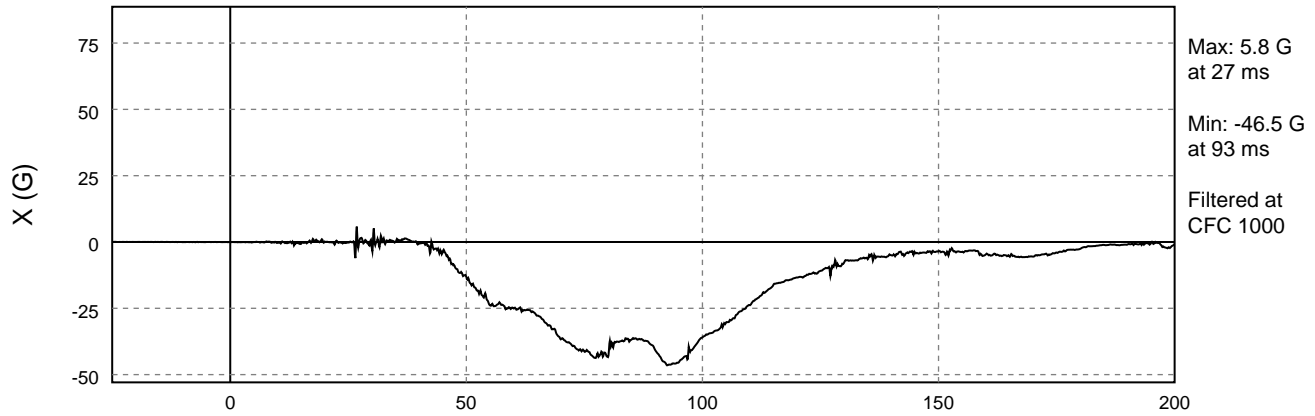


## **TEST SIGNALS**



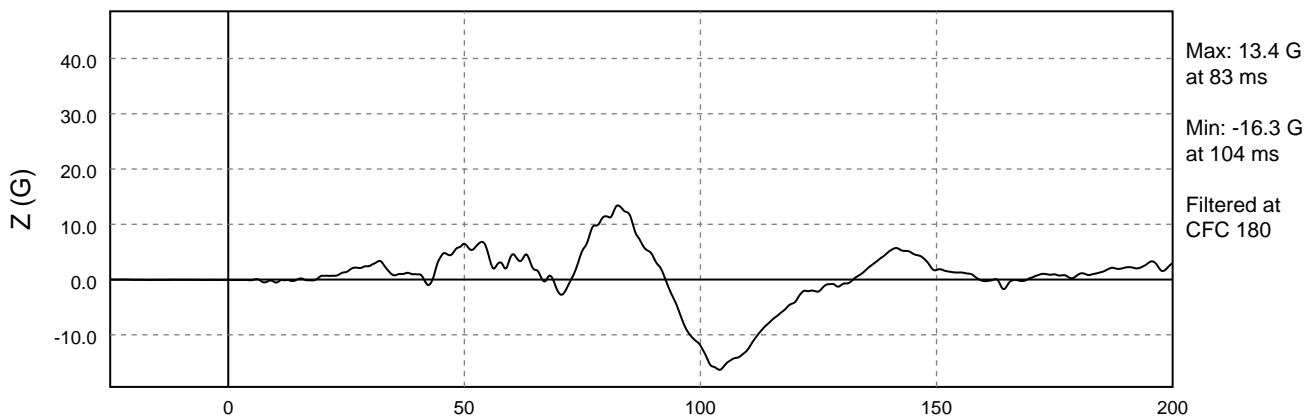
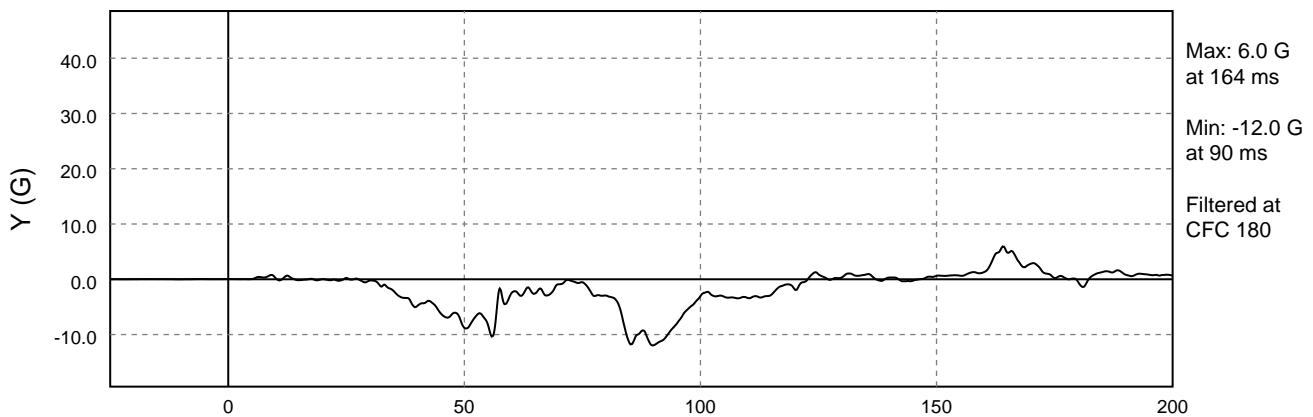
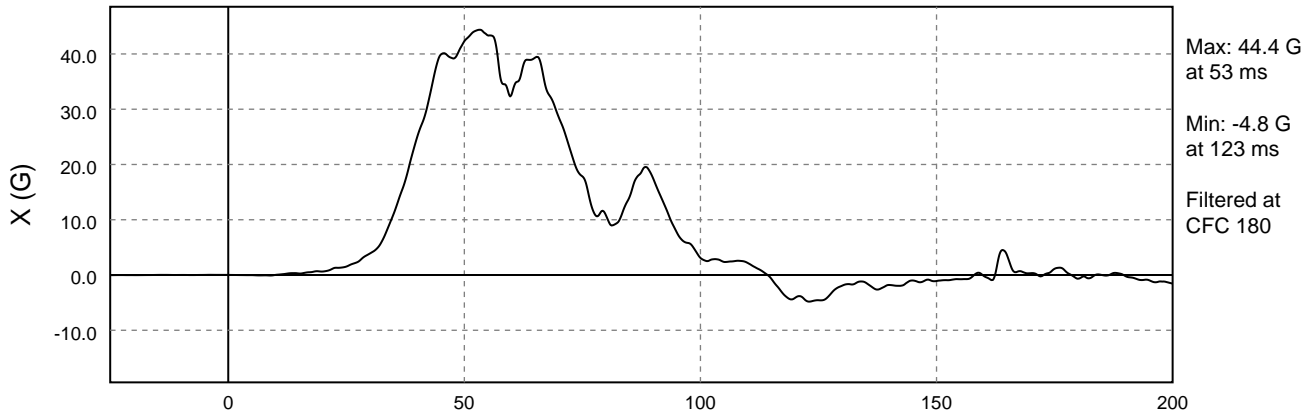
Continuous time under -15.0 G was 65.8 ms  
Total time under -20.0 G was 31.7 ms  
Sled Decel Peak = -23.5 G  
Sled Plateau Average Level = -20.4 G  
Sled Pulse Duration = 79.0 ms

Stopping Dist. (est) = 0.565 m  
Sled Delta V = 49.0 kph (30.5 mph)  
Efficiency =  $V_{out} / V_{in} = 21.60 / 27.44 = 78.7\%$



H.I.C. (15) = 714.3  
H.I.C. (UN) = 1108.9

From: 66.8 to 81.8 ms  
From: 51.7 to 106.5 ms



Total time over 60.0 G was 0.0 ms  
3.0 ms Clipped Peak = 44.7G

From: 51.5 to 54.5 ms

