**REPORT NUMBER: NCAP-MGA-21-023**

# NEW CAR ASSESSMENT PROGRAM (NCAP)
## Frontal Barrier Impact Test

**FCA USA LLC**
**2021 Ram 2500 Crew Cab 4x4**
**NHTSA No.: M20210301**

**MGA RESEARCH CORPORATION**
**5000 Warren Road**
**Burlington, WI 53105**

**Test Date: February 24, 2021**

**Final Report Date: June 10, 2021**

**FINAL REPORT**

**U.S. DEPARTMENT OF TRANSPORTATION**
**National Highway Traffic Safety Administration**
**Office of Crashworthiness Standards**
**1200 New Jersey Ave, SE**
**Room W43-410**
**Washington, DC 20590**

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Prepared by: _____
Ben Fischer, Program Manager

Approved by: _____
Robert Schnorenberg, Project Engineer

Approval Date: June 10, 2021

FINAL REPORT ACCEPTANCE BY OCWS:

_____
Division Chief, New Car Assessment Program
NHTSA, Office of Crashworthiness Standards

Date: _____

_____
COTR, New Car Assessment Program
NHTSA, Office of Crashworthiness Standards

Date: _____

## TECHNICAL REPORT DOCUMENTATION PAGE

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| Final Report of New Car Assessment Program Frontal Impact Testing of a 2021 Ram 2500 Crew Cab 4x4, NHTSA No.: M20210301 | June 10, 2021 |
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| **7. Author(s)** Ben Fischer, Program Manager | **8. Performing Organization Report No.** NCAP-MGA-21-023 |
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| | **11. Contract or Grant No.** 693JJ919D000006 |
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**15. Supplementary Notes**


**16. Abstract**

A 56.3 km/h NCAP Frontal Rigid Barrier Impact Test was conducted on a 2021 Ram 2500 Crew Cab 4x4 in accordance with the specifications of the Office of Crashworthiness Standards Laboratory Procedure for NCAP Full Frontal Rigid Barrier Impact Testing. The test was conducted at MGA Research Corporation in Burlington, Wisconsin on February 24, 2021.

The impact velocity of the vehicle was 56.95 km/h and the ambient temperature at the barrier face at the time of impact was 21.8°C. The target vehicle post-test maximum crush was 755 mm located at the vehicle centerline. The test vehicle's performance was as follows:

| Measurement Description | Units | Driver ATD | | Passenger ATD | |
|---|---|---|---|---|---|
| | | Threshold | Result | Threshold | Result |
| Head Injury Criteria ($HIC_{15}$) | | 700 | 170 | 700 | 190 |
| Maximum Chest Compression | mm | 63 | 33 | 52 | 9 |
| Nij | | 1 | 0.31 | 1 | 0.34 |
| Neck Tension | N | 4170 | 1022 | 2620 | 773 |
| Neck Compression | N | 4000 | 57 | 2520 | 145 |
| Left Femur Force | N | 10008 | 2846 | 6805 | 1868 |
| Right Femur Force | N | 10008 | 2347 | 6805 | 2596 |


| 17. Key Words | 18. Distribution Statement |
|---|---|
| 35 mph Frontal Barrier Impact Test<br>New Car Assessment Program (NCAP) | Copies of this report are available from:<br>National Highway Traffic Safety Administration<br>Technical Information Services Division<br>1200 New Jersey Ave, SE<br>Washington, DC 20590 |

| 19. Security Classification of Report | 20. Security Classification of Page | 21. No. of Pages | 22. Price |
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| Unclassified | Unclassified | 178 | |

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## SECTION 1
## PURPOSE AND SUMMARY OF TEST

### PURPOSE

This 56.3 km/h frontal barrier impact test is part of the Vehicle Barrier Impact Testing Program sponsored by the National Highway Traffic Safety Administration (NHTSA) under contract number 693JJ919D000006. The purpose of this test was to obtain vehicle crashworthiness and occupant restraint system performance data for consumer information purposes.

The 56.3 km/h frontal barrier impact was conducted in accordance with the Office of Crashworthiness Standards Laboratory Procedure for NCAP Full Frontal Rigid Barrier Impact Testing.

### SUMMARY

A load cell barrier consisting of 176 load cells was impacted by a 2021 Ram 2500 Crew Cab 4x4 at a velocity of 56.95 km/h. The test was performed at MGA Research Corporation on February 24, 2021. Pre-test and post-test photographs of the vehicle and dummies can be found in Appendix A.

Two (2) real-time cameras and sixteen (16) high-speed cameras were used to document the frontal barrier impact event. Camera locations and other pertinent camera information can be found in this report.

One Part 572E 50$^{th}$ percentile male anthropomorphic test device (ATD), was placed in the driver seating position and one Part 572O 5$^{th}$ percentile female test device (ATD) was placed in the right-front passenger seating position according to dummy placement instructions specified in the Laboratory Procedure for NCAP Full Frontal Rigid Barrier Impact Testing.

Both ATDs were fully instrumented with head, chest and pelvis tri-axial accelerometers, chest displacement potentiometers, upper neck transducers, right/left femur load cells, and lower leg instrumentation. Seat belt load cells were installed on the driver's and passenger's lap and shoulder belts to measure dummy torso and pelvic section loading.

The driver (position 1) ATD (Serial No. 351) and the right-front passenger (position 2) ATD (Serial No. DH1659) were qualified previous to this test. Certification details, along with instrumentation calibration data, are found in Appendix C of this report.

The 634 channels of data were recorded on a data acquisition system. Appendix B contains the dummy response data traces.

There was 100 percent windshield retention and no intrusion into the protected zone of the windshield during the event. There was no Stoddard Solvent leakage after the event or during any phase of the static rollover.

The maximum static crush of the vehicle was 755 mm located at the vehicle centerline and both the driver and passenger side doors remained closed during the impact event and were operable after the impact.

The driver's visible contact points were as follows: The driver's head contacted the airbag. The driver's head also contacted the headrest. The driver's knees contacted the knee bolster.
The passenger's visible contact points were as follows: The passenger's head contacted the airbag. The passenger's head also contacted the headrest. The passenger's knees contacted the glove box.

The occupant data is summarized below:

| ATD position | $HIC_{15}$ | Nij | Neck Tension (N) | Neck Comp. (N) | 3ms Chest Clip (g) | Chest Disp. (mm) | Left Femur (N) | Right Femur (N) |
|---|---|---|---|---|---|---|---|---|
| Driver ($50^{th}$) | 170 | 0.31 | 1022 | 57 | 38.7 | 33 | 2846 | 2347 |
| Passenger ($5^{th}$) | 190 | 0.34 | 773 | 145 | 38.3 | 9 | 1868 | 2596 |

The test data can be found on the NHTSA website at www.nhtsa.gov

**TEST NOTES**

High-Resolution Load Cell Barrier was not installed due to insufficient overlap with the front of the test vehicle. Barrier A-01 thru Barrier K-16 data channels are not available for this test.

## SECTION 2
## OCCUPANT AND VEHICLE INFORMATION / DATA SHEETS

**DATA SHEET NO. 1**
**GENERAL TEST AND VEHICLE PARAMETER DATA**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**TEST VEHICLE INFORMATION AND OPTIONS**

| | | | |
|---|---|---|---|
| NHTSA No. | M20210301 | Traction Control System (TCS) | Yes |
| Model Year | 2021 | Power Steering | Yes |
| Make | Ram | Power Window Auto-Reverse | Yes |
| Model | 2500 Crew Cab 4x4 | Driver Frontal Airbag | Yes |
| Body Style | Truck | Driver Curtain Airbag | Yes |
| VIN | 3C6UR5HJ9MG502676 | Driver Head/Torso Airbag | No |
| Body Color | Olive Green Pearl-Coat | Driver Torso Airbag | No |
| Odometer (km/mi) | 19 km / 12 mi | Driver Torso/Pelvis Airbag | Yes |
| Engine Displacement (L) | 6.4 L | Driver Pelvis Airbag | No |
| Type/No. Cylinders | V8 | Driver Knee Airbag | No |
| Engine Placement | Longitudinal | Front Pass. Frontal Airbag | Yes |
| Transmission Type | Automatic | Front Pass. Curtain Airbag | Yes |
| Transmission Speeds | 8 | Front Pass. Head/Torso Airbag | No |
| Overdrive | Yes | Front Pass. Torso Airbag | No |
| Final Drive | 4WD | Front Pass. Torso/Pelvis Airbag | Yes |
| Roof Rack | No | Front Pass. Pelvis Airbag | No |
| Sunroof/T-Top | No | Front Pass. Knee Airbag | No |
| Running Boards | No | Driver Pretensioner | Yes |
| Tilt Steering Wheel | Yes | Driver Load Limiter | Yes |
| Power Seats | No | Front Pass. Pretensioner | Yes |
| Anti-Lock Brakes (ABS) | Yes | Front Pass. Load Limiter | Yes |
| Automatic Door Locks (ADLs) | Yes | Other | N/A |

| | |
|---|---|
| Does owner's manual provide instructions to turn off automatic door locks? | No |

**DATA FROM CERTIFICATION LABEL**

| | |
|---|---|
| Manufactured By | FCA USA LLC |
| Date of Manufacture | 11/20 |

| | |
|---|---|
| GVWR (kg) | 4536 |
| GAWR Front (kg) | 2495 |
| GAWR Rear (kg) | 2722 |

**VEHICLE SEATING AND WEIGHT CAPACITY DATA**

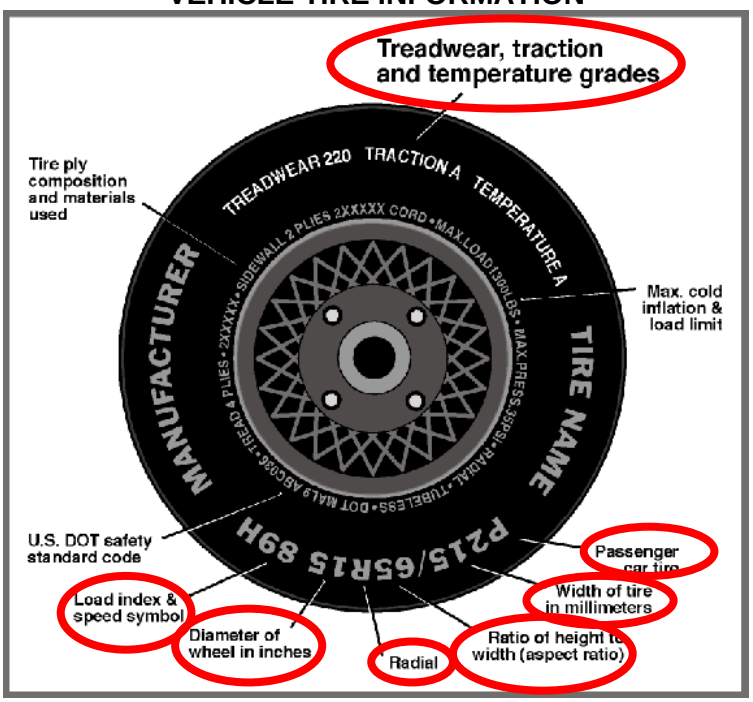
| Measured Parameter | Front | Rear | Third | Total |
|---|---|---|---|---|
| Type of Seats | Bucket | Bench | | |
| Designated Seating Capacity (DSC) | 3 | 3 | | 6 |
| Capacity Weight (VCW) (kg) | | | | 1350 |
| Cargo Weight (RCLW) (kg) | | | | 136 |

* Rated Cargo and Luggage Weight (RCLW) limited to maximum of 300 lbs (136 kg).

**DATA SHEET NO. 1 (CONTINUED)**
**GENERAL TEST AND VEHICLE PARAMETER DATA**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**VEHICLE TIRE INFORMATION**




| Measured Parameter | Front | Rear |
|---|---|---|
| Max. Tire Pressure (kPa) | 550 | 550 |
| Cold Pressure (kPa) | 520 | 550 |
| Recommended Tire Size | 245/70R17 | 245/70R17 |
| Tire Size on Vehicle | 245/70R17 | 245/70R17 |
| Tire Manufacturer | Firestone | Firestone |
| Tire Model | Transforce | Transforce |
| Treadwear | N/A | N/A |
| Traction | N/A | N/A |
| Temperature Grade | N/A | N/A |
| Tire Plies Sidewall | 2 Polyester | 2 Polyester |
| Tire Plies Body | 2 Polyester, 2 Steel, 1 Nylon | 2 Polyester, 2 Steel, 1 Nylon |
| Load Index/Speed Symbol | 119/116 R | 119/116 R |
| Tire Material | Rubber | Rubber |
| DOT Safety Code Left | VNP8 TF7 | VNP8 TF7 |
| DOT Safety Code Right | VNP8 TF7 | VNP8 TF7 |

**DATA SHEET NO. 1 (CONTINUED)**
**GENERAL TEST AND VEHICLE PARAMETER DATA**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**TEST VEHICLE WEIGHTS**

| | Units | As Delivered (UVW) | | | As Tested (ATW) | | |
|---|---|---|---|---|---|---|---|
| | | Front | Rear | Total | Front | Rear | Total |
| Left | kg | 911.5 | 681.0 | | 964.0 | 775.5 | |
| Right | kg | 900.0 | 634.5 | | 930.5 | 728.0 | |
| Ratio | % | 57.9% | 42.1% | | 55.8% | 44.2% | |
| Totals | kg | 1811.5 | 1315.5 | 3127.0 | 1894.5 | 1503.5 | 3398.0 |

**TARGET TEST WEIGHT CALCULATION**

| Measured Parameter | Units | Value |
|---|---|---|
| Total Delivered Weight (UVW) | kg | 3127.0 |
| Weight of 1 P572E ATD & 1 P572O ATD | kg | 141 |
| Rated Cargo/Luggage Weight (RCLW) | kg | 136 |
| Calculated Test Vehicle Target Weight (TVTW) | kg | 3404.0 |

**TEST VEHICLE ATTITUDES AND CG**

| | Units | LF | RF | LR | RR | CG (aft of front axle) |
|---|---|---|---|---|---|---|
| As Delivered | mm | 1001 | 1010 | 1062 | 1065 | 1812 |
| As Tested | mm | 998 | 1001 | 1040 | 1050 | 1906 |
| Post Test | mm | 1162 | 1110 | 1074 | 1018 | |

**GENERAL TEST VEHICLE DATA**

| Measurement Description | Units | Value |
|---|---|---|
| Total Vehicle Wheel Base | mm | 4308 |
| Total Vehicle Length at Left Side | mm | 5996 |
| Total Vehicle Length at Centerline | mm | 6639 |
| Total Vehicle Length at Right Side | mm | 5993 |
| Weight of Ballast in Cargo Area | kg | 79 |
| Weight of Vehicle Components Removed | kg | 11 |
| Amount of Stoddard Solvent in Fuel Tank | L | 112.8 |

List of components removed to meet test weight: None.

List of components removed for instrumentation, data box, and equipment installation: None.

**DATA SHEET NO. 1 (CONTINUED)**
**GENERAL TEST AND VEHICLE PARAMETER DATA**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**TARGET VEHICLE STRUCTURAL MEASUREMENT**

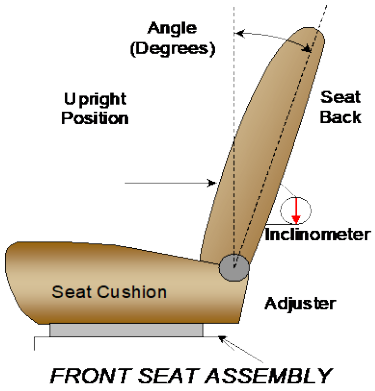
| | Elements | Pre-Test (mm) |
|---|---|---|
| 1 | Total Length | 6639 |
| 2 | Total Width | 2190 |
| 3 | Bumper Top Height | 848 |
| 4 | Bumper Bottom Height | 432 |
| 5 | Longitudinal Member Top Height | 756 |
| 6 | Distance between Longitudinal Members | 743 |
| 7 | Longitudinal Member Width | 884 |
| 8 | Engine Top Height | 1228 |
| 9 | Engine Bottom Height | 440 |
| 10 | Engine and Gearbox Width | 1245 |
| 11 | Front Bumper-Engine Distance | 730 |
| 12 | Front Shock Absorber Fixing Height | 850 |
| 13 | Bonnet Leading Edge Height | 1342 |
| 14 | Front Shock Absorber Fixing Width | 1100 |
| 15 | Front Bumper – Front Axle Distance | 1016 |
| 16 | Front Axle – A-Pillar Distance | 579 |
| 17 | A-Pillar – B-Pillar Distance | 1114 |
| 18 | B-Pillar – Rear Axle Distance | 2617 |
| 19 | B-Pillar – C-Pillar Distance | 967 |
| 20 | Roof Sill Bottom Height | 1858 |
| 21 | Roof Sill Top Height | 1951 |
| 22 | Floor Sill Bottom Height | 432 |
| 23 | Floor Sill Top Height | 640 |

**DATA SHEET NO. 2**
**SEAT ADJUSTMENT, FUEL SYSTEM, AND STEERING WHEEL DATA**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**NOMINAL DESIGN RIDING POSITION**

The driver seat back is positioned as close as possible to the manufacturer's design angle. For the passenger seat back, seat back is adjusted following Appendix F, "Driver & Passenger Dummy Seating & Positioning Procedures" in the NCAP Test Procedure dated May 2018.




| | Degrees |
|---|---|
| Driver Seat Back Angle | 5.3° on outboard headrest post |
| Passenger Seat Back Angle | 3.0° on outboard headrest post |

**SEAT FORE/AFT POSITIONS**

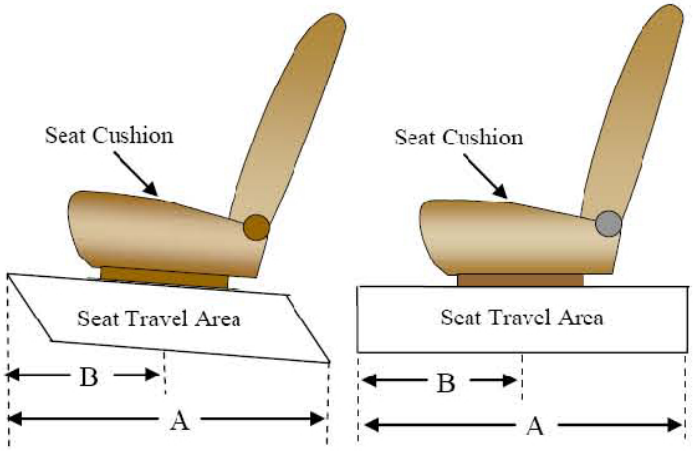
The driver and passenger seat fore/aft positions are adjusted following Appendix F, "Driver & Passenger Dummy Seating & Positioning Procedures" in the NCAP Test Procedure dated May 2018.

| | Total Fore/Aft Travel | Placed in Position # |
|---|---|---|
| Driver Seat | 230 mm / 24 detents (1st as 1) | 120 mm / 12th detent (1st as 0) |
| Passenger Seat | 230 mm / 24 detents (1st as 1) | 0 mm / 0th detent (1st as 0) |

**SEAT BELT UPPER ANCHORAGES**

The seat belt upper anchorages are set following the manufacturer's specified position as listed in Form 1.

| | Total # of Positions | Placed in Position # |
|---|---|---|
| Driver Seat | 5 (1st as 1) | 0 (1st as 0) |
| Passenger Seat | 5 (1st as 1) | 0 (1st as 0) |



**DATA SHEET NO. 2 (CONTINUED)**
**SEAT ADJUSTMENT, FUEL SYSTEM, AND STEERING WHEEL DATA**

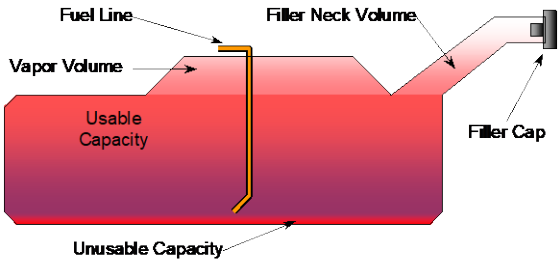
Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**FUEL TANK CAPACITY DATA**

| | Liters |
|---|---|
| Usable Capacity of "Standard Tank" | 121.1 |
| Usable Capacity of "Optional Tank" | |
| 92-94% of Usable Capacity | 111.4 to 113.8 |
| Actual Amount of Solvent used | 112.8 |
| 1/3 of Usable Capacity | 40.4 |

**FUEL PUMP**

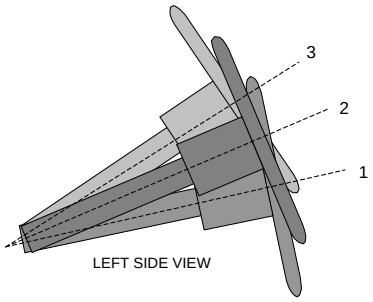
The vehicle is equipped with an electronic fuel pump. The fuel pump will run with ignition key in and turned to the run position. The filler neck is located on the driver's side.




*VEHICLE FUEL TANK ASSEMBLY*

**STEERING COLUMN ADJUSTMENT**

Steering wheel and column adjustments are made so that the steering wheel hub is at the geometric center of the locus it describes when moved through its full range of motion. An aluminum plate is placed across the rim of the steering wheel, an inclinometer is placed on the plate and the angle is measured.



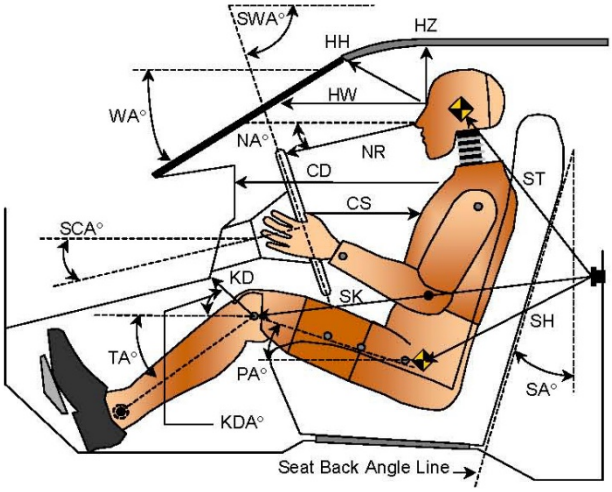

*STEERING COLUMN ASSEMBLY*

**STEERING COLUMN POSITION**

| | Degrees | Fore/Aft Position (mm) |
|---|---|---|
| Lowermost Position 1 | 75.9 | |
| Geometric Center Position 2 | 68.4 | |
| Uppermost Position 3 | 60.8 | |
| Telescoping Steering Wheel Travel | | Fixed |
| Test Position | 68.4 | |

**DATA SHEET NO. 3**
**DUMMY LONGITUDINAL CLEARANCE DIMENSIONS**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

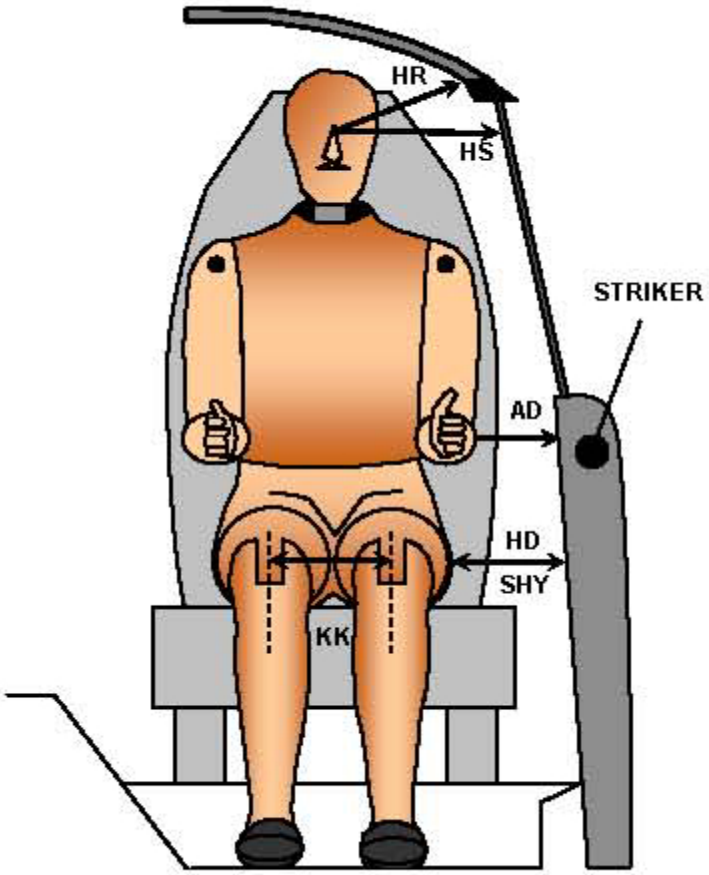



**LEFT SIDE VIEW**

| Code | Measurement Description | Driver | | Passenger | |
|---|---|---|---|---|---|
| | | Length (mm) | Angle (°) | Length (mm) | Angle (°) |
| WA° | Windshield Angle | | 27.7 | | |
| SWA° | Steering Wheel Angle | | 68.4 | | |
| SCA° | Steering Column Angle | | 21.6 | | |
| SA° | Seat Back Angle | | 5.3 | | 3.0 |
| HZ | Head to Roof (Z) | 233 | 90 | 267 | 90 |
| HH | Head to Header | 442 | 14.5 | 385 | 34.2 |
| HW | Head to Windshield | 676 | 0 | 712 | 0 |
| NR | Nose to Rim | 408 | 18.4 | | |
| CD | Chest to Dash | 565 | | 422 | |
| CS | Chest to Steering Hub | 333 | 10.3 | | |
| RA | Rim to Abdomen | 212 | 0 | | |
| KDL | Left Knee to Dash | 151 | 28.7 | 59 | 25.0 |
| KDR | Right Knee to Dash | 126 | 30.0 | 69 | 25.9 |
| PA° | Pelvic Angle | | 24.5 | | 22.2 |
| TA° | Tibia Angle | | 56.5 | | 57.5 |
| SK | Striker to Knee | 611 | 99.0 | 648 | 71.6 |
| ST | Striker to Head | 675 | 8.1 | 612 | 19.1 |
| SH | Striker to H-Point | 192 | 91.2 | 344 | 89.6 |

**DATA SHEET NO. 4**
**DUMMY LATERAL CLEARANCE DIMENSIONS**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

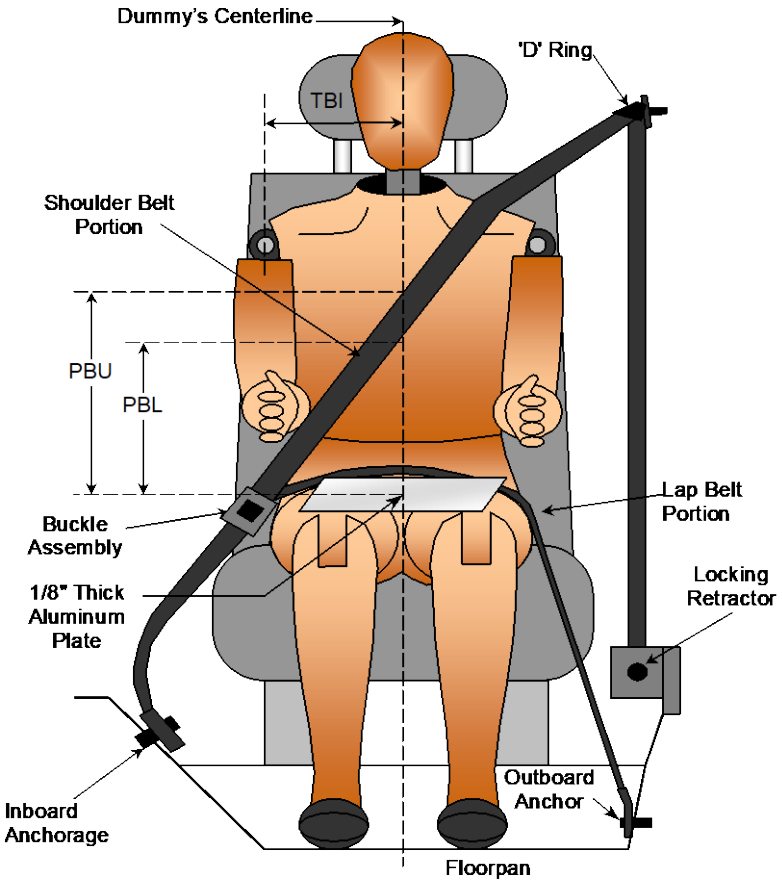



**FRONT VIEW OF DUMMY**

| Code | Measurement Description | Driver | Passenger |
|---|---|---|---|
| | | Length (mm) | |
| AD | Arm to Door | 141 | 66 |
| HD | H-Point to Door | 153 | 167 |
| HR | Head to Side Header | 208 | 251 |
| HS | Head to Side Window | 335 | 341 |
| KK | Knee to Knee | 310 | 226 |
| SHY | Striker to H-Point (Y Direction) | 300 | 293 |
| AA | Ankle to Ankle | 275 | 167 |

**DATA SHEET NO. 5**
**SEAT BELT POSITIONING DATA**

| | | | |
|---|---|---|---|
| Test Vehicle: | 2021 Ram 2500 Crew Cab 4x4 | NHTSA No.: | M20210301 |
| Test Program: | NCAP Frontal Barrier Impact Test | Test Date: | 2/24/2021 |




**FRONT VIEW OF DUMMY**

**SEAT BELT POSITIONING MEASUREMENTS**

| Measurement Description | Units | Driver | Passenger |
|---|---|---|---|
| PBU - Top surface of reference to belt upper edge | mm | 350 | 340 |
| PBL - Top surface of reference to belt lower edge | mm | 265 | 245 |

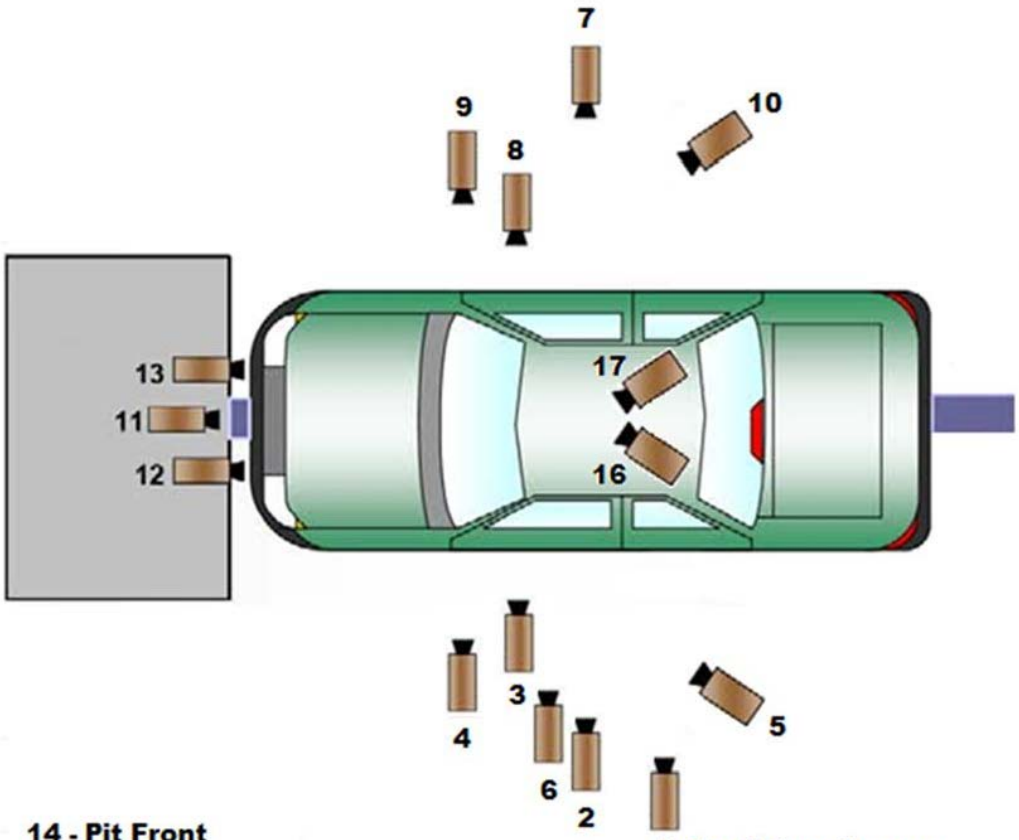
**BELT LENGTH DATA**

| Measurement Description | Units | Driver | Passenger |
|---|---|---|---|
| Shoulder Belt Length as measured on ATD | mm | 845 | 870 |
| Lap Belt Length as measured on ATD | mm | 690 | 750 |
| Remainder of belt on reel | mm | 1085 | 1000 |
| Total Belt Length for Continuous Webbing Systems | mm | 2950 | 2950 |

**DATA SHEET NO. 6**
**HIGH-SPEED CAMERA LOCATIONS AND DATA**

| | | | |
|---|---|---|---|
| Test Vehicle: | 2021 Ram 2500 Crew Cab 4x4 | NHTSA No.: | M20210301 |
| Test Program: | NCAP Frontal Barrier Impact Test | Test Date: | 2/24/2021 |

**CAMERA POSITIONS FOR FRONTAL IMPACTS**




**14 - Pit Front**
**15 - Pit Rear**
**16 & 17 - Driver and Passenger Onboard**

***Camera locations are approximate and not to scale*

**DATA SHEET NO. 6 (CONTINUED)**
**HIGH-SPEED CAMERA LOCATIONS AND DATA**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

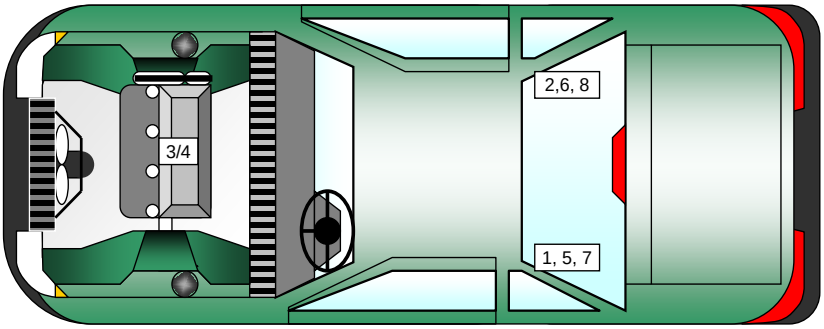
**CAMERA LOCATIONS**

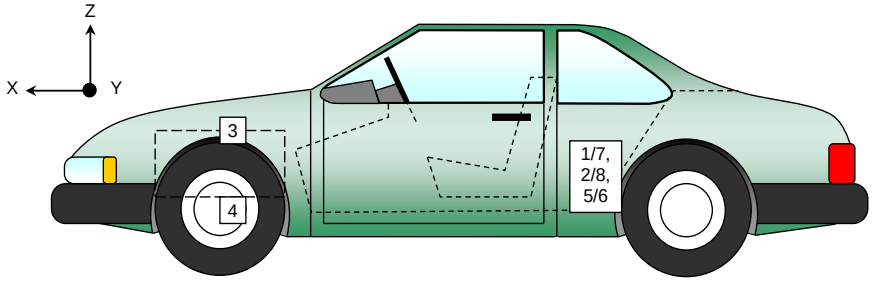
| No. | Camera View | Coordinates* (mm) | | | Lens (mm) | Speed (fps) |
|---|---|---|---|---|---|---|
| | | X | Y | Z | | |
| 1 | Real-Time Left Overall | | | | | 30 |
| 2 | Left Overall | -2445 | -6530 | -1505 | 12 | 1000 |
| 3 | Driver Close-Up | -1900 | -6925 | -2015 | 50 | 1000 |
| 4 | Left Front Half | -1485 | -5530 | -1480 | 24 | 1000 |
| 5 | Left Angle | -7405 | -5790 | -2020 | 75 | 1000 |
| 6 | Steering Column | -1495 | -6460 | -1400 | 50 | 1000 |
| 7 | Right Overall | -2490 | 6215 | -1535 | 12 | 1000 |
| 8 | Passenger Close-Up | -1795 | 6485 | -1985 | 50 | 1000 |
| 9 | Right Front Half | -1470 | 5465 | -1495 | 24 | 1000 |
| 10 | Right Angle | -7455 | 5500 | -2010 | 75 | 1000 |
| 11 | Windshield | 100 | 0 | -2310 | 12 | 1000 |
| 12 | Driver Windshield | 170 | -375 | -2230 | 25 | 1000 |
| 13 | Passenger Windshield | 170 | 375 | -2230 | 25 | 1000 |
| 14 | Pit Front | -710 | 0 | 3340 | 24 | 1000 |
| 15 | Pit Rear | -3260 | 0 | 3340 | 24 | 1000 |
| 16 | Driver Onboard | | | | 12 | 1000 |
| 17 | Passenger Onboard | | | | 12 | 1000 |
| 18 | Real-Time Pan View | | | | | 30 |

*COORDINATES:
+X = forward of impact plane
+Y = right of monorail centerline
+Z = below ground level

**DATA SHEET NO. 7**
**VEHICLE ACCELEROMETER LOCATIONS**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021




**VEHICLE ACCELEROMETER PRE-TEST LOCATIONS**

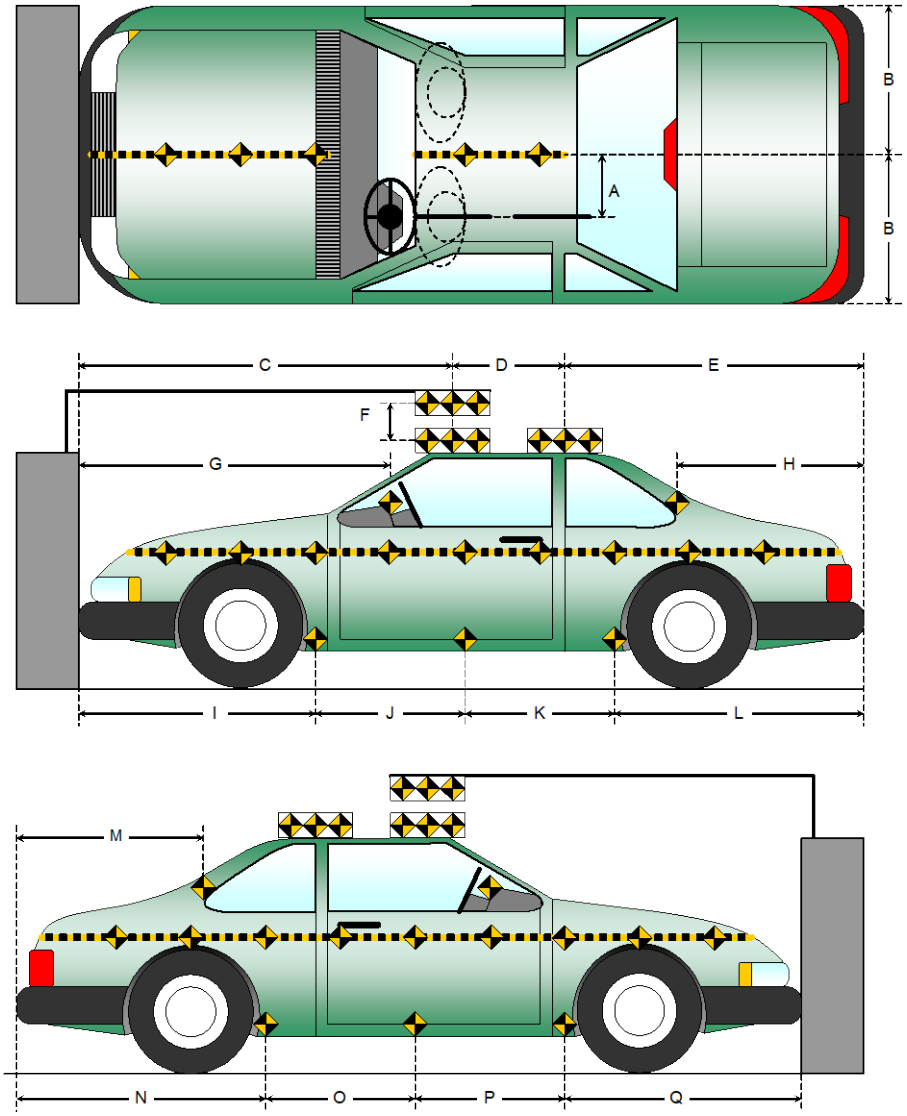
| No. | Accelerometer Location | Measurements (mm) | | |
|---|---|---|---|---|
| | | X | Y | Z |
| 1 | Left Rear Crossmember Accelerometer – X Direction | 2841 | -452 | -850 |
| 2 | Right Rear Crossmember Accelerometer – X Direction | 2841 | 438 | -843 |
| 3 | Engine Top X | 5513 | 10 | -1228 |
| 4 | Engine Bottom X | 5375 | -10 | -420 |
| 5 | Left Rear Crossmember Accelerometer – Z Direction | 2841 | -452 | -850 |
| 6 | Right Rear Crossmember Accelerometer – Z Direction | 2841 | 438 | -843 |
| 7 | Left Rear Crossmember Accelerometer Redundant – X Direction | 2841 | -412 | -850 |
| 8 | Right Rear Crossmember Accelerometer Redundant – X Direction | 2841 | 398 | -843 |

Reference Points: X - Rear Surface of Vehicle (+ forward)
Y - Vehicle Centerline (+ to right)
Z - Ground Plane (+ down)

**DATA SHEET NO. 8**
**PHOTOGRAPHIC REFERENCE TARGET LOCATIONS**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

| Item | Value (mm) |
|---|---|
| A | 450 |
| B | 1095 |
| C | 2535 |
| D | 610 |
| E | 3494 |
| F | 30 |
| G | |
| H | 2963 |
| I | 1614 |
| J | 1040 |
| K | 1040 |
| L | 2945 |
| M | 2963 |
| N | 2945 |
| O | 1040 |
| P | 1040 |
| Q | 1614 |



**DATA SHEET NO. 9**
**LOAD CELL LOCATIONS ON FIXED BARRIER**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**ADVANCED RESEARCH LOAD CELL BARRIER**

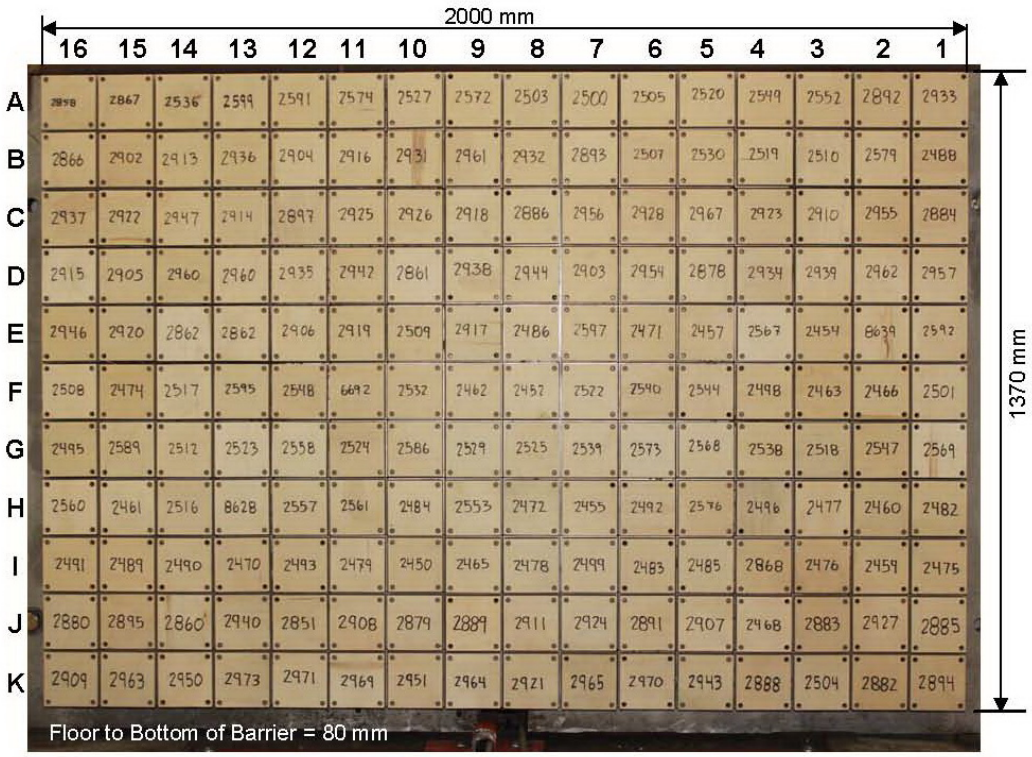



Photo for Reference Only

Centerline

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A-16 | A-15 | A-14 | A-13 | A-12 | A-11 | A-10 | A-09 | A-08 | A-07 | A-06 | A-05 | A-04 | A-03 | A-02 | A-01 |
| B-16 | B-15 | B-14 | B-13 | B-12 | B-11 | B-10 | B-09 | B-08 | B-07 | B-06 | B-05 | B-04 | B-03 | B-02 | B-01 |
| C-16 | C-15 | C-14 | C-13 | C-12 | C-11 | C-10 | C-09 | C-08 | C-07 | C-06 | C-05 | C-04 | C-03 | C-02 | C-01 |
| D-16 | D-15 | D-14 | D-13 | D-12 | D-11 | D-10 | D-09 | D-08 | D-07 | D-06 | D-05 | D-04 | D-03 | D-02 | D-01 |
| E-16 | E-15 | E-14 | E-13 | E-12 | E-11 | E-10 | E-09 | E-08 | E-07 | E-06 | E-05 | E-04 | E-03 | E-02 | E-01 |
| F-16 | F-15 | F-14 | F-13 | F-12 | F-11 | F-10 | F-09 | F-08 | F-07 | F-06 | F-05 | F-04 | F-03 | F-02 | F-01 |
| G-16 | G-15 | G-14 | G-13 | G-12 | G-11 | G-10 | G-09 | G-08 | G-07 | G-06 | G-05 | G-04 | G-03 | G-02 | G-01 |
| H-16 | H-15 | H-14 | H-13 | H-12 | H-11 | H-10 | H-09 | H-08 | H-07 | H-06 | H-05 | H-04 | H-03 | H-02 | H-01 |
| I-16 | I-15 | I-14 | I-13 | I-12 | I-11 | I-10 | I-09 | I-08 | I-07 | I-06 | I-05 | I-04 | I-03 | I-02 | I-01 |
| J-16 | J-15 | J-14 | J-13 | J-12 | J-11 | J-10 | J-09 | J-08 | J-07 | J-06 | J-05 | J-04 | J-03 | J-02 | J-01 |
| K-16 | K-15 | K-14 | K-13 | K-12 | K-11 | K-10 | K-09 | K-08 | K-07 | K-06 | K-05 | K-04 | K-03 | K-02 | K-01 |

Load Cells are 121 mm x 121 mm with a 7 mm gap in between each load cell.

**DATA SHEET NO. 10**
**TEST VEHICLE SUMMARY OF RESULTS**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**INSTRUMENTATION**

| Instrumentation | Number of Channels Collected |
|---|---|
| Driver Dummy Data Channels | 49 |
| Passenger Dummy Data Channels | 49 |
| Vehicle Structure Accelerometers | 8 |
| Barrier Channels | 0 |
| Total | 106 |

**CAMERA COVERAGE**

| Type of Camera | Number Used in this Test |
|---|---|
| High-Speed Vehicle Onboard | 2 |
| High-Speed Offboard | 14 |
| Real-Time | 2 |
| Total | 18 |

**DATA SHEET NO. 11**
**POST-TEST OBSERVATIONS**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**TEST DUMMY INFORMATION AND CONTACT LOCATIONS**

| Description | Driver | Passenger |
|---|---|---|
| Dummy Type / Serial No. | HIII 50% / 351 | HIII 5% / DH1659 |
| Head Contact | Frontal Airbag, Headrest | Frontal Airbag, Headrest |
| Upper Torso Contact | Frontal Airbag | Frontal Airbag |
| Lower Torso Contact | None | None |
| Left Knee Contact | Knee Bolster | Glove Box |
| Right Knee Contact | Knee Bolster | Glove Box |

**DOOR OPENING, TRUNK OPENING, AND SEAT TRACK INFORMATION**

| Description | Driver | Passenger |
|---|---|---|
| Locked/Unlocked Doors | Doors were locked | Doors were locked |
| Front Door Opening | Remained closed and unlocked; opened without tools | Remained closed and unlocked; opened without tools |
| Rear Door Opening | Remained closed and unlocked; opened without tools | Remained closed and unlocked; opened without tools |
| Trunk/Hatch/Tailgate Opening | Remained closed; opened without tools | |
| Seat Track Shift (mm) | 0 | 0 |
| Seat Back Movement | None | None |

**OTHER VEHICLE POST-TEST OBSERVATIONS**

| Critical Areas of Performance | Observations and Conclusions |
|---|---|
| Windshield Damage | Cracked |
| Window Damage | None |
| Other Notable Effects | None |

**VEHICLE REBOUND FROM BARRIER**

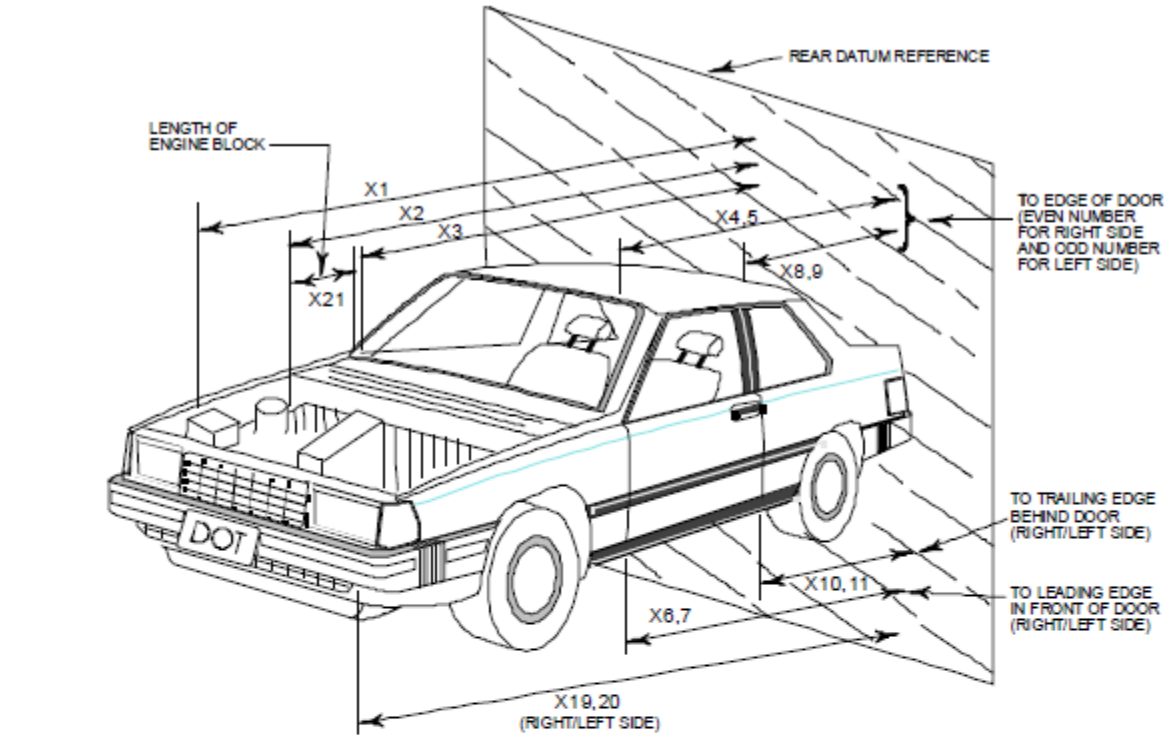
| Measured Parameter | Units | Value |
|---|---|---|
| Left Side | mm | 2345 |
| Center | mm | 1952 |
| Right Side | mm | 2255 |
| Average | mm | 2184 |

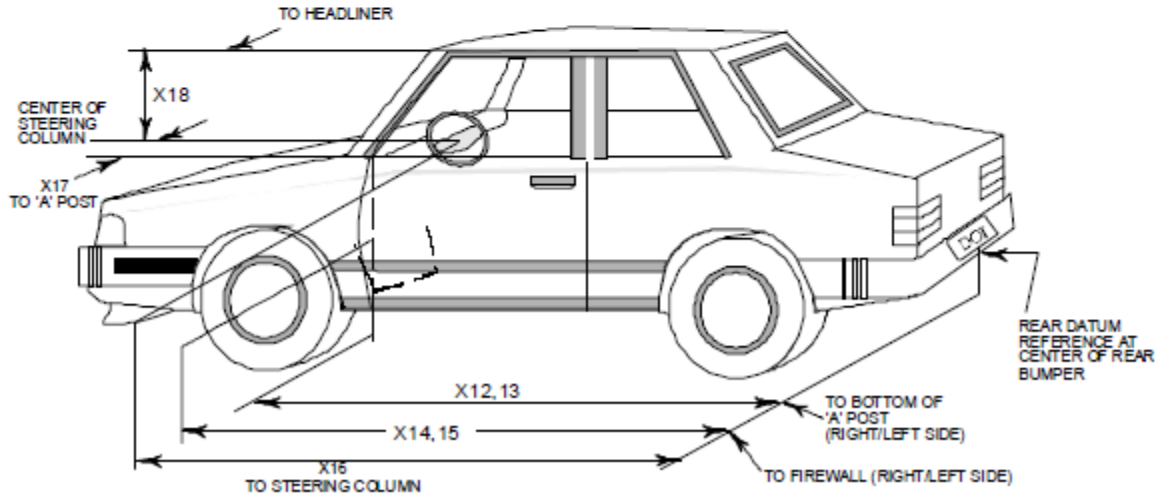
**SUPPLEMENTAL RESTRAINT SYSTEM INFORMATION**

| Restraint Type | Driver | | Passenger | |
|---|---|---|---|---|
| | Mounted | Deployed | Mounted | Deployed |
| Frontal Airbag | Yes | Yes | Yes | Yes |
| Curtain Side Airbag | Yes | No | Yes | No |
| Torso/Pelvis Side Airbag | Yes | No | Yes | No |
| Knee Airbag | No | | No | |
| Seat Belt Pretensioner | Yes | Yes | Yes | Yes |
| Seat Belt Load Limiter | Yes | | Yes | |
| Other | | | | |

**DATA SHEET NO. 12**
**VEHICLE PROFILE MEASUREMENTS**

| | | | |
|---|---|---|---|
| Test Vehicle: | 2021 Ram 2500 Crew Cab 4x4 | NHTSA No.: | M20210301 |
| Test Program: | NCAP Frontal Barrier Impact Test | Test Date: | 2/24/2021 |



**DATA SHEET NO. 12 (CONTINUED)**
**VEHICLE PROFILE MEASUREMENTS**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

| No. | Measurement Description | Pre-Test | Post-Test | Difference |
|---|---|---|---|---|
| 1 | Total Length of Vehicle at Centerline | 6639 | 5884 | 755 |
| 2 | RSOV to Front of Engine | 5748 | 5459 | 289 |
| 3 | RSOV to Firewall | 5421 | 5328 | 93 |
| 4 | RSOV to Upper Leading Edge of Right Door | 5032 | 5023 | 9 |
| 5 | RSOV to Upper Leading Edge of Left Door | 5032 | 5002 | 30 |
| 6 | RSOV to Lower Leading Edge of Right Door | 4968 | 4975 | -7 |
| 7 | RSOV to Lower Leading Edge of Left Door | 4968 | 4970 | -2 |
| 8 | RSOV to Upper Trailing Edge of Right Door | 3914 | 3892 | 22 |
| 9 | RSOV to Upper Trailing Edge of Left Door | 3914 | 3870 | 44 |
| 10 | RSOV to Lower Trailing Edge of Right Door | 3905 | 3902 | 3 |
| 11 | RSOV to Lower Trailing Edge of Left Door | 3905 | 3896 | 9 |
| 12 | RSOV to Bottom of “A” Post of Right Side | 4978 | 4969 | 9 |
| 13 | RSOV to Bottom of “A” Post of Left Side | 4969 | 4964 | 5 |
| 14 | RSOV to Firewall, Right Side | 5409 | 5386 | 23 |
| 15 | RSOV to Firewall, Left Side | 5409 | 5363 | 46 |
| 16 | RSOV to Steering Column | 4504 | 4500 | 4 |
| 17 | Center of Steering Column to “A” Post | 406 | 396 | 10 |
| 18 | Center of Steering Column to Headliner | 457 | 475 | -18 |
| 19 | RSOV to Right Side of Front Bumper | 5993 | 5592 | 401 |
| 20 | RSOV to Left Side of Front Bumper | 5993 | 5491 | 502 |
| 21 | Length of Engine Block | 455 | 455 | 0 |
| RD | RSOV to Right Side of Dash Panel | 4821 | 4819 | 2 |
| CD | RSOV to Center of Dash Panel | 4893 | 4826 | 67 |
| LD | RSOV to Left Side of Dash Panel | 4828 | 4810 | 18 |

All Dimensions in mm

**DATA SHEET NO. 13**
**ACCIDENT INVESTIGATION DIVISION DATA**

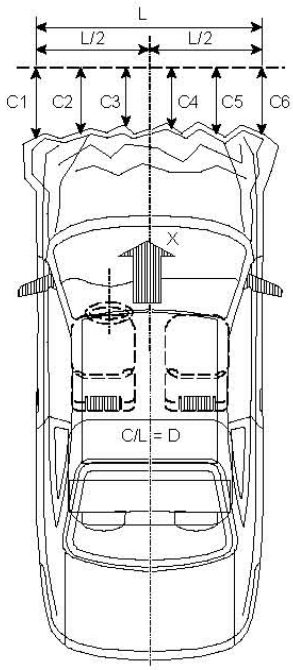
Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**VEHICLE INFORMATION**

VIN: 3C6UR5HJ9MG502676 Wheelbase (mm): 4308
Vehicle Size Category: Truck Test Weight (kg): 3398.0

**ACCELEROMETER DATA**

Accelerometer Locations: As per Data Sheet No. 7
Cal. Procedure/Interval: MGA Procedure / 6 month
Integration Algorithm: Trapezoidal
Linearity: > 99%
Impact Velocity (km/h): 56.95
Velocity Change (km/h): 66.6
Time of Separation (msec) 122




**CRUSH PROFILE**

Collision Deformation Classification: 12FDEW4
Midpoint of Damage: Centerline
Damage Region Length (mm): 2732
Impact Mode: Frontal

| No. | Measurement Description | Units | Pre-Test | Post-Test | Difference |
|---|---|---|---|---|---|
| C1 | Crush zone 1 at left side | mm | 5996 | 5491 | 505 |
| C2 | Crush zone 2 at left side | mm | 6471 | 5820 | 651 |
| C3 | Crush zone 3 at left side | mm | 6612 | 5859 | 753 |
| C4 | Crush zone 4 at right side | mm | 6612 | 5865 | 747 |
| C5 | Crush zone 5 at right side | mm | 6471 | 5844 | 627 |
| C6 | Crush zone 6 at right side | mm | 5993 | 5592 | 401 |
| L | C1 TO C6 | mm | 2732 | 2736 | -4 |

**DATA SHEET NO. 14**
**VEHICLE INTRUSION MEASUREMENTS**

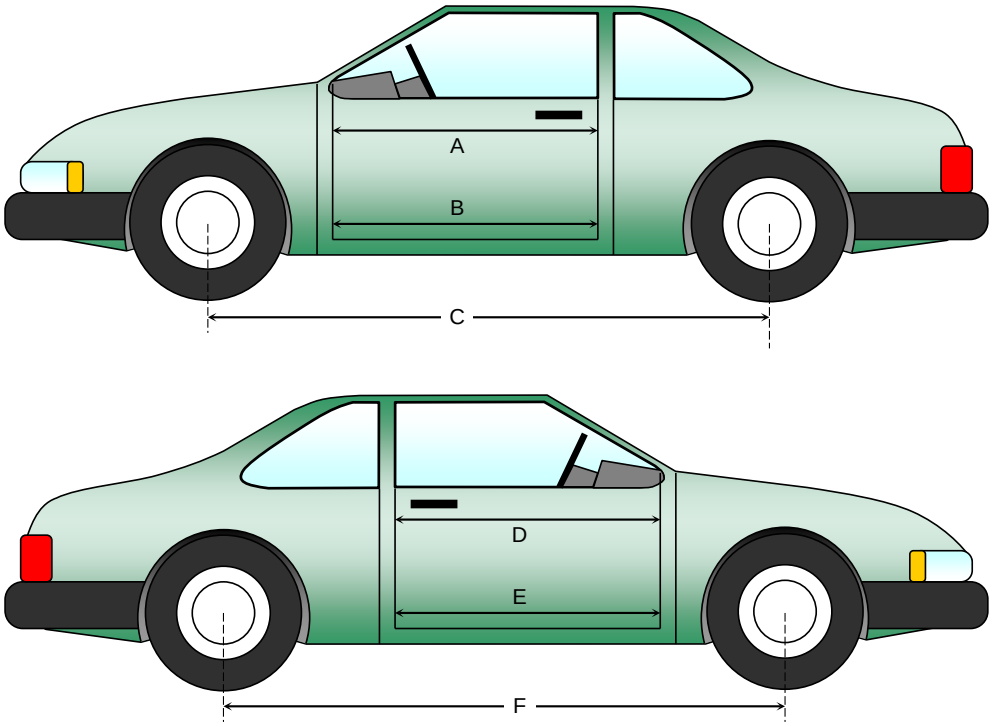
Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**DOOR OPENING WIDTH**

| Item | Description | Units | Pre-Test | Post-Test | Difference |
|---|---|---|---|---|---|
| A | Left Side Upper | mm | 978 | 978 | 0 |
| B | Left Side Lower | mm | 948 | 948 | 0 |
| D | Right Side Upper | mm | 977 | 977 | 0 |
| E | Right Side Lower | mm | 947 | 947 | 0 |

**WHEELBASE MEASUREMENTS**

| Item | Description | Units | Pre-Test | Post-Test | Difference |
|---|---|---|---|---|---|
| C | Left Side Wheelbase | mm | 4308 | 4209 | 99 |
| F | Right Side Wheelbase | mm | 4308 | 4241 | 67 |



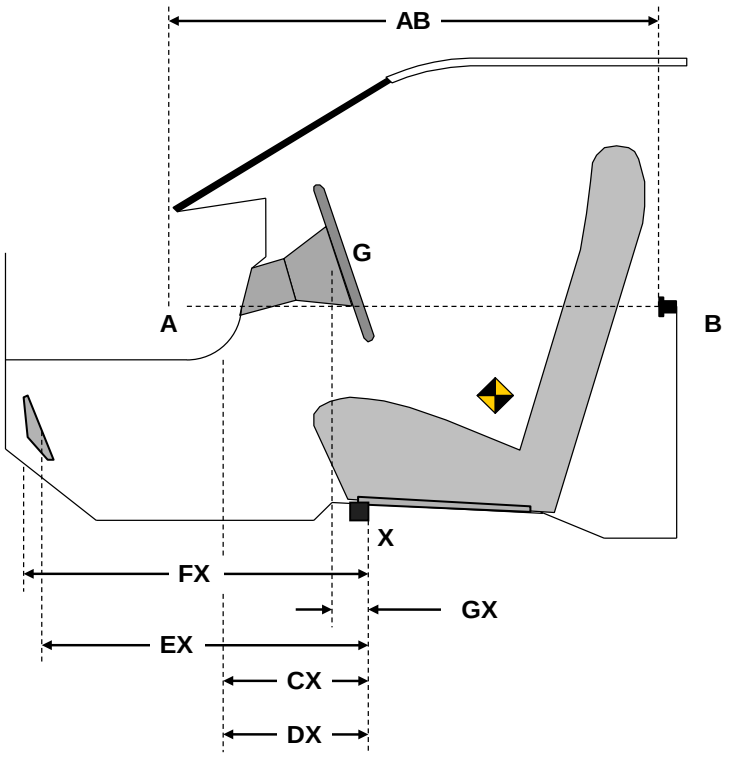
**DATA SHEET NO. 14 (CONTINUED)**
**VEHICLE INTRUSION MEASUREMENTS**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**DRIVER COMPARTMENT INTRUSION**

| Item | Description | Units | Pre-Test | Post-Test | Difference |
|---|---|---|---|---|---|
| AB | Door Opening (Inside Window Jam) | mm | 746 | 746 | 0 |
| CX | Left Knee Bolster to X | mm | 295 | 296 | -1 |
| DX | Right Knee Bolster to X | mm | 287 | 258 | 29 |
| EX | Brake Pedal to X | mm | 538 | 463 | 75 |
| FX | Foot Rest to X | mm | 875 | 651 | 224 |
| GX | Center of Steering Column Wheel Hub to X | mm | 78 | 54 | 24 |

X = Front of Seat Track (stationary)




**DRIVER COMPARTMENT**

**DATA SHEET NO. 15**
**SUMMARY OF FMVSS 212 AND FMVSS 219 (PARTIAL) DATA**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**WINDSHIELD MOUNTING DETAILS**

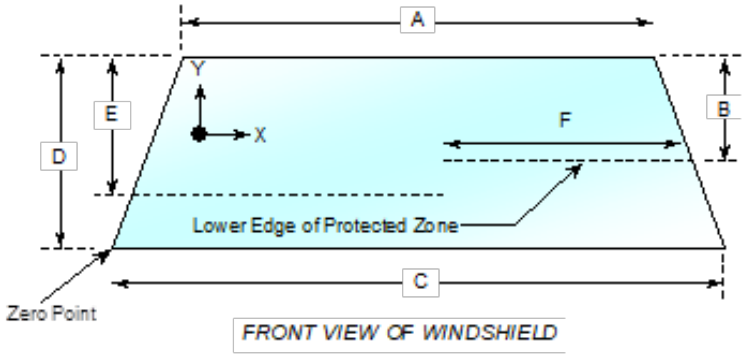
Windshield glass is secured to the vehicle frame with a rubber trim and glue.

The standard requires that the post-test retention measurement be a minimum of 75 percent of the pre-test total periphery measurement for vehicles not equipped with occupant passive restraints and 50 percent for each side of the windshield for vehicles which are equipped with occupant passive restraints.

**Temperature of windshield molding during test:** 21.8°C.

**WINDSHIELD PERIPHERY MEASUREMENTS**

| Measurement | Pre-Test (mm) | Post-Test (mm) | % of Retention |
|---|---|---|---|
| Left Side | 2265 | 2265 | 100 |
| Right Side | 2265 | 2265 | 100 |
| Total | 4530 | 4530 | 100 |



FRONT VIEW OF WINDSHIELD

| Item | Units | Value |
|---|---|---|
| A | mm | 1388 |
| B | mm | 445 |
| C | mm | 1568 |
| D | mm | 787 |
| E | mm | 505 |
| F | mm | 453 |

**AREA OF PROTECTED ZONE FAILURES**

A. Provide coordinates of the area that the protected zone was penetrated more than 0.25 inches by a vehicle component other than one that is normally in contact with the windshield. **None**

| X | Y |
|---|---|
| | |
| | |
| | |
| | |

B. Provide coordinates of the area beneath the protected zone that the inner surface of the windshield was penetrated by a vehicle component. **None**

| X | Y |
|---|---|
| | |
| | |
| | |
| | |

**DATA SHEET NO. 16**
**FMVSS 301 BARRIER IMPACT AND STATIC ROLLOVER**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

## FMVSS 301 FUEL SYSTEM INTEGRITY POST IMPACT DATA

Temperature at Time of Impact: 21.8°C Test Time: 11:13 a.m.

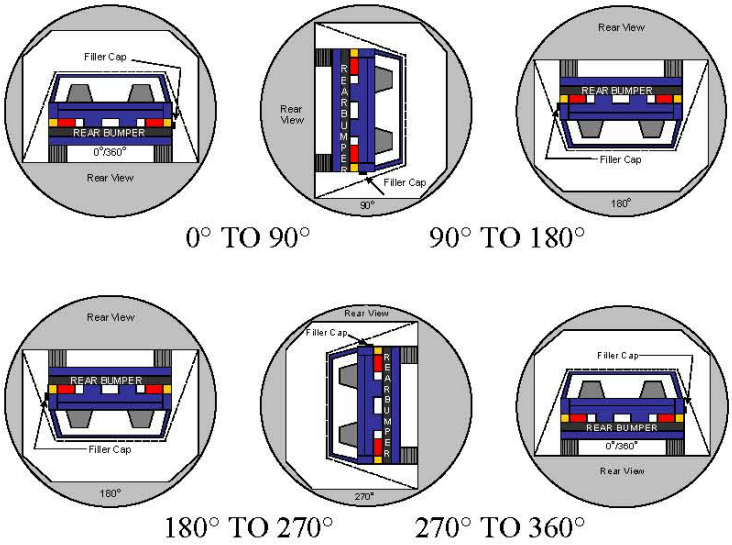
A. From impact until vehicle motion ceases: (Maximum Allowable = 1 ounce) 0.0 oz.

B. For the 5 minute period after motion ceases: (Maximum Allowable = 5 ounces) 0.0 oz.

C. For the following 25 minutes: (Maximum Allowable = 1 ounce / minute) None

D. Spillage Details: None

## FMVSS 301 STATIC ROLLOVER RESULTS




1. The specified fixture rollover rate for each 90° of rotation is 60 to 180 seconds.
2. The position hold time at each position is 300 seconds (minimum).
3. Details of Stoddard Solvent spillage: **None**

**SOLVENT COLLECTION TIME TABLE IN SECONDS**

| Test Phase | Rotation Time | Hold Time | Total Time |
|---|---|---|---|
| 0° to 90° | 91 | 300 | 391 |
| 90° to 180° | 90 | 300 | 390 |
| 180° to 270° | 85 | 300 | 385 |
| 270° to 360° | 86 | 300 | 386 |

**DATA SHEET NO. 16 (CONTINUED)**
**FMVSS 301 BARRIER IMPACT AND STATIC ROLLOVER**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021

**FMVSS 301 SPILLAGE TABLE (UNITS IN OUNCES)**

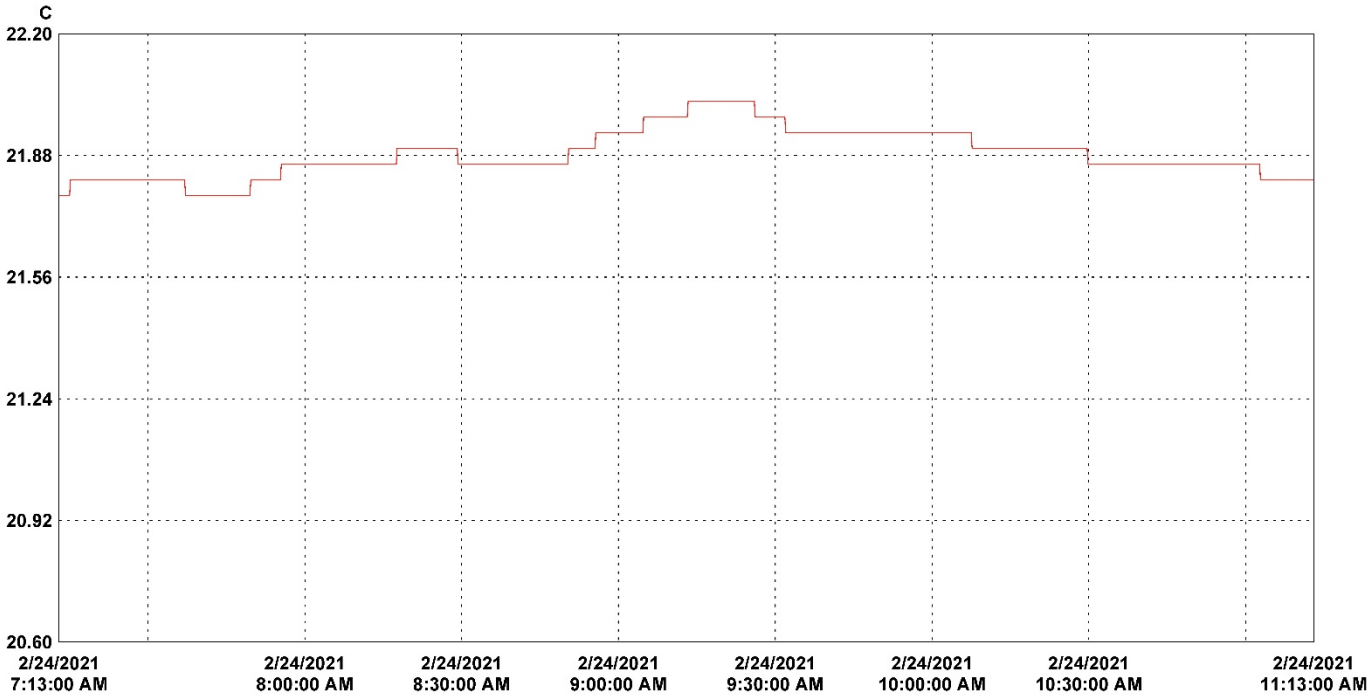
| Test Phase | First 5 Minutes | Sixth Minute | Seventh Minute | Eight Minute |
|---|---|---|---|---|
| 0° to 90° | 0 | 0 | 0 | |
| 90° to 180° | 0 | 0 | 0 | |
| 180° to 270° | 0 | 0 | 0 | |
| 270° to 360° | 0 | 0 | 0 | |

**SOLVENT SPILLAGE LOCATION TABLE**

| Test Phase | Spillage Location |
|---|---|
| 0° to 90° | |
| 90° to 180° | |
| 180° to 270° | |
| 270° to 360° | |

**DATA SHEET NO. 17**
**DUMMY/VEHICLE TEMPERATURE STABILIZATION DATA**

Test Vehicle: 2021 Ram 2500 Crew Cab 4x4 NHTSA No.: M20210301
Test Program: NCAP Frontal Barrier Impact Test Test Date: 2/24/2021




| LN | Serial # | Description | CH | Value | Maximum | Average | Minimum | Units | CH description | Logger file |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 18352041 | VSC_Prep_Room | 1 | | 22.02 | 21.88 | 21.77 | C | Temperature | 18352041_VSC_Prep_Room.spl |

# APPENDIX A
# PHOTOGRAPHS

## TABLE OF PHOTOGRAPHS

# PHOTOGRAPH NOT APPLICABLE

Photo No. 001 - Load Cell Location

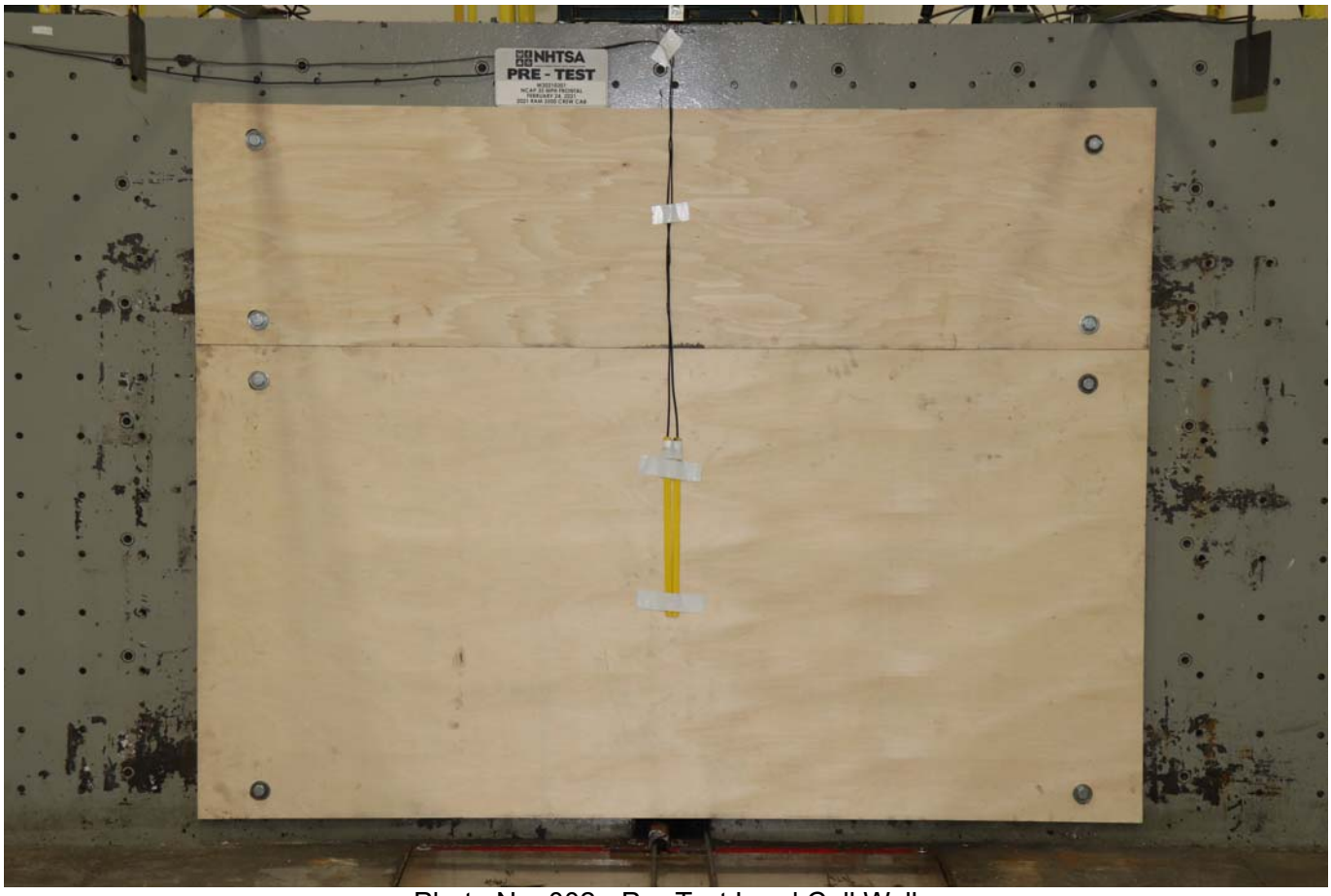



Photo No. 002 - Pre-Test Load Cell Wall


Photo No. 003 - Post-Test Load Cell Wall


Photo No. 004 - Manufacturer Label

Photo No. 005 - Tire Placard

Photo No. 006 - 2021 Ram 2500 Crew Cab 4x4 Truck Frontal As Delivered

Photo No. 007 - Left Rear 3-4 View, As Received

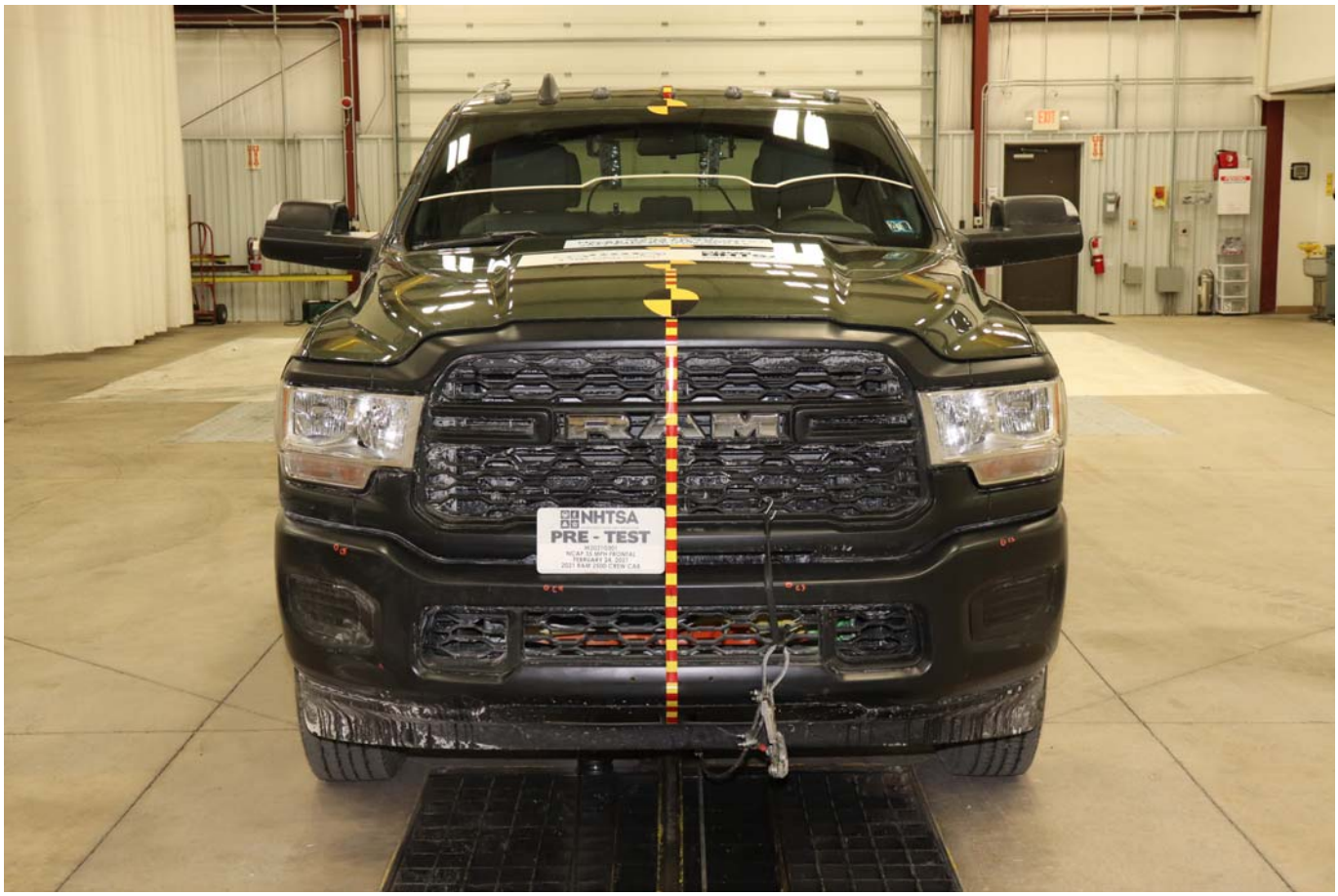


Photo No. 008 - Pre-Test Front View of Test Vehicle

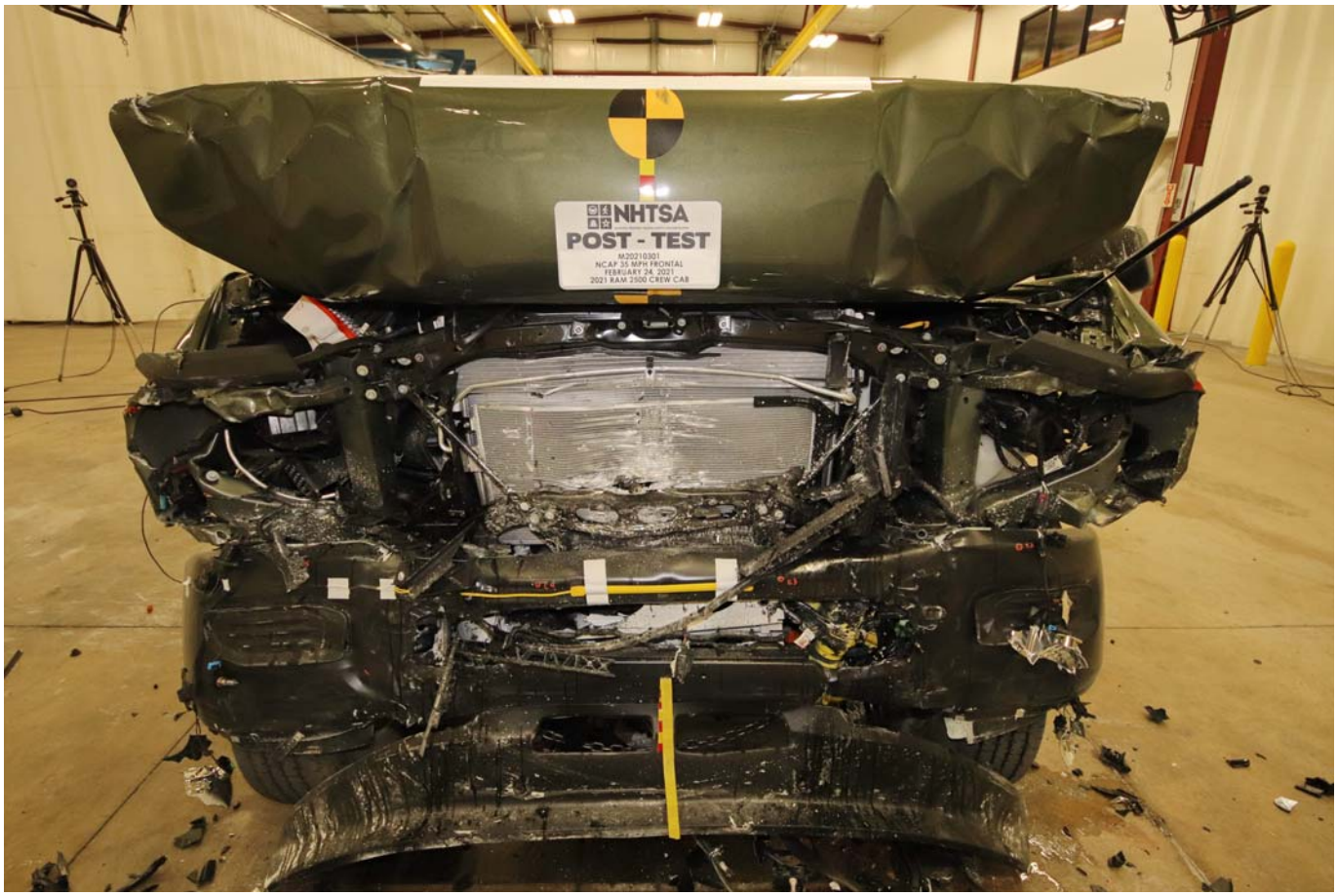


Photo No. 009 - Post-Test Front View of Test Vehicle

Photo No. 010 - Pre-Test Left View of Test Vehicle


Photo No. 011 - Post-Test Left View of Test Vehicle


Photo No. 012 - Pre-Test Right View of Test Vehicle


Photo No. 013 - Post-Test Right View of Test Vehicle


Photo No. 014 - Pre-Test Right Front 3-4 View

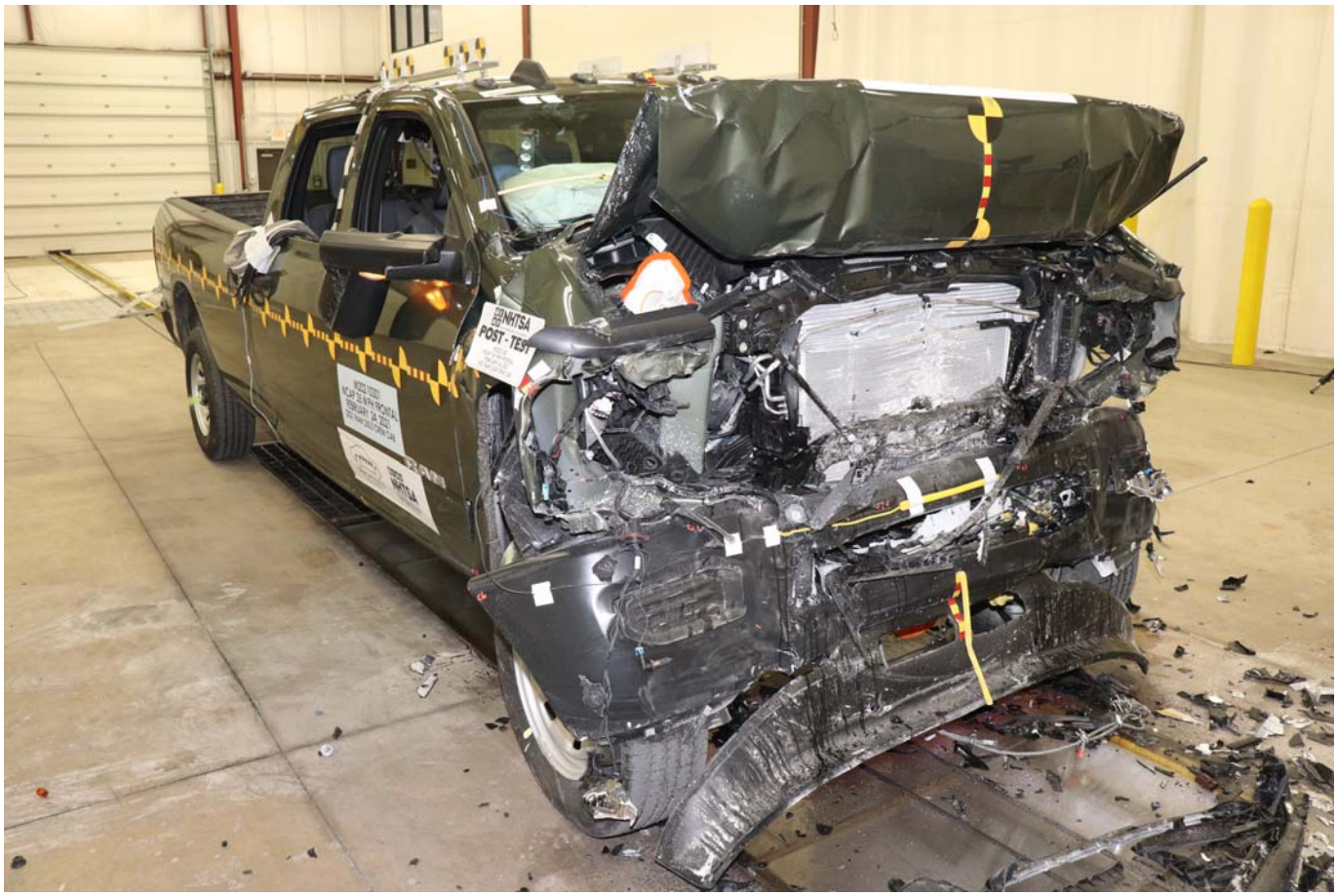



Photo No. 015 - Post-Test Right Front 3-4 View


Photo No. 016 - Pre-Test Left Rear 3-4 View


Photo No. 017 - Post-Test Left Rear 3-4 View


Photo No. 018 - Pre-Test Windshield View

Photo No. 019 - Post-Test Windshield View

Photo No. 020 - Pre-Test Engine Compartment View

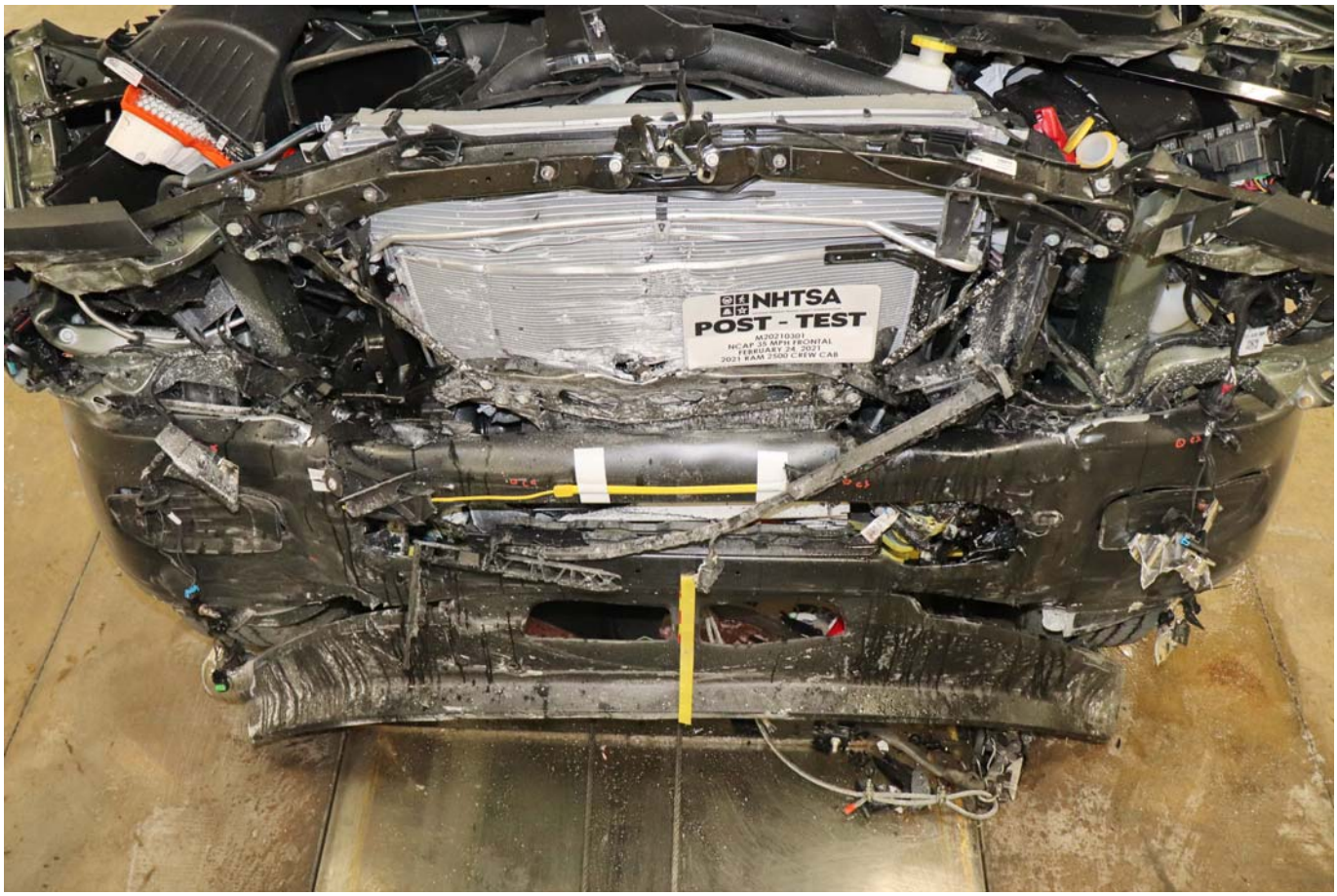


Photo No. 021 - Post-Test Engine Compartment View

Photo No. 022 - Pre-Test Fuel Filler Cap View

Photo No. 023 - Post-Test Fuel Filler Cap View

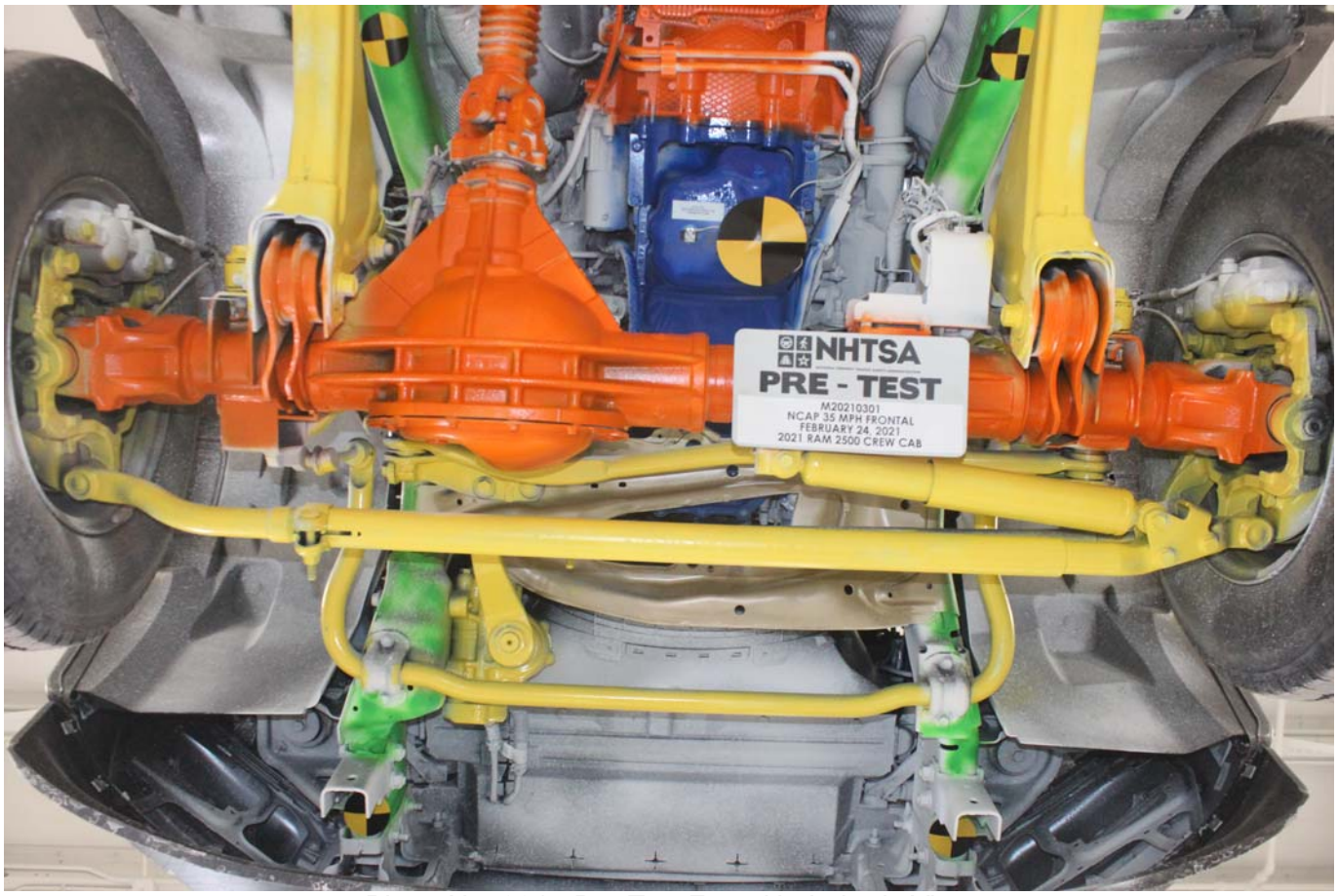


Photo No. 024 - Pre-Test Front Underbody View

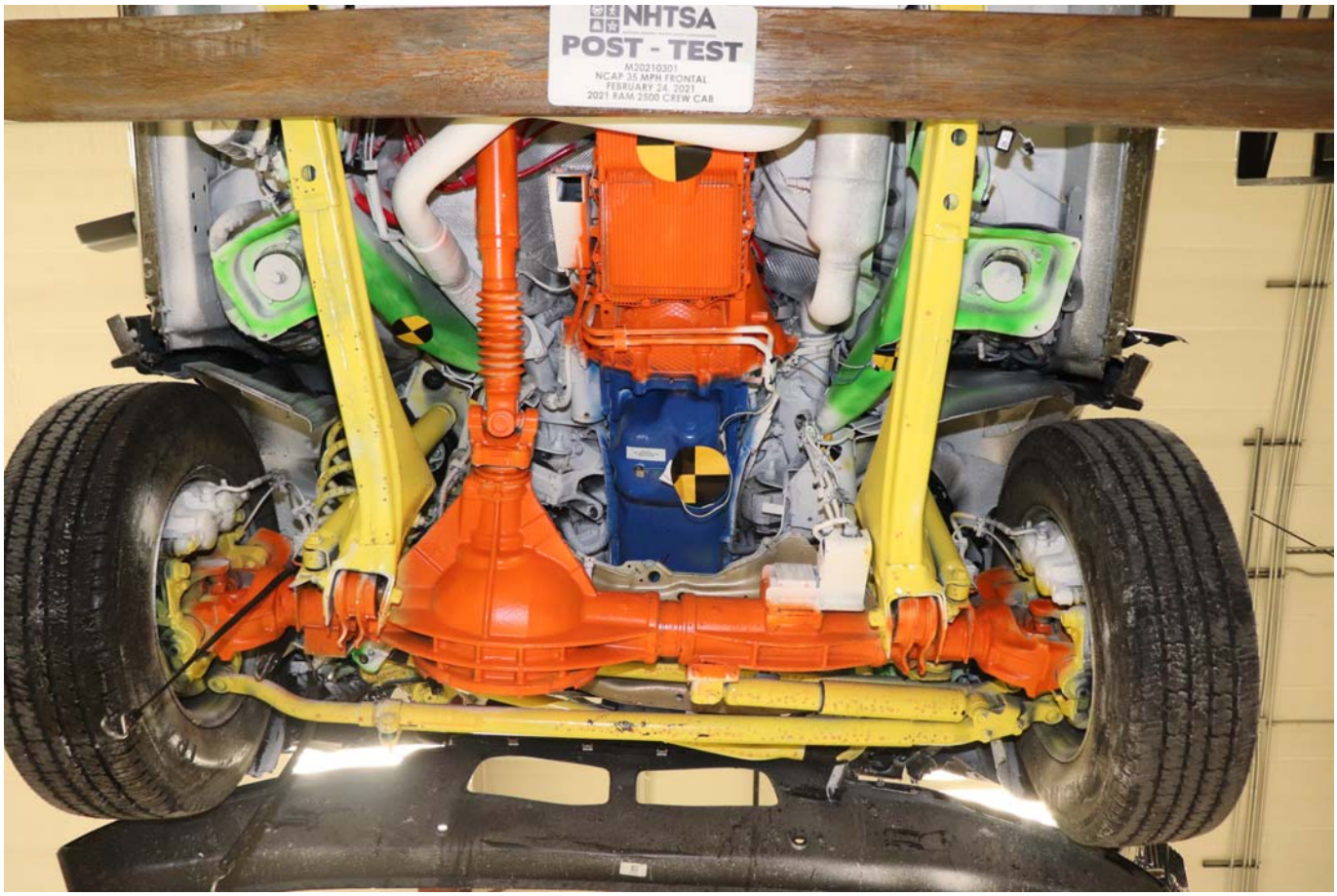


Photo No. 025 - Post-Test Front Underbody View

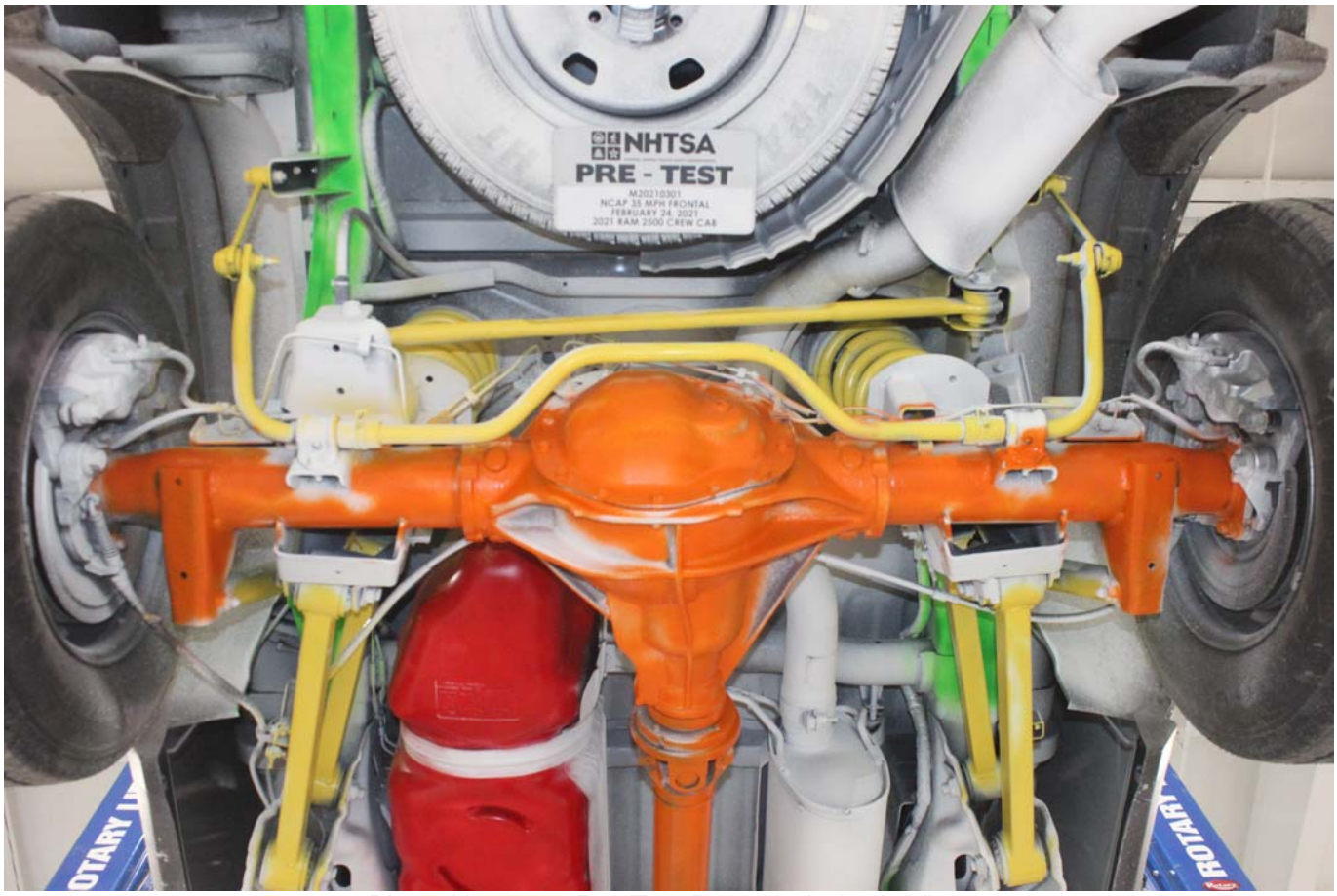


Photo No. 026 - Pre-Test Rear Underbody View

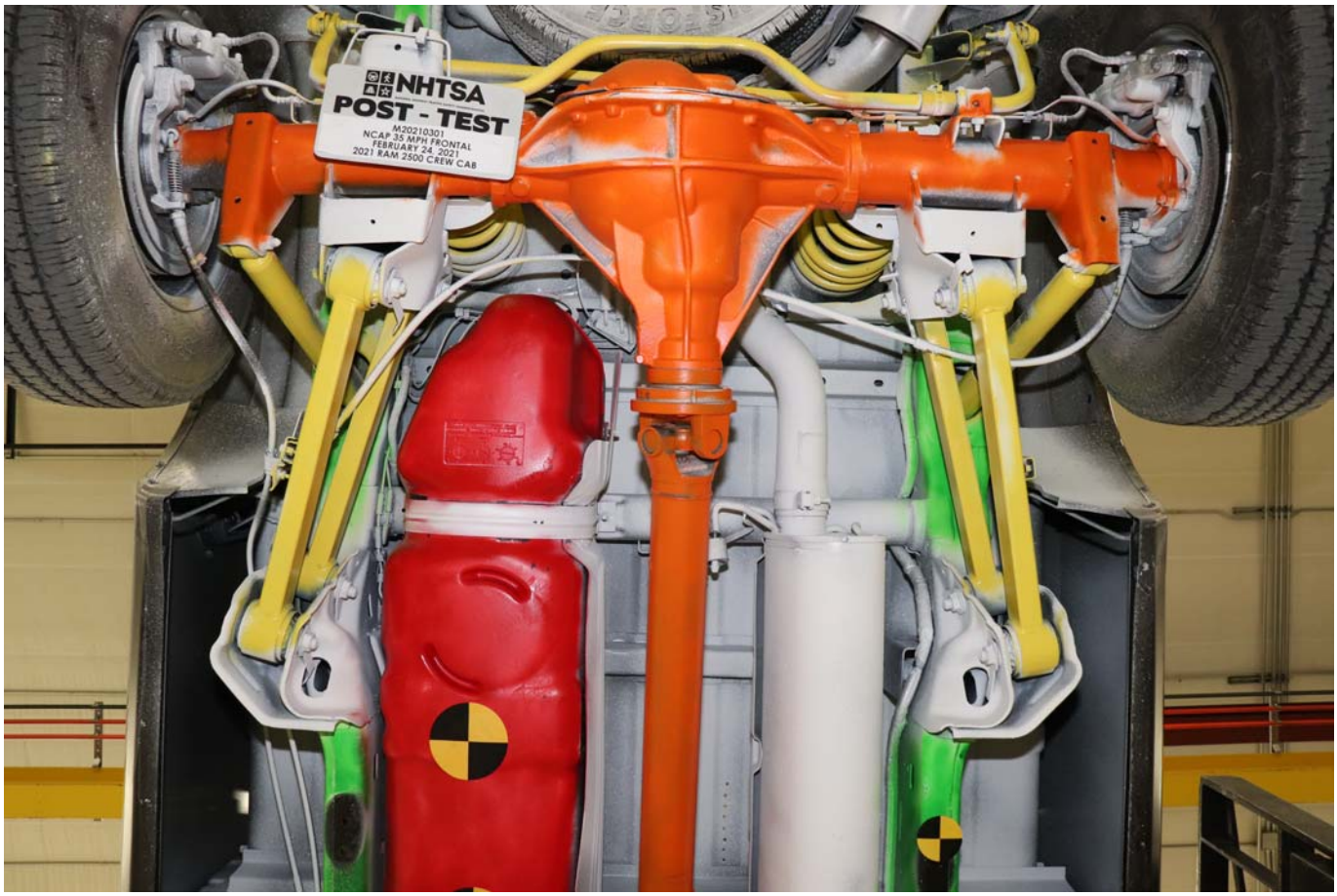


Photo No. 027 - Post-Test Rear Underbody View

Photo No. 028 - Pre-Test Dummy Cable Routing

Photo No. 029 - Post-Test Dummy Cable Routing

Photo No. 030 - Pre-Test Driver Dummy Front View

Photo No. 031 - Post-Test Driver Dummy Front View

Photo No. 032 - Pre-Test Driver Dummy Window View

Photo No. 033 - Post-Test Driver Dummy Window View

Photo No. 034 - Pre-Test Driver Dummy and Vehicle Interior


Photo No. 035 - Post-Test Driver Dummy and Vehicle Interior


Photo No. 036 - Pre-Test Driver Seat Fore-Aft Markings

Photo No. 037 - Post-Test Driver Seat Fore-Aft Markings

Photo No. 038 - Pre-Test View of Belt Anchorage for Driver Dummy

Photo No. 039 - Post-Test View of Belt Anchorage for Driver Dummy

Photo No. 040 - Pre-Test View of Belt Buckle and Latch Plate for Driver Dummy

Photo No. 041 - Post-Test View of Belt Buckle and Latch Plate for Driver Dummy

Photo No. 042 - Pre-Test Driver Dummy Feet

Photo No. 043 - Post-Test Driver Dummy Feet

Photo No. 044 - Pre-Test Driver Side Knee Bolster

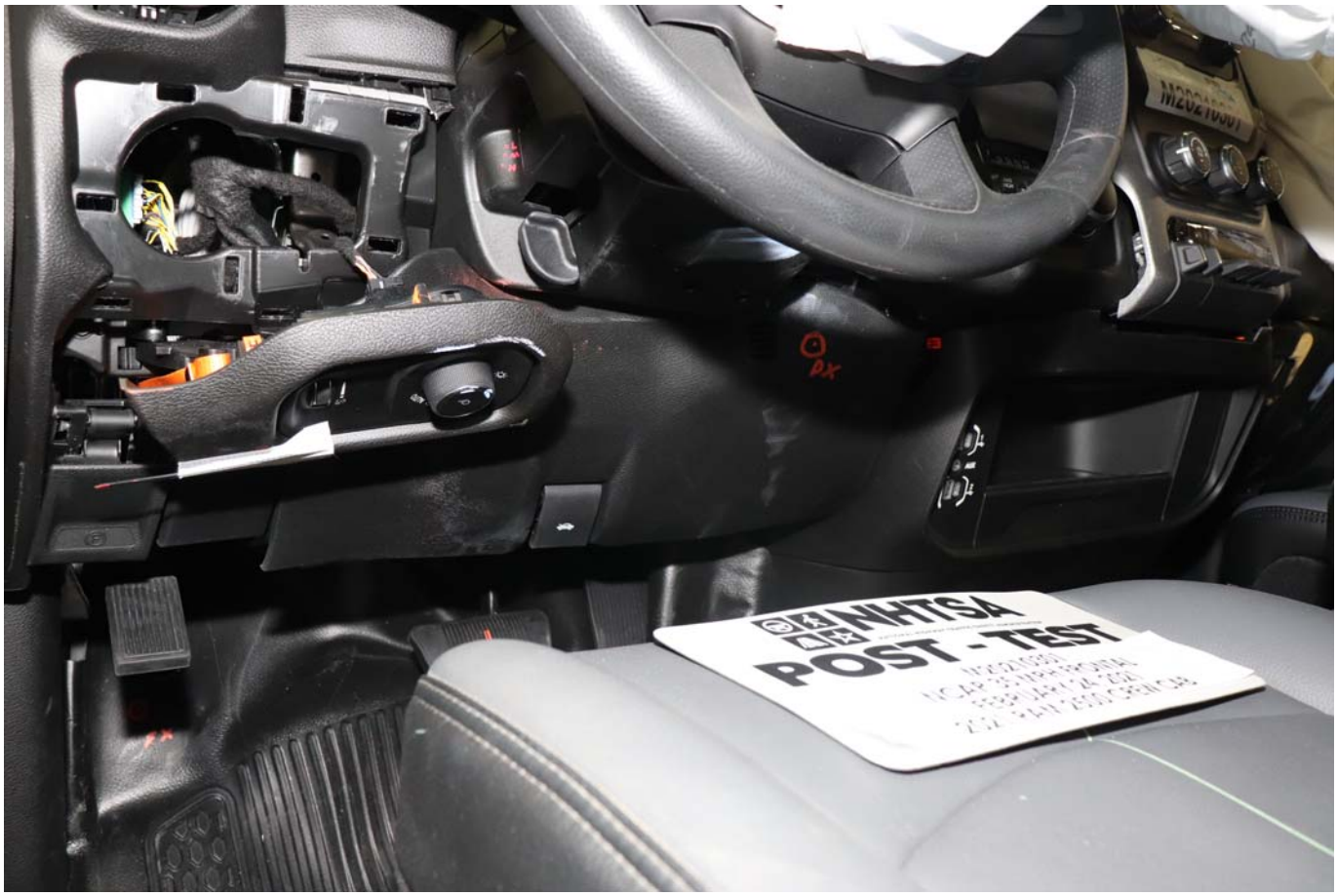


Photo No. 045 - Post-Test Driver Side Knee Bolster

Photo No. 046 - Pre-Test Driver Side Floorpan

Photo No. 047 - Post-Test Driver Side Floorpan

Photo No. 048 - Post-Test Driver Dummy Face

Photo No. 049 - Post-Test Driver Dummy Contact with Airbag

Photo No. 050 - Post-Test Driver Dummy Contact with Headrest

Photo No. 051 - Pre-Test View of the Steering Wheel

Photo No. 052 - Post-Test View of the Steering Wheel

Photo No. 053 - Pre-Test Passenger Dummy Front View

Photo No. 054 - Post-Test Passenger Dummy Front View

Photo No. 055 - Pre-Test Passenger Dummy Window View

Photo No. 056 - Post-Test Passenger Dummy Window View

Photo No. 057 - Pre-Test Passenger Dummy and Vehicle Interior

Photo No. 058 - Post-Test Passenger Dummy and Vehicle Interior

Photo No. 059 - Pre-Test Passenger Seat Fore-Aft Markings

Photo No. 060 - Post-Test Passenger Seat Fore-Aft Markings

Photo No. 061 - Pre-Test View of Belt Anchorage for Passenger Dummy

Photo No. 062 - Post-Test View of Belt Anchorage for Passenger Dummy

Photo No. 063 - Pre-Test View of Belt Buckle and Latch Plate for Passenger Dummy

Photo No. 064 - Post-Test View of Belt Buckle and Latch Plate for Passenger Dummy

Photo No. 065 - Pre-Test Passenger Dummy Feet

Photo No. 066 - Post-Test Passenger Dummy Feet

Photo No. 067 - Pre-Test Passenger Side Knee Bolster

Photo No. 068 - Post-Test Passenger Side Knee Bolster

Photo No. 069 - Pre-Test Passenger Side Floorpan

Photo No. 070 - Post-Test Passenger Side Floorpan

Photo No. 071 - Post-Test Passenger Dummy Face

Photo No. 072 - Post-Test Passenger Dummy Contact with Airbag

Photo No. 073 - Post-Test Passenger Dummy Contact with Headrest

Photo No. 074 - Ballast Installed in Vehicle

PHOTOGRAPH NOT APPLICABLE

Photo No. 075 - Post-Test Stoddard Solvent Spillage Location View


Photo No. 076 - Post-Test Speed Trap Read-Out

Photo No. 077 - Vehicle at 0 Degrees on Static Rollover Device

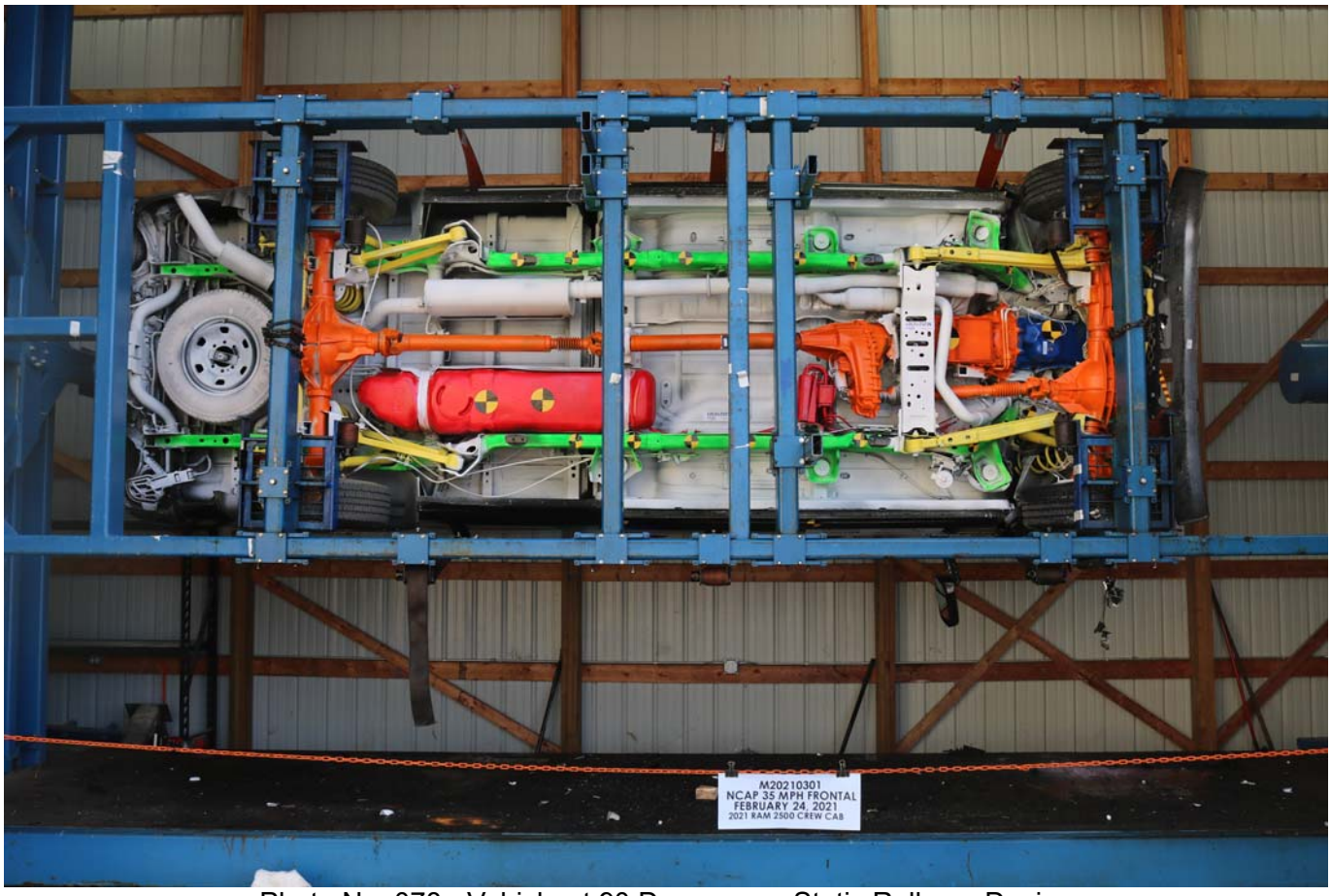


Photo No. 078 - Vehicle at 90 Degrees on Static Rollover Device


Photo No. 079 - Vehicle at 180 Degrees on Static Rollover Device

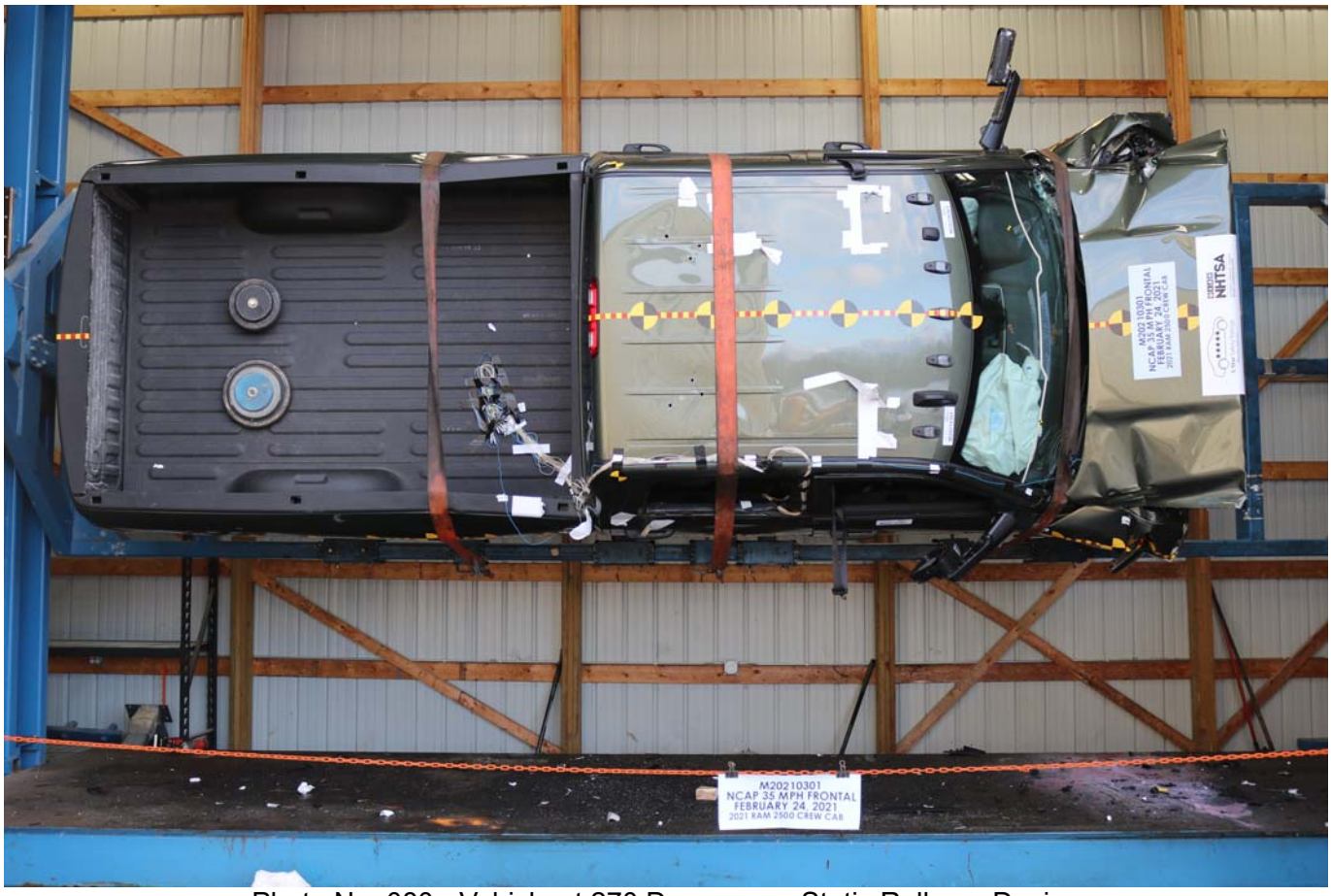



Photo No. 080 - Vehicle at 270 Degrees on Static Rollover Device


Photo No. 081 - Vehicle at 360 Degrees on Static Rollover Device


Photo No. 082 - 2021 Ram 2500 Crew Cab 4x4 Truck Frontal Impact Event

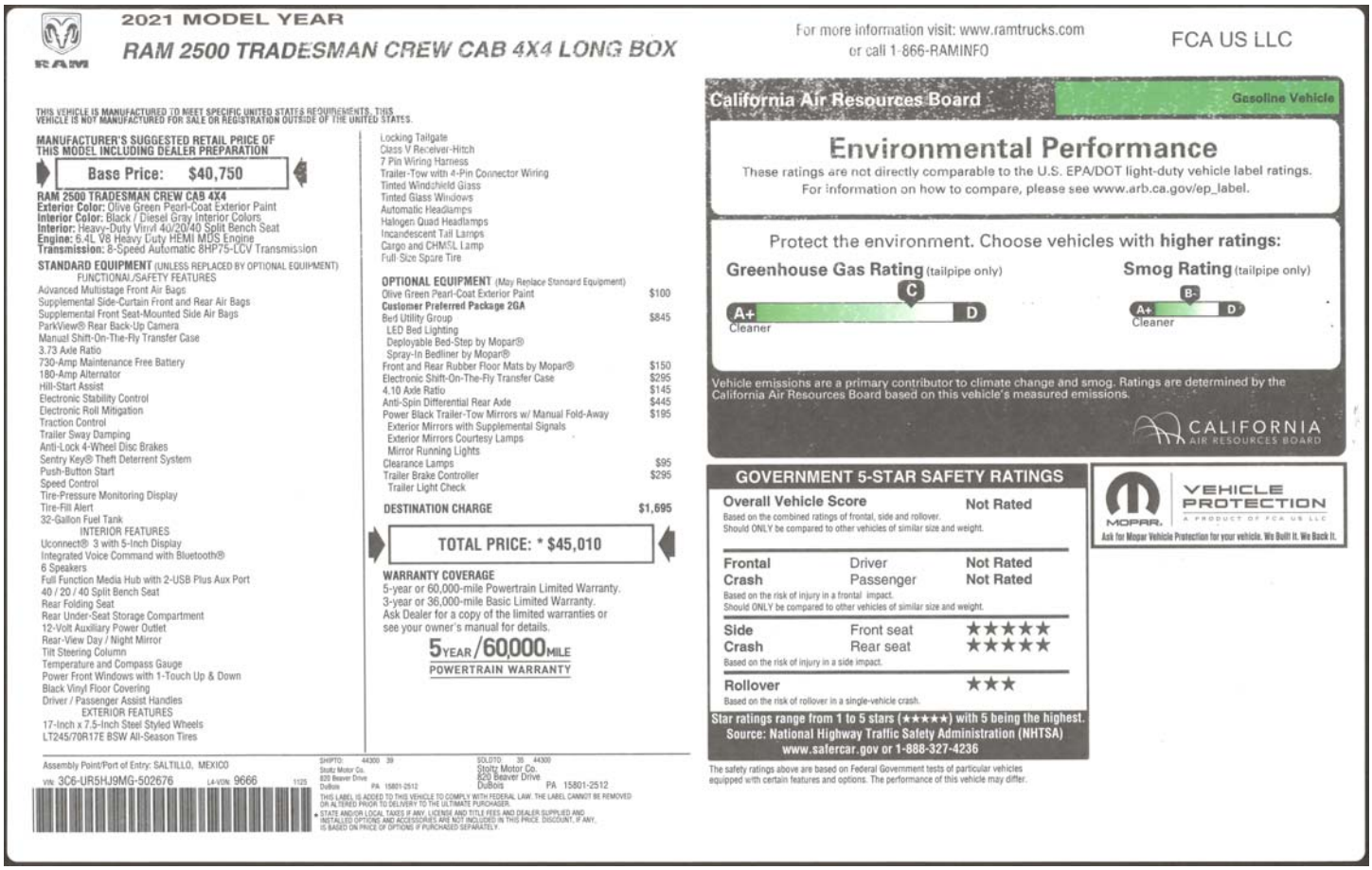



Photo No. 083 - Monroney Label Photograph

# APPENDIX B
# DUMMY RESPONSE DATA TRACES

## TABLE OF DATA PLOTS

**The following additional dummy and vehicle response data can be found in the R&D section of the NHTSA website at www.nhtsa.gov**

Driver Head X Redundant

Driver Head Y Redundant

Driver Head Z Redundant

Driver Head Angular Velocity X

Driver Head Angular Velocity Y

Driver Head Angular Velocity Z

Driver Upper Neck Force Y

Driver Upper Neck Moment X

Driver Upper Neck Moment Z

Driver Chest X Redundant

Driver Chest Y Redundant

Driver Chest Z Redundant

Driver Pelvis X

Driver Pelvis Y

Driver Pelvis Z

Driver Left Femur Redundant

Driver Right Femur Redundant

Driver Left Upper Tibia Moment X

Driver Left Upper Tibia Moment Y

Driver Left Upper Tibia Force Z

Driver Left Lower Tibia Moment X

Driver Left Lower Tibia Moment Y

Driver Left Lower Tibia Force Z

Driver Right Upper Tibia Moment X

Driver Right Upper Tibia Moment Y

Driver Right Upper Tibia Force Z

Driver Right Lower Tibia Moment X

Driver Right Lower Tibia Moment Y

Driver Right Lower Tibia Force Z

Driver Left Foot Fore Z

Driver Left Foot Aft X

Driver Left Foot Aft Z

Driver Right Foot Fore Z

Driver Right Foot Aft X

Driver Right Foot Aft Z

Driver Lap Belt Force

Driver Shoulder Belt Force

Passenger Head X Redundant

Passenger Head Y Redundant

Passenger Head Z Redundant

Passenger Head Angular Velocity X

Passenger Head Angular Velocity Y

Passenger Head Angular Velocity Z

Passenger Upper Neck Force Y

Passenger Upper Neck Moment X

Passenger Upper Neck Moment Z

Passenger Chest X Redundant

Passenger Chest Y Redundant

Passenger Chest Z Redundant

Passenger Pelvis X

Passenger Pelvis Y

Passenger Pelvis Z

Passenger Left Femur Redundant

Passenger Right Femur Redundant

Passenger Left Upper Tibia Moment X

Passenger Left Upper Tibia Moment Y

Passenger Left Upper Tibia Force Z

Passenger Left Lower Tibia Moment X

Passenger Left Lower Tibia Moment Y

Passenger Left Lower Tibia Force Z

Passenger Right Upper Tibia Moment X

Passenger Right Upper Tibia Moment Y

Passenger Right Upper Tibia Force Z

Passenger Right Lower Tibia Moment X

Passenger Right Lower Tibia Moment Y

Passenger Right Lower Tibia Force Z

Passenger Left Foot Fore Z

Passenger Left Foot Aft X

Passenger Left Foot Aft Z

Passenger Right Foot Fore Z

Passenger Right Foot Aft X

Passenger Right Foot Aft Z

Passenger Lap Belt Force

Passenger Shoulder Belt Force

Left Rear Seat Crossmember X

Right Rear Seat Crossmember X

Vehicle Engine Top X

Vehicle Engine Bottom X

Left Rear Seat Crossmember Z

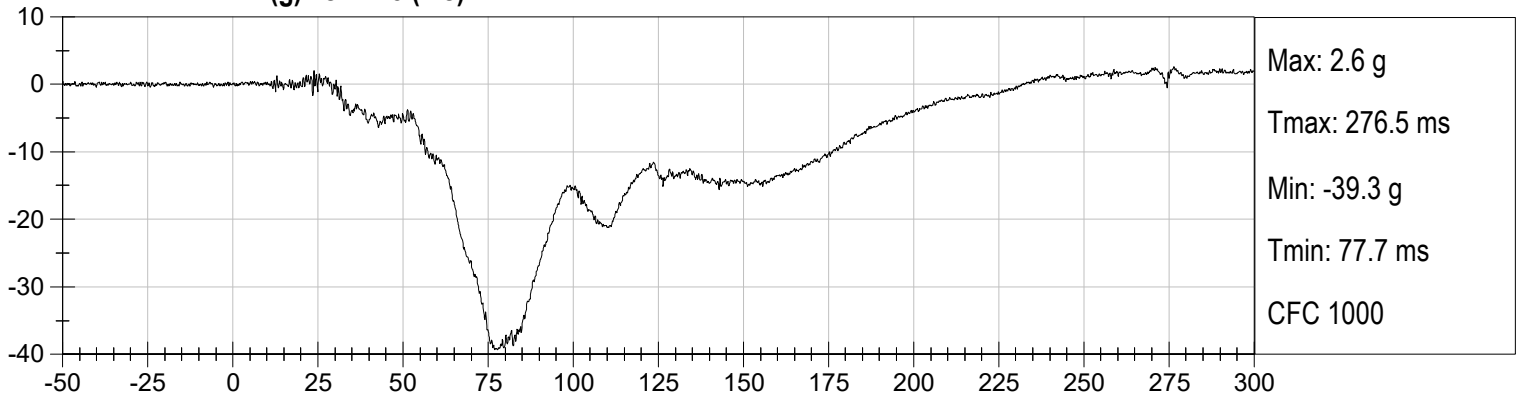
Right Rear Seat Crossmember Z

Left Rear Seat Crossmember Xr

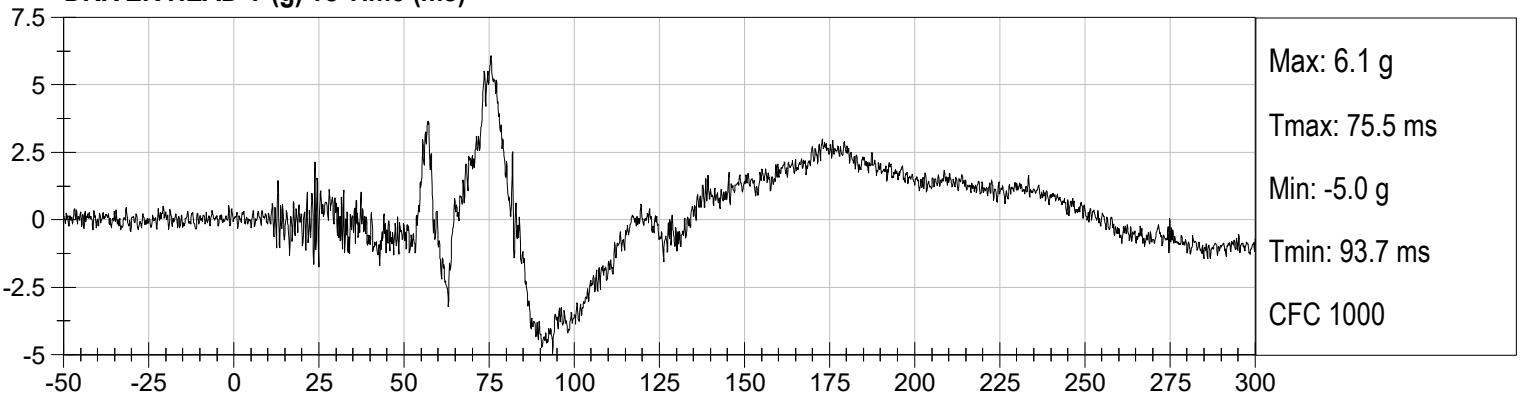
Right Rear Seat Crossmember Xr

Advanced Research Load Cell Barrier – 528 channels

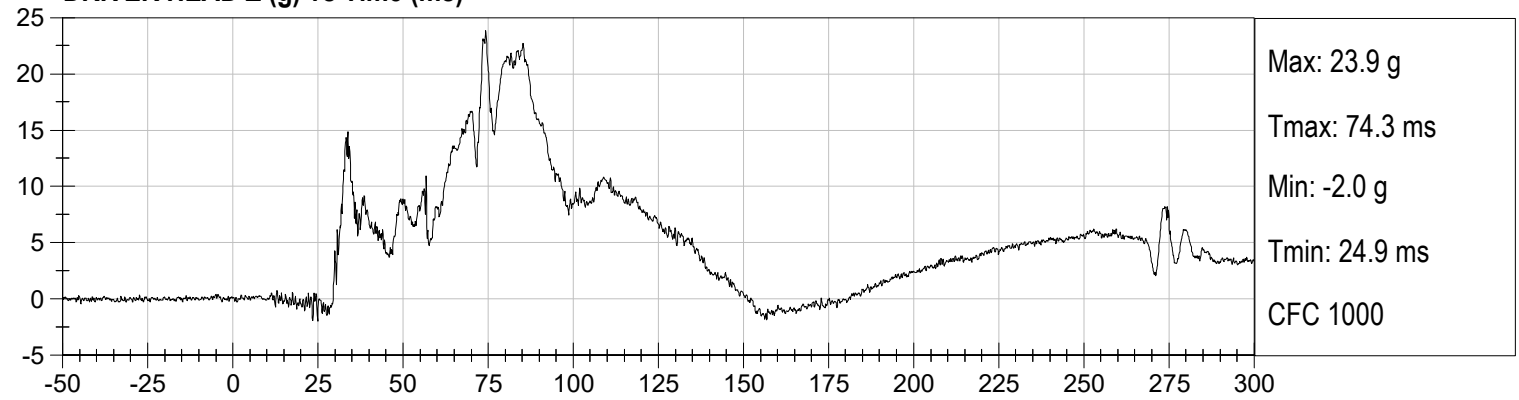
**DRIVER HEAD X (g) vs Time (ms)**



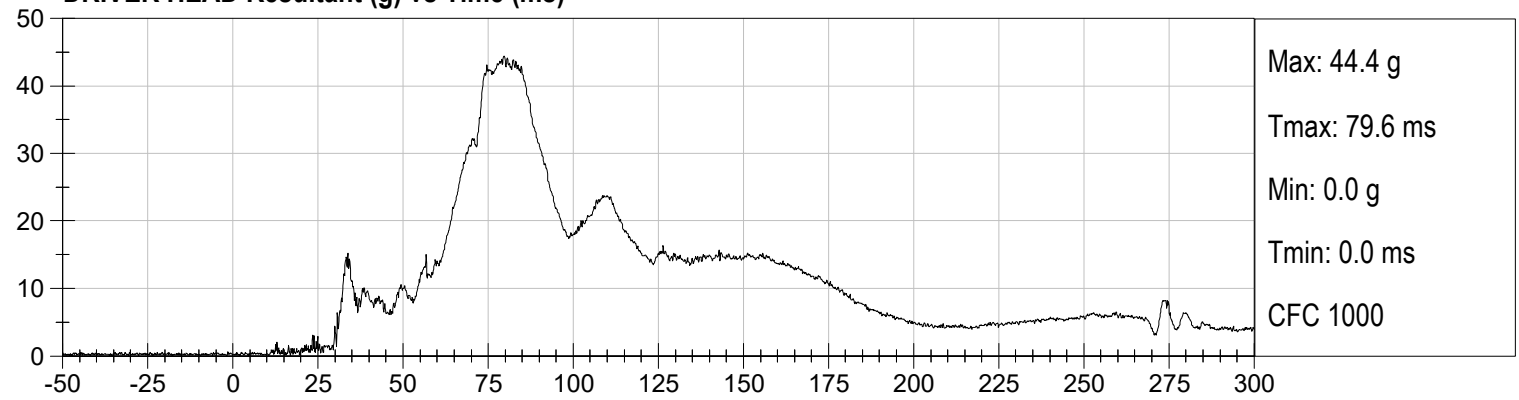

**DRIVER HEAD Y (g) vs Time (ms)**



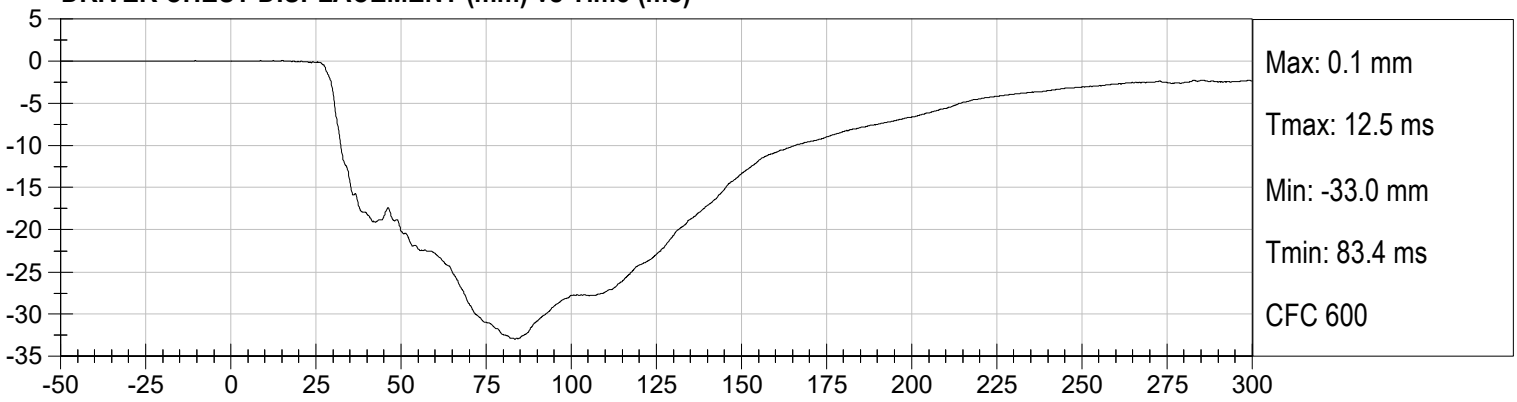

**DRIVER HEAD Z (g) vs Time (ms)**



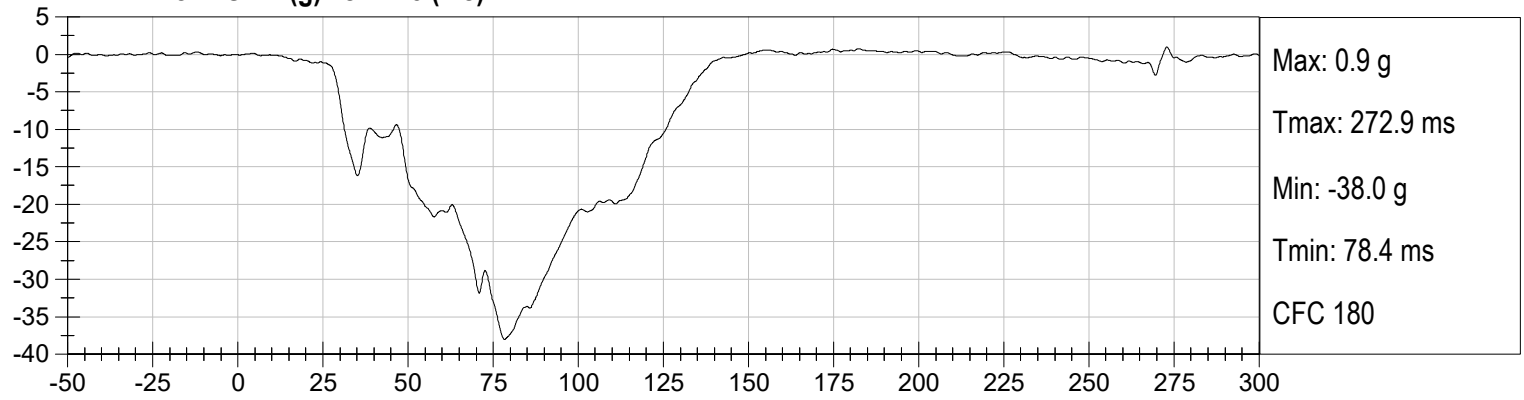

**DRIVER HEAD Resultant (g) vs Time (ms)**



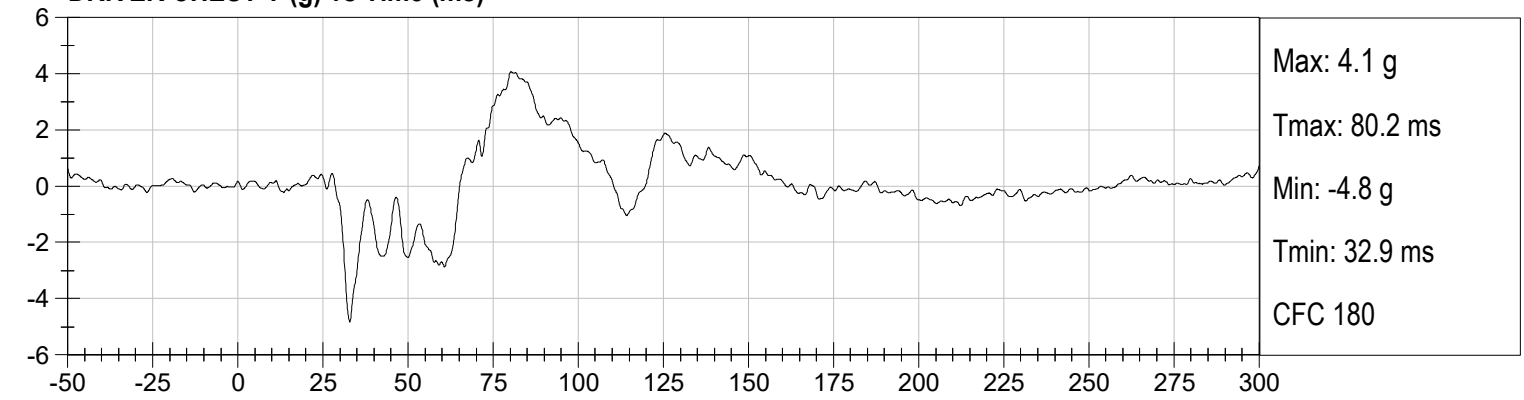
**DRIVER CHEST DISPLACEMENT (mm) vs Time (ms)**



## DRIVER CHEST X (g) vs Time (ms)

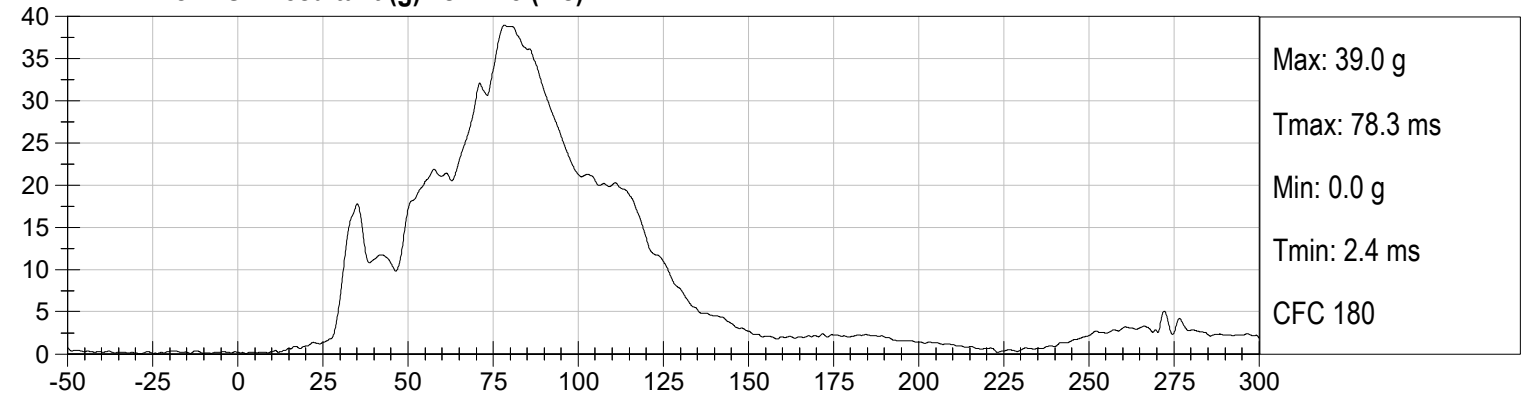



## DRIVER CHEST Y (g) vs Time (ms)

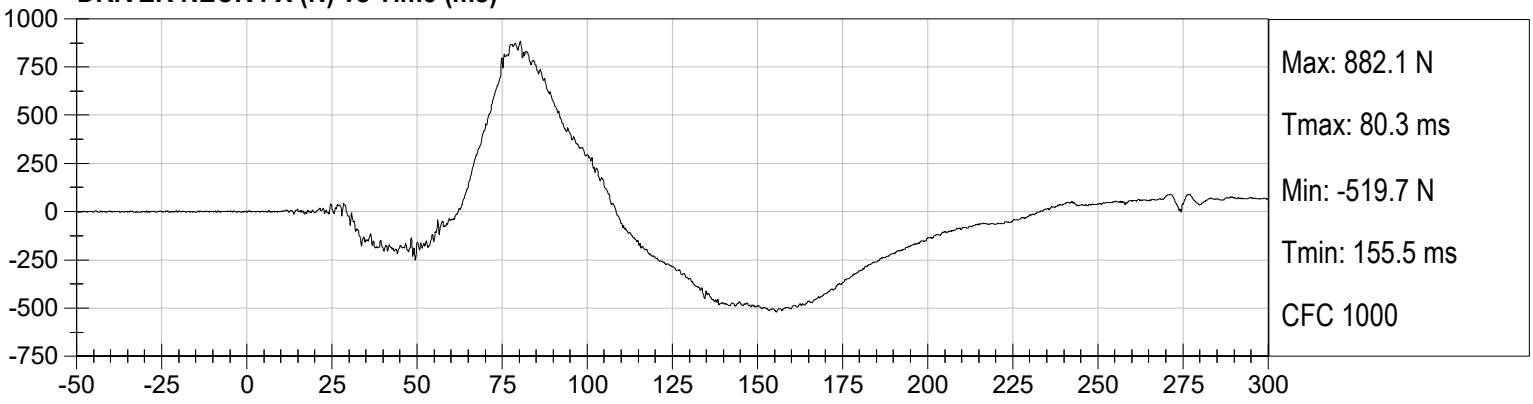



## DRIVER CHEST Z (g) vs Time (ms)

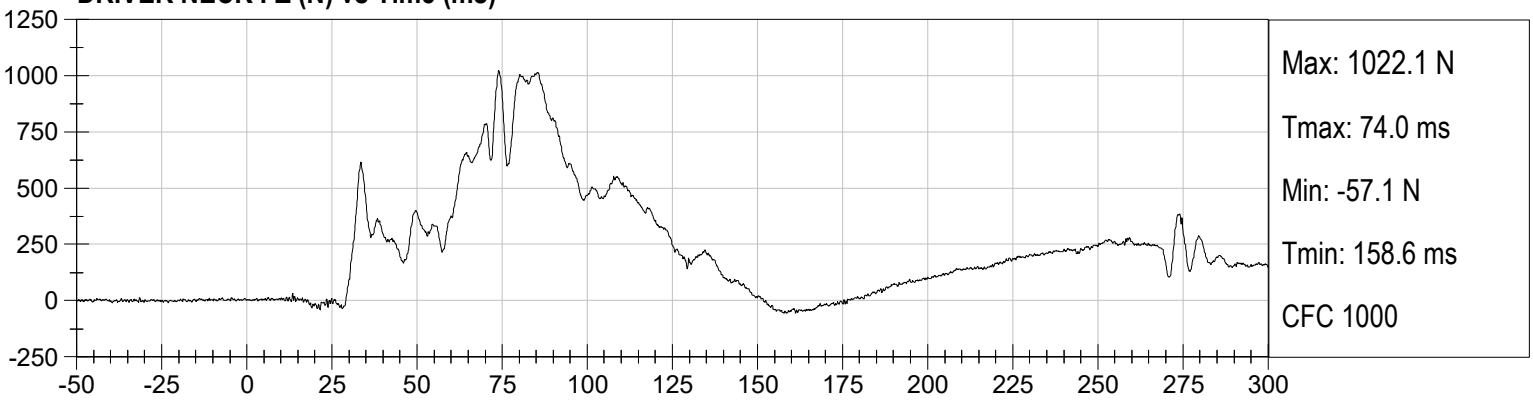

## DRIVER CHEST Resultant (g) vs Time (ms)



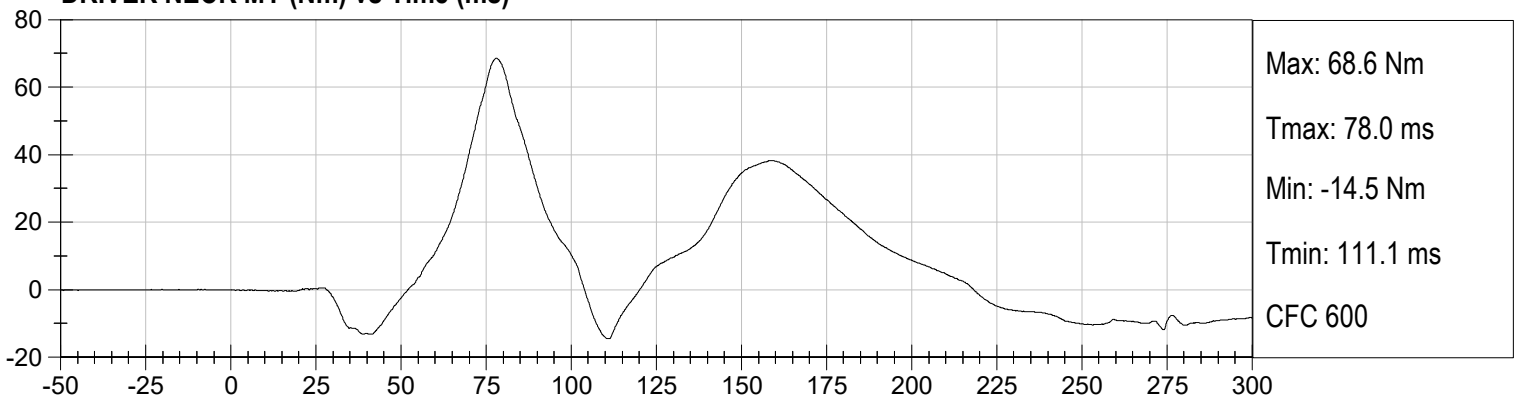
**DRIVER NECK FX (N) vs Time (ms)**



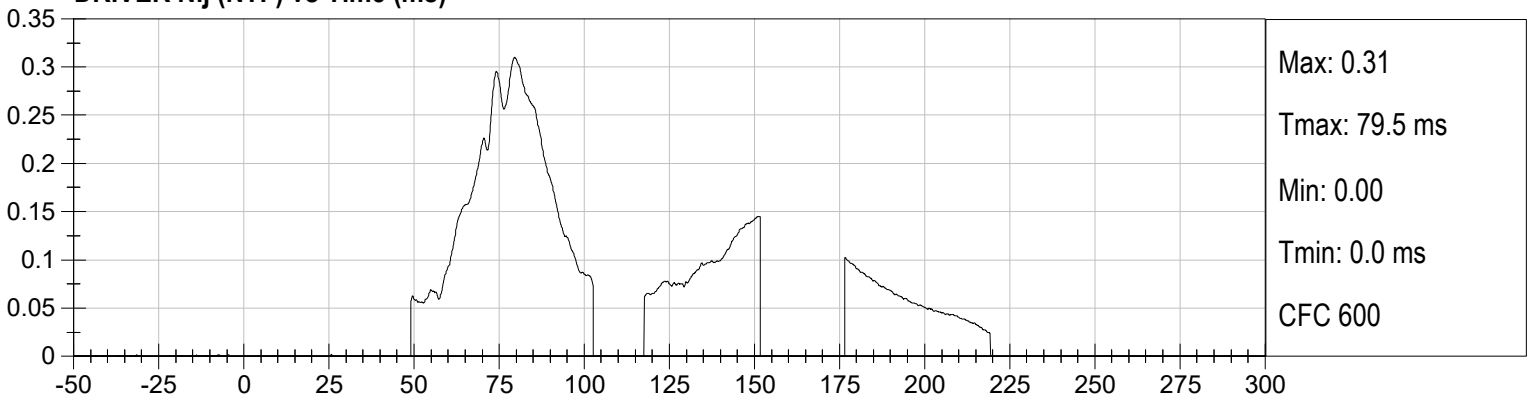

**DRIVER NECK FZ (N) vs Time (ms)**



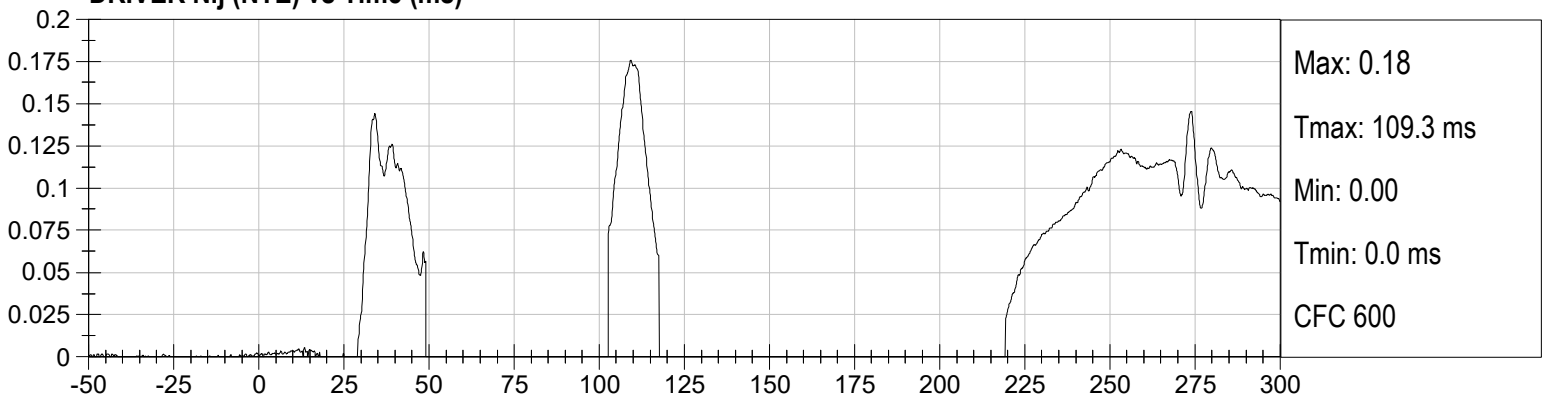

**DRIVER NECK MY (Nm) vs Time (ms)**



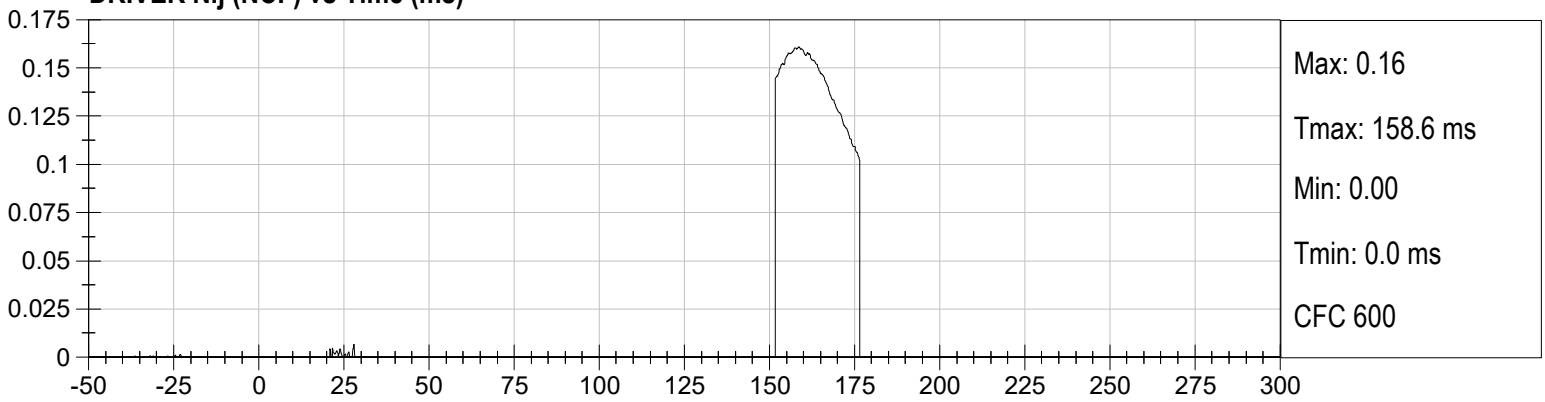
## DRIVER Nij (NTF) vs Time (ms)



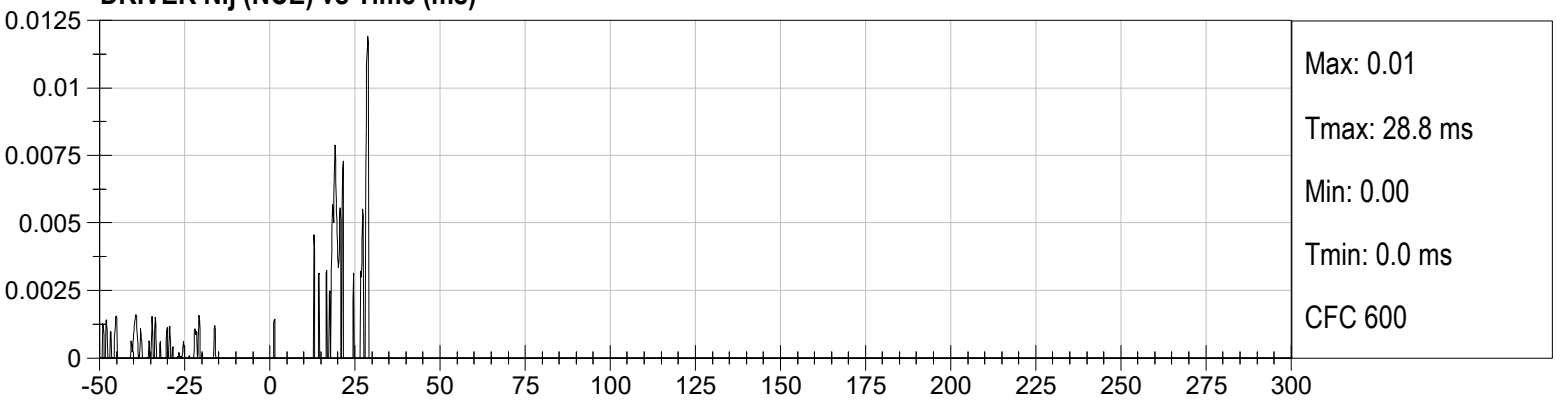

## DRIVER Nij (NTE) vs Time (ms)



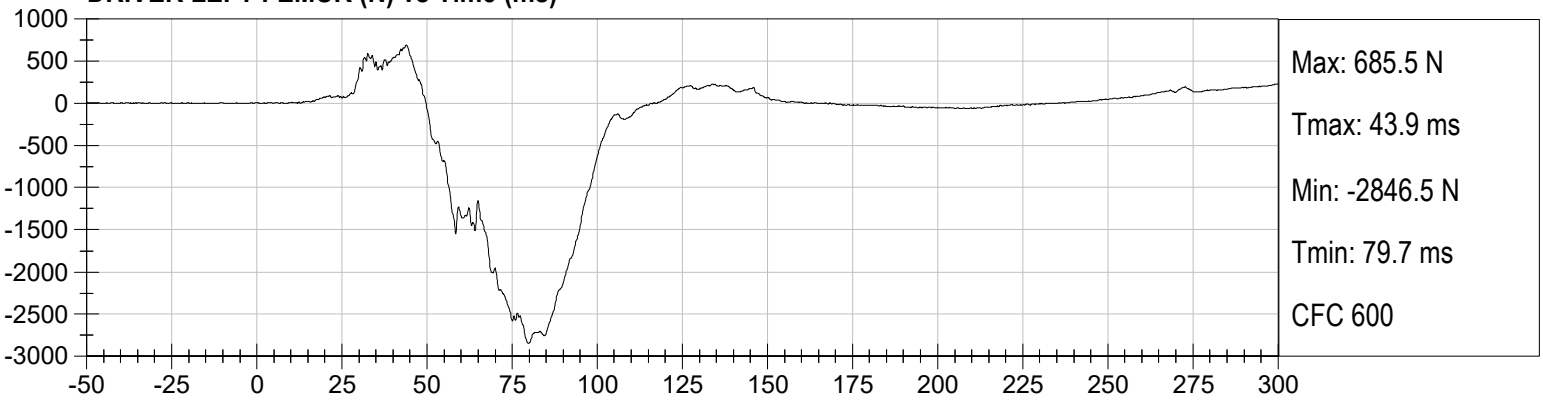

## DRIVER Nij (NCF) vs Time (ms)



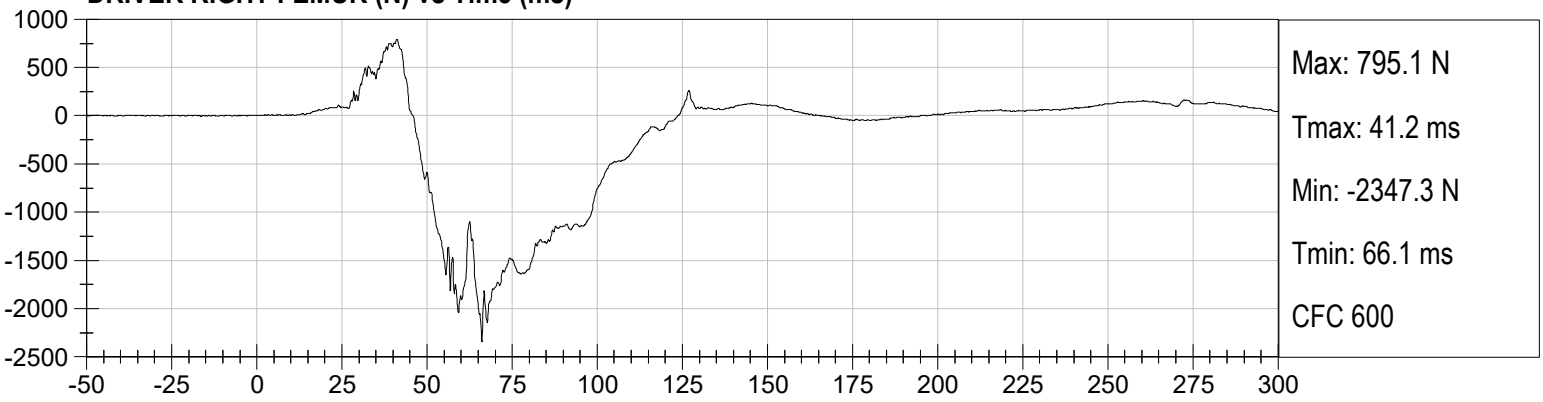

## DRIVER Nij (NCE) vs Time (ms)



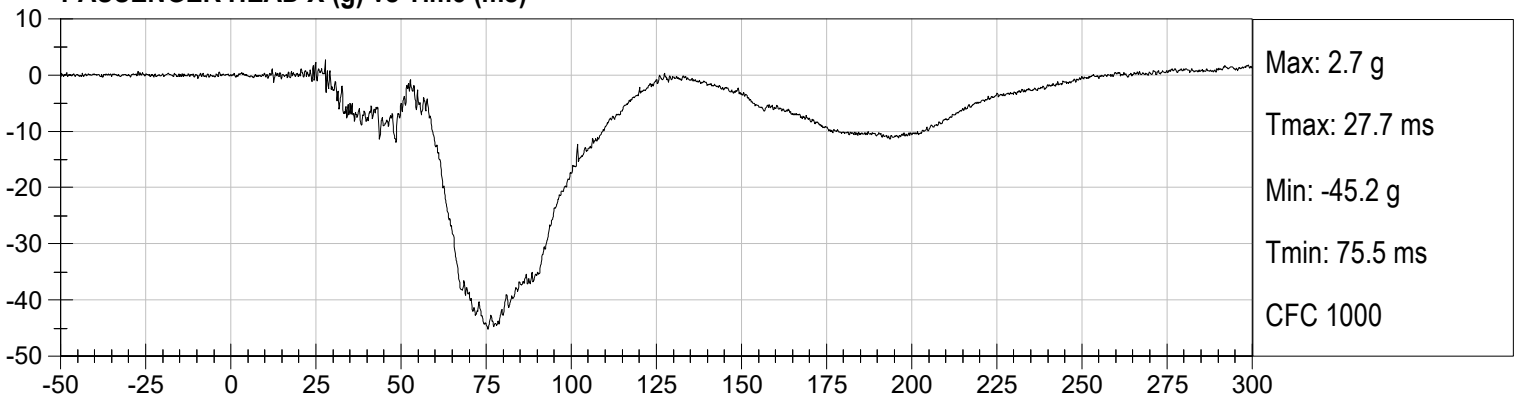
**DRIVER LEFT FEMUR (N) vs Time (ms)**



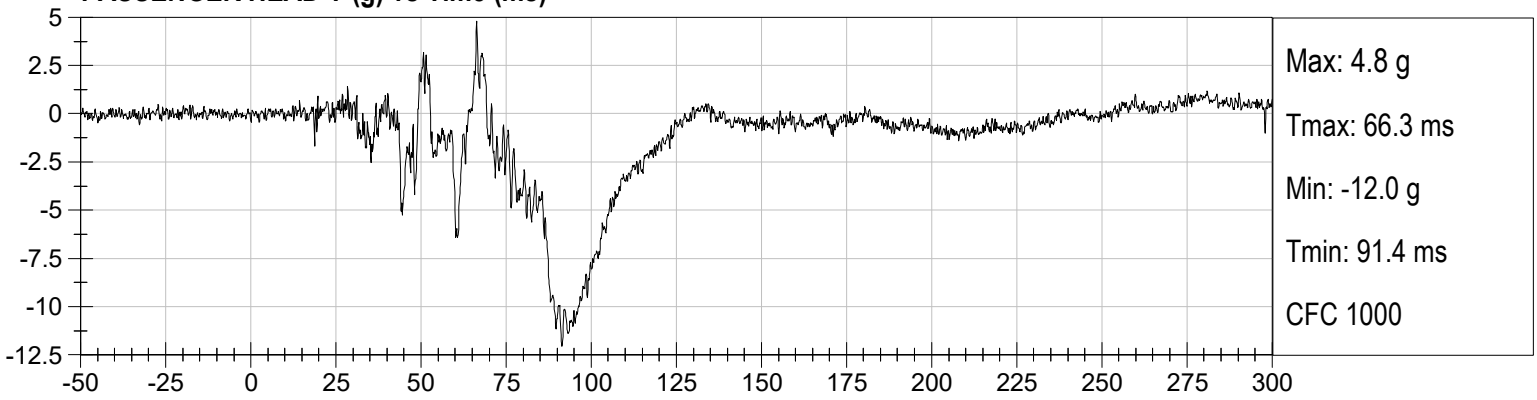

**DRIVER RIGHT FEMUR (N) vs Time (ms)**



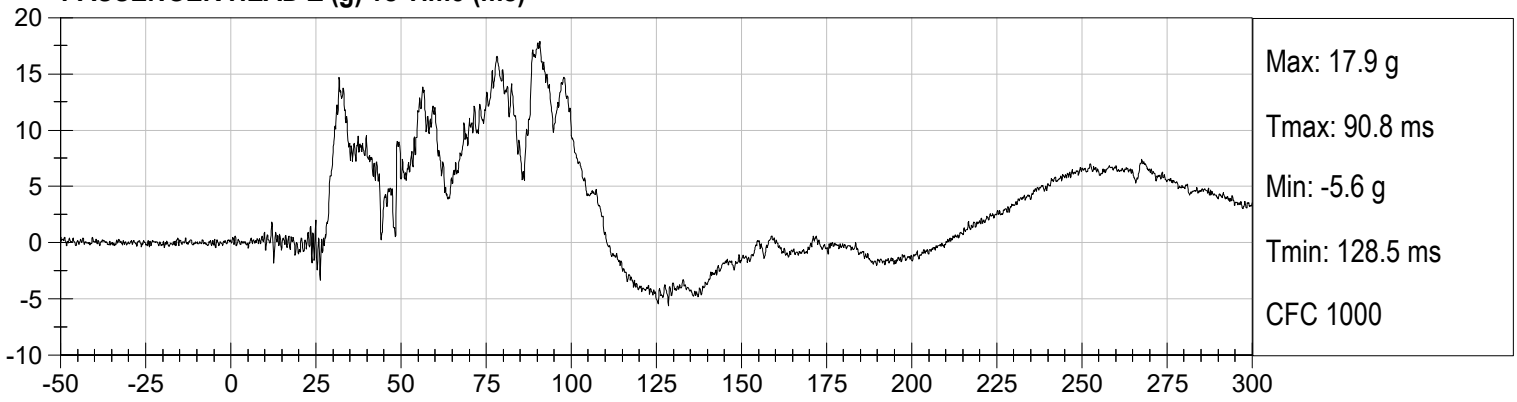
## PASSENGER HEAD X (g) vs Time (ms)



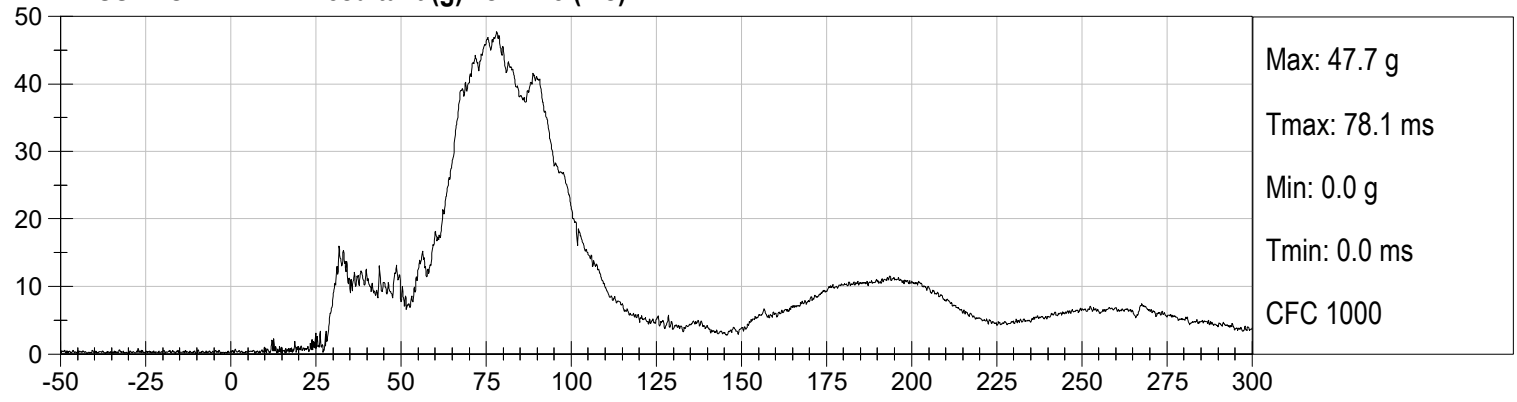

## PASSENGER HEAD Y (g) vs Time (ms)



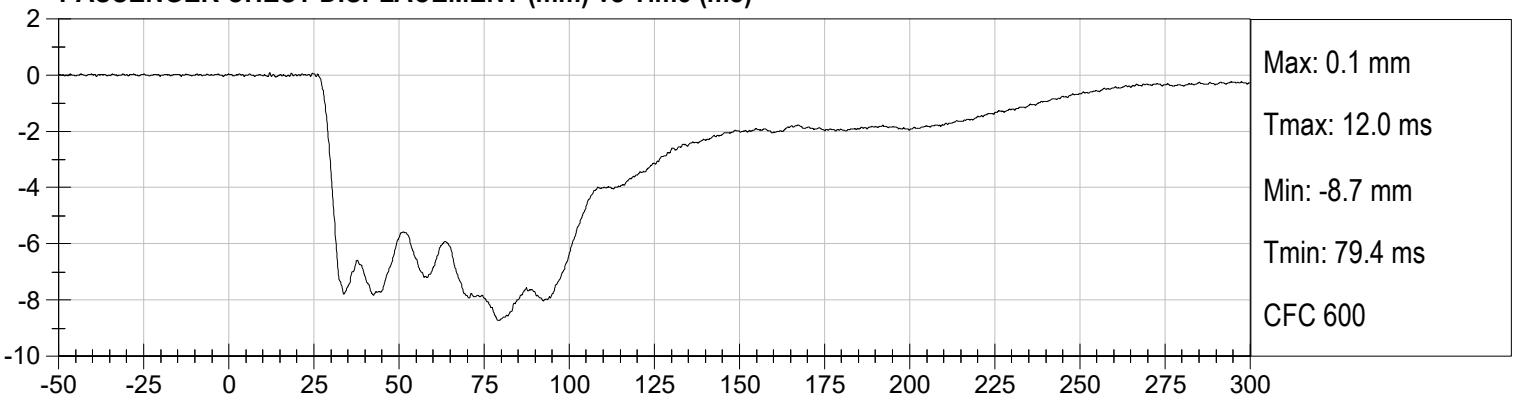

## PASSENGER HEAD Z (g) vs Time (ms)



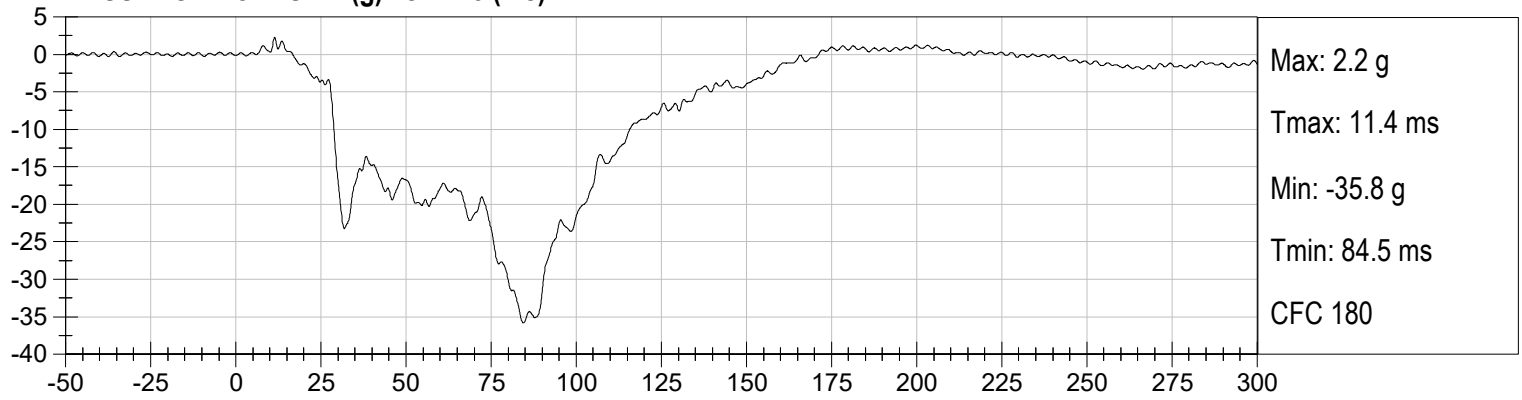

## PASSENGER HEAD Resultant (g) vs Time (ms)



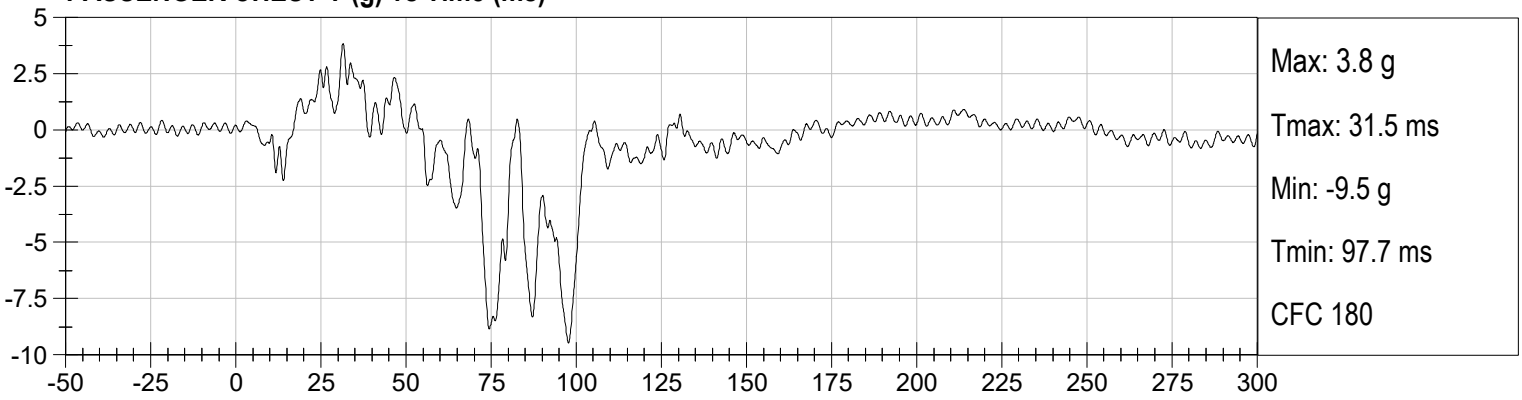
**PASSENGER CHEST DISPLACEMENT (mm) vs Time (ms)**



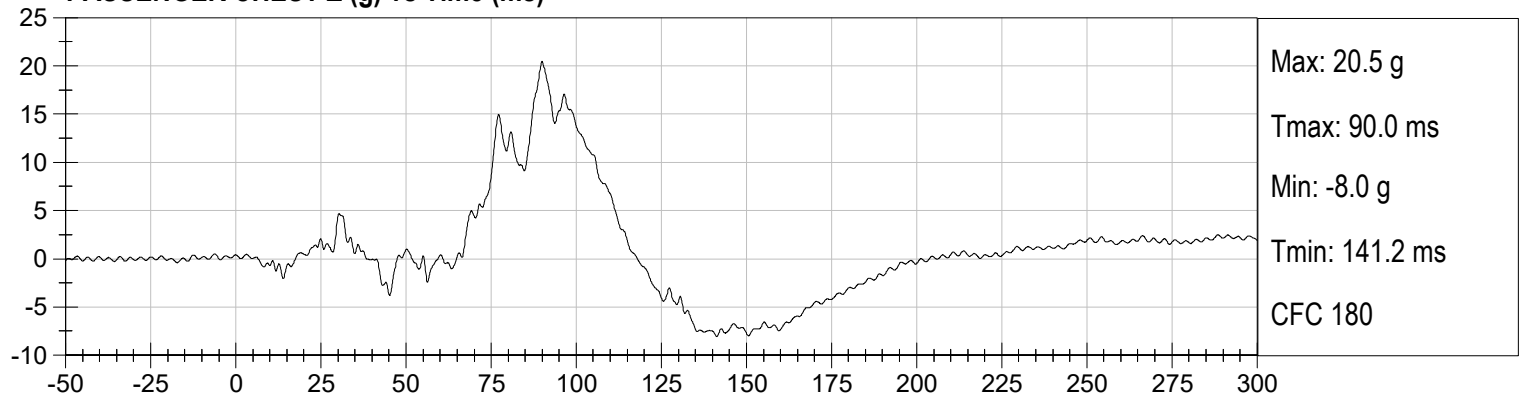
## PASSENGER CHEST X (g) vs Time (ms)



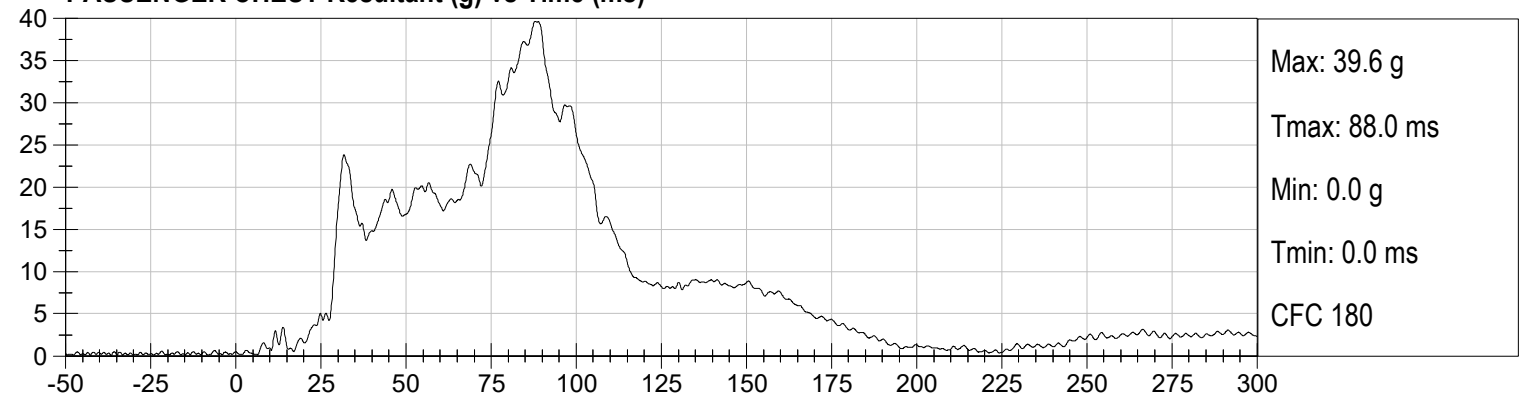

## PASSENGER CHEST Y (g) vs Time (ms)



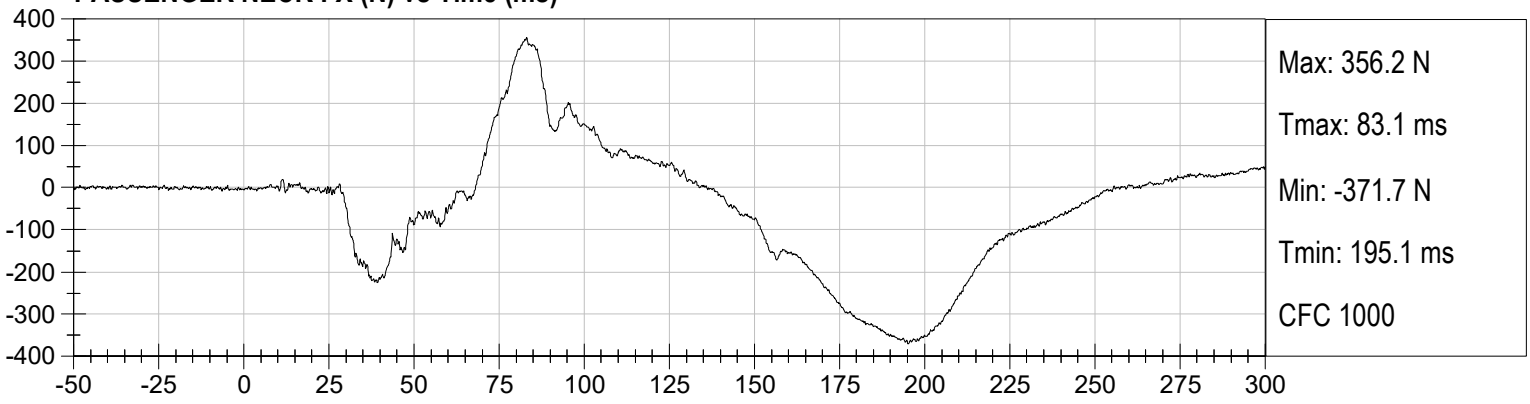

## PASSENGER CHEST Z (g) vs Time (ms)



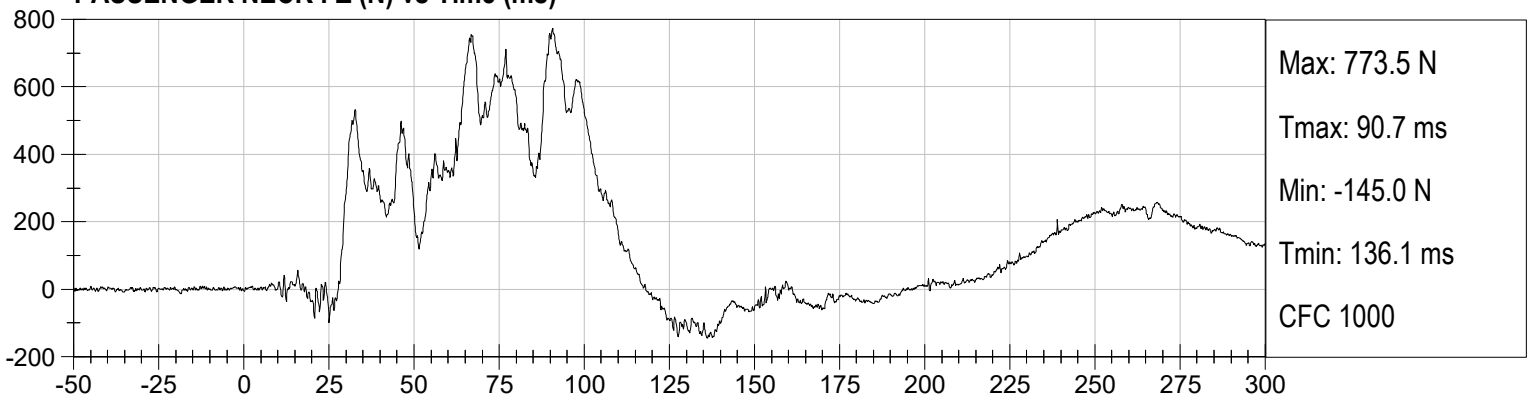

## PASSENGER CHEST Resultant (g) vs Time (ms)



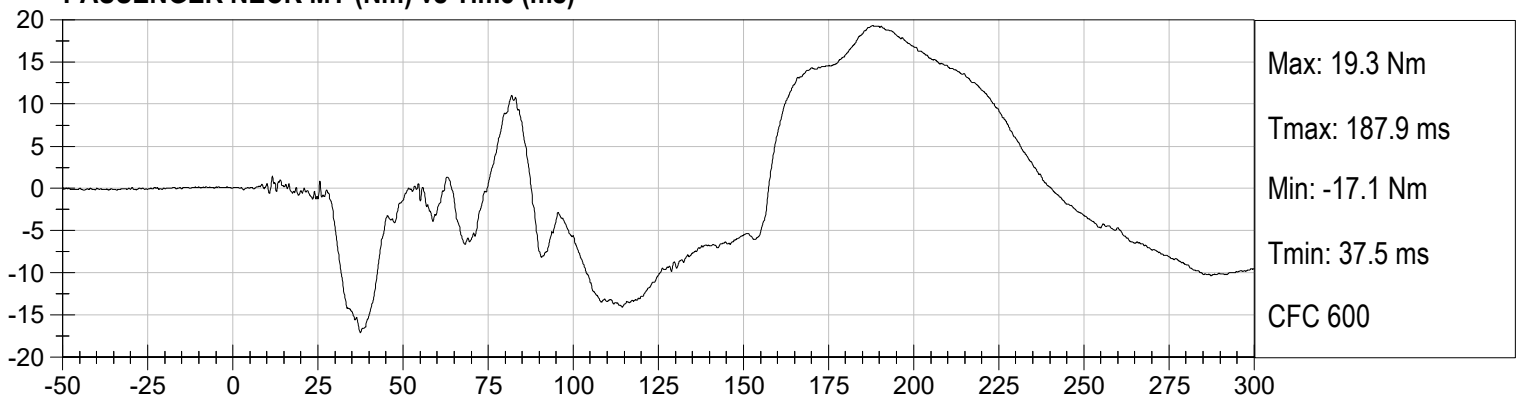
**PASSENGER NECK FX (N) vs Time (ms)**



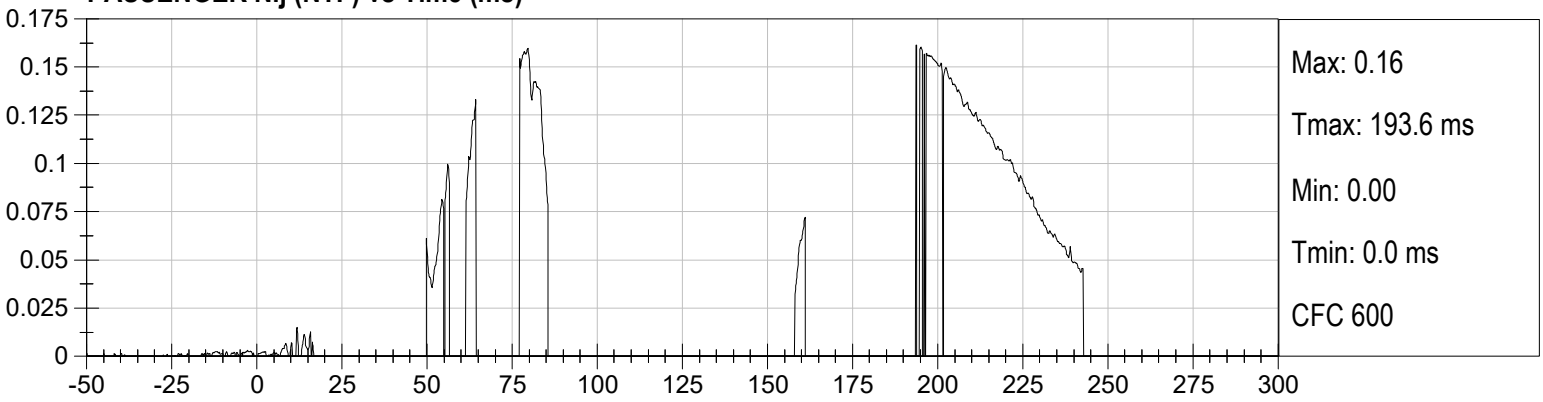

**PASSENGER NECK FZ (N) vs Time (ms)**



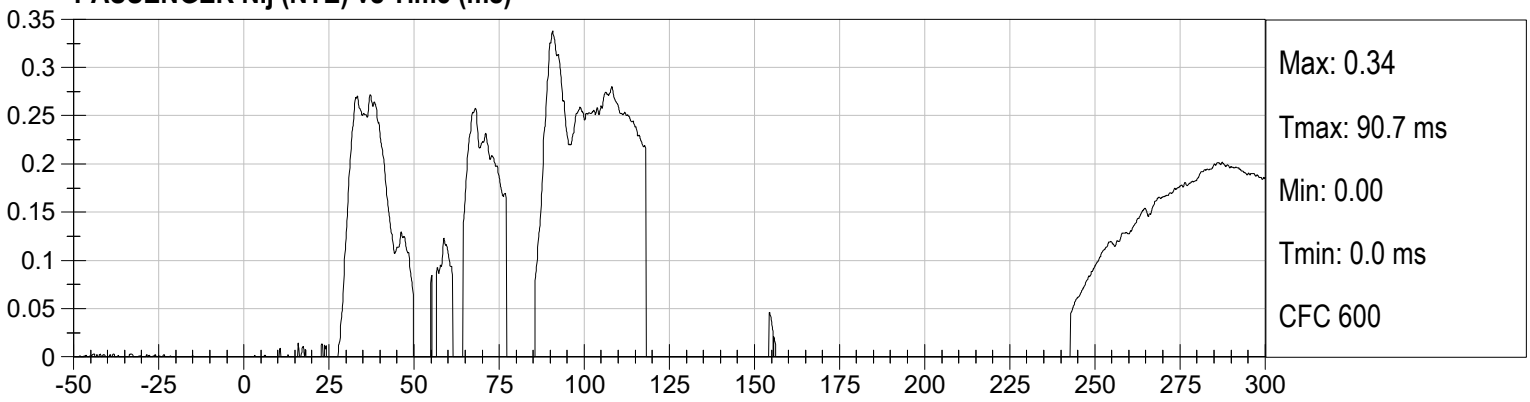

**PASSENGER NECK MY (Nm) vs Time (ms)**



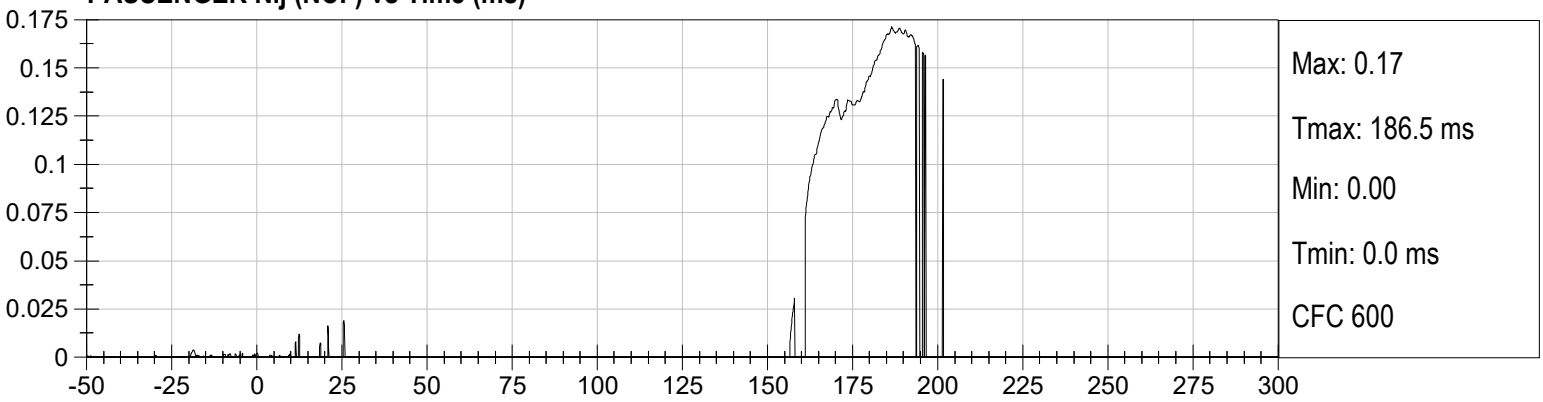
## PASSENGER Nij (NTF) vs Time (ms)



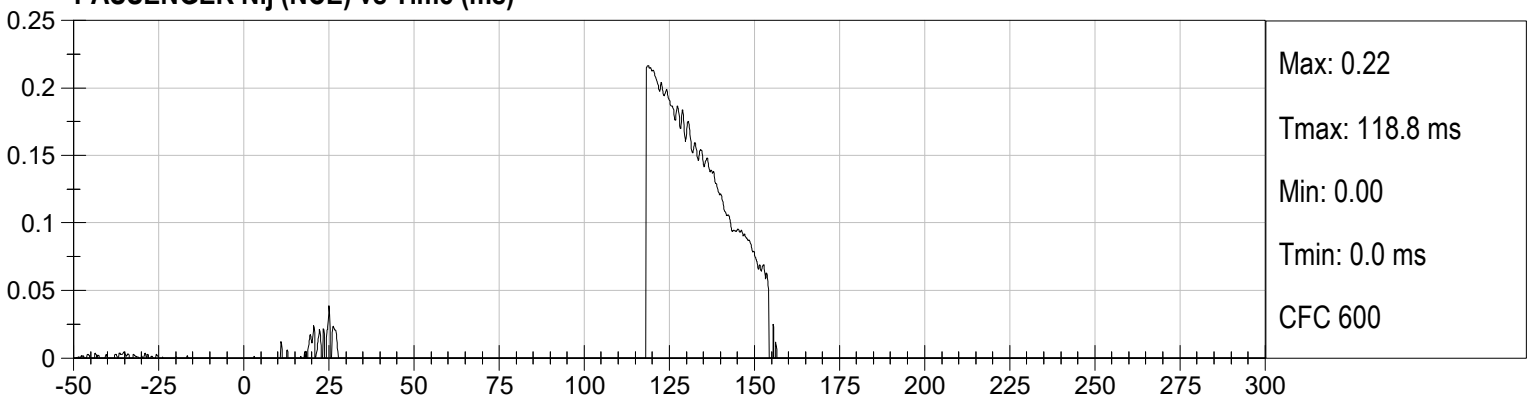

## PASSENGER Nij (NTE) vs Time (ms)



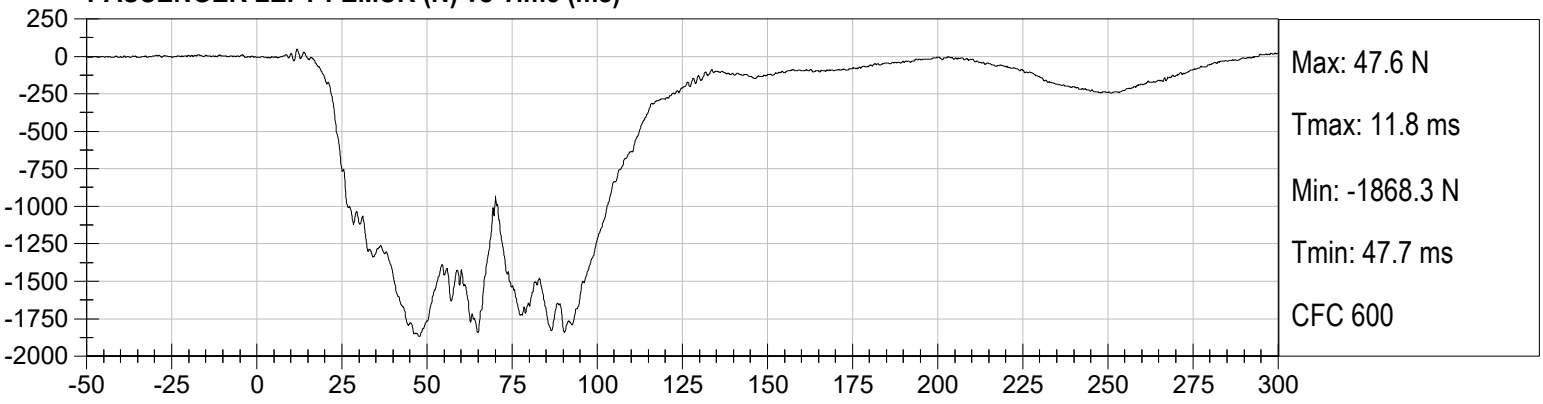

## PASSENGER Nij (NCF) vs Time (ms)



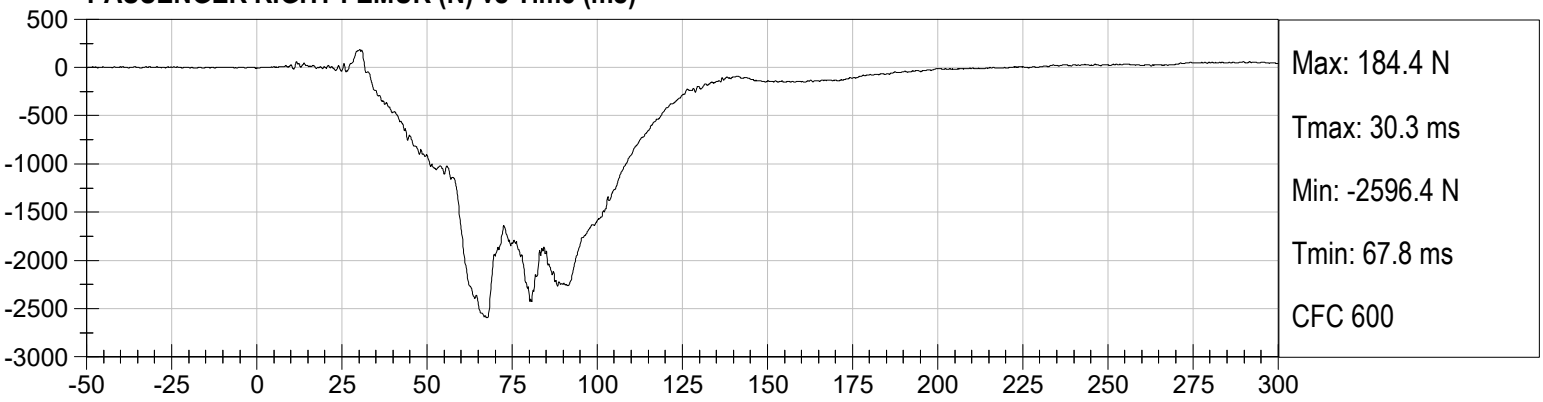

## PASSENGER Nij (NCE) vs Time (ms)



**PASSENGER LEFT FEMUR (N) vs Time (ms)**




**PASSENGER RIGHT FEMUR (N) vs Time (ms)**



# APPENDIX C
# DUMMY CALIBRATION AND PERFORMANCE VERIFICATION DATA

## CALIBRATION TEST RESULTS

## PRE-TEST

## HYBRID III 50$^{TH}$ PERCENTILE MALE - DRIVER ATD

**Hybrid III, 50th External Measurements**
**SN: 351**

| HYBRID III, PART 572, SUBPART E EXTERNAL DIMENSIONS | | | | |
|---|---|---|---|---|
| DIMENSION | DESCRIPTION | DETAILS | ASSEMBLY DIMENSION (inches) | ACTUAL MEASUREMENT |
| A | TOTAL SITTING HEIGHT | Seat surface to highest point on top of the head. | 34.6–35.0 | 34.8 |
| B | SHOULDER PIVOT HEIGHT | Centerline of shoulder pivot bolt to the seat surface. | 19.9-20.5 | 20.0 |
| C | H-POINT HEIGHT | Reference | 3.3-3.5 | 3.4 |
| D | H-POINT LOCATION FROM BACKLINE | Reference | 5.3-5.5 | 5.5 |
| E | SHOULDER PIVOT FROM BACKLINE | Center of the shoulder clevis to the rear vertical surface of the fixture. | 3.3-3.7 | 3.5 |
| F | THIGH CLEARANCE | Measured at the highest point on the upper femur segment. | 5.5-6.1 | 6.0 |
| G | BACK OF ELBOW TO WRIST PIVOT | back of the elbow flesh to the wrist pivot in line with the elbow and wrist pivots | 11.4-12.0 | 11.8 |
| H | HEAD BACK TO BACKLINE | Back of Skull cap skin to seat rear vertical surface (Reference) | 1.6-1.8 | 1.7 |
| I | SHOULDER TO- ELBOW LENGTH | Measure from the highest point on top of the shoulder clevis to the lowest part of the flesh on the elbow in line with the elbow pivot bolt. | 13.0-13.6 | 13.3 |
| J | ELBOW REST HEIGHT | Measure from the flesh below the elbow pivot bolt to the seat surface. | 7.5-8.3 | 7.8 |
| K | BUTTOCK TO KNEE LENGTH | The forward most part of the knee flesh to the rear vertical surface of the fixture. | 22.8-23.8 | 23.8 |
| L | POPLITEAL HEIGHT | Seat surface to the plane of the horizontal plane of the bottom of the feet. | 16.9-17.9 | 17.0 |
| M | KNEE PIVOT HEIGHT | Centerline of knee pivot bolt to the horizontal plane of the bottom of the feet. | 19.1-19.7 | 19.5 |
| N | BUTTOCK POPLITEAL LENGTH | The rearmost surface of the lower leg to the same point on the rear surface of the buttocks used for dim. “K”. | 17.8-18.8 | 18.8 |

| HYBRID III, SUBPART E EXTERIOR DIMENSIONS, continued | | | | |
|---|---|---|---|---|
| DIMENSION | DESCRIPTION | DETAILS | | ACTUAL MEASUREMENT |
| O | CHEST DEPTH WITHOUT JACKET | Measured 16.9-17.1 in. above seat surface | 8.4-9.0 | 8.5 |
| P | FOOT LENGTH | Tip of toe to rear of heel | 9.9-10.5 | 10.3 |
| V | SHOULDER BREADTH | Outside edges of right and left shoulder clevises | 16.3-17.2 | 16.5 |
| W | FOOT BREADTH | The widest part of the foot | 3.6-4.2 | 4.0 |
| Y | CHEST CIRCUMFERENCE (WITH CHEST JACKET) | Measured 16.9-17.1 in. above seat surface | 38.2-39.4 | 39.2 |
| Z | WAIST CIRCUMFERENCE | Measured 8.9-9.1 in. above seat surface | 32.9-34.1 | 33.7 |
| AA | REFERENCE LOCATION FOR MEASUREMENT OF CHEST CIRCUMFERENCE | Reference | 16.9-17.1 | 17.0 |
| BB | REFERENCE LOCATION FOR MEASUREMENT OF WAIST CIRCUMFERENCE | Reference | 8.9-9.1 | 9.0 |

**NOTE:** THE H-POINT IS LOCATED 1.83 INCHES FORWARD AND 2.57 INCHES DOWN FROM THE CENTER OF THE PELVIS ANGLE REFERENCE HOLE.

**MGA RESEARCH CORPORATION**

**HEAD DROP TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test ID:** D210451

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.6 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 24 | Pass |
| Peak Resultant Acceleration | G's | 225 to 275 | 255 | Pass |
| Peak Lateral Acceleration | G's | <= +/- 15.0 | 1.3 | Pass |
| Unimodal | N/A | Yes | Yes | Pass |
| Oscillations | N/A | within 10% of peak | Yes | Pass |
| | | Overall Test Results | | Pass |

Gerald Guerrero
Laboratory Technician

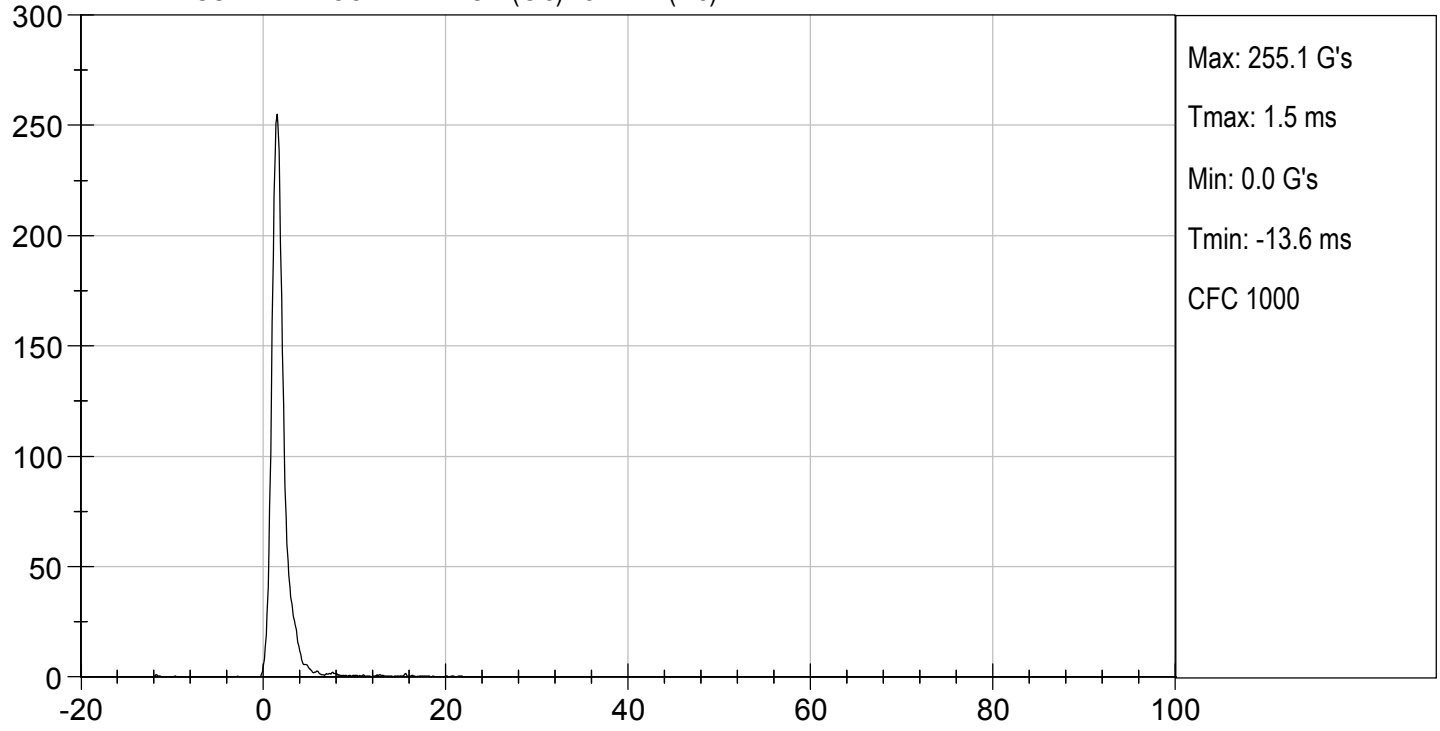
02/18/2021
Test Date

Approved By

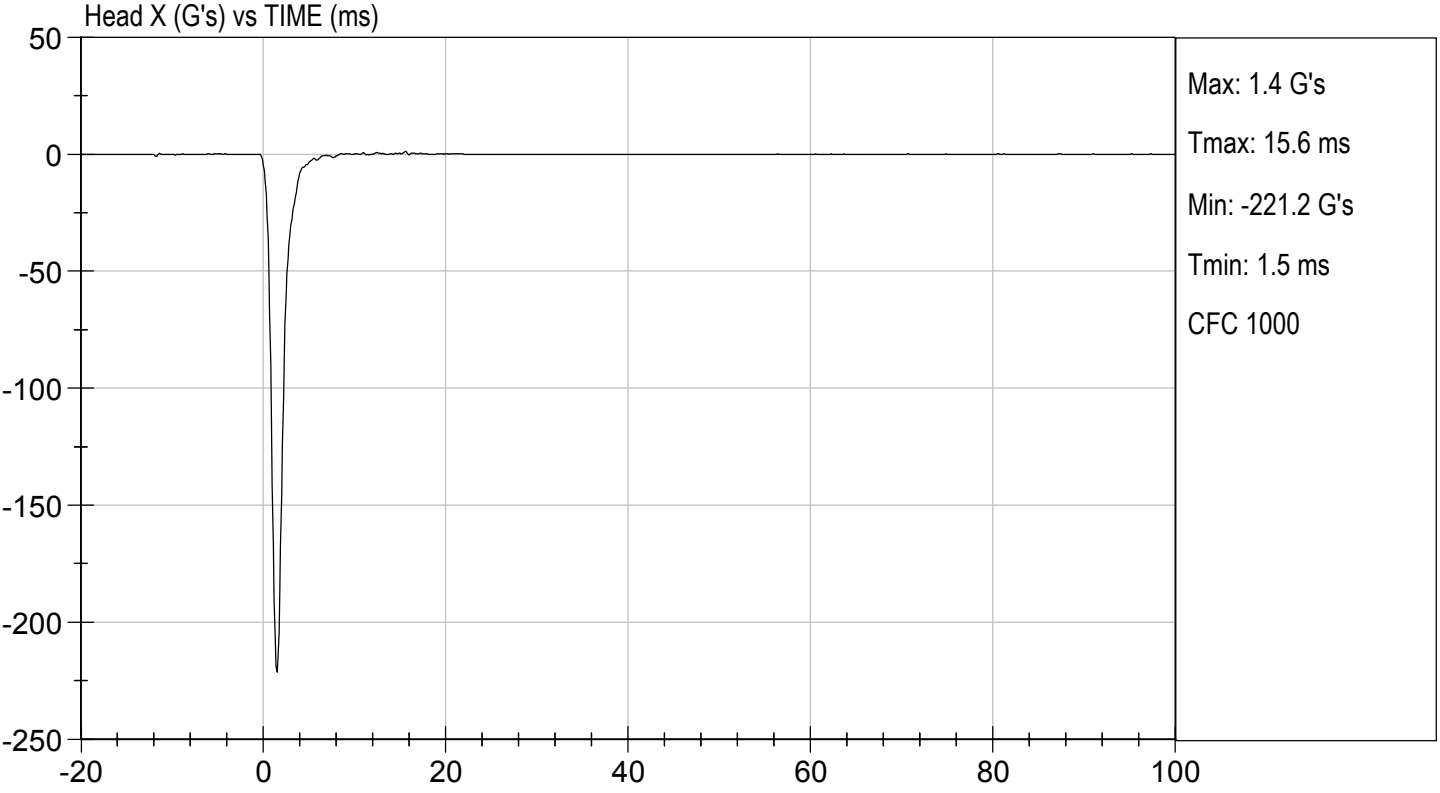
TEST DESC: HEAD DROP

TEST DATE: 02/18/2021
TEST #: D210451

HEAD RESULTANT ACCELERATION (G's) vs TIME (ms)

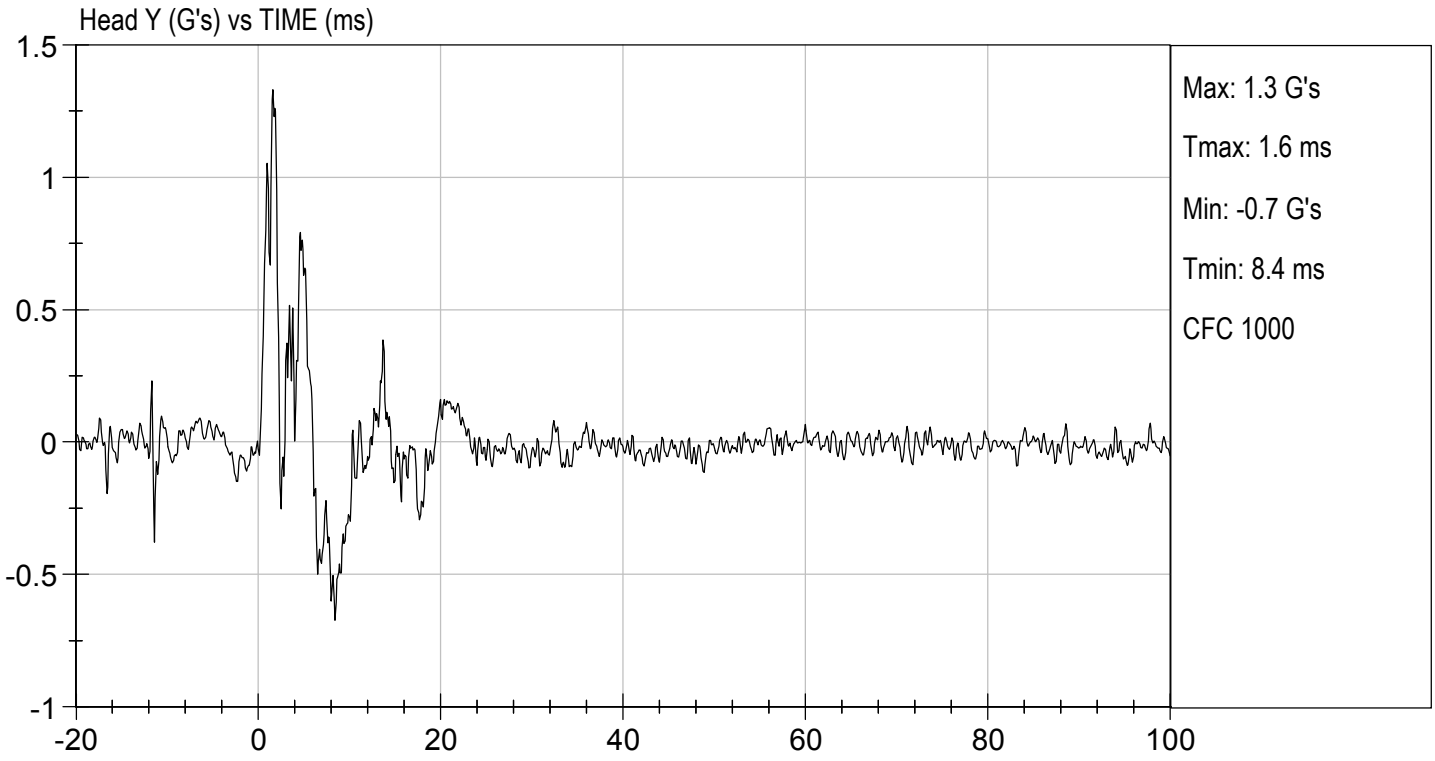


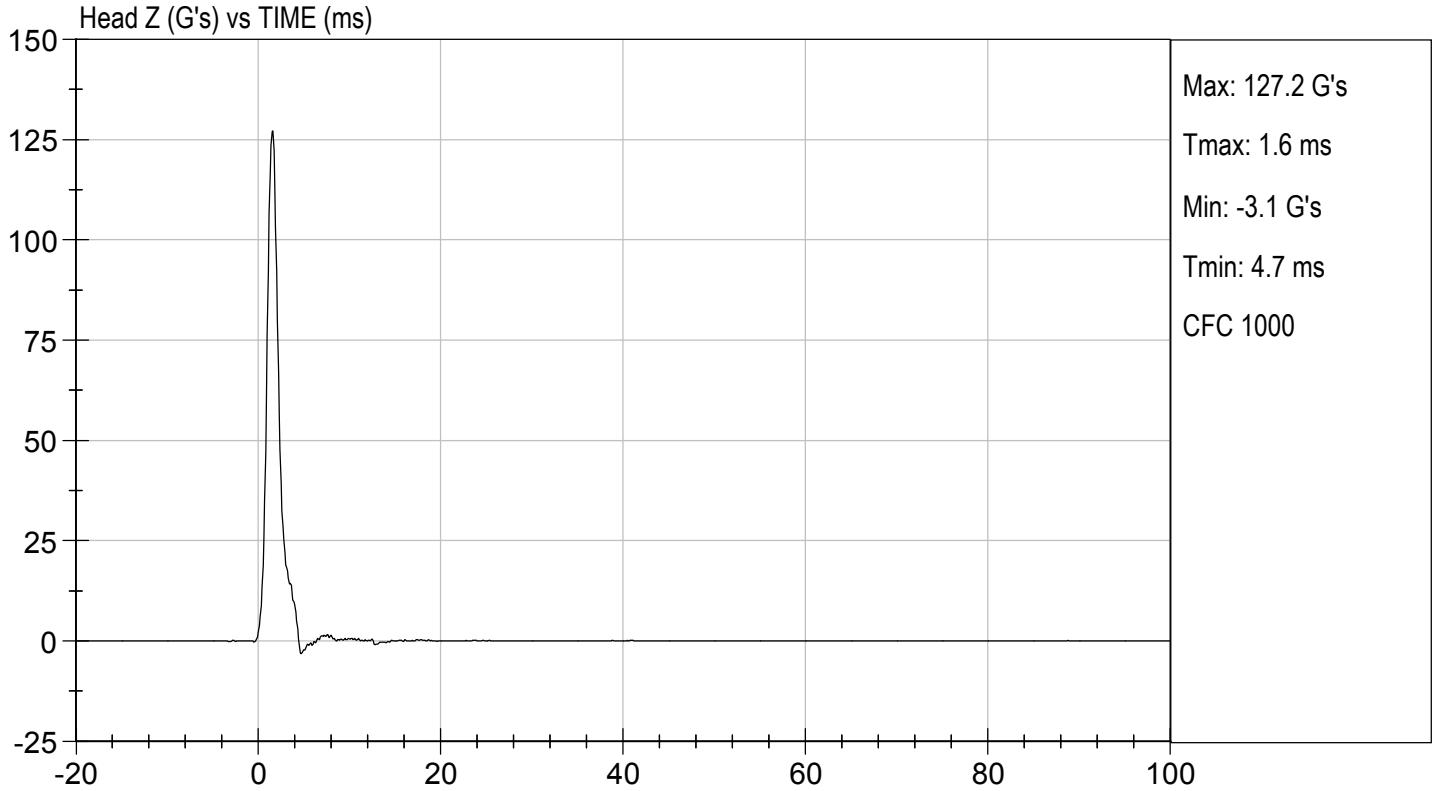

Head X (G's) vs TIME (ms)



TEST DESC: HEAD DROP

TEST DATE: 02/18/2021
TEST #: D210451



**MGA RESEARCH CORPORATION**

**NECK FLEXION TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210452

| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Laboratory Temperature | | deg C | 20.6 to 22.2 | 20.9 | Pass |
| Laboratory Relative Humidity | | % | 10 to 70 | 19 | Pass |
| Pendulum Velocity | | m/s | 6.89 to 7.13 | 7.06 | Pass |
| Pendulum Deceleration | 10 ms | G's | 22.50 to 27.50 | 23.21 | Pass |
| | 20 ms | G's | 17.60 to 22.60 | 20.35 | Pass |
| | 30 ms | G's | 12.50 to 18.50 | 14.74 | Pass |
| Peak Pendulum Deceleration After 30 ms | | G's | <= 29.0 | 14.6 | Pass |
| Deceleration Decay Time to Cross 5 G's | | ms | 34.0 to 42.0 | 37.1 | Pass |
| Maximum "D" Plane Rotation | Maximum | Deg | 64.0 to 78.0 | 69.8 | Pass |
| | Time | ms | 57.0 to 64.0 | 58.3 | Pass |
| "D" Plane Rotation Decay Time To Zero Crossing | | ms | 113.0 to 128.0 | 115.3 | Pass |
| Moment About Occipital Condyle | Maximum | Nm | 88.1 to 108.5 | 94.0 | Pass |
| | Time | ms | 47.0 to 58.0 | 49.6 | Pass |
| Positive Moment Decay Time To Zero Crossing | | ms | 97.0 to 107.0 | 100.3 | Pass |
| | | | Overall Test Results | | Pass |

Gerald Guerrero
Laboratory Technician

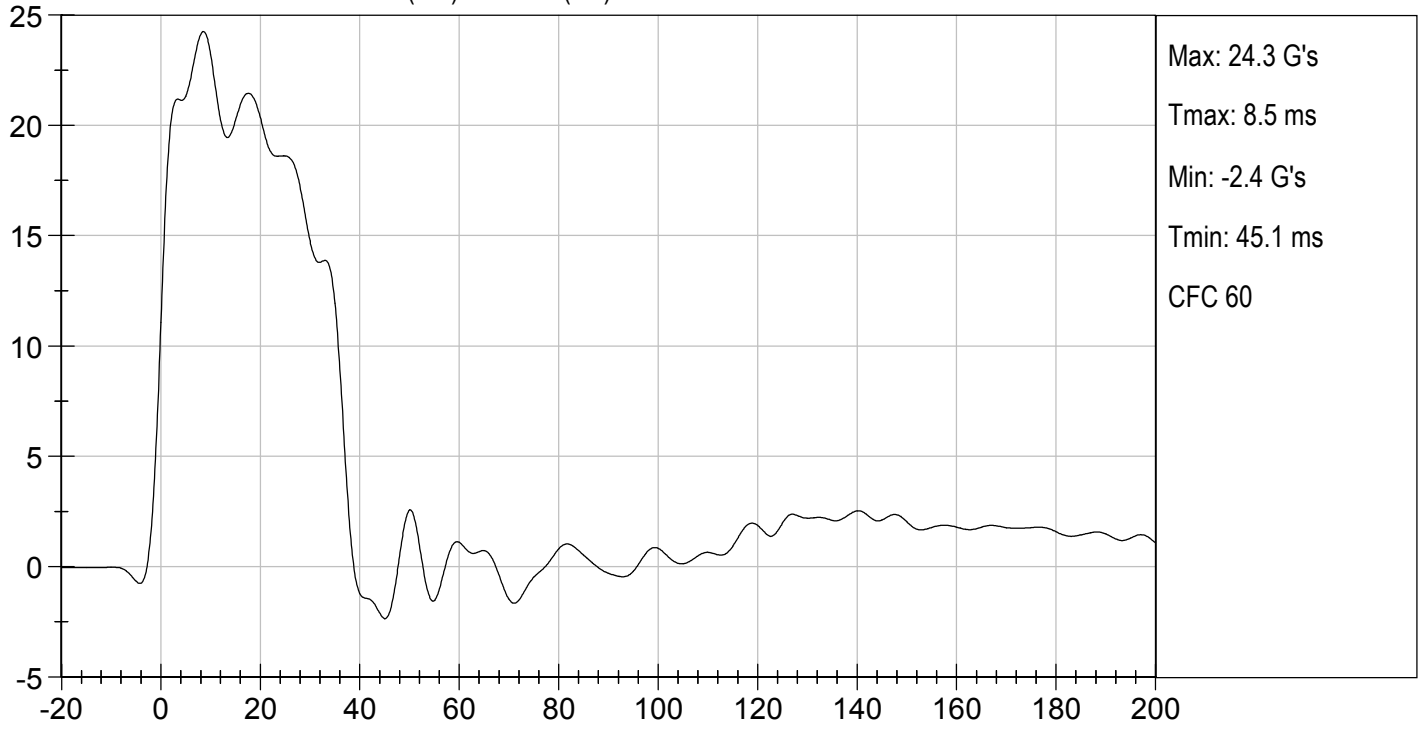
02/18/2021
Test Date

Approved By

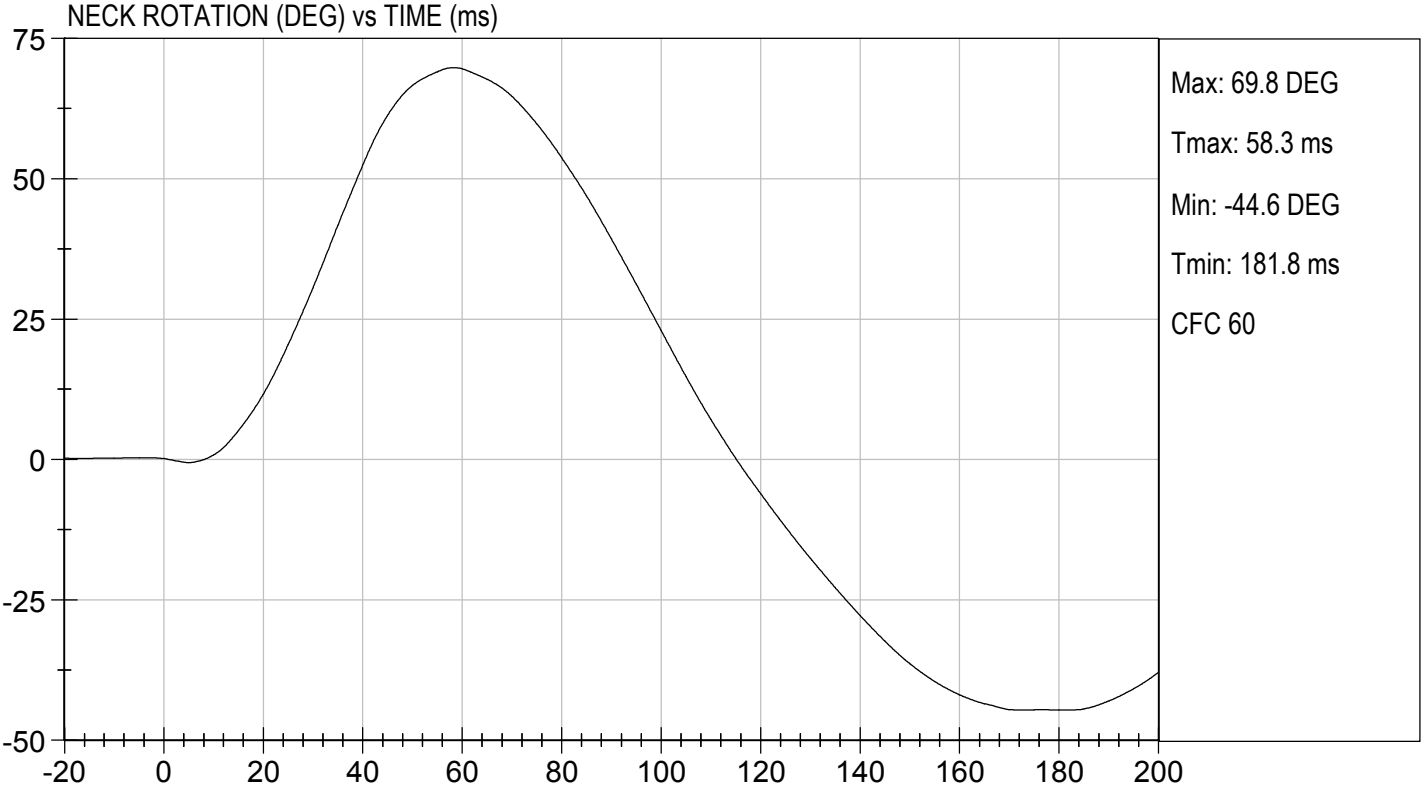
TEST DESC: NECK FLEXION
VELOCITY: 23.15 ft/s, 7.06 m/s

TEST DATE: 02/18/2021
TEST #: D210452

PENDULUM DECELERATION (G's) vs TIME (ms)

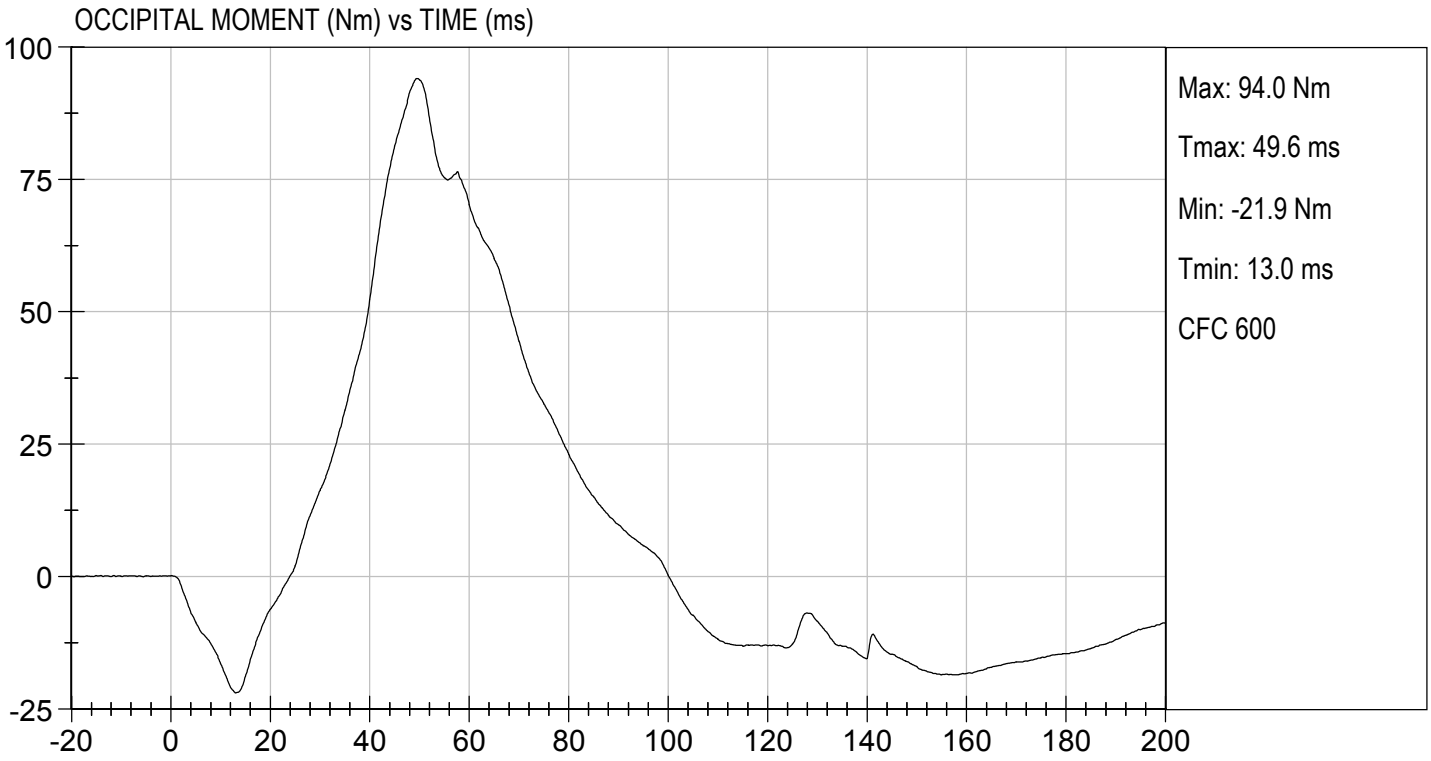



NECK ROTATION (DEG) vs TIME (ms)



TEST DESC: NECK FLEXION
VELOCITY: 23.15 ft/s, 7.06 m/s

TEST DATE: 02/18/2021
TEST #: D210452



**MGA RESEARCH CORPORATION**

**NECK EXTENSION TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210453

| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Laboratory Temperature | | deg C | 20.6 to 22.2 | 20.9 | Pass |
| Laboratory Relative Humidity | | % | 10 to 70 | 19 | Pass |
| Pendulum Velocity | | m/s | 5.95 to 6.19 | 6.12 | Pass |
| Pendulum Deceleration | 10 ms | G's | 17.20 to 21.20 | 17.99 | Pass |
| | 20 ms | G's | 14.00 to 19.00 | 16.53 | Pass |
| | 30 ms | G's | 11.00 to 16.00 | 12.97 | Pass |
| Peak Pendulum Deceleration After 30 ms | | G's | <= 22.0 | 14.5 | Pass |
| Deceleration Decay Time to Cross 5 G's | | ms | 38.0 to 46.0 | 40.1 | Pass |
| Maximum "D" Plane Rotation | Maximum | Degrees | 81.0 to 106.0 | 93.8 | Pass |
| | Time | ms | 72.0 to 82.0 | 76.6 | Pass |
| "D" Plane Rotation Decay Time To Zero Crossing | | ms | 147.0 to 174.0 | 157.1 | Pass |
| Moment About Occipital Condyle | Maximum | Nm | -52.9 to -79.9 | -62.5 | Pass |
| | Time | ms | 65.0 to 79.0 | 70.7 | Pass |
| Negative Moment Decay Time To Zero Crossing | | ms | 120.0 to 148.0 | 141.8 | Pass |
| | | | Overall Test Results | | Pass |

Gerald Guerrero
Laboratory Technician

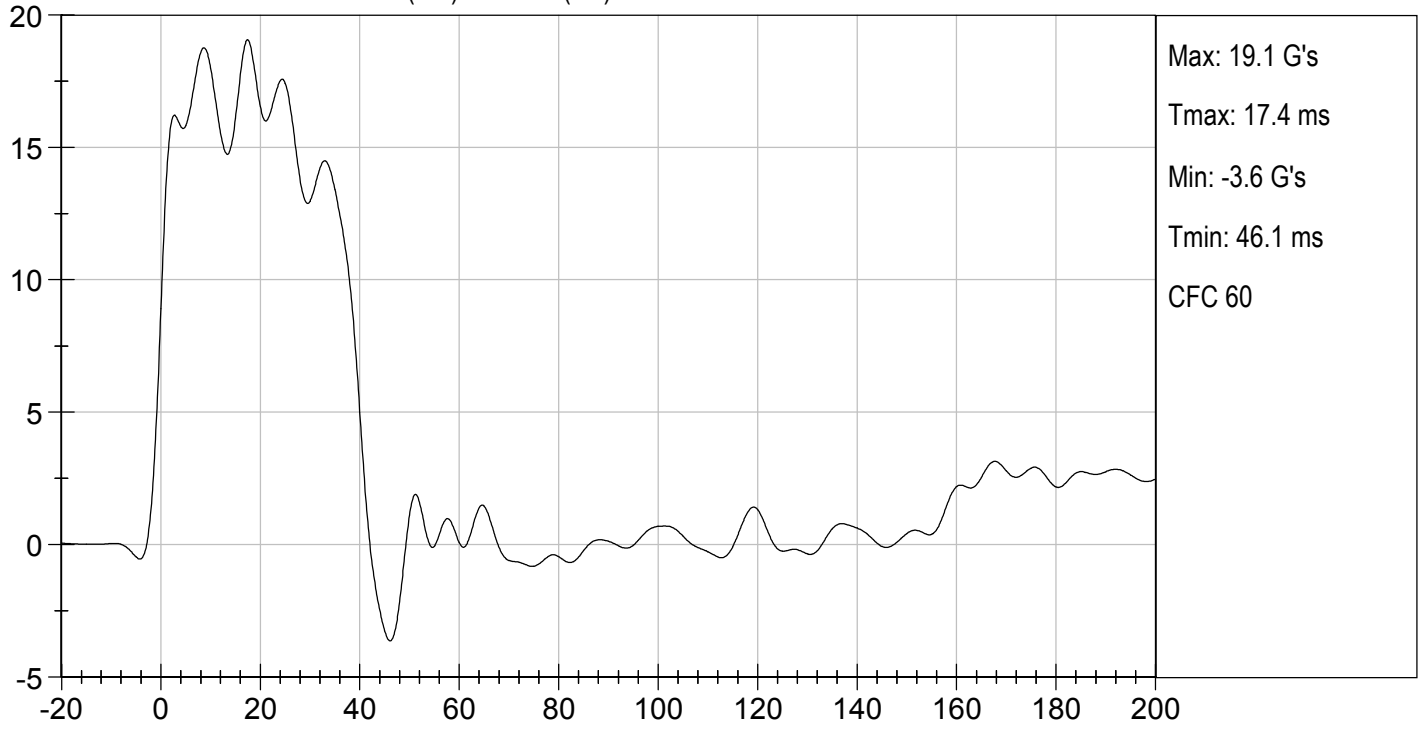
02/18/2021
Test Date

Approved By

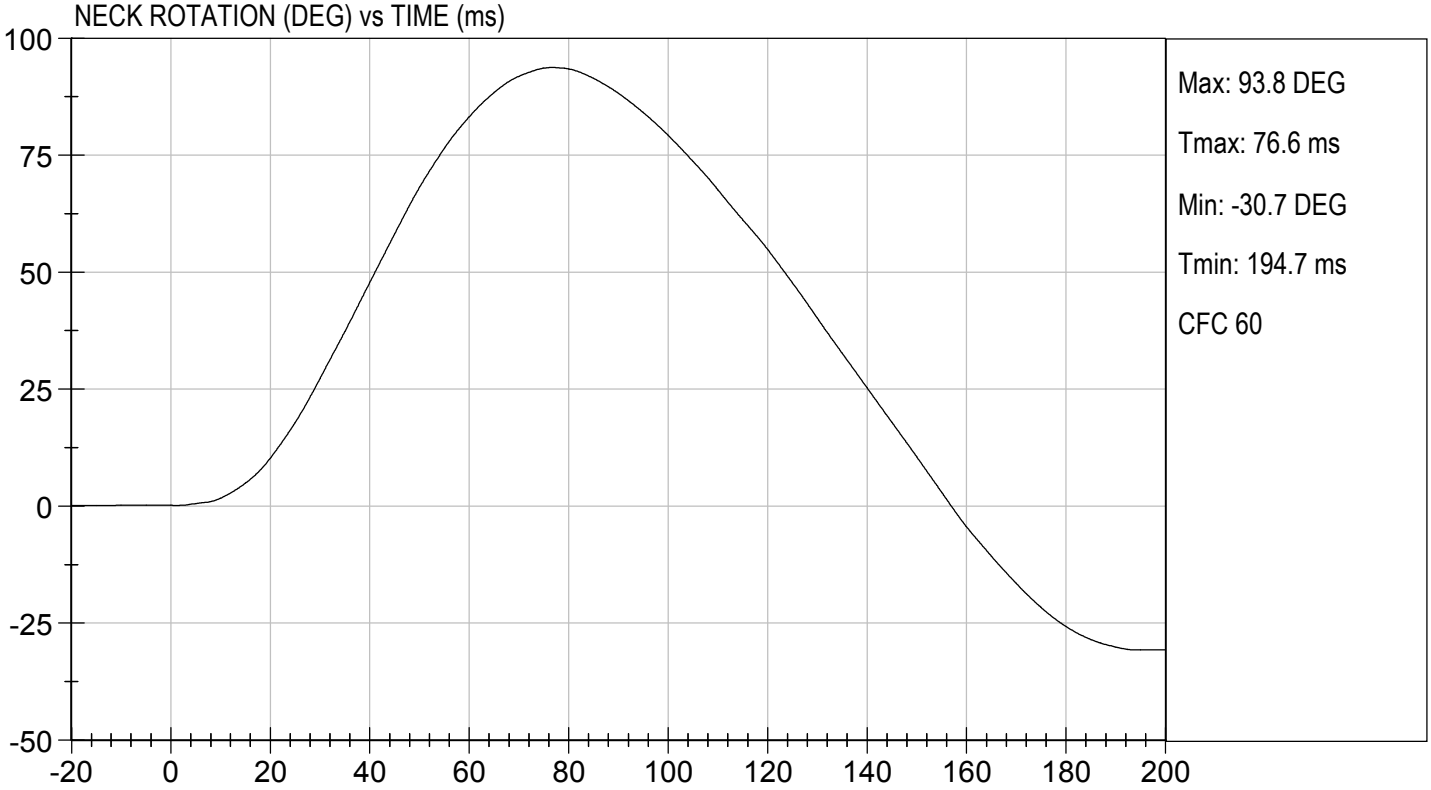
TEST DESC: NECK EXTENSION
VELOCITY: 20.08 ft/s, 6.12 m/s

TEST DATE: 02/18/2021
TEST #: D210453

PENDULUM DECELERATION (G's) vs TIME (ms)

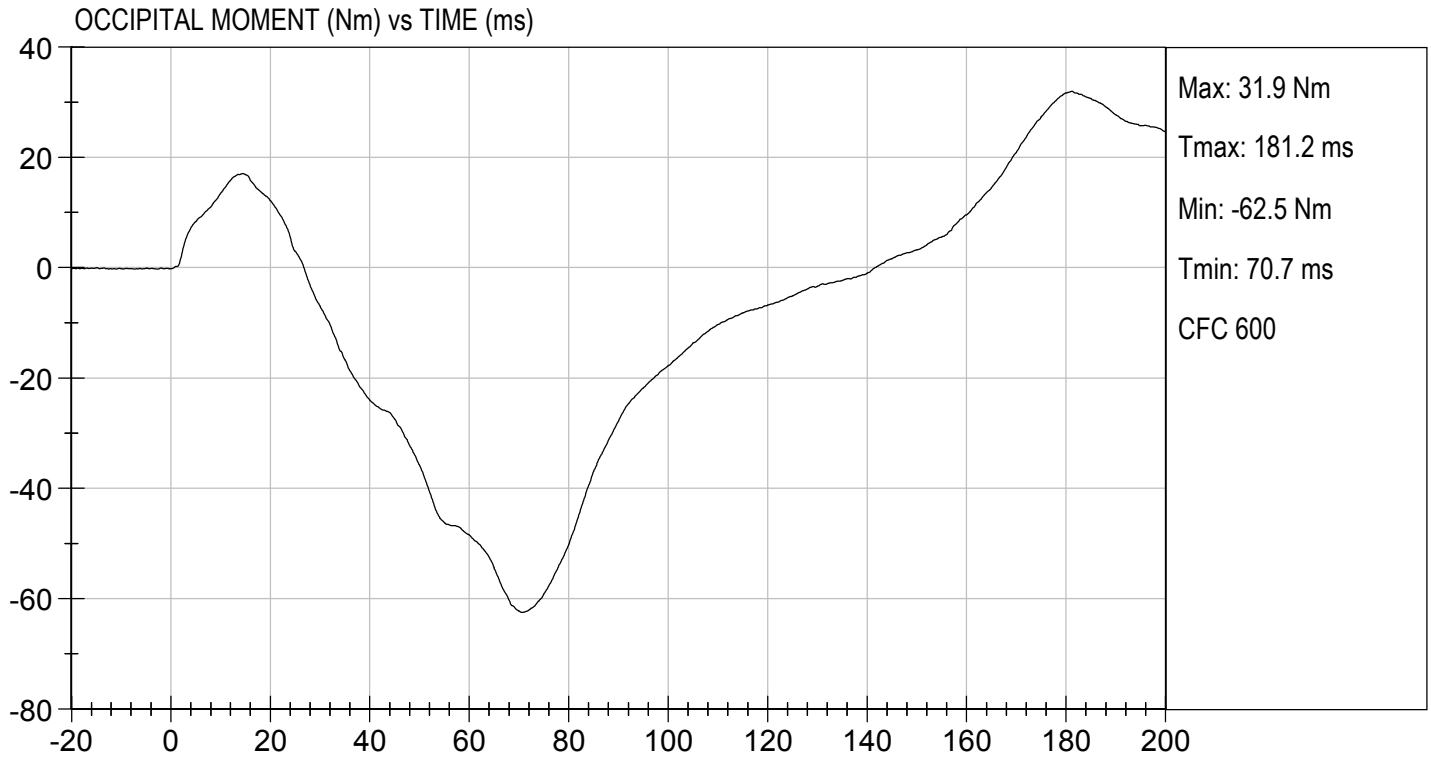



NECK ROTATION (DEG) vs TIME (ms)



TEST DESC: NECK EXTENSION
VELOCITY: 20.08 ft/s, 6.12 m/s

TEST DATE: 02/18/2021
TEST #: D210453



**MGA RESEARCH CORPORATION**

**THORAX IMPACT**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210454

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 20.6 to 22.2 | 21.6 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 24 | Pass |
| Probe Velocity | m/s | 6.58 to 6.82 | 6.68 | Pass |
| Peak Probe Force | N | 5159 to 5893 | 5,454 | Pass |
| Peak Sternum Displacement | cm | 6.35 to 7.26 | 7.13 | Pass |
| Internal Hysteresis | % | 69 to 85 | 70 | Pass |
| | | Overall Test Results | | Pass |

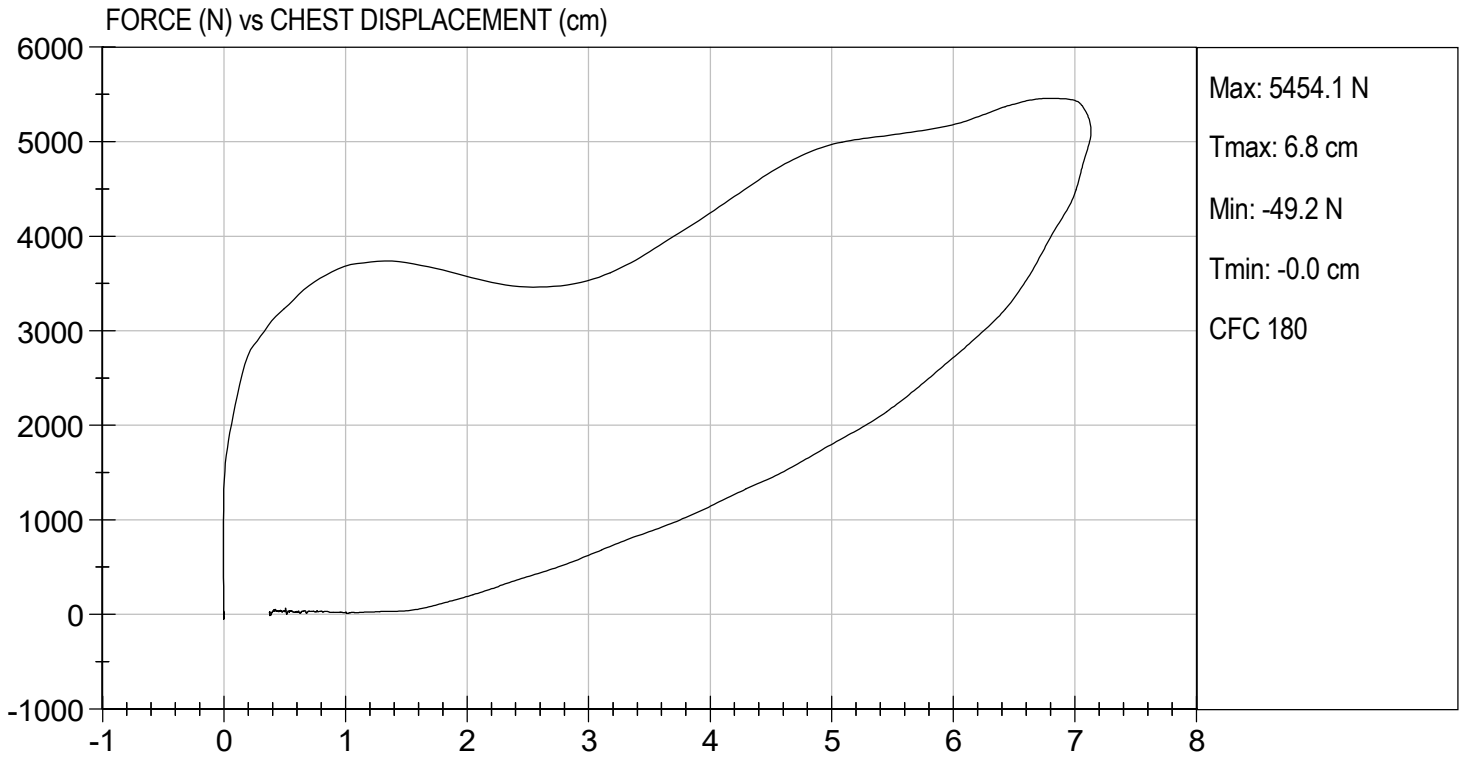
Laboratory Technician

02/18/2021
Test Date

Approved By

TEST DESC: THORAX IMPACT
VELOCITY: 21.93 ft/s, 6.68 m/s

TEST DATE: 02/18/2021
TEST #: D210454



**MGA RESEARCH CORPORATION**

**RIGHT KNEE IMPACT TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210455

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.2 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 20 | Pass |
| Probe Velocity | m/s | 2.07 to 2.13 | 2.12 | Pass |
| Peak Probe Force | N | 4715 to 5782 | 5,131 | Pass |
| | | Overall Test Results | | Pass |

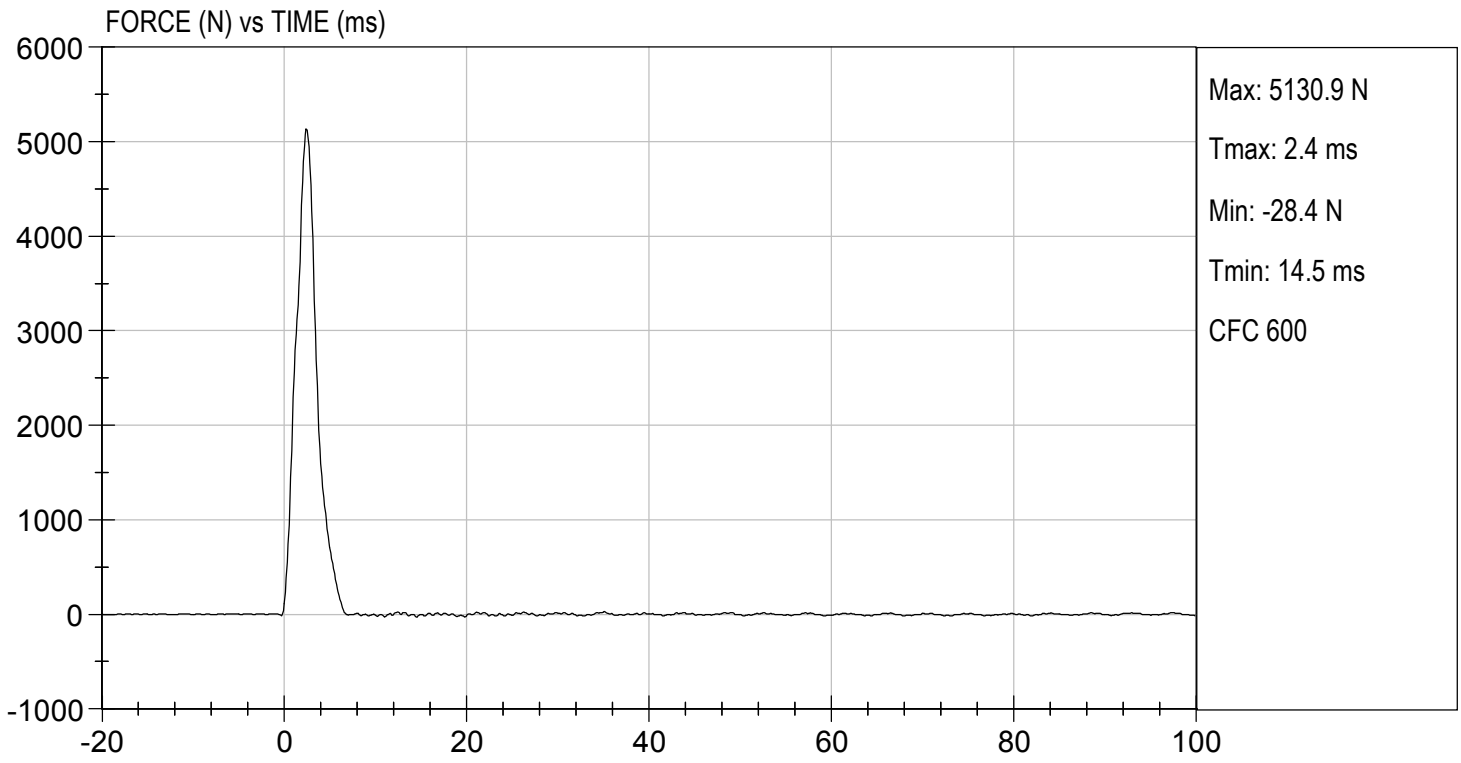
Laboratory Technician

02/18/2021
Test Date

Approved By

TEST DESC: RIGHT KNEE
VELOCITY: 6.97 ft/s, 2.12 m/s

TEST DATE: 02/18/2021
TEST #: D210455



**MGA RESEARCH CORPORATION**

**LEFT KNEE IMPACT TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210456

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.2 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 20 | Pass |
| Probe Velocity | m/s | 2.07 to 2.13 | 2.13 | Pass |
| Peak Probe Force | N | 4715 to 5782 | 5,367 | Pass |
| | | Overall Test Results | | Pass |

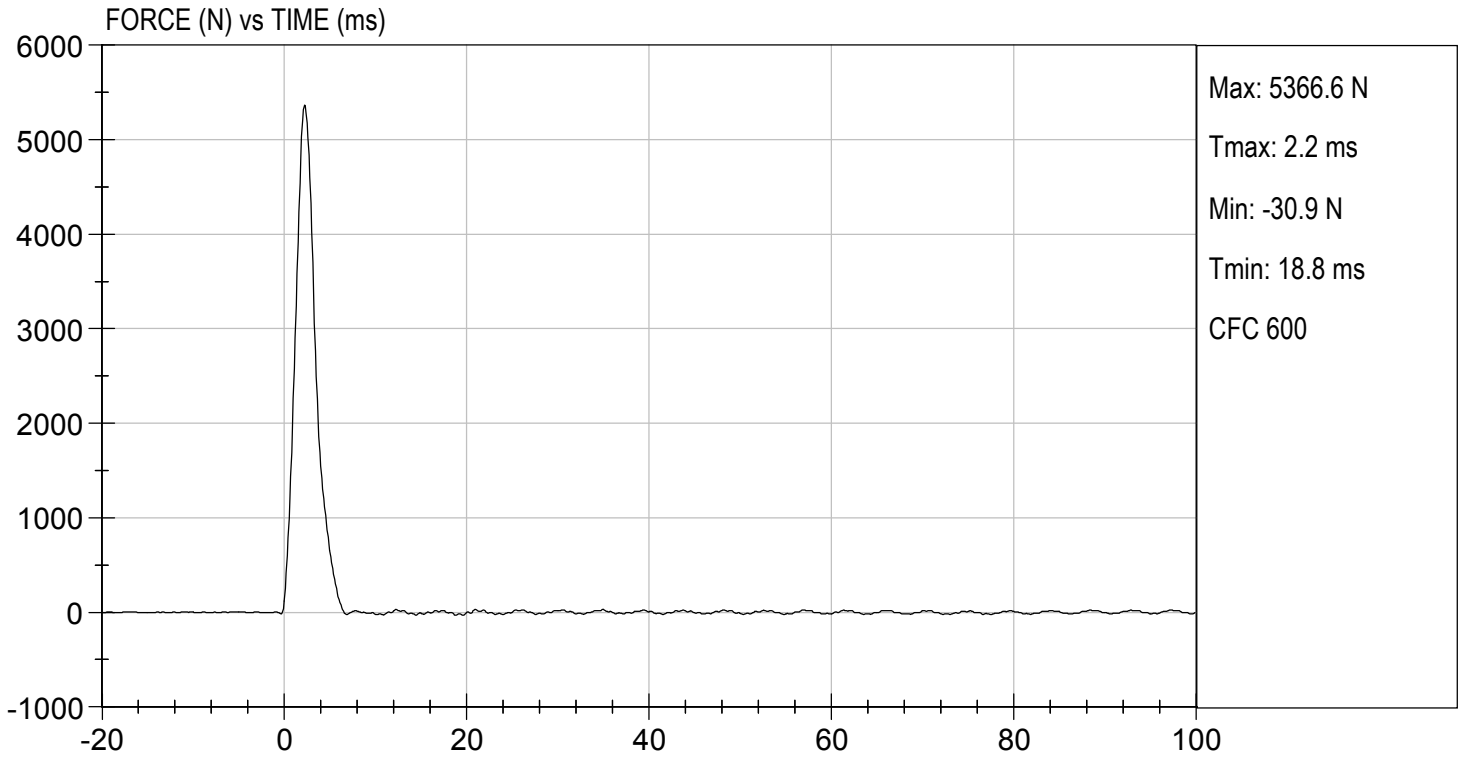
Laboratory Technician

02/18/2021
Test Date

Approved By

TEST DESC: LEFT KNEE
VELOCITY: 7.00 ft/s, 2.13 m/s

TEST DATE: 02/18/2021
TEST #: D210456



**MGA RESEARCH CORPORATION**

**HIP-FEMUR FLEXION TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210450

| Tested Parameter | Units | Specification | Result | | Pass/Fail |
|---|---|---|---|---|---|
| | | | Right | Left | |
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.1 | 21.1 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 21 | 21 | Pass |
| Rotation Rate | deg/s | 5.0 to 10.0 | 6.4 | 6.4 | Pass |
| 30 Degrees | Nm | 94.9 Nm Max | 88.5 | 88.4 | Pass |
| 150 ft-lbf / 203.4 Nm | Deg | 40.0 to 50.0 Degree Max Rotation | 43.9 | 44.5 | Pass |
| | | Overall Test Results | | | Pass |

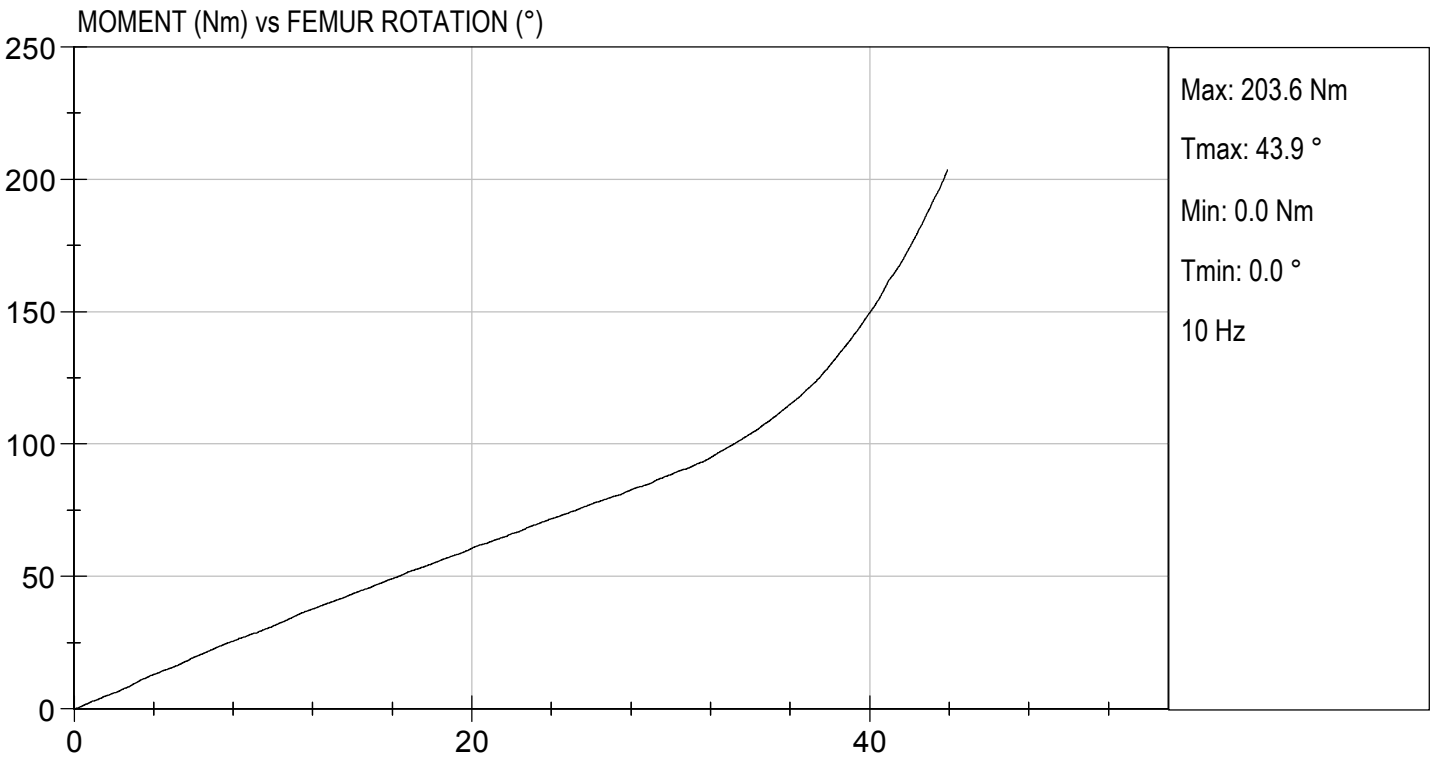
Laboratory Technician

02/18/2021
Test Date

Approved By

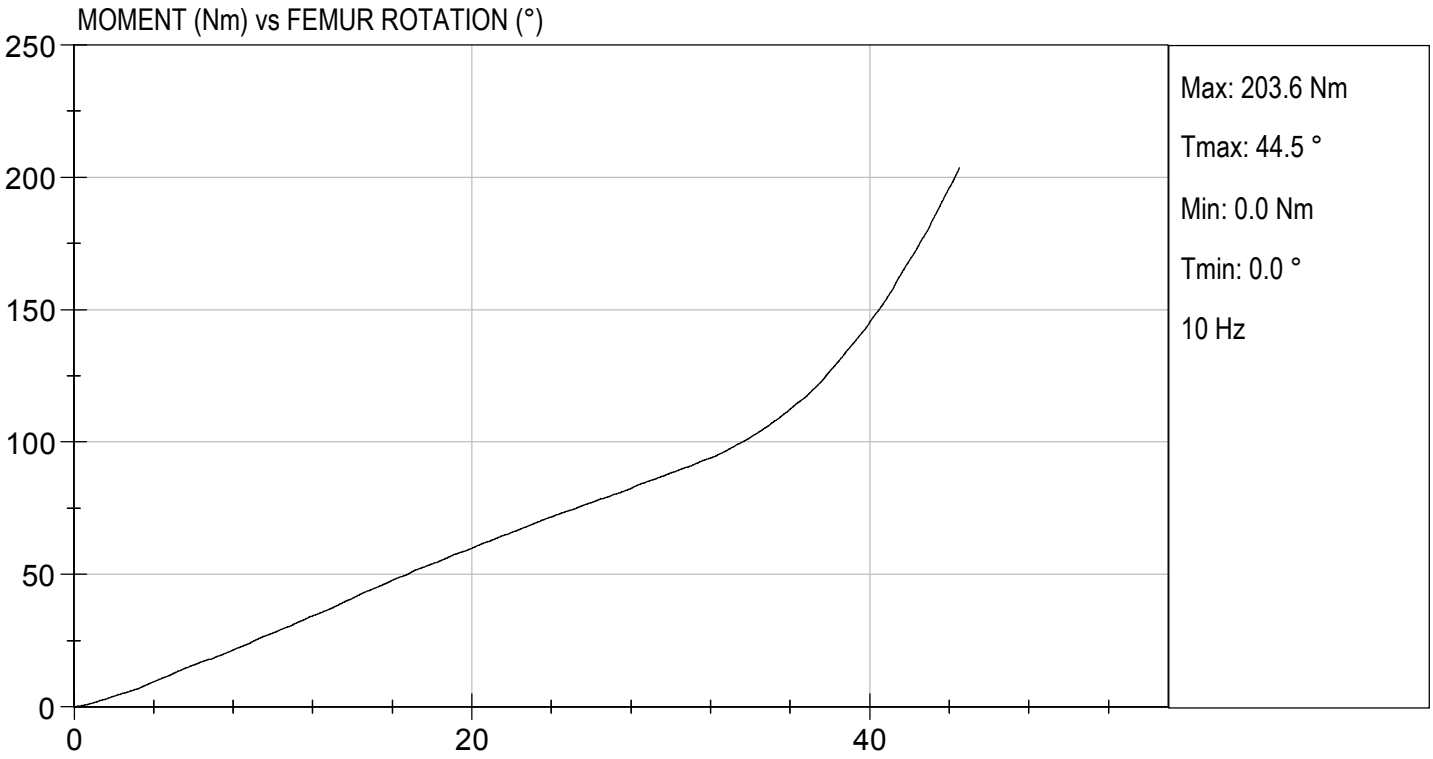
TEST DESC: RIGHT HIP FEMUR FLEXION

TEST DATE: 02/18/2021
TEST #: D210459



TEST DESC: LEFT HIP FEMUR FLEXION

TEST DATE: 02/18/2021
TEST #: D210450



**CALIBRATION TEST RESULTS**

**POST-TEST**

**HYBRID III 50$^{TH}$ PERCENTILE MALE - DRIVER ATD**

**MGA RESEARCH CORPORATION**

**HEAD DROP TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test ID:** D210571

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.7 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 23 | Pass |
| Peak Resultant Acceleration | G's | 225 to 275 | 249 | Pass |
| Peak Lateral Acceleration | G's | <= +/- 15.0 | -5.2 | Pass |
| Unimodal | N/A | Yes | Yes | Pass |
| Oscillations | N/A | within 10% of peak | Yes | Pass |
| | | Overall Test Results | | Pass |

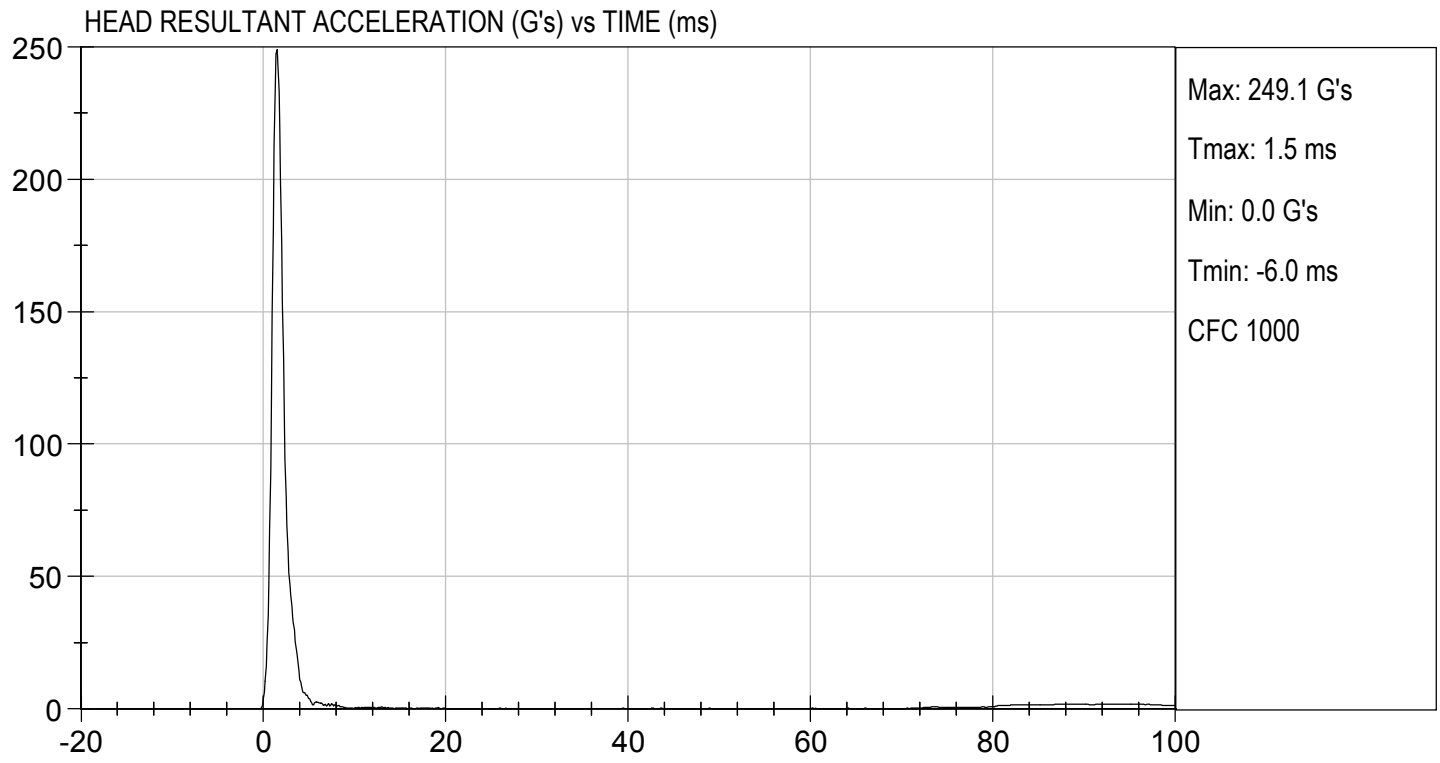
Laboratory Technician

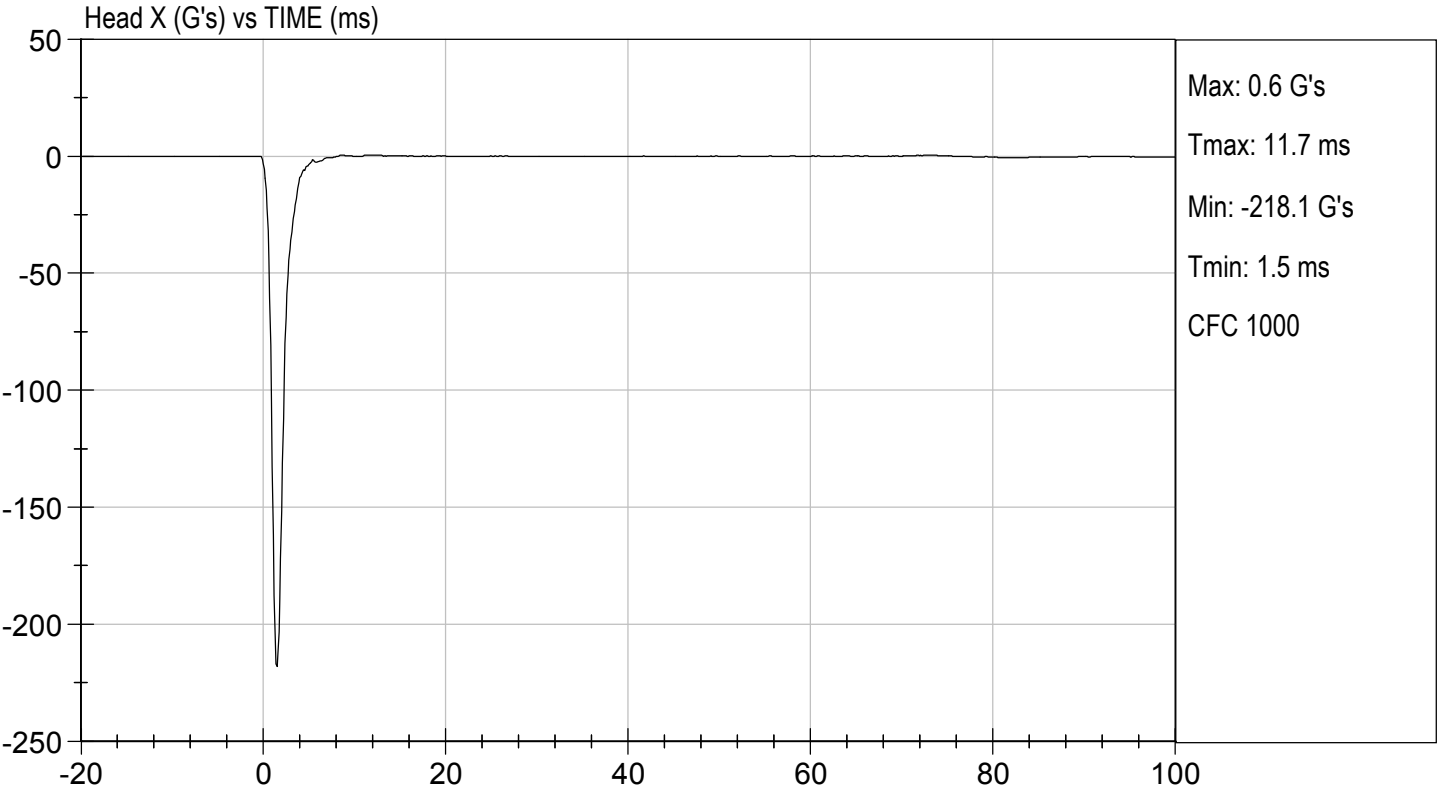
02/25/2021
Test Date

Approved By

TEST DESC: HEAD DROP

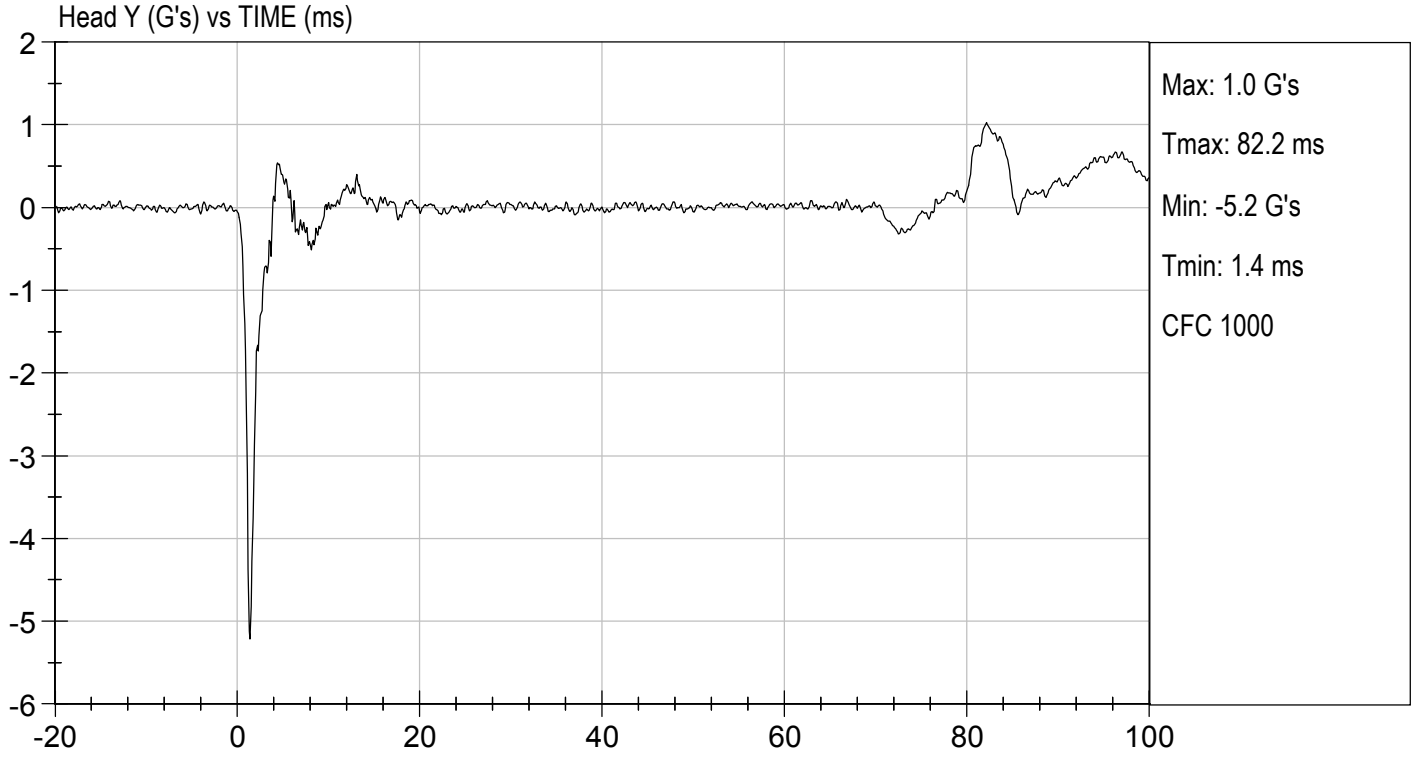
TEST DATE: 02/25/2021
TEST #: D210571

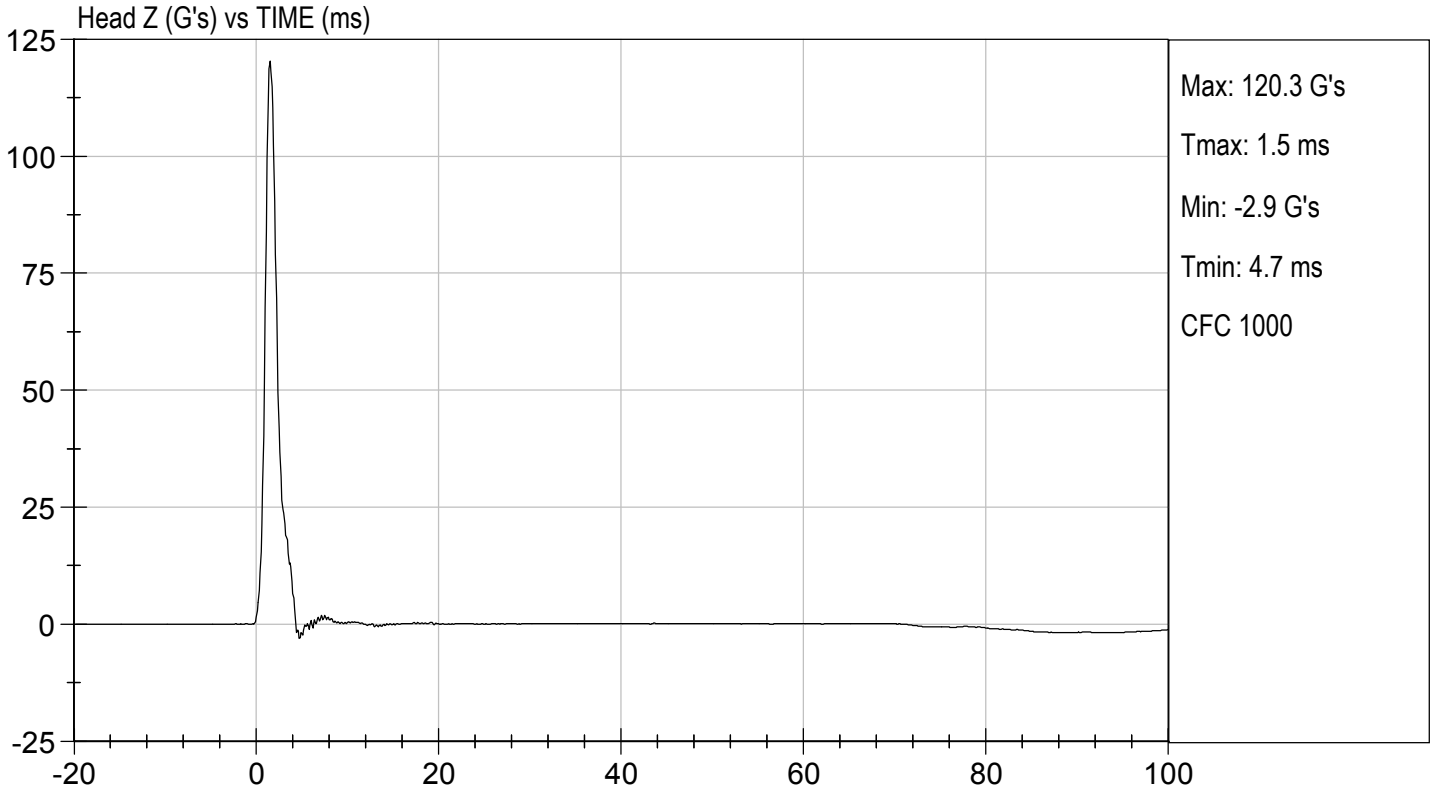


TEST DESC: HEAD DROP

TEST DATE: 02/25/2021
TEST #: D210571



**MGA RESEARCH CORPORATION**

**NECK FLEXION TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210572

| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Laboratory Temperature | | deg C | 20.6 to 22.2 | 21.4 | Pass |
| Laboratory Relative Humidity | | % | 10 to 70 | 21 | Pass |
| Pendulum Velocity | | m/s | 6.89 to 7.13 | 7.06 | Pass |
| Pendulum Deceleration | 10 ms | G's | 22.50 to 27.50 | 23.40 | Pass |
| | 20 ms | G's | 17.60 to 22.60 | 20.45 | Pass |
| | 30 ms | G's | 12.50 to 18.50 | 14.87 | Pass |
| Peak Pendulum Deceleration After 30 ms | | G's | <= 29.0 | 15.1 | Pass |
| Deceleration Decay Time to Cross 5 G's | | ms | 34.0 to 42.0 | 36.9 | Pass |
| Maximum "D" Plane Rotation | Maximum | Deg | 64.0 to 78.0 | 68.9 | Pass |
| | Time | ms | 57.0 to 64.0 | 58.8 | Pass |
| "D" Plane Rotation Decay Time To Zero Crossing | | ms | 113.0 to 128.0 | 116.3 | Pass |
| Moment About Occipital Condyle | Maximum | Nm | 88.1 to 108.5 | 91.5 | Pass |
| | Time | ms | 47.0 to 58.0 | 48.8 | Pass |
| Positive Moment Decay Time To Zero Crossing | | ms | 97.0 to 107.0 | 99.1 | Pass |
| | | | Overall Test Results | | Pass |

Laboratory Technician

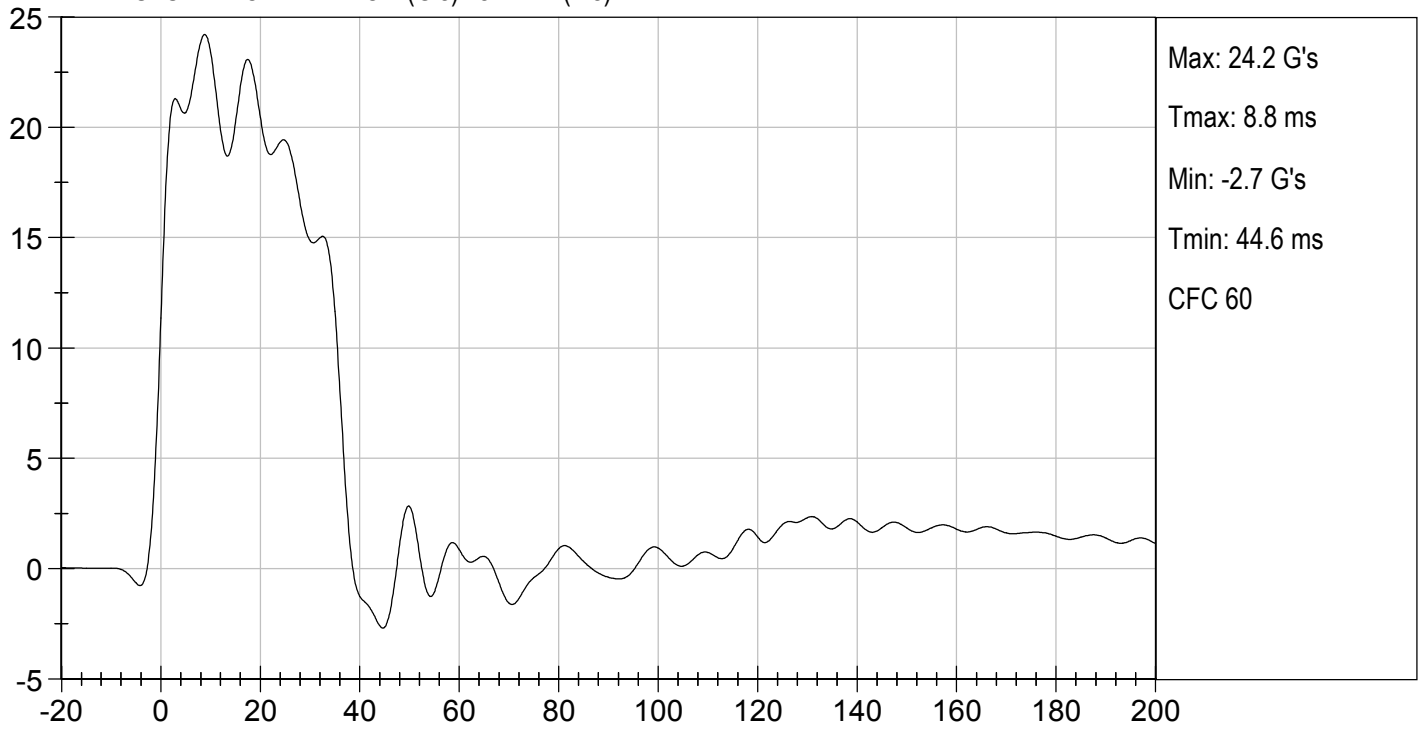
02/25/2021
Test Date

Approved By

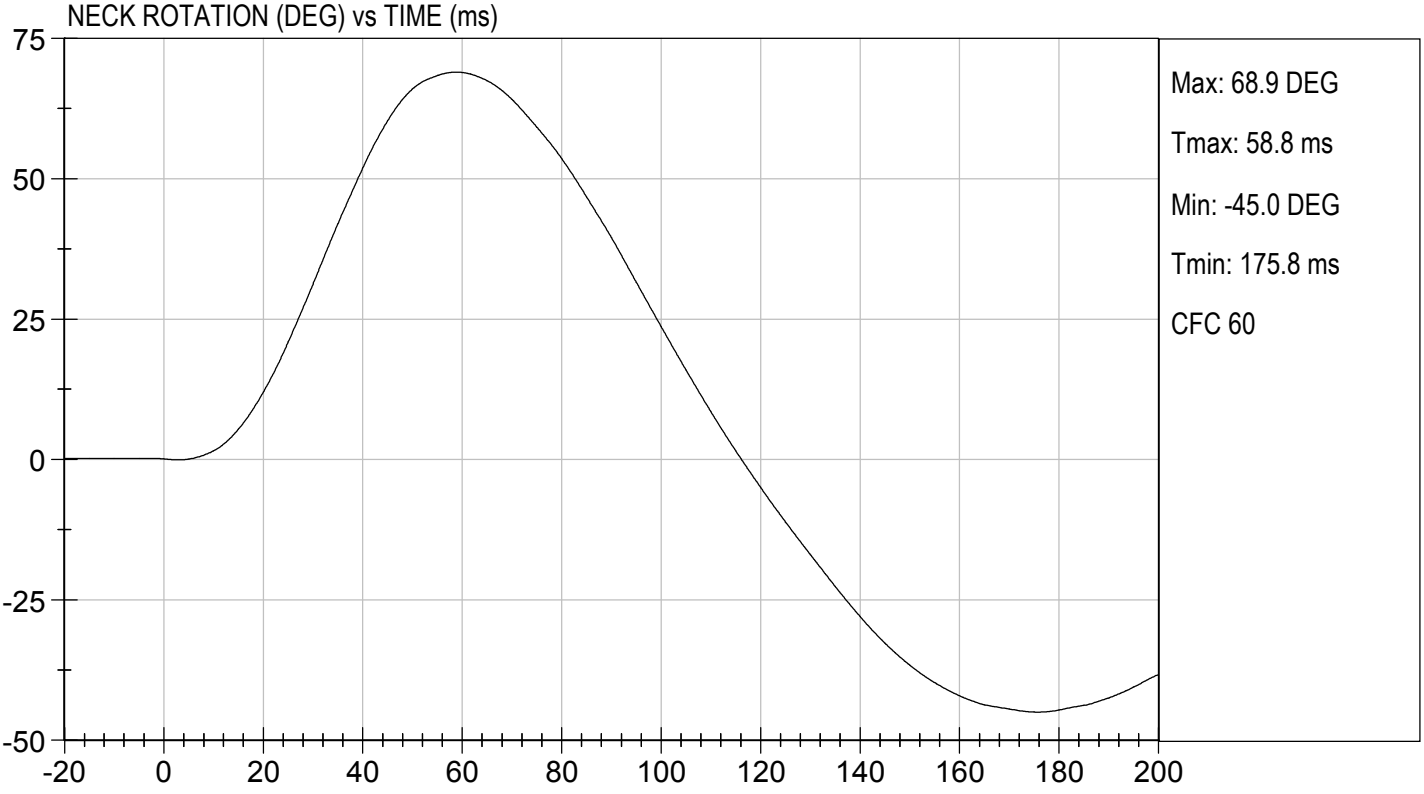
TEST DESC: NECK FLEXION
VELOCITY: 23.15 ft/s, 7.06 m/s

TEST DATE: 02/25/2021
TEST #: D210572

PENDULUM DECELERATION (G's) vs TIME (ms)

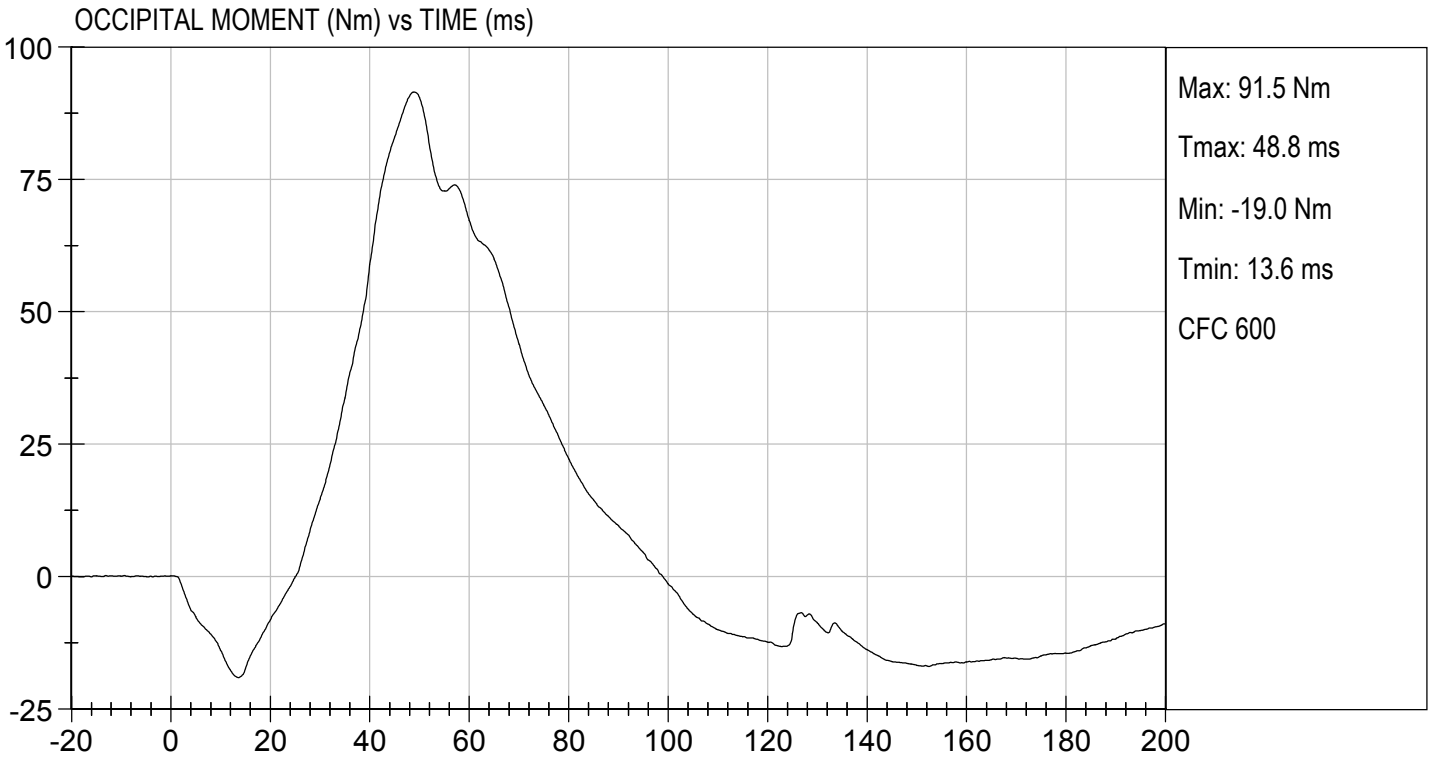



NECK ROTATION (DEG) vs TIME (ms)



TEST DESC: NECK FLEXION
VELOCITY: 23.15 ft/s, 7.06 m/s

TEST DATE: 02/25/2021
TEST #: D210572



**MGA RESEARCH CORPORATION**

**NECK EXTENSION TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210573

| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Laboratory Temperature | | deg C | 20.6 to 22.2 | 21.4 | Pass |
| Laboratory Relative Humidity | | % | 10 to 70 | 21 | Pass |
| Pendulum Velocity | | m/s | 5.95 to 6.19 | 6.18 | Pass |
| Pendulum Deceleration | 10 ms | G's | 17.20 to 21.20 | 17.59 | Pass |
| | 20 ms | G's | 14.00 to 19.00 | 16.70 | Pass |
| | 30 ms | G's | 11.00 to 16.00 | 14.00 | Pass |
| Peak Pendulum Deceleration After 30 ms | | G's | <= 22.0 | 14.1 | Pass |
| Deceleration Decay Time to Cross 5 G's | | ms | 38.0 to 46.0 | 40.2 | Pass |
| Maximum "D" Plane Rotation | Maximum | Degrees | 81.0 to 106.0 | 97.4 | Pass |
| | Time | ms | 72.0 to 82.0 | 76.4 | Pass |
| "D" Plane Rotation Decay Time To Zero Crossing | | ms | 147.0 to 174.0 | 160.1 | Pass |
| Moment About Occipital Condyle | Maximum | Nm | -52.9 to -79.9 | -61.2 | Pass |
| | Time | ms | 65.0 to 79.0 | 72.3 | Pass |
| Negative Moment Decay Time To Zero Crossing | | ms | 120.0 to 148.0 | 143.1 | Pass |
| | | | Overall Test Results | | Pass |

Laboratory Technician

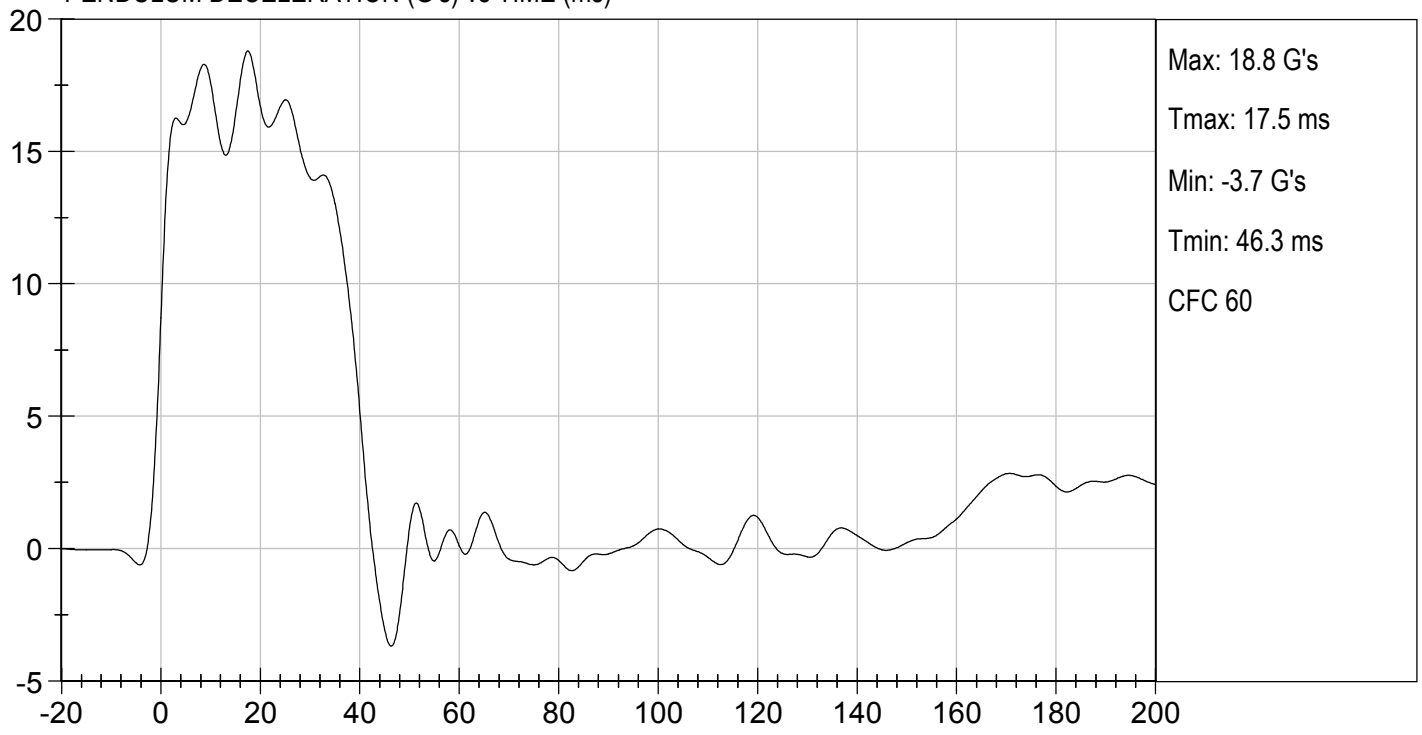
02/25/2021
Test Date

Approved By

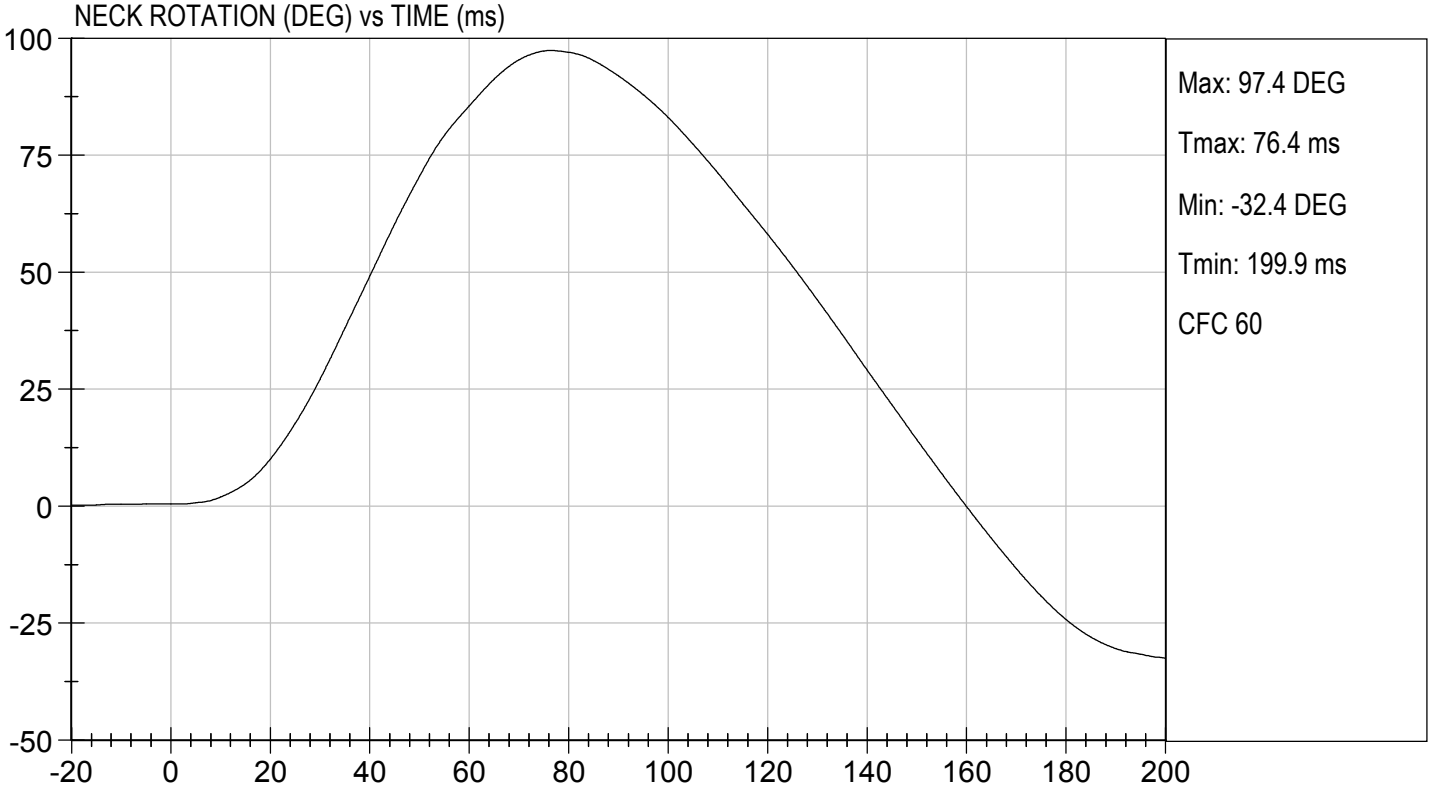
TEST DESC: NECK EXTENSION
VELOCITY: 20.28 ft/s, 6.18 m/s

TEST DATE: 02/25/2021
TEST #: D210573

PENDULUM DECELERATION (G's) vs TIME (ms)

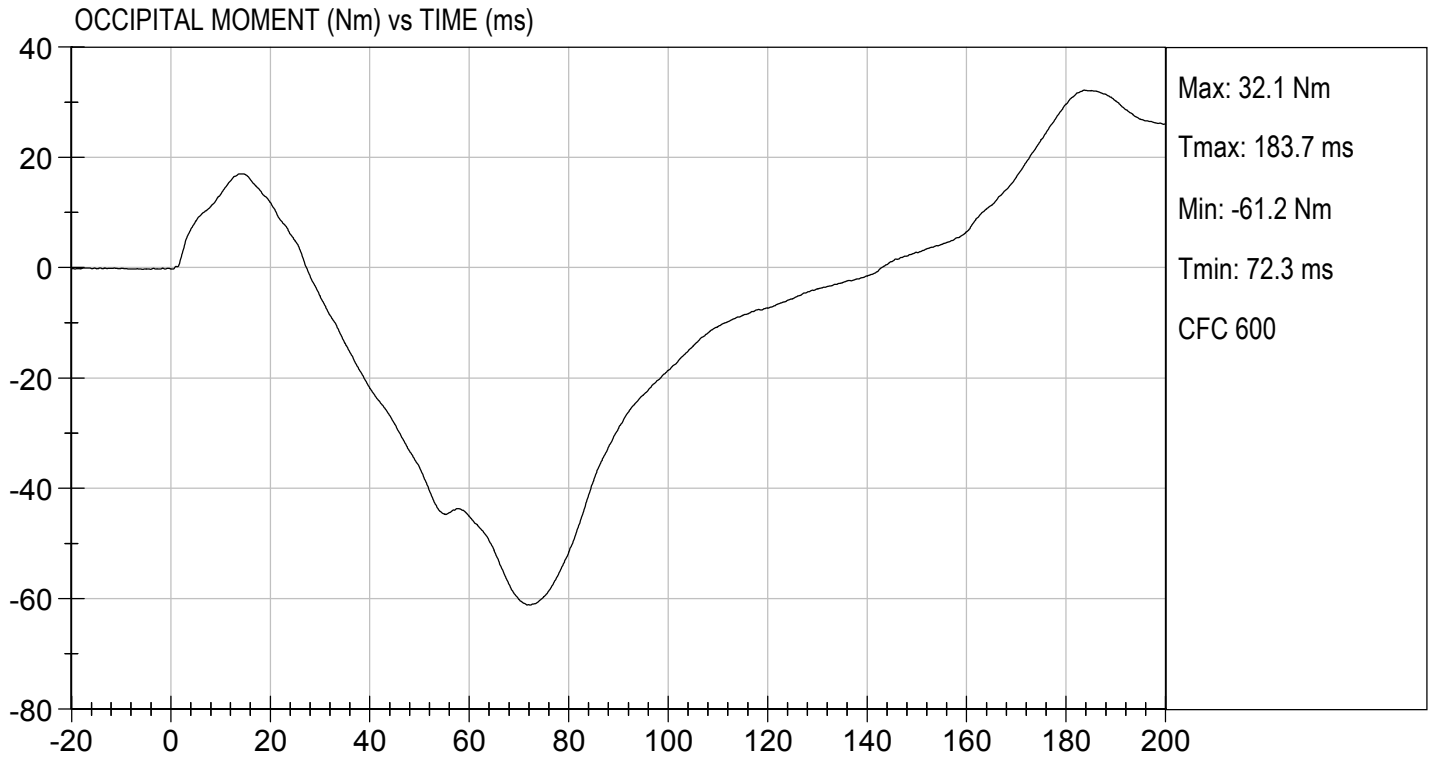



NECK ROTATION (DEG) vs TIME (ms)



TEST DESC: NECK EXTENSION
VELOCITY: 20.28 ft/s, 6.18 m/s

TEST DATE: 02/25/2021
TEST #: D210573



**MGA RESEARCH CORPORATION**

**THORAX IMPACT**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210574

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 20.6 to 22.2 | 21.8 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 28 | Pass |
| Probe Velocity | m/s | 6.58 to 6.82 | 6.68 | Pass |
| Peak Probe Force | N | 5159 to 5893 | 5,388 | Pass |
| Peak Sternum Displacement | cm | 6.35 to 7.26 | 7.22 | Pass |
| Internal Hysteresis | % | 69 to 85 | 69 | Pass |
| | | Overall Test Results | | Pass |

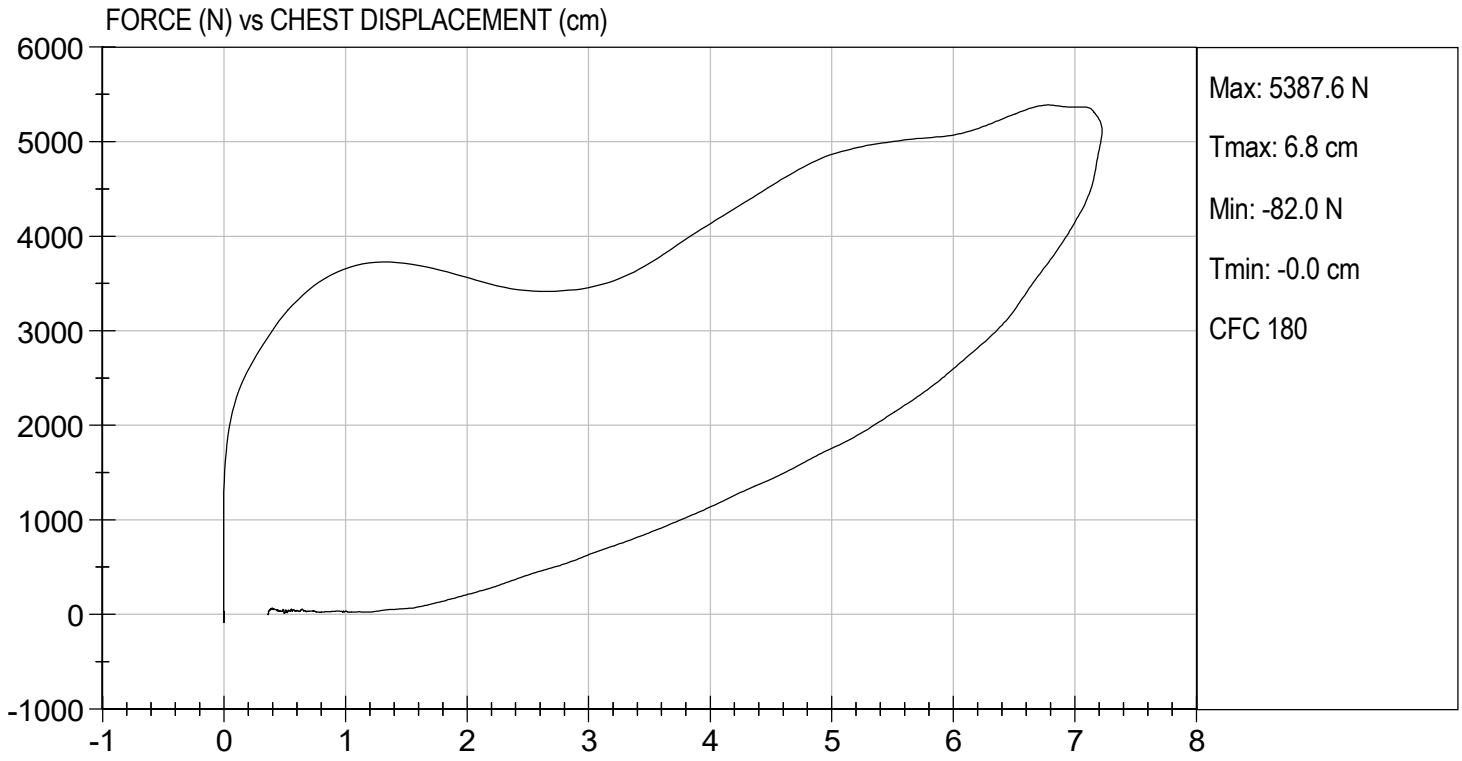
Laboratory Technician

02/24/2021
Test Date

Approved By

TEST DESC: THORAX IMPACT
VELOCITY: 21.93 ft/s, 6.68 m/s

TEST DATE: 02/24/2021
TEST #: D210574



**MGA RESEARCH CORPORATION**

**RIGHT KNEE IMPACT TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210575

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.8 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 20 | Pass |
| Probe Velocity | m/s | 2.07 to 2.13 | 2.07 | Pass |
| Peak Probe Force | N | 4715 to 5782 | 4,914 | Pass |
| | | Overall Test Results | | Pass |

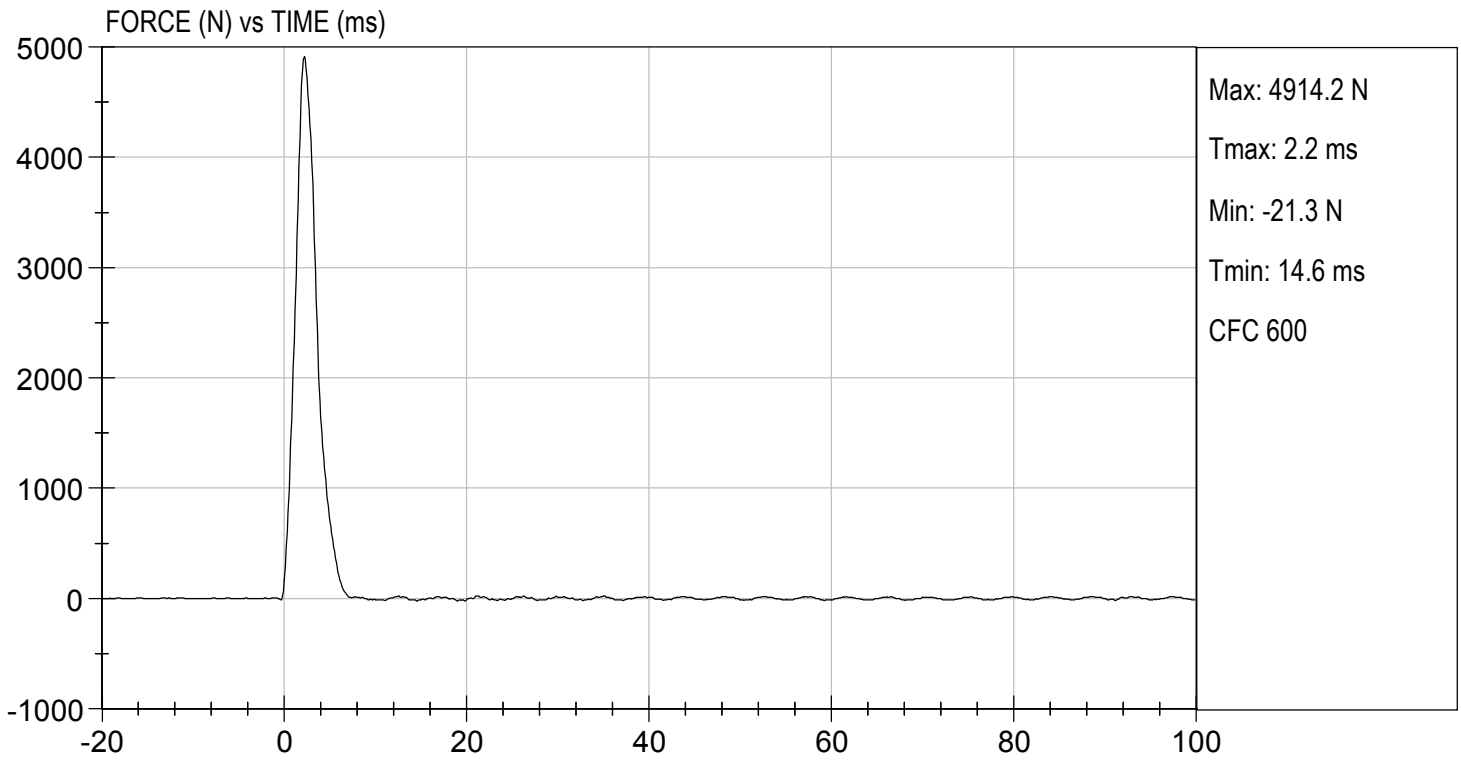
Laboratory Technician

02/26/2021
Test Date

Approved By

TEST DESC: RIGHT KNEE
VELOCITY: 6.79 ft/s, 2.07 m/s

TEST DATE: 02/26/2021
TEST #: D210575



**MGA RESEARCH CORPORATION**

**LEFT KNEE IMPACT TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210576

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.8 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 20 | Pass |
| Probe Velocity | m/s | 2.07 to 2.13 | 2.09 | Pass |
| Peak Probe Force | N | 4715 to 5782 | 4,872 | Pass |
| | | Overall Test Results | | Pass |

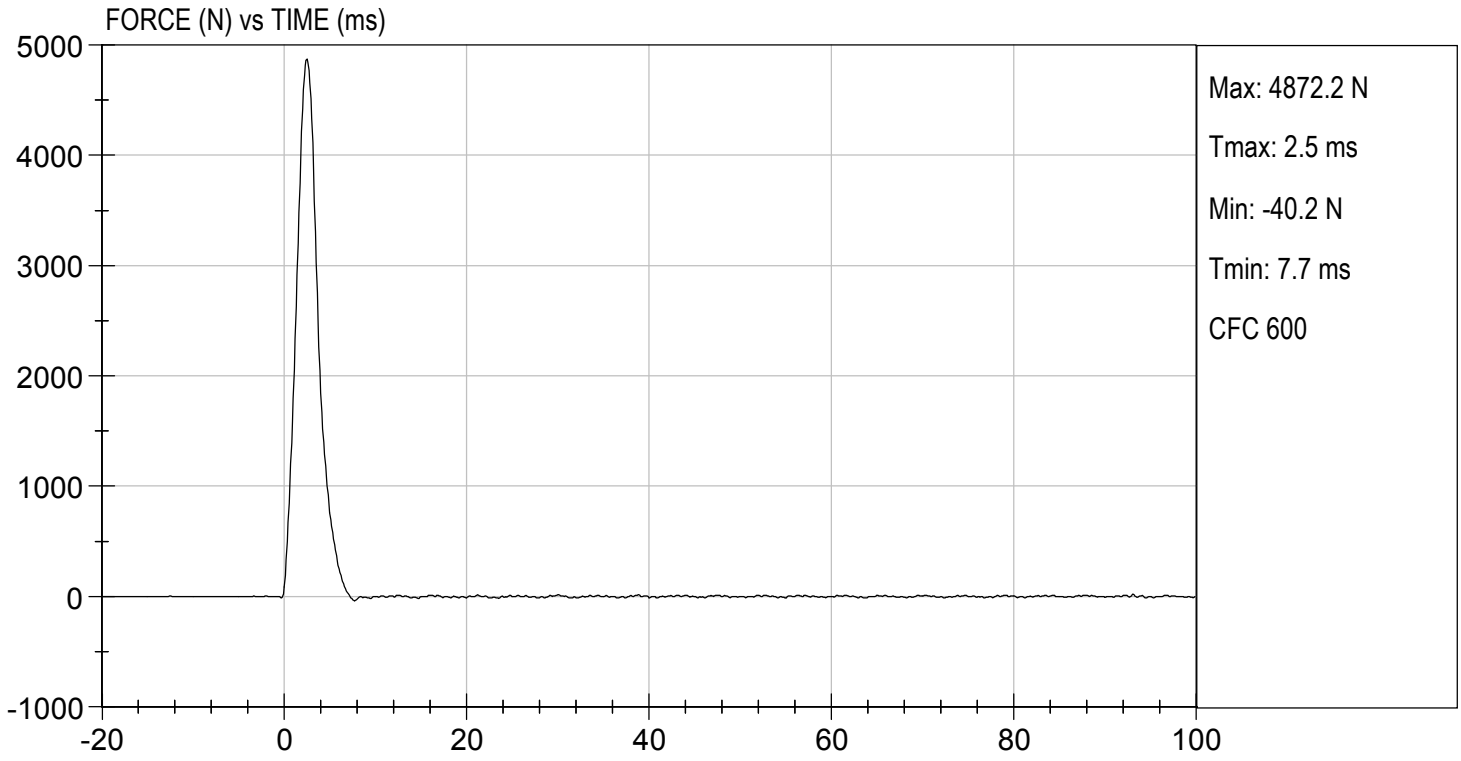
Laboratory Technician

02/26/2021
Test Date

Approved By

TEST DESC: LEFT KNEE
VELOCITY: 6.86 ft/s, 2.09 m/s

TEST DATE: 02/26/2021
TEST #: D210576



**MGA RESEARCH CORPORATION**

**HIP-FEMUR FLEXION TEST**

**HYBRID III 50TH PERCENTILE MALE**

**ATD Serial No:** 351 **Test I.D:** D210570

| Tested Parameter | Units | Specification | Result | | Pass/Fail |
|---|---|---|---|---|---|
| | | | Right | Left | |
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.7 | 21.7 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 23 | 23 | Pass |
| Rotation Rate | deg/s | 5.0 to 10.0 | 6.4 | 6.4 | Pass |
| 30 Degrees | Nm | 94.9 Nm Max | 85.5 | 89.5 | Pass |
| 150 ft-lbf / 203.4 Nm | Deg | 40.0 to 50.0 Degree Max Rotation | 44.5 | 44.4 | Pass |
| | | Overall Test Results | | | Pass |

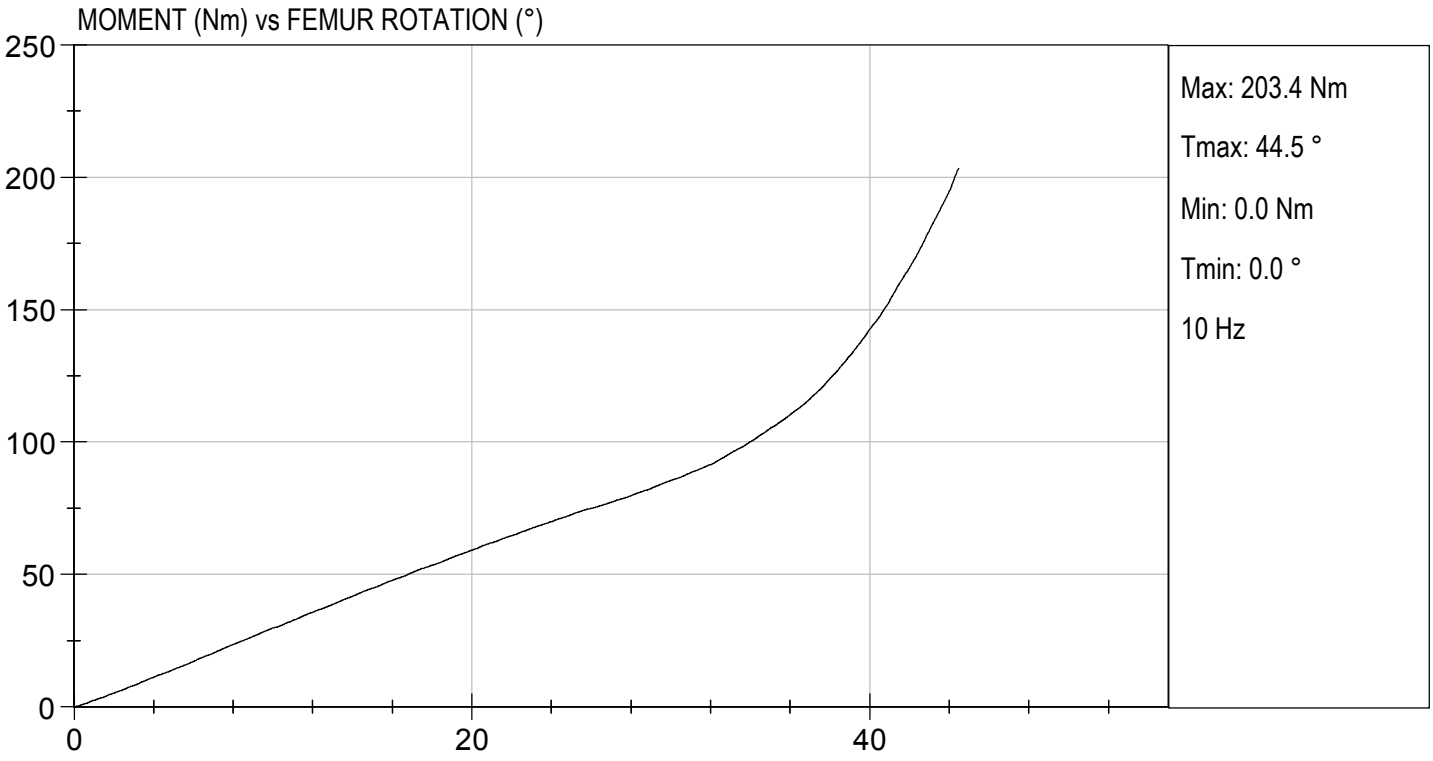
Laboratory Technician

02/25/2021
Test Date

Approved By

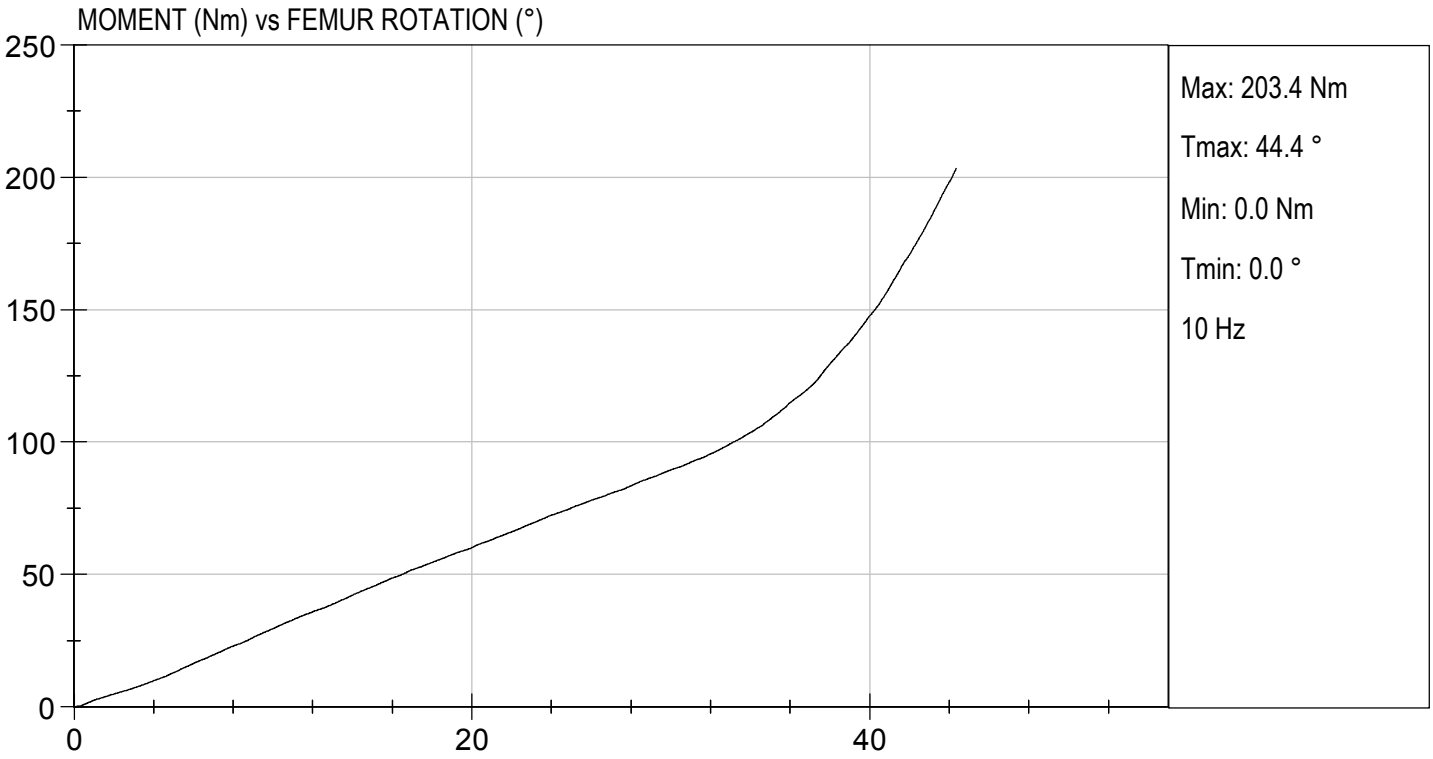
TEST DESC: RIGHT HIP FEMUR FLEXION

TEST DATE: 02/25/2021
TEST #: D210579



TEST DESC: LEFT HIP FEMUR FLEXION

TEST DATE: 02/25/2021
TEST #: D210570



## CALIBRATION TEST RESULTS

## PRE-TEST

## HYBRID III 5TH PERCENTILE FEMALE - PASSENGER ATD

## Hybrid III, 5th External Measurements
## SN: DH1659

| HYBRID III, PART 572, SUBPART O EXTERNAL DIMENSIONS | | | | |
|---|---|---|---|---|
| DIMENSION | DESCRIPTION | DETAILS | ASSEMBLY DIMENSION (mm) | ACTUAL MEASUREMENT |
| A | TOTAL SITTING HEIGHT | Seat surface to highest point on top of the head. | 774.7-800.1 | 778 |
| B | SHOULDER PIVOT HEIGHT | Centerline of shoulder pivot bolt to the seat surface. | 431.8-457.2 | 440 |
| C | H-POINT HEIGHT | Reference | 81.3-86.3 | 85 |
| D | H-POINT LOCATION FROM BACKLINE | Reference | 144.8-149.8 | 147 |
| E | SHOULDER PIVOT FROM BACKLINE | Center of the shoulder clevis to the rear vertical surface of the fixture. | 68.6-83.8 | 82 |
| F | THIGH CLEARANCE | Measured at the highest point on the upper femur segment. | 119.4-134.6 | 130 |
| G | BACK OF ELBOW TO WRIST PIVOT | back of the elbow flesh to the wrist pivot in line with the elbow and wrist pivots | 243.9-259.1 | 251 |
| H | HEAD BACK TO BACKLINE | Back of Skull cap skin to seat rear vertical surface (Reference) | 43.2-48.2 | 45 |
| I | SHOULDER TO- ELBOW LENGTH | Measure from the highest point on top of the shoulder clevis to the lowest part of the flesh on the elbow in line with the elbow pivot bolt. | 276.8-297.2 | 285 |
| J | ELBOW REST HEIGHT | Measure from the flesh below the elbow pivot bolt to the seat surface. | 182.8-203.2 | 189 |
| K | BUTTOCK TO KNEE LENGTH | The forward most part of the knee flesh to the rear vertical surface of the fixture. | 520.7-546.1 | 543 |
| L | POPLITEAL HEIGHT | Seat surface to the plane of the horizontal plane of the bottom of the feet. | 355.6-376 | 357 |
| M | KNEE PIVOT HEIGHT | Centerline of knee pivot bolt to the horizontal plane of the bottom of the feet. | 393.7-419.1 | 398 |
| N | BUTTOCK POPLITEAL LENGTH | The rearmost surface of the lower leg to the same point on the rear surface of the buttocks used for dim. “K”. | 414-439.4 | 435 |

| HYBRID III, SUBPART O EXTERNAL DIMENSIONS, continued | | | | |
|---|---|---|---|---|
| DIMENSION | DESCRIPTION | DETAILS | ASSEMBLY DIMENSION (mm) | ACTUAL MEASUREMENT |
| O | CHEST DEPTH WITHOUT JACKET | Measured 304.8 ± 5.1 mm above seat surface | 175.3-190.5 | 182 |
| P | FOOT LENGTH | Tip of toe to rear of heal | 218.5-233.7 | 221 |
| Q | STANDING HEIGHT | (THEORETICAL) | 1501.1 | N/A |
| R | BUTTOCK TO KNEE PIVOT LENGTH | The rear surface of the buttocks to the knee pivot bolt | 457.2-482.6 | 469 |
| S | HEAD BREADTH | The widest part of the head | 137.1-147.3 | 141 |
| T | HEAD DEPTH | Back of the head to the forehead | 177.8-188 | 182 |
| U | HIP BREADTH | The widest part of the hip | 299.7-314.9 | 306 |
| V | SHOULDER BREADTH | Outside edges of right and left shoulder clevises | 350.5-365.7 | 357 |
| W | FOOT BREADTH | The widest part of the foot | 78.8-94 | 83 |
| X | HEAD CIRCUMFERENCE | Measured at the point as in dim. “T” | 528.3-548.7 | 542 |
| Y | CHEST CIRCUMFERENCE (WITH CHEST JACKET) | Measured 345.4 ± 12.7 mm above seat surface | 850.9-881.3 | 865 |
| Z | WAIST CIRCUMFERENCE | Measured 165.1 ± 5.1 mm above seat surface | 759.5-789.9 | 785 |
| AA | REFERENCE LOCATION FOR MEASUREMENT OF CHEST CIRCUMFERENCE | Reference | 332.7-358.1 | 345 |
| BB | REFERENCE LOCATION FOR MEASUREMENT OF WAIST CIRCUMFERENCE | Reference | 160.1-170.2 | 165 |

**MGA RESEARCH CORPORATION**

**HEAD DROP TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test ID:** D210361

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 20.8 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 13 | Pass |
| Peak Resultant Acceleration | G's | 250 to 300 | 278 | Pass |
| Peak Lateral Acceleration | G's | <= +/- 15.0 | -6.6 | Pass |
| Unimodal | N/A | Yes | Yes | Pass |
| Oscillations | N/A | within 10% of peak | Yes | Pass |
| | | Overall Test Results | | Pass |

Gerald Guerrero
Laboratory Technician

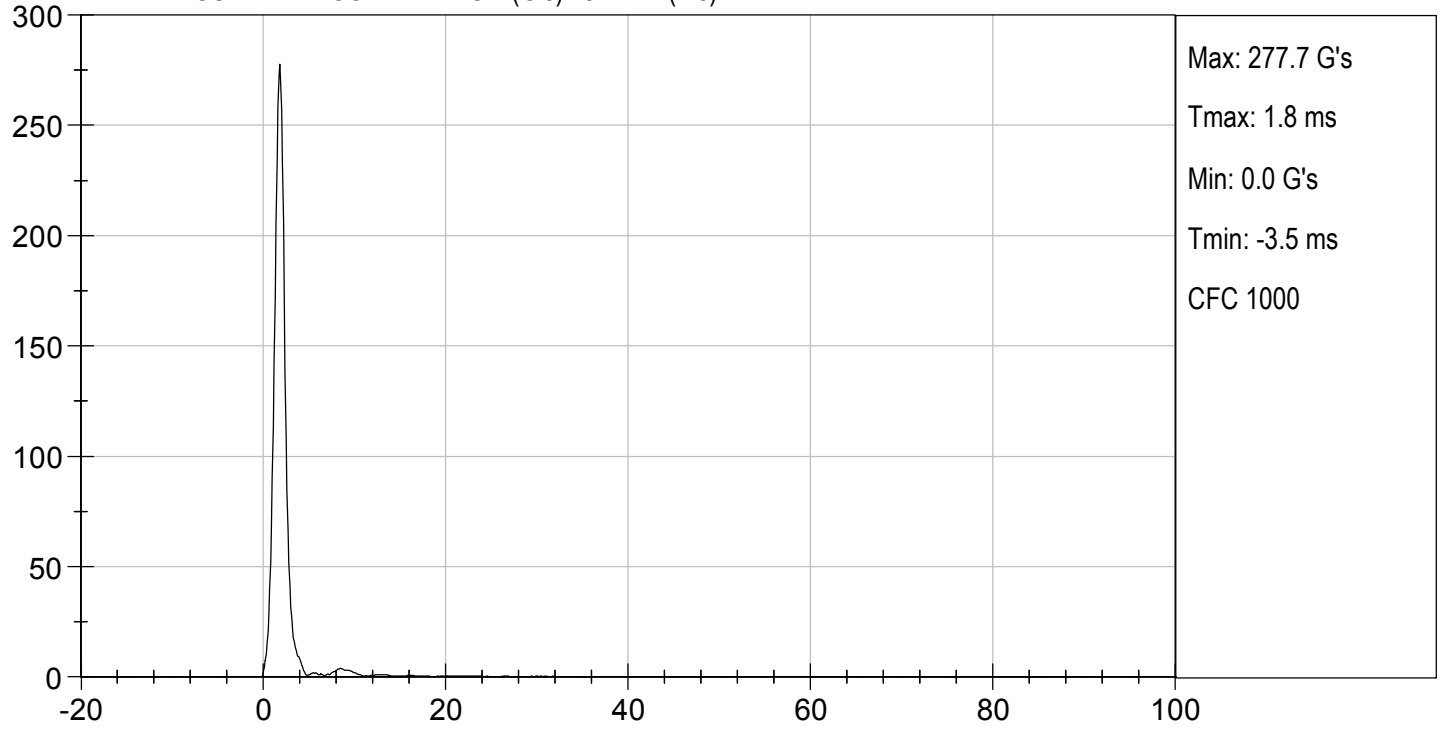
02/12/2021
Test Date

Approved By

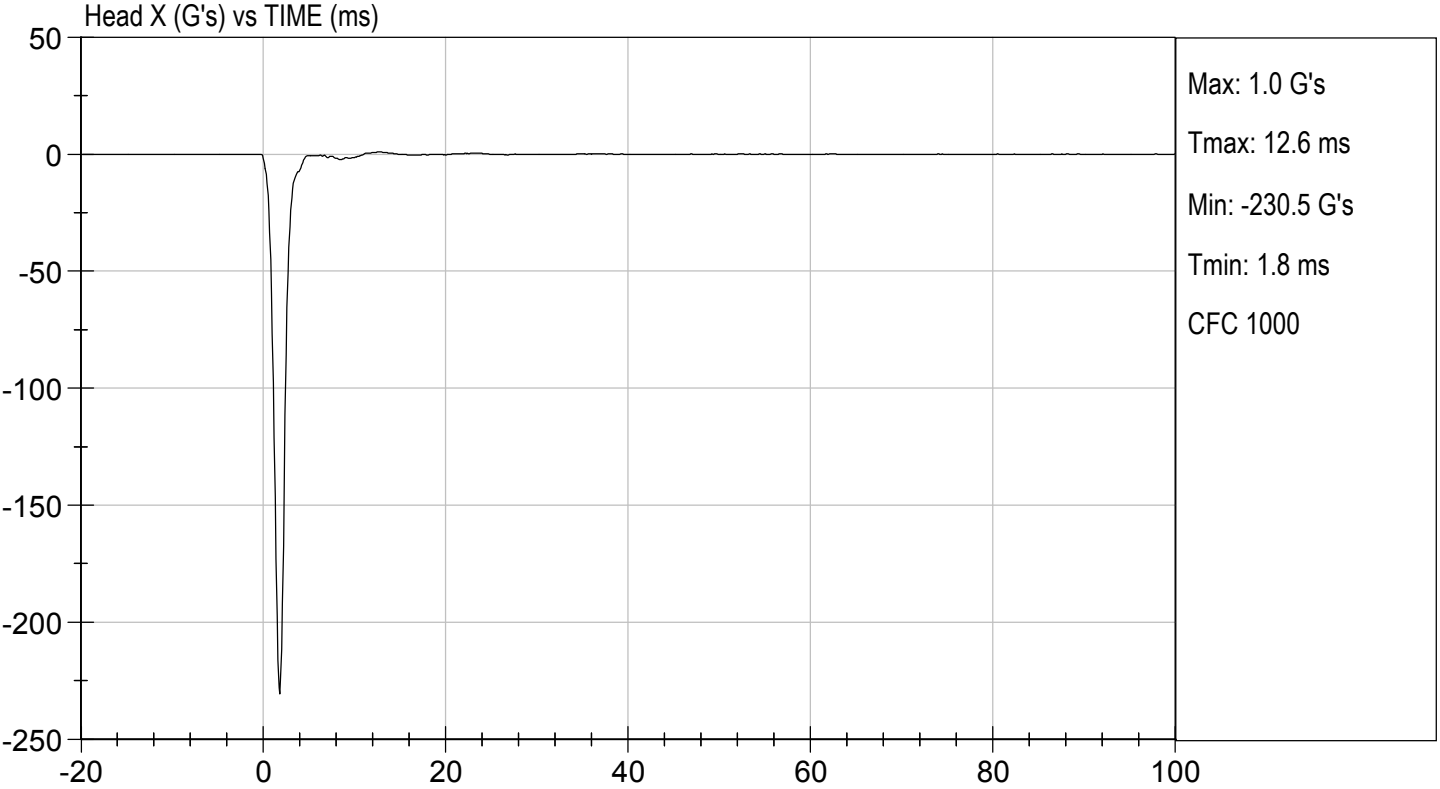
TEST DESC: HEAD DROP

TEST DATE: 02/12/2021
TEST #: D210361

HEAD RESULTANT ACCELERATION (G's) vs TIME (ms)

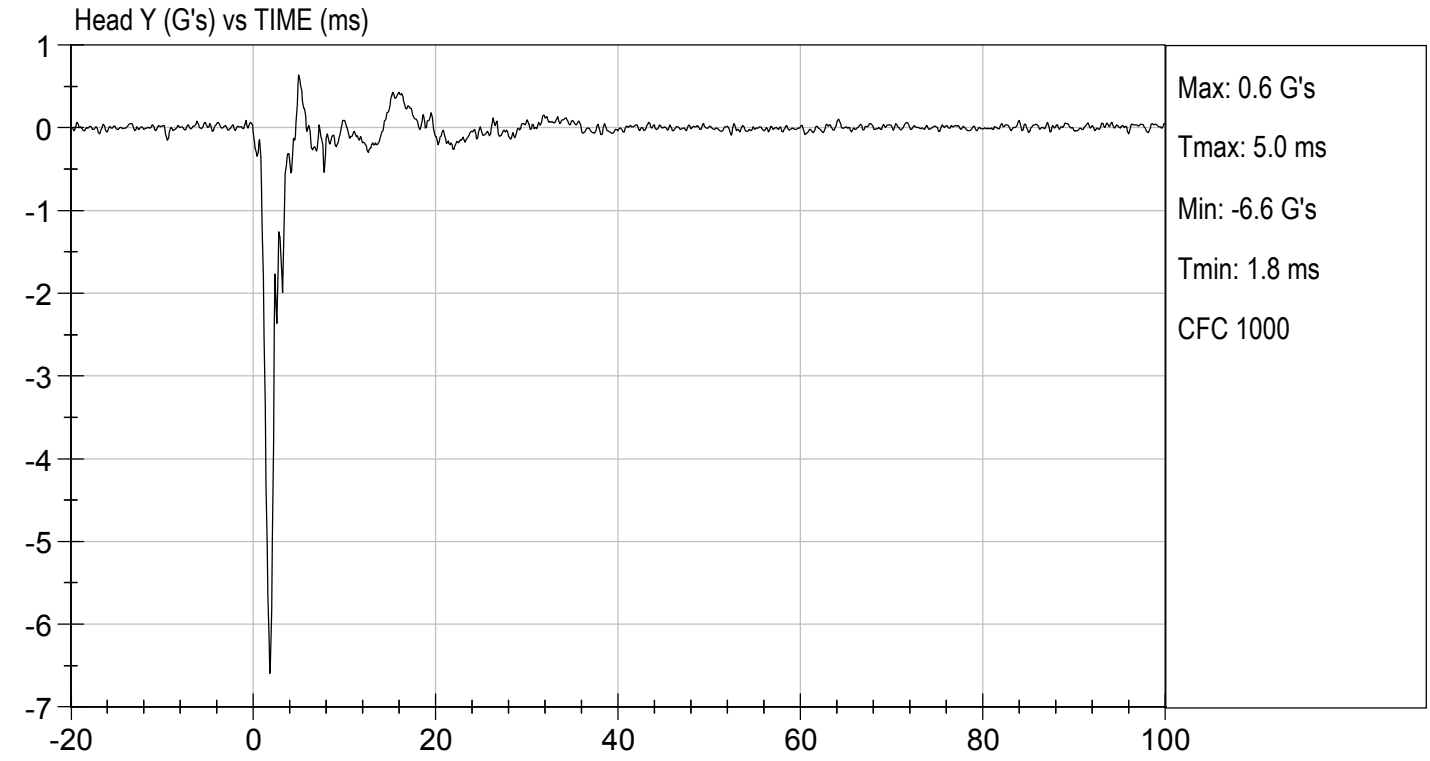


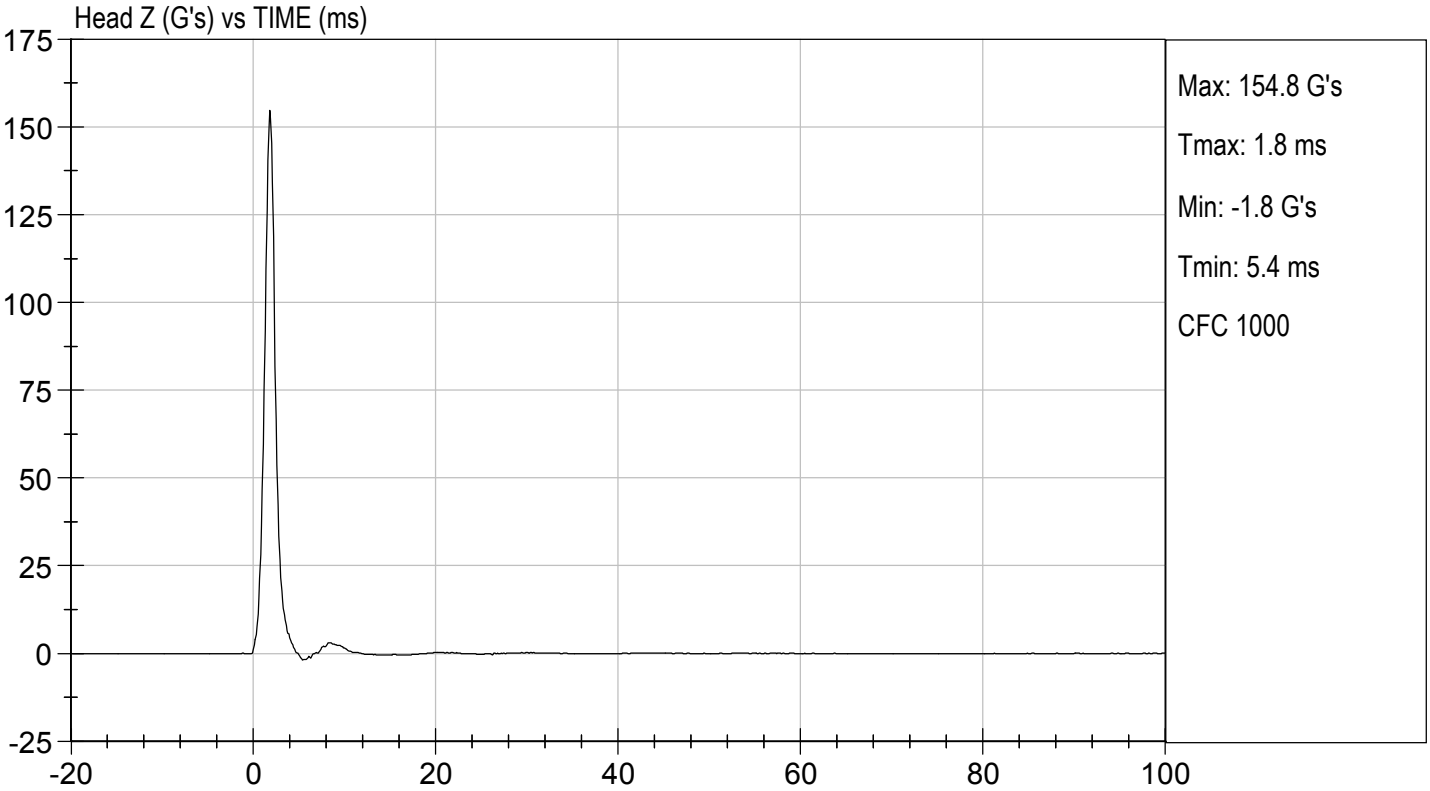

Head X (G's) vs TIME (ms)



TEST DESC: HEAD DROP

TEST DATE: 02/12/2021
TEST #: D210361



**MGA RESEARCH CORPORATION**

**NECK FLEXION TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210362

| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Laboratory Temperature | | deg C | 20.6 to 22.2 | 21.0 | Pass |
| Laboratory Relative Humidity | | % | 10 to 70 | 18 | Pass |
| Pendulum Speed | | m/s | 6.89 to 7.13 | 7.06 | Pass |
| Pendulum Velocity | 10 ms | m/s | 2.1 to 2.5 | 2.4 | Pass |
| | 20 ms | m/s | 4.0 to 5.0 | 4.8 | Pass |
| | 30 ms | m/s | 5.8 to 7.0 | 6.8 | Pass |
| D Plane Rotation | Max | deg | 77 to 91 | 81 | Pass |
| Occipital Condyle Moment within Rotation Corridor | | Nm | 69 to 83 | 71 | Pass |
| Positive Moment Time Curve Decay to 10 Nm | | ms | 80 to 100 | 83 | Pass |
| | | | Overall Results | | Pass |

Alex Thomas

Laboratory Technician

02/11/2021

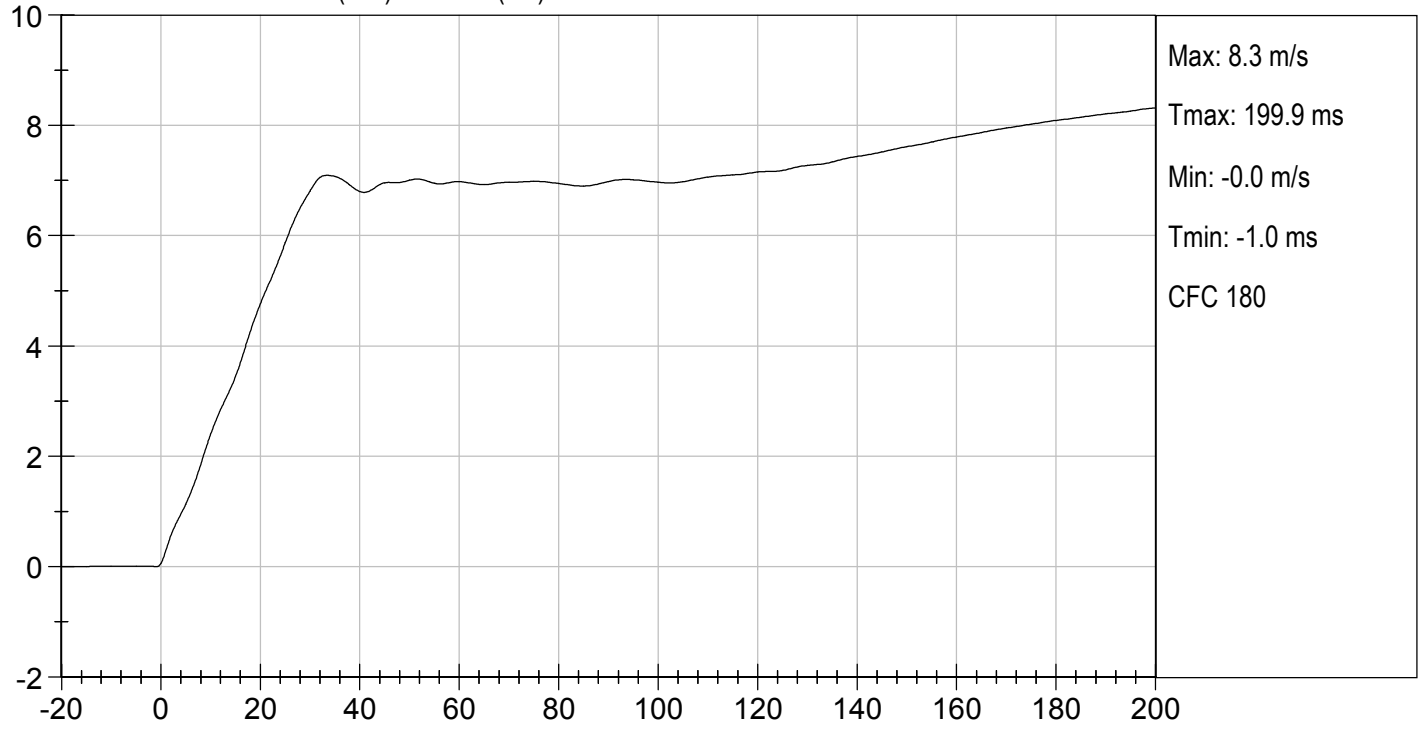
Test Date

Approved By

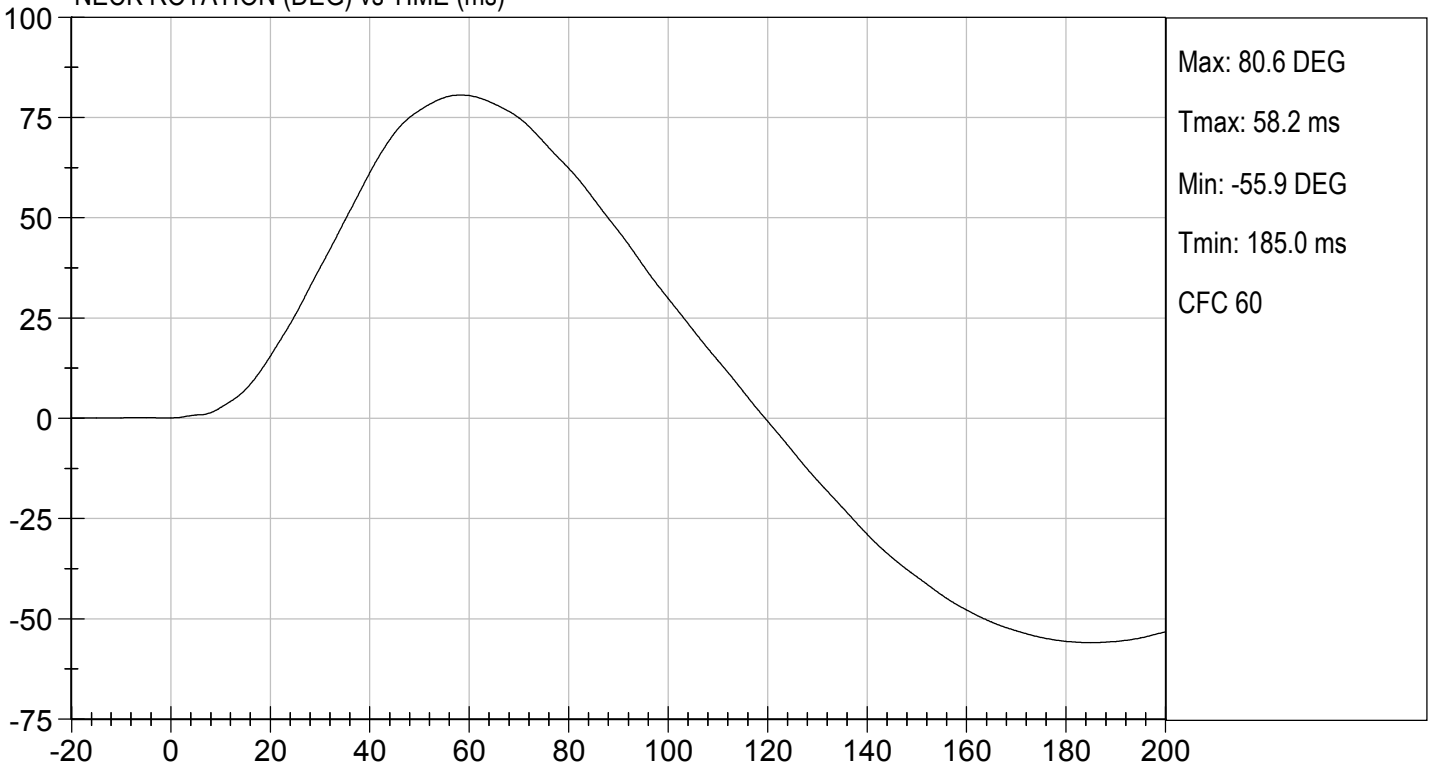
TEST DESC: NECK FLEXION
VELOCITY: 23.15 ft/s, 7.06 m/s

TEST DATE: 02/11/2021
TEST #: D210362

PENDULUM VELOCITY (m/s) vs TIME (ms)

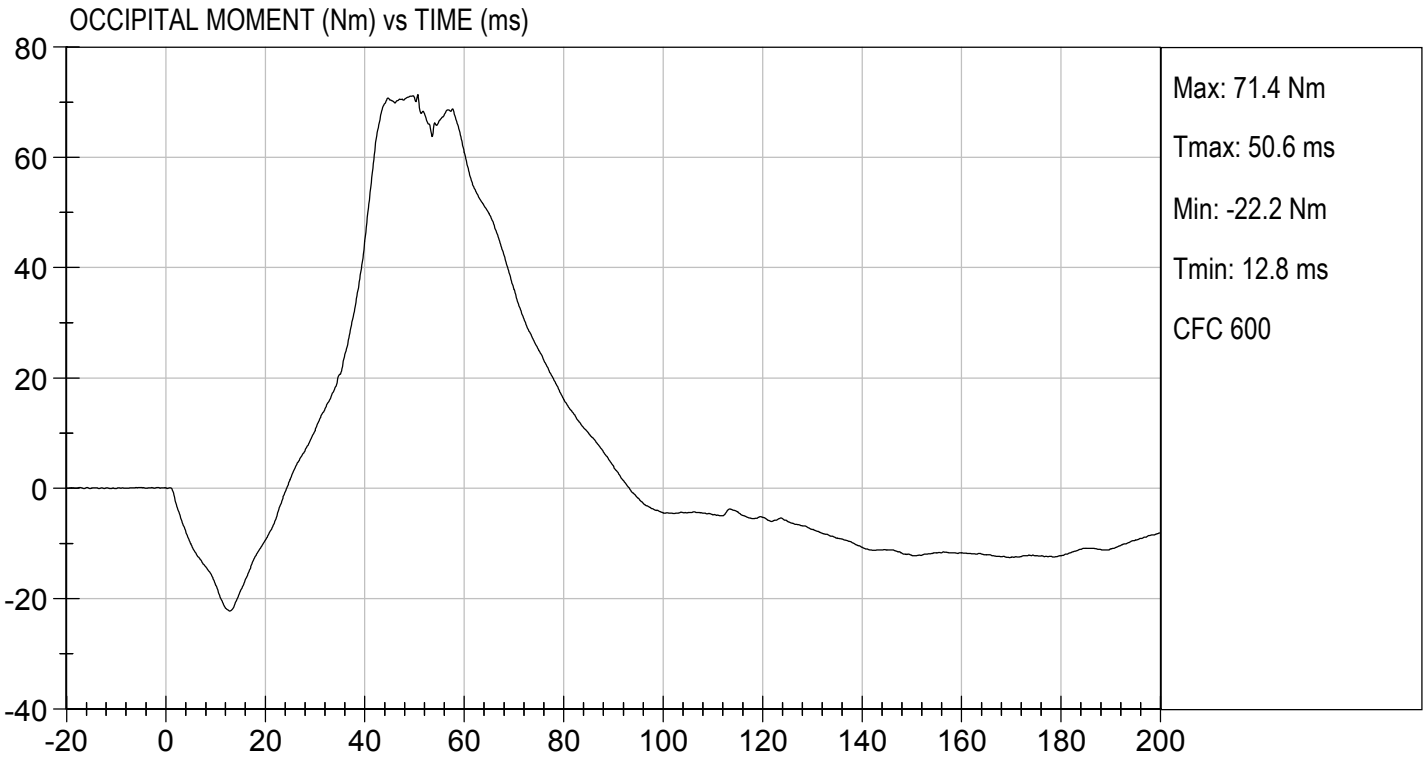



NECK ROTATION (DEG) vs TIME (ms)



TEST DESC: NECK FLEXION
VELOCITY: 23.15 ft/s, 7.06 m/s

TEST DATE: 02/11/2021
TEST #: D210362



**MGA RESEARCH CORPORATION**

**NECK EXTENSION TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210363

| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Laboratory Temperature | | deg C | 20.6 to 22.2 | 21.0 | Pass |
| Laboratory Relative Humidity | | % | 10 to 70 | 18 | Pass |
| Pendulum Speed | | m/s | 5.95 to 6.19 | 6.12 | Pass |
| Pendulum Velocity | 10 ms | m/s | 1.5 to 1.9 | 1.9 | Pass |
| | 20 ms | m/s | 3.1 to 3.9 | 3.7 | Pass |
| | 30 ms | m/s | 4.6 to 5.6 | 5.4 | Pass |
| D Plane Rotation | Max | deg | 99 to 114 | 107 | Pass |
| Occipital Condyle Moment within Rotation Corridor | | Nm | -65 to -53 | -57 | Pass |
| Negative Moment Time Curve Decay to -10 Nm | | ms | 94 to 114 | 103 | Pass |
| | | | Overall Results | | Pass |

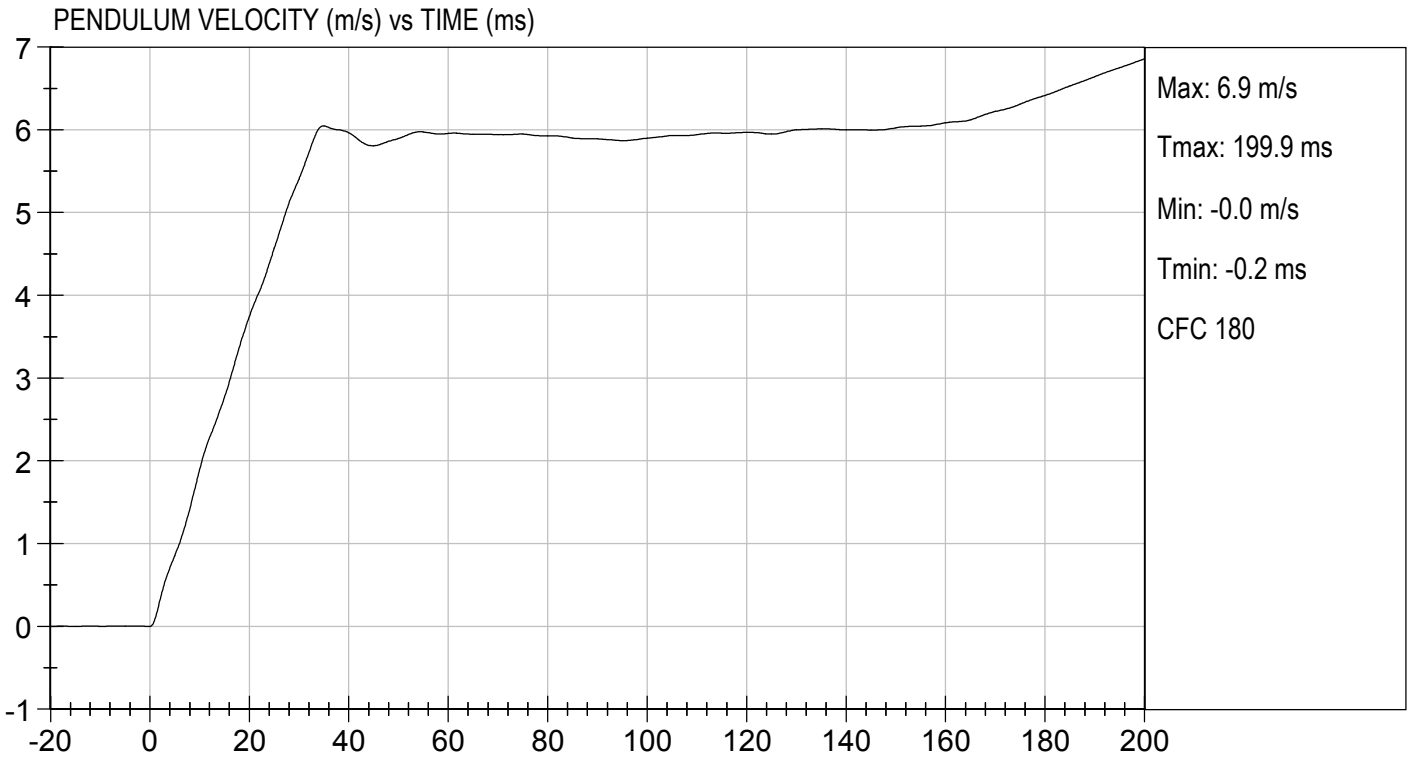
Laboratory Technician

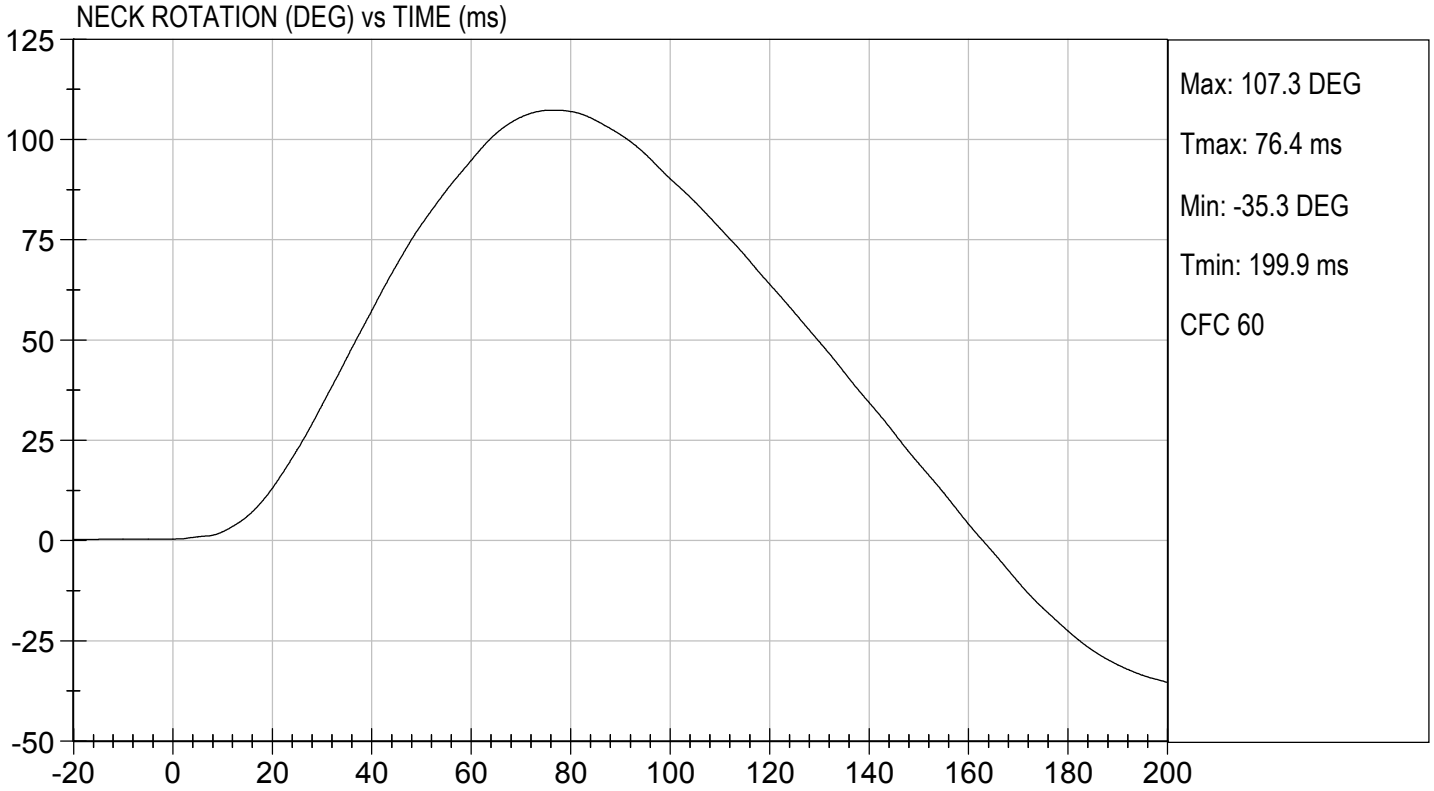
02/11/2021
Test Date

Approved By

TEST DESC: NECK EXTENSION
VELOCITY: 20.08 ft/s, 6.12 m/s

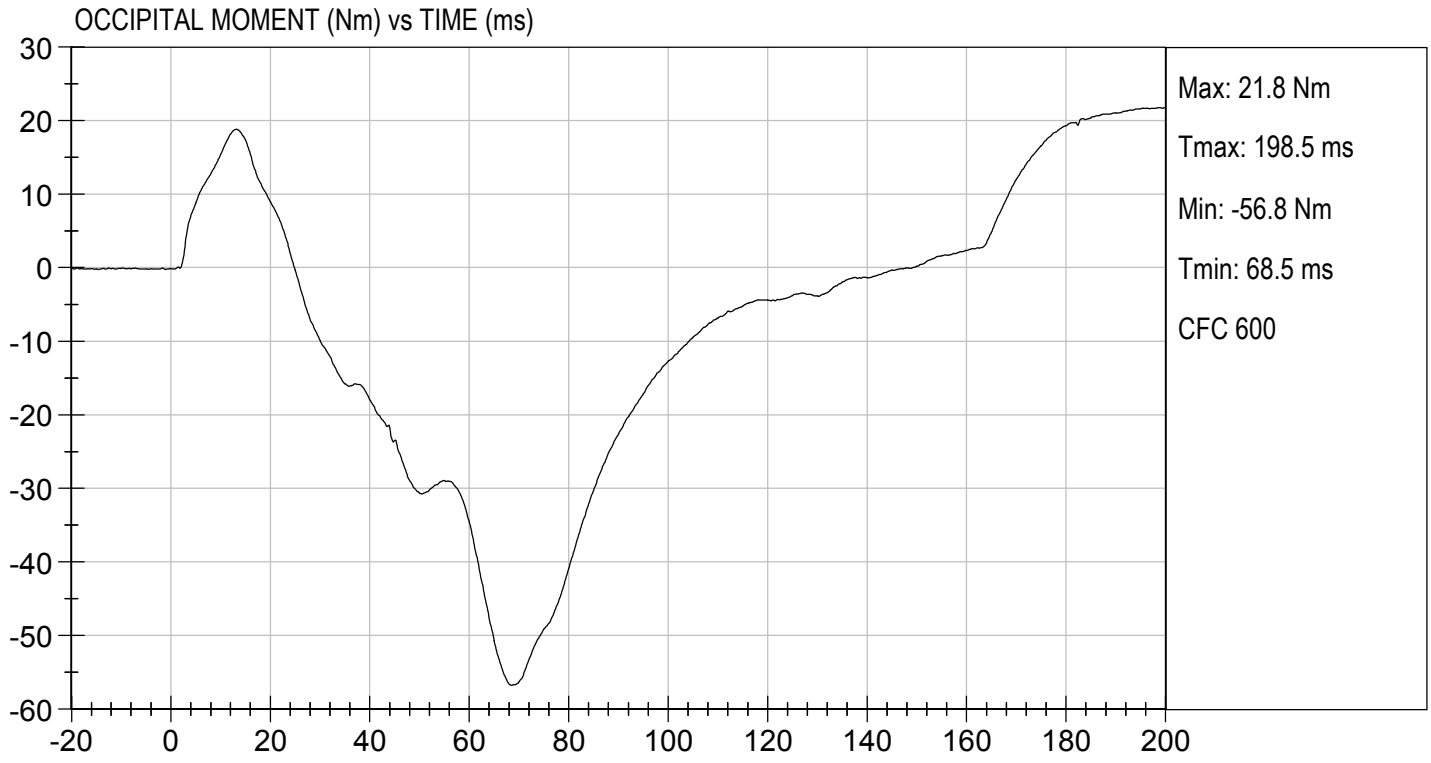
TEST DATE: 02/11/2021
TEST #: D210363



TEST DESC: NECK EXTENSION
VELOCITY: 20.08 ft/s, 6.12 m/s

TEST DATE: 02/11/2021
TEST #: D210363



**MGA RESEARCH CORPORATION**

**THORAX IMPACT**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210364

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Temperature | deg C | 20.6 to 22.2 | 20.8 | Pass |
| Relative Humidity | % | 10 to 70 | 13 | Pass |
| Probe Speed | m/s | 6.59 to 6.83 | 6.77 | Pass |
| Peak Deflection | mm | 50 to 58 | 51 | Pass |
| Peak Resistive Force w/in Deflection Corridor | N | 3900 to 4400 | 4382 | Pass |
| Internal Hysteresis | % | 69 to 85 | 74 | Pass |
| Peak Force 18 mm - 50 mm | N | <= 4600 | 4486 | Pass |
| | | Overall Test Results | | Pass |

Gerald Guerrero
Laboratory Technician

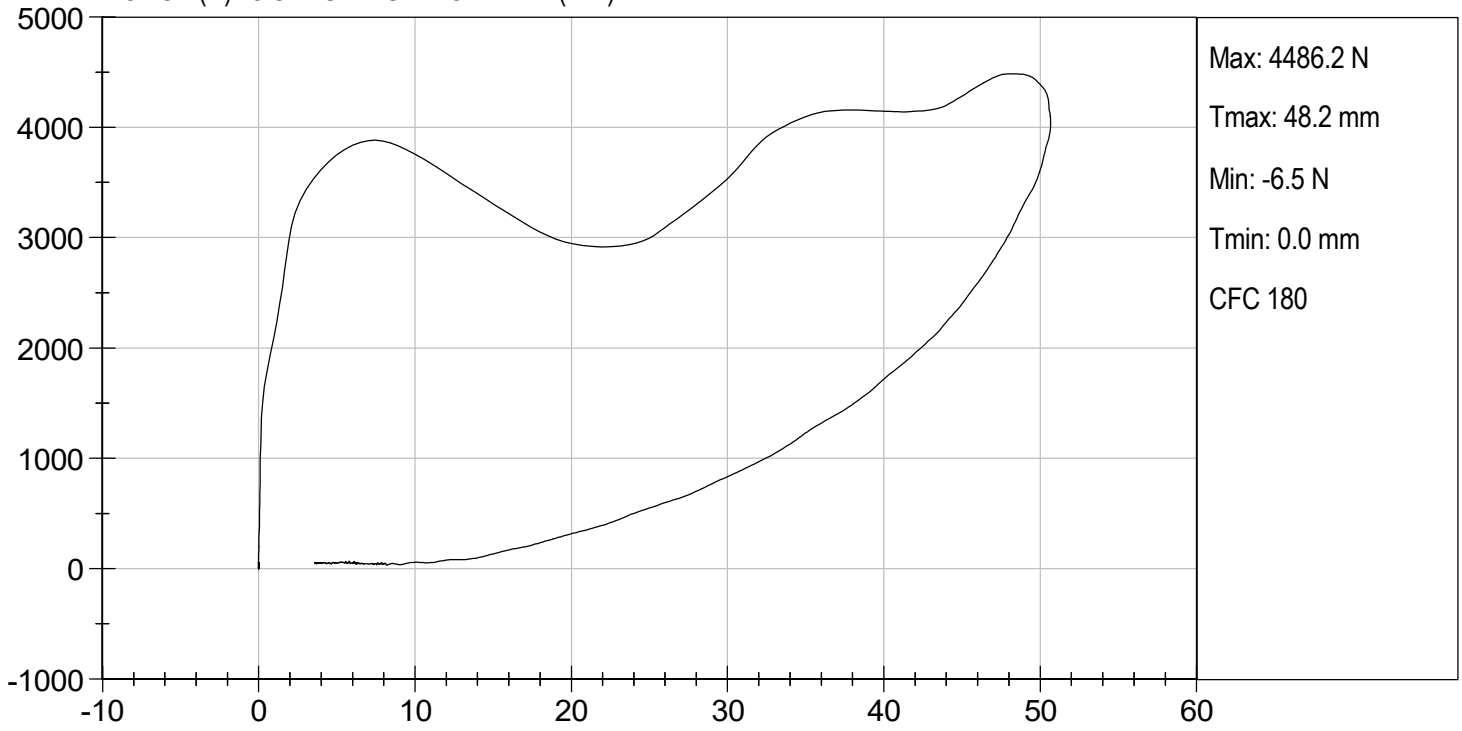
02/12/2021
Test Date

Approved By

TEST DESC: THORAX IMPACT
VELOCITY: 22.22 ft/s, 6.77 m/s

TEST DATE: 02/12/2021
TEST #: D210364

FORCE (N) vs CHEST DISPLACEMENT (mm)



**MGA RESEARCH CORPORATION**

**RIGHT KNEE IMPACT TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210365

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.7 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 21 | Pass |
| Probe Speed | m/s | 2.07 to 2.13 | 2.09 | Pass |
| Maximum Force | N | 3450 to 4060 | 3831 | Pass |
| | | Overall Test Results | | Pass |

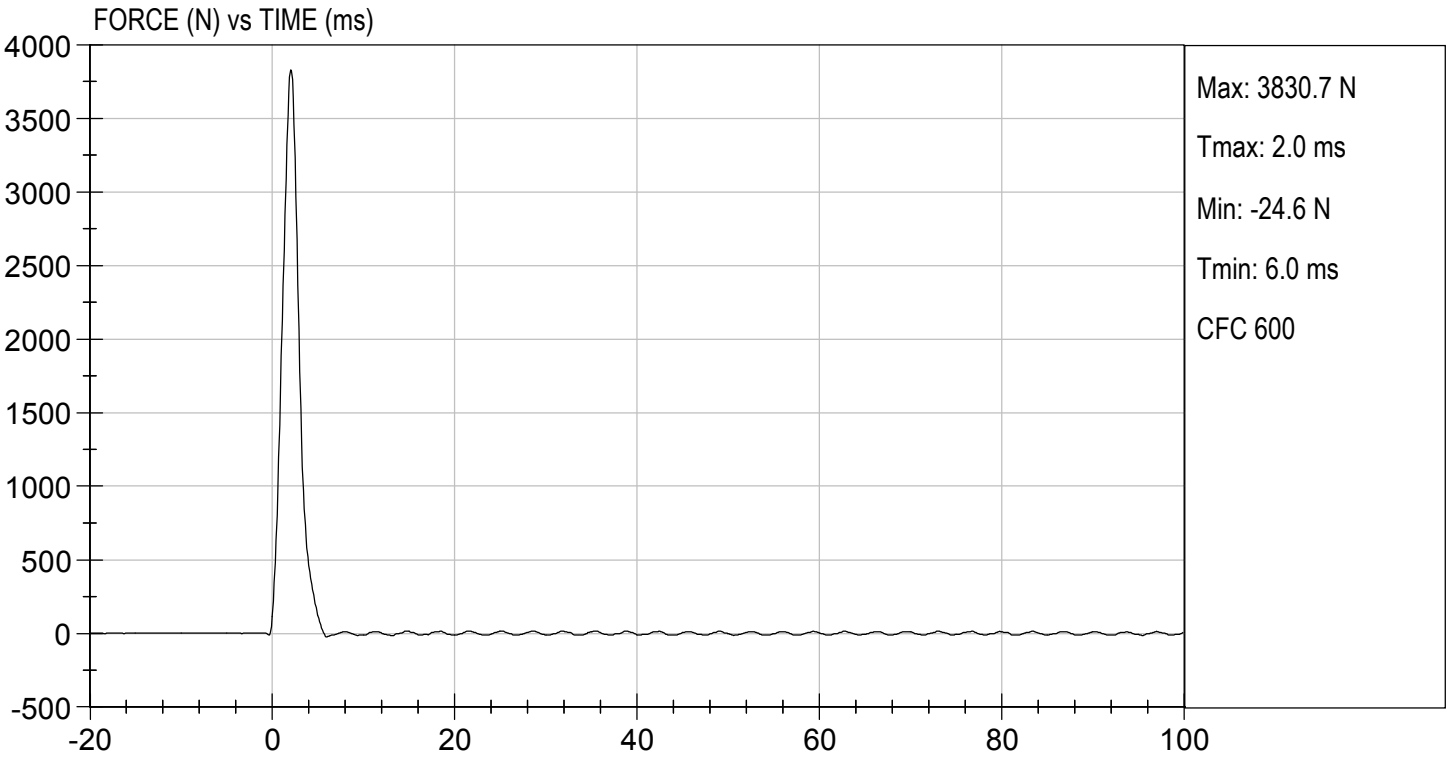
Laboratory Technician

02/11/2021
Test Date

Approved By

TEST DESC: RIGHT KNEE
VELOCITY: 6.86 ft/s, 2.09 m/s

TEST DATE: 02/11/2021
TEST #: D210365



**MGA RESEARCH CORPORATION**

**LEFT KNEE IMPACT TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210366

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.7 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 21 | Pass |
| Probe Speed | m/s | 2.07 to 2.13 | 2.08 | Pass |
| Maximum Force | N | 3450 to 4060 | 3755 | Pass |
| | | Overall Test Results | | Pass |

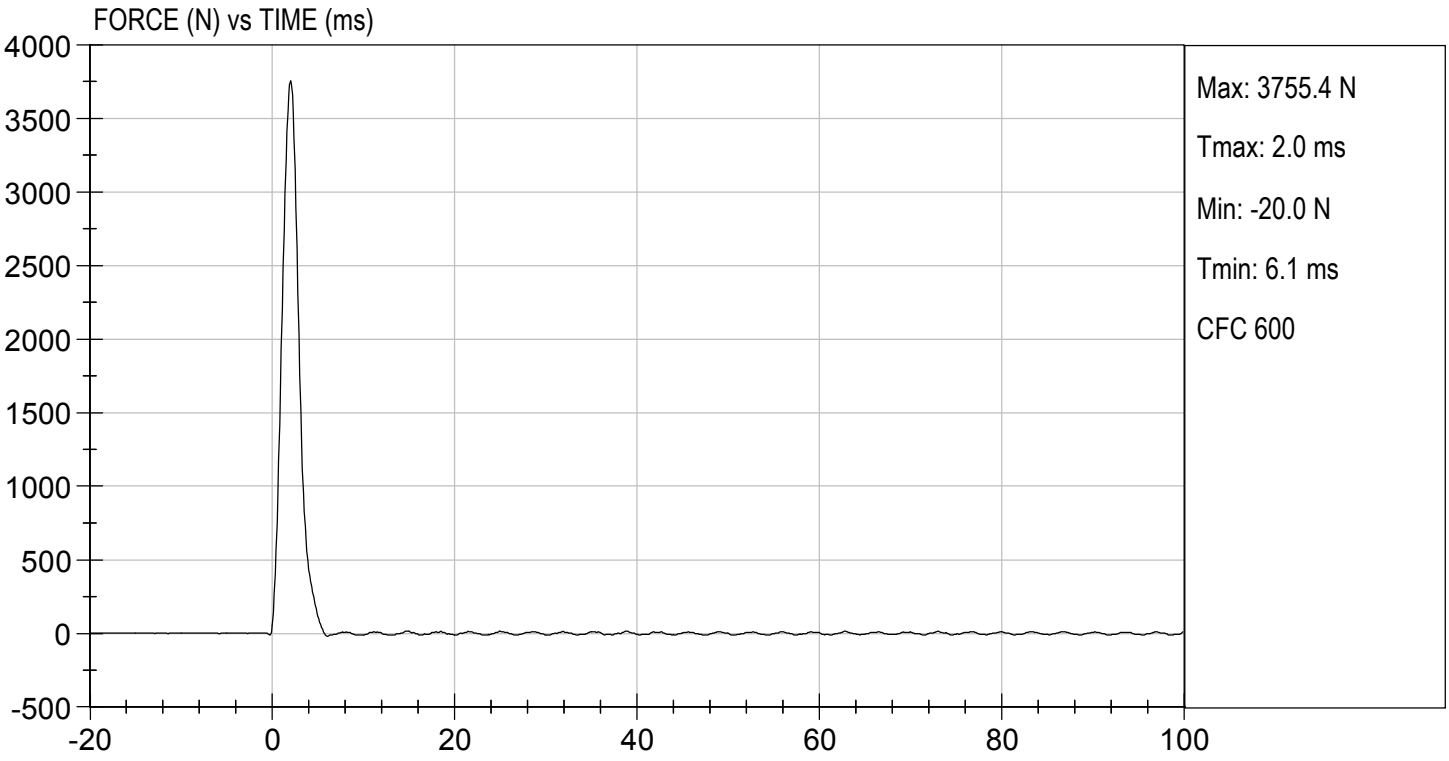
Laboratory Technician

02/11/2021
Test Date

Approved By

TEST DESC: LEFT KNEE
VELOCITY: 6.83 ft/s, 2.08 m/s

TEST DATE: 02/11/2021
TEST #: D210366



**MGA RESEARCH CORPORATION**

**TORSO FLEXION TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210367

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.7 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 21 | Pass |
| Initial Angle | deg | 0 to 20 | 20 | Pass |
| Return Angle | deg | +/- 8 | 2 | Pass |
| Force at 45 deg | N | 320 to 390 | 335 | Pass |
| Upper Torso Deflection Rate | deg/s | 0.5 to 1.5 | 0.5 | Pass |
| | | Overall Result | | Pass |

Laboratory Technician

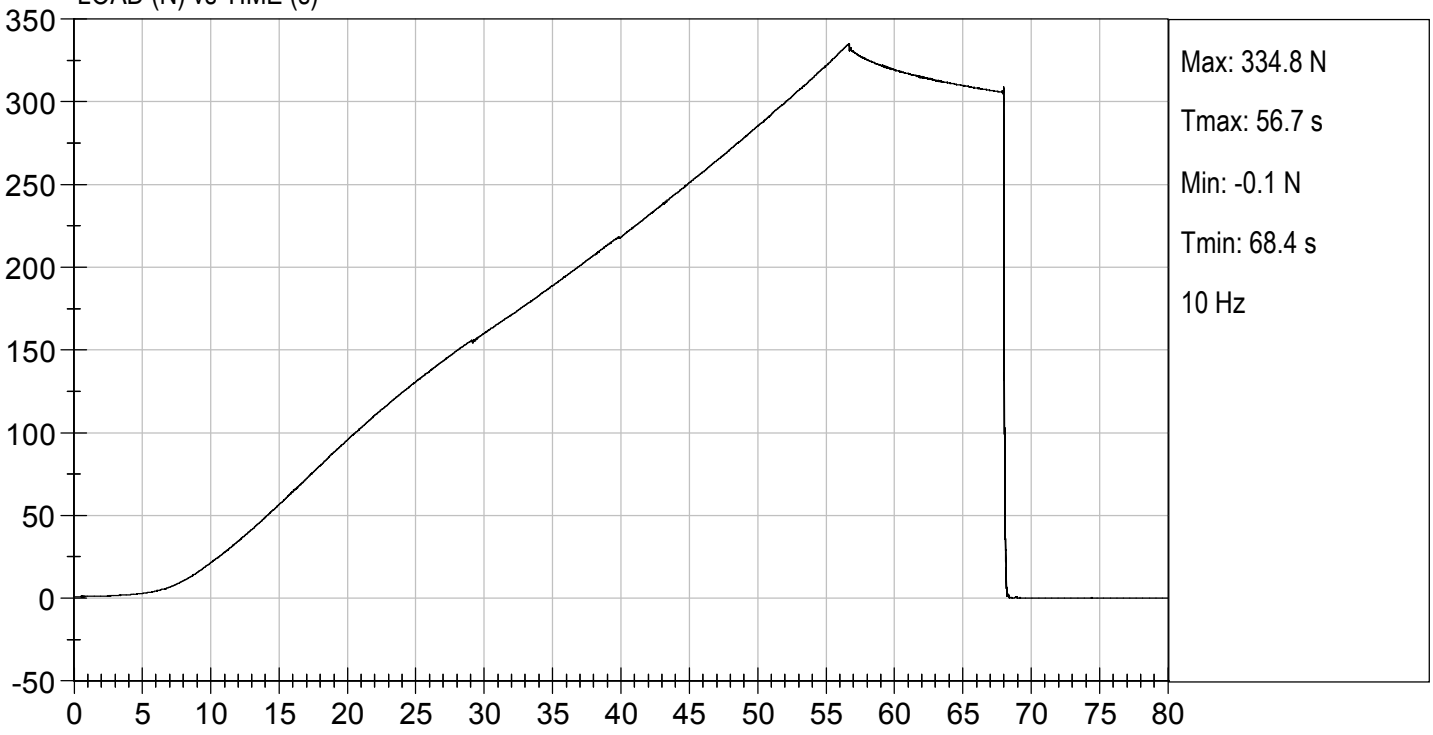
02/11/2021
Test Date

Approved By

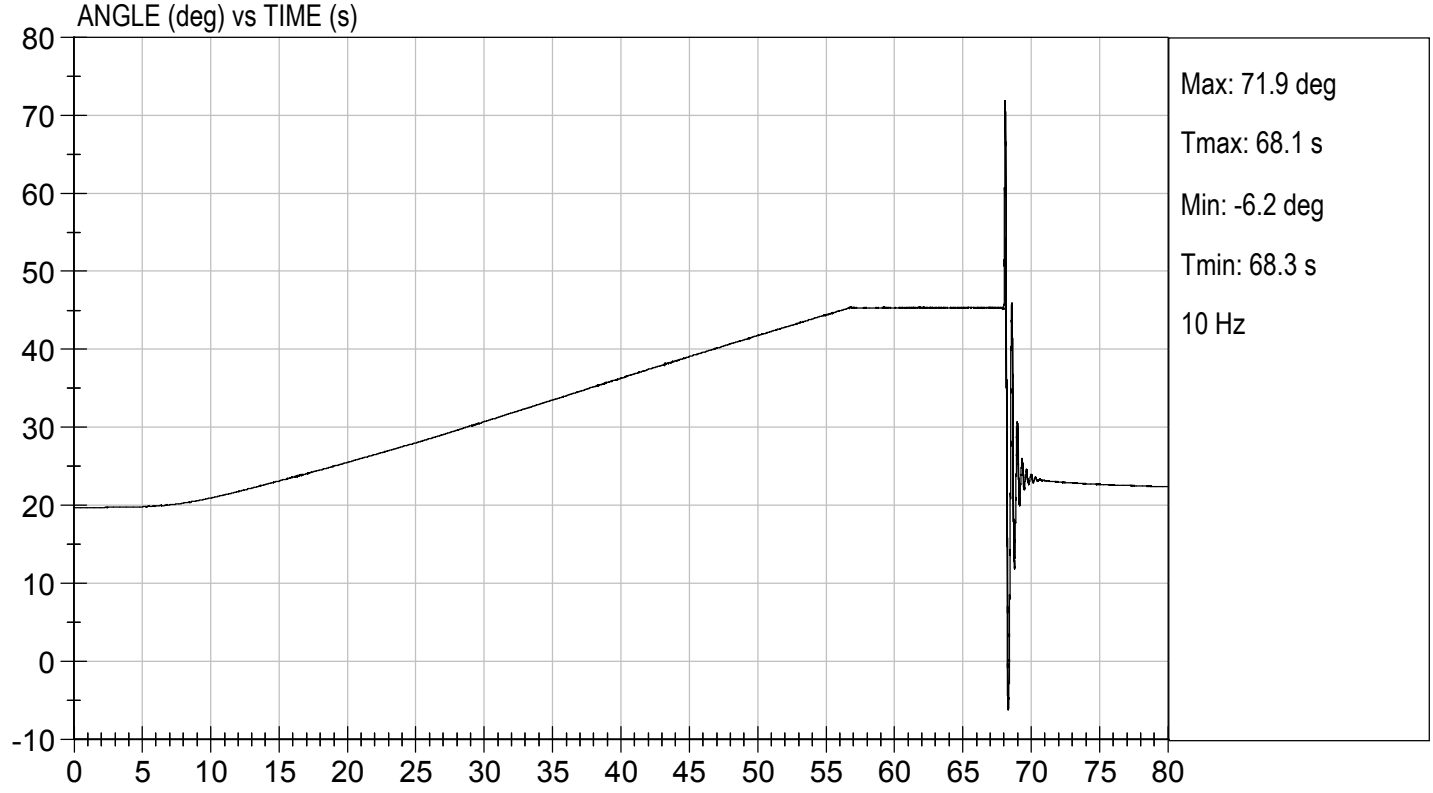
TEST DESC: LUMBAR FLEXION

TEST DATE: 02/11/2021
TEST #: D210367

LOAD (N) vs TIME (s)




ANGLE (deg) vs TIME (s)



## CALIBRATION TEST RESULTS

## POST-TEST

## HYBRID III 5TH PERCENTILE FEMALE - PASSENGER ATD

**MGA RESEARCH CORPORATION**

**HEAD DROP TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test ID:** D210581

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.7 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 23 | Pass |
| Peak Resultant Acceleration | G's | 250 to 300 | 282 | Pass |
| Peak Lateral Acceleration | G's | <= +/- 15.0 | -2.1 | Pass |
| Unimodal | N/A | Yes | Yes | Pass |
| Oscillations | N/A | within 10% of peak | Yes | Pass |
| | | Overall Test Results | | Pass |

Gerald Guerrero
Laboratory Technician

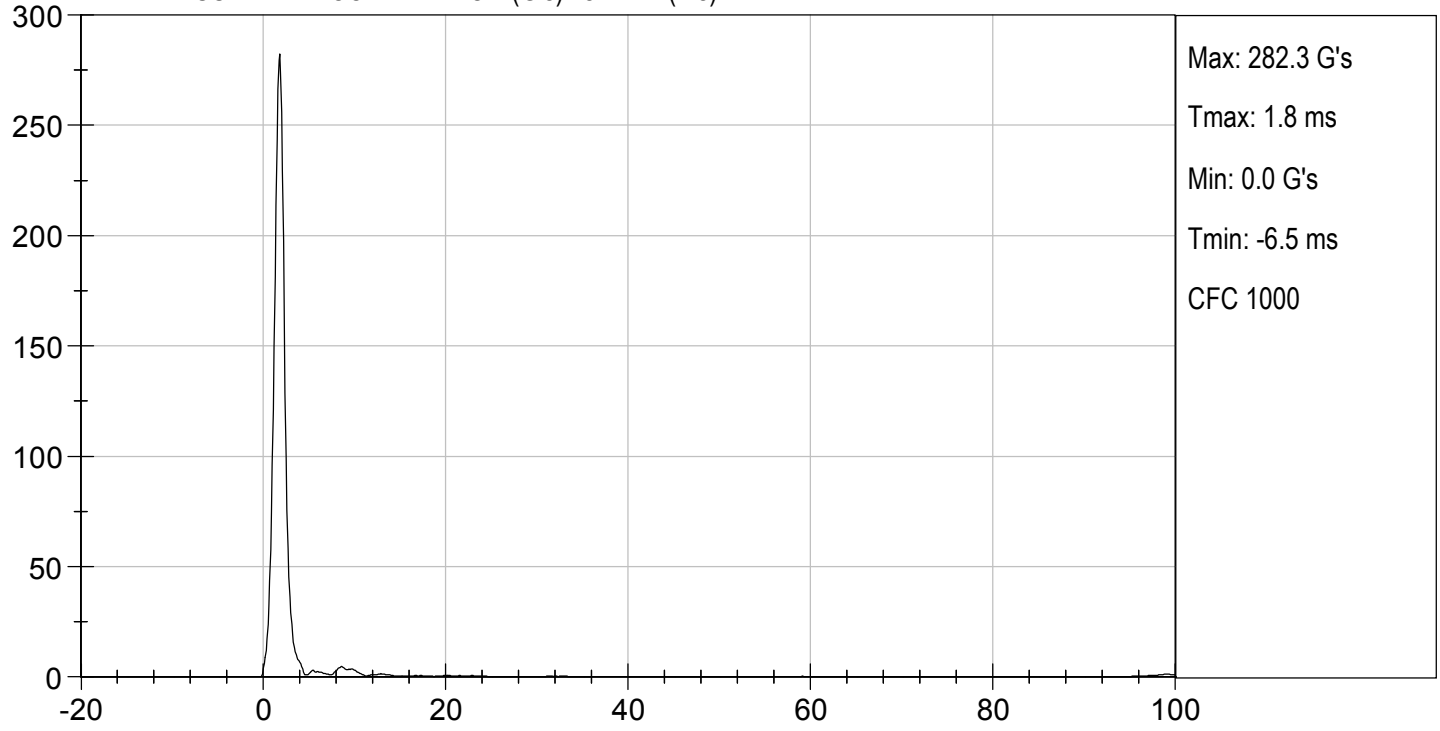
02/25/2021
Test Date

Approved By

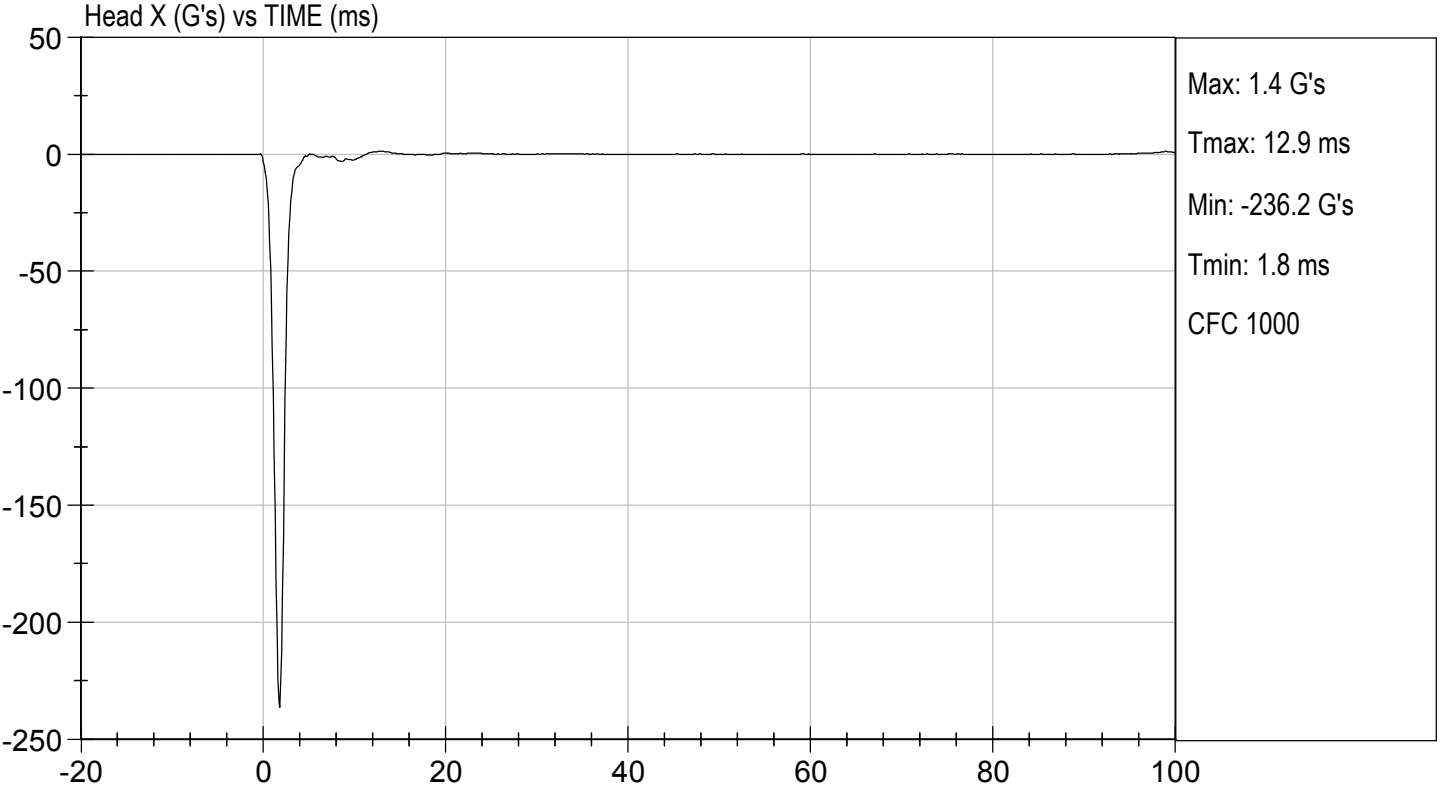
TEST DESC: HEAD DROP

TEST DATE: 02/25/2021
TEST #: D210581

HEAD RESULTANT ACCELERATION (G's) vs TIME (ms)

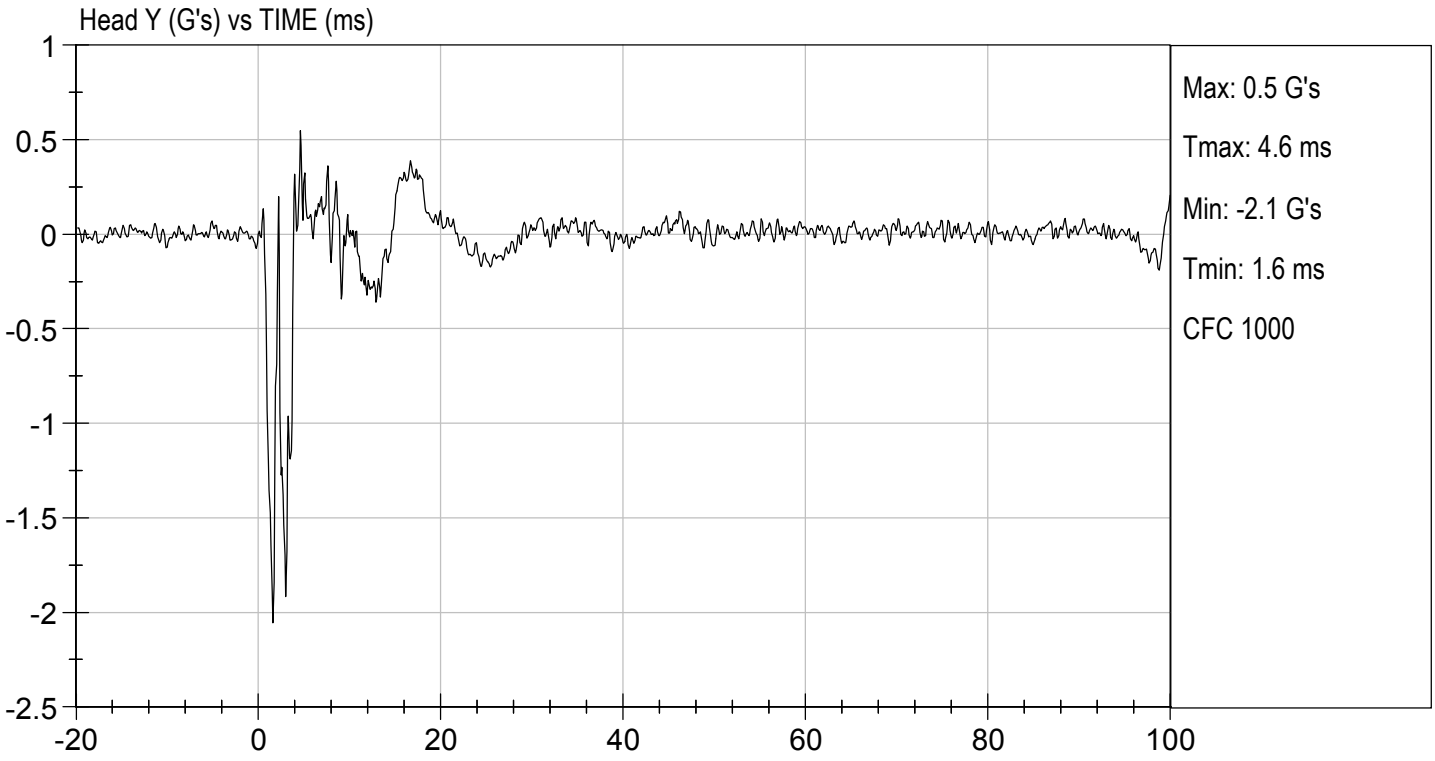


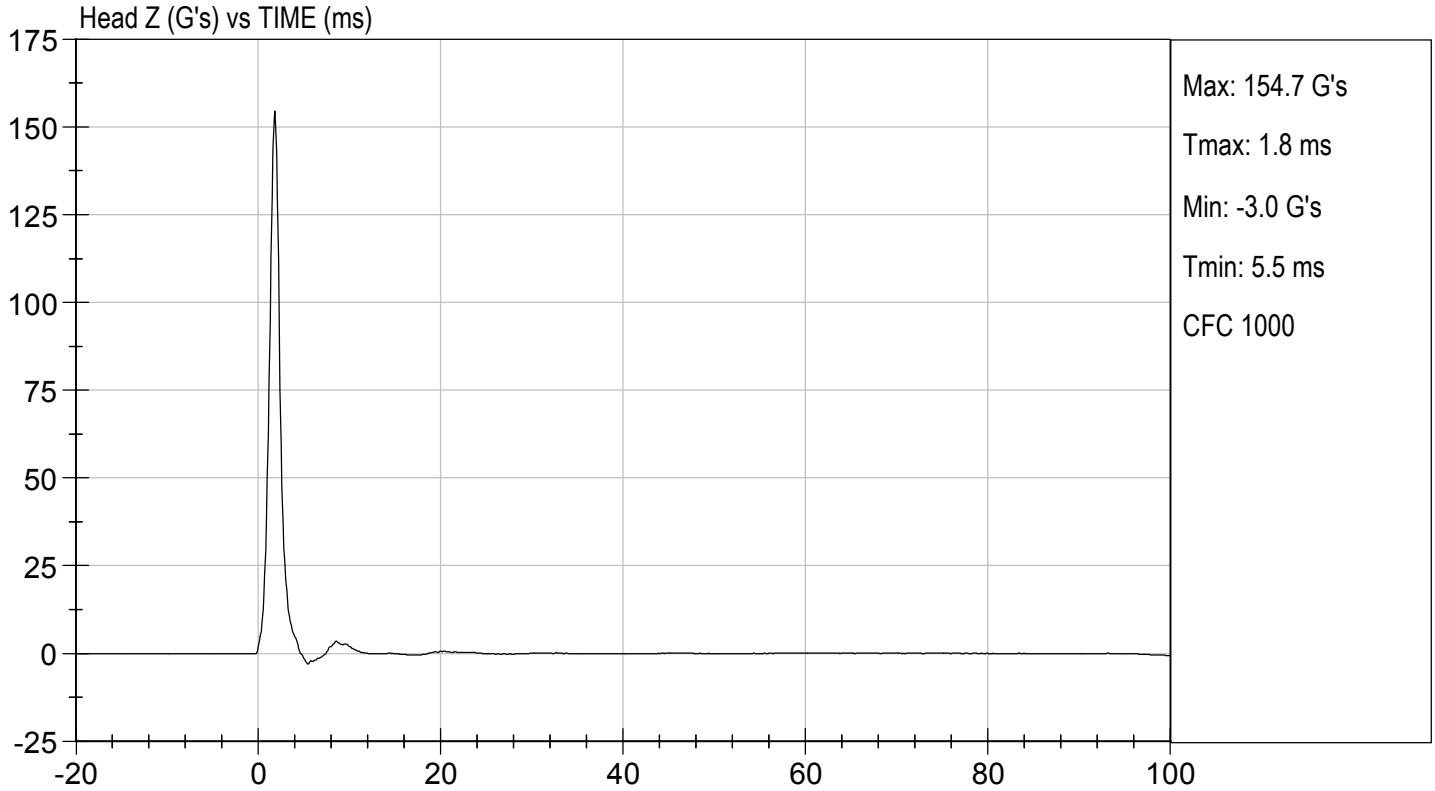

Head X (G's) vs TIME (ms)



TEST DESC: HEAD DROP

TEST DATE: 02/25/2021
TEST #: D210581



**MGA RESEARCH CORPORATION**

**NECK FLEXION TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210582

| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Laboratory Temperature | | deg C | 20.6 to 22.2 | 21.4 | Pass |
| Laboratory Relative Humidity | | % | 10 to 70 | 21 | Pass |
| Pendulum Speed | | m/s | 6.89 to 7.13 | 7.06 | Pass |
| Pendulum Velocity | 10 ms | m/s | 2.1 to 2.5 | 2.4 | Pass |
| | 20 ms | m/s | 4.0 to 5.0 | 4.9 | Pass |
| | 30 ms | m/s | 5.8 to 7.0 | 7.0 | Pass |
| D Plane Rotation | Max | deg | 77 to 91 | 82 | Pass |
| Occipital Condyle Moment within Rotation Corridor | | Nm | 69 to 83 | 73 | Pass |
| Positive Moment Time Curve Decay to 10 Nm | | ms | 80 to 100 | 82 | Pass |
| | | | Overall Results | | Pass |

Gerald Guerrero
Laboratory Technician

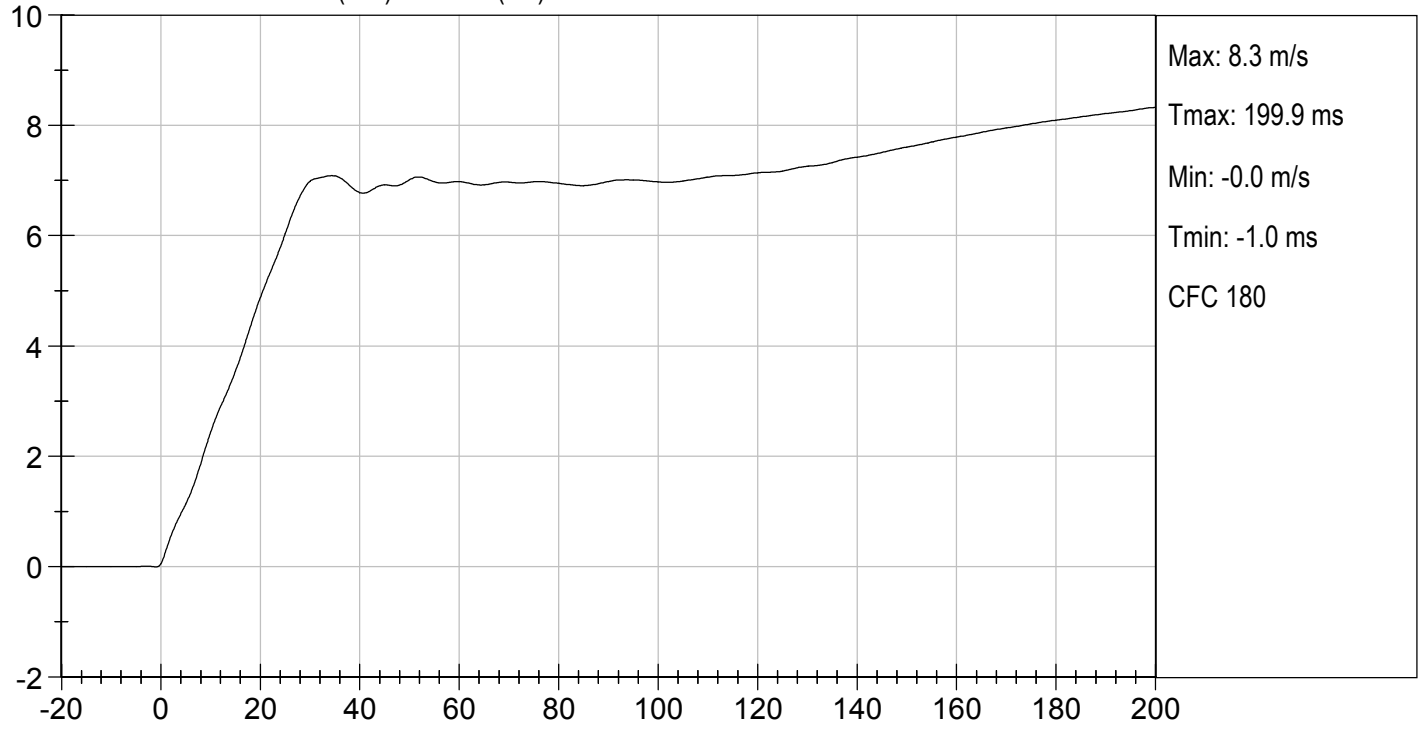
02/25/2021
Test Date

Approved By

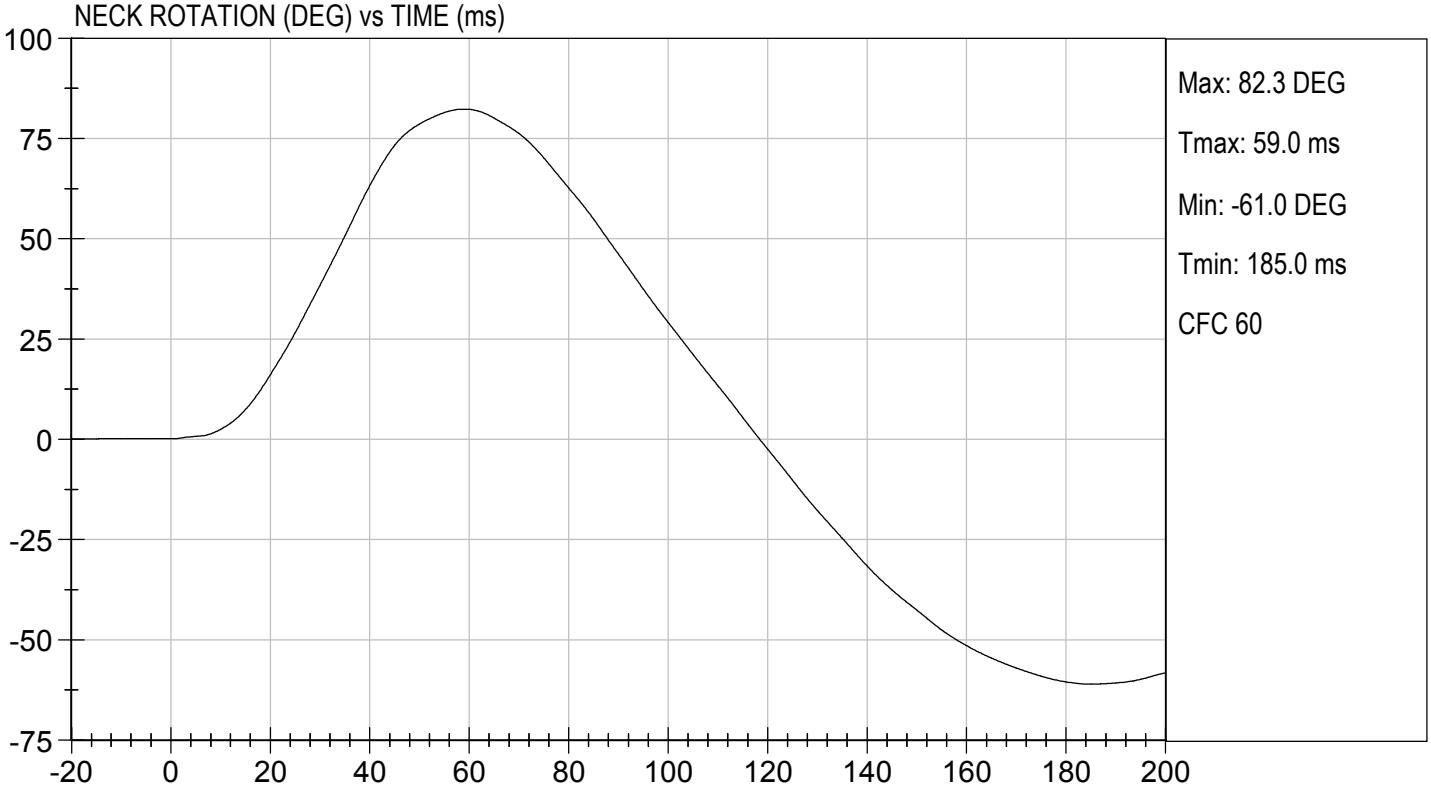
TEST DESC: NECK FLEXION
VELOCITY: 23.15 ft/s, 7.06 m/s

TEST DATE: 02/25/2021
TEST #: D210582

PENDULUM VELOCITY (m/s) vs TIME (ms)

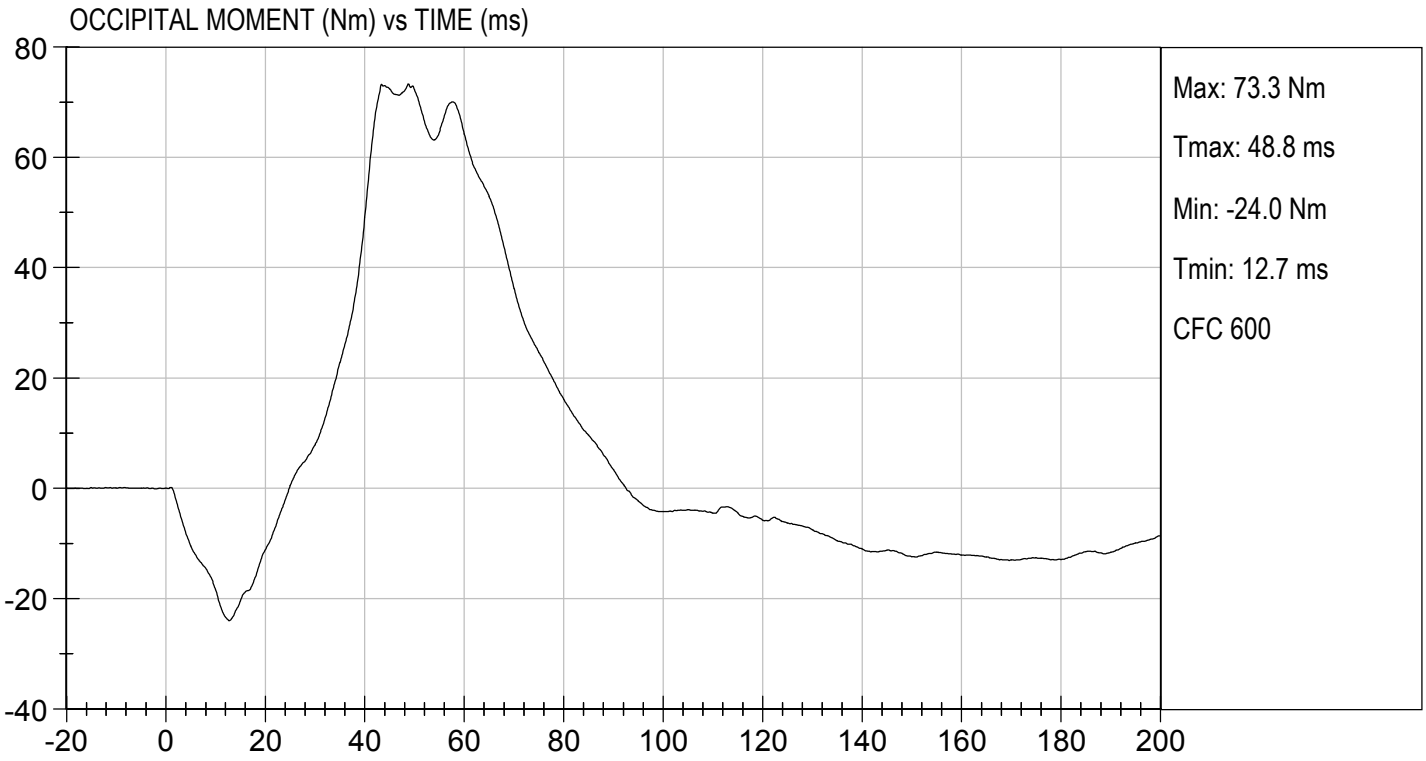



NECK ROTATION (DEG) vs TIME (ms)



TEST DESC: NECK FLEXION
VELOCITY: 23.15 ft/s, 7.06 m/s

TEST DATE: 02/25/2021
TEST #: D210582



**MGA RESEARCH CORPORATION**

**NECK EXTENSION TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210583

| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Laboratory Temperature | | deg C | 20.6 to 22.2 | 21.4 | Pass |
| Laboratory Relative Humidity | | % | 10 to 70 | 21 | Pass |
| Pendulum Speed | | m/s | 5.95 to 6.19 | 6.12 | Pass |
| Pendulum Velocity | 10 ms | m/s | 1.5 to 1.9 | 1.9 | Pass |
| | 20 ms | m/s | 3.1 to 3.9 | 3.8 | Pass |
| | 30 ms | m/s | 4.6 to 5.6 | 5.5 | Pass |
| D Plane Rotation | Max | deg | 99 to 114 | 109 | Pass |
| Occipital Condyle Moment within Rotation Corridor | | Nm | -65 to -53 | -58 | Pass |
| Negative Moment Time Curve Decay to -10 Nm | | ms | 94 to 114 | 105 | Pass |
| | | | Overall Results | | Pass |

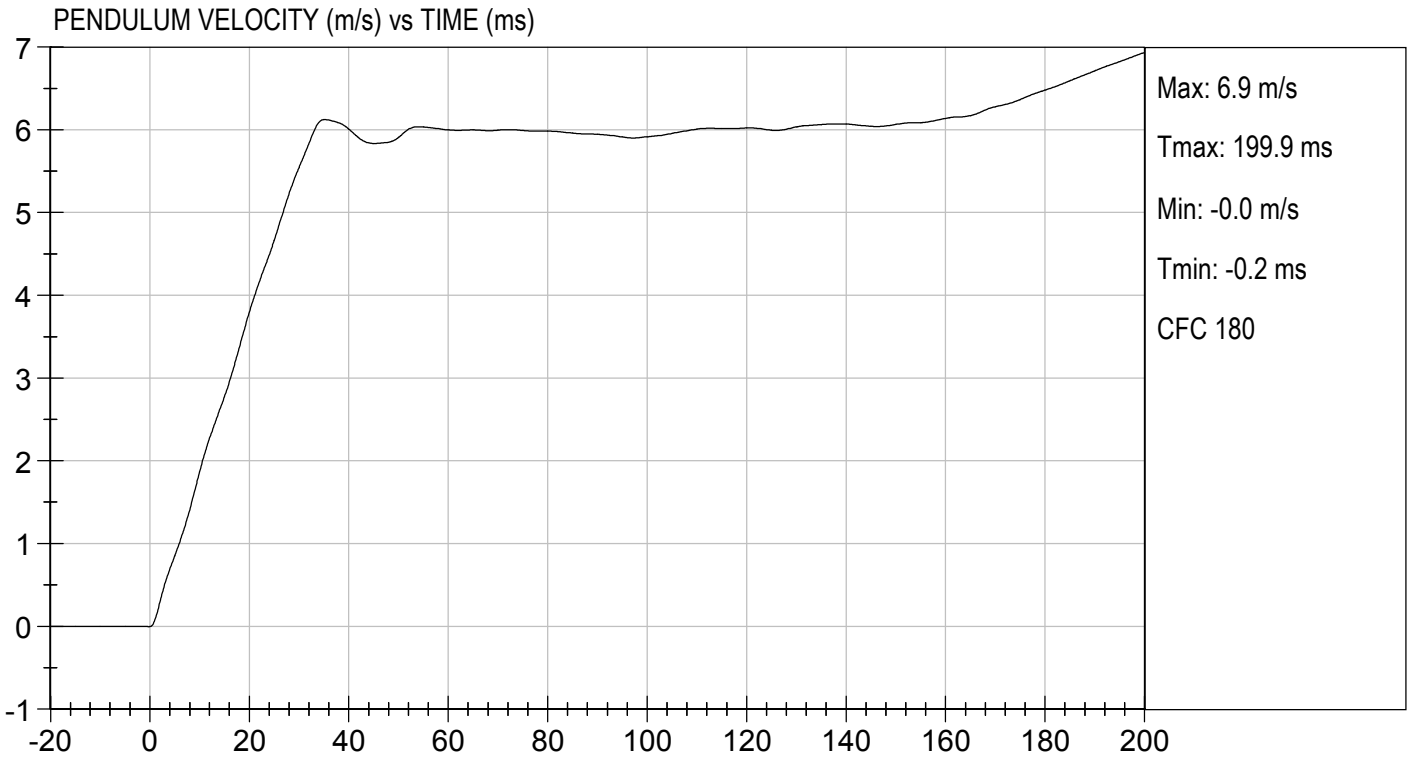
Gerald Guerrero
Laboratory Technician

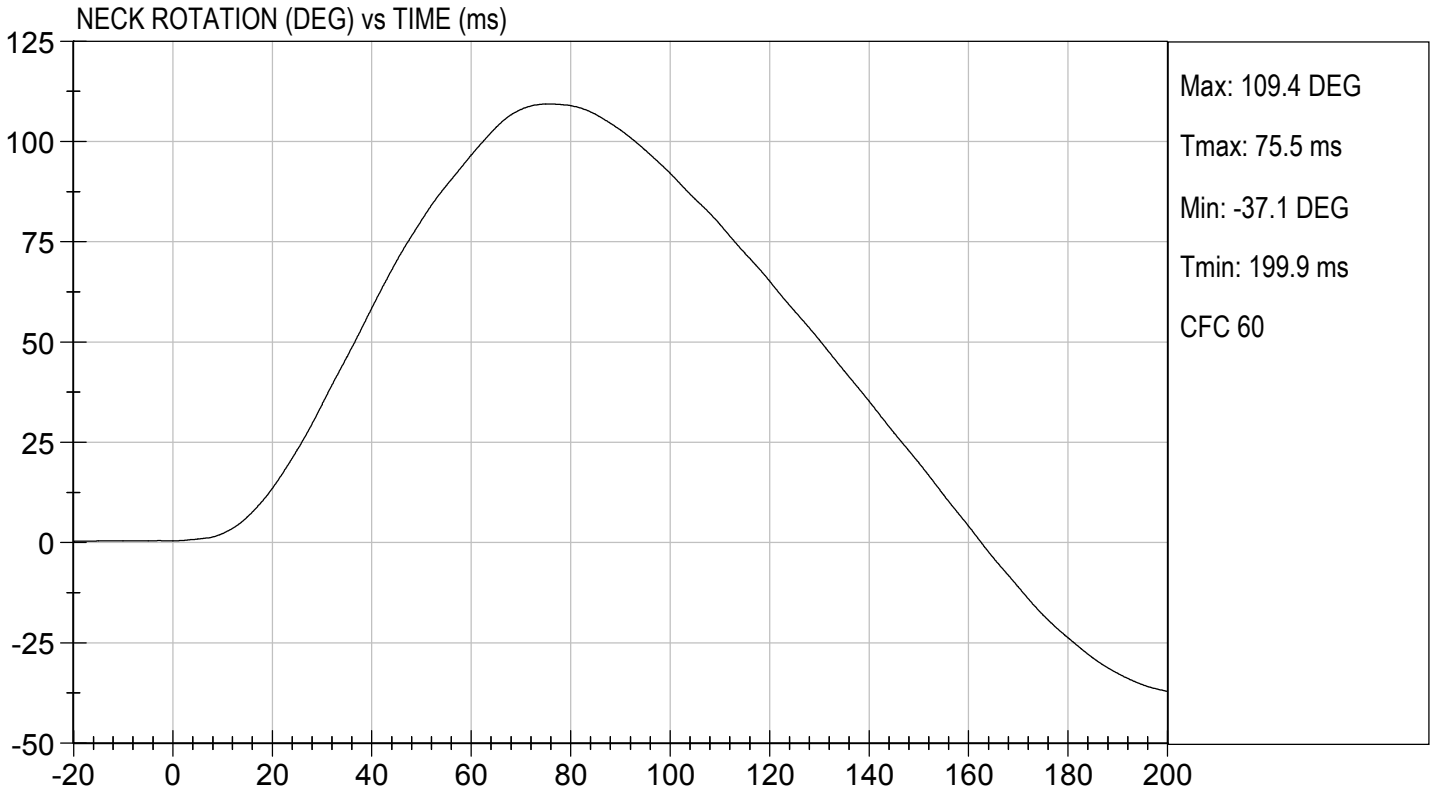
02/25/2021
Test Date

Approved By

TEST DESC: NECK EXTENSION
VELOCITY: 20.08 ft/s, 6.12 m/s

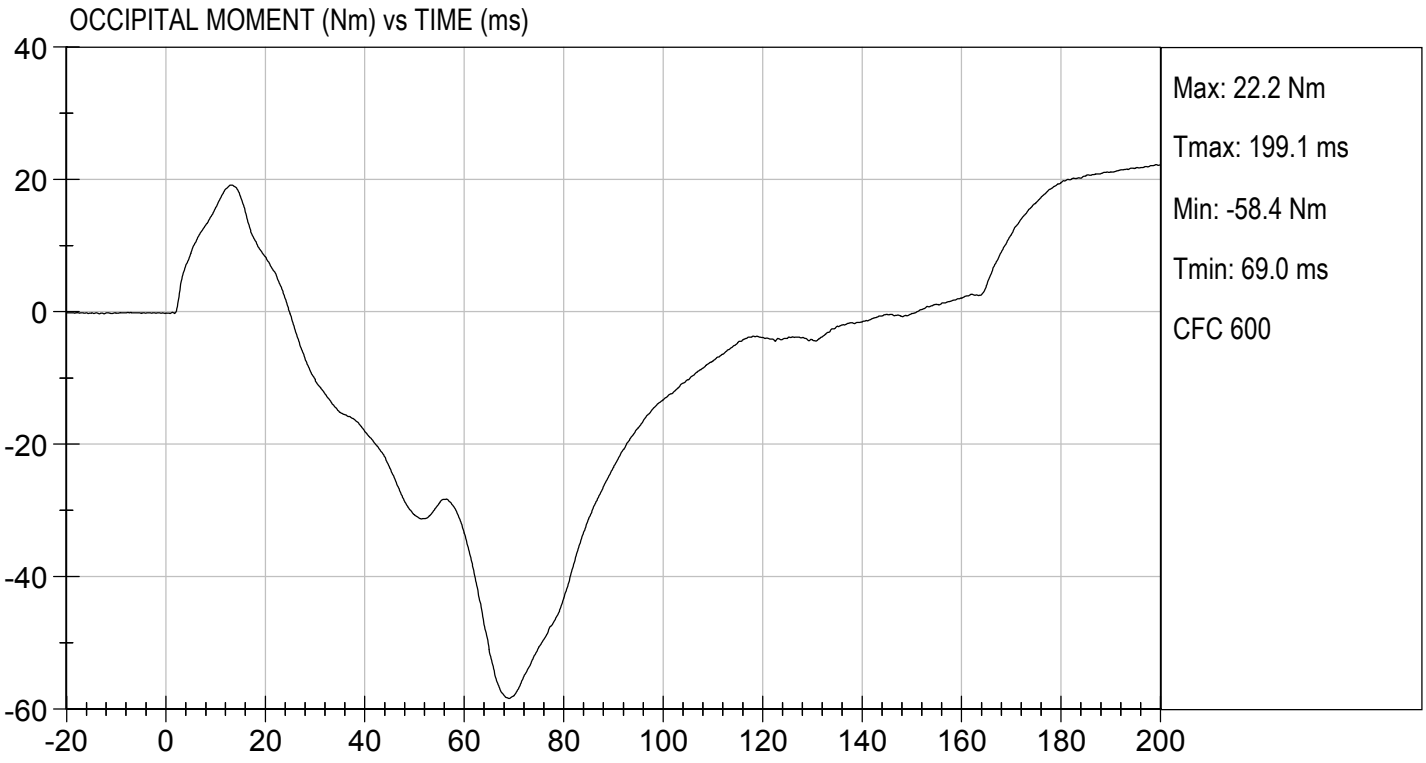
TEST DATE: 02/25/2021
TEST #: D210583



TEST DESC: NECK EXTENSION
VELOCITY: 20.08 ft/s, 6.12 m/s

TEST DATE: 02/25/2021
TEST #: D210583



**MGA RESEARCH CORPORATION**

**THORAX IMPACT**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210584

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Temperature | deg C | 20.6 to 22.2 | 21.8 | Pass |
| Relative Humidity | % | 10 to 70 | 28 | Pass |
| Probe Speed | m/s | 6.59 to 6.83 | 6.77 | Pass |
| Peak Deflection | mm | 50 to 58 | 52 | Pass |
| Peak Resistive Force w/in Deflection Corridor | N | 3900 to 4400 | 4385 | Pass |
| Internal Hysteresis | % | 69 to 85 | 74 | Pass |
| Peak Force 18 mm - 50 mm | N | <= 4600 | 4405 | Pass |
| | | Overall Test Results | | Pass |

Gerald Guerrero
Laboratory Technician

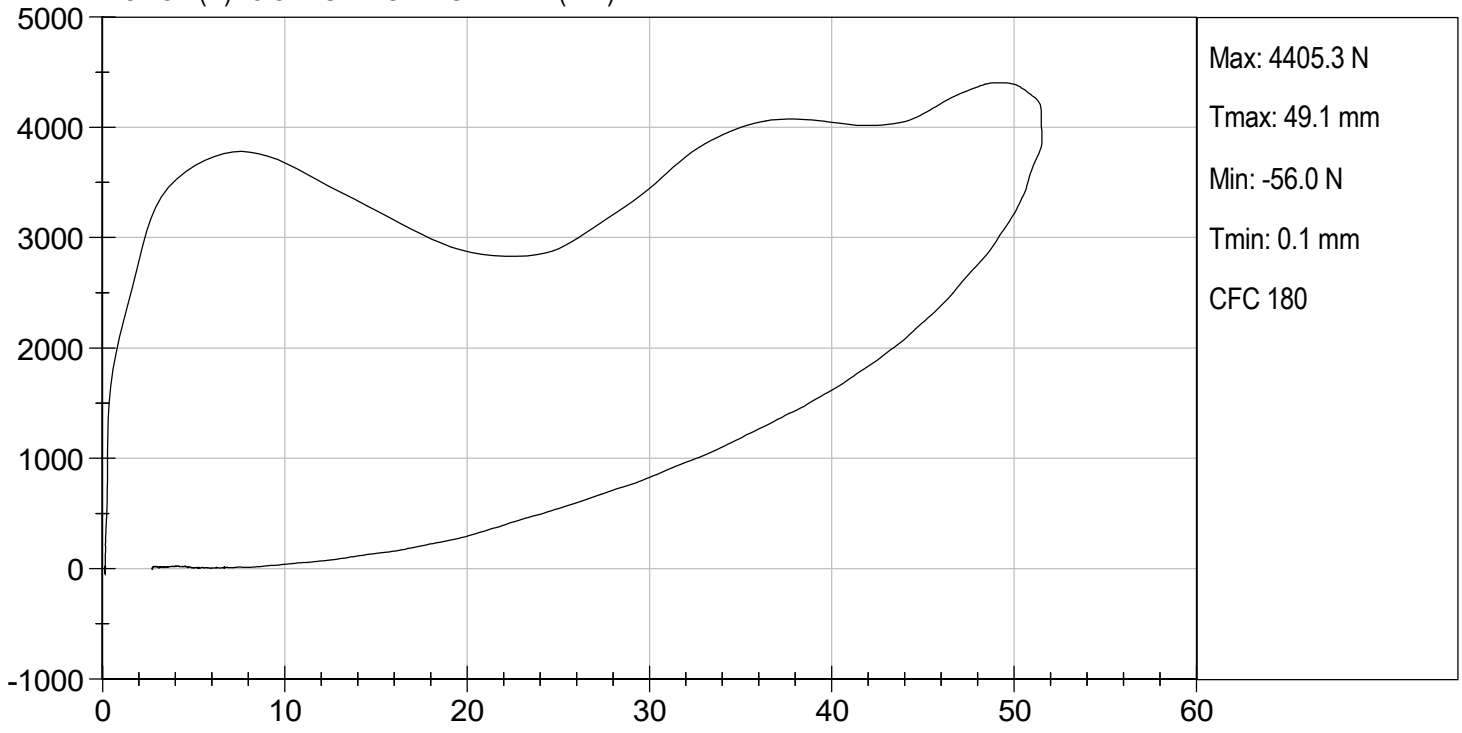
02/24/2021
Test Date

Approved By

TEST DESC: THORAX IMPACT
VELOCITY: 22.22 ft/s, 6.77 m/s

TEST DATE: 02/24/2021
TEST #: D210584

FORCE (N) vs CHEST DISPLACEMENT (mm)



**MGA RESEARCH CORPORATION**

**RIGHT KNEE IMPACT TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210585

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.8 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 20 | Pass |
| Probe Speed | m/s | 2.07 to 2.13 | 2.11 | Pass |
| Maximum Force | N | 3450 to 4060 | 3853 | Pass |
| | | Overall Test Results | | Pass |

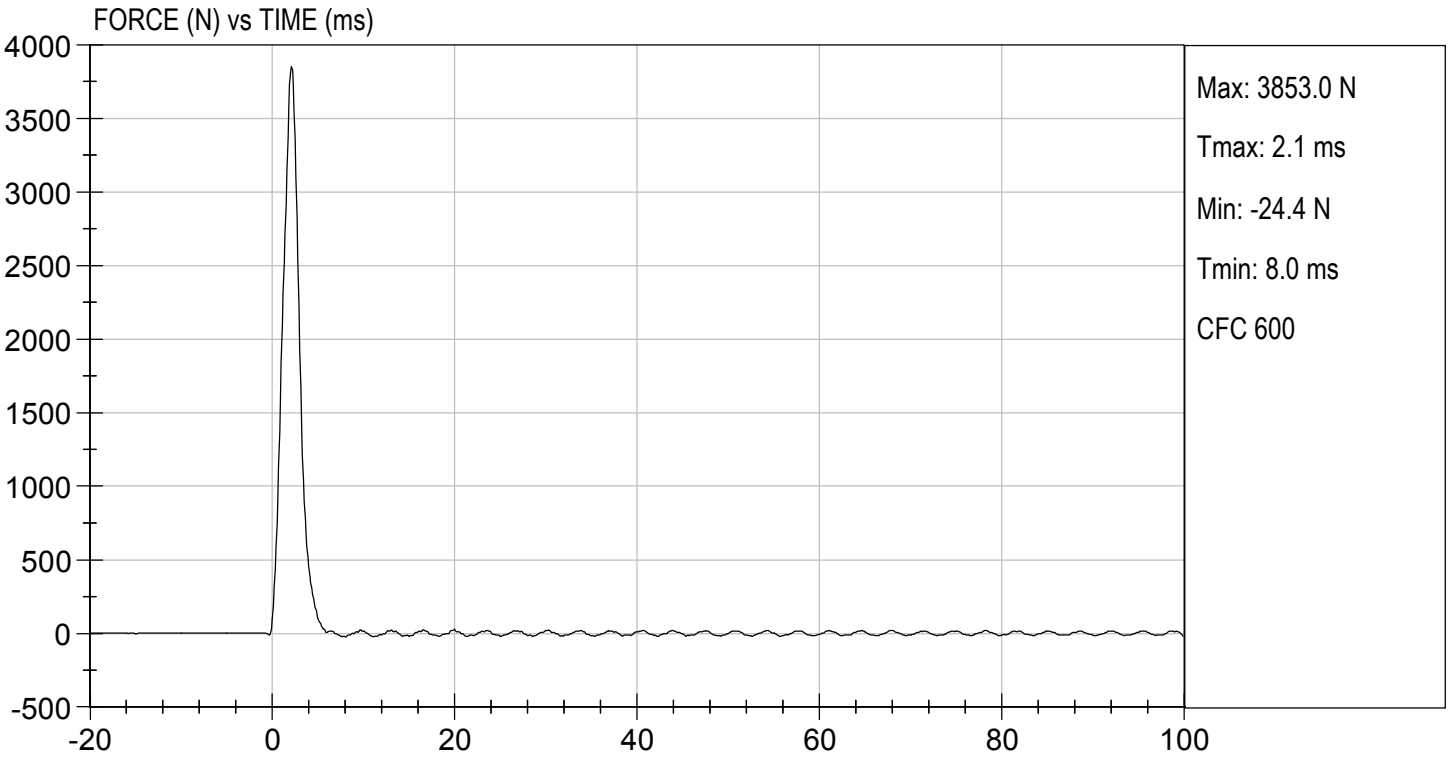
Gerald Guerrero
Laboratory Technician

02/26/2021
Test Date

Approved By

TEST DESC: RIGHT KNEE
VELOCITY: 6.92 ft/s, 2.11 m/s

TEST DATE: 02/26/2021
TEST #: D210585



**MGA RESEARCH CORPORATION**

**LEFT KNEE IMPACT TEST**

**HYBRID III 5TH PERCENTILE**

**ATD Serial No:** DH1659 **Test I.D:** D210586

| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.8 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 20 | Pass |
| Probe Speed | m/s | 2.07 to 2.13 | 2.11 | Pass |
| Maximum Force | N | 3450 to 4060 | 3716 | Pass |
| | | Overall Test Results | | Pass |

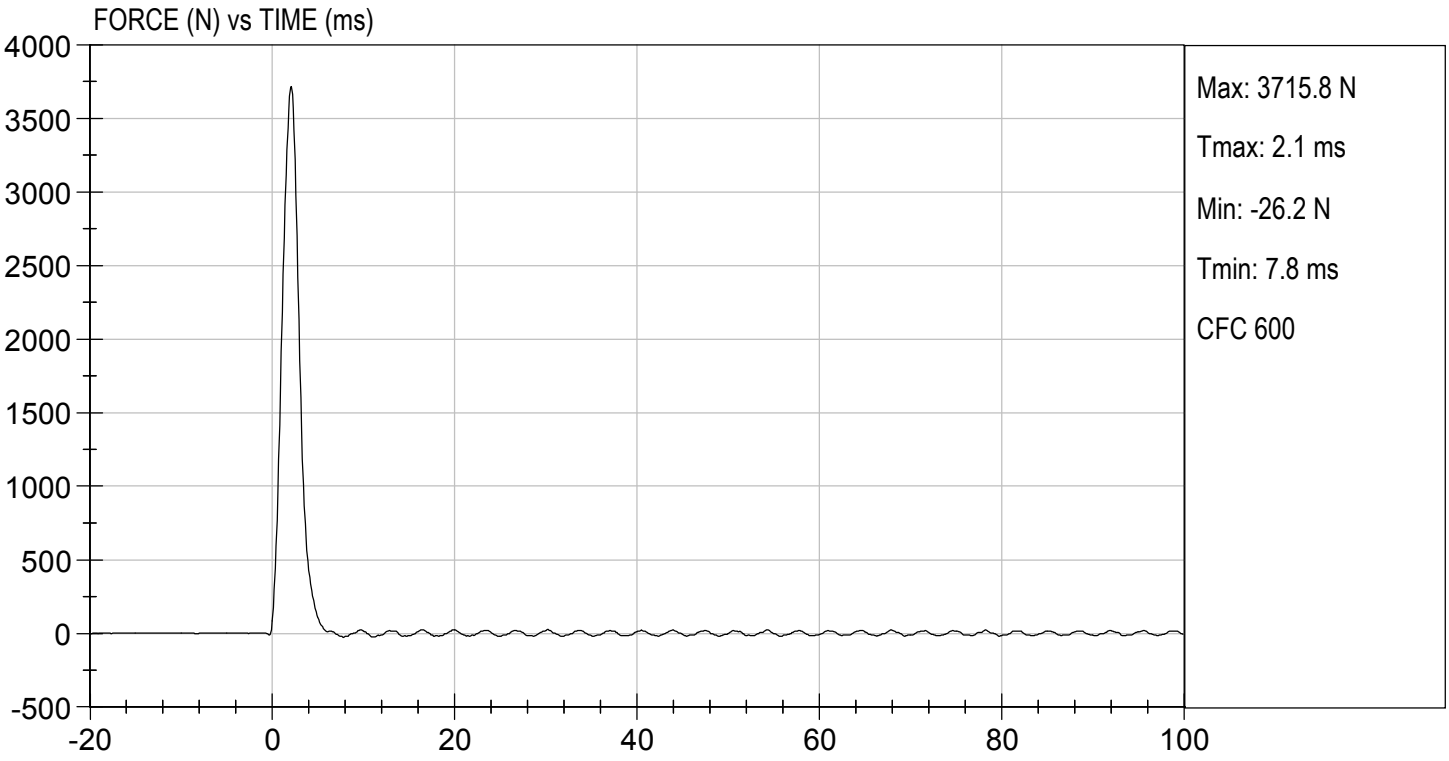
Gerald Guerrero
Laboratory Technician

02/26/2021
Test Date

Approved By

TEST DESC: LEFT KNEE
VELOCITY: 6.92 ft/s, 2.11 m/s

TEST DATE: 02/26/2021
TEST #: D210586



**MGA RESEARCH CORPORATION**

**TORSO FLEXION TEST**

**HYBRID III 5TH PERCENTILE**

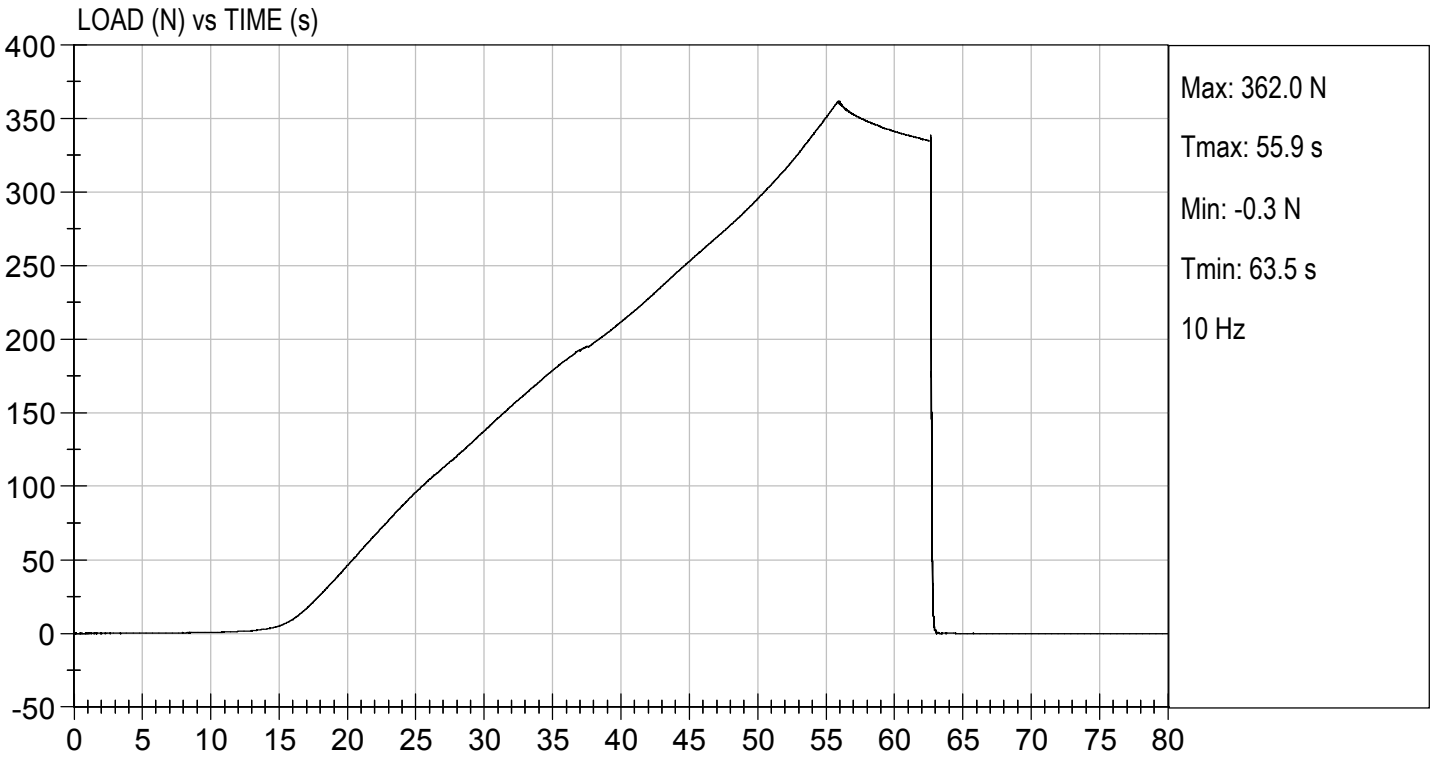
**ATD Serial No:** DH1659 **Test I.D:** D210587

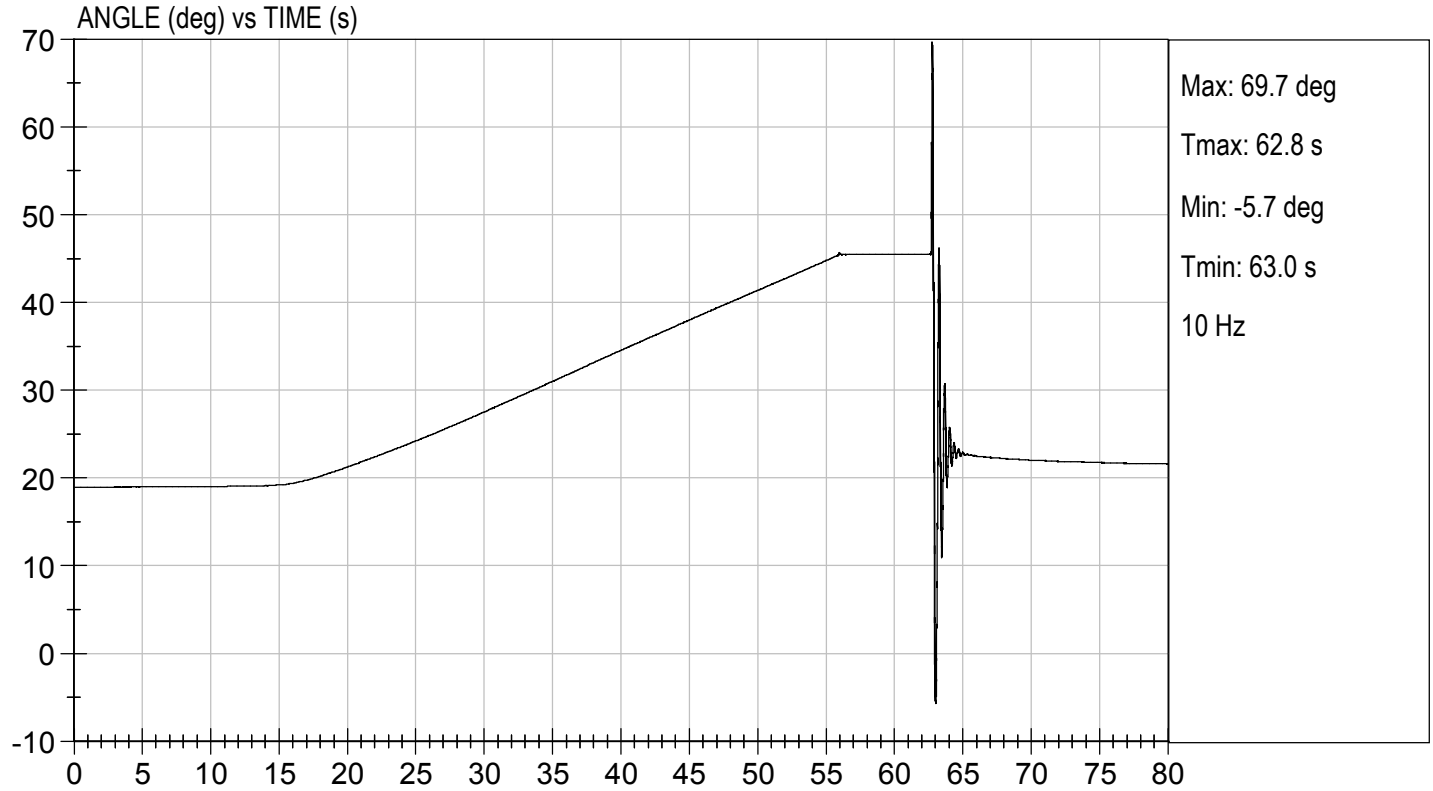
| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | deg C | 18.9 to 25.6 | 21.7 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 23 | Pass |
| Initial Angle | deg | 0 to 20 | 19 | Pass |
| Return Angle | deg | +/- 8 | 2 | Pass |
| Force at 45 deg | N | 320 to 390 | 362 | Pass |
| Upper Torso Deflection Rate | deg/s | 0.5 to 1.5 | 0.7 | Pass |
| | | Overall Result | | Pass |

Gerald Guerrero
Laboratory Technician

02/26/2021
Test Date

Approved By


LOAD (N) vs TIME (s)
400
350
300
250
200
150
100
50
0
-50
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
Max: 362.0 N
Tmax: 55.9 s
Min: -0.3 N
Tmin: 63.5 s
10 Hz


ANGLE (deg) vs TIME (s)
70
60
50
40
30
20
10
0
-10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
Max: 69.7 deg
Tmax: 62.8 s
Min: -5.7 deg
Tmin: 63.0 s
10 Hz

# APPENDIX D
# TEST EQUIPMENT AND INSTRUMENTATION CALIBRATION DATA

**TABLE 1 – DRIVER DUMMY INSTRUMENTATION**

| Instrument Location | | | Axis | Hybrid III 50th S/N 351 | | |
|---|---|---|---|---|---|---|
| | | | | Serial Number | Manufacturer | Calibration Date |
| Head Accelerometers | | Primary | X | P79741 | Endevco | 09/02/2020 |
| | | | Y | P79743 | Endevco | 09/02/2020 |
| | | | Z | P79744 | Endevco | 09/02/2020 |
| | | Redundant | X | P94834 | Endevco | 09/02/2020 |
| | | | Y | P94856 | Endevco | 09/02/2020 |
| | | | Z | P97412 | Endevco | 09/02/2020 |
| Head Angular Rate Sensors | | | X | ARS7402 | DTS | 08/04/2020 |
| | | | Y | ARS7416 | DTS | 08/04/2020 |
| | | | Z | ARS7366 | DTS | 08/04/2020 |
| Upper Neck Load Cell | | | Fx, Fy, Fz Mx, My, Mz | NG1915 | Denton | 03/05/2020 |
| Chest Accelerometers | | Primary | X | P86792 | Endevco | 09/02/2020 |
| | | | Y | P86793 | Endevco | 09/02/2020 |
| | | | Z | P88348 | Endevco | 09/02/2020 |
| | | Redundant | X | P88666 | Endevco | 09/02/2020 |
| | | | Y | P88667 | Endevco | 09/02/2020 |
| | | | Z | P94109 | Endevco | 09/02/2020 |
| Chest Potentiometer | | | X | 351 | Servo | 09/02/2020 |
| Pelvis Accelerometers | | | X | P95526 | Endevco | 09/01/2020 |
| | | | Y | P96038 | Endevco | 09/01/2020 |
| | | | Z | P97742 | Endevco | 09/01/2020 |
| Femur Load Cells | Right | Primary | Z | FG121P | Denton | 09/02/2020 |
| | | Redundant | Z | FG121R | Denton | 09/02/2020 |
| | Left | Primary | Z | FG122P | Denton | 09/02/2020 |
| | | Redundant | Z | FG122R | Denton | 09/02/2020 |
| Tibia Load Cells | Right | Upper | Mx, My, Fz | TGDH3308 | FTSS | 03/05/2020 |
| | | Lower | Mx, My, Fz | AGDI4208 | FTSS | 03/05/2020 |
| | Left | Upper | Mx, My, Fz | TGDG6744 | FTSS | 03/05/2020 |
| | | Lower | Mx, My, Fz | AGDI4273 | FTSS | 03/05/2020 |
| Foot Accelerometers | Right | Rear | X | T22486 | Endevco | 10/06/2020 |
| | | | Z | P97382 | Endevco | 10/01/2020 |
| | | Front | Z | P82120 | Endevco | 09/02/2020 |
| | Left | Rear | X | T16468 | Endevco | 09/01/2020 |
| | | | Z | T16496 | Endevco | 09/01/2020 |
| | | Front | Z | T16501 | Endevco | 09/01/2020 |
| Seat Belt Load Cells | | Lap | | SBG161 | FTSS | 11/13/2019 |
| | | Shoulder | | SBG157 | FTSS | 11/13/2019 |

**TABLE 2 – FRONT PASSENGER DUMMY INSTRUMENTATION**

| Instrument Location | | | Axis | Hybrid III 5th S/N DH1659 | | |
|---|---|---|---|---|---|---|
| | | | | Serial Number | Manufacturer | Calibration Date |
| Head Accelerometers | | Primary | X | P97377 | Endevco | 02/10/2021 |
| | | | Y | P94800 | Endevco | 02/10/2021 |
| | | | Z | P94802 | Endevco | 02/10/2021 |
| | | Redundant | X | P94799 | Endevco | 02/10/2021 |
| | | | Y | P94801 | Endevco | 02/10/2021 |
| | | | Z | P94803 | Endevco | 02/10/2021 |
| Head Angular Rate Sensors | | | X | ARS7340 | DTS | 08/04/2020 |
| | | | Y | ARS7357 | DTS | 08/04/2020 |
| | | | Z | ARS7442 | DTS | 08/04/2020 |
| Upper Neck Load Cell | | | Fx, Fy, Fz Mx, My, Mz | NG2256 | Denton | 05/04/2020 |
| Chest Accelerometers | | Primary | X | P94793 | Endevco | 02/10/2021 |
| | | | Y | P95322 | Endevco | 02/10/2021 |
| | | | Z | P88719 | Endevco | 02/10/2021 |
| | | Redundant | X | P94794 | Endevco | 02/10/2021 |
| | | | Y | P95370 | Endevco | 02/10/2021 |
| | | | Z | P94785 | Endevco | 02/10/2021 |
| Chest Potentiometer | | | X | DH1659 | Servo | 02/10/2021 |
| Pelvis Accelerometers | | | X | P94798 | Endevco | 02/10/2021 |
| | | | Y | P97705 | Endevco | 02/10/2021 |
| | | | Z | P82646 | Endevco | 02/10/2021 |
| Femur Load Cells | Right | Primary | Z | FG126P | Denton | 02/10/2021 |
| | | Redundant | Z | FG126R | Denton | 02/10/2021 |
| | Left | Primary | Z | FG127P | Denton | 02/10/2021 |
| | | Redundant | Z | FG127R | Denton | 02/10/2021 |
| Tibia Load Cells | Right | Upper | Mx, My, Fz | TG467 | Denton | 05/04/2020 |
| | | Lower | Mx, My, Fz | AG491 | Denton | 05/04/2020 |
| | Left | Upper | Mx, My, Fz | TG478 | Denton | 05/04/2020 |
| | | Lower | Mx, My, Fz | AG500 | Denton | 05/04/2020 |
| Foot Accelerometers | Right | Rear | X | P94795 | Endevco | 02/10/2021 |
| | | | Z | P94796 | Endevco | 02/10/2021 |
| | | Front | Z | P94797 | Endevco | 02/10/2021 |
| | Left | Rear | X | P83167 | Endevco | 02/10/2021 |
| | | | Z | P83168 | Endevco | 02/10/2021 |
| | | Front | Z | P83169 | Endevco | 02/10/2021 |
| Seat Belt Load Cells | | Lap | | SBG273 | FTSS | 11/13/2019 |
| | | Shoulder | | SBG272 | FTSS | 11/13/2019 |

**TABLE 3 – VEHICLE INSTRUMENTATION**

| Instrument Location | | | Axis | Serial Number | Manufacturer | Calibration Date |
|---|---|---|---|---|---|---|
| Crossmember / Rear Seat Accelerometers | Left | Primary | X | T19009 | Endevco | 02/19/2021 |
| | | | Z | T22808 | Endevco | 02/19/2021 |
| | | Redundant | X | T22576 | MSI | 02/19/2021 |
| | Right | Primary | X | A337162 | MSI | 12/03/2020 |
| | | | Z | P82096 | Endevco | 12/30/2020 |
| | | Redundant | X | A360973 | MSI | 12/14/2020 |
| Engine Accelerometers | | Top | X | PCB1446 | PCB | 02/19/2021 |
| | | Bottom | X | PCB1403 | PCB | 02/15/2021 |