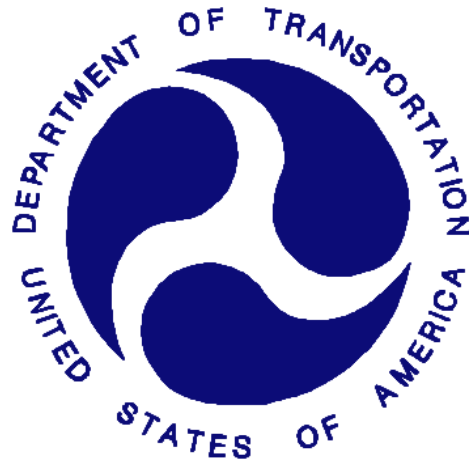


**REPORT NUMBER: TWG-MGA-19-004**

**SIDE AIRBAG OUT-OF-POSITION INJURY  
TECHNICAL WORKING GROUP**

**HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC  
2019 Hyundai Santa Fe SE 5-Door SUV  
NHTSA No.: M20194205TWG2**

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



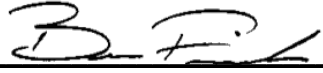
**Test Date: July 19, 2019**

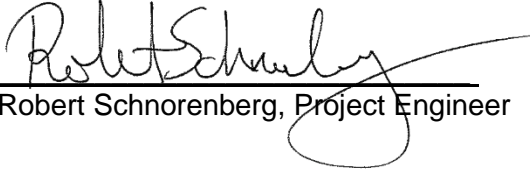
**Final Report Date: June 29, 2020**

**FINAL REPORT**

**U.S. DEPARTMENT OF TRANSPORTATION  
National Highway Traffic Safety Administration  
Office of Crashworthiness Standards  
Mail Code: NRM-110  
1200 New Jersey Ave, SE  
Room W43-410  
Washington, DC 20590**

**SIGNATURE APPROVAL PAGE**

Prepared by:   
Ben Fischer, Project Engineer

Approved by:   
Robert Schnorenberg, Project Engineer

Approval Date: June 29, 2020

FINAL REPORT ACCEPTANCE BY:

\_\_\_\_\_

Date: \_\_\_\_\_

The results presented in this report relate only to the specified test items.

**TECHNICAL REPORT DOCUMENTATION PAGE**

<b>1. Report No.</b> TWG-MGA-19-004	<b>2. Government Accession No.</b>	<b>3. Recipient's Catalog No.</b>
<b>4. Title and Subtitle</b> Final Report of Side Airbag Out-of-Position Injury Technical Working Group evaluation of a 2019 Hyundai Santa Fe SE 5-Door SUV, NHTSA No.: M20194205TWG2		<b>5. Report Date</b> June 29, 2020
<b>7. Author(s)</b> Ben Fischer, Project Engineer		<b>6. Performing Organization Code</b> MGA
<b>9. Performing Organization Name and Address</b> MGA Research Corporation 5000 Warren Road Burlington, WI 53105		<b>8. Performing Organization Report No.</b> TWG-MGA-19-004
<b>12. Sponsoring Agency Name and Address</b> U.S. Department of Transportation National Highway Traffic Safety Administration Office of Crashworthiness Standards (NRM-110) 1200 New Jersey Ave, SE, Room W43-410 Washington, D.C. 20590		<b>10. Work Unit No.</b>
		<b>11. Contract or Grant No.</b> DTNH22-13-D-00311L
		<b>13. Type of Report and Period Covered:</b> Final Test Report July 19, 2019 to June 29, 2020
<b>15. Supplementary Notes</b>		<b>14. Sponsoring Agency Code</b> NRM-110

**16. Abstract**

A Side Airbag Out-of-Position Injury evaluation was conducted on the subject 2019 Hyundai Santa Fe SE 5-Door SUV in accordance with the specifications of the Side Airbag Out-of-Position Injury Technical Working Group Laboratory Test Procedure for the generation of consumer information. The test was conducted at MGA Research Corporation in Burlington, Wisconsin on July 19, 2019.

Measurement Description	Units	Driver ATD (SID-IIs)	
		Threshold	Result
Head Injury Criteria (HIC <sub>15</sub> )		723	18
Nij		1	0.56
Neck Tension	N	1490	283
Neck Compression	N	1820	978
Maximum Chest Displacement	mm		
Maximum Chest Displacement Rate	m/s		

**17. Key Words**

Side Airbag Out-of-Position  
Technical Working Group  
OOP TWG  
HIII 6YO

**18. Distribution Statement**

Copies of this report are available from:  
National Highway Traffic Safety Administration  
Technical Information Services Division, NPO-411  
1200 New Jersey Ave, SE  
Washington, DC 20590

<b>19. Security Classification of Report</b> Unclassified	<b>20. Security Classification of Page</b> Unclassified	<b>21. No. of Pages</b> 78	<b>22. Price</b>
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**SECTION 1**  
**TEST PUPOSE AND PROCEDURE**

This side airbag out-of-position test is part of the MY2019 New Car Assessment Program (NCAP), sponsored by the National Highway Traffic Safety Administration (NHTSA) under contract number DTNH22-13-D-00311L. The purpose of this test is to obtain data on the performance of side airbags with out-of-position occupants in a 2019 Hyundai Santa Fe SE 5-Door SUV. The airbag test was conducted in accordance with the Office of Crashworthiness Standard's Side Airbag Out-of-Position Laboratory Test Procedure, dated April 2018.

## **SECTION 2 SUMMARY OF TEST RESULTS**

The effects of both a curtain and torso airbag deployment in a 2019 Hyundai Santa Fe SE 5-Door SUV with an out-of-position Hybrid III 6-Year-Old child dummy were evaluated. The curtain and seat airbags were fired remotely. The test was performed by MGA Research Corporation on July 19, 2019. Pre- and post-test photographs of the vehicle and dummy can be found in Appendix A.

Three high-speed cameras (2,700 fps) were used to document the side airbag deployment event. The following camera locations were used:

- Left Side Through Removed Driver Door
- Front Through Windshield
- Left Side  $\frac{3}{4}$  View Through Windshield

One Hybrid III 6-Year-Old child dummy (Serial Number 144) was placed in the right front passenger seat situated in the forward-facing position along the outboard edge of the seat per Section 3.3.3.5 according to dummy placement instructions specified in the Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags as prepared by the Side Airbag Out-of-Position Injury Technical Working Group (TWG).

The dummy was instrumented with the following instrumentation:

- Head Accelerometers
- Upper Neck Load Cell
- Lower Neck Load Cell

The 18 channels of data were recorded using an off board data acquisition system. Appendix B contains the dummy data traces.

The Hybrid III 6-Year-Old child dummy's visible contact points were as follows:

- Side curtain airbag to top of head
- Side torso/pelvis airbag to right side of torso and pelvis

The Hybrid III 6-Year-Old child dummy was placed in the right front passenger seat. The dummy was seated on the outboard edge of a foam block aligning the upper spine with the deployment trajectory of the airbag. The head was placed between the seat bolster and pillar/side trim to minimize the fore-aft clearance between the neck and seatback. Legs were aligned such that they cross the heel placement points on the seat cushion. The dummy's pelvis was slid forward (parallel to the centerline of the vehicle) until the neck/torso junction was aligned vertically with the top edge of the airbag module. The dummy's outboard arm was raised to clear the vehicle armrest. The pelvis/torso of the dummy was in contact with the door.

The dummy's skullcap seam was covered with 4mm electrical tape to prevent the airbag from getting caught in the seam. The dummy's head skin was cleaned with alcohol and dusted with baby powder to achieve acceptable frictional characteristics.

This orientation complies with Section 3.3.3.5 of the TWG Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags as defined by Lund, et al and the Technical Working Group First Revision dated July 2003.

**SECTION 3  
OCCUPANT AND VEHICLE INFORMATION**



**DATA SHEET NO. 1  
TEST SUMMARY**

Test Vehicle: 2019 Hyundai Santa Fe SE 5-Door SUV  
 Test Program: NCAP Side Airbag Out-of-Position

NHTSA No.: M20194205TWG2  
 Test Date: 7/19/2019

**TEST CONFIGURATION INFORMATION**

Seating Position	P2	Right Front Seating Position
Test Section	3.3.3.5*	Forward-Facing Child Dummy
Curtain Airbag	Roof-Rail Mounted	Side Curtain Airbag
Torso Airbag	Seat Mounted	Side Torso/Pelvis Airbag
ATD Type/Serial No.	Hybrid III 6-Year-Old	S/N: 144
Vehicle	Hyundai	Santa Fe
Previous Crash Test	Side MDB NCAP	January 4, 2019 – M20194205

\*Procedure as defined by Lund, et al and the Technical Working Group dated July 2003

**EQUIPMENT INFORMATION**

Number of Data Channels	18
Number of Airbag Channels	4
Number of High-Speed Video	3

**VISIBLE DUMMY CONTACT POINTS**

Head	Side curtain airbag to top of head
Upper Torso	Side torso/pelvis airbag
Lower Torso	Side torso/pelvis airbag
Knee	None

**DATA SHEET NO. 2  
GENERAL TEST AND VEHICLE PARAMETER DATA**

Test Vehicle: 2019 Hyundai Santa Fe SE 5-Door SUV  
 Test Program: NCAP Side Airbag Out-of-Position

NHTSA No.: M20194205TWG2  
 Test Date: 7/19/2019

**TEST VEHICLE INFORMATION AND OPTIONS**

NHTSA No.	M20194205	Traction Control System (TCS)	Yes
Model Year	2019	Auto-Leveling System	No
Make	Hyundai	Automatic Door Locks (ADL)	Yes
Model	Santa Fe SE	Power Window Auto-Reverse	Yes
Body Style	5-Door SUV	Other Optional Feature	No
VIN	5NMS23AD3KH023099	Driver Front Airbag	Yes
Body Color	Machine Gray	Driver Curtain Airbag	Yes
Odometer Reading (km/mi)	101 km / 63 mi	Driver Head/Torso Airbag	No
Engine Displacement (L)	2.4 L	Driver Torso Airbag	No
Type/No. Cylinders	Inline 4	Driver Torso/Pelvis Airbag	Yes
Engine Placement	Lateral	Driver Pelvis Airbag	No
Transmission Type	Automatic	Driver Knee Airbag	No
Transmission Speeds	8	Rear Pass. Curtain Airbag	Yes
Overdrive	Yes	Rear Pass. Head/Torso Airbag	No
Final Drive	FWD	Rear Pass. Torso Airbag	No
Roof Rack	No	Rear Pass. Torso/Pelvis Airbag	No
Sunroof/T-Top	No	Rear Pass. Pelvis Airbag	No
Running Boards	No	Driver Seat Belt Pretensioner	Yes
Tilt Steering Wheel	Yes	Rear Pass. Seat Belt	No
Power Seats	No	Driver Load Limiter	Yes
Anti-Lock Brakes (ABS)	Yes	Rear Pass. Load Limiter	No
		Other Restraint Feature	N/A

**DATA FROM CERTIFICATION LABEL**

Manufactured By	HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC
Date of Manufacture	Aug/06/18
Vehicle Type	MPV

GVWR (kg)	2145
GAWR Front (kg)	1300
GAWR Rear (kg)	1395

**VEHICLE SEATING AND WEIGHT CAPACITY DATA**

Measured Parameter	Front	Rear	Third	Total	
Designated Seating Capacity (DSC)	2	3		5	
Capacity Weight (VCW) (kg)				480	(A)
DSC x 68.04 kg				340	(B)
Rated Cargo and Luggage Weight (RCLW) (kg)				140	(A-B)

**VEHICLE SEAT TYPE**

Seating Location	Type of Seat Pan				Type of Seat Back		
	Bucket	Bench	Split Bench	Contoured	Fixed	Adjustable	
						Manual	Power
Front Seat	X					w/ Lever	
Rear or Second Row			X			w/ Lever	
Third Row Seat							

**DATA SHEET NO. 3  
SEAT ADJUSTMENT DATA**

Test Vehicle: 2019 Hyundai Santa Fe SE 5-Door SUV  
 Test Program: NCAP Side Airbag Out-of-Position

NHTSA No.: M20194205TWG2  
 Test Date: 7/19/2019

**VEHICLE SEAT FORE/AFT POSITION**

Seat	Total Fore/Aft Travel		Test Position from Forward-Most Position	
	mm	Detents (1 <sup>st</sup> as 1)	mm	Detent (1 <sup>st</sup> as 0)
Right Front Passenger Seat	240	38	52	8
Right Rear Passenger Seat				
Seat Fore/Aft Position per TWG Guidelines	Initial Position: Rearmost and lowest adjustment			
	Seat Track Adjustments: Allowed to ensure proper alignment of the ATD upper spine and airbag deployment trajectory			
Reason for Deviation from TWG Guidelines	No deviation from TWG guidelines			

**VEHICLE SEAT BACK ANGLE ADJUSTMENT**

Seat	Total Seat Back Angle Range		Test Position from Vertical	
	Degrees	Detents (1 <sup>st</sup> as 1)	Degrees	Detent (1 <sup>st</sup> as 0)
Right Front Passenger Seat	63.8	33	0.8	
Right Rear Passenger Seat				
OEM Back Angle Design Position	1.0° rearward of vertical			
Method of Measuring Back Angle Position	Angle measured on outboard headrest post			
Seat Back Position per TWG Guidelines	Initial Position: Manufacturer's design angle			
	Seat Back Adjustments: None			
Reason for Deviation from TWG Guidelines	No deviation from TWG guidelines			

**VEHICLE SEAT HEIGHT ADJUSTMENT**

Seat	Total Seat Height Travel		Test Position from Lowest Position	
	mm	Detents (1 <sup>st</sup> as 1)	mm	Detent (1 <sup>st</sup> as 0)
Right Front Passenger Seat	Fixed		Fixed	
Right Rear Passenger Seat				
Seat Fore/Aft Position per TWG Guidelines	Initial Position: Rearmost and lowest adjustment			
	Seat Height Adjustments: None			
Reason for Deviation from TWG Guidelines	No deviation from TWG guidelines			

**DATA SHEET NO. 4**  
**DUMMY SETUP AND POSITIONING DATA**

Test Vehicle: 2019 Hyundai Santa Fe SE 5-Door SUV  
Test Program: NCAP Side Airbag Out-of-Position

NHTSA No.: M20194205TWG2  
Test Date: 7/19/2019

ATD Type	Hybrid III 6-Year-Old child dummy
Serial Number	144
Qualification Date	7/16/2019
Qualification Type	Full
Clothing	Cotton shirt and pants, shoes
Other ATD Preparation	Skullcap seam covered with 4mm electrical tape. Head skin cleaned with alcohol and dusted with baby powder.

**DATA SHEET NO. 5  
DUMMY INJURY CRITERIA VALUES**

Test Vehicle: 2019 Hyundai Santa Fe SE 5-Door SUV  
 Test Program: NCAP Side Airbag Out-of-Position

NHTSA No.: M20194205TWG2  
 Test Date: 7/19/2019

**RECORDED DATA – MINIMUMS AND MAXIMUMS**

Channel	Unit	CFC	Maximum	Time (ms)	Minimum	Time (ms)
Passenger Head X	g	1000	35.1	12.3	-14.2	12.1
Passenger Head Y			11.2	299.2	-44.7	12.2
Passenger Head Z			82.1	12.0	-19.1	12.3
Passenger Upper Neck Fx	N	1000	205.4	16.0	-56.4	169.2
Passenger Upper Neck Fy			29.1	26.8	-235.9	13.0
Passenger Upper Neck Fz			282.6	129.1	-978.0	19.1
Passenger Upper Neck Mx	Nm	600	16.5	13.0	-25.9	26.9
Passenger Upper Neck My			25.0	17.0	-15.0	36.2
Passenger Upper Neck Mz			4.0	73.5	-7.5	33.9
Passenger Lower Neck Fx	N	1000	133.5	42.1	-324.2	14.9
Passenger Lower Neck Fy			74.0	47.0	-386.0	14.5
Passenger Lower Neck Fz			314.5	129.1	-904.5	19.5
Passenger Lower Neck Mx	Nm	600	6.6	145.5	-31.7	15.9
Passenger Lower Neck My			10.5	170.6	-18.0	74.0
Passenger Lower Neck Mz			6.0	47.6	-23.2	14.3

**HEAD INJURY SUMMARY**

HIC <sub>15</sub>	T <sub>1</sub> (ms)	T <sub>2</sub> (ms)	HIC <sub>36</sub>	T <sub>1</sub> (ms)	T <sub>2</sub> (ms)
18	11.7	13.4	18	11.7	13.4

**NECK INJURY SUMMARY**

Injury Criteria	Unit	Value	Time (ms)
Upper Neck NTF		0.11	149.7
Upper Neck NTE		0.35	66.2
Upper Neck NCF		0.56	17.6
Upper Neck NCE		0.49	38.1
Peak Tension	N	283	129.1
Peak Compression	N	978	19.1

**DATA SHEET NO. 5 (CONT.)  
DUMMY INJURY CRITERIA DATA**

Test Vehicle: 2019 Hyundai Santa Fe SE 5-Door SUV  
Test Program: NCAP Side Airbag Out-of-Position

NHTSA No.: M20194205TWG2  
Test Date: 7/19/2019

**CHEST INJURY SUMMARY**

<b>Injury Criteria</b>	<b>Unit</b>	<b>Value</b>	<b>Time (ms)</b>
Chest Deflection	mm		
Deflection Rate <sup>1</sup>	m/s		

<sup>1</sup>Deflection rate is calculated based on Chest Deflection potentiometer.

**RESEARCH VALUE SUMMARY**

<b>Research Injury Criteria<sup>1</sup></b>	<b>Unit</b>	<b>Value</b>	<b>Time (ms)</b>
Upper Neck Lateral Moment	Nm	25.9	26.9
Upper Neck Twist Moment	Nm	7.5	33.9
Lower Neck Flexion Moment	Nm	10.5	170.6
Lower Neck Extension Moment	Nm	18.0	74.0
Lower Neck Lateral Moment	Nm	31.7	15.9
Lower Neck Twist Moment	Nm	23.2	14.3
Lower Neck Tension	N	314.5	129.1
Lower Neck Compression	N	904.5	19.5
Spine Acceleration	g		

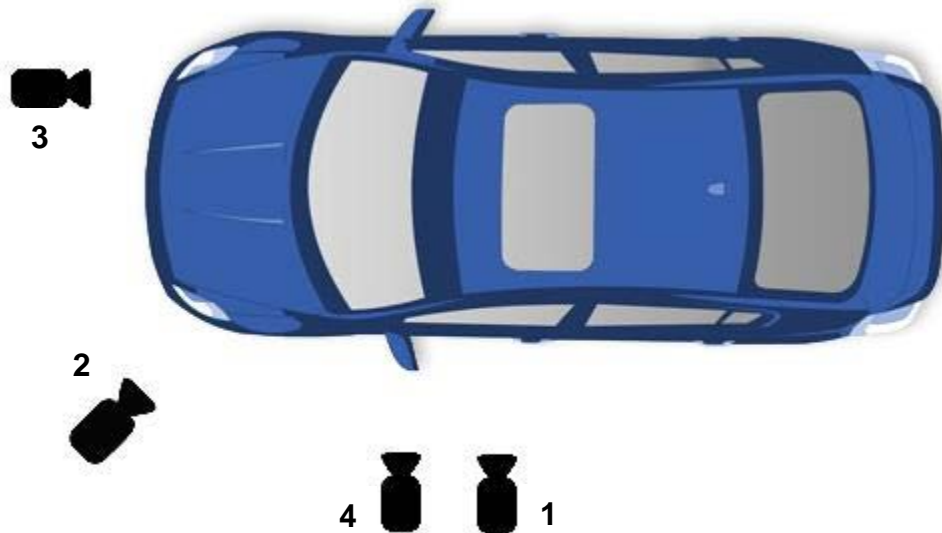
<sup>1</sup>These injury criteria are only monitored and not considered pass/fail.

**DATA SHEET NO. 6  
CAMERA SETUP AND DESCRIPTION**

Test Vehicle: 2019 Hyundai Santa Fe SE 5-Door SUV  
 Test Program: NCAP Side Airbag Out-of-Position

NHTSA No.: M20194205TWG2  
 Test Date: 7/19/2019

**CAMERA SETUP DIAGRAM FOR OOP TESTS**



**CAMERA LOCATIONS**

No.	Camera View	Location			Lens (mm)	Speed (fps)
		X	Y	Z		
1	Left View	270	-2431	-1379	24	2700
2	Oblique View	1747	-1921	-1950	24	2700
3	Front View	2772	384	-2148	24	2700
4	Real Time (optional)					30

Reference:

+X = Forward of Rear Surface of Vehicle (RSOV)

+Y = Right of Vehicle Centerline

+Z = Down from Ground

**APPENDIX A**  
**PHOTOGRAPHS**

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Photo No. 001 - Right Front Three-Quarter View of Vehicle, As Delivered



Photo No. 002 - Vehicle Certification Label



Photo No. 003 - Pre-Test Vehicle Left Side View



Photo No. 004 - Post-Test Vehicle Left Side View



Photo No. 005 - Pre-Test Vehicle Location of Air Bag 1



Photo No. 006 - Pre-Test Vehicle Location of Air Bag 2



Photo No. 007 - Pre-Test Vehicle Location of Air Bag 3



Photo No. 008 - Pre-Test Vehicle Seat Back Angle



Photo No. 009 - Pre-Test Dummy Left Side View



Photo No. 010 - Post-Test Dummy Left Side View



Photo No. 011 - Pre-Test Dummy Left Side Close-up View



Photo No. 012 - Post-Test Dummy Left Side Close-up View



Photo No. 013 - Pre-Test Dummy Left Three-Quarter Front View



Photo No. 014 - Post-Test Dummy Left Three-Quarter Front View



Photo No. 015 - Pre-Test Dummy Left Three-Quarter Front Close-up View



Photo No. 016 - Post-Test Dummy Left Three-Quarter Front Close-up View





Photo No. 017 - Pre-Test Dummy Front View



Photo No. 018 - Post-Test Dummy Front View



Photo No. 019 - Pre-Test Dummy Front Close-up View



Photo No. 020 - Post-Test Dummy Front Close-up View

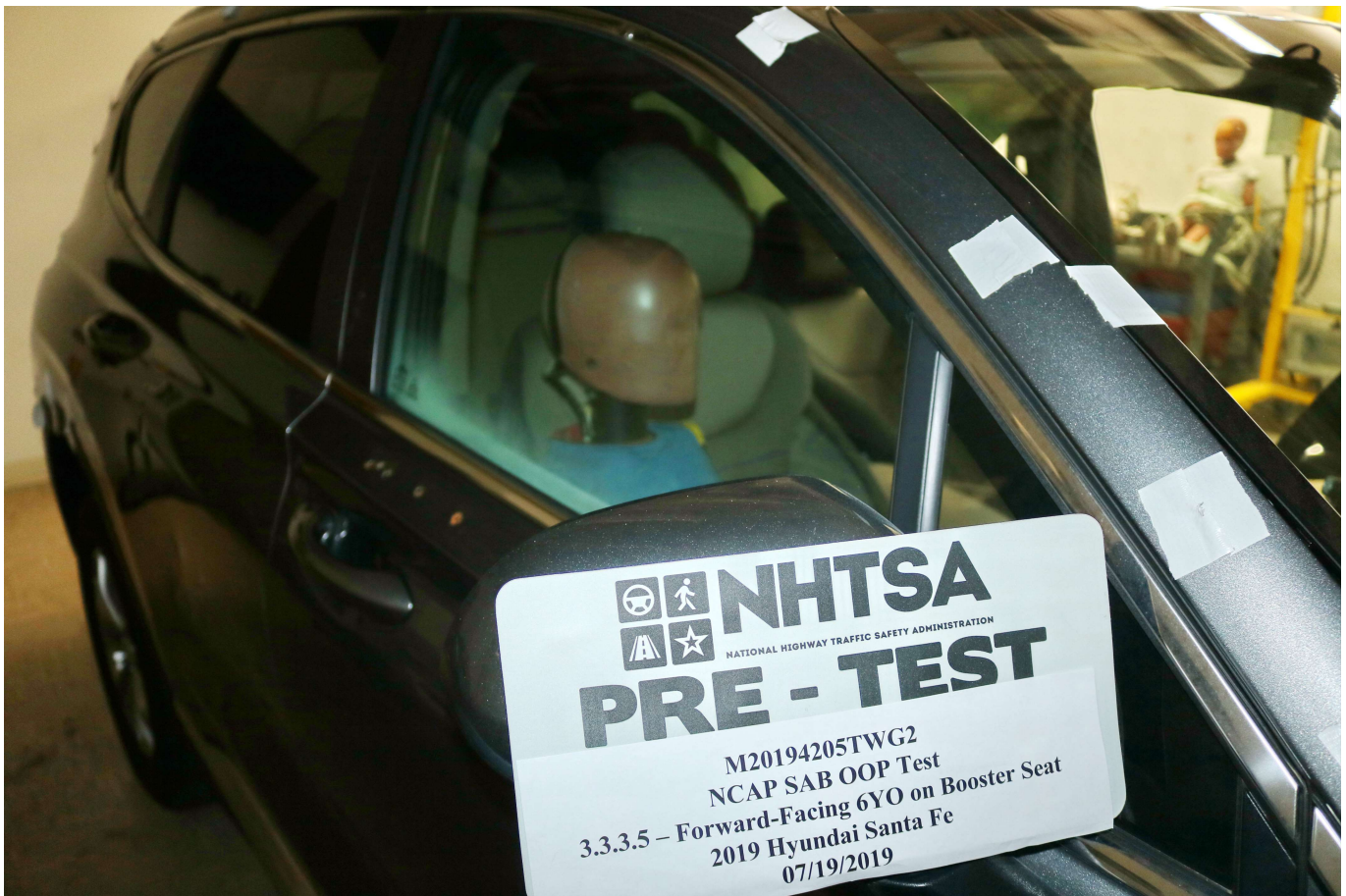


Photo No. 021 - Pre-Test Dummy Right Three-Quarter Front View



Photo No. 022 - Post-Test Dummy Right Three-Quarter Front View

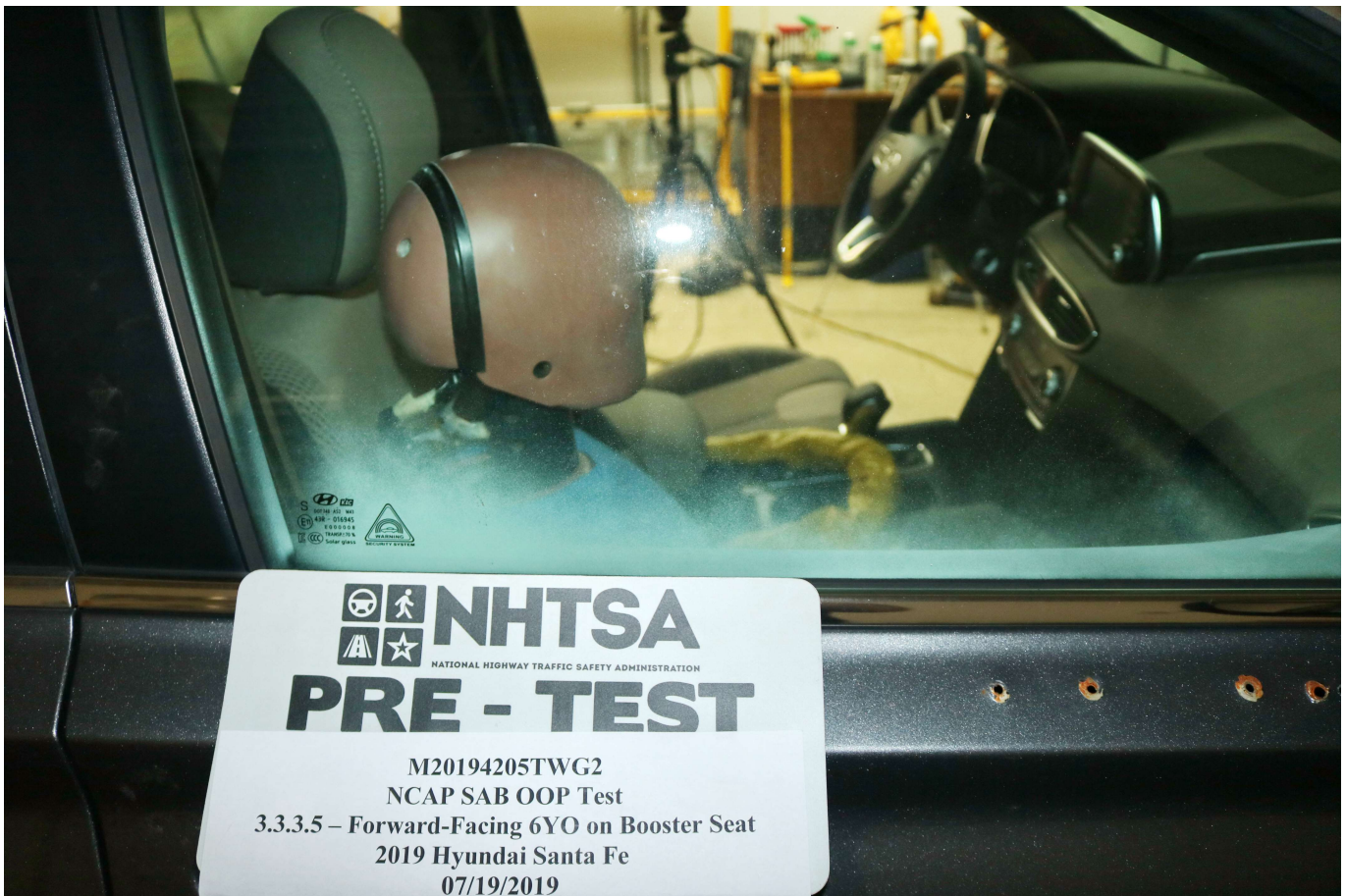


Photo No. 023 - Pre-Test Dummy Right Side View



Photo No. 024 - Post-Test Dummy Right Side View



Photo No. 025 - Post-Test Dummy Right Side View (Door Open)



Photo No. 026 - Post-Test Curtain Air Bag Left Side View



Photo No. 027 - Post-Test Curtain Air Bag Left Three-Quarter Front View



Photo No. 028 - Post-Test Curtain Air Bag Front View



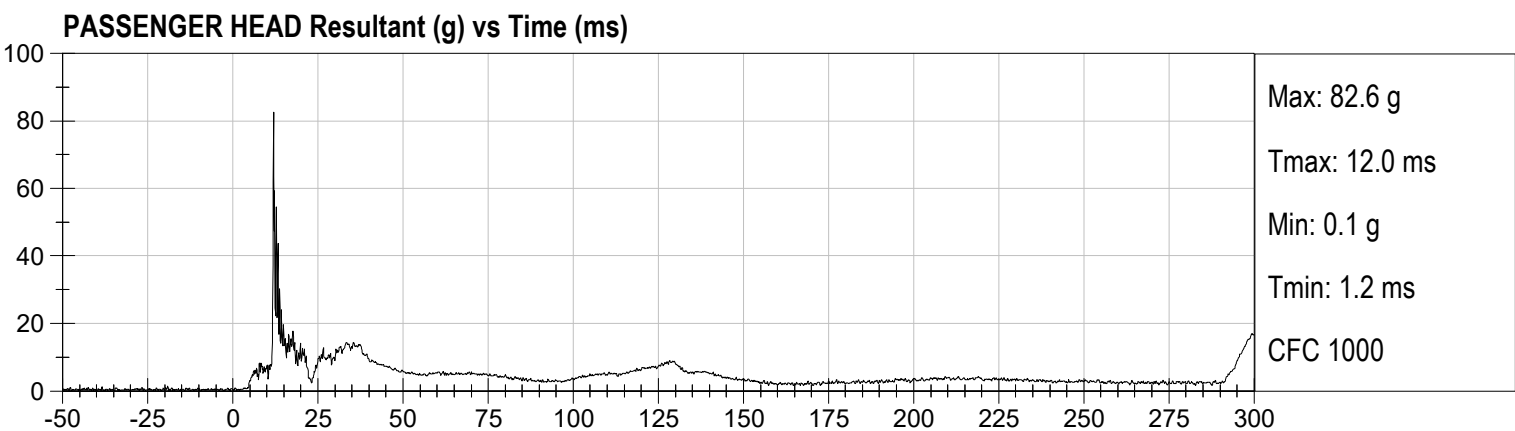
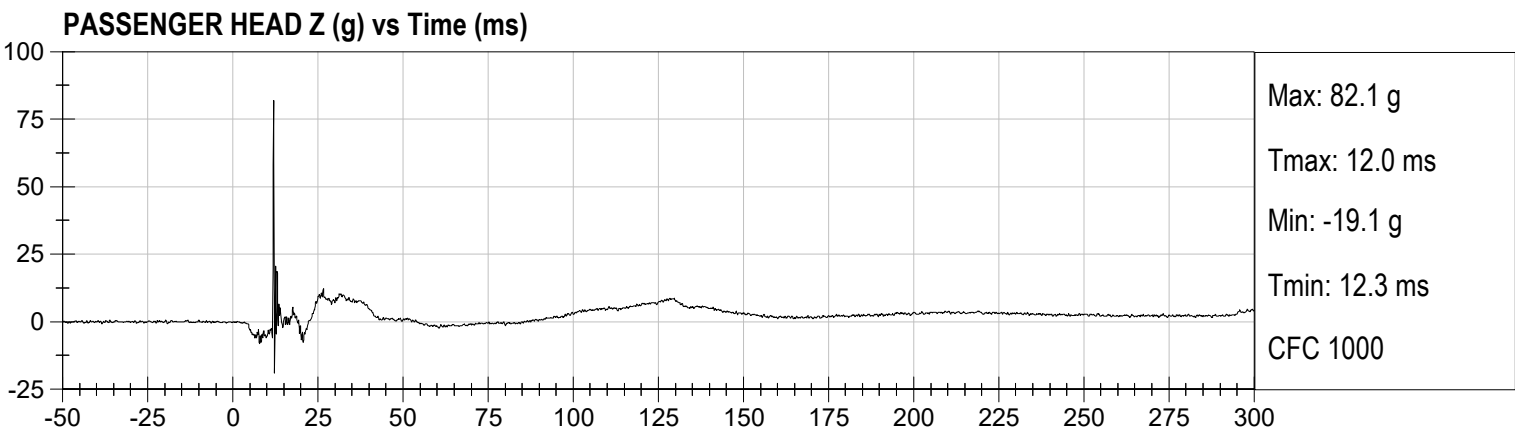
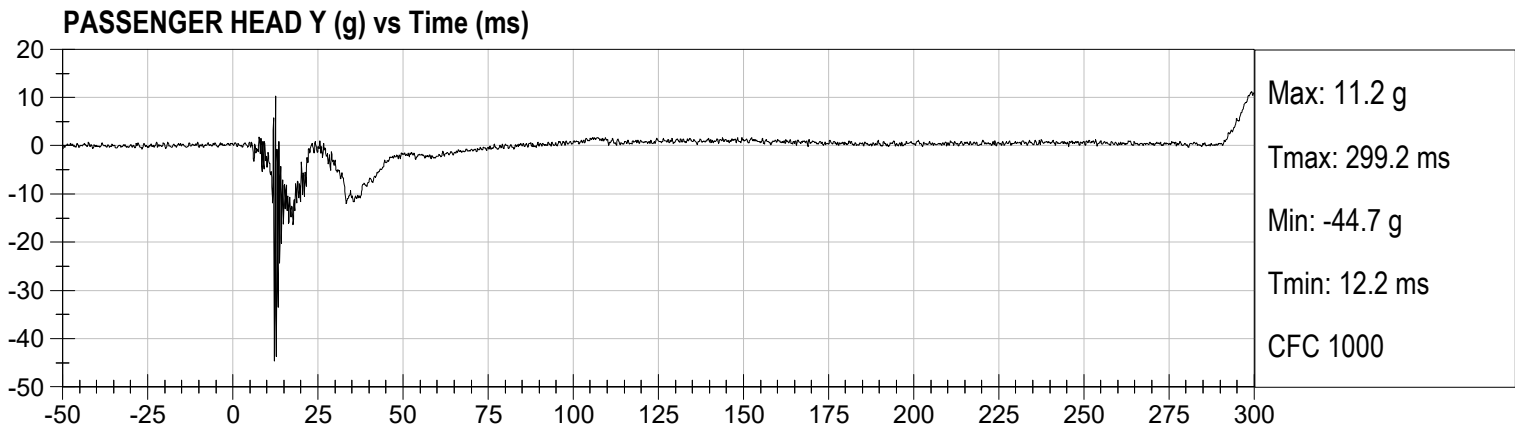
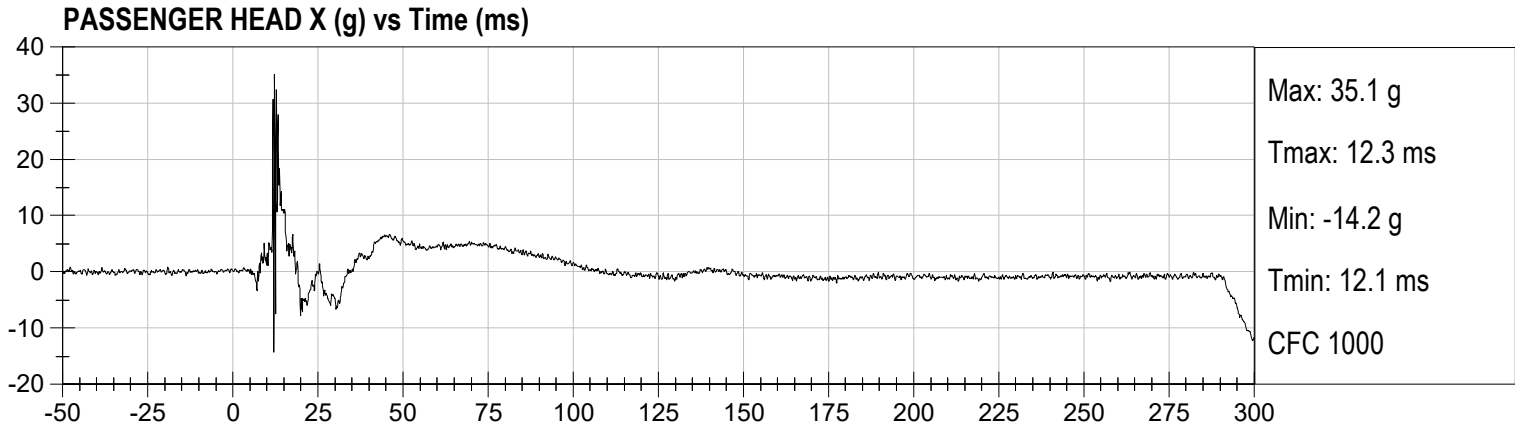
Photo No. 029 - Post-Test Curtain Air Bag Right Side View (Door Open)

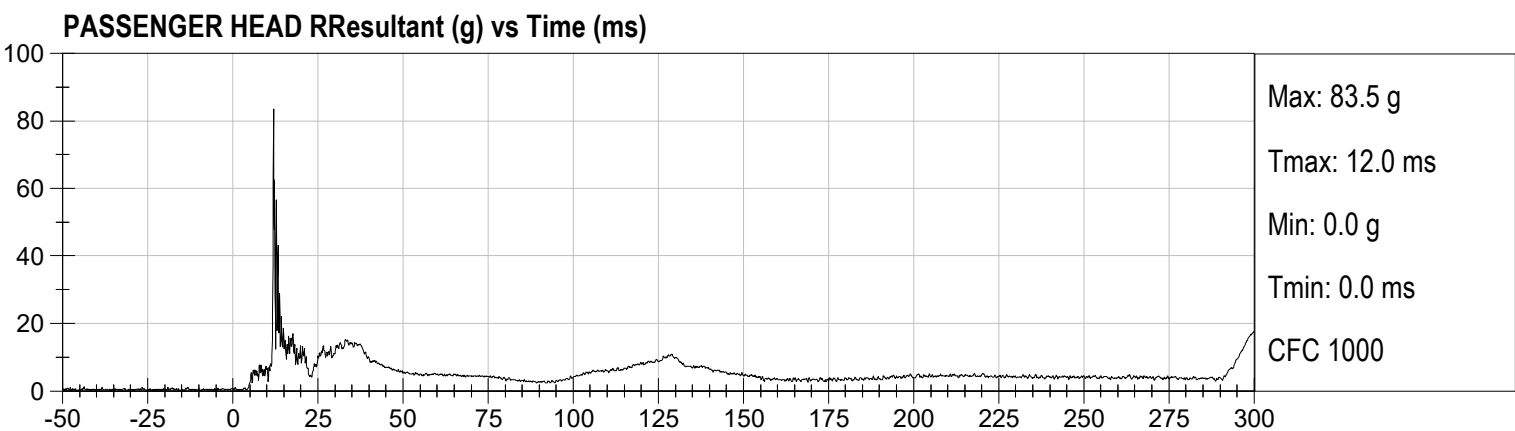
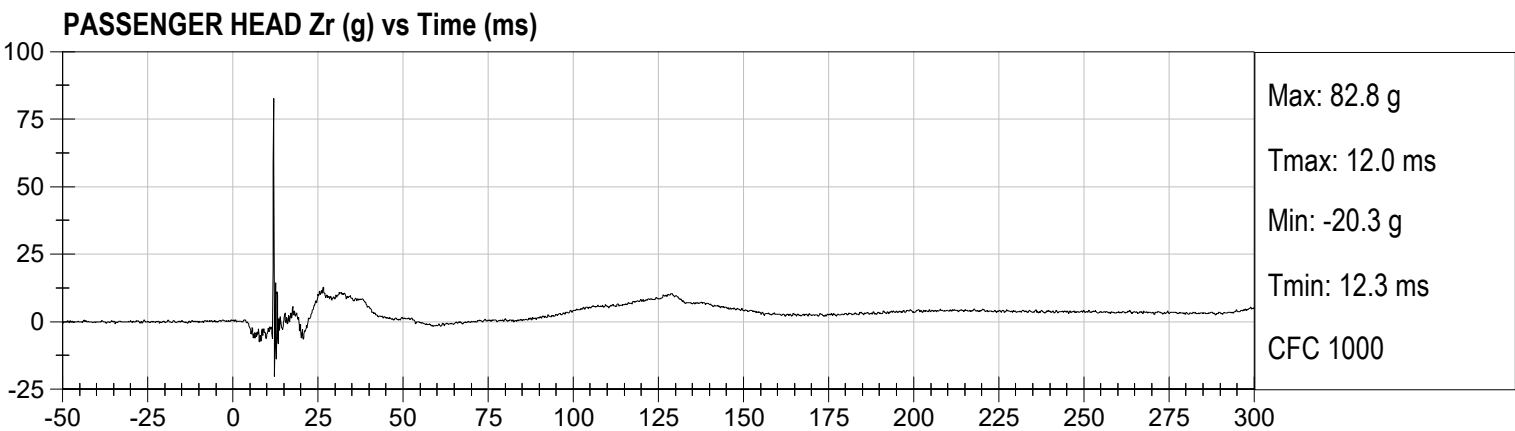
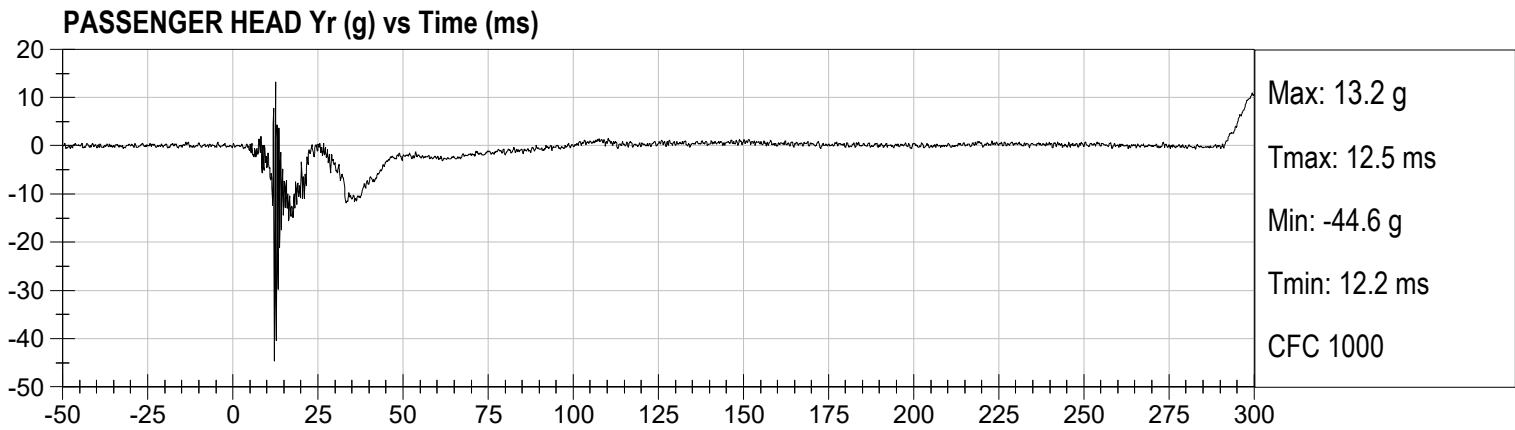
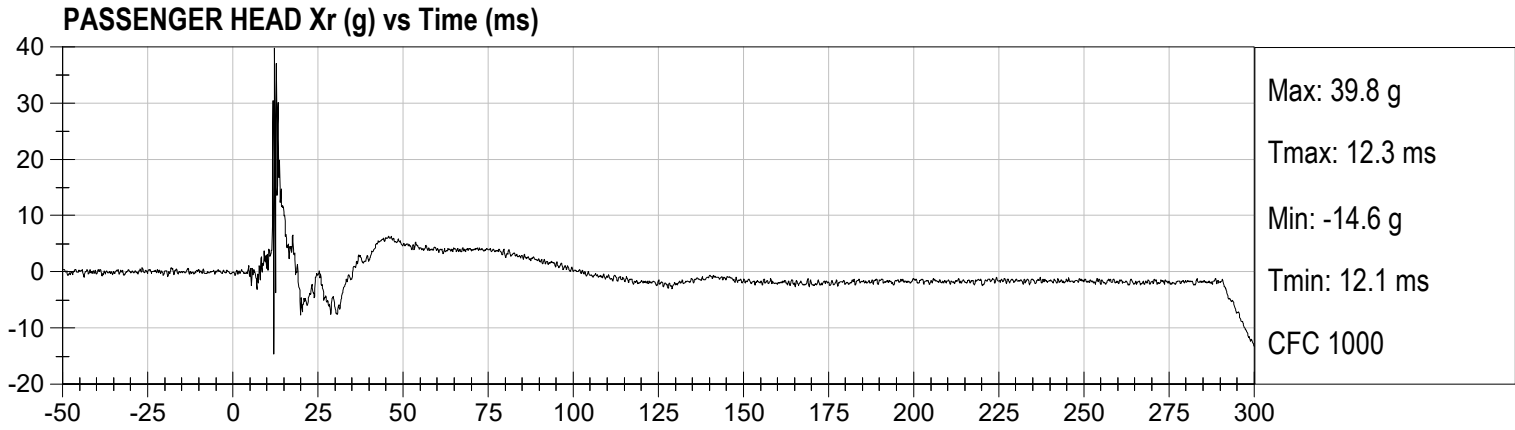
**APPENDIX B**  
**DUMMY RESPONSE DATA TRACES**

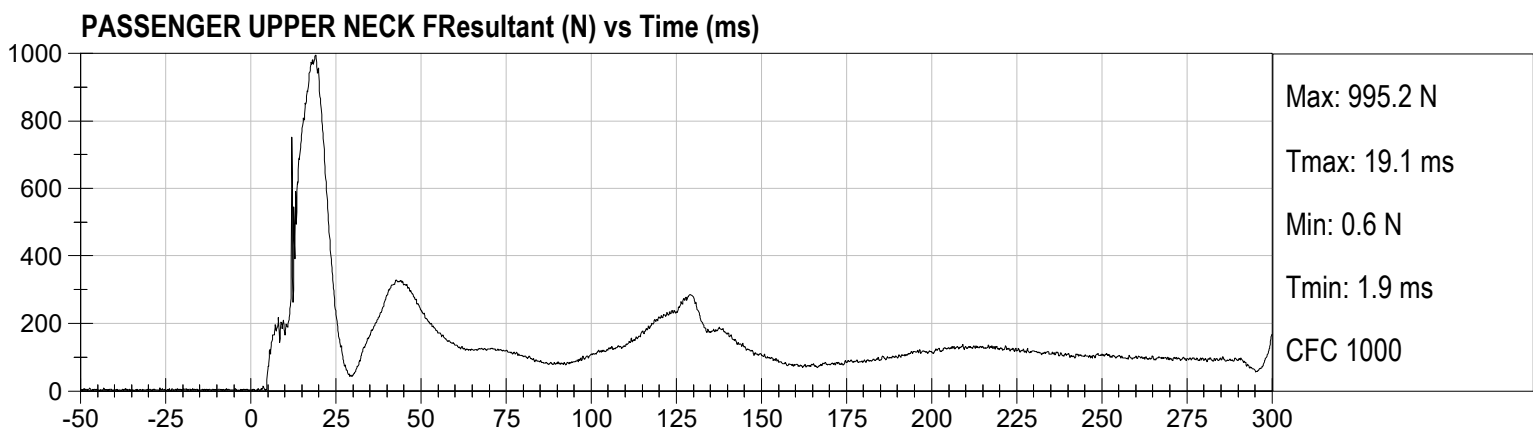
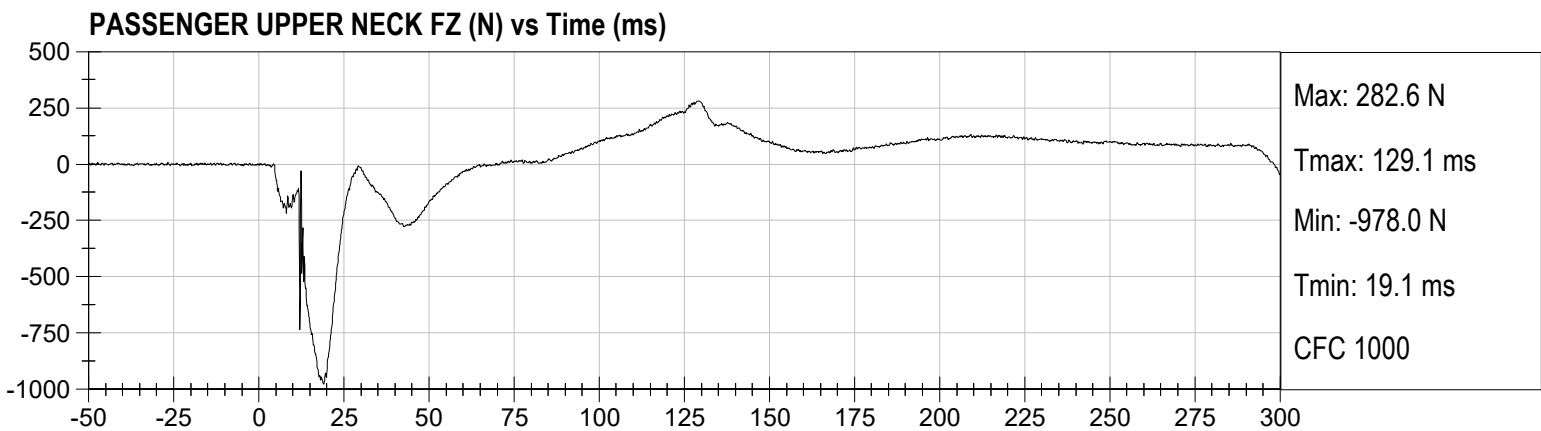
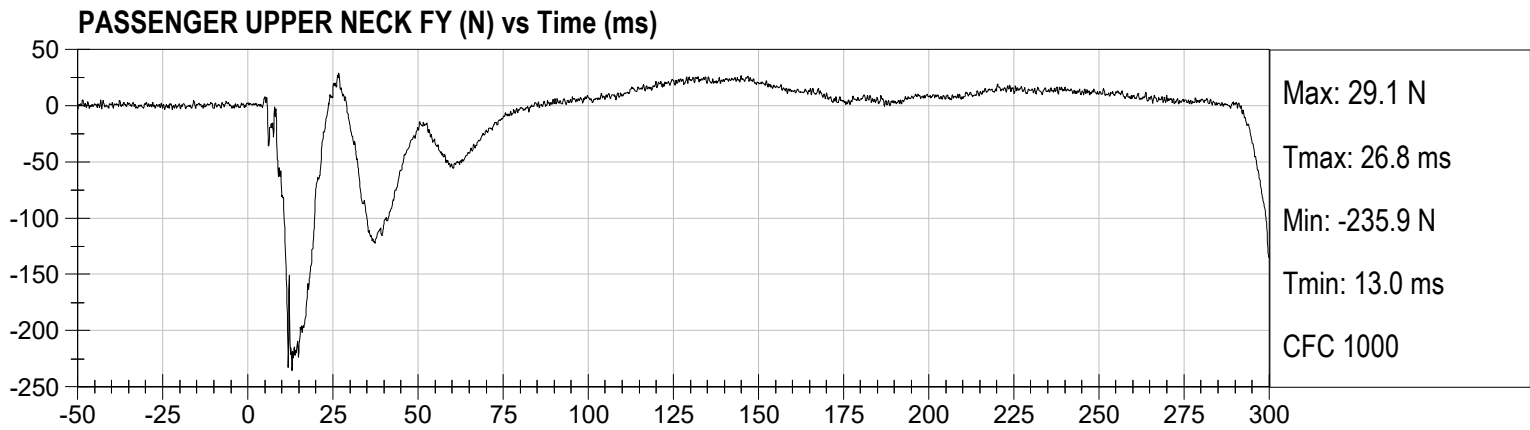
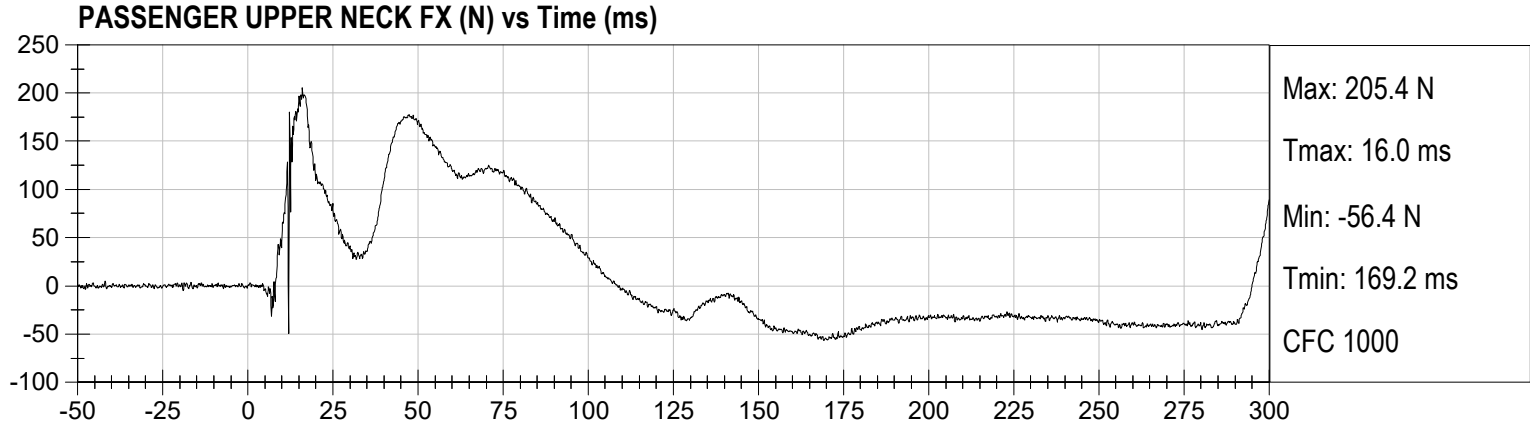
**TABLE OF DATA PLOTS**

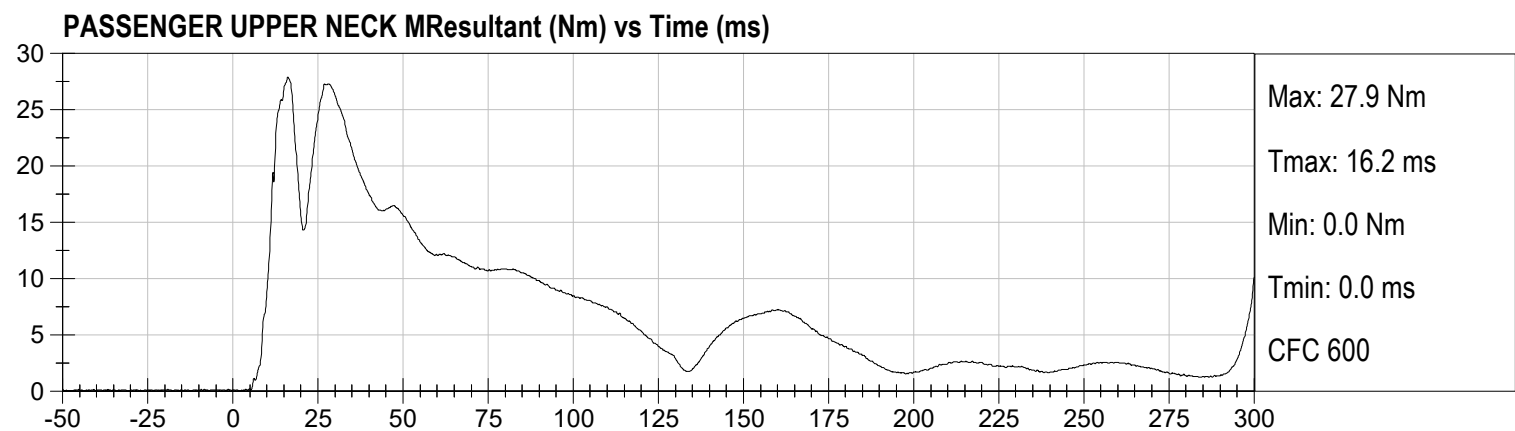
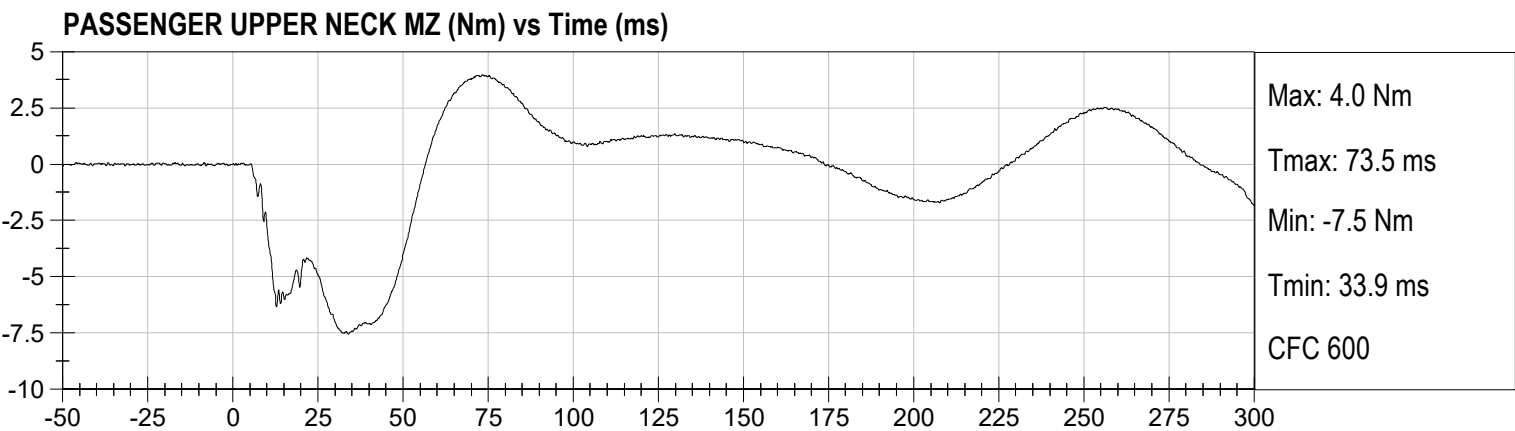
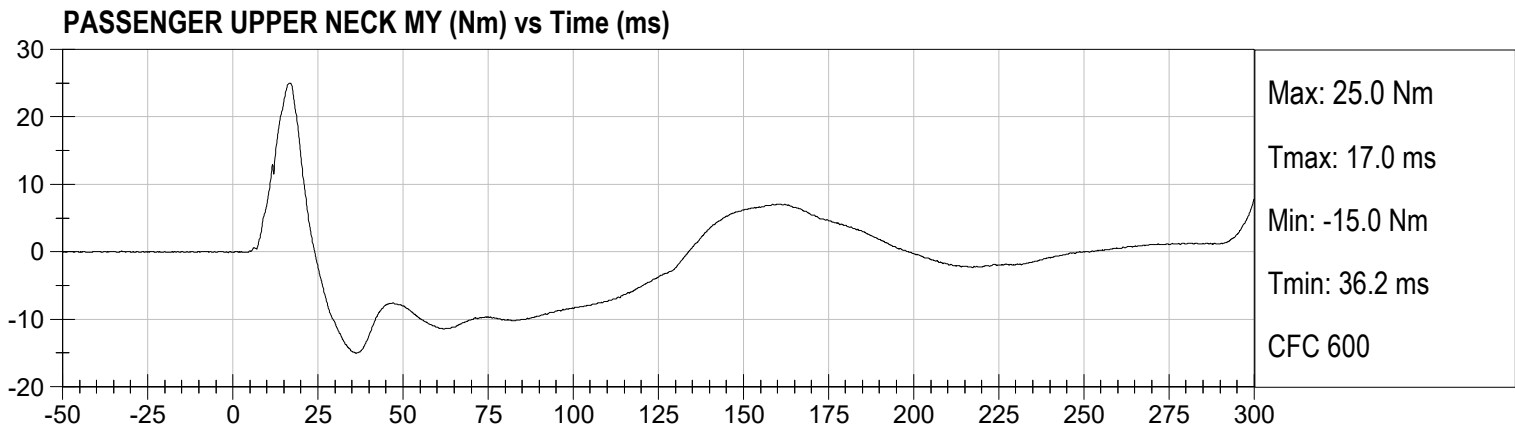
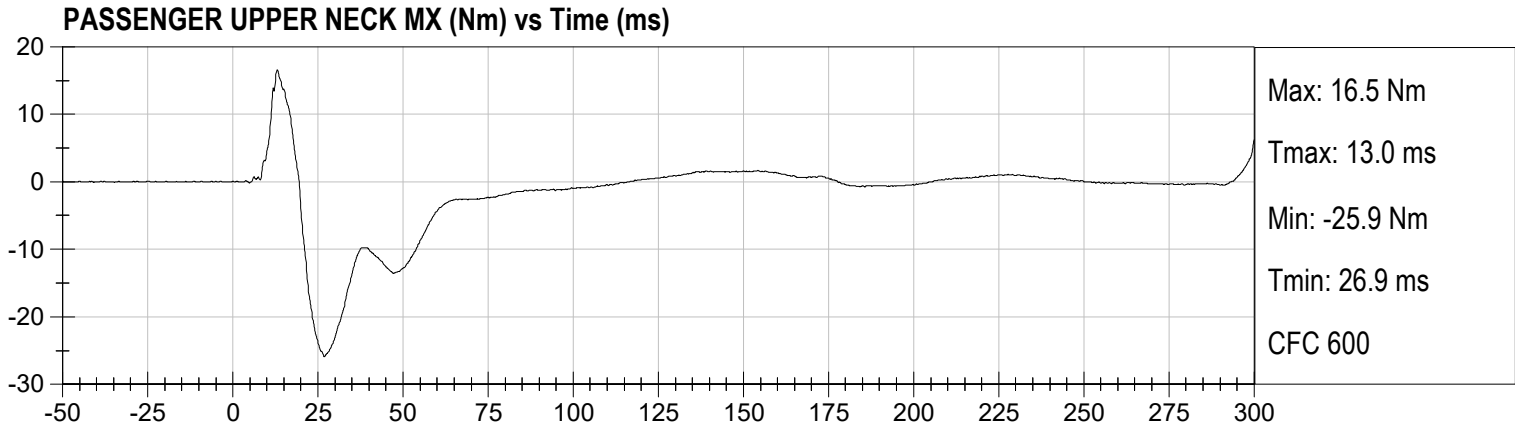
	<u>Page No.</u>
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Passenger Head Y Acceleration vs. Time	B-1
Passenger Head Z Acceleration vs. Time	B-1
Passenger Head Resultant Acceleration vs. Time	B-1
Passenger Upper Neck X Force vs. Time	B-2
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Passenger Upper Neck Z Force vs. Time	B-2
Passenger Upper Neck Resultant Force vs. Time	B-2
Passenger Upper Neck X Moment vs. Time	B-3
Passenger Upper Neck Y Moment vs. Time	B-3
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Passenger Upper Neck Resultant Moment vs. Time	B-3
Passenger Lower Neck X Force vs. Time	B-4
Passenger Lower Neck Y Force vs. Time	B-4
Passenger Lower Neck Z Force vs. Time	B-4
Passenger Lower Neck Resultant Force vs. Time	B-4
Passenger Lower Neck X Moment vs. Time	B-5
Passenger Lower Neck Y Moment vs. Time	B-5
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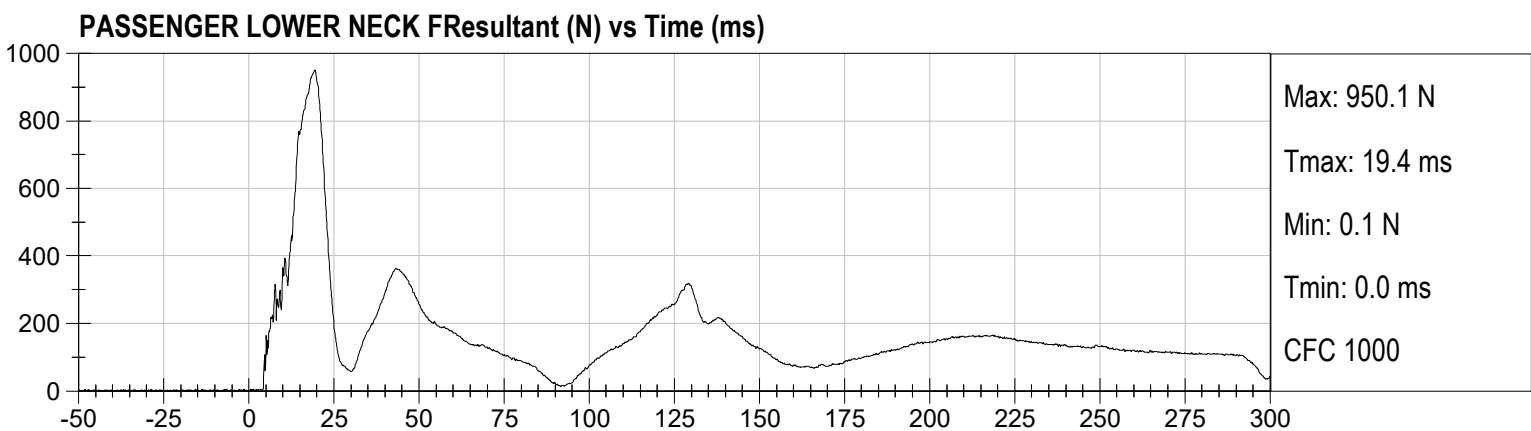
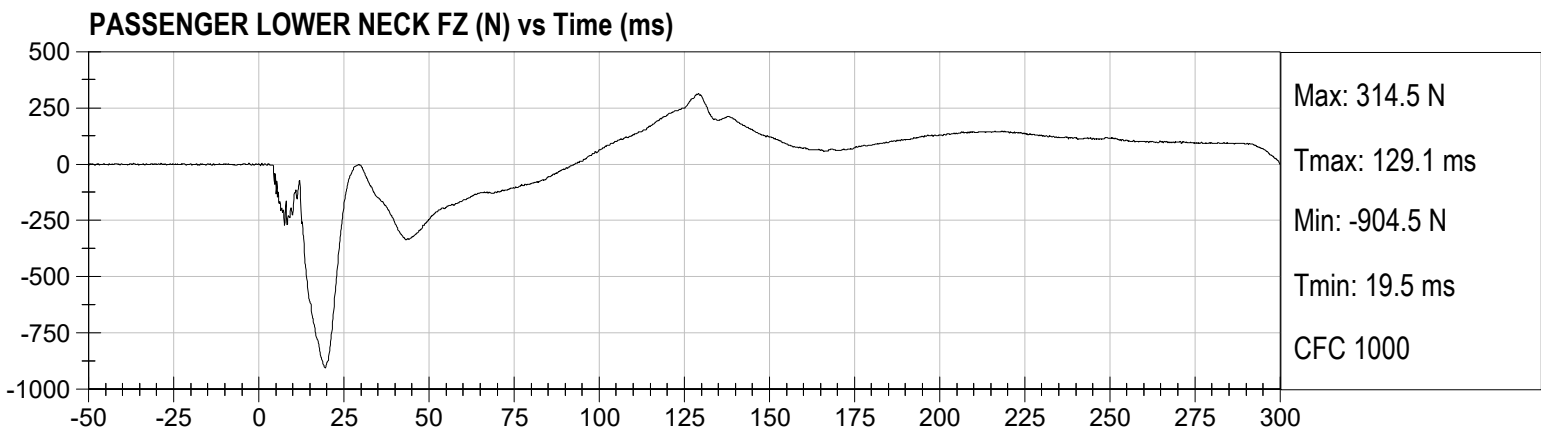
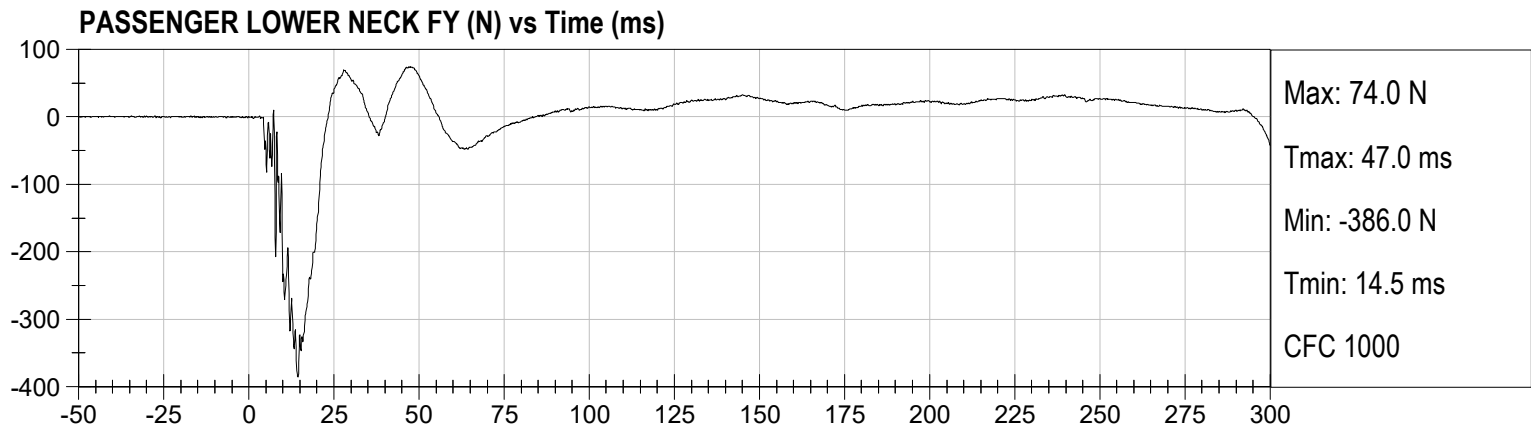
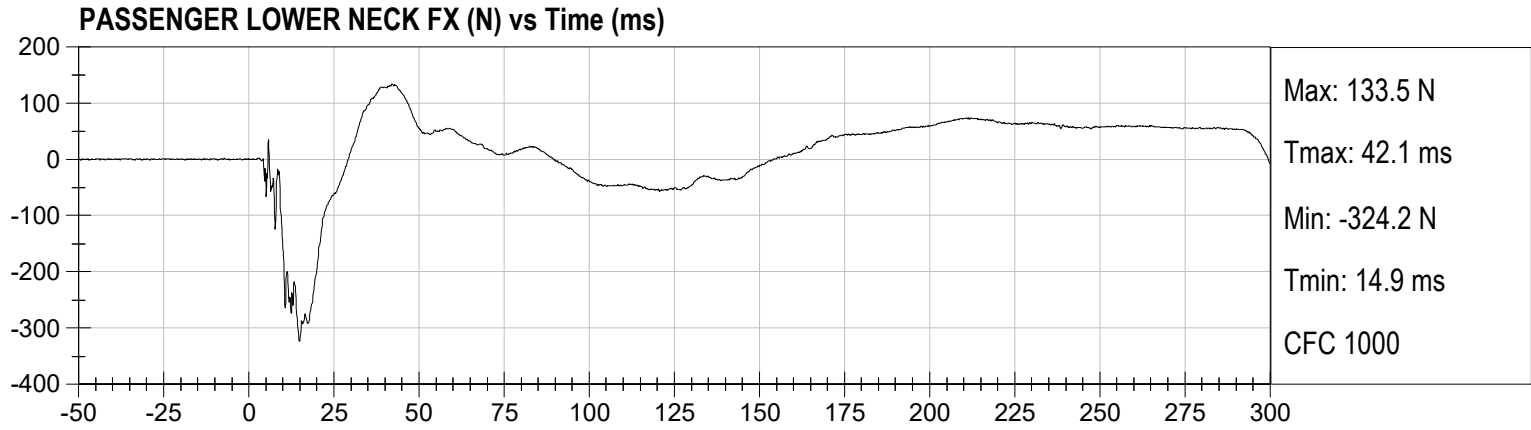




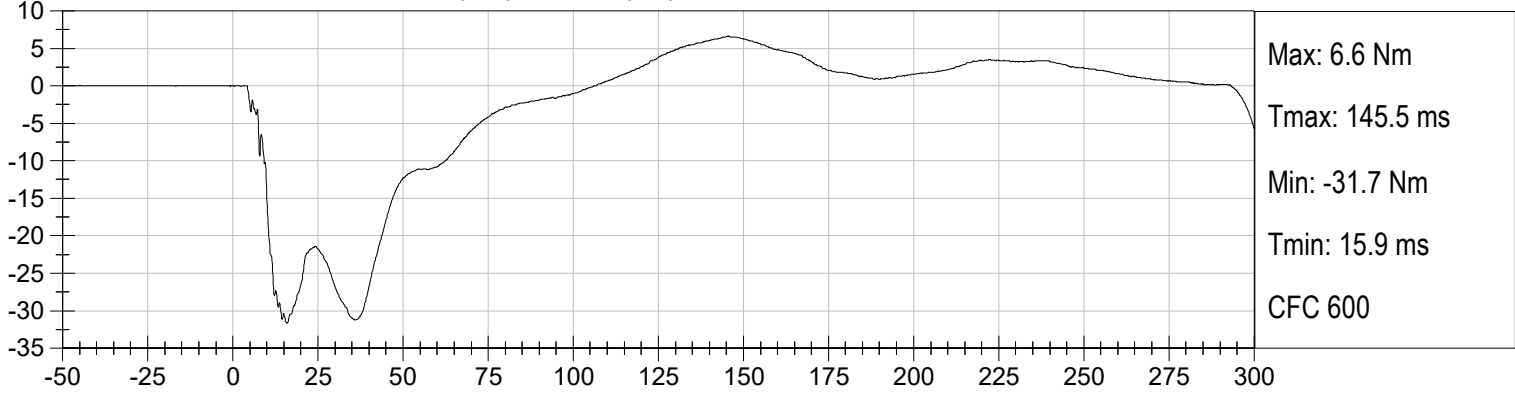




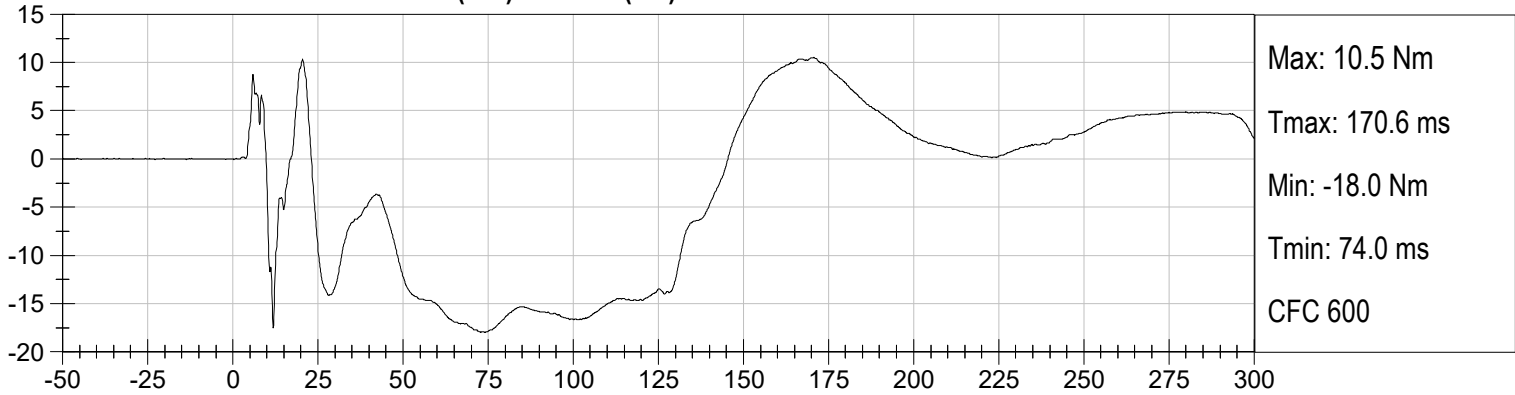




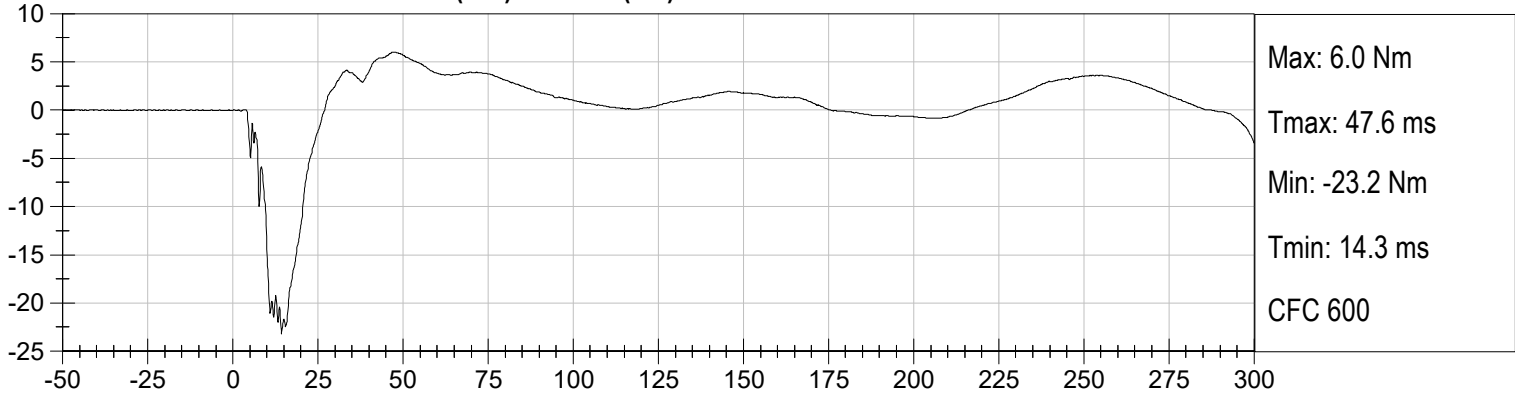
**PASSENGER LOWER NECK MX (Nm) vs Time (ms)**



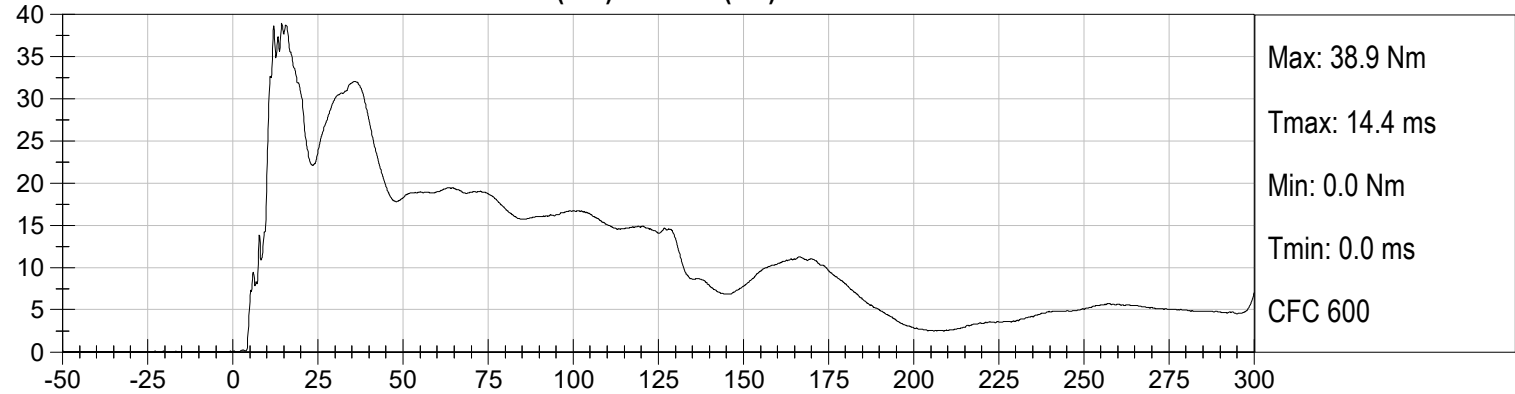
**PASSENGER LOWER NECK MY (Nm) vs Time (ms)**



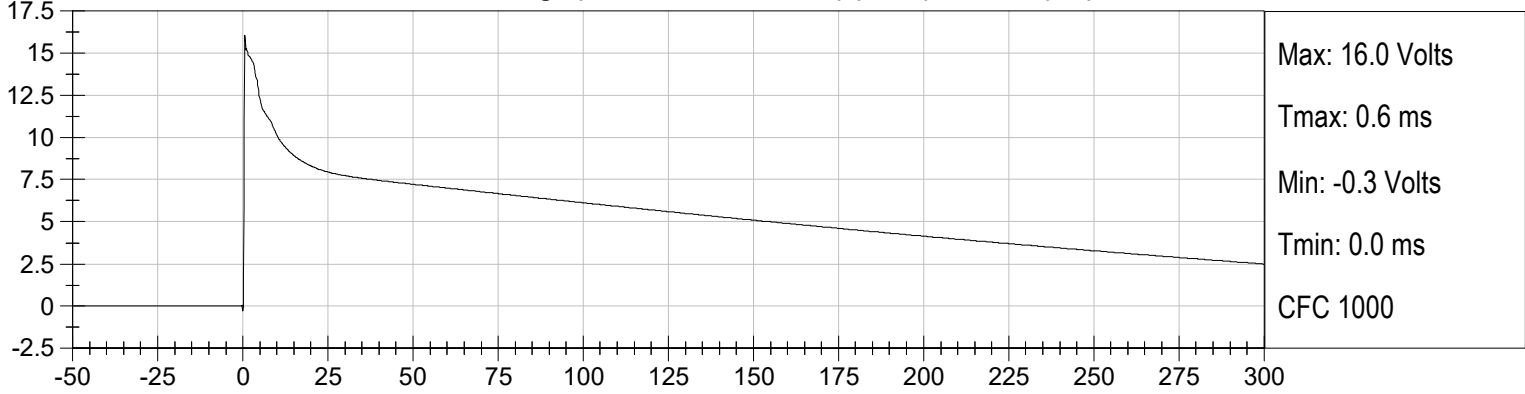
**PASSENGER LOWER NECK MZ (Nm) vs Time (ms)**



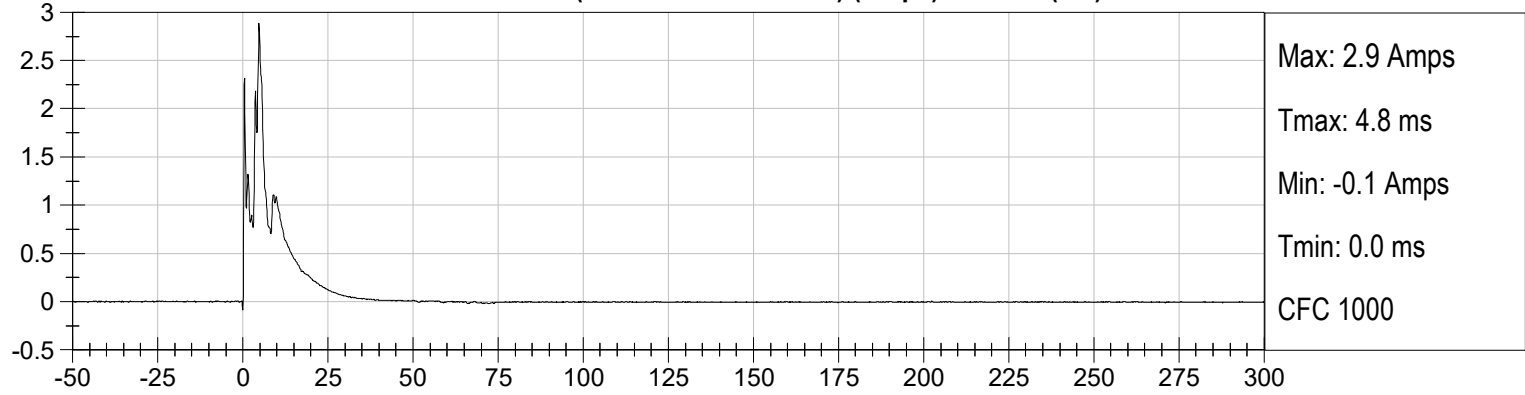
**PASSENGER LOWER NECK MResultant (Nm) vs Time (ms)**



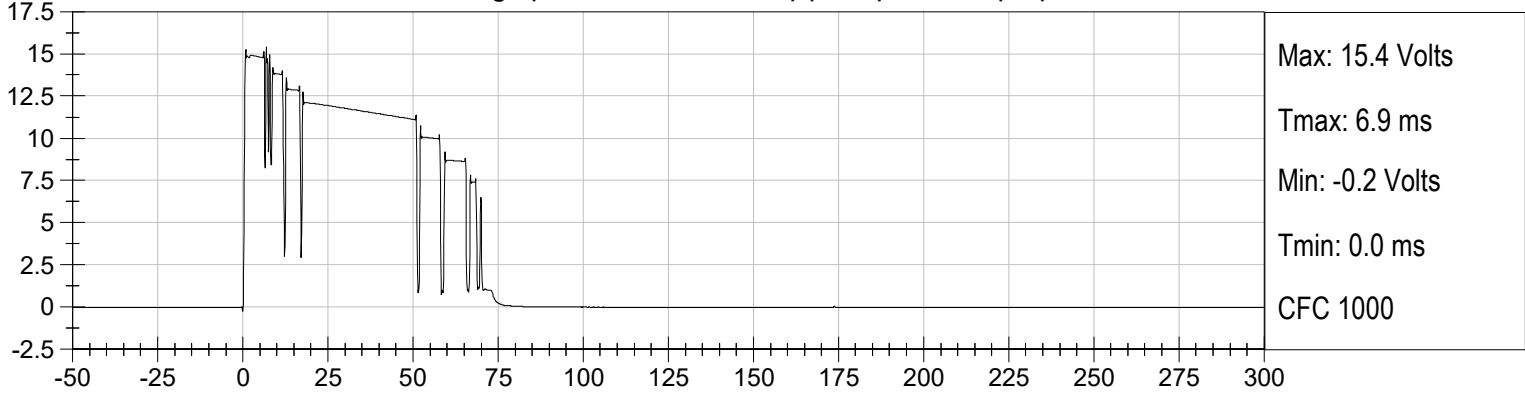
**PASSENGER CURTAIN AB - Fire Voltage (DC Constant Current) (Volts) vs Time (ms)**



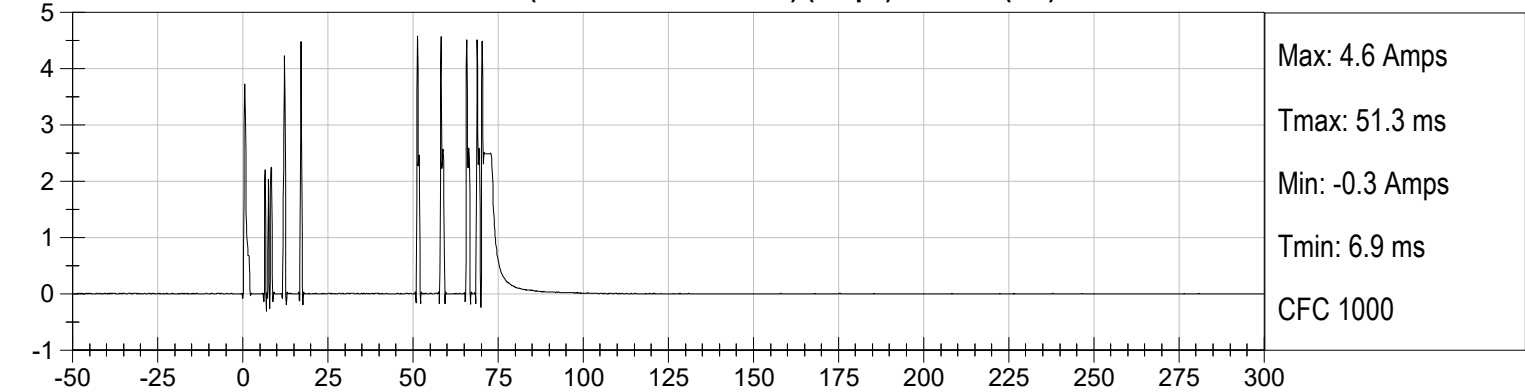
**PASSENGER CURTAIN AB - Fire Current (DC Constant Current) (Amps) vs Time (ms)**

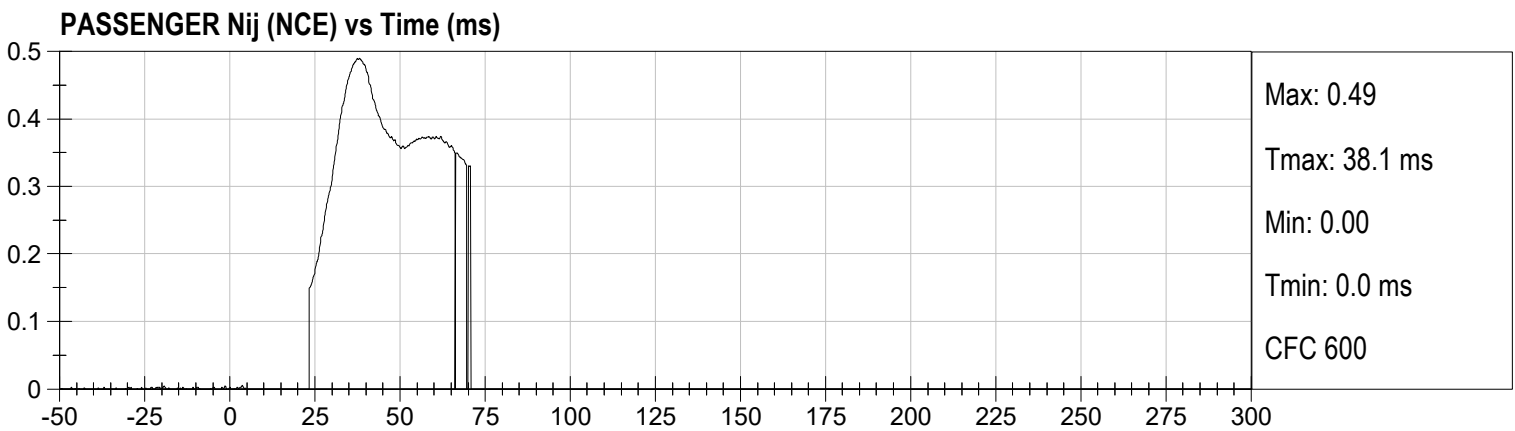
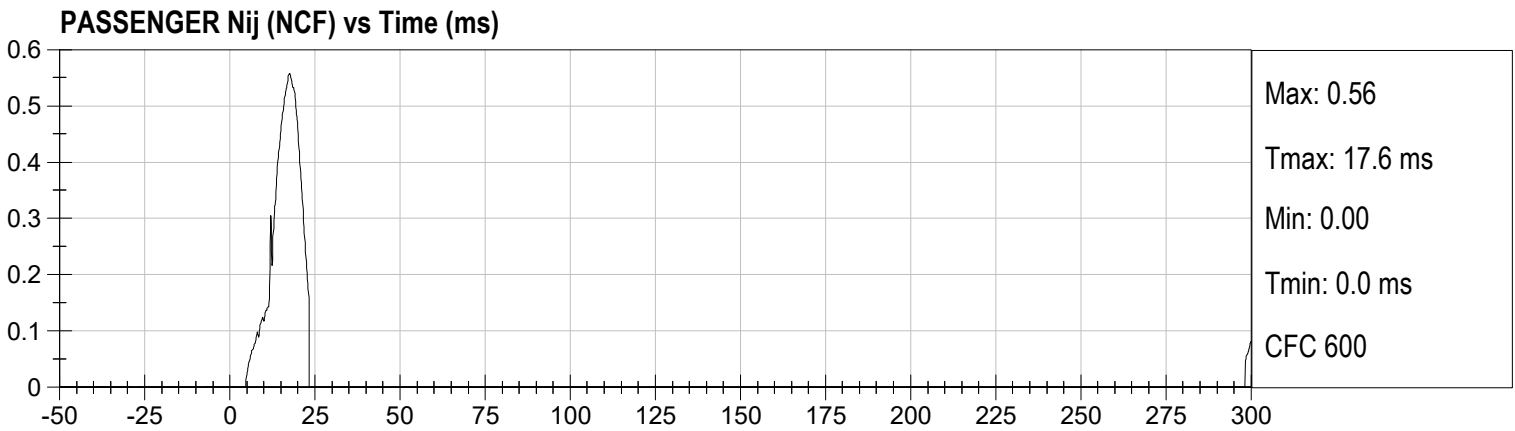
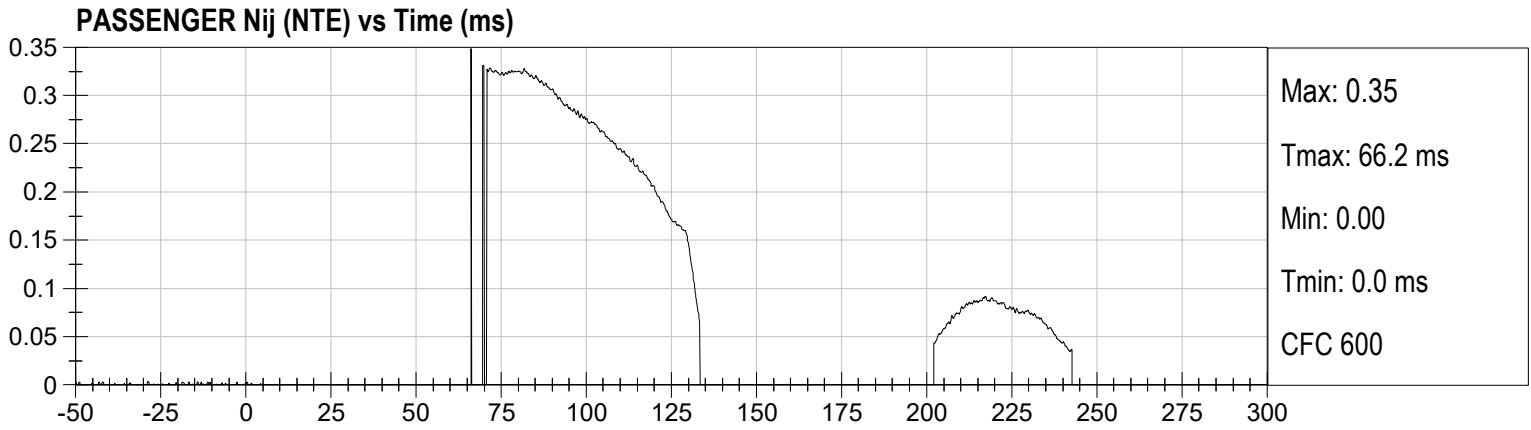
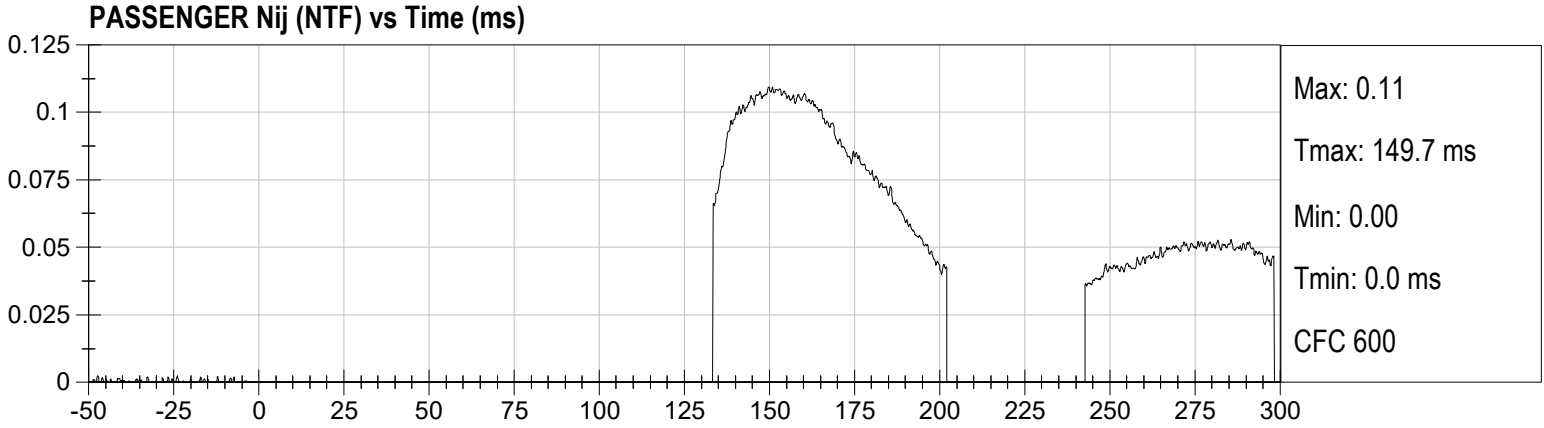


**PASSENGER SEAT AB - Fire Voltage (DC Constant Current) (Volts) vs Time (ms)**



**PASSENGER SEAT AB - Fire Current (DC Constant Current) (Amps) vs Time (ms)**







**APPENDIX C**  
**DUMMY CONFIGURATION AND PERFORMANCE VERIFICATION DATA**

**CALIBRATION TEST RESULTS**

**PRE-TEST**

**Hybrid III 6-Year-Old ATD**

**MGA RESEARCH CORPORATION**  
**HEAD DROP TEST**  
**HYBRID III 6 YEAR OLD**

ATD Serial No: 144

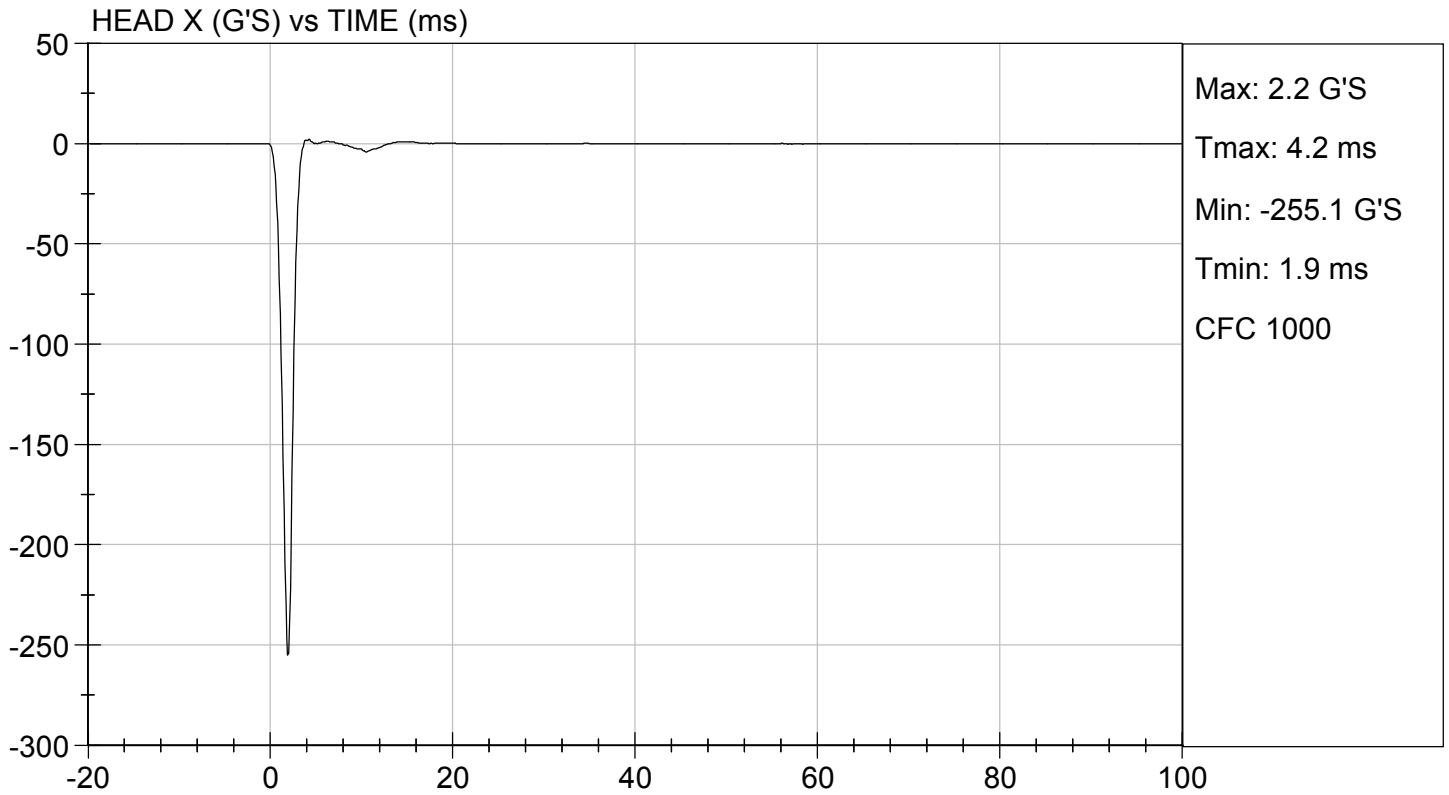
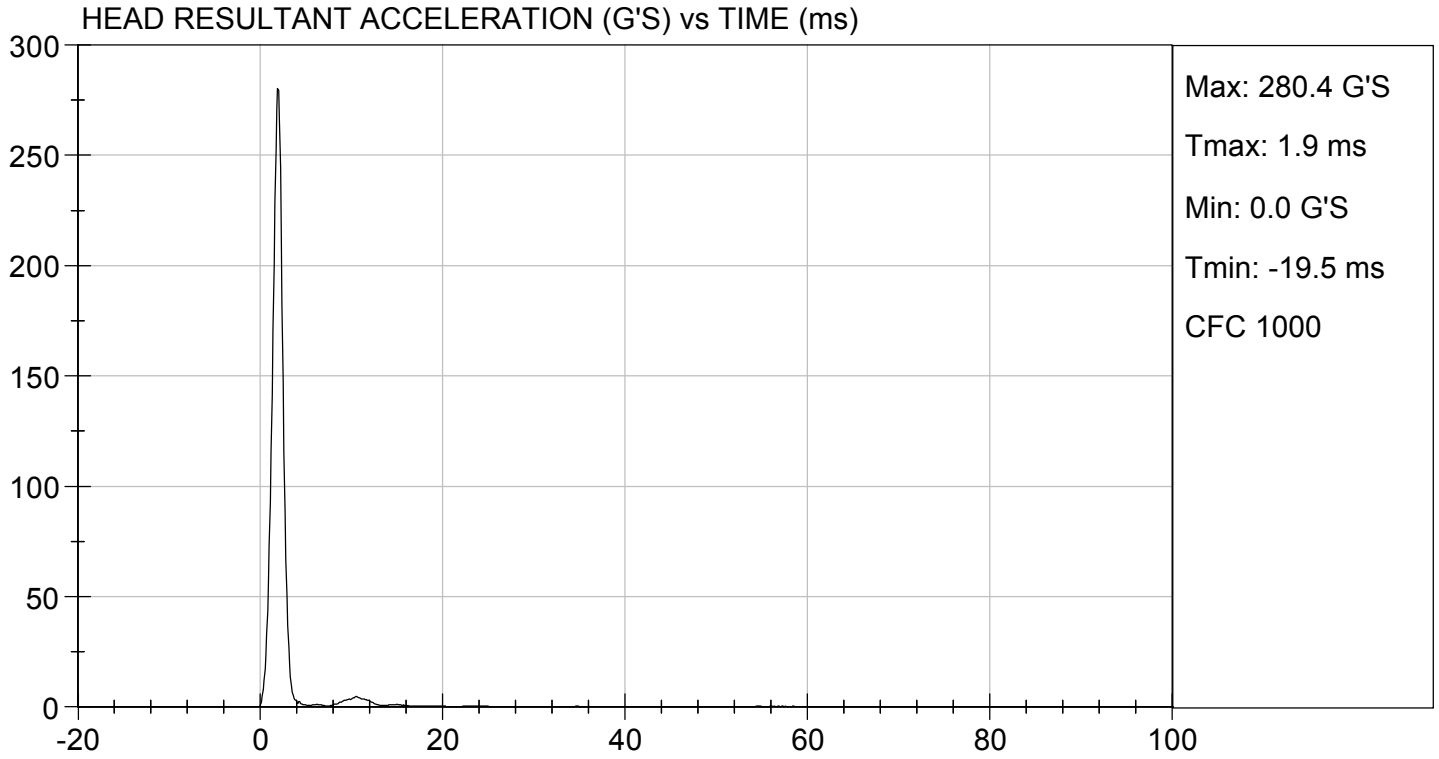
Test ID: D192161

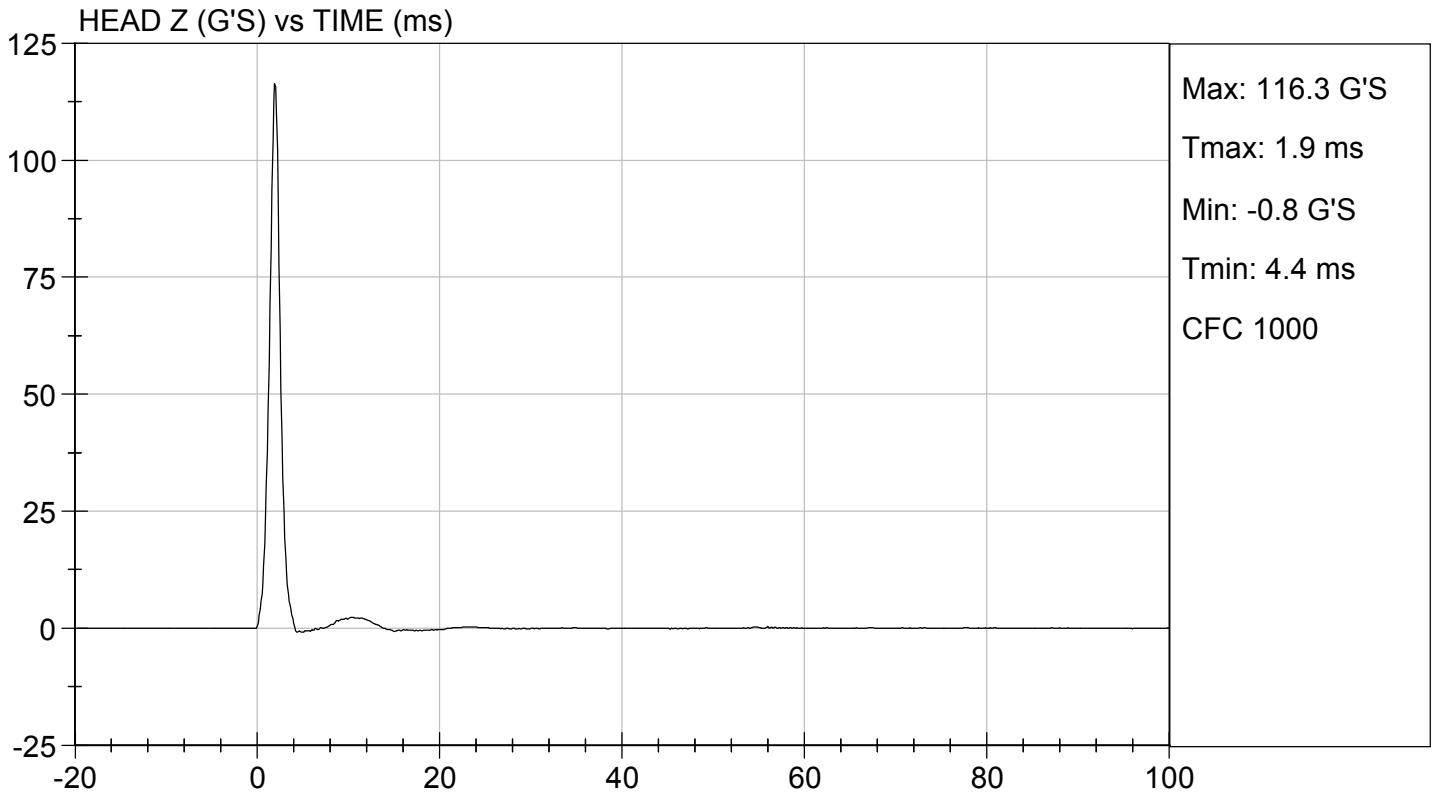
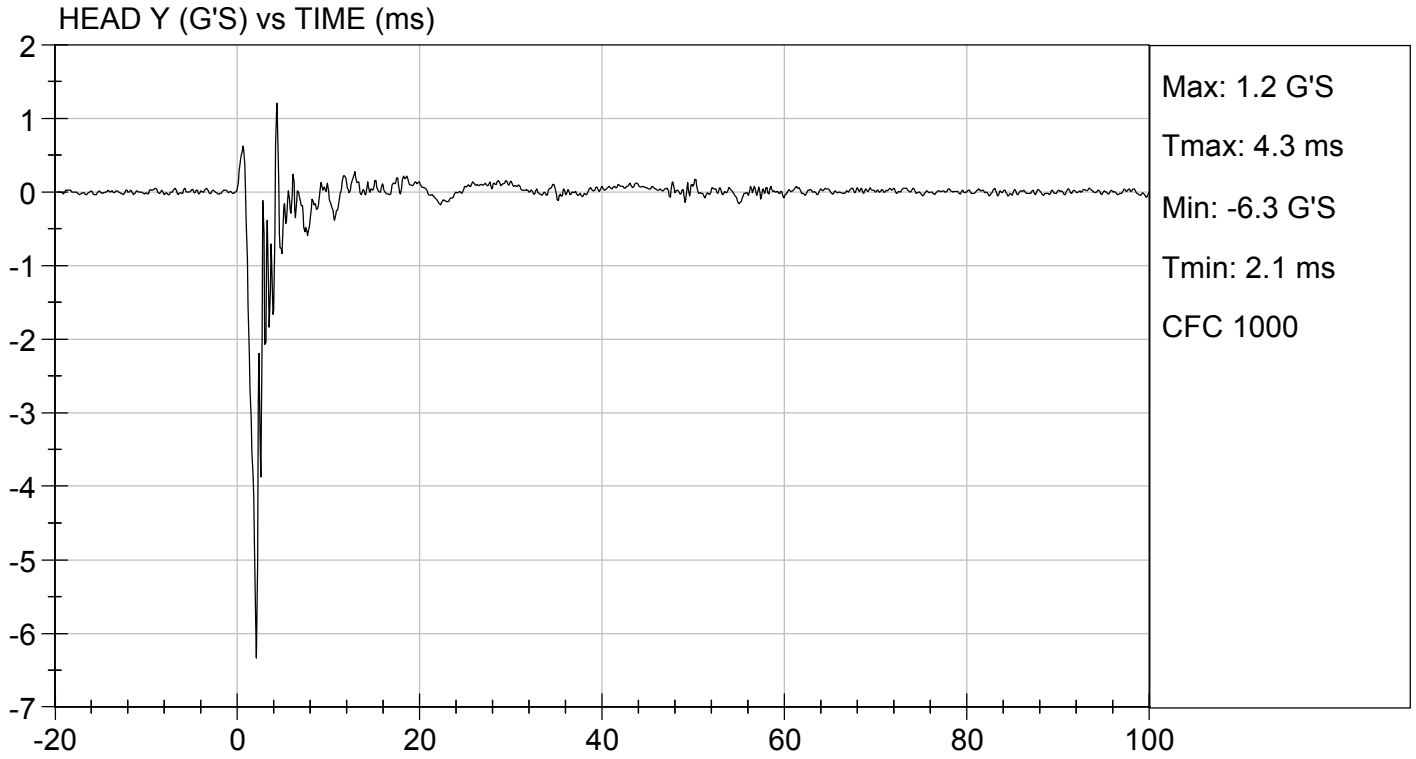
Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.6	21.9	Pass
Laboratory Relative Humidity	%	10 to 70	43	Pass
Peak Resultant Acceleration	G's	245 to 300	280	Pass
Peak Lateral Acceleration	G's	<= +/- 15.0	-6.3	Pass
Unimodal	N/A	Yes	Yes	Pass
Oscillations	N/A	within 10% of peak	Yes	Pass
Overall Test Results				Pass

Brian Roach  
Laboratory Technician

07/15/2019  
Test Date

B.F.L.  
Approved By





**MGA RESEARCH CORPORATION**

**NECK FLEXION TEST**

**HYBRID III 6 YEAR OLD**

**ATD Serial No:** 144

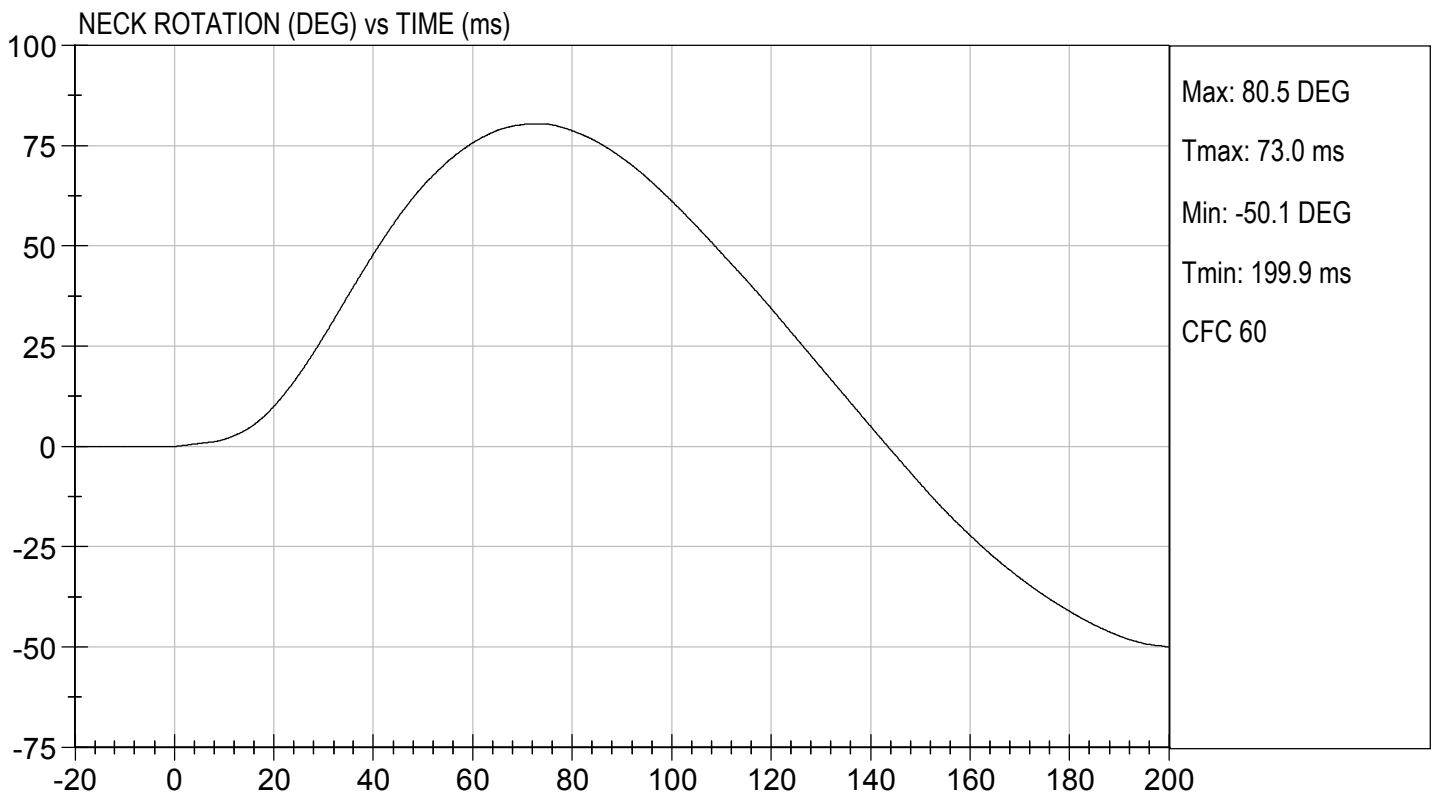
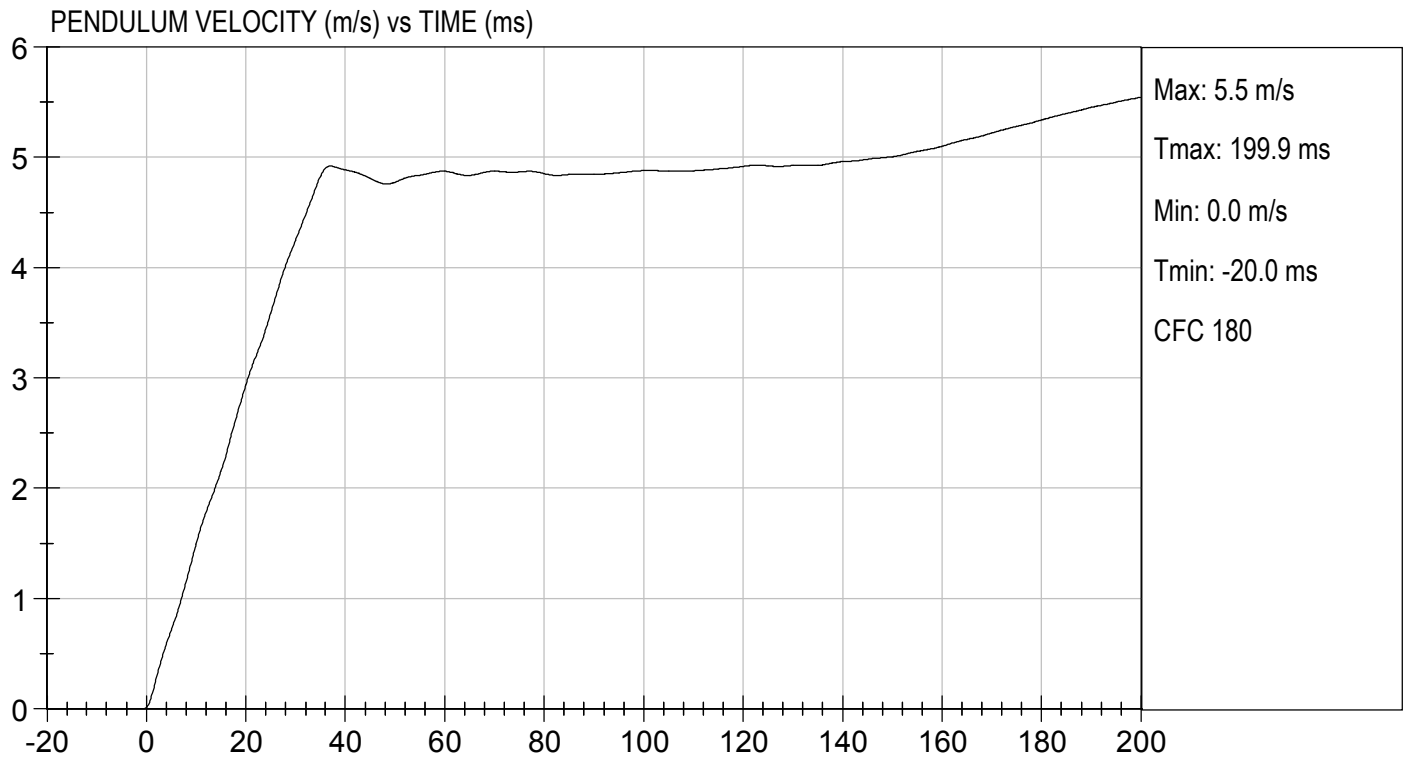
**Test I.D.:** D192162

Tested Parameter	Units	Specification	Result	Pass/Fail	
Laboratory Temperature	deg C	20.6 to 22.2	21.9	Pass	
Laboratory Relative Humidity	%	10 to 70	43	Pass	
Pendulum Speed	m/s	4.83 to 5.07	4.98	Pass	
Pendulum Velocity	10 ms	m/s	1.2 to 1.6	1.5	Pass
	20 ms	m/s	2.4 to 3.4	2.9	Pass
	30 ms	m/s	3.8 to 5.0	4.2	Pass
D Plane Rotation	Max	deg	74 to 92	80	Pass
Occipital Condyle Moment within Deflection Corridor	Nm	27 to 33	32.0	Pass	
Positive Moment Time Curve Decay to 5 Nm	ms	103 to 123	108	Pass	
<b>Overall Results</b>				<b>Pass</b>	

Brian Roach  
Laboratory Technician

07/15/2019  
Test Date

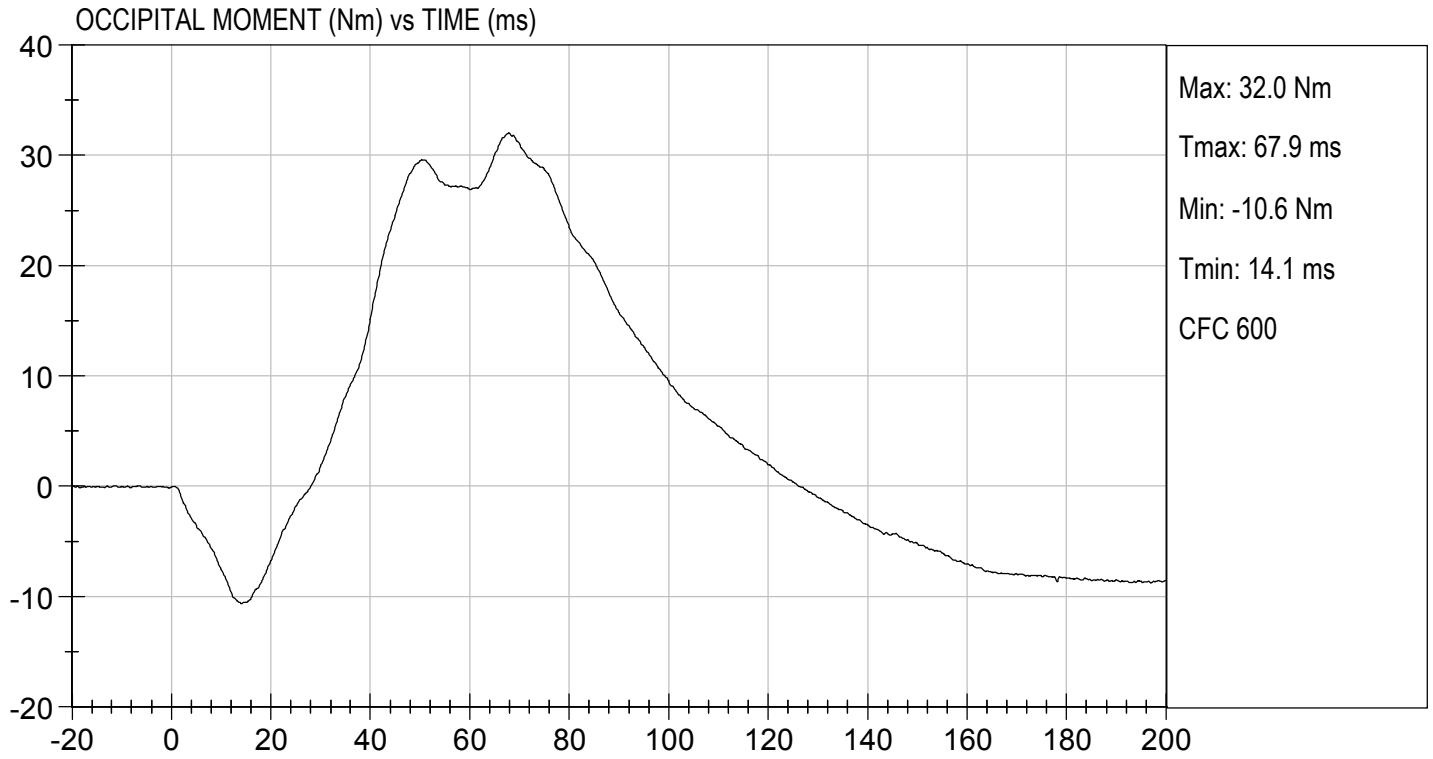
B. F. K.  
Approved By





TEST DESC: NECK FLEXION  
VELOCITY: 16.34 ft/s, 4.98 m/s

TEST DATE: 07/15/2019  
TEST #: D192162





**MGA RESEARCH CORPORATION**

**NECK EXTENSION TEST**

**HYBRID III 6 YEAR OLD**

**ATD Serial No:** 144

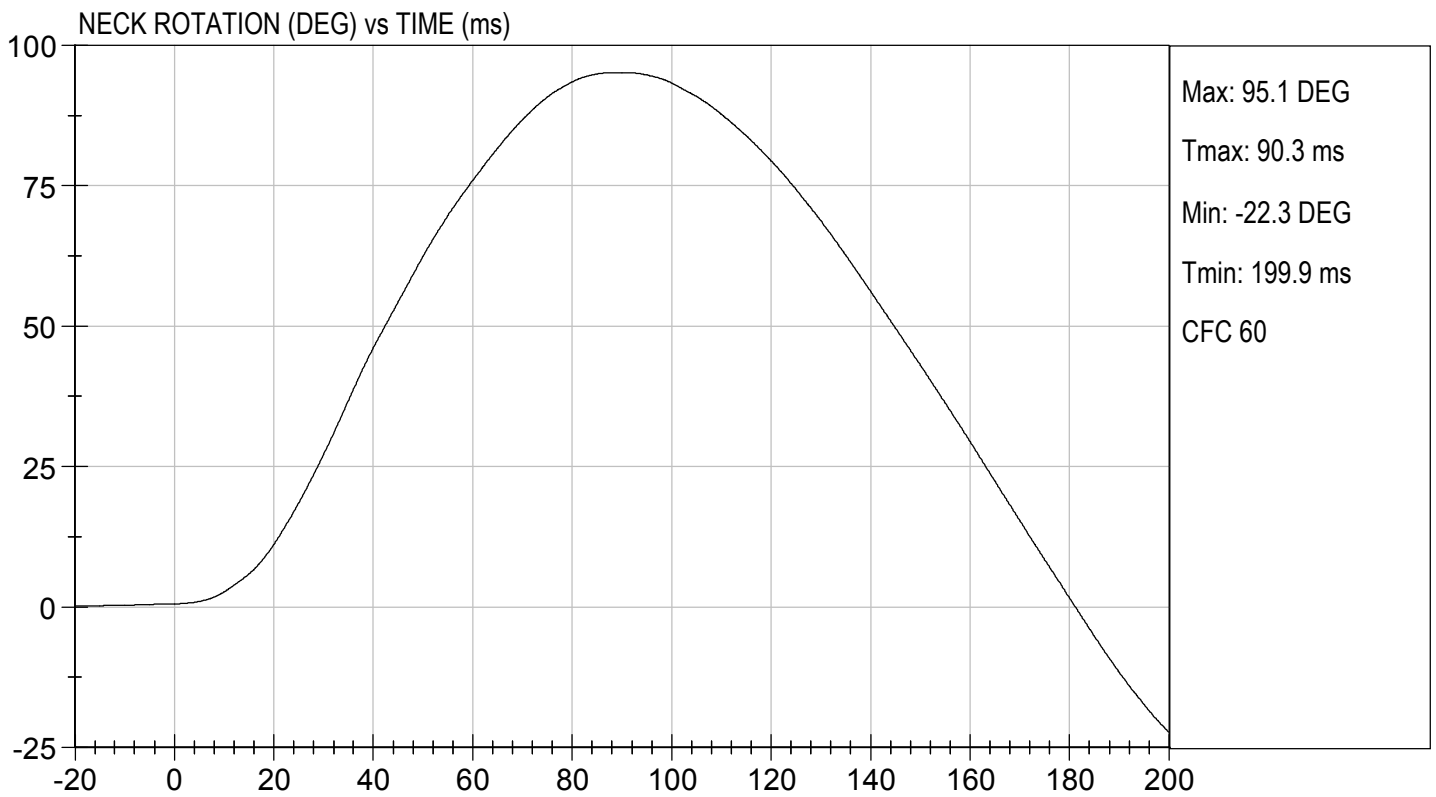
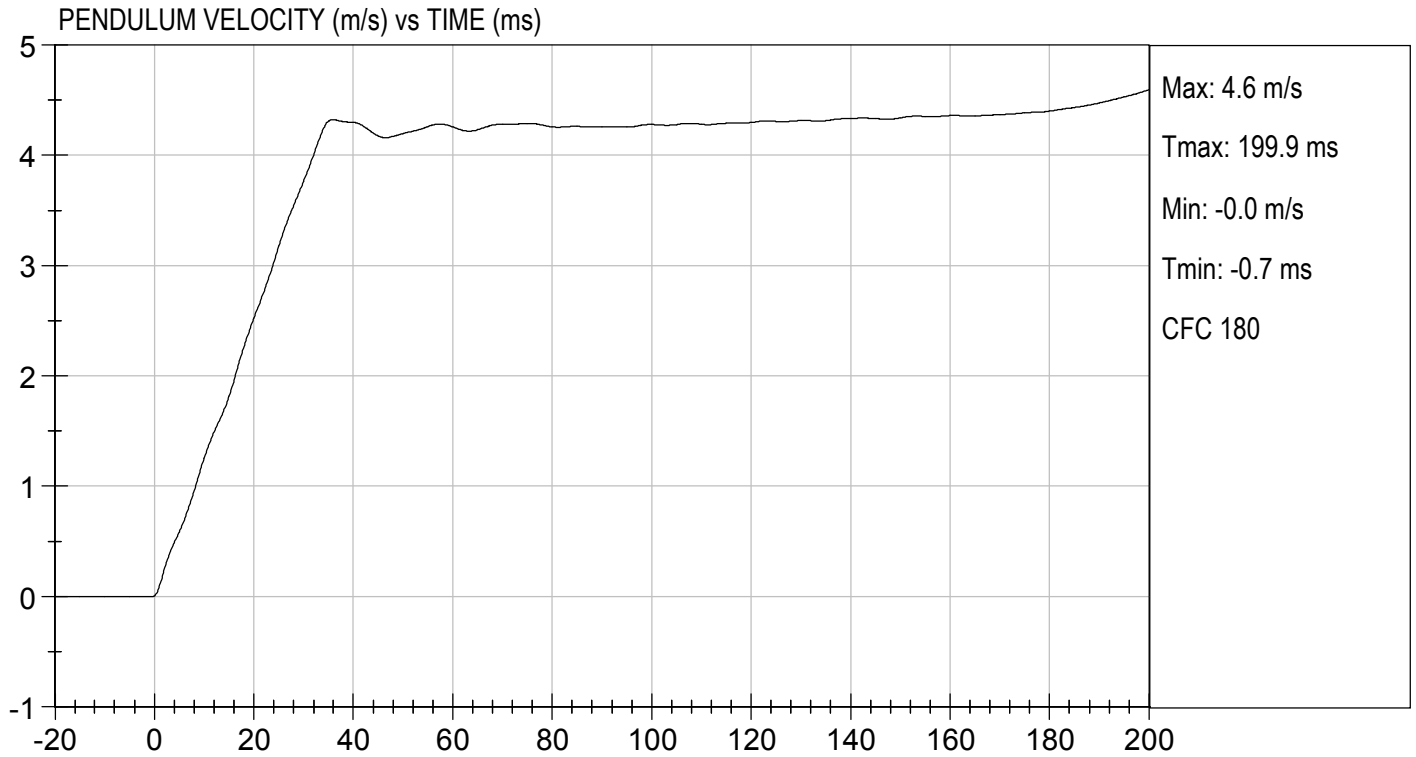
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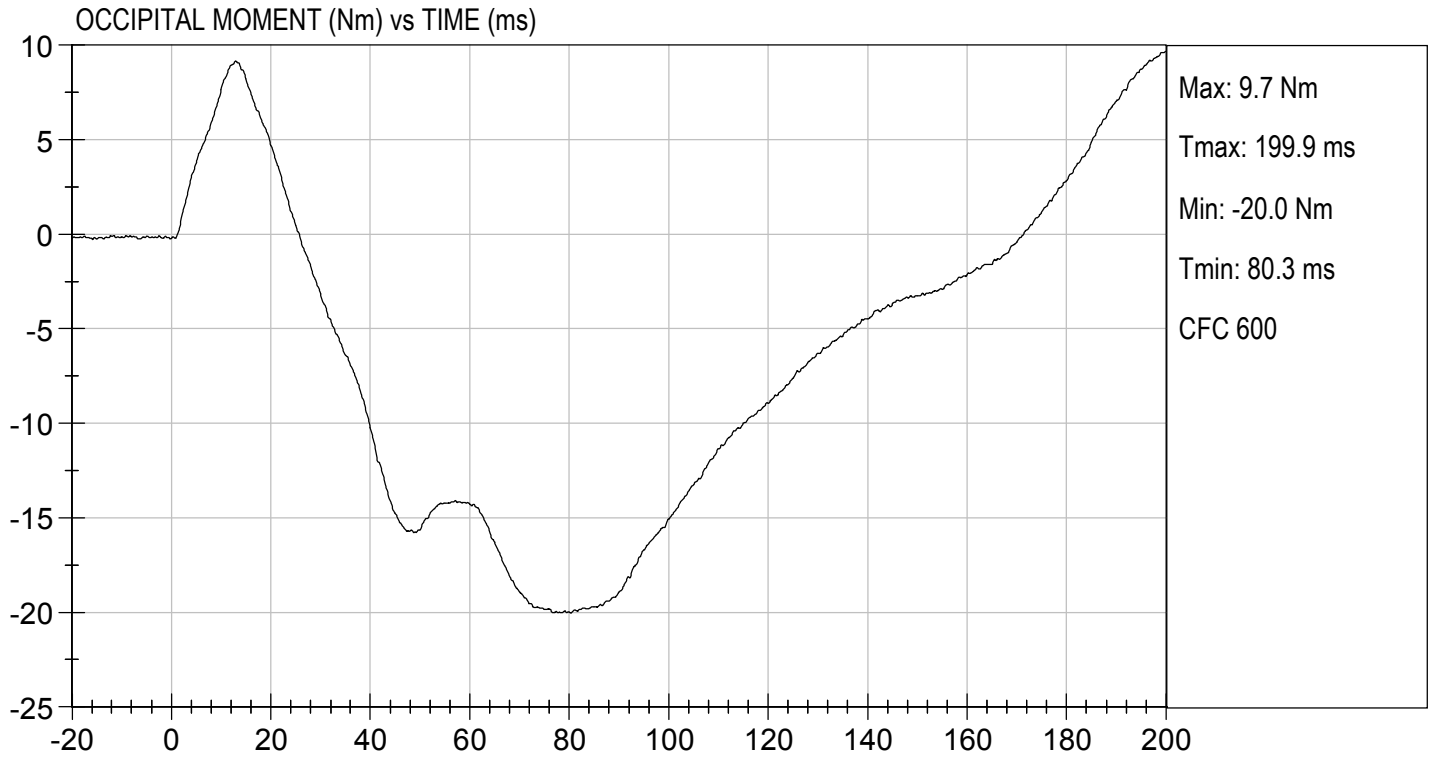
Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	20.6 to 22.2	21.9	Pass
Laboratory Relative Humidity		%	10 to 70	43	Pass
Pendulum Speed		m/s	4.18 to 4.42	4.27	Pass
Pendulum Velocity	10 ms	m/s	1.0 to 1.4	1.3	Pass
	20 ms	m/s	2.2 to 3.0	2.5	Pass
	30 ms	m/s	3.2 to 4.2	3.8	Pass
D Plane Rotation	Max	deg	85 to 103	95	Pass
Occipital Condyle Moment within Deflection Corridor		Nm	-19 to -24	-20	Pass
Positive Moment Time Curve Decay to 5 Nm		msec	123 to 147	133	Pass
<b>Overall Results</b>					<b>Pass</b>

Brian Roach  
Laboratory Technician

07/15/2019  
Test Date

B. F. K.  
Approved By





**MGA RESEARCH CORPORATION**

**THORAX IMPACT**

**HYBRID III 6 YEAR OLD**

**ATD Serial No:** 144

**Test I.D:** D192164

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	20.9	Pass
Relative Humidity	%	10 to 70	46	Pass
Probe Speed	m/s	6.59 to 6.83	6.77	Pass
Peak Deflection	mm	38.0 to 46.0	39.9	Pass
Peak Resistive Force w/in Deflection Corridor	N	1150 to 1380	1,321	Pass
Internal Hysteresis	%	65 to 85	77	Pass
Peak Force 12.5 mm - 38.0 mm	N	<= 1,500	1,341	Pass
<b>Overall Test Results</b>				<b>Pass</b>

*Brian Roach*

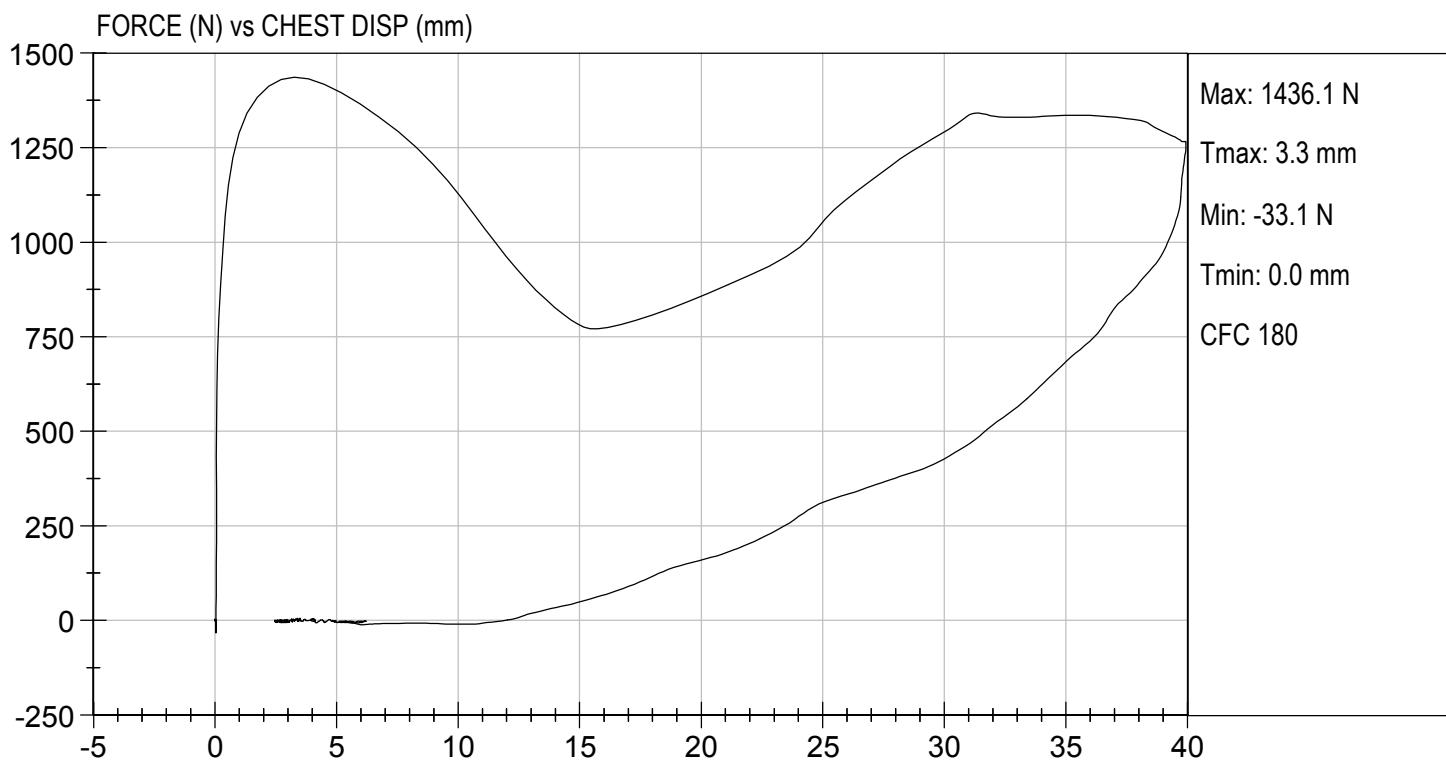
Laboratory Technician

07/16/2019

Test Date

*B. Fink*

Approved By



**MGA RESEARCH CORPORATION**  
**RIGHT KNEE IMPACT TEST**  
**HYBRID III 6 YEAR OLD**

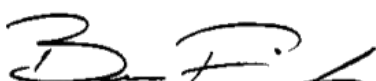
**ATD Serial No:** 144

**Test I.D:** D192165

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.5	21.9	Pass
Laboratory Relative Humidity	%	10 to 70	43	Pass
Probe Speed	m/s	2.07 to 2.13	2.08	Pass
Maximum Force	N	2000 to 3000	2525	Pass
Overall Test Results				Pass

  
\_\_\_\_\_  
Laboratory Technician

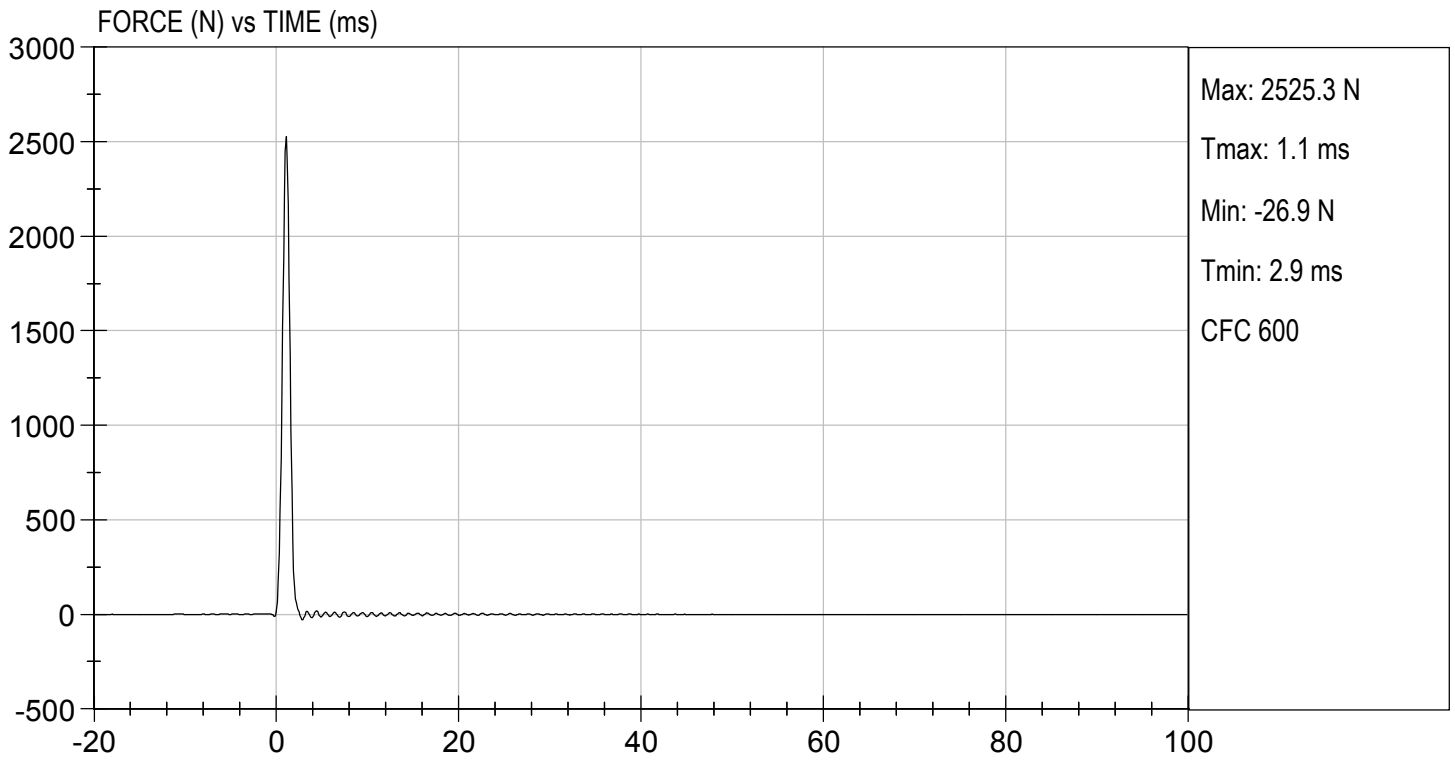
07/15/2019  
\_\_\_\_\_  
Test Date

  
\_\_\_\_\_  
Approved By



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

TEST DATE: 07/15/2019  
TEST #: D192165



**MGA RESEARCH CORPORATION**  
**LEFT KNEE IMPACT TEST**  
**HYBRID III 6 YEAR OLD**

ATD Serial No: 144

Test I.D: D192166

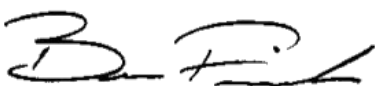
Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.5	21.9	Pass
Laboratory Relative Humidity	%	10 to 70	43	Pass
Probe Speed	m/s	2.07 to 2.13	2.10	Pass
Maximum Force	N	2000 to 3000	2540	Pass
Overall Test Results				Pass



Laboratory Technician

07/15/2019

Test Date



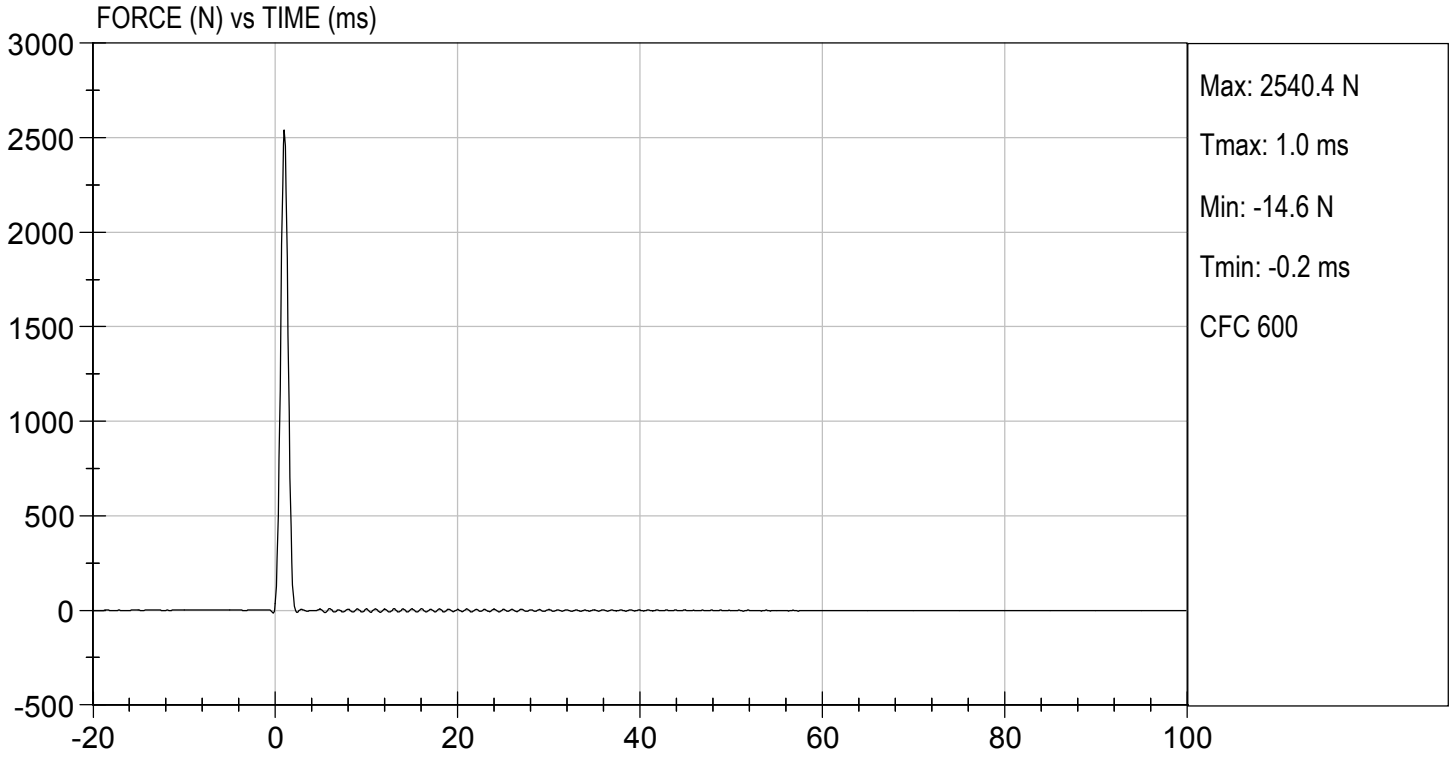
Approved By





TEST DESC: LEFT KNEE  
VELOCITY: 6.89 ft/s, 2.10 m/s

TEST DATE: 07/15/2019  
TEST #: D192166



**MGA RESEARCH CORPORATION**

**TORSO FLEXION TEST**

**HYBRID III 6 YEAR OLD**

**ATD Serial No:** 144

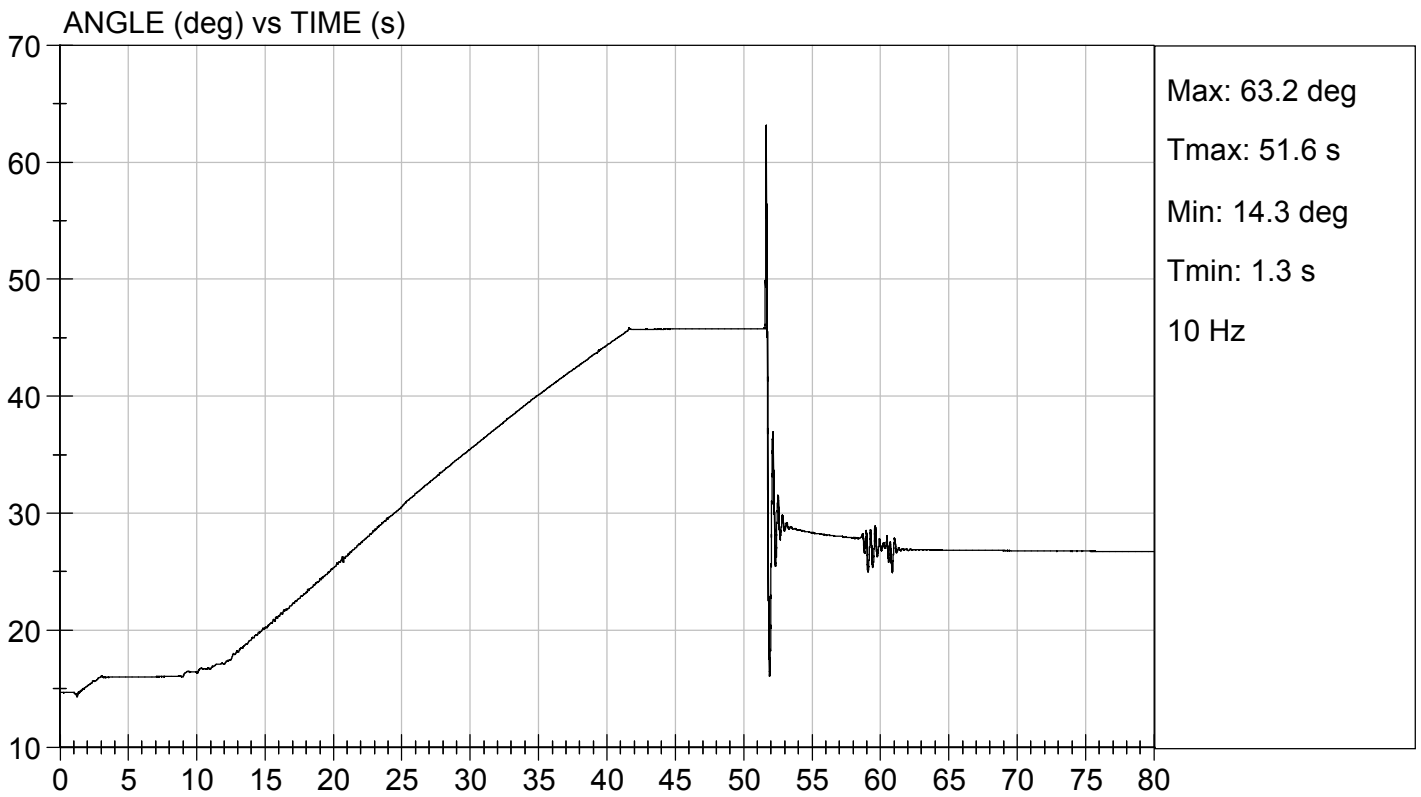
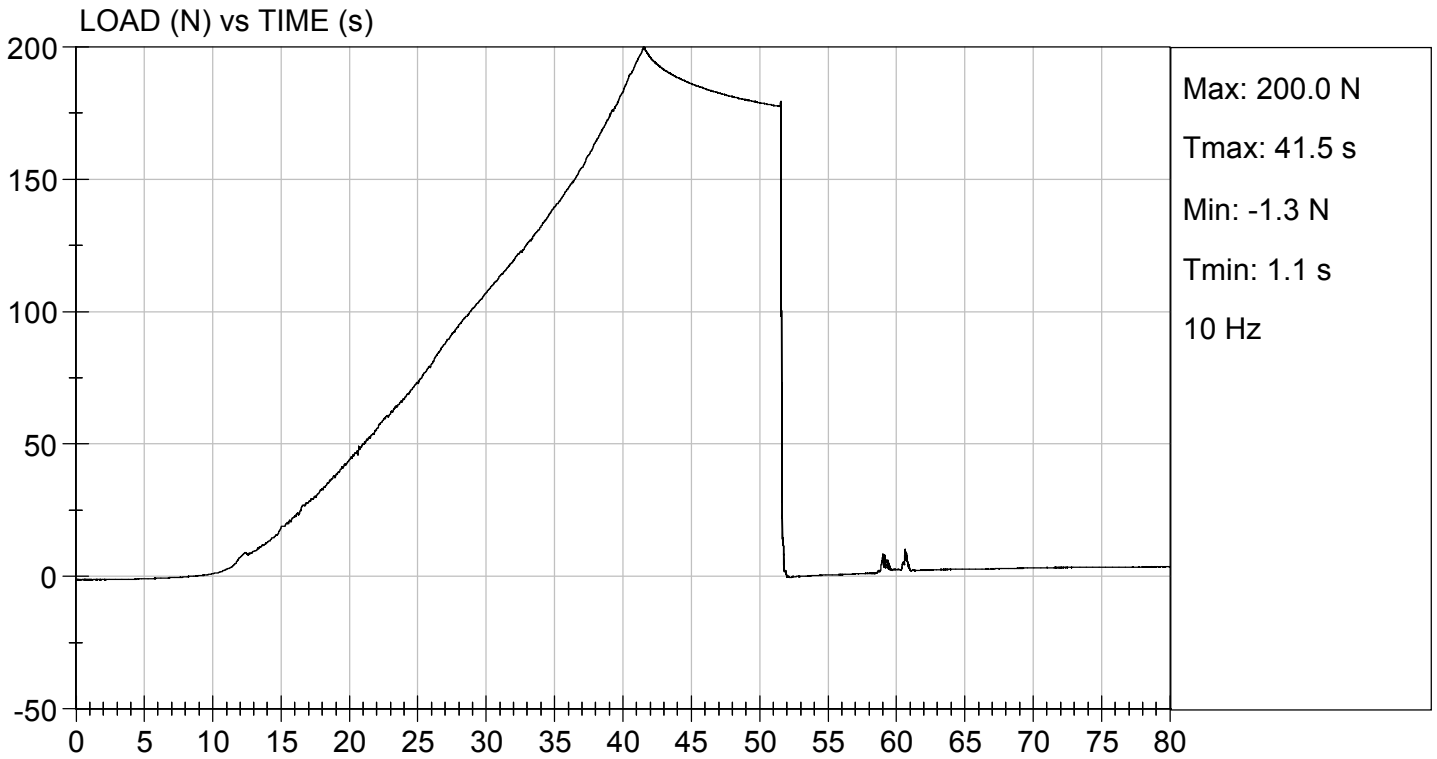
**Test I.D:** D192167

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.6	20.9	Pass
Laboratory Relative Humidity	%	10 to 70	47	Pass
Initial Angle	deg	0 to 22	15	Pass
Return Angle	deg	+/- 8	7	Pass
Force at 45 deg	N	147 to 200	200	Pass
Upper Torso Deflection Rate	deg/s	0.5 to 1.5	0.9	Pass
Overall Result				Pass

Brian Roach  
Laboratory Technician

07/16/2019  
Test Date

B. F. K.  
Approved By



**CALIBRATION TEST RESULTS**

**POST-TEST**

**Hybrid III 6-Year-Old ATD**

**MGA RESEARCH CORPORATION**  
**HEAD DROP TEST**  
**HYBRID III 6 YEAR OLD**

ATD Serial No: 144

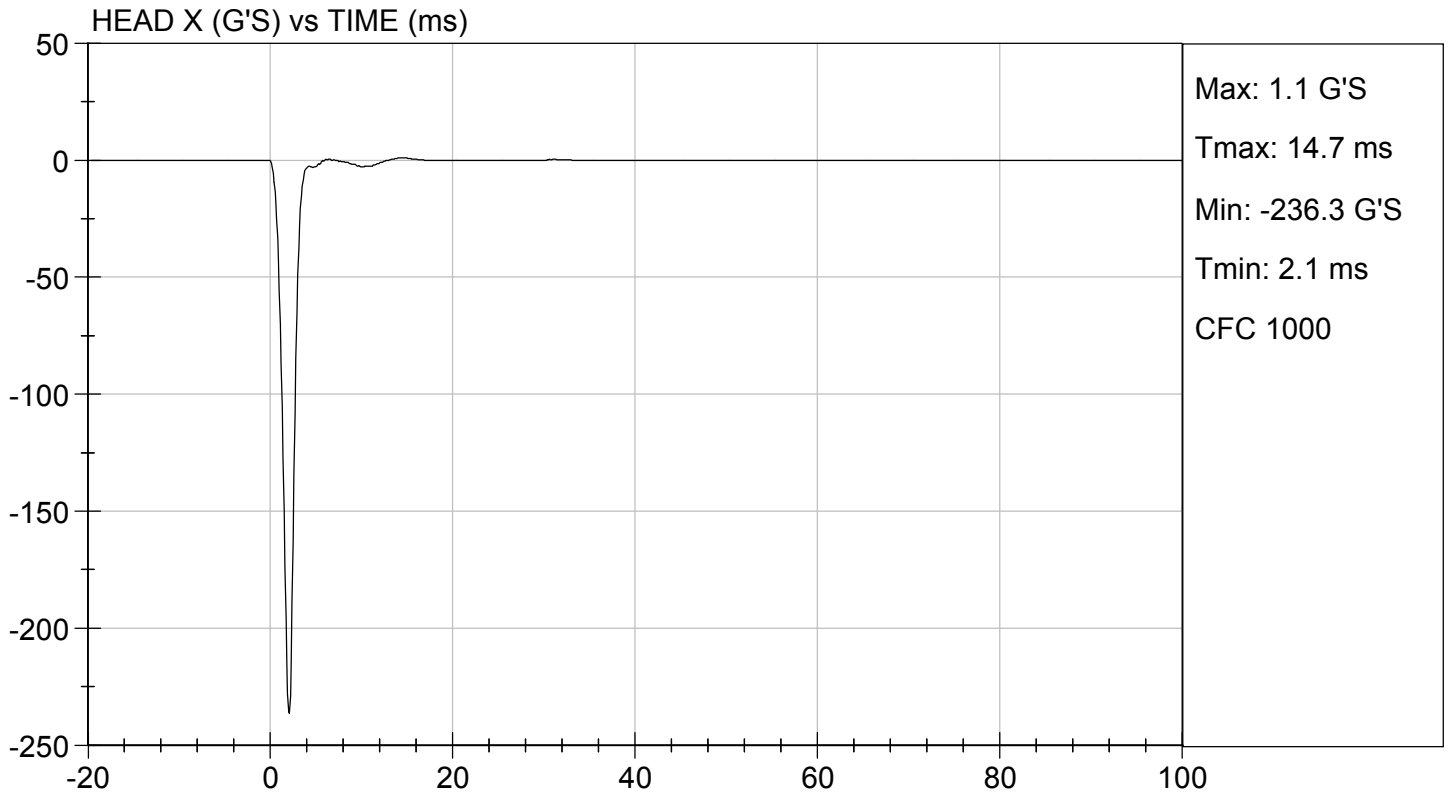
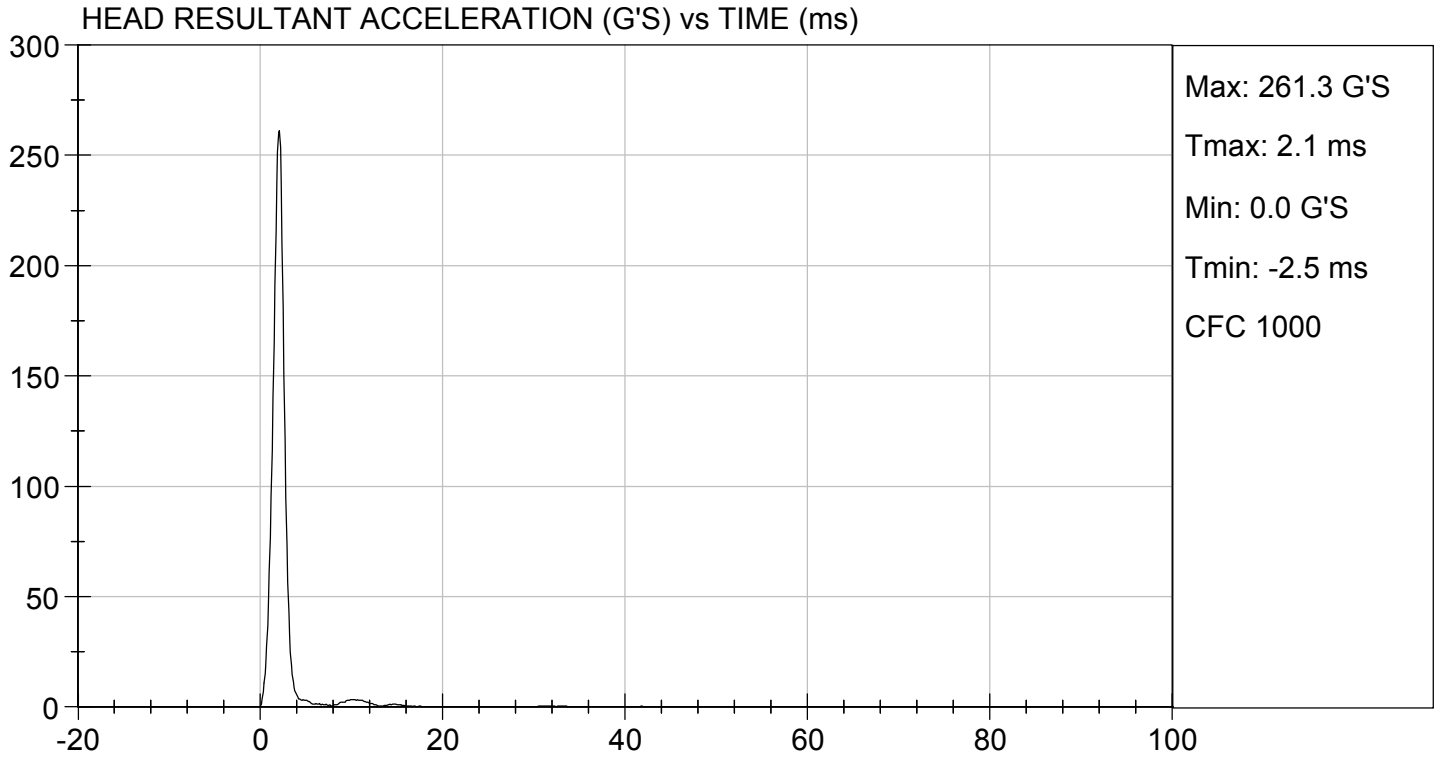
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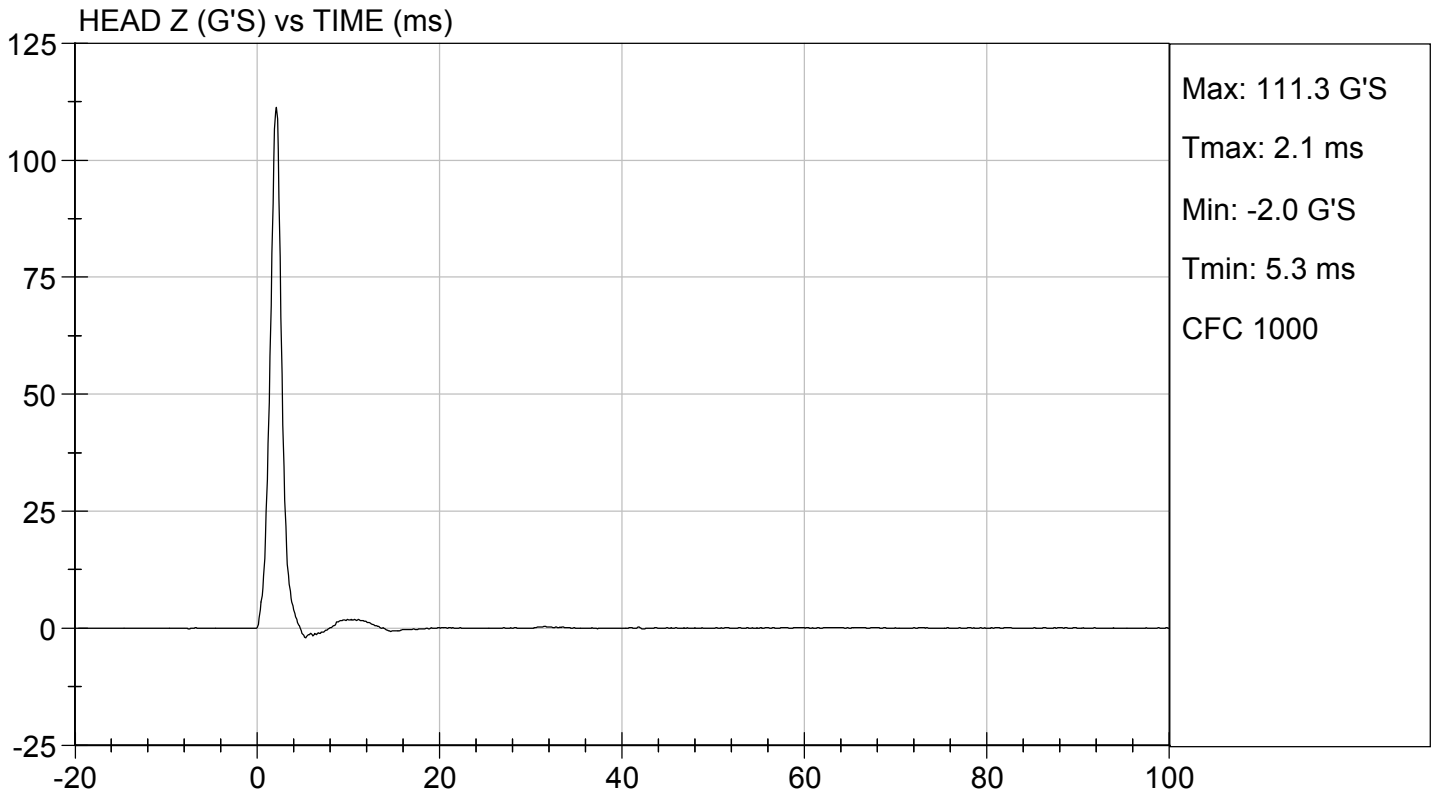
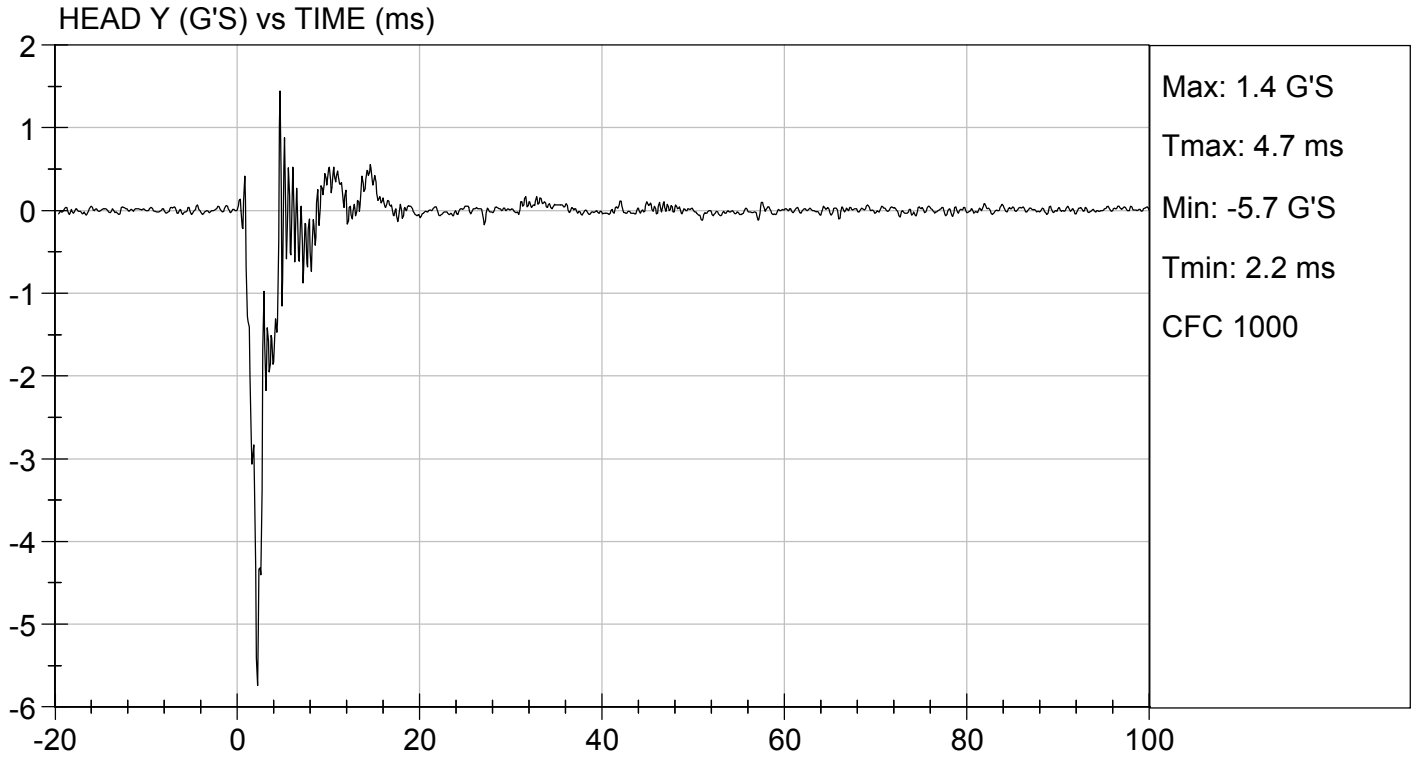
Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.6	21.6	Pass
Laboratory Relative Humidity	%	10 to 70	42	Pass
Peak Resultant Acceleration	G's	245 to 300	261	Pass
Peak Lateral Acceleration	G's	<= +/- 15.0	-5.7	Pass
Unimodal	N/A	Yes	Yes	Pass
Oscillations	N/A	within 10% of peak	Yes	Pass
Overall Test Results				Pass

Brian Roach  
 Laboratory Technician

07/29/2019  
 Test Date

B. F. K.  
 Approved By





**MGA RESEARCH CORPORATION**

**NECK FLEXION TEST**

**HYBRID III 6 YEAR OLD**

**ATD Serial No:** 144

**Test I.D.:** D192352

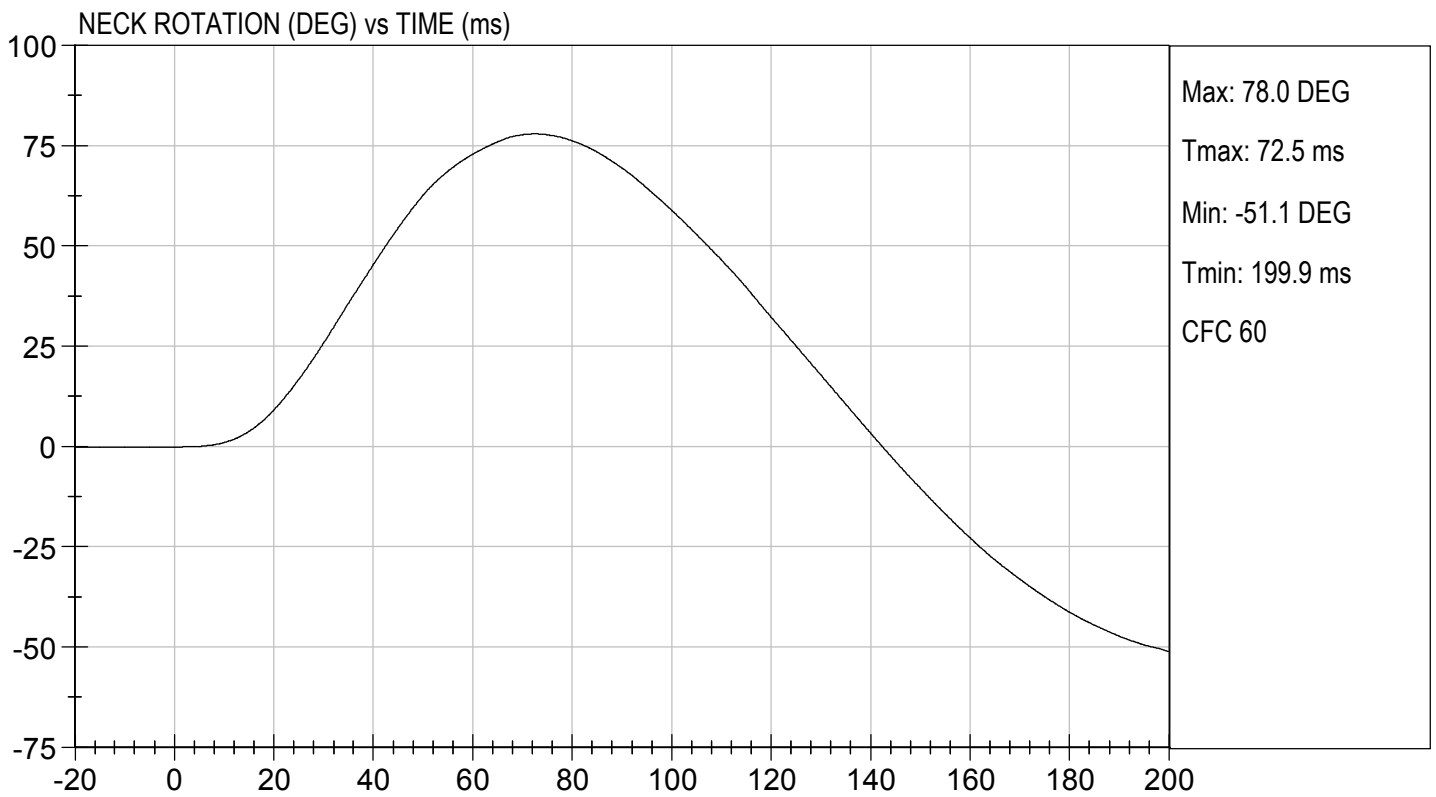
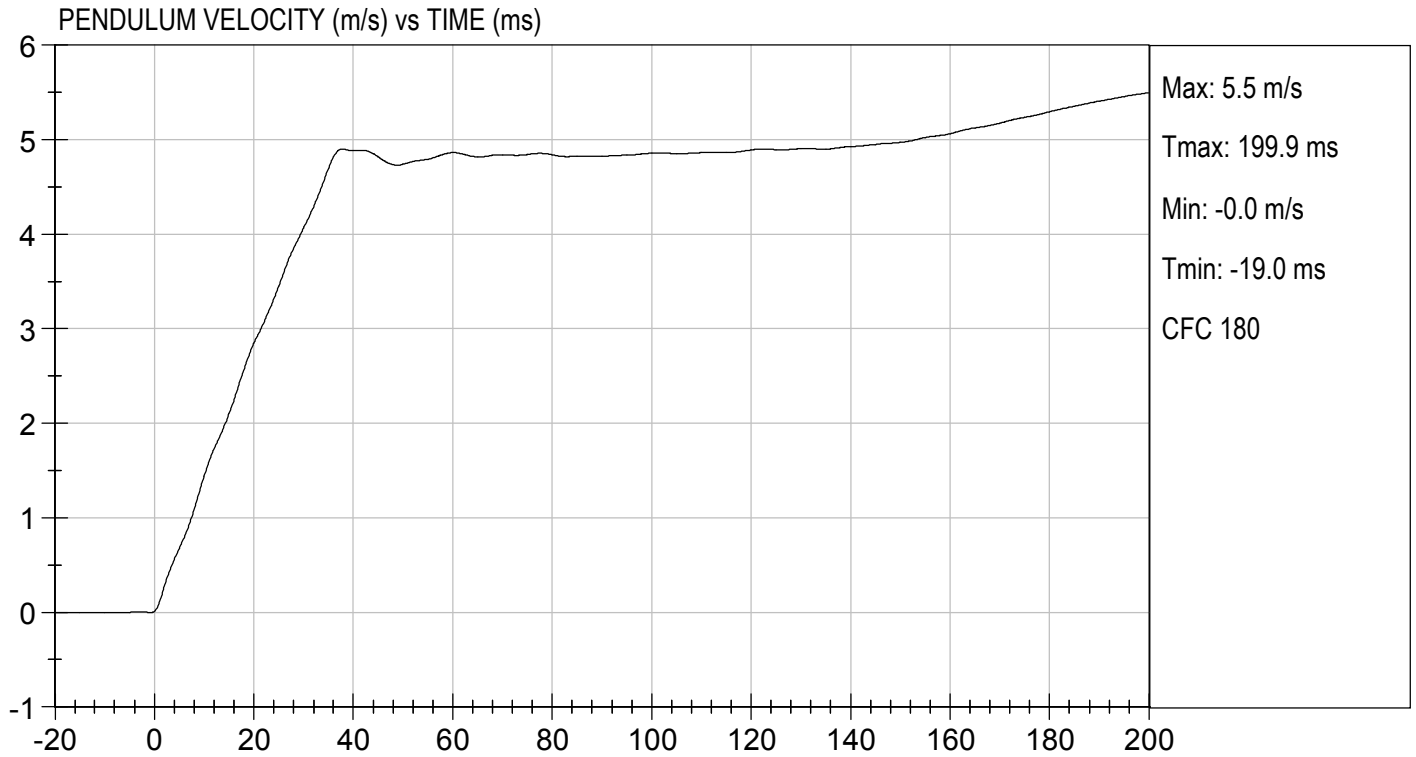
Tested Parameter	Units	Specification	Result	Pass/Fail	
Laboratory Temperature	deg C	20.6 to 22.2	21.6	Pass	
Laboratory Relative Humidity	%	10 to 70	42	Pass	
Pendulum Speed	m/s	4.83 to 5.07	4.93	Pass	
Pendulum Velocity	10 ms	m/s	1.2 to 1.6	1.4	Pass
	20 ms	m/s	2.4 to 3.4	2.8	Pass
	30 ms	m/s	3.8 to 5.0	4.1	Pass
D Plane Rotation	Max	deg	74 to 92	78	Pass
Occipital Condyle Moment within Deflection Corridor	Nm	27 to 33	30.7	Pass	
Positive Moment Time Curve Decay to 5 Nm	ms	103 to 123	108	Pass	
Overall Results				Pass	

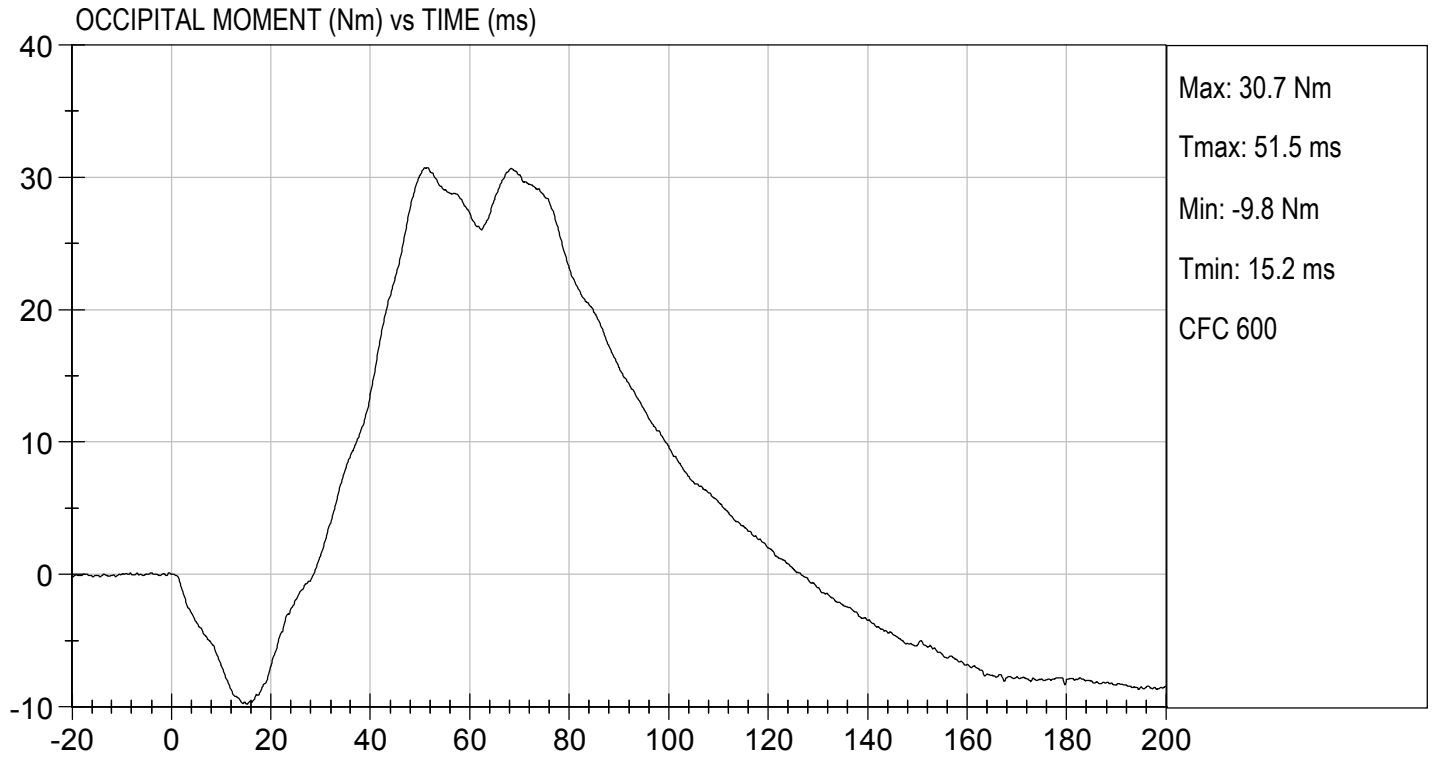
Brian Roach  
Laboratory Technician

07/29/2019  
Test Date

B. F. K.  
Approved By







**MGA RESEARCH CORPORATION**

**NECK EXTENSION TEST**

**HYBRID III 6 YEAR OLD**

**ATD Serial No:** 144

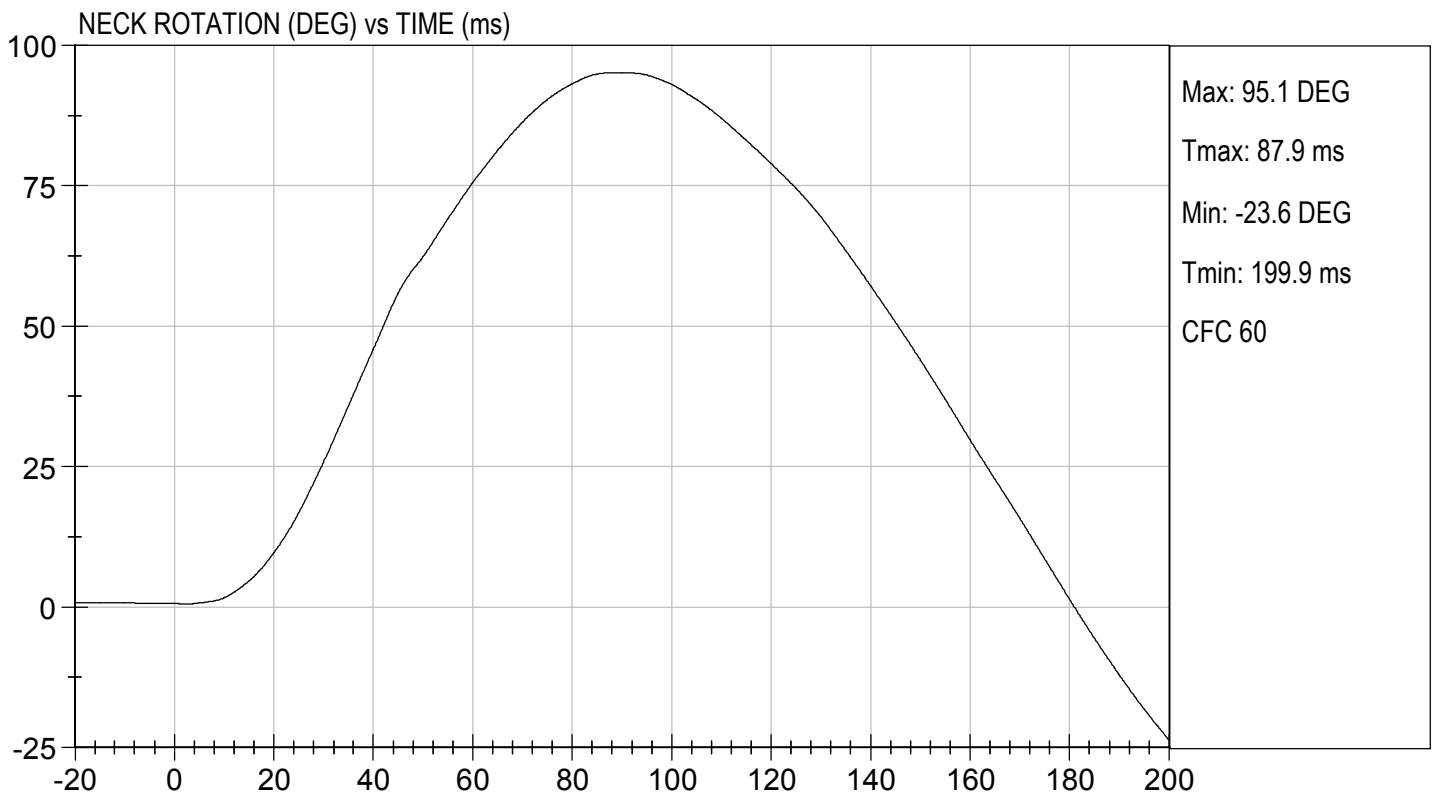
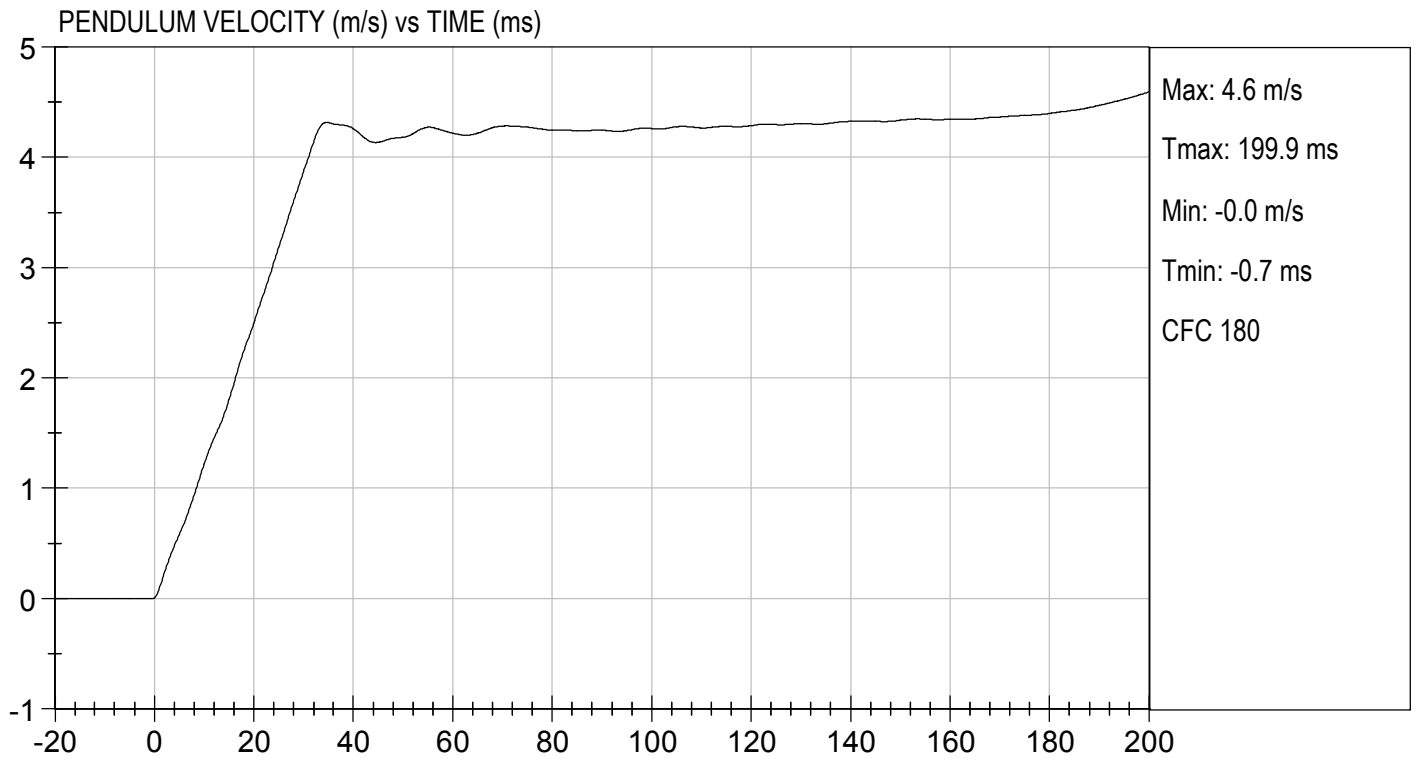
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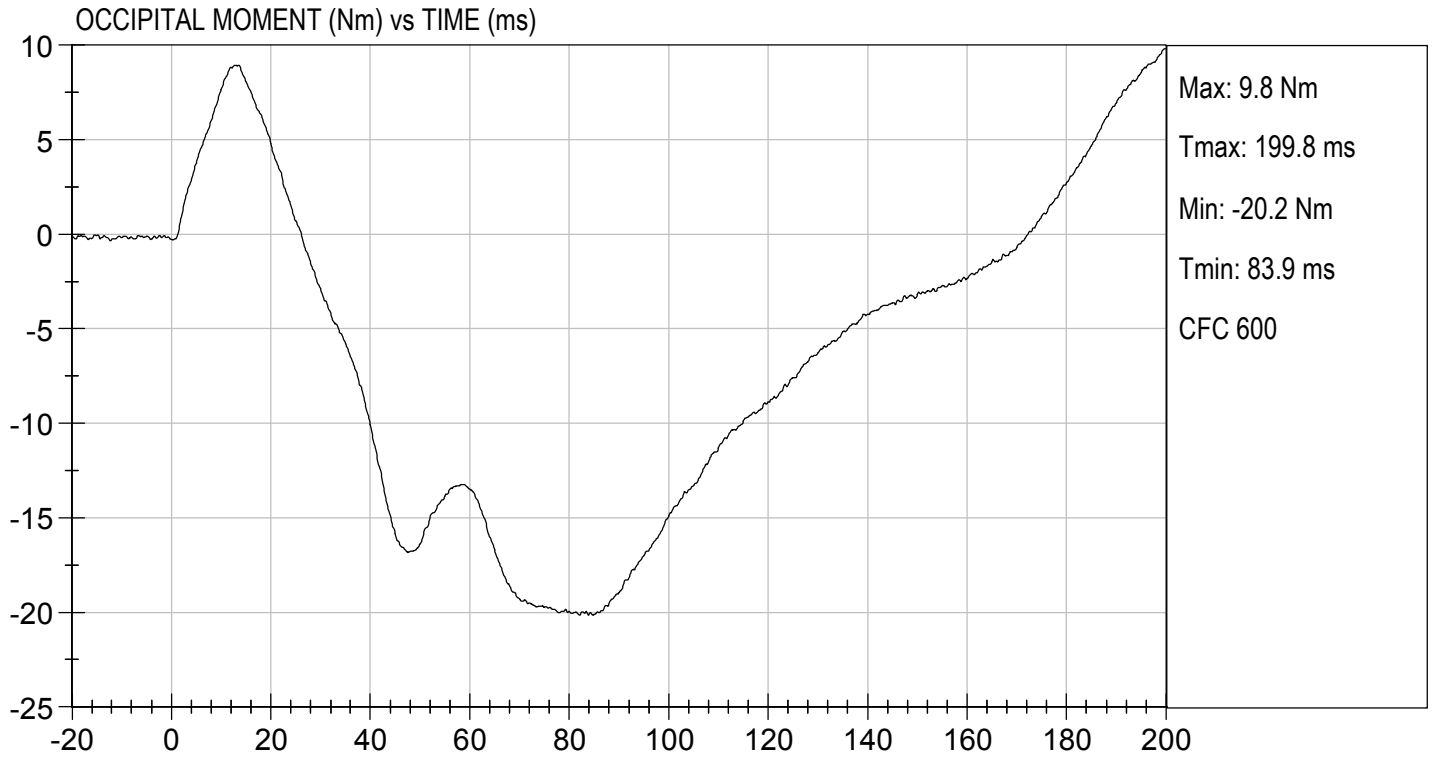
Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	20.6 to 22.2	21.6	Pass
Laboratory Relative Humidity		%	10 to 70	42	Pass
Pendulum Speed		m/s	4.18 to 4.42	4.30	Pass
Pendulum Velocity	10 ms	m/s	1.0 to 1.4	1.2	Pass
	20 ms	m/s	2.2 to 3.0	2.5	Pass
	30 ms	m/s	3.2 to 4.2	3.9	Pass
D Plane Rotation	Max	deg	85 to 103	95	Pass
Occipital Condyle Moment within Deflection Corridor		Nm	-19 to -24	-20	Pass
Positive Moment Time Curve Decay to 5 Nm		msec	123 to 147	134	Pass
<b>Overall Results</b>					<b>Pass</b>

Brian Roach  
Laboratory Technician

07/29/2019  
Test Date

B. F. K.  
Approved By





**MGA RESEARCH CORPORATION**

**THORAX IMPACT**

**HYBRID III 6 YEAR OLD**

**ATD Serial No:** 111

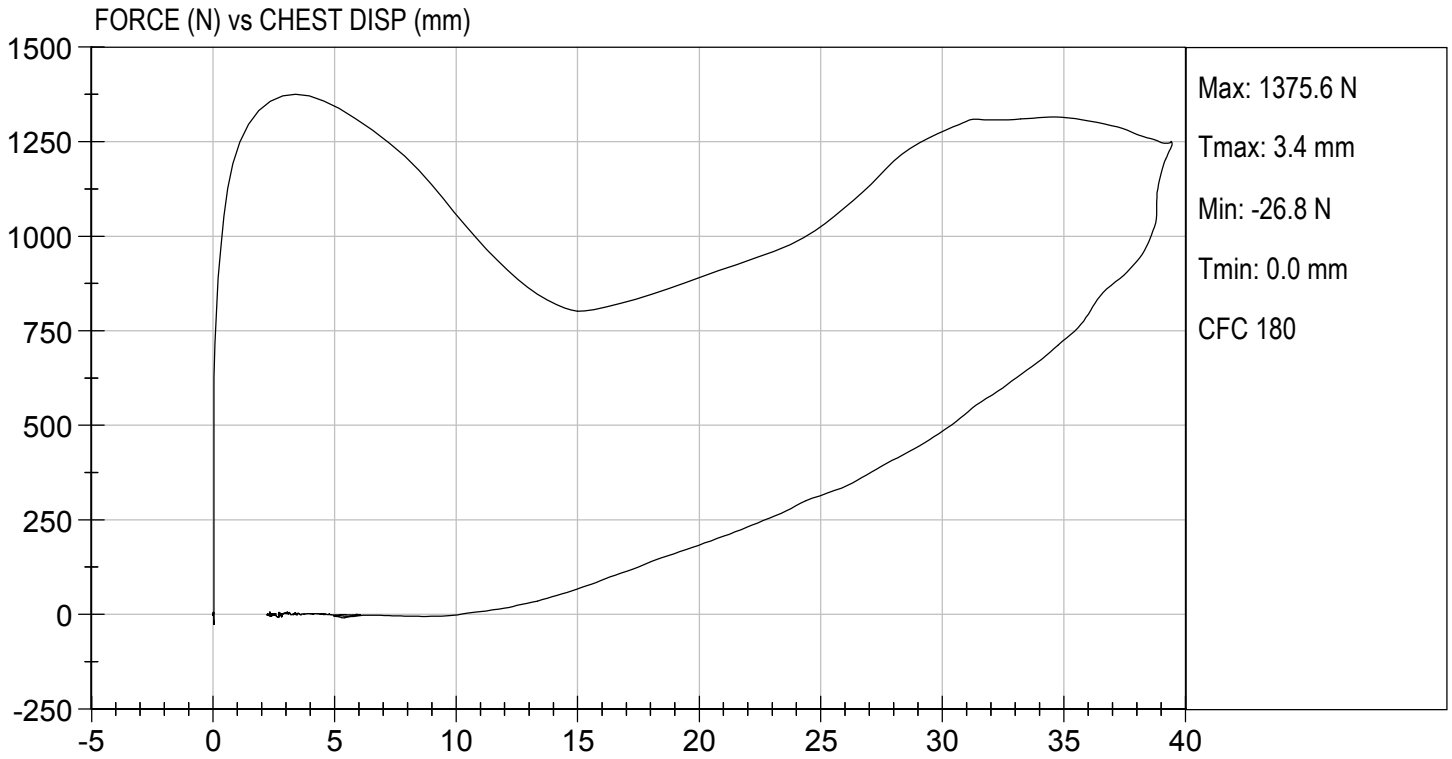
**Test I.D:** D192354

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.2	Pass
Relative Humidity	%	10 to 70	44	Pass
Probe Speed	m/s	6.59 to 6.83	6.66	Pass
Peak Deflection	mm	38.0 to 46.0	39.5	Pass
Peak Resistive Force w/in Deflection Corridor	N	1150 to 1380	1,268	Pass
Internal Hysteresis	%	65 to 85	75	Pass
Peak Force 12.5 mm - 38.0 mm	N	<= 1,500	1,315	Pass
<b>Overall Test Results</b>				<b>Pass</b>

Brian Roach  
Laboratory Technician

07/30/2019  
Test Date

B. F. H.  
Approved By



**MGA RESEARCH CORPORATION**  
**RIGHT KNEE IMPACT TEST**  
**HYBRID III 6 YEAR OLD**

ATD Serial No: 144

Test I.D: D192355

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.5	21.6	Pass
Laboratory Relative Humidity	%	10 to 70	42	Pass
Probe Speed	m/s	2.07 to 2.13	2.09	Pass
Maximum Force	N	2000 to 3000	2356	Pass
Overall Test Results				Pass

Brian Roach  
 Laboratory Technician

07/29/2019  
 Test Date

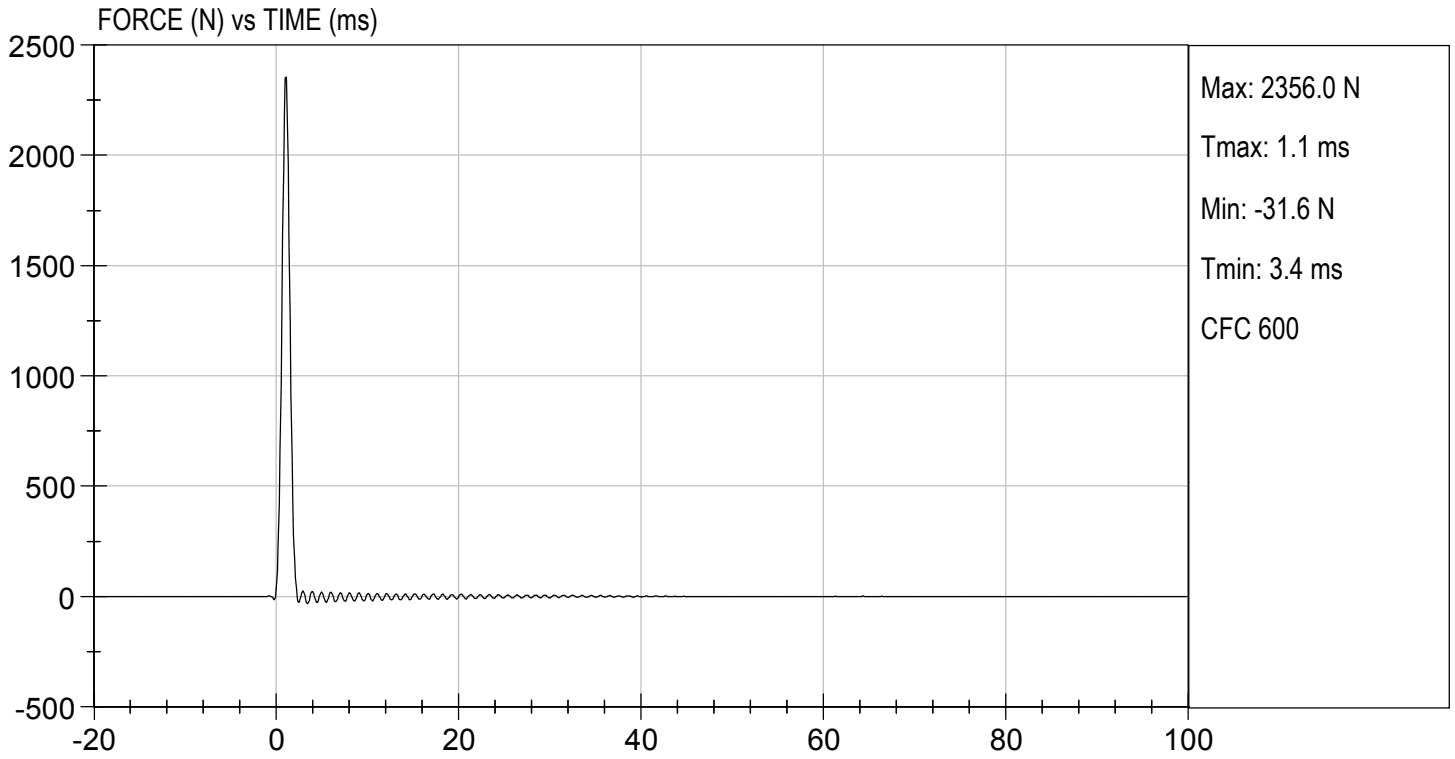
B. F. K.  
 Approved By





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

TEST DATE: 07/29/2019  
TEST #: D192355



**MGA RESEARCH CORPORATION**  
**LEFT KNEE IMPACT TEST**  
**HYBRID III 6 YEAR OLD**

**ATD Serial No:** 144

**Test I.D:** D192356

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.5	21.6	Pass
Laboratory Relative Humidity	%	10 to 70	42	Pass
Probe Speed	m/s	2.07 to 2.13	2.08	Pass
Maximum Force	N	2000 to 3000	2245	Pass
Overall Test Results				Pass

Brian Roach  
 Laboratory Technician

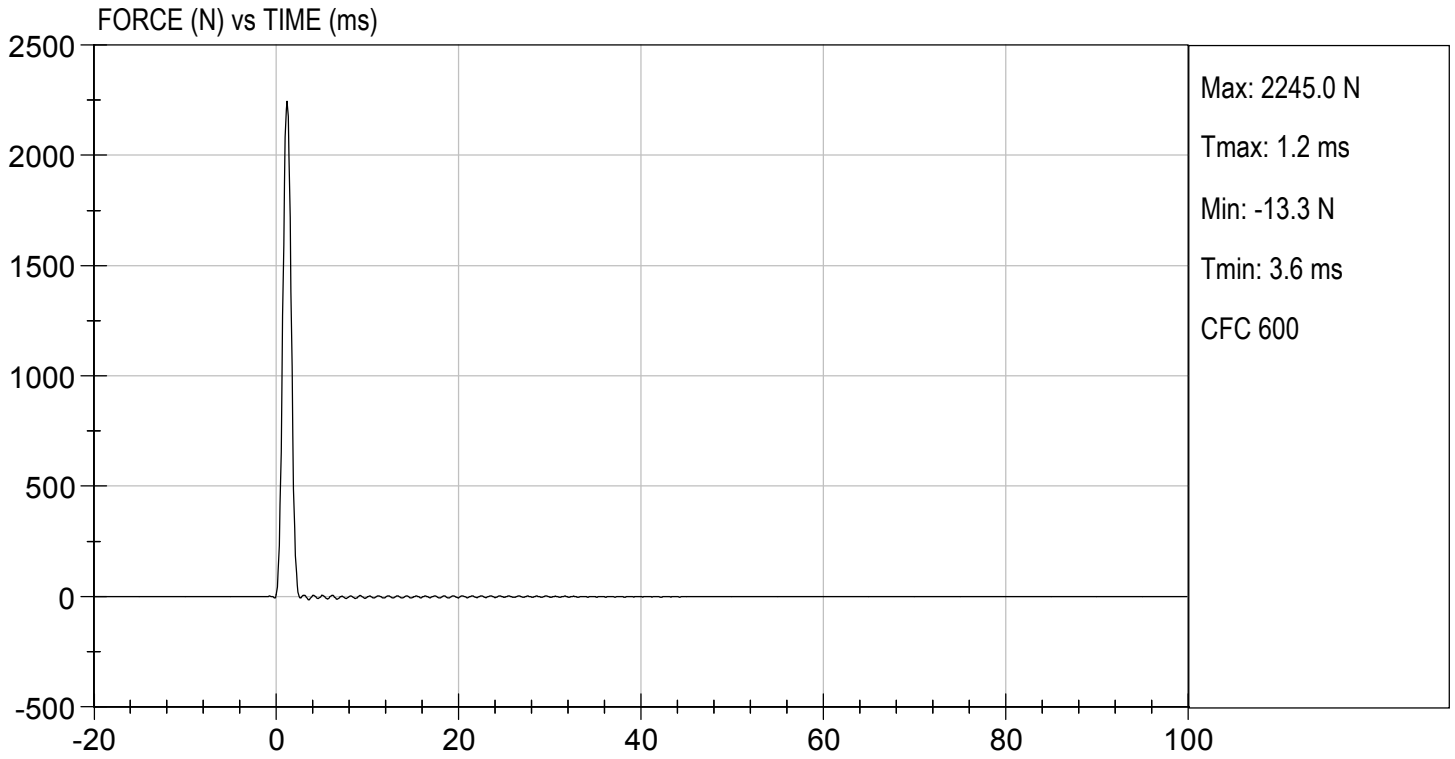
07/29/2019  
 Test Date

B. F. H.  
 Approved By



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

TEST DATE: 07/29/2019  
TEST #: D192356



**MGA RESEARCH CORPORATION**

**TORSO FLEXION TEST**

**HYBRID III 6 YEAR OLD**

**ATD Serial No:** 144

**Test I.D:** D192357

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	42	Pass
Initial Angle	deg	0 to 22	16	Pass
Return Angle	deg	+/- 8	8	Pass
Force at 45 deg	N	147 to 200	166	Pass
Upper Torso Deflection Rate	deg/s	0.5 to 1.5	0.9	Pass
Overall Result				Pass

*Brian Roach*

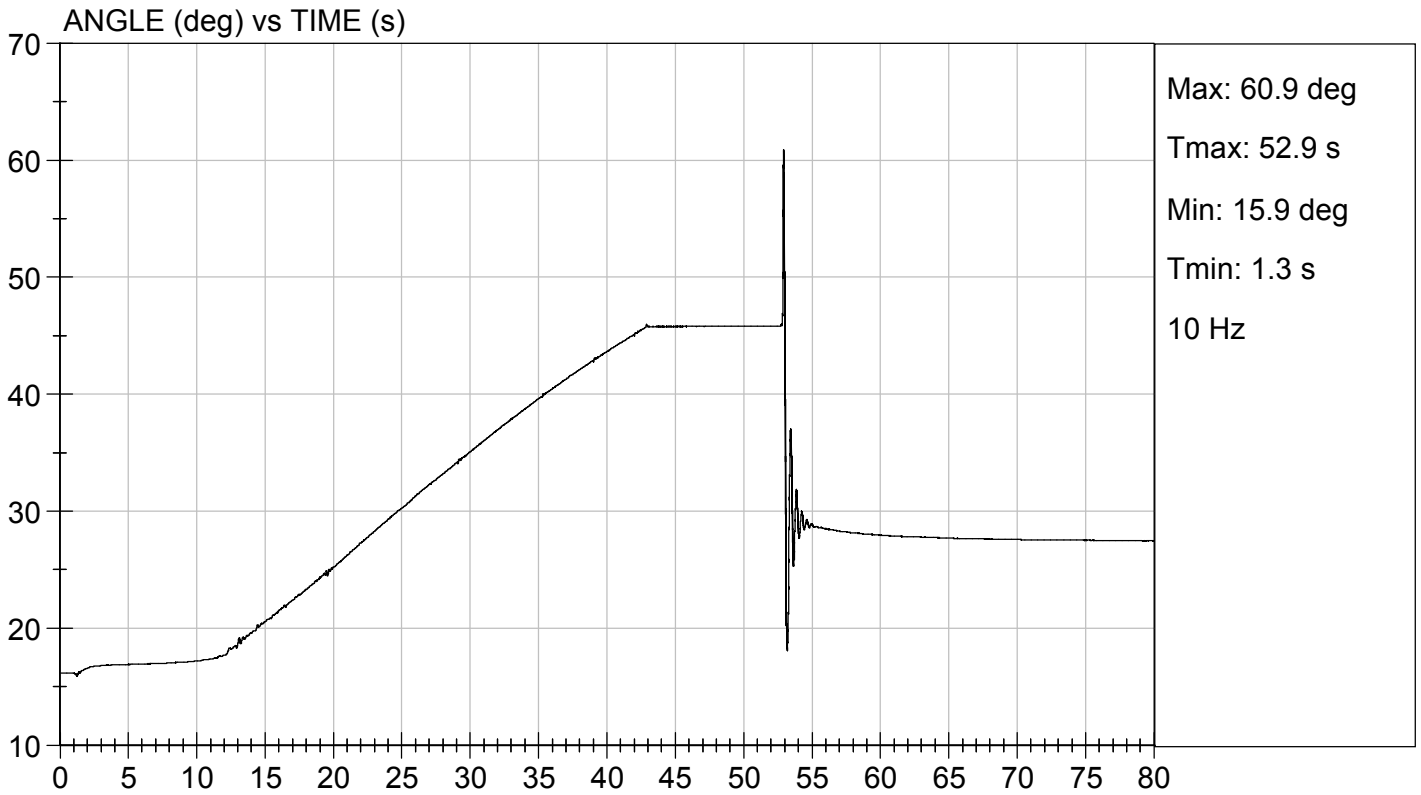
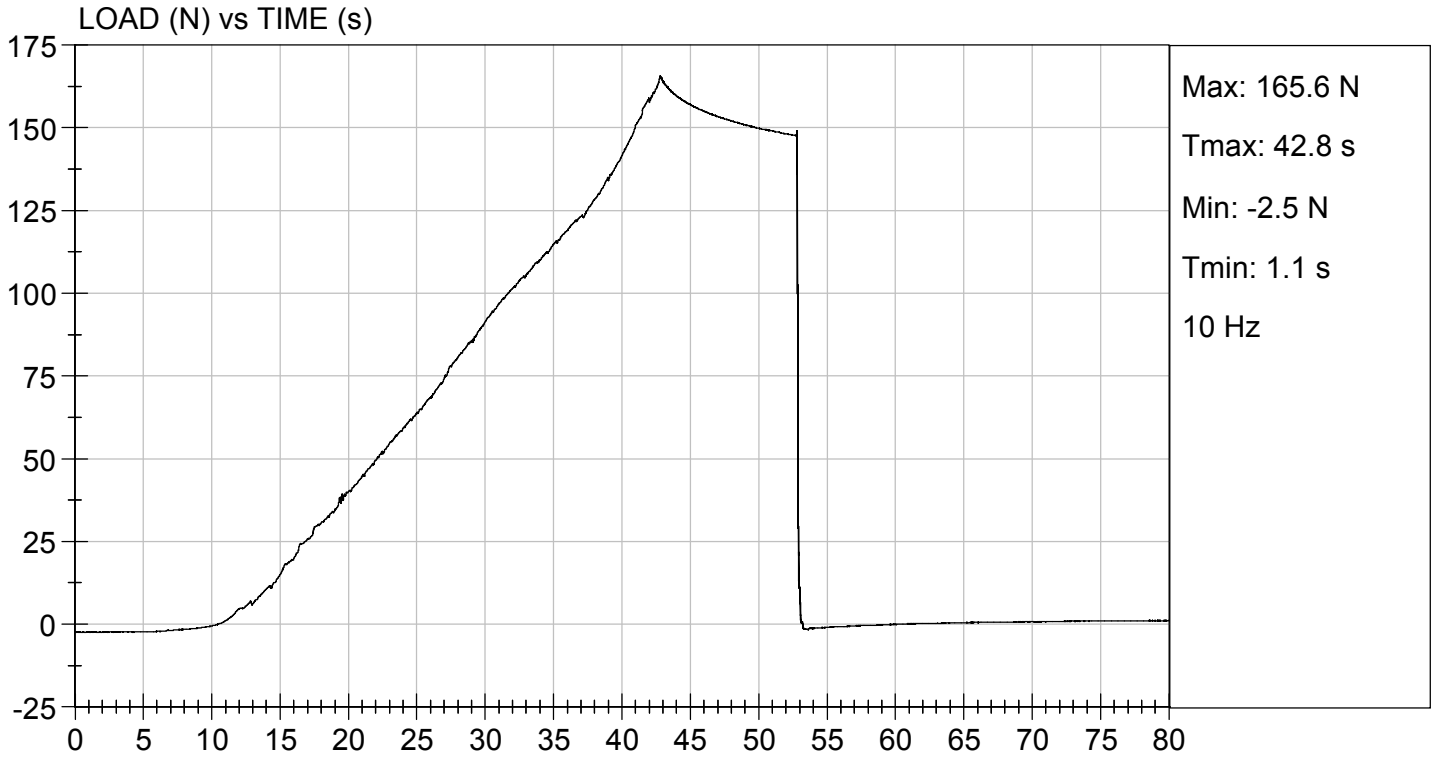
Laboratory Technician

07/29/2019

Test Date

*B. F.*

Approved By



**APPENDIX D  
TEST EQUIPMENT AND INSTRUMENTATION CALIBRATION DATA**

**Table 1 – Dummy Instrumentation**

		<b>HIII 6-Year-Old S/N 144</b>		
		<b>Serial Number</b>	<b>Manufacturer</b>	<b>Calibration Date</b>
Head CG Accelerometers	X	P82104	Endevco	07/08/19
	Y	P82105	Endevco	07/08/19
	Z	P82106	Endevco	07/08/19
Upper Neck Load Cell		NG1746	Denton	08/02/18
Lower Neck Load Cell		LNG139	Denton	08/02/18