REPORT NUMBER: TWG-MGA-20-007

SIDE AIRBAG OUT-OF-POSITION INJURY
TECHNICAL WORKING GROUP

NISSAN MOTOR CO., LTD.
2020 Nissan Leaf S 5-Door Hatchback
NHTSA No.: M20205205TWG2

MGA RESEARCH CORPORATION
5000 Warren Road
Burlington, WI 53105

Test Date: February 12, 2021

Final Report Date: June 28, 2021

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

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Approval Date: June 28, 2021

FINAL REPORT ACCEPTANCE BY:

_____

Date: _____

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

TECHNICAL REPORT DOCUMENTATION PAGE

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TWG-MGA-20-007		

4. Title and Subtitle	5. Report Date
Final Report of Side Airbag Out-of-Position Injury Technical Working Group evaluation of a 2020 Nissan Leaf S 5-Door Hatchback, NHTSA No.: M20205205TWG2	June 28, 2021
	6. Performing Organization Code MGA
7. Author(s) Ben Fischer, Project Manager	**8. Performing Organization Report No.** TWG-MGA-20-007
9. Performing Organization Name and Address MGA Research Corporation 5000 Warren Road Burlington, WI 53105	**10. Work Unit No.**
	11. Contract or Grant No. 693JJ919D000006
12. Sponsoring Agency Name and Address 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	**13. Type of Report and Period Covered:** Final Test Report February 12, 2021 to June 28, 2021
	14. Sponsoring Agency Code NRM-110

15. Supplementary Notes

16. Abstract

A Side Airbag Out-of-Position Injury evaluation was conducted on the subject 2020 Nissan Leaf S 5-Door Hatchback 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 February 12, 2021.

Measurement Description	Units	Driver ATD (SID-IIs)	
		Threshold	Result
Head Injury Criteria (HIC_{15})		779	12
Nij		1	0.74
Neck Tension	N	2070	367
Neck Compression	N	2520	1801
Maximum Chest Displacement	mm		
Maximum Chest Displacement Rate	m/s		

17. Key Words	18. Distribution Statement
Side Airbag Out-of-Position Technical Working Group OOP TWG SID-IIs	Copies of this report are available from: National Highway Traffic Safety Administration Technical Information Services Division 1200 New Jersey Ave, SE Washington, DC 20590

19. Security Classification of Report	20. Security Classification of Page	21. No. of Pages	22. Price
Unclassified	Unclassified	96	

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SECTION 1
TEST PURPOSE AND PROCEDURE

This side airbag out-of-position test is part of the MY2020 New Car Assessment Program (NCAP), sponsored by the National Highway Traffic Safety Administration (NHTSA) under contract number 693JJ919D000006. The purpose of this test is to obtain data on the performance of side airbags with out-of-position occupants in a 2020 Nissan Leaf S 5-Door Hatchback. The airbag test was conducted in accordance with the Office of Crashworthiness Standard's Side Airbag Out-of-Position Laboratory Test Procedure, dated November 2019.

SECTION 2
SUMMARY OF TEST RESULTS

The effects of both a curtain and torso airbag deployment in a 2020 Nissan Leaf S 5-Door Hatchback with an out-of-position SID-IIs Build Level D 5th-percentile female dummy were evaluated. The curtain and seat airbags were fired remotely. The test was performed by MGA Research Corporation on February 12, 2021. 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
- Left Side Oblique Through Windshield
- Front Through Windshield

One SID-IIs Build Level D 5th-percentile female dummy (Serial Number 304) was placed in the right front passenger seat situated in the inboard-facing position along the outboard edge of the seat per Section 3.3.5.3 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 SID-IIs Build Level D 5th-percentile female dummy's visible contact points were as follows:

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

The SID-IIs Build Level D 5th-percentile female dummy was placed in the right front passenger seat facing toward the center of the vehicle with its arm against the seatback. The arm was rotated horizontally in the forward direction with respect to the dummy. The seat track was adjusted forward to minimize the vertical distance between the dummy's head and curtain airbag. The dummy's pelvis was slid outboard until the dummy's back contacted the door trim panel or armrest and the CG of the head was centered in the deployment trajectory of the airbag. The vertical plane through the centerline of the dummy's rib-stiffener and shoulder bolt was parallel to the centerline of the vehicle.

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 3.3.5.3 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: 2020 Nissan Leaf S 5-Door Hatchback NHTSA No.: M20205205TWG2
Test Program: NCAP Side Airbag Out-of-Position Test Date: 2/12/2021

TEST CONFIGURATION INFORMATION

Seating Position	P2	Right Front Seating Position
Test Section	3.3.5.3*	Inboard Facing SID-IIs on Raised Seat
Curtain Airbag	Roof-Rail Mounted	Side Curtain Airbag
Torso Airbag	Seat Mounted	Side Torso/Pelvis Airbag
ATD Type/Serial No.	SID-IIs Build Level D	S/N: 304
Vehicle	Nissan	Leaf
Previous Crash Test	Side MDB NCAP	August 6, 2020 – M20205205

*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
Left Shoulder Contact	None
Left Torso Contact	Side torso/pelvis airbag to torso
Left Pelvis Contact	Side torso/pelvis airbag to pelvis

DATA SHEET NO. 2
GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2020 Nissan Leaf S 5-Door Hatchback NHTSA No.: M20205205TWG2
Test Program: NCAP Side Airbag Out-of-Position Test Date: 2/12/2021

TEST VEHICLE INFORMATION AND OPTIONS

NHTSA No.	M20205205	Traction Control System (TCS)	Yes
Model Year	2020	Auto-Leveling System	No
Make	Nissan	Automatic Door Locks (ADL)	Yes
Model	Leaf S	Power Window Auto-Reverse	Yes
Body Style	5-Door Hatchback	Other Optional Feature	No
VIN	1N4AZ1BP9LC301028	Driver Front Airbag	Yes
Body Color	Deep Blue Pearl	Driver Curtain Airbag	Yes
Odometer Reading (km/mi)	16 km / 10 mi	Driver Head/Torso Airbag	No
Engine Displacement (L)		Driver Torso Airbag	No
Type/No. Cylinders	Electric	Driver Torso/Pelvis Airbag	Yes
Engine Placement	Lateral	Driver Pelvis Airbag	No
Transmission Type	Automatic	Driver Knee Airbag	Yes
Transmission Speeds	1	Rear Pass. Curtain Airbag	Yes
Overdrive	No	Rear Pass. Head/Torso Airbag	No
Final Drive	FWD	Rear Pass. Torso Airbag	No
Roof Rack	No	Rear Pass. Torso/Pelvis Airbag	Yes
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 Pretensioner	Yes
Power Seats	No	Driver Load Limiter	Yes
Anti-Lock Brakes (ABS)	Yes	Rear Pass. Load Limiter	Yes
		Other Safety Restraint	N/A

DATA FROM CERTIFICATION LABEL

Manufactured By	NISSAN MOTOR CO., LTD.
Date of Manufacture	12/19
Vehicle Type	Passenger Car

GVWR (kg)	2035
GAWR Front (kg)	1070
GAWR Rear (kg)	985

VEHICLE SEATING AND WEIGHT CAPACITY DATA

Measured Parameter	Front	Rear	Third	Total	
Designated Seating Capacity (DSC)	2	3		5	
Capacity Weight (VCW) (kg)				390	(A)
DSC x 68.04 kg				340	(B)
Rated Cargo and Luggage Weight (RCLW) (kg)				50	(A-B)

VEHICLE SEAT TYPE

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

DATA SHEET NO. 3
SEAT ADJUSTMENT DATA

Test Vehicle: 2020 Nissan Leaf S 5-Door Hatchback NHTSA No.: M20205205TWG2
Test Program: NCAP Side Airbag Out-of-Position Test Date: 2/12/2021

VEHICLE SEAT FORE/AFT POSITION

Seat	Total Fore/Aft Travel		Test Position from Forward-Most Position	
	mm	Detents (1st as 1)	mm	Detent (1st as 0)
Right Front Passenger Seat	210	22	110	11
Right Rear Passenger Seat				
Seat Fore/Aft Position per TWG Guidelines	Initial Position: Rearmost and highest adjustment			
	Seat Track Adjustments: Allowed to ensure proper alignment of the ATD head and vertical centerline of the airbag deployment trajectory and maximize head/neck interaction			
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 (1st as 1)	Degrees	Detent (1st as 0)
Right Front Passenger Seat	55.5	28	8.8	5
Right Rear Passenger Seat				
OEM Back Angle Design Position	8.8° rearward of vertical, measured on outboard headrest post			
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 (1st as 1)	mm	Detent (1st as 0)
Right Front Passenger Seat	Fixed		Fixed	
Right Rear Passenger Seat				
Seat Fore/Aft Position per TWG Guidelines	Initial Position: Rearmost and highest 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: 2020 Nissan Leaf S 5-Door Hatchback NHTSA No.: M20205205TWG2
Test Program: NCAP Side Airbag Out-of-Position Test Date: 2/12/2021

ATD Type	SID-IIs Build Level D 5th-percentile female dummy
Serial Number	304
Qualification Date	2/4/2021
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: 2020 Nissan Leaf S 5-Door Hatchback
Test Program: NCAP Side Airbag Out-of-Position
NHTSA No.: M20205205TWG2
Test Date: 2/12/2021

RECORDED DATA – MINIMUMS AND MAXIMUMS

Channel	Unit	CFC	Maximum	Time (ms)	Minimum	Time (ms)
Passenger Head X	g	1000	9.2	24.0	-16.4	12.6
Passenger Head Y			15.6	16.1	-18.5	12.5
Passenger Head Z			44.7	11.9	-12.9	15.3
Passenger Upper Neck Fx	N	1000	382.8	76.7	-173.7	190.9
Passenger Upper Neck Fy			285.3	25.3	-159.7	12.4
Passenger Upper Neck Fz			366.5	156.5	-1801.0	23.9
Passenger Upper Neck Mx	Nm	600	6.9	107.6	-23.9	25.2
Passenger Upper Neck My			37.1	18.6	-23.4	60.8
Passenger Upper Neck Mz			10.1	24.2	-8.6	92.7
Passenger Lower Neck Fx	N	1000	504.3	17.1	-564.2	55.9
Passenger Lower Neck Fy			316.0	11.8	-102.2	198.5
Passenger Lower Neck Fz			408.5	156.8	-1839.4	15.8
Passenger Lower Neck Mx	Nm	600	28.5	70.6	-30.7	186.4
Passenger Lower Neck My			60.4	24.6	-12.9	140.7
Passenger Lower Neck Mz			19.4	26.4	-19.8	90.6

HEAD INJURY SUMMARY

HIC_{15}	T_1 (ms)	T_2 (ms)	HIC_{36}	T_1 (ms)	T_2 (ms)
12	11.6	19.3	22	11.6	47.6

NECK INJURY SUMMARY

Injury Criteria	Unit	Value	Time (ms)
Upper Neck NTF		0.16	156.5
Upper Neck NTE		0.30	109.9
Upper Neck NCF		0.63	17.0
Upper Neck NCE		0.74	36.9
Peak Tension	N	366.5	156.5
Peak Compression	N	1801.0	23.9

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

Test Vehicle: 2020 Nissan Leaf S 5-Door Hatchback
Test Program: NCAP Side Airbag Out-of-Position
NHTSA No.: M20205205TWG2
Test Date: 2/12/2021

CHEST INJURY SUMMARY

Injury Criteria	Unit	Value	Time (ms)
Chest Deflection	mm		
Deflection Rate[1]	m/s		

[1]Deflection rate is calculated based on Chest Deflection potentiometer.

RESEARCH VALUE SUMMARY

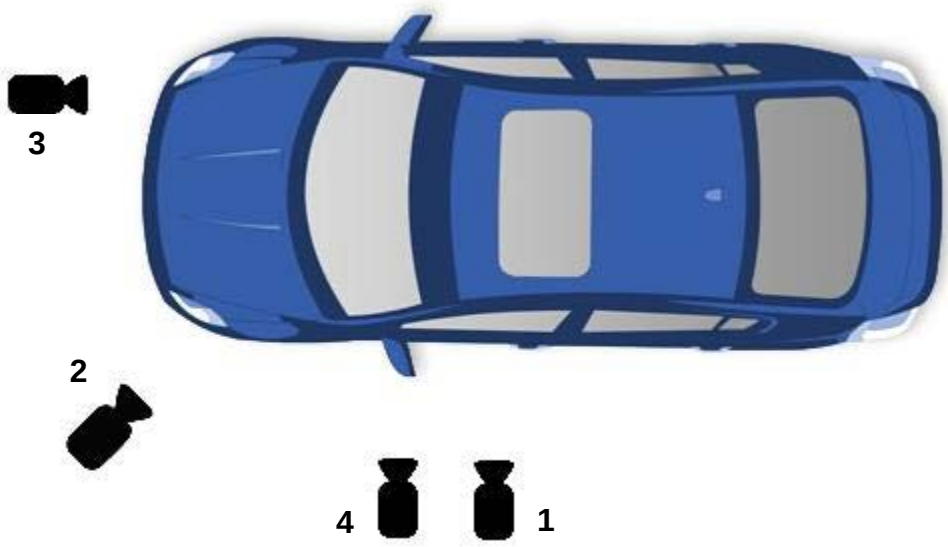
Research Injury Criteria[1]	Unit	Value	Time (ms)
Upper Neck Lateral Moment	Nm	23.9	25.2
Upper Neck Twist Moment	Nm	10.1	24.2
Lower Neck Flexion Moment	Nm	60.4	24.6
Lower Neck Extension Moment	Nm	12.9	140.7
Lower Neck Lateral Moment	Nm	30.7	186.4
Lower Neck Twist Moment	Nm	19.8	90.6
Lower Neck Tension	N	408.5	156.8
Lower Neck Compression	N	1839.4	15.8
Spine Acceleration	g		

[1]These injury criteria are only monitored and not considered pass/fail.

DATA SHEET NO. 6
CAMERA SETUP AND DESCRIPTION

Test Vehicle: 2020 Nissan Leaf S 5-Door Hatchback NHTSA No.: M20205205TWG2
Test Program: NCAP Side Airbag Out-of-Position Test Date: 2/12/2021

CAMERA SETUP DIAGRAM FOR OOP TESTS



CAMERA LOCATIONS

No.	Camera View	Location			Lens (mm)	Speed (fps)
		X	Y	Z		
1	Left View	2020	-2180	-1180	24	2700
2	Oblique View	4010	-1340	-1330	35	2700
3	Front View	5280	320	-1480	50	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

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

Photo No. 002 - Vehicle Certification Placard

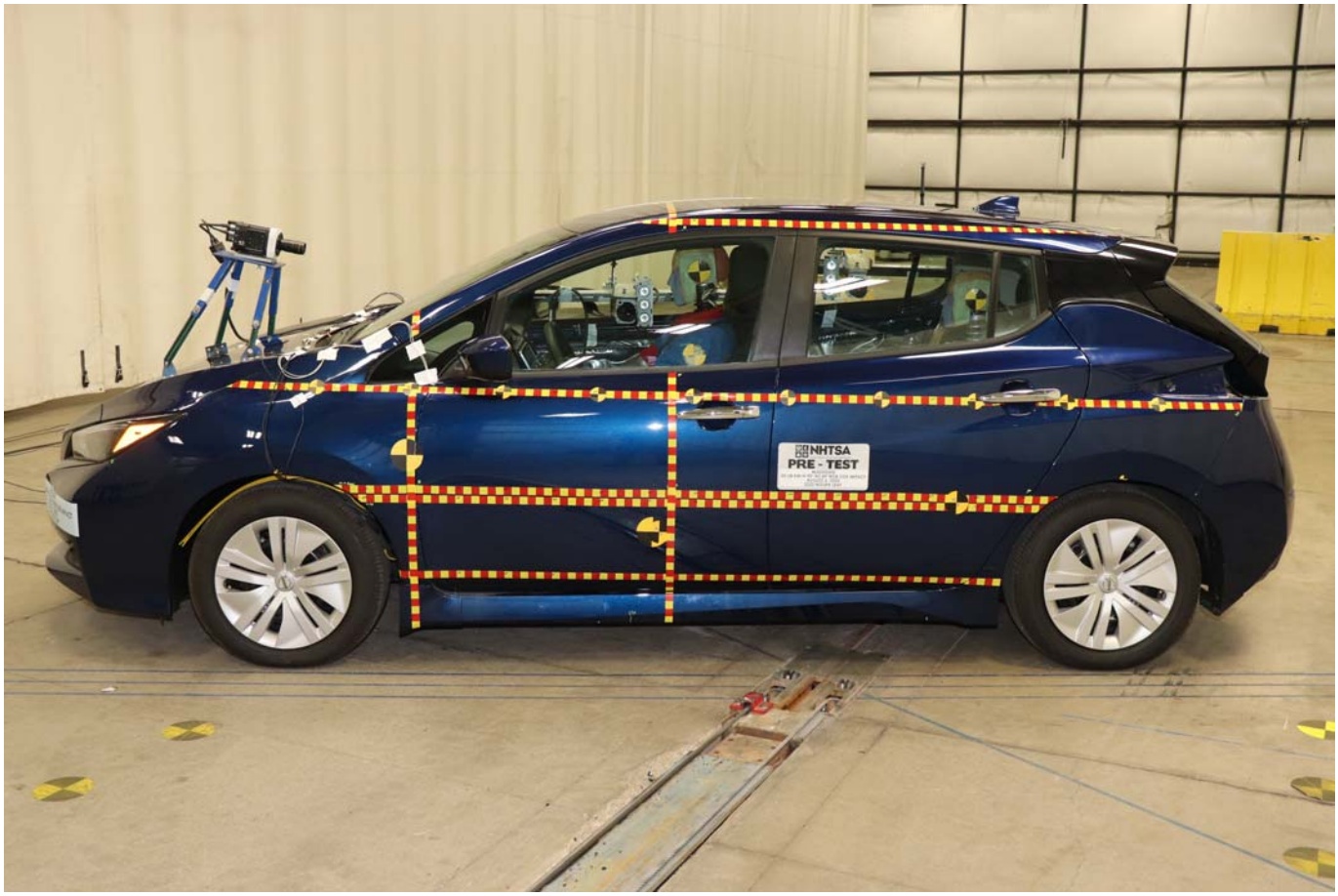


Photo No. 003 - Pre-Test Vehicle Left Side View

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

Photo No. 005 - Pre-Test Dummy Left Side View

Photo No. 006 - Post-Test Dummy Left Side View

Photo No. 007 - Pre-Test Dummy Left Side Close-Up View


Photo No. 008 - Post-Test Dummy Left Side Close-Up View

Photo No. 009 - Pre-Test Dummy Left Three-Quarter Front View

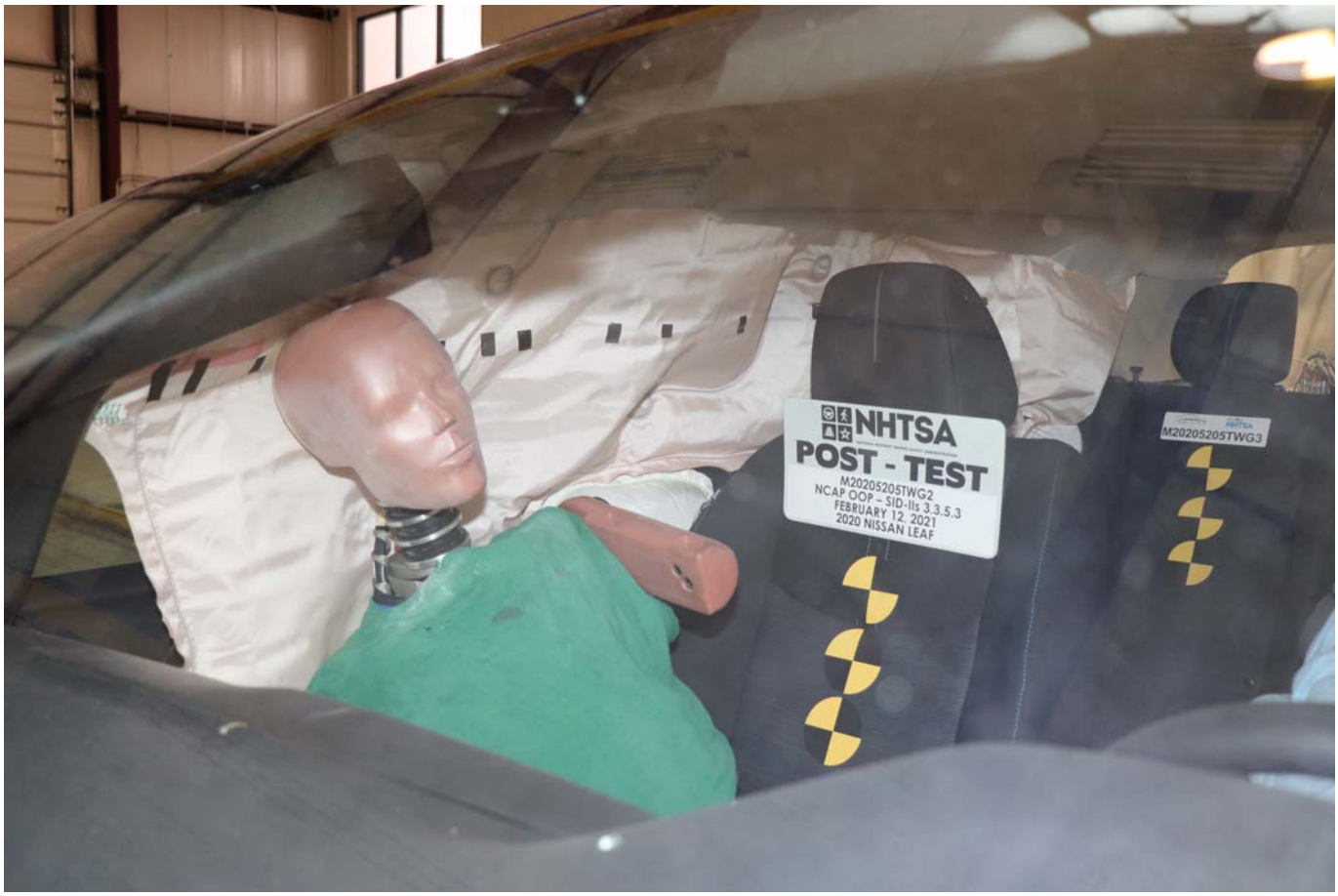


Photo No. 010 - Post-Test Dummy Left Three-Quarter Front View

Photo No. 011 - Pre-Test Dummy Left Three-Quarter Front Close-Up View

Photo No. 012 - Post-Test Dummy Left Three-Quarter Front Close-Up View

Photo No. 013 - Pre-Test Dummy Front View

Photo No. 014 - Post-Test Dummy Front View

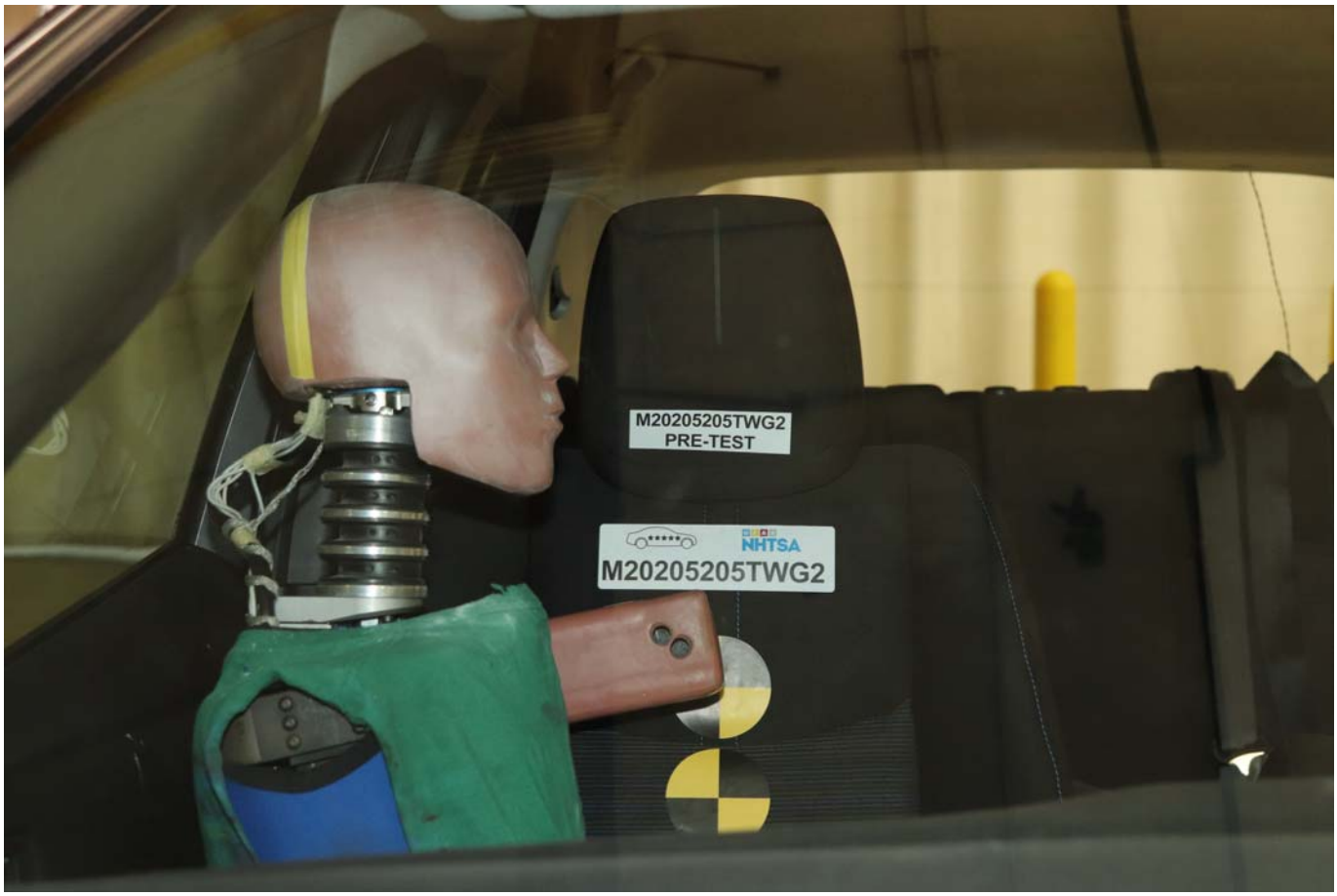


Photo No. 015 - Pre-Test Dummy Front Close-Up View

Photo No. 016 - Post-Test Dummy Front Close-Up View

Photo No. 017 - Pre-Test Dummy Right Three-Quarter Front View

Photo No. 018 - Post-Test Dummy Right Three-Quarter Front View

Photo No. 019 - Pre-Test Dummy Right Side View

Photo No. 020 - Post-Test Dummy Right Side View

Photo No. 021 - Post-Test Dummy Right Side View (Door Open)

Photo No. 022 - Post-Test Curtain Airbag Left Side View

Photo No. 023 - Post-Test Curtain Airbag Left Three-Quarter Front View

Photo No. 024 - Post-Test Curtain Airbag Front View

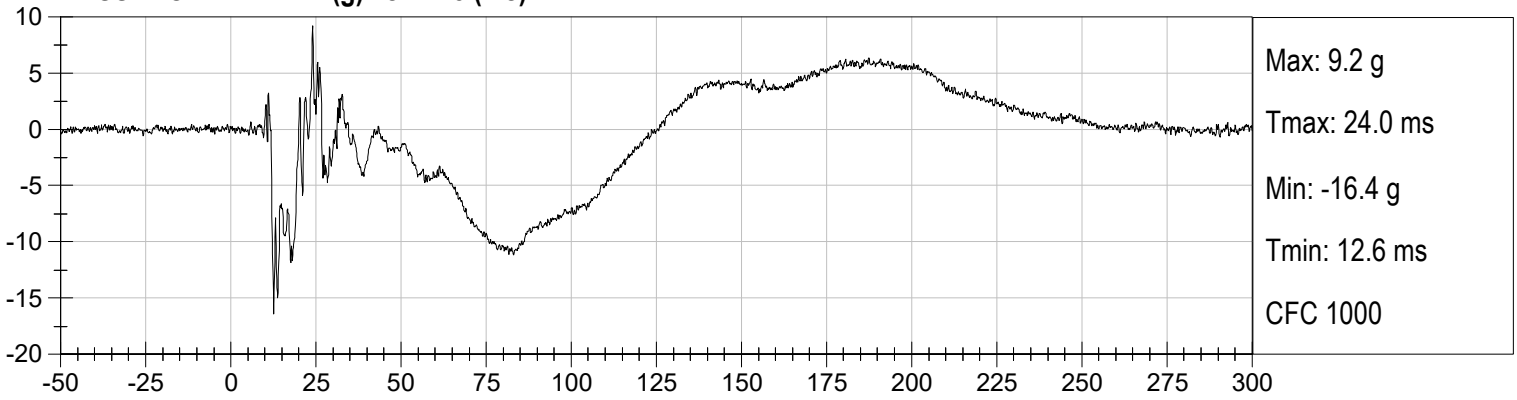
Photo No. 025 - Post-Test Curtain Airbag Right Side View (Door Open)

APPENDIX B

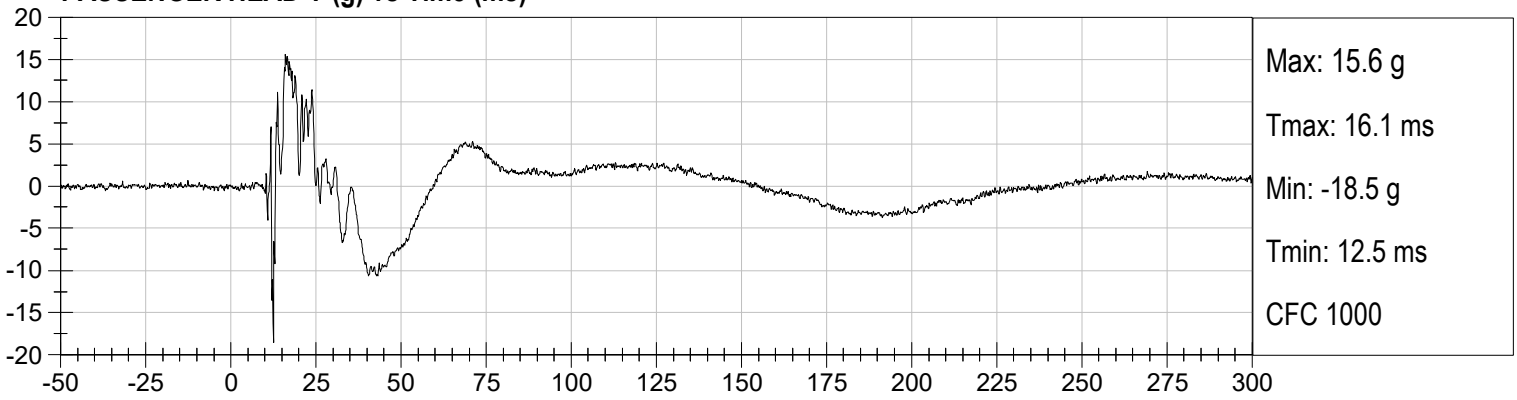
DUMMY RESPONSE DATA TRACES

TABLE OF DATA PLOTS

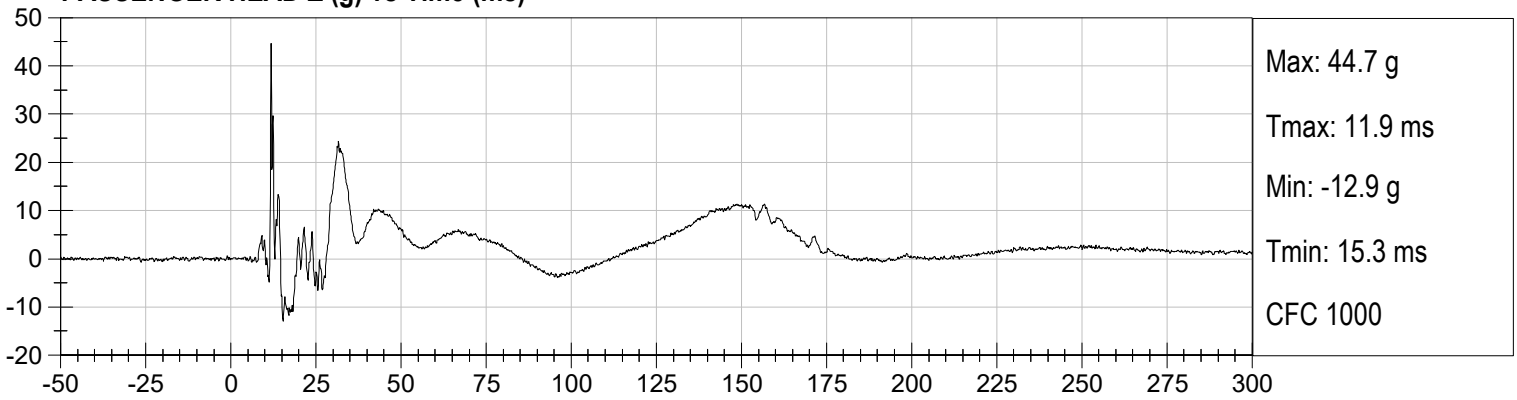
PASSENGER HEAD X (g) vs Time (ms)



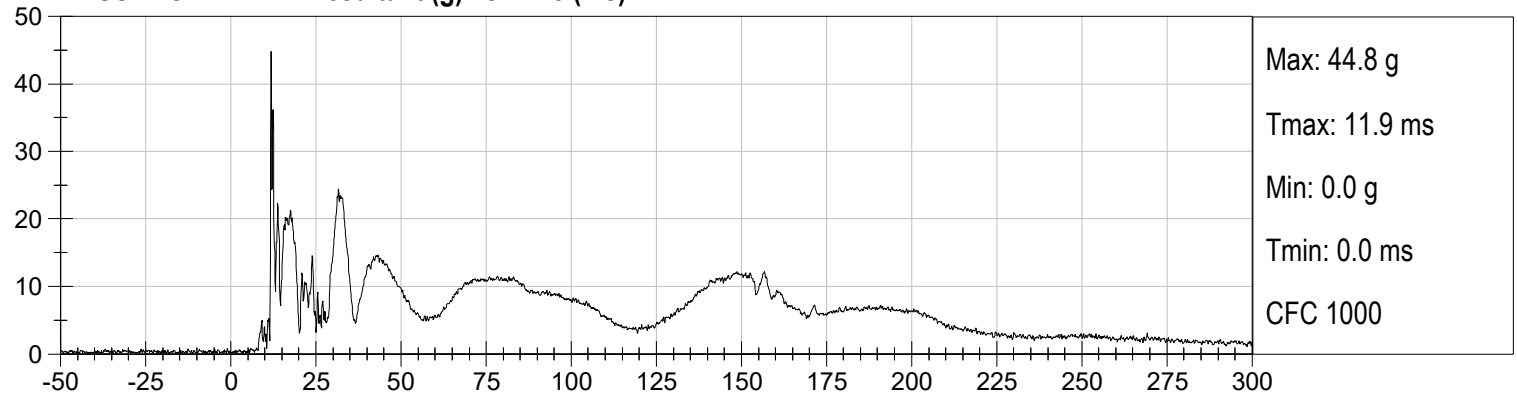
PASSENGER HEAD Y (g) vs Time (ms)



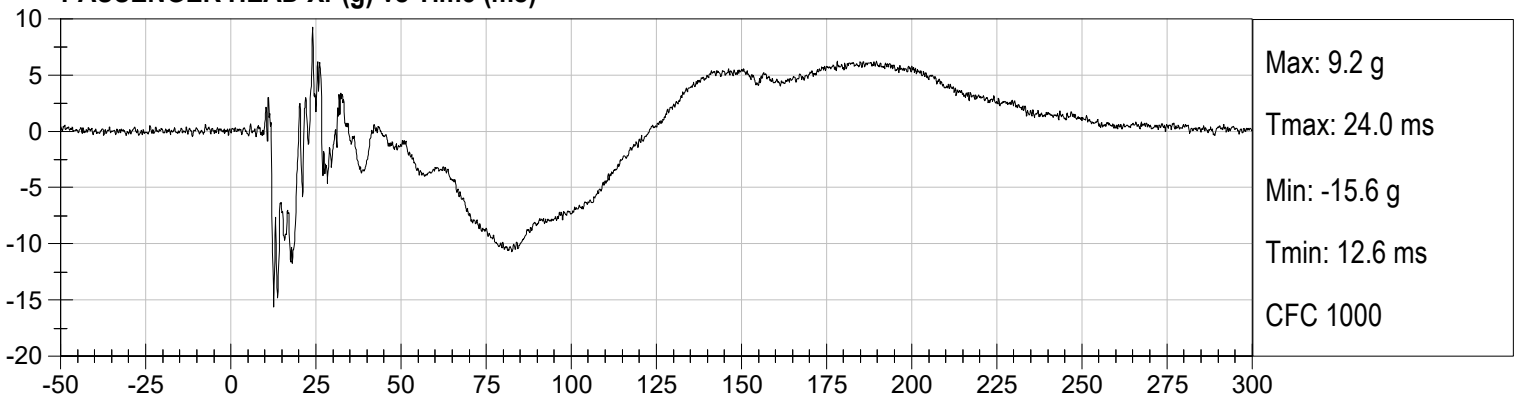
PASSENGER HEAD Z (g) vs Time (ms)



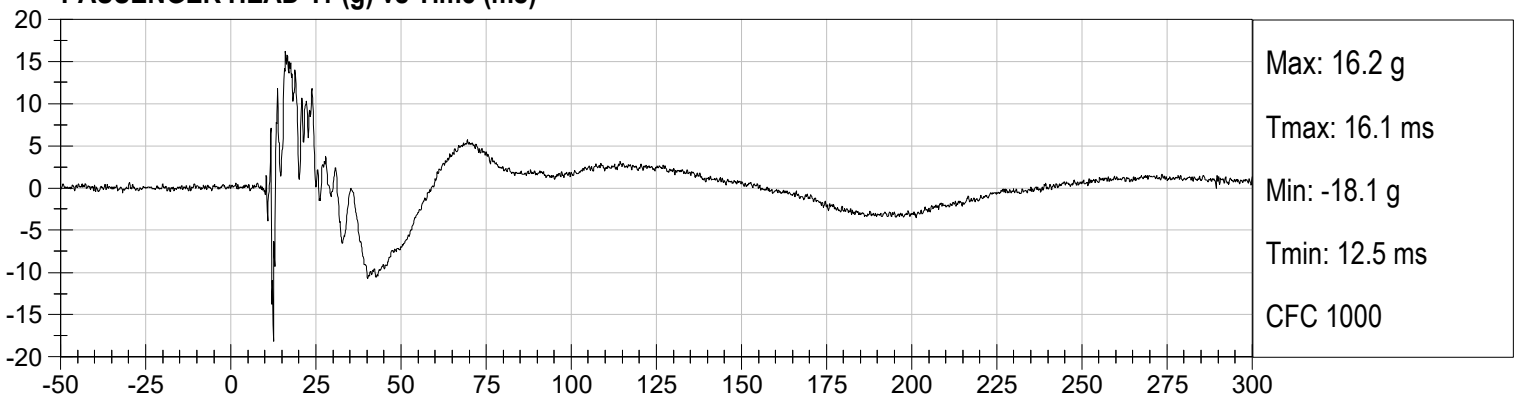
PASSENGER HEAD Resultant (g) vs Time (ms)



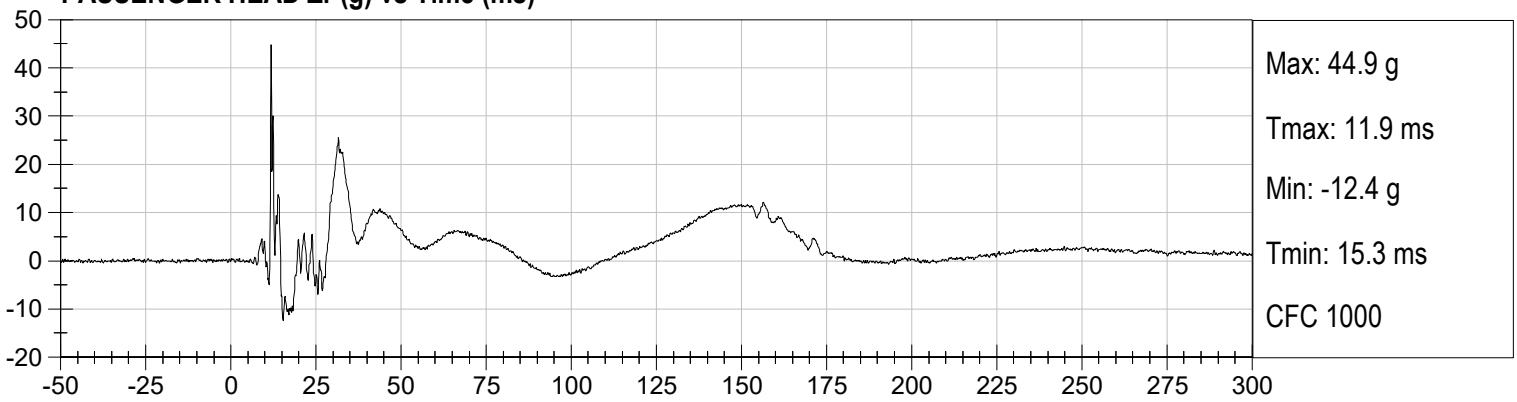
PASSENGER HEAD Xr (g) vs Time (ms)



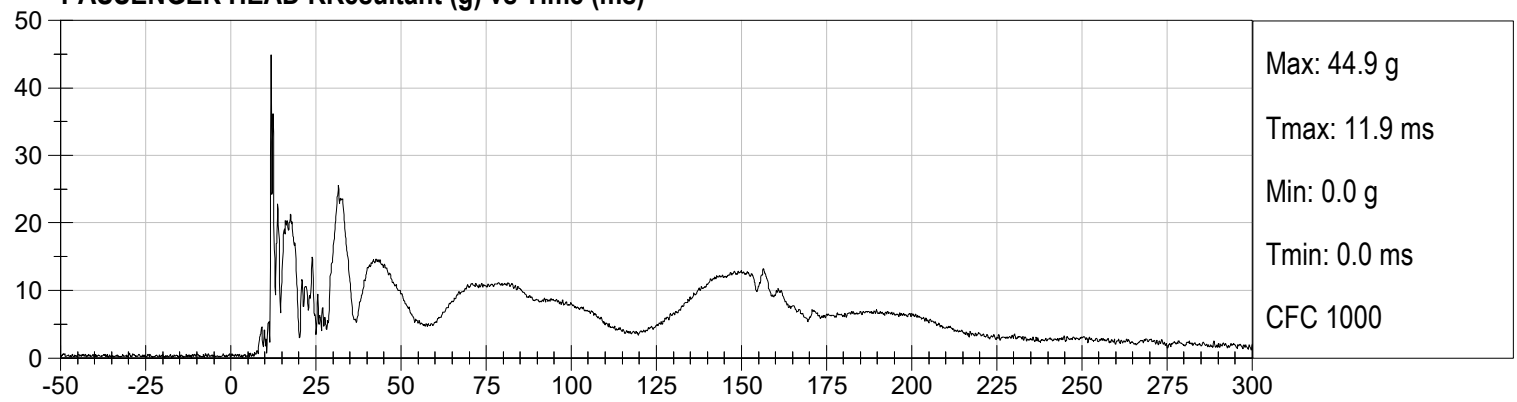
PASSENGER HEAD Yr (g) vs Time (ms)



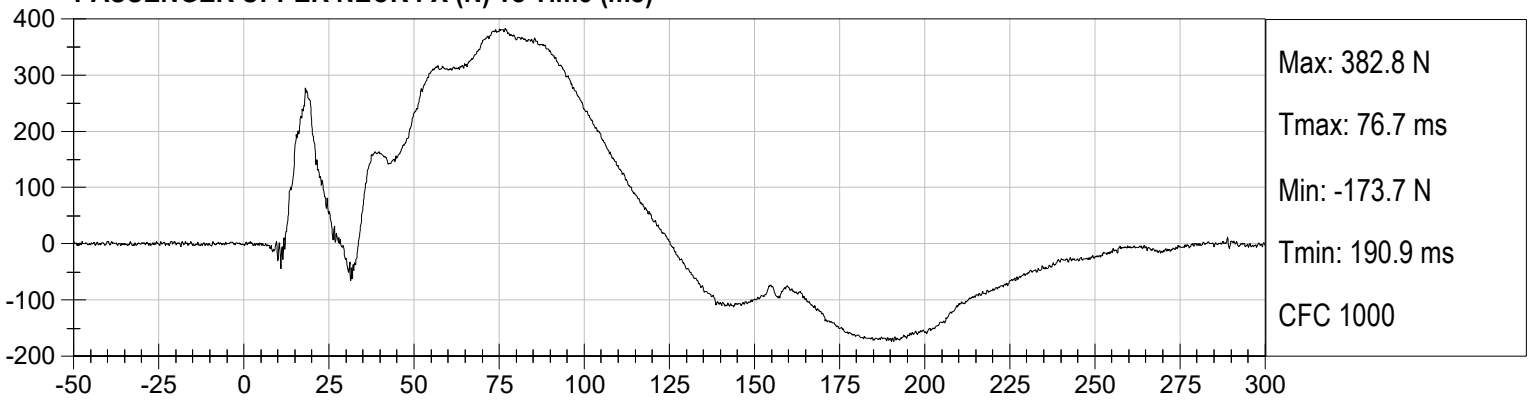
PASSENGER HEAD Zr (g) vs Time (ms)



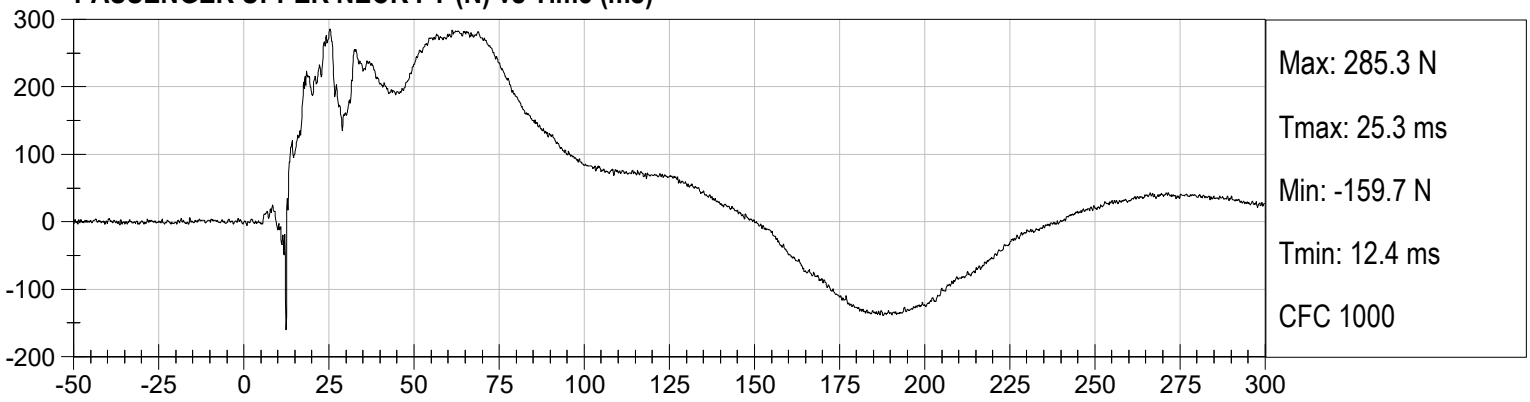
PASSENGER HEAD RResultant (g) vs Time (ms)



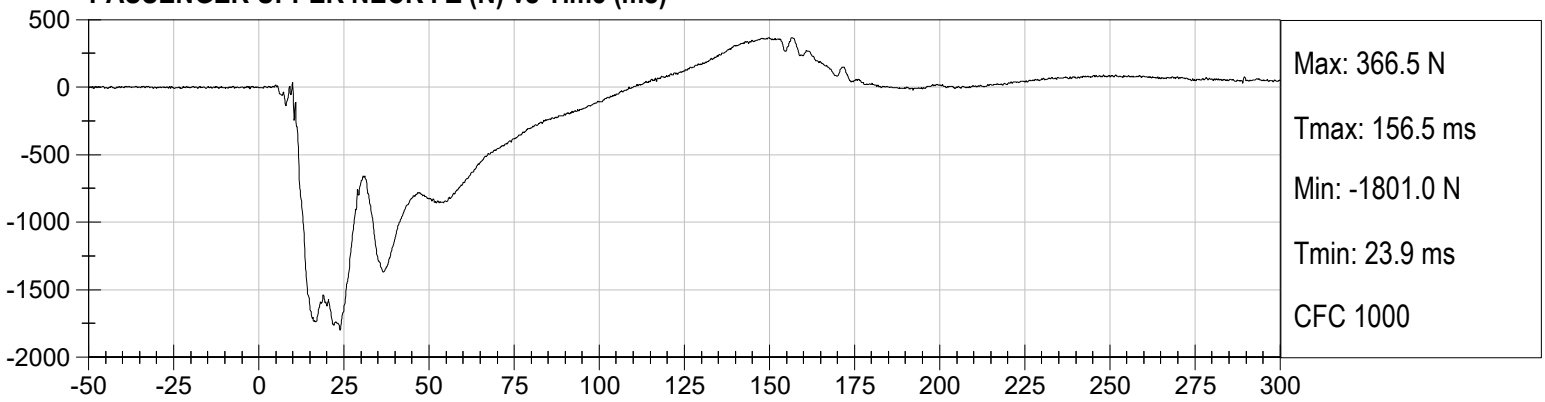
PASSENGER UPPER NECK FX (N) vs Time (ms)



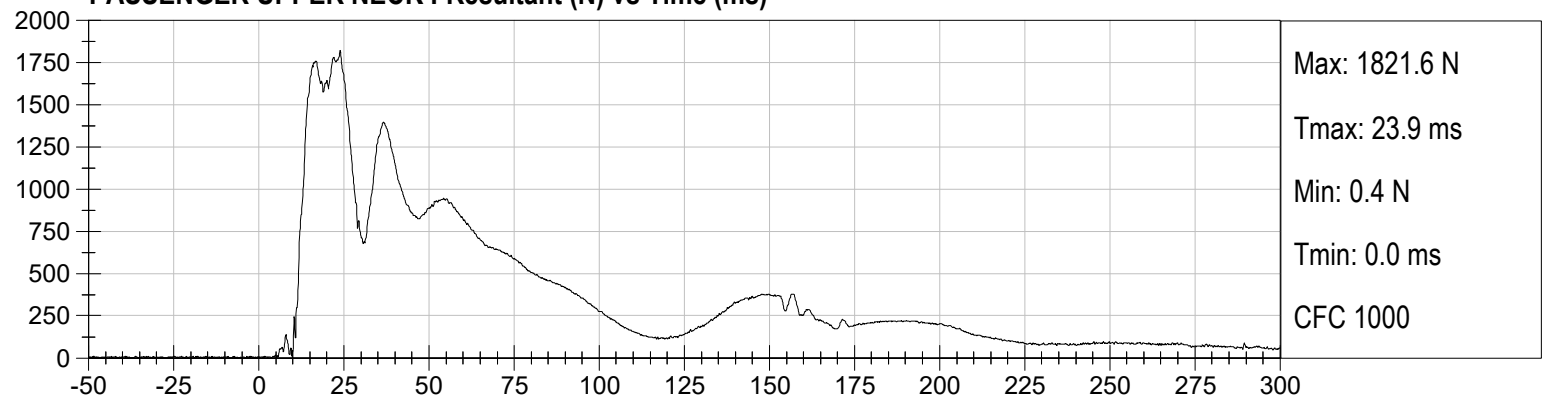
PASSENGER UPPER NECK FY (N) vs Time (ms)



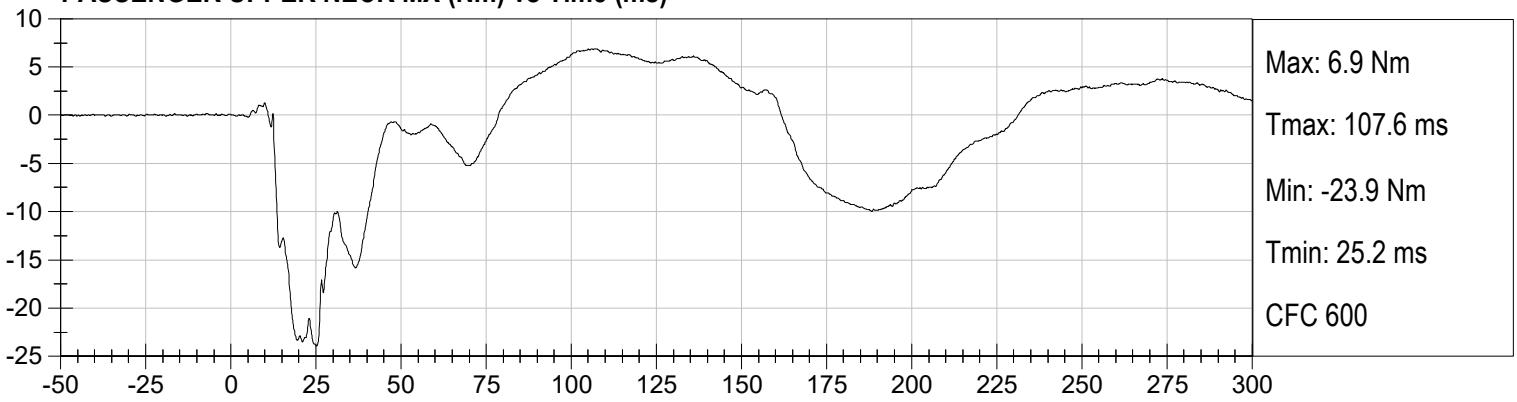
PASSENGER UPPER NECK FZ (N) vs Time (ms)



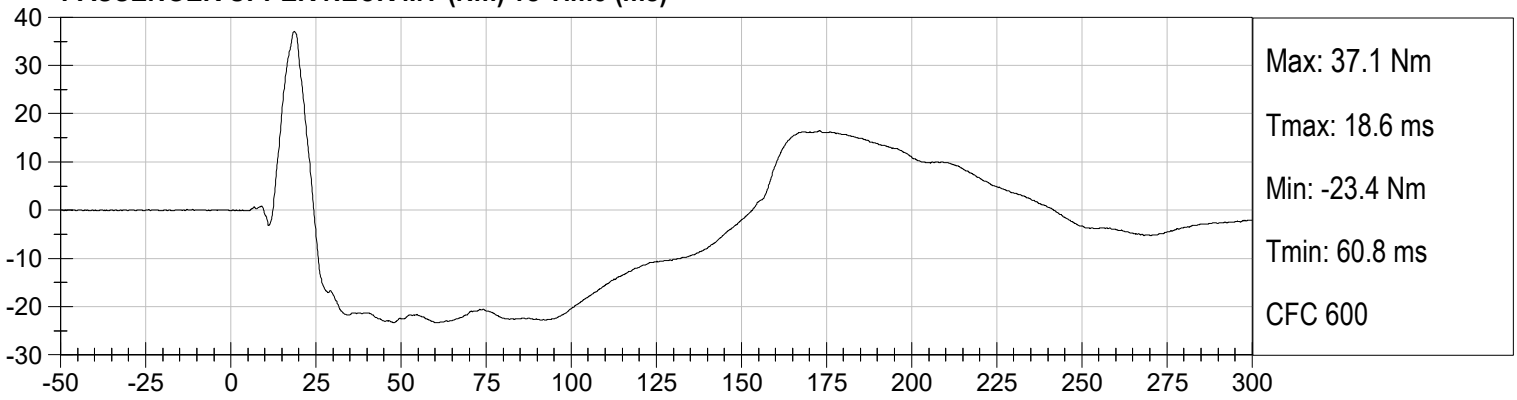
PASSENGER UPPER NECK FResultant (N) vs Time (ms)



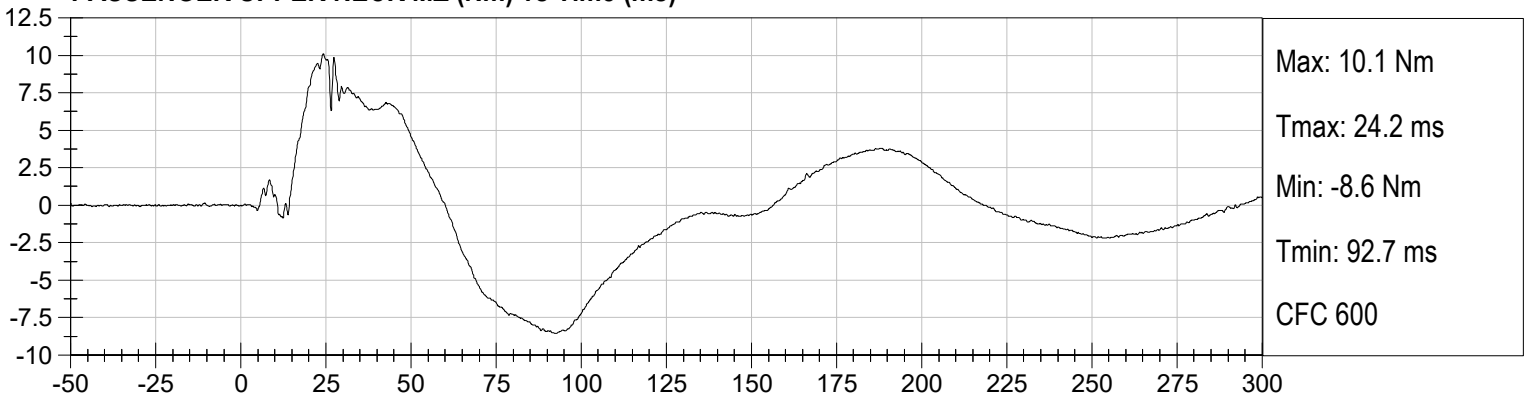
PASSENGER UPPER NECK MX (Nm) vs Time (ms)



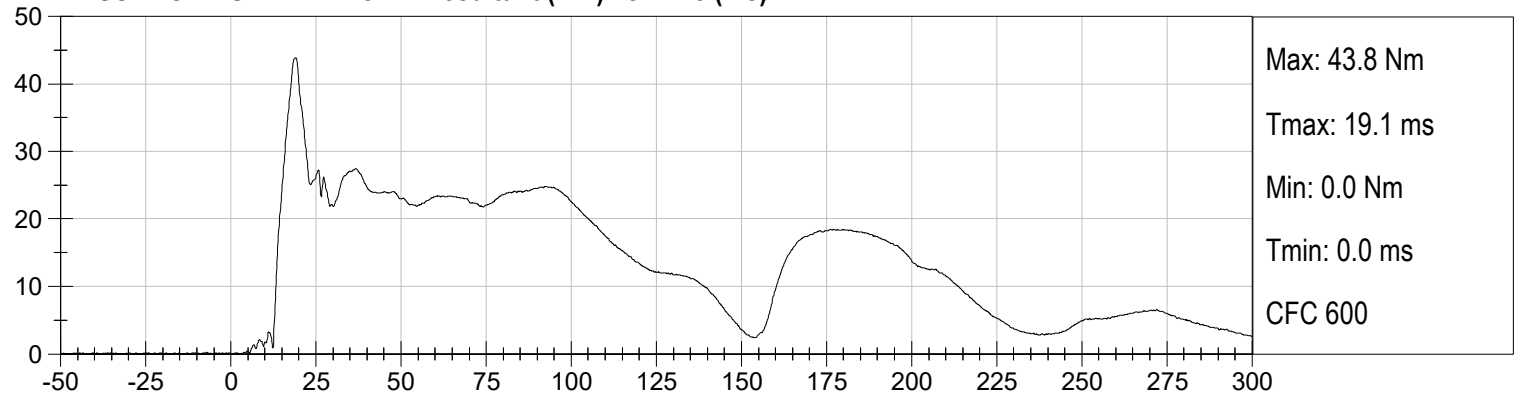
PASSENGER UPPER NECK MY (Nm) vs Time (ms)



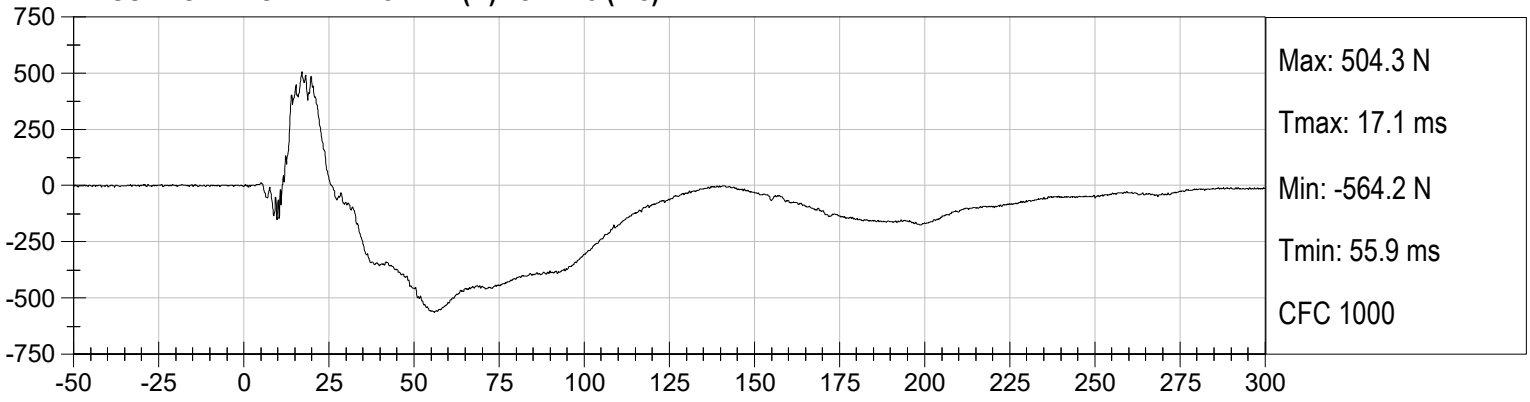
PASSENGER UPPER NECK MZ (Nm) vs Time (ms)



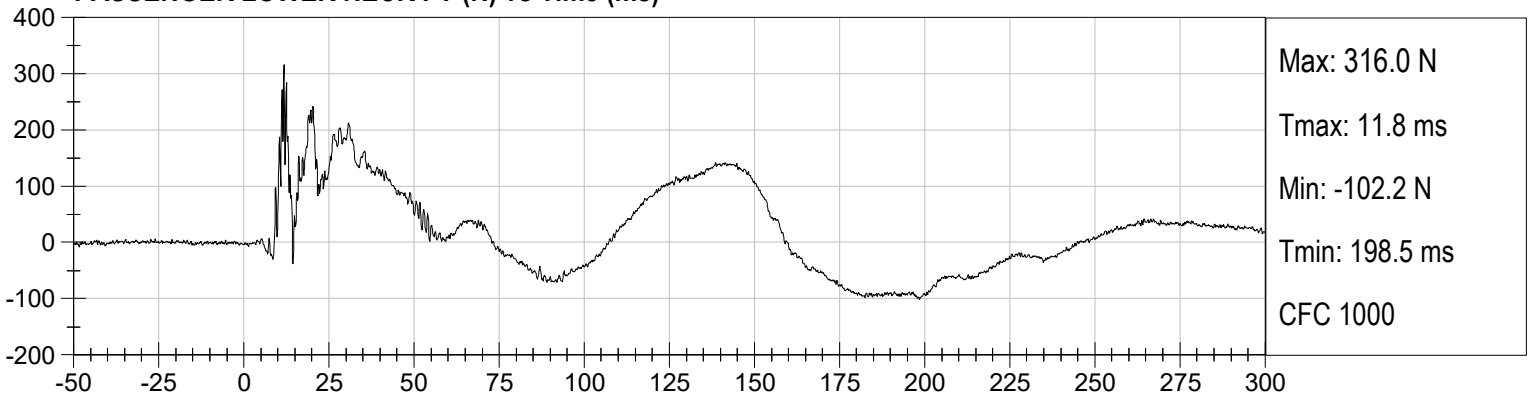
PASSENGER UPPER NECK MResultant (Nm) vs Time (ms)



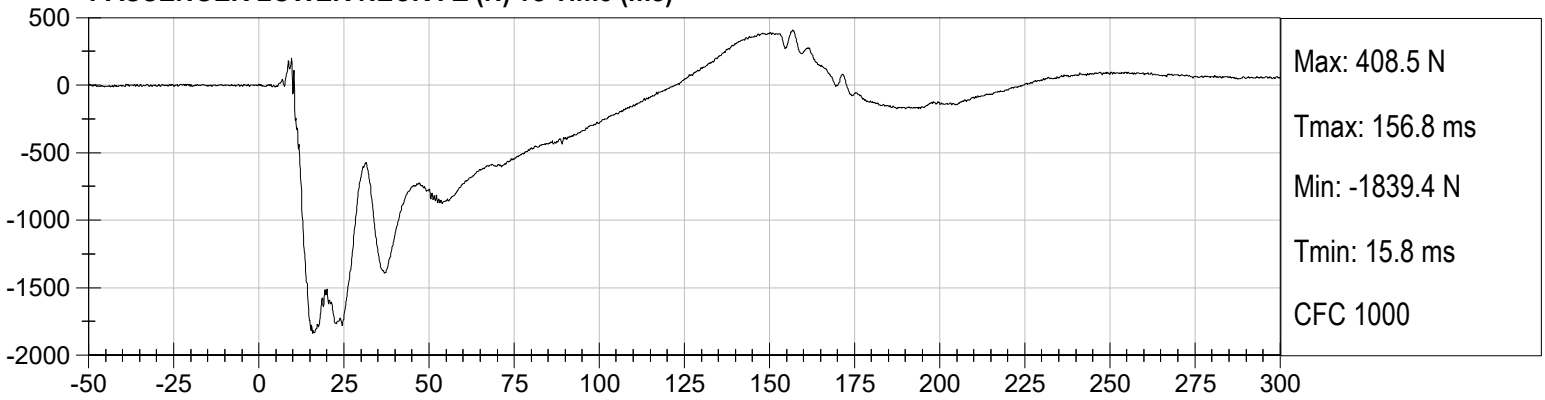
PASSENGER LOWER NECK FX (N) vs Time (ms)



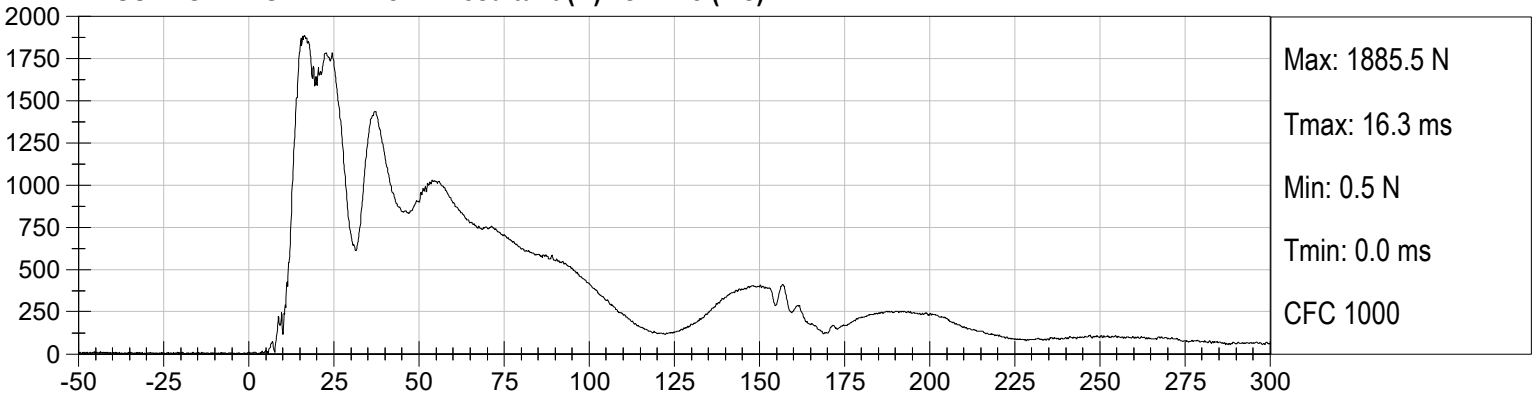
PASSENGER LOWER NECK FY (N) vs Time (ms)



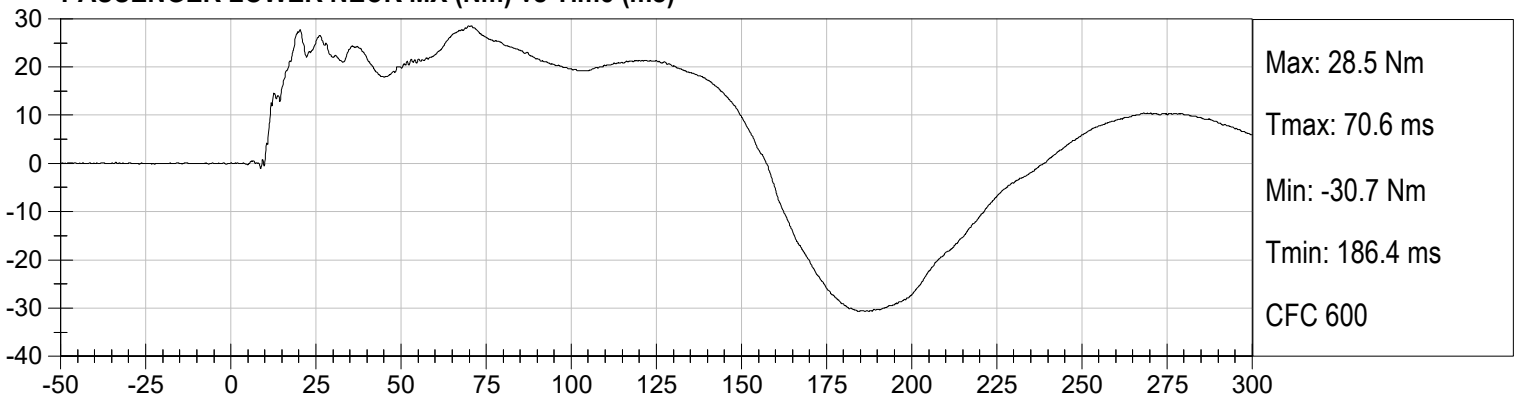
PASSENGER LOWER NECK FZ (N) vs Time (ms)



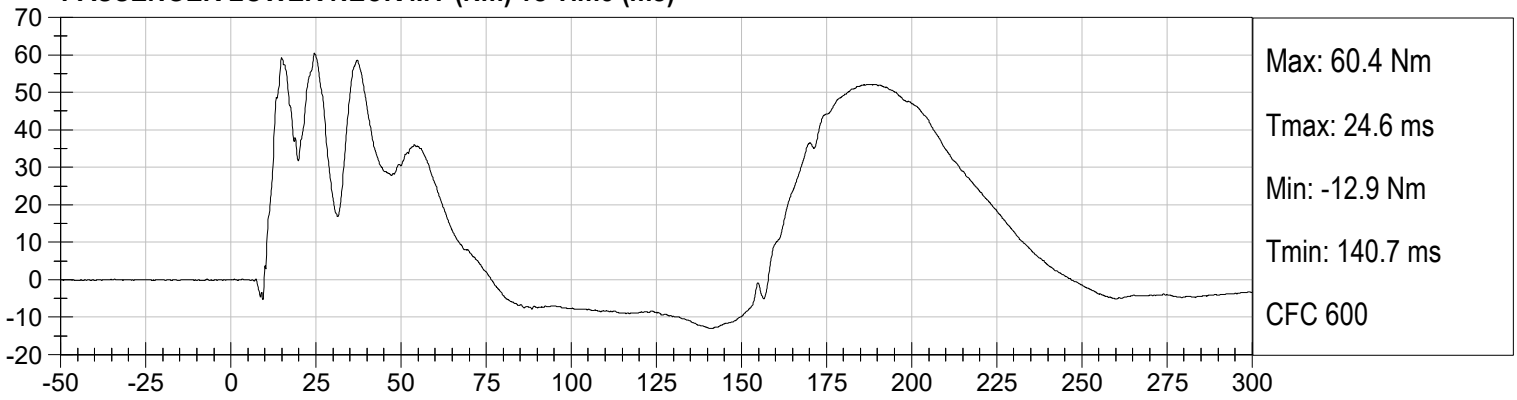
PASSENGER LOWER NECK FResultant (N) vs Time (ms)



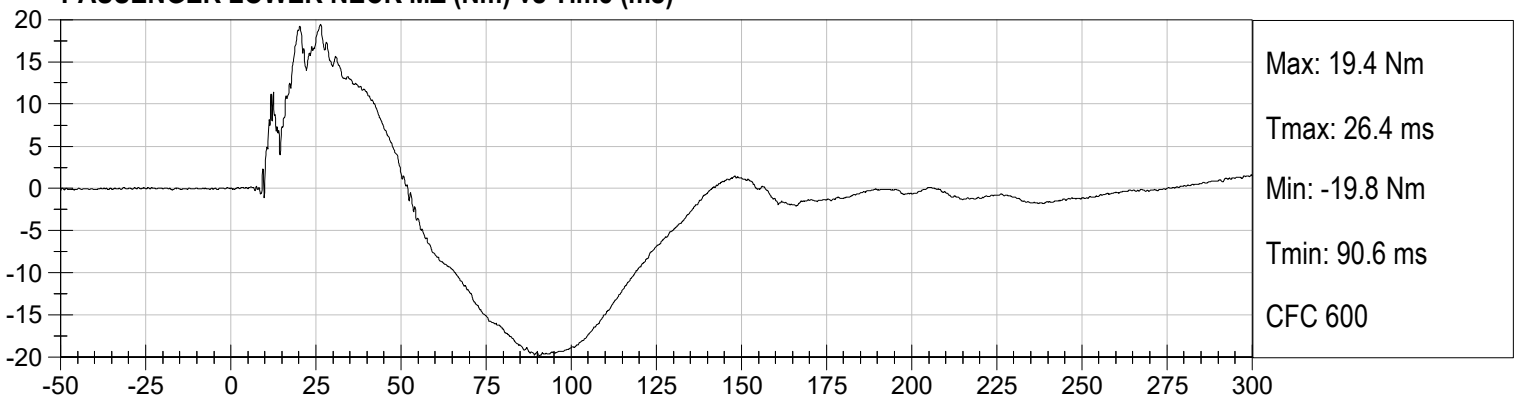
PASSENGER LOWER NECK MX (Nm) vs Time (ms)



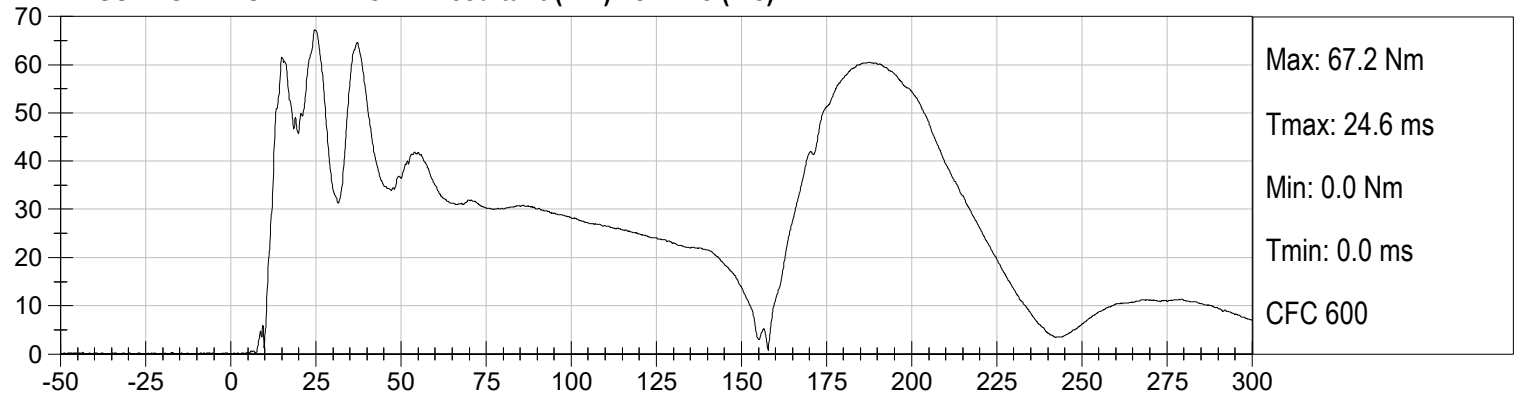
PASSENGER LOWER NECK MY (Nm) vs Time (ms)



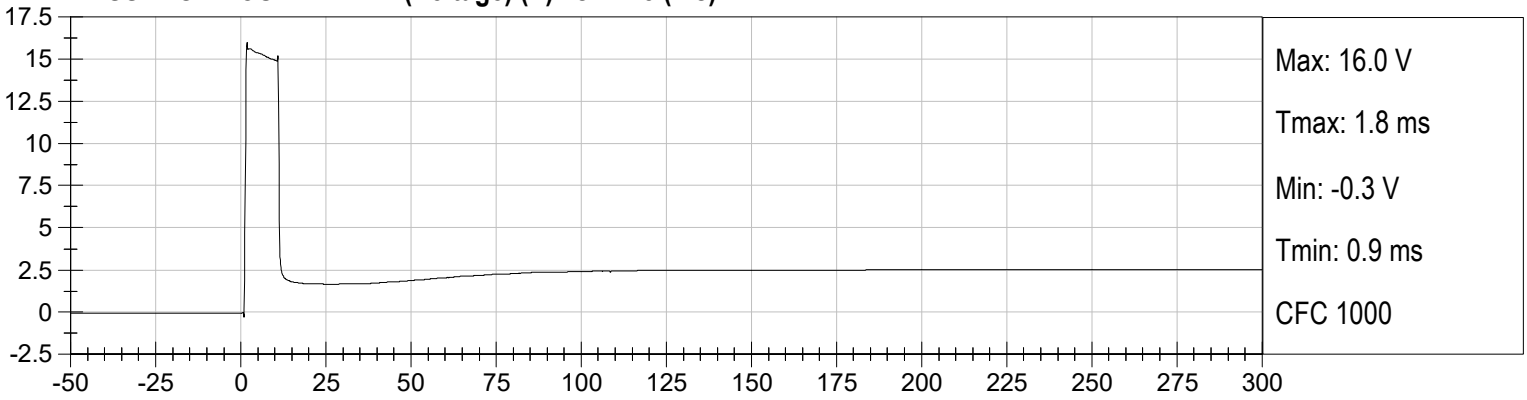
PASSENGER LOWER NECK MZ (Nm) vs Time (ms)



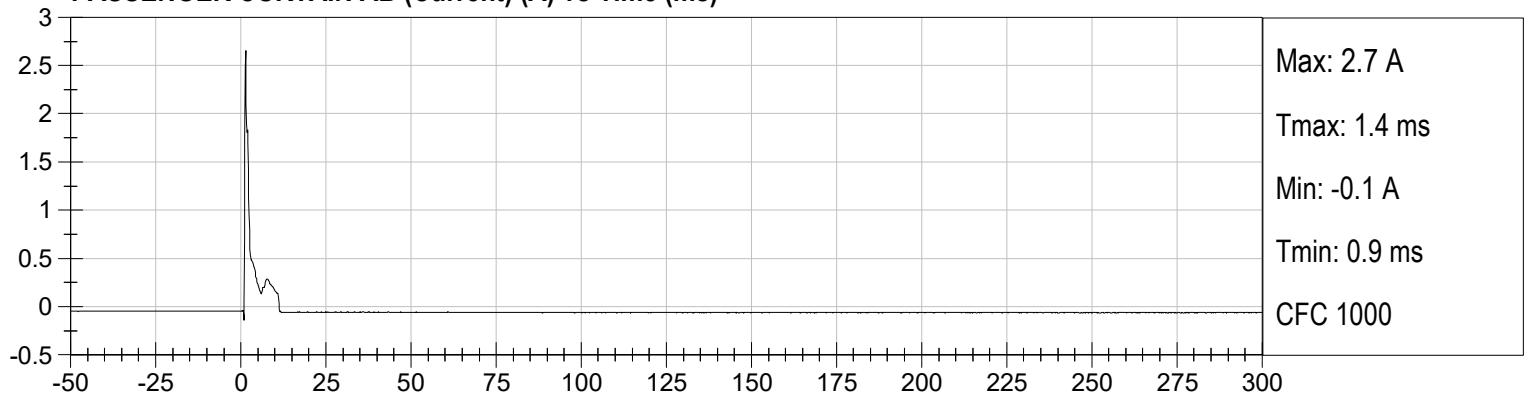
PASSENGER LOWER NECK MResultant (Nm) vs Time (ms)



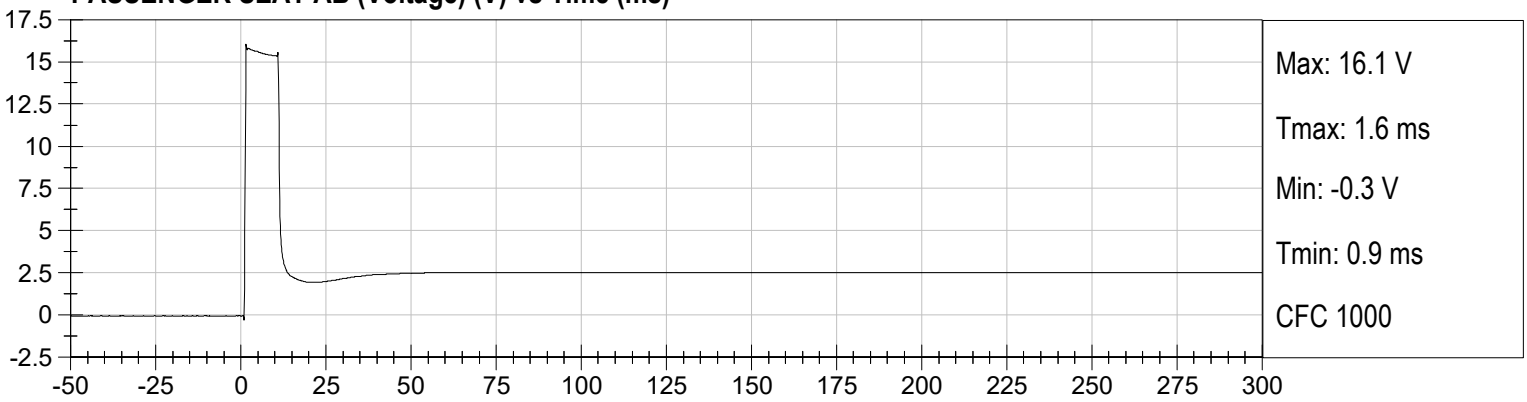
PASSENGER CURTAIN AB (Voltage) (V) vs Time (ms)



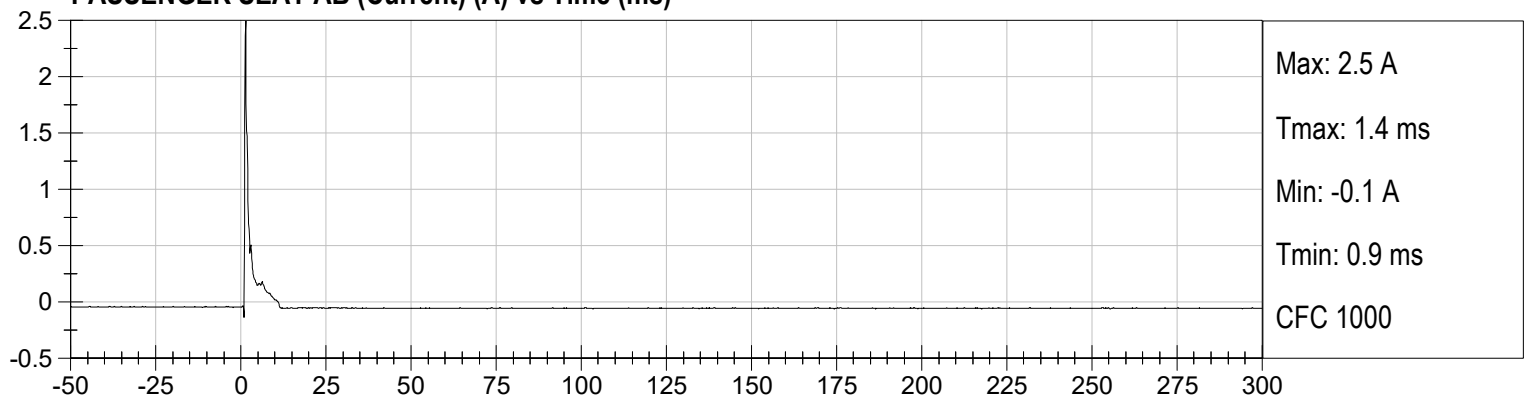
PASSENGER CURTAIN AB (Current) (A) vs Time (ms)



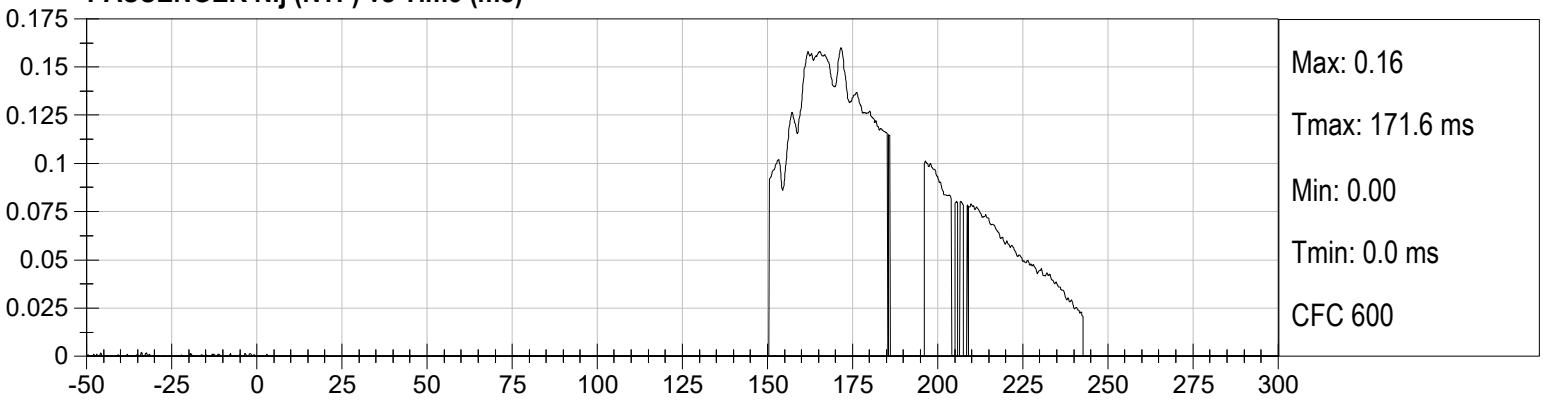
PASSENGER SEAT AB (Voltage) (V) vs Time (ms)



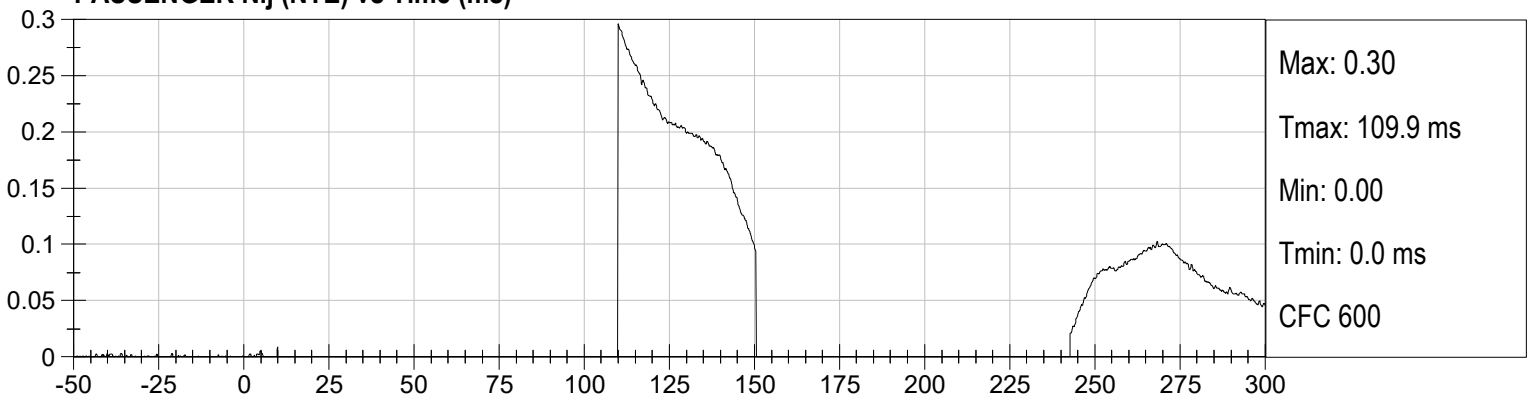
PASSENGER SEAT AB (Current) (A) vs Time (ms)



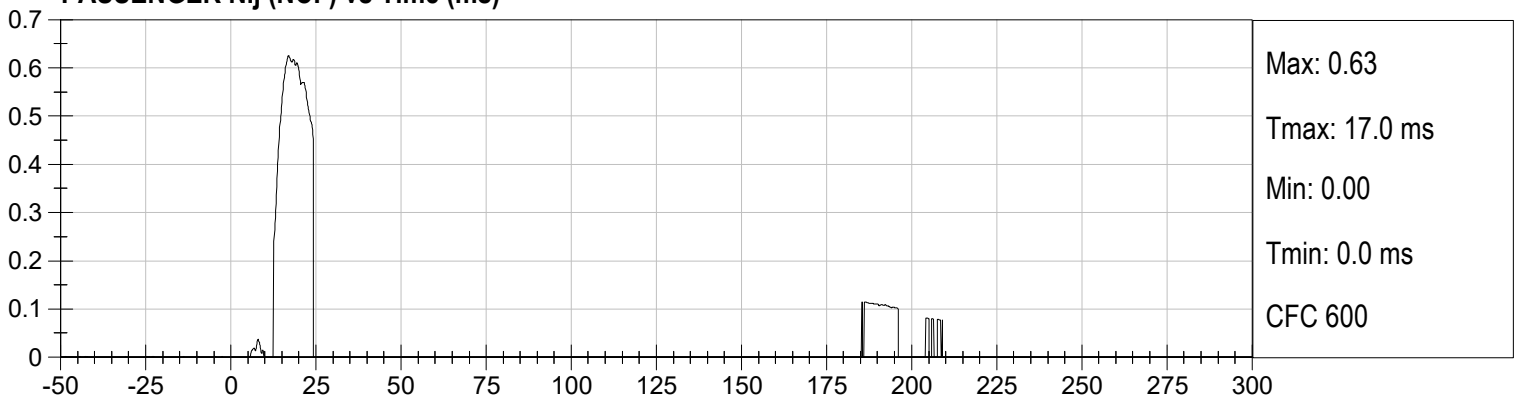
PASSENGER Nij (NTF) vs Time (ms)



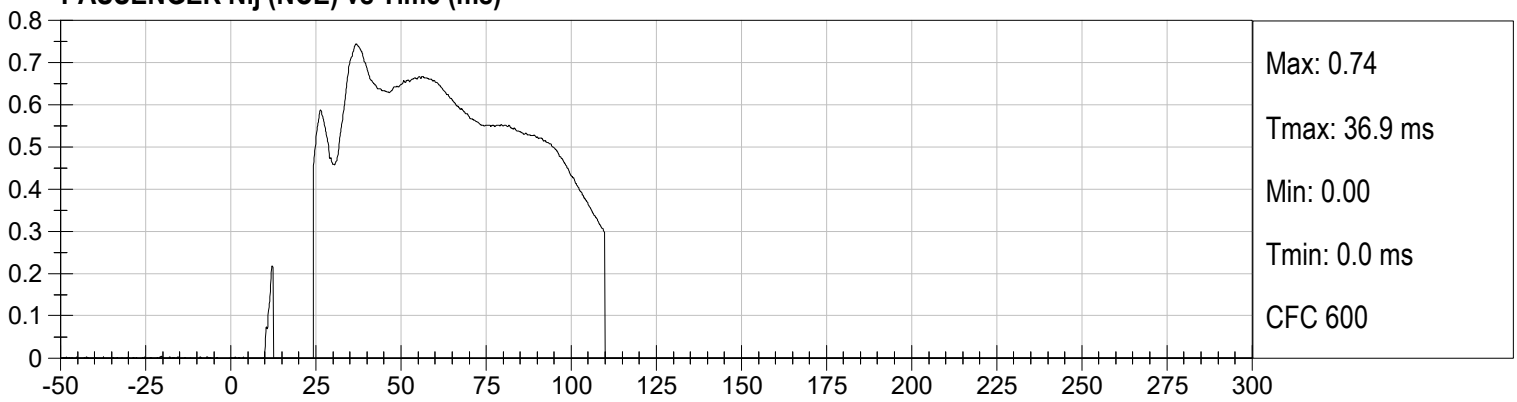
PASSENGER Nij (NTE) vs Time (ms)



PASSENGER Nij (NCF) vs Time (ms)



PASSENGER Nij (NCE) vs Time (ms)



APPENDIX C
DUMMY CONFIGURATION AND PERFORMANCE VERIFICATION DATA

CALIBRATION TEST RESULTS

PRE-TEST

SID-IIs 5TH PERCENTILE FEMALE ATD

MGA RESEARCH CORPORATION

HEAD DROP TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test ID:** D210251

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	21.5	Pass
Laboratory Relative Humidity	%	10 to 70	25	Pass
Peak Resultant Acceleration	G's	115 to 137	118	Pass
Peak Longitudinal Acceleration	G's	+/- 15	6.0	Pass
Unimodal	N/A	Yes	Yes	Pass
Oscillations	N/A	<15%	Yes	Pass
		Overall Test Results		Pass

Alex Thomas
Laboratory Technician

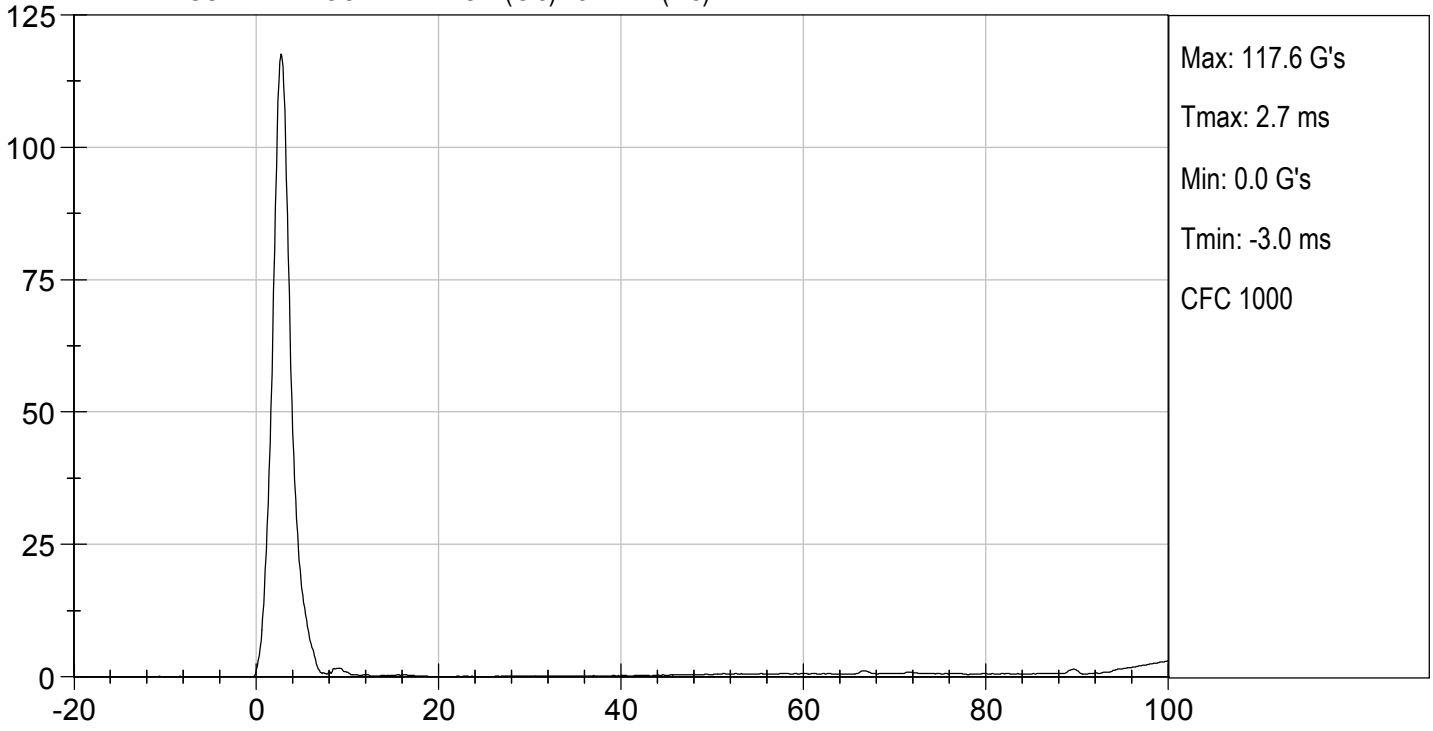
02/02/2021
Test Date

Approved By

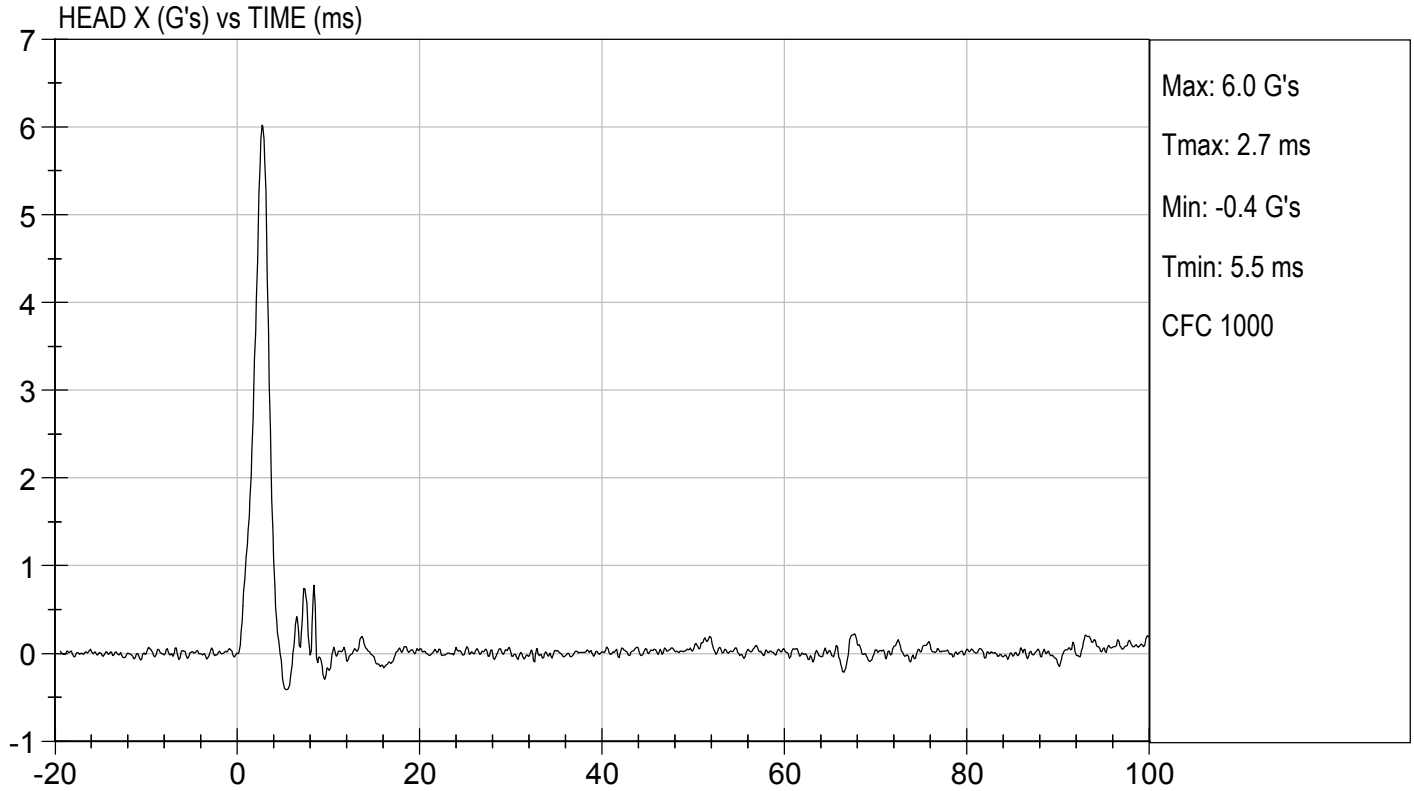
TEST DESC: HEAD DROP

TEST DATE: 02/02/2021
TEST #: D210251

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

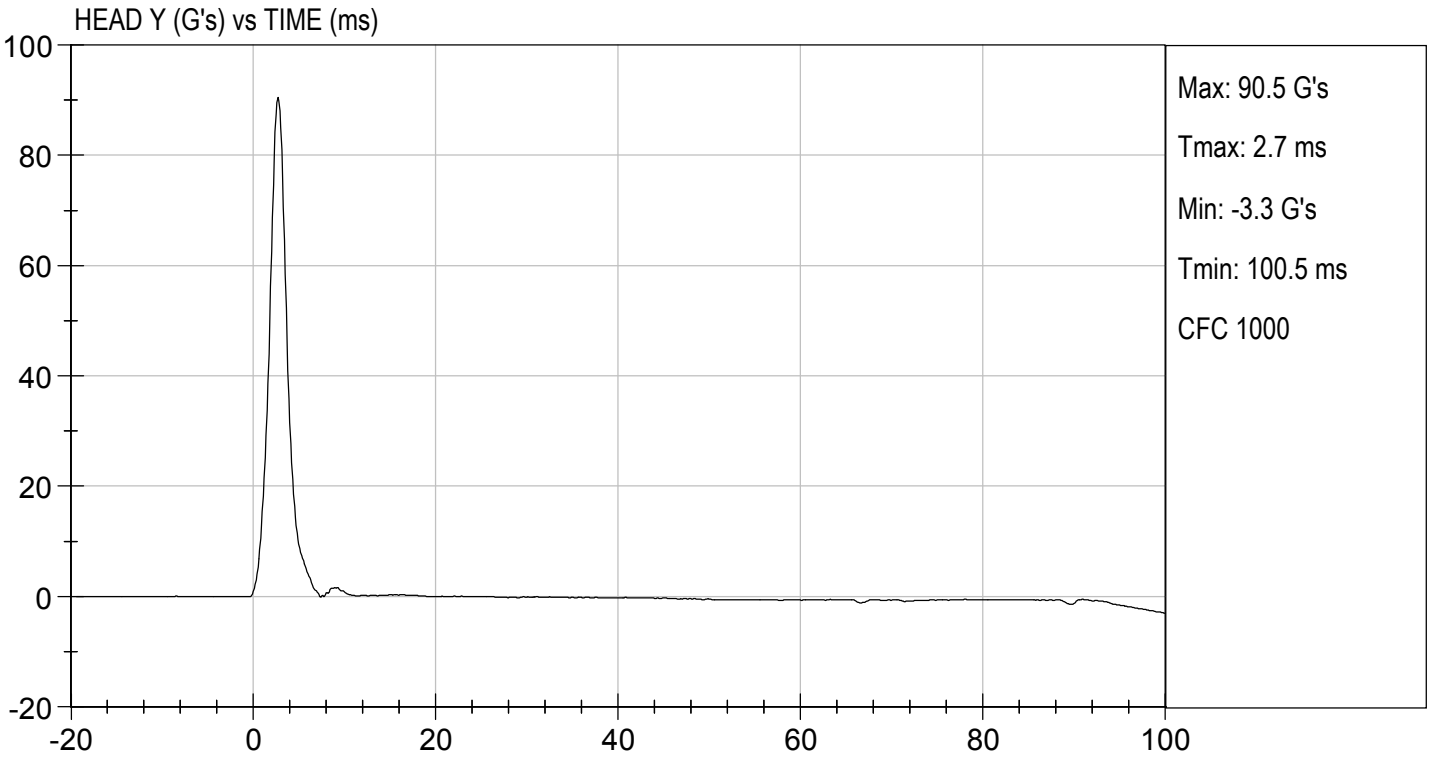


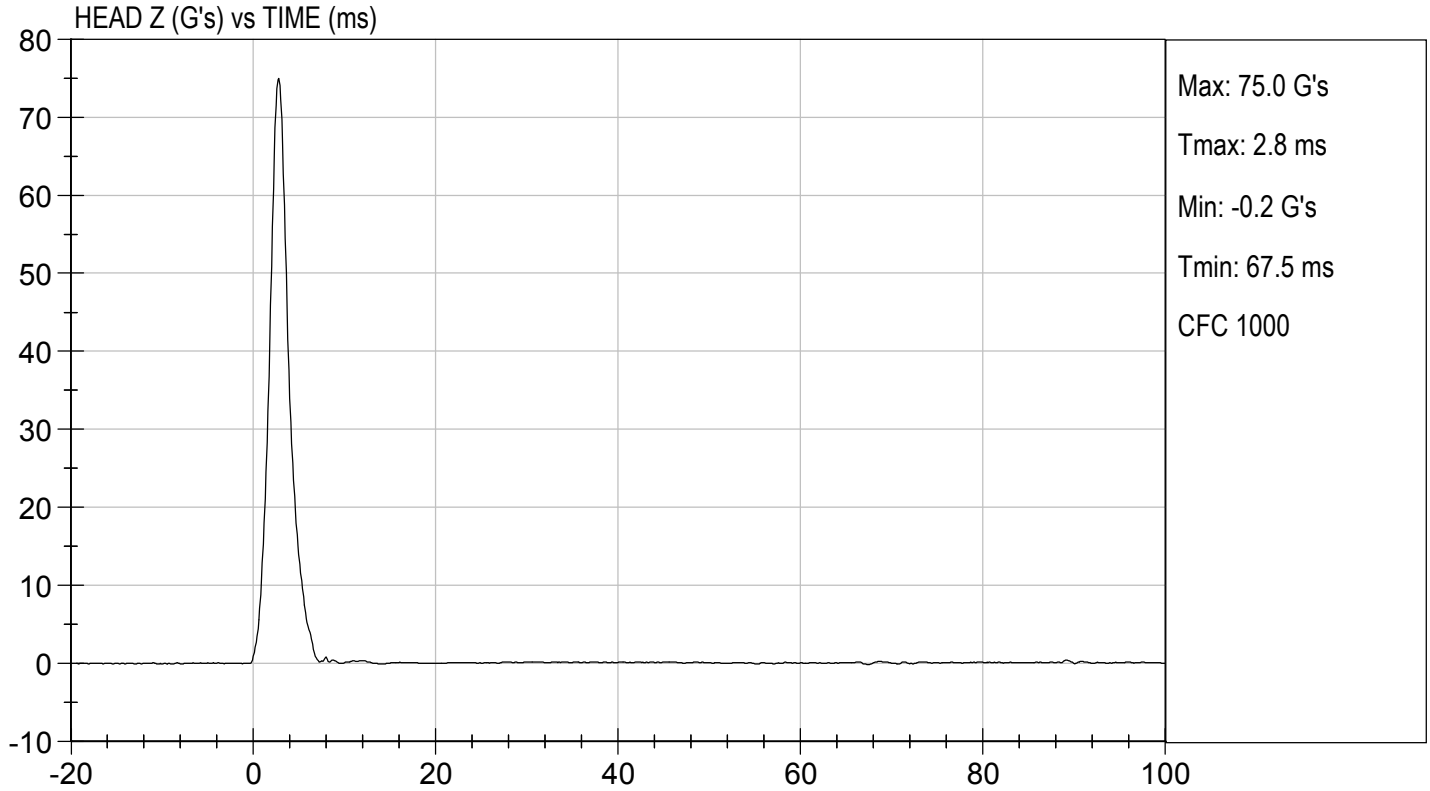
HEAD X (G's) vs TIME (ms)



TEST DESC: HEAD DROP

TEST DATE: 02/02/2021
TEST #: D210251





MGA RESEARCH CORPORATION

LATERAL NECK PENDULUM TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210252

Tested Parameter		Units	Specification	Result	Pass/Fail
Temperature		deg C	20.6 to 22.2	21.0	Pass
Humidity		%	10 to 70	22	Pass
Impact Velocity		m/s	5.51 to 5.63	5.63	Pass
Pendulum Velocity	10 ms	m/s	2.20 to 2.80	2.74	Pass
	15 ms	m/s	3.30 to 4.10	3.87	Pass
	20 ms	m/s	4.40 to 5.40	5.11	Pass
	25 ms	m/s	5.40 to 6.10	5.77	Pass
	25-100 ms	m/s	5.50 to 6.20	5.78	Pass
Maximum D-Plane Rotation		deg	71 to 81	72	Pass
Time of Maximum D-Plane Rotation		ms	50 to 70	58	Pass
Maximum Occipital Condyle Moment		Nm	-44 to -36	-41	Pass
Time of Moment Decay to 0 Nm		ms	102 to 126	112	Pass
			Overall Test Results		Pass

Laboratory Technician

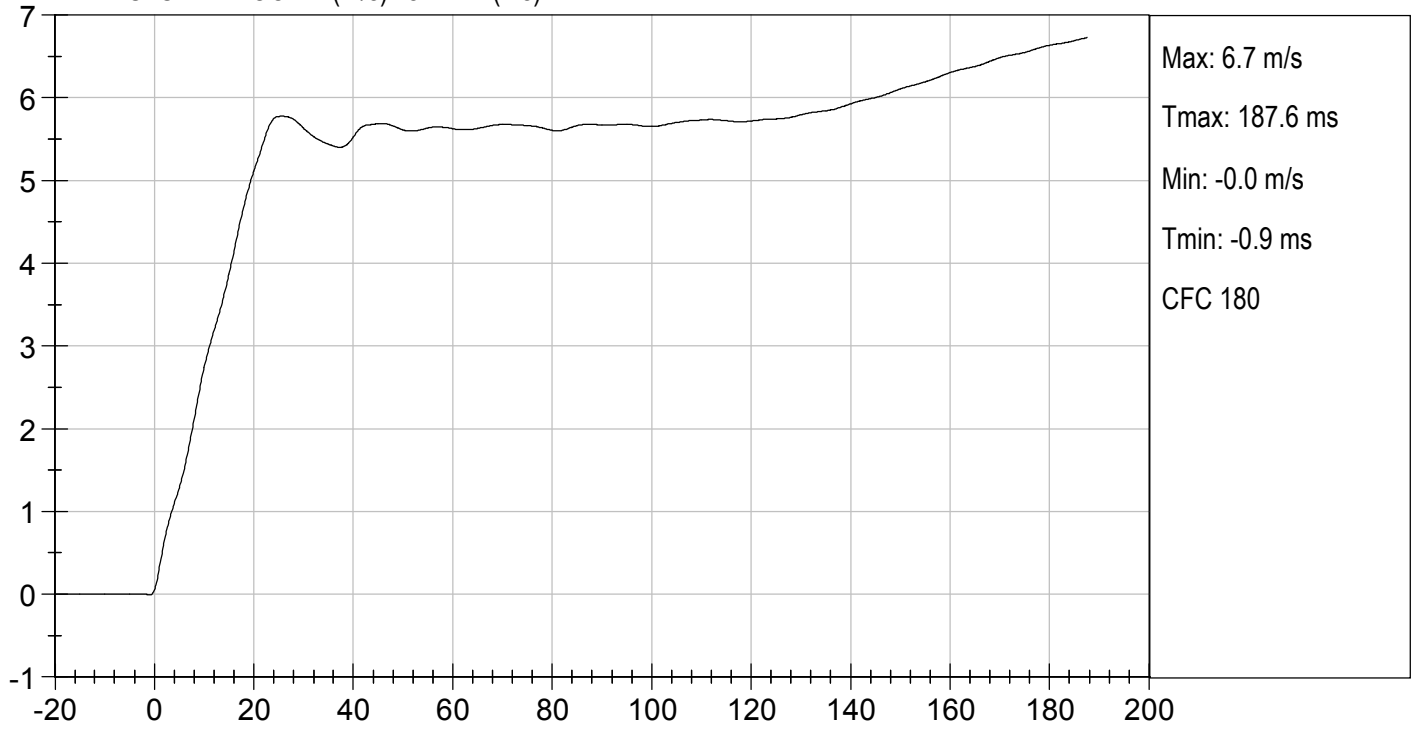
02/03/2021
Test Date

Approved By

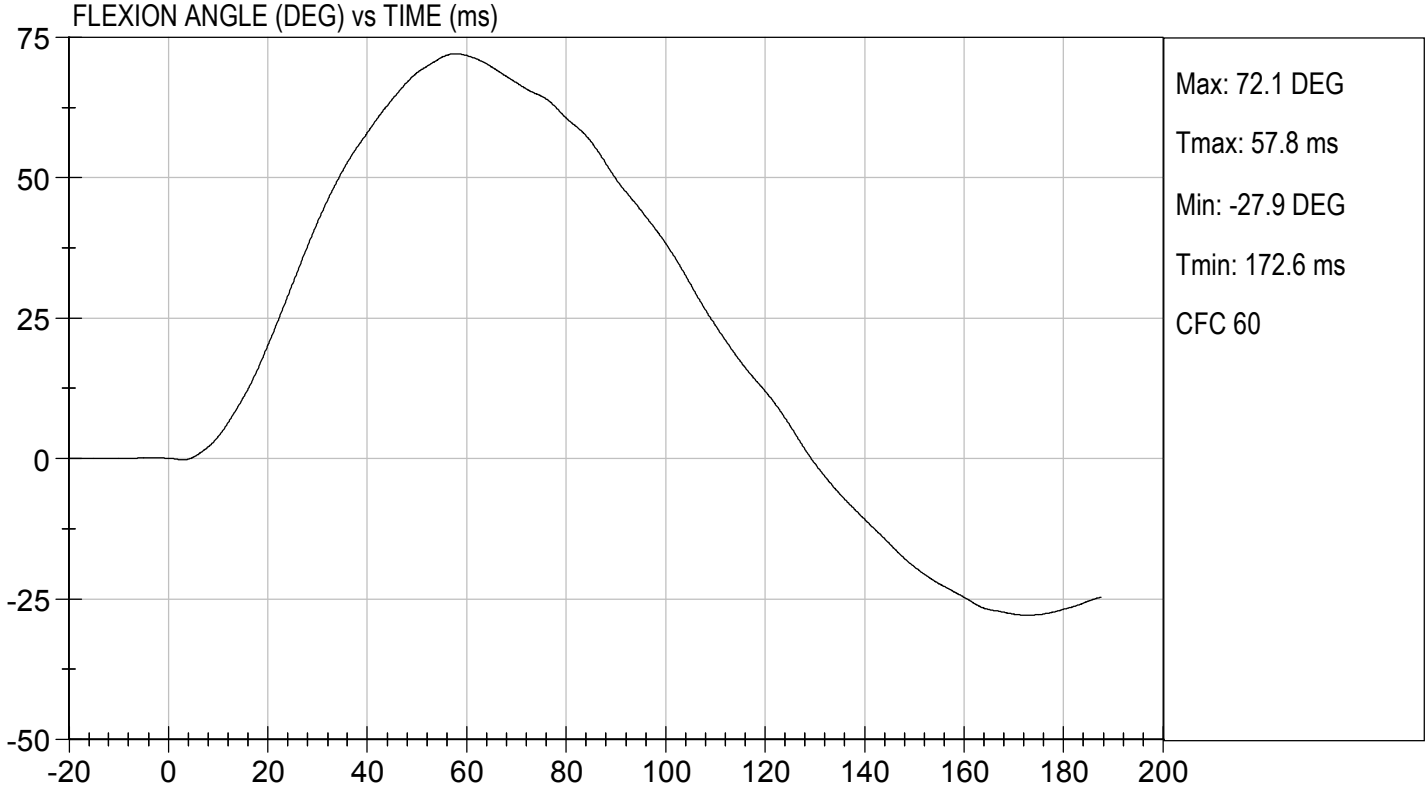
TEST DESC: NECK BENDING
VELOCITY: 18.48 ft/s, 5.63 m/s

TEST DATE: 02/03/2021
TEST #: D210252

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

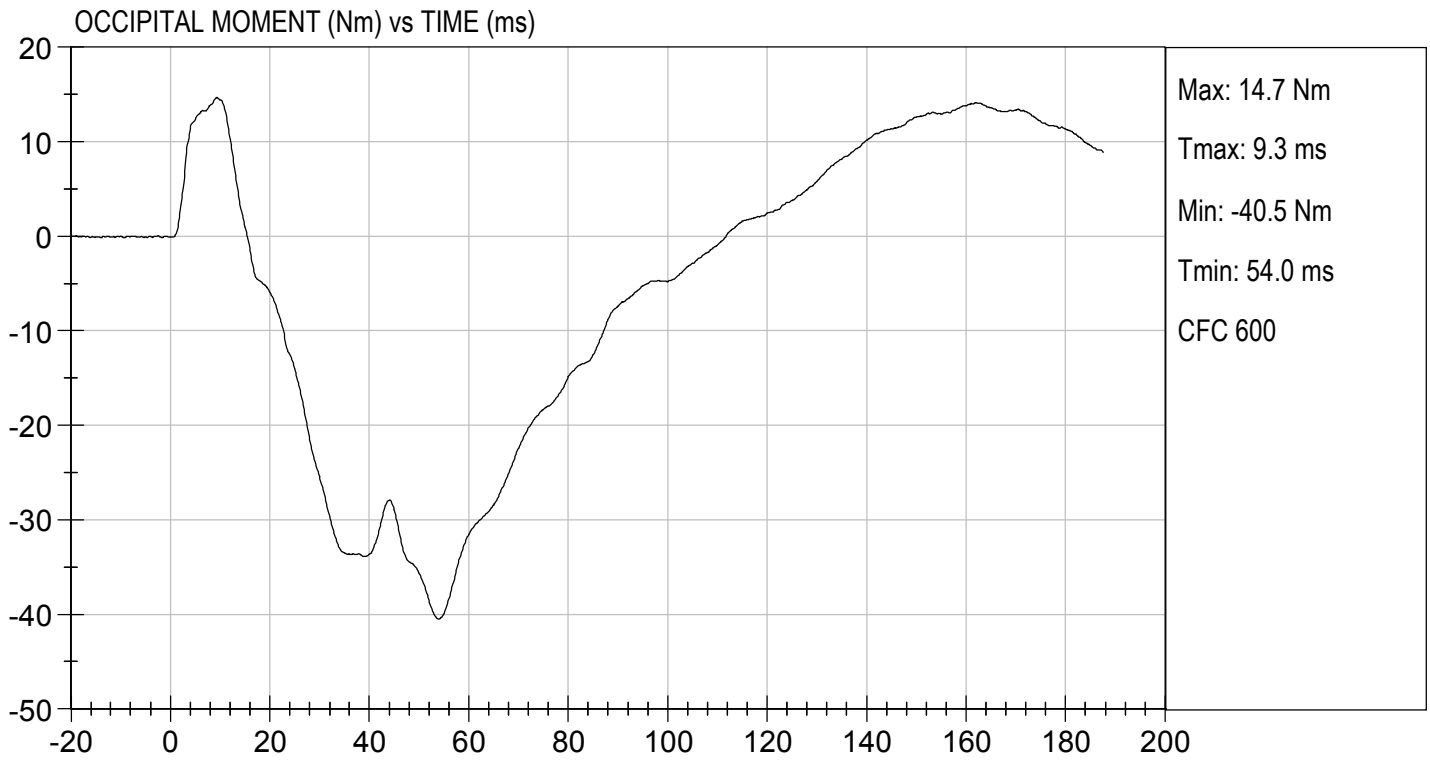


FLEXION ANGLE (DEG) vs TIME (ms)



TEST DESC: NECK BENDING
VELOCITY: 18.48 ft/s, 5.63 m/s

TEST DATE: 02/03/2021
TEST #: D210252



MGA RESEARCH CORPORATION

SHOULDER IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test ID:** D210253

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	21	Pass
Impact Velocity	m/s	4.20 to 4.40	4.23	Pass
Maximum Probe Acceleration	G's	13 to 18	16	Pass
Shoulder Displacement	mm	28 to 37	29	Pass
Upper Spine (T1) Y Acceleration	G's	17 to 22	19	Pass
		Overall Test Results		Pass

Laboratory Technician

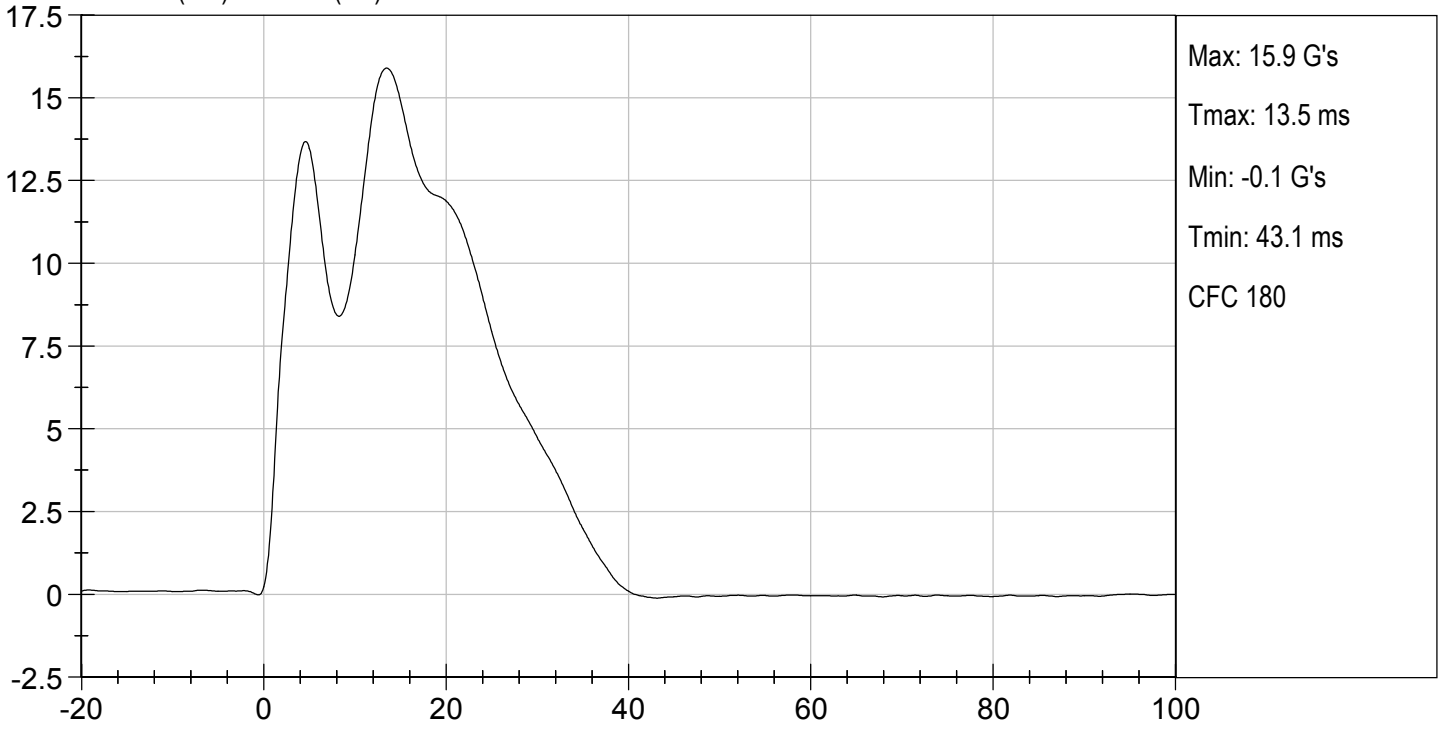
02/03/2021
Test Date

Approved By

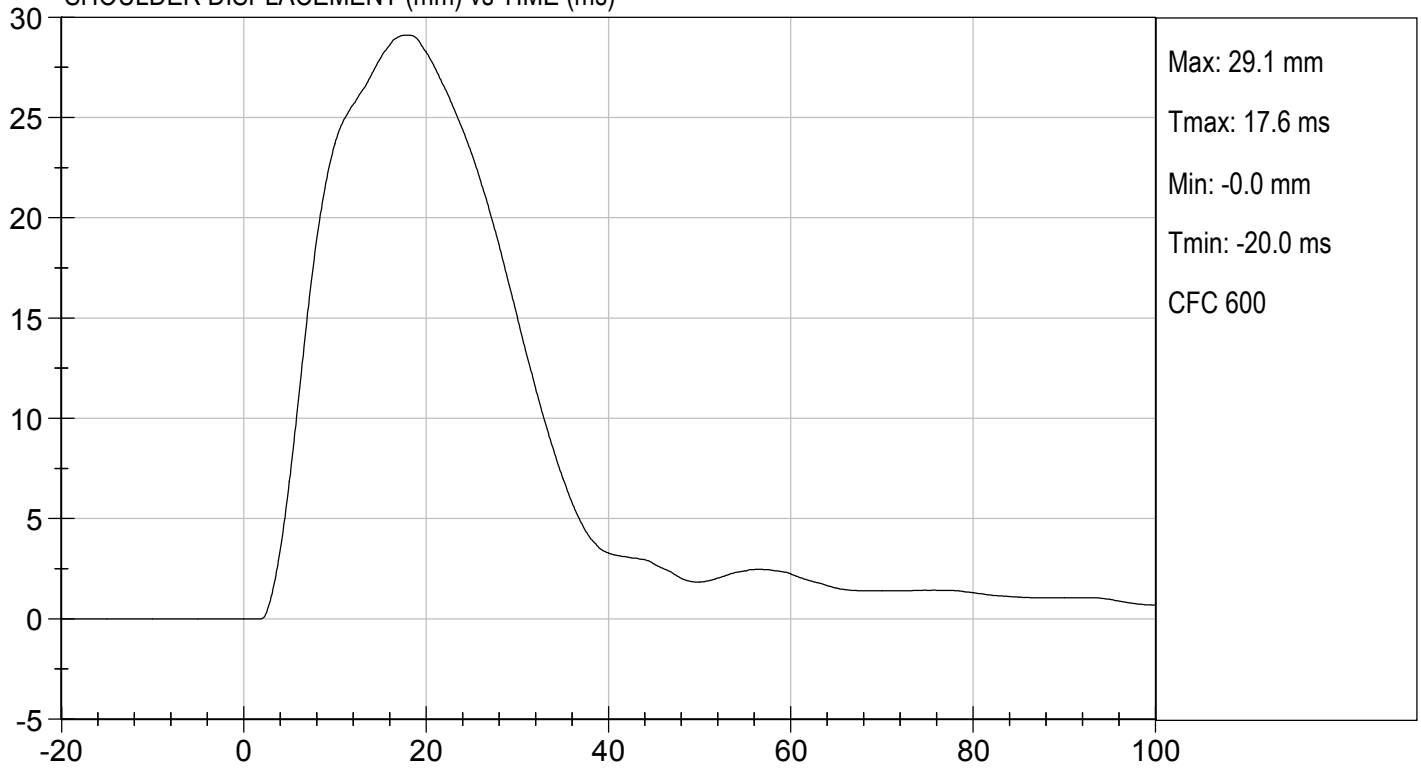
TEST DESC: SHOULDER IMPACT
VELOCITY: 13.89 ft/s, 4.23 m/s

TEST DATE: 02/03/2021
TEST #: D210253

PROBE (G's) vs TIME (ms)



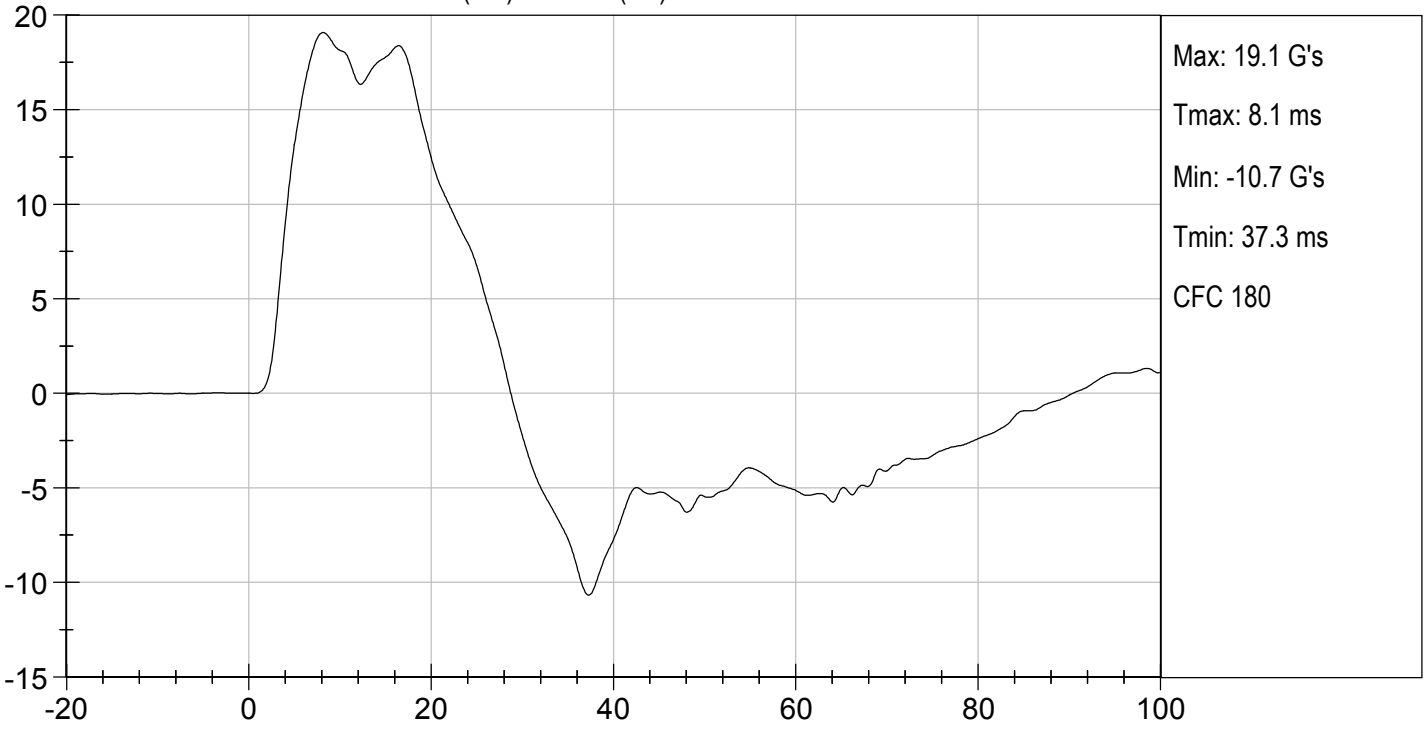
SHOULDER DISPLACEMENT (mm) vs TIME (ms)



TEST DESC: SHOULDER IMPACT
VELOCITY: 13.89 ft/s, 4.23 m/s

TEST DATE: 02/03/2021
TEST #: D210253

UPPER SPINE Y ACCELERATION (G's) vs TIME (ms)



MGA RESEARCH CORPORATION

THORAX (WITH ARM) IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210254

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.0	Pass
Humidity	%	10 to 70	21	Pass
Impact Velocity	m/s	6.60 to 6.80	6.77	Pass
Maximum Probe Acceleration	G's	30 to 36	35	Pass
Shoulder Displacement	mm	31 to 40	32	Pass
Upper Rib Displacement	mm	25 to 32	27	Pass
Middle Rib Displacement	mm	30 to 36	32	Pass
Lower Rib Displacement	mm	32 to 38	35	Pass
Upper Spine (T1) Y Acceleration	G's	34 to 43	39	Pass
Lower Spine (T12) Y Acceleration	G's	29 to 37	33	Pass
		Overall Test Results		Pass

Laboratory Technician

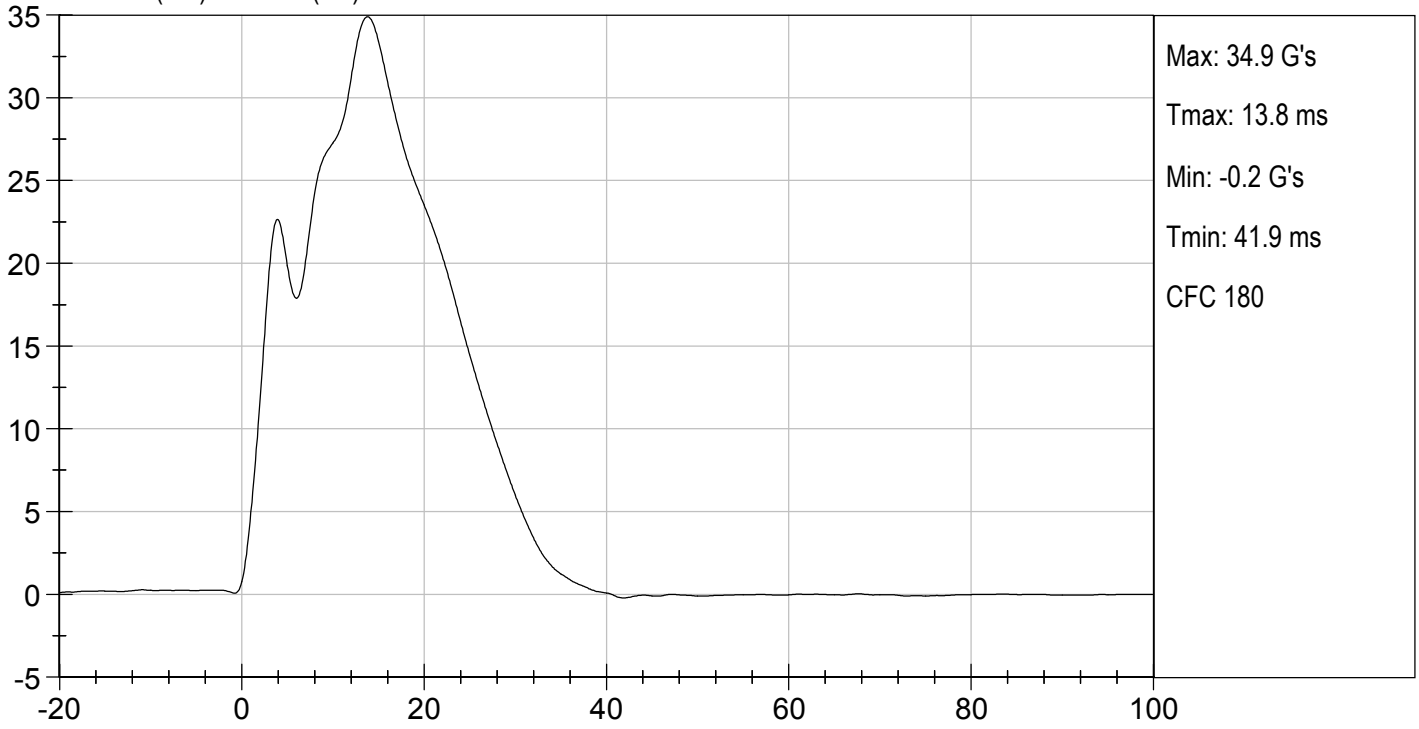
02/03/2021
Test Date

Approved By

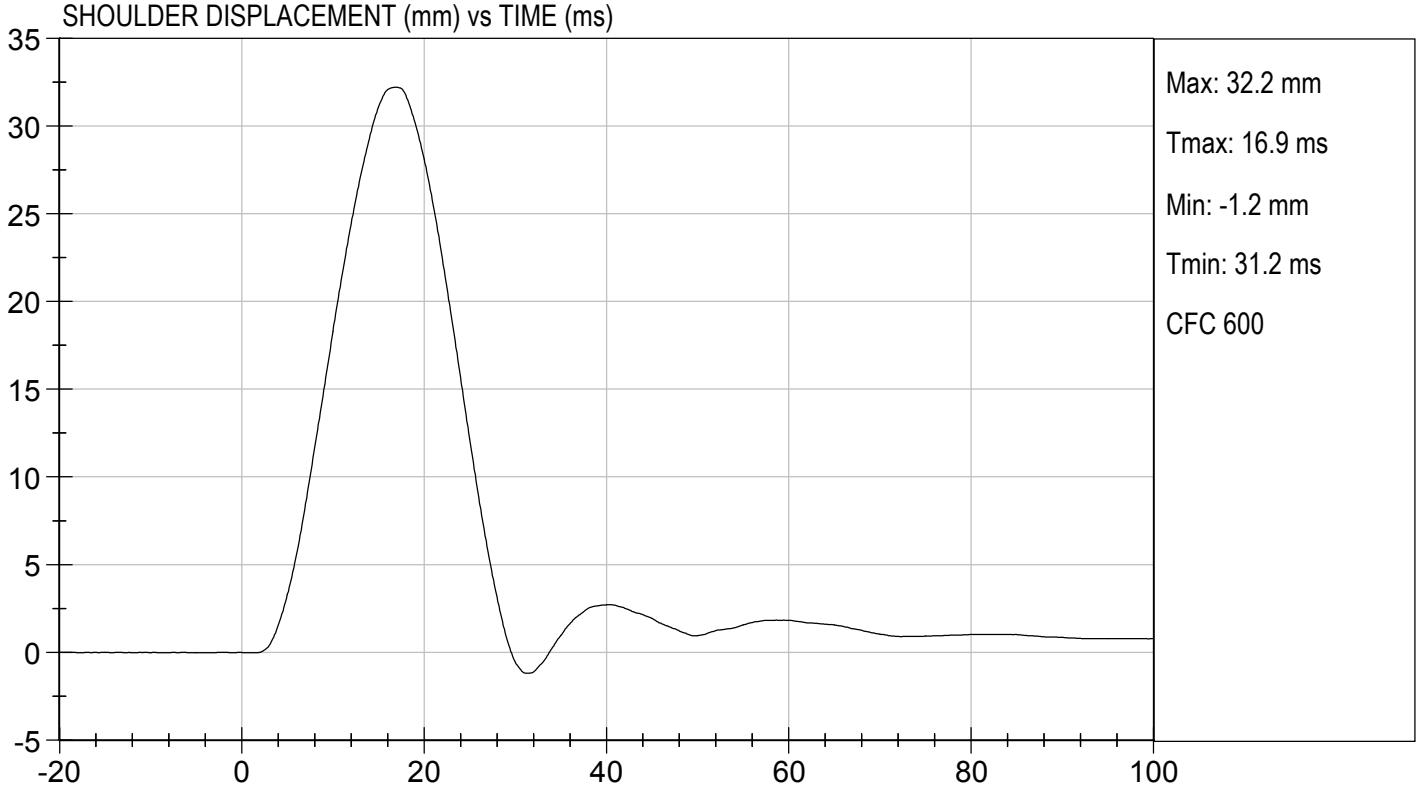
TEST DESC: THORAX IMPACT WITH ARM
VELOCITY: 22.22 ft/s, 6.77 m/s

TEST DATE: 02/03/2021
TEST #: D210254

PROBE (G's) vs TIME (ms)



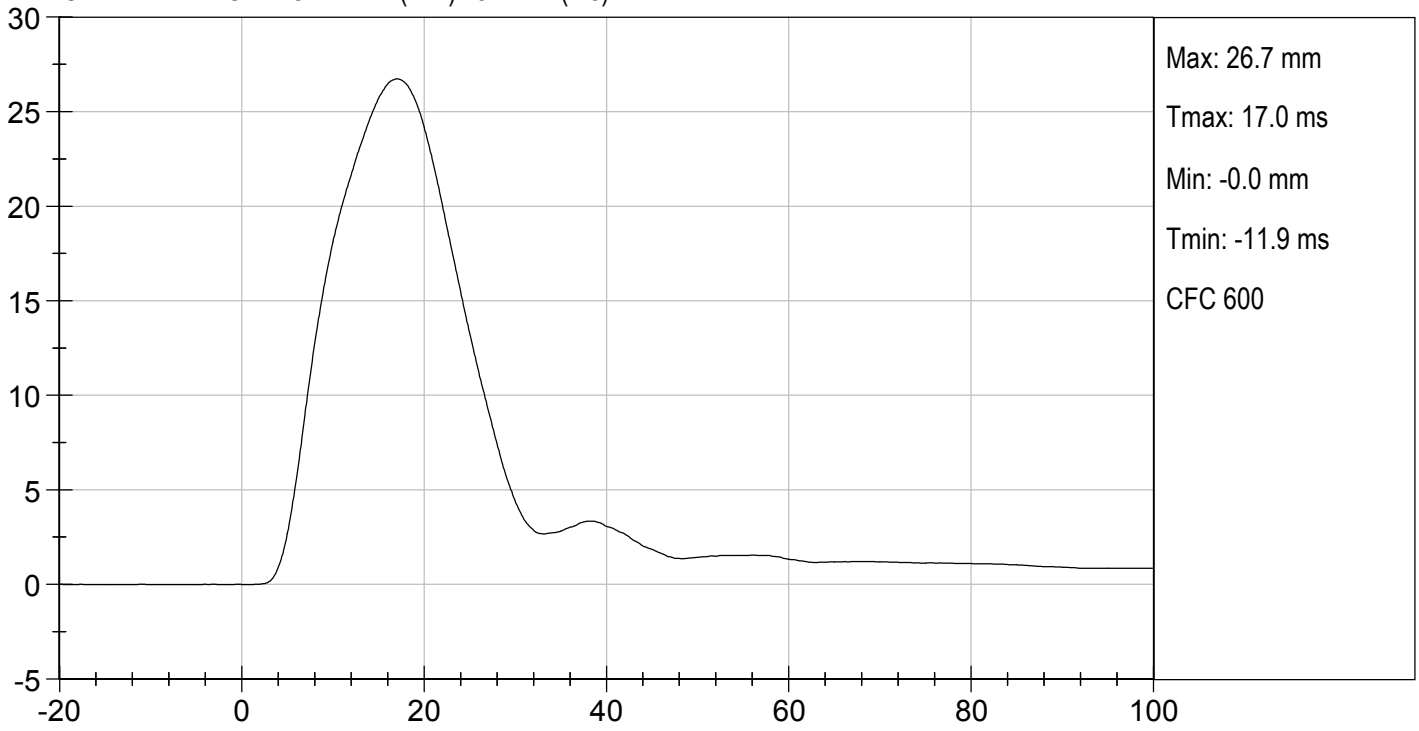
SHOULDER DISPLACEMENT (mm) vs TIME (ms)



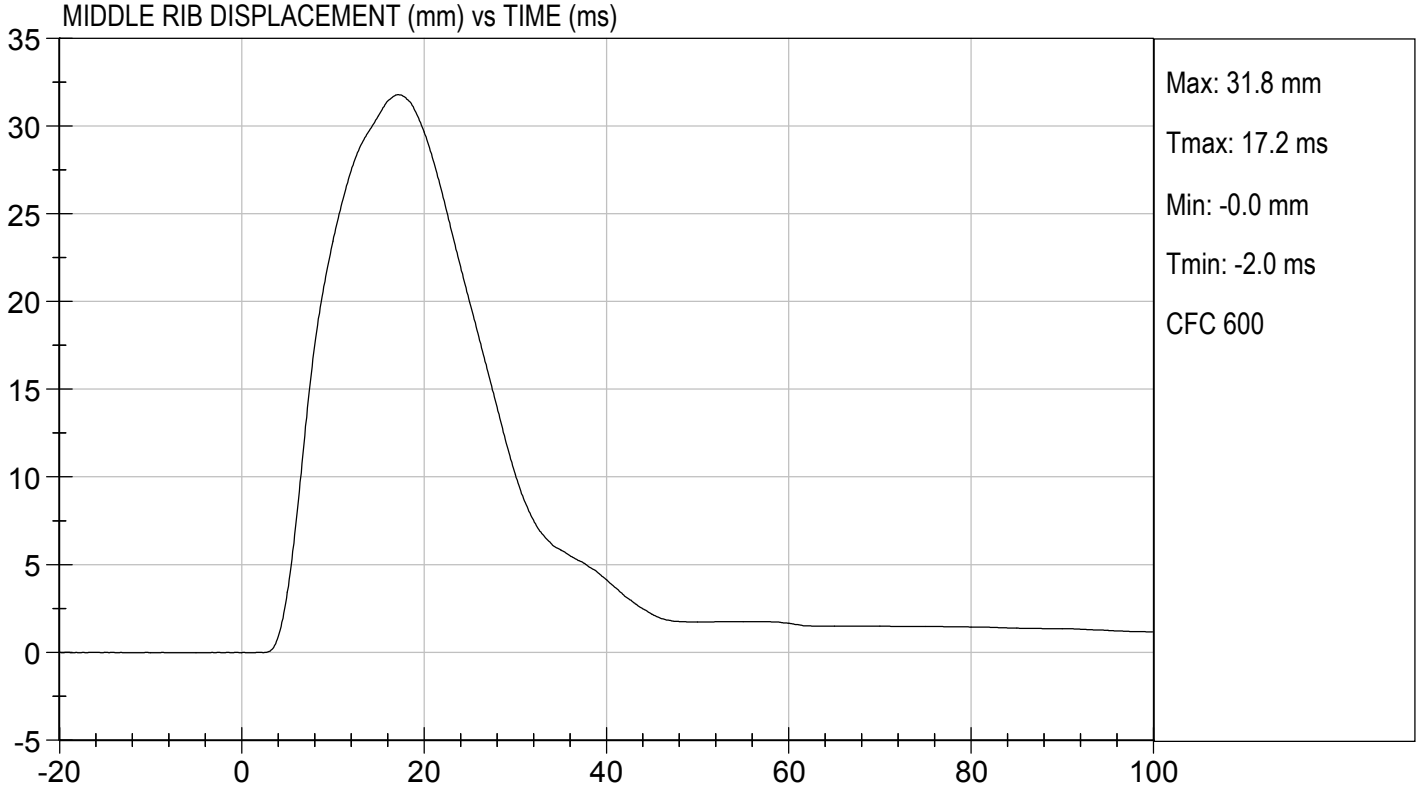
TEST DESC: THORAX IMPACT WITH ARM
VELOCITY: 22.22 ft/s, 6.77 m/s

TEST DATE: 02/03/2021
TEST #: D210254

UPPER RIB DISPLACEMENT (mm) vs TIME (ms)



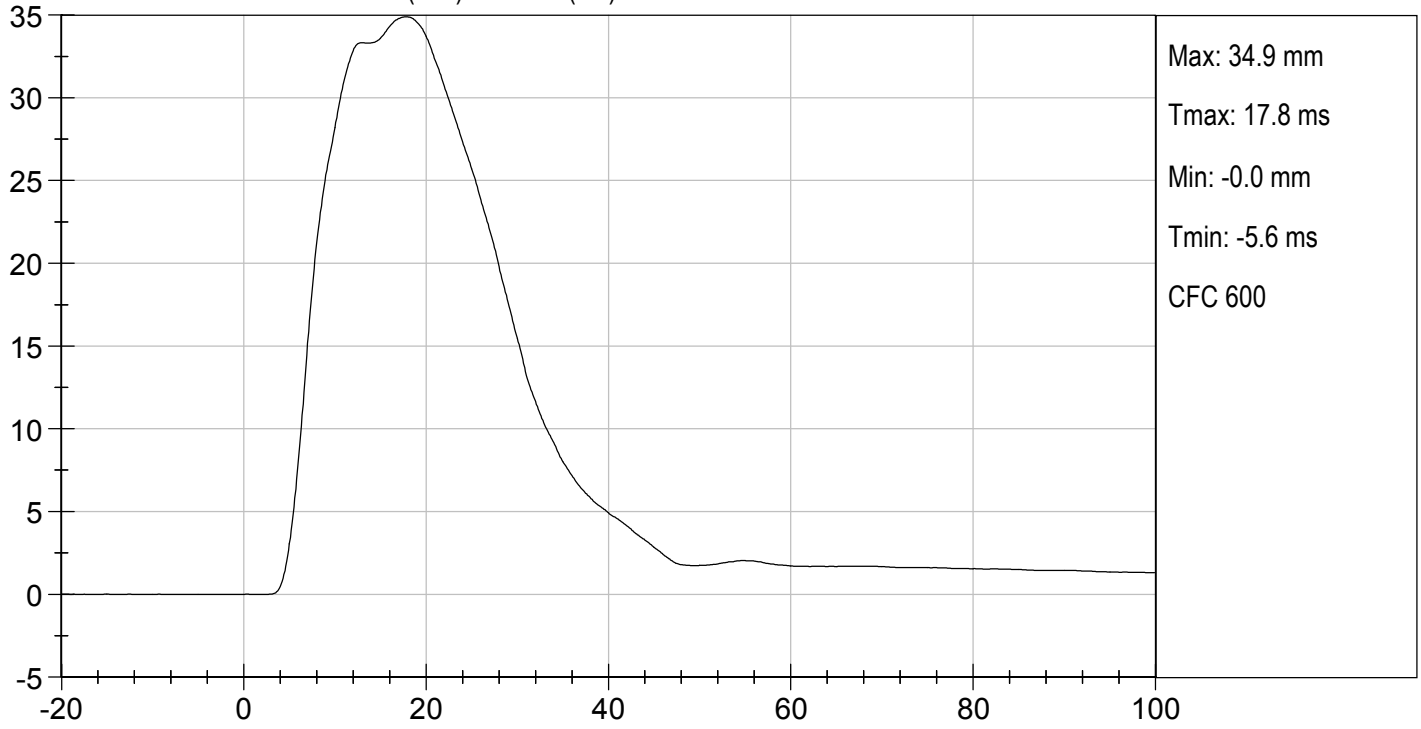
MIDDLE RIB DISPLACEMENT (mm) vs TIME (ms)



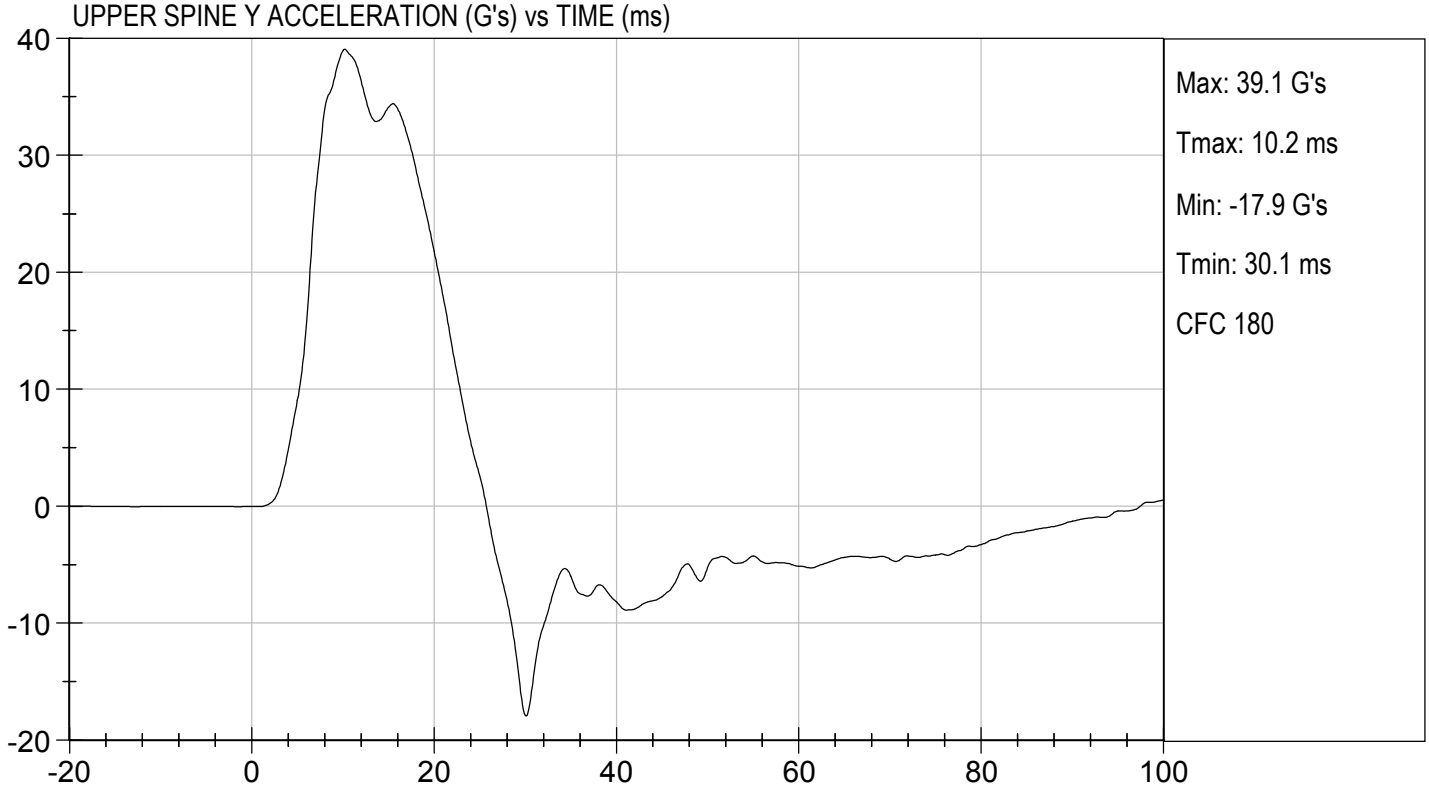
TEST DESC: THORAX IMPACT WITH ARM
VELOCITY: 22.22 ft/s, 6.77 m/s

TEST DATE: 02/03/2021
TEST #: D210254

LOWER RIB DISPLACEMENT (mm) vs TIME (ms)



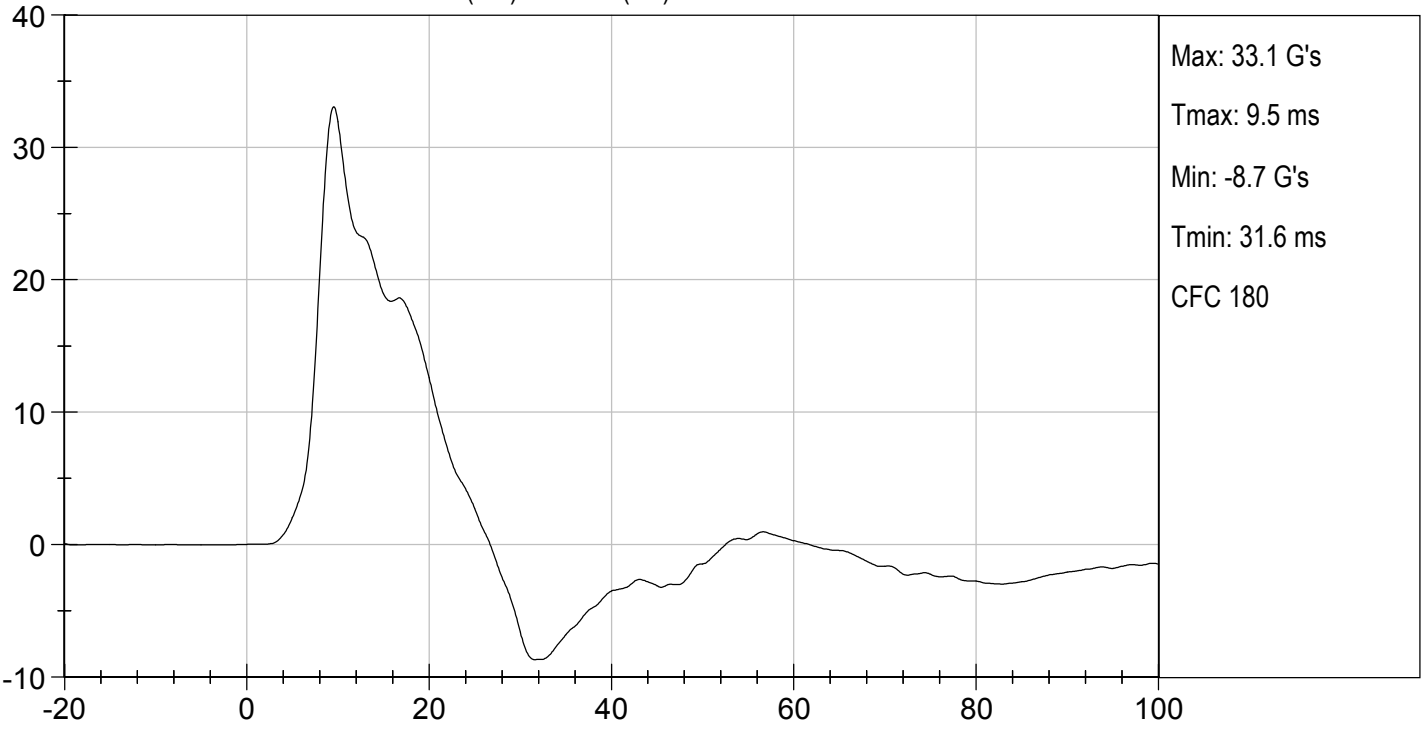
UPPER SPINE Y ACCELERATION (G's) vs TIME (ms)



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

TEST DATE: 02/03/2021
TEST #: D210254

LOWER SPINE Y ACCELERATION (G's) vs TIME (ms)



MGA RESEARCH CORPORATION

THORAX (WITHOUT ARM) IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210255

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.0	Pass
Humidity	%	10 to 70	21	Pass
Impact Velocity	m/s	4.20 to 4.40	4.20	Pass
Maximum Probe Acceleration	G's	14 to 18	16	Pass
Upper Rib Displacement	mm	32 to 40	34	Pass
Middle Rib Displacement	mm	39 to 45	39	Pass
Lower Rib Displacement	mm	35 to 43	36	Pass
Upper Spine (T1) Y Acceleration	G's	13 to 17	15	Pass
Lower Spine (T12) Y Acceleration	G's	7 to 11	9	Pass
		Overall Test Results		Pass

Laboratory Technician

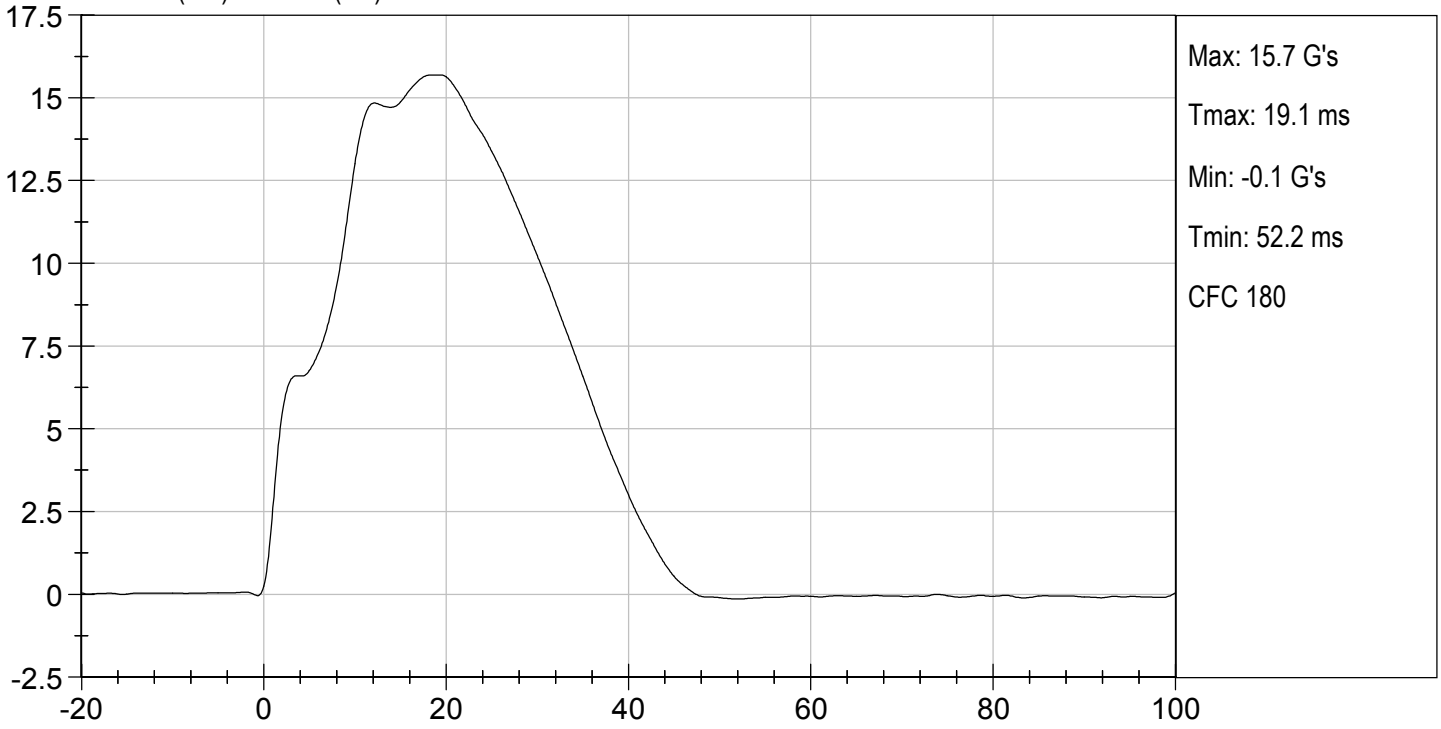
02/03/2021
Test Date

Approved By

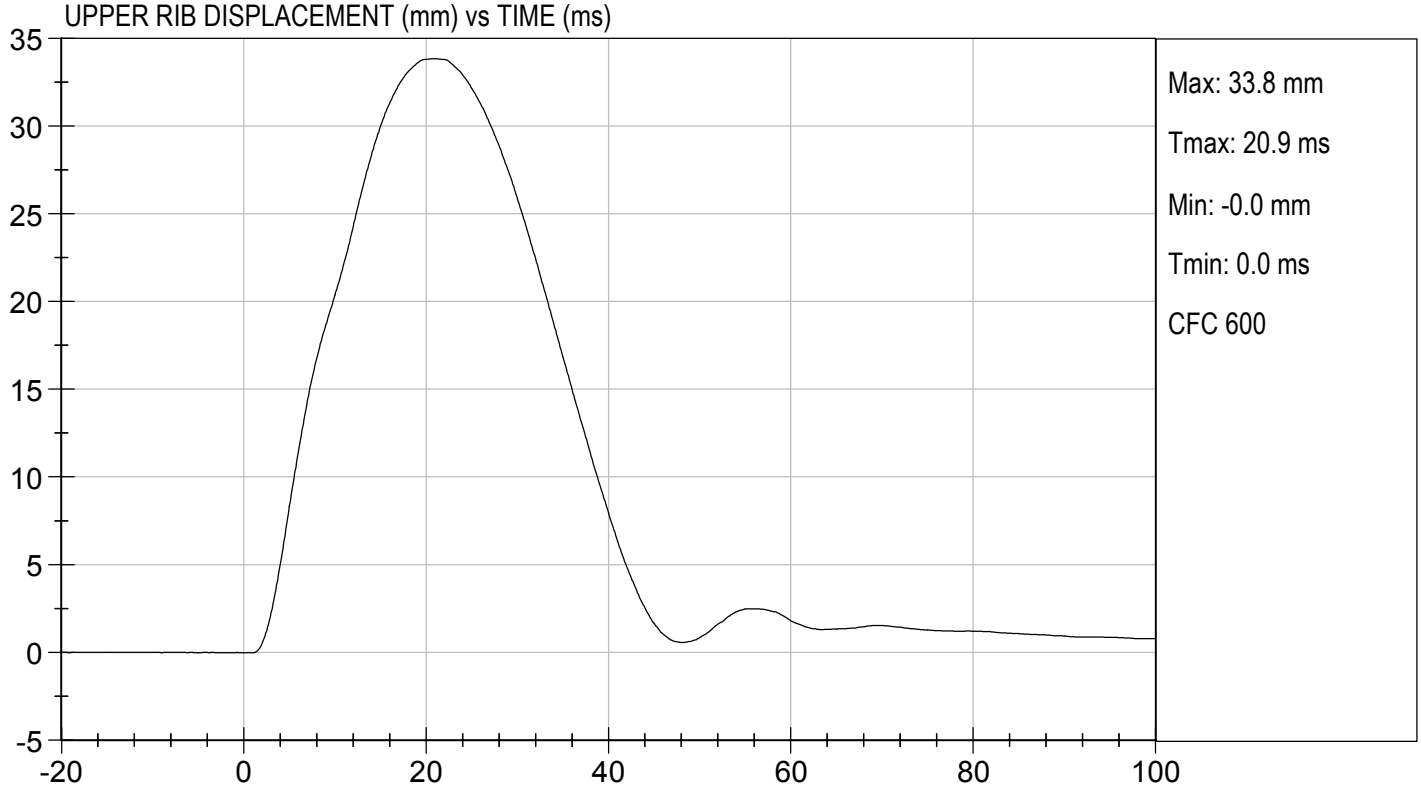
TEST DESC: THORAX IMPACT WITHOUT ARM
VELOCITY: 13.77 ft/s, 4.20 m/s

TEST DATE: 02/03/2021
TEST #: D210255

PROBE (G's) vs TIME (ms)



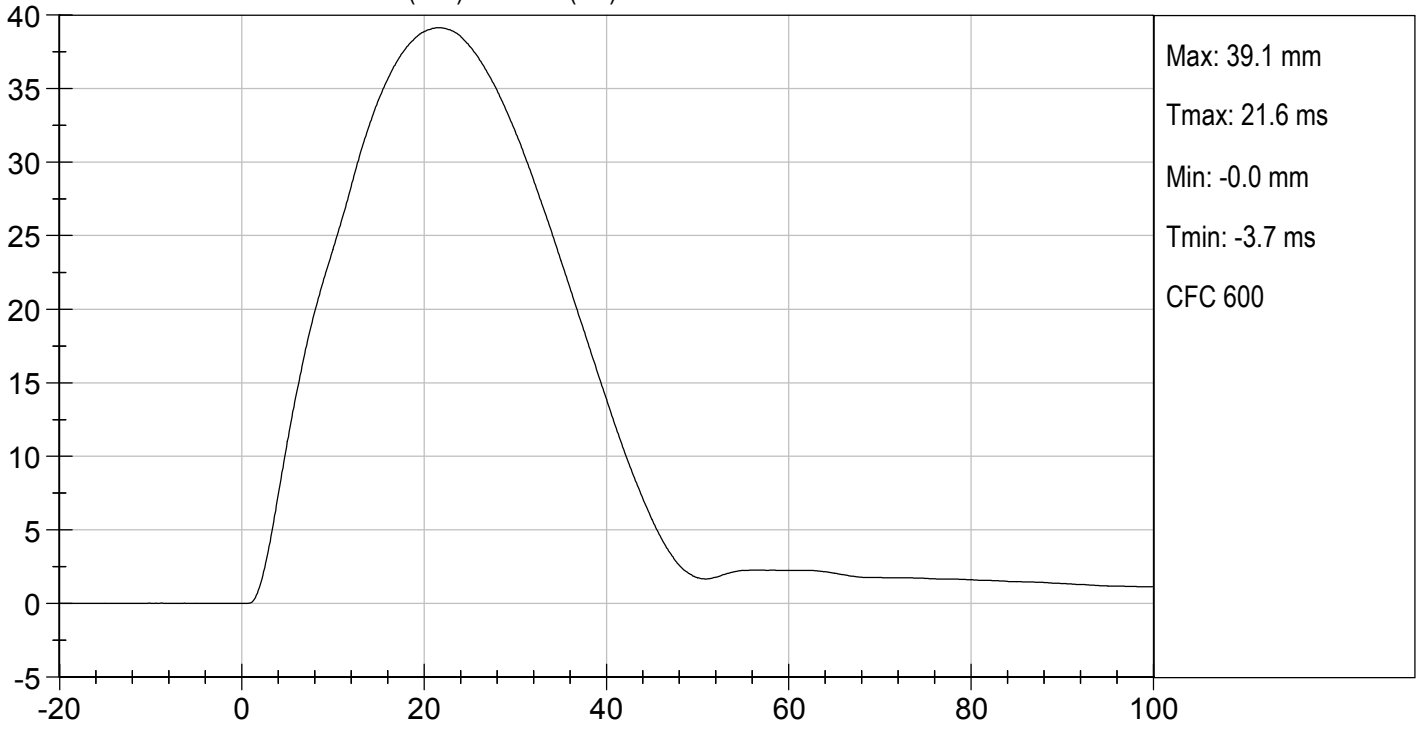
UPPER RIB DISPLACEMENT (mm) vs TIME (ms)



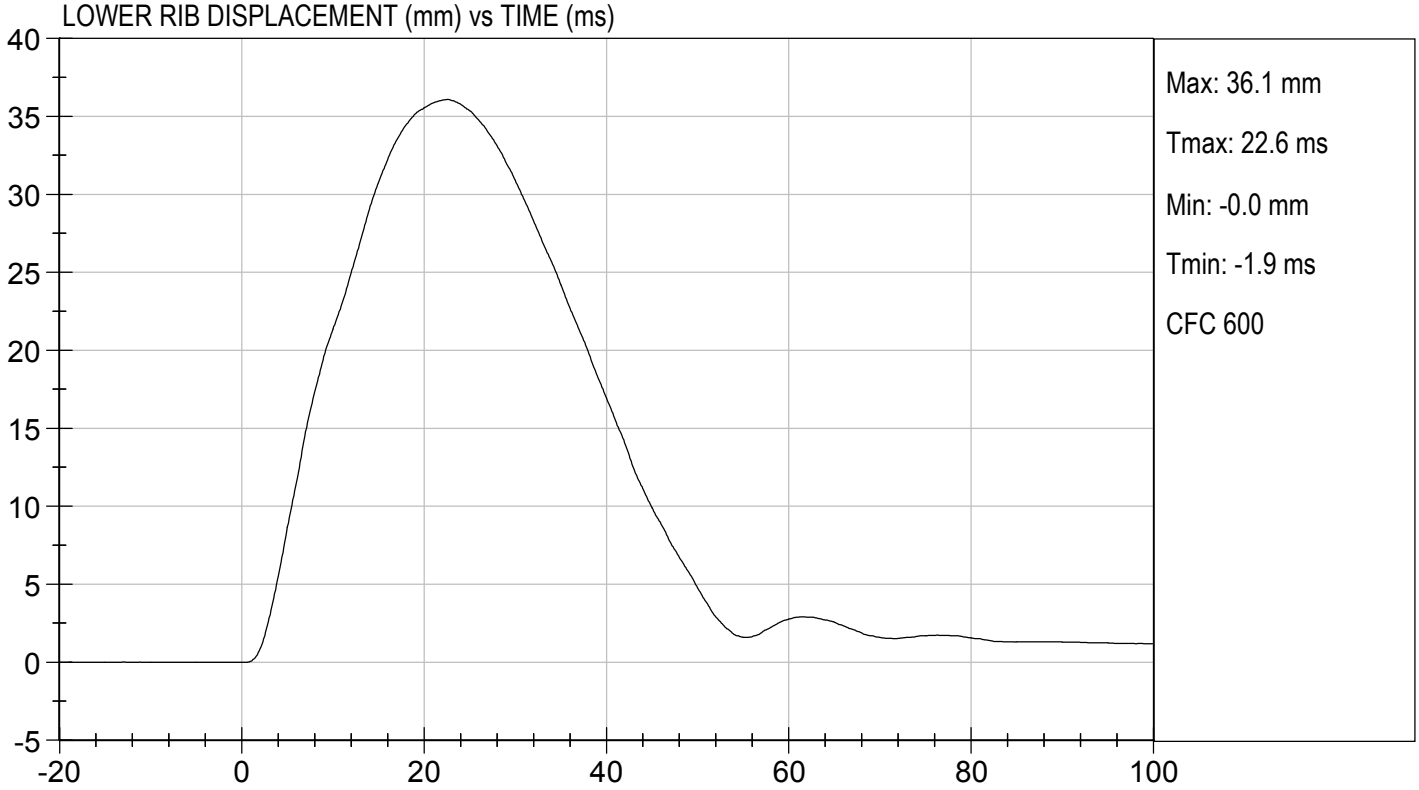
TEST DESC: THORAX IMPACT WITHOUT ARM
VELOCITY: 13.77 ft/s, 4.20 m/s

TEST DATE: 02/03/2021
TEST #: D210255

MIDDLE RIB DISPLACEMENT (mm) vs TIME (ms)



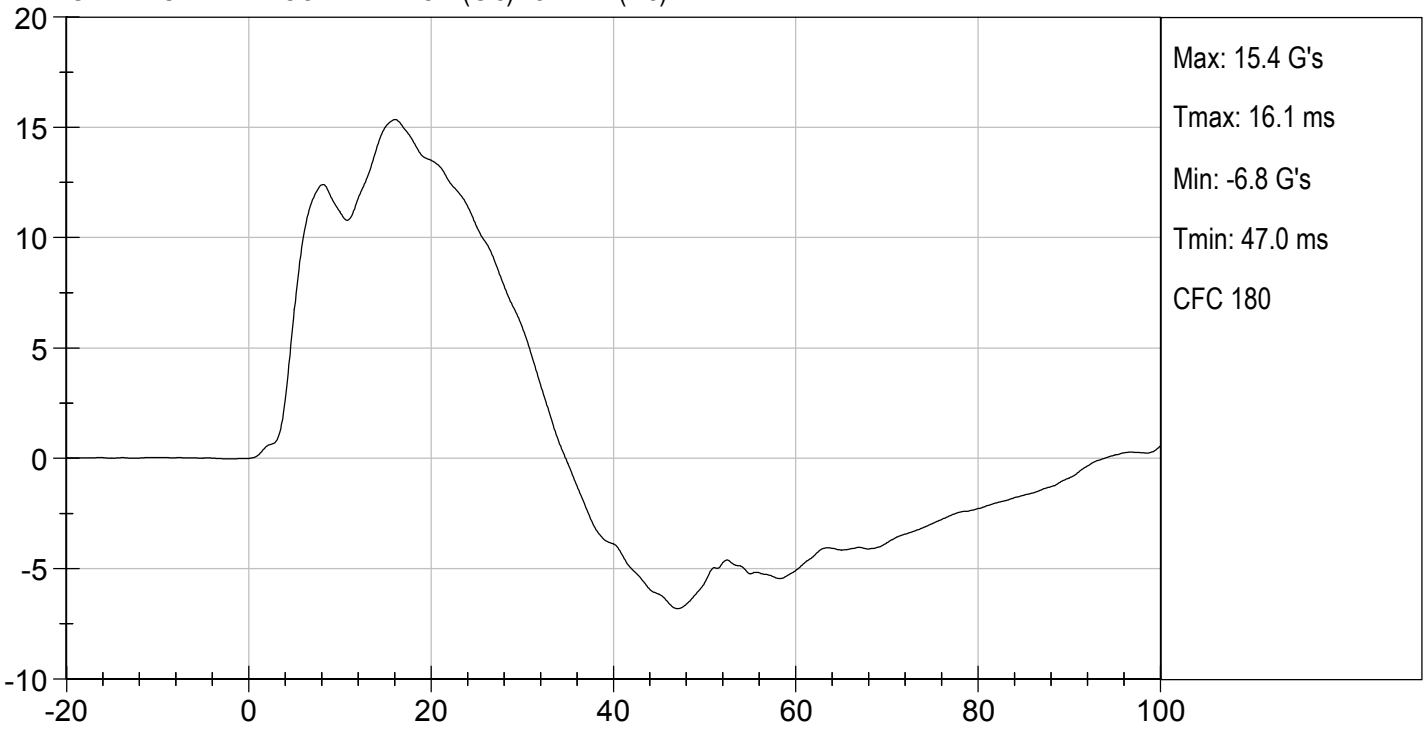
LOWER RIB DISPLACEMENT (mm) vs TIME (ms)



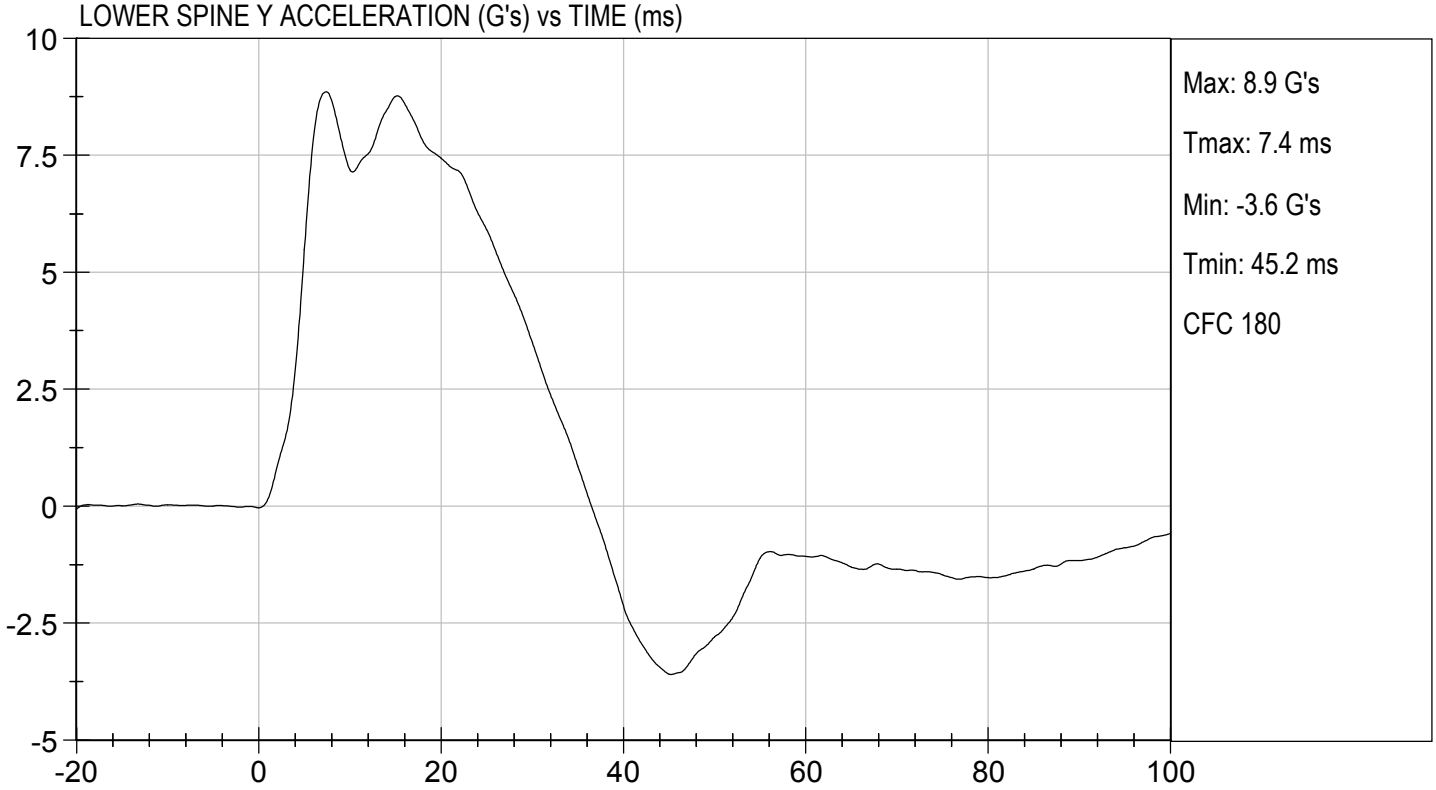
TEST DESC: THORAX IMPACT WITHOUT ARM
VELOCITY: 13.77 ft/s, 4.20 m/s

TEST DATE: 02/03/2021
TEST #: D210255

UPPER SPINE Y ACCELERATION (G's) vs TIME (ms)



LOWER SPINE Y ACCELERATION (G's) vs TIME (ms)



MGA RESEARCH CORPORATION

ABDOMINAL IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210256

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.0	Pass
Humidity	%	10 to 70	21	Pass
Impact Velocity	m/s	4.20 to 4.40	4.21	Pass
Maximum Probe Acceleration	G's	12 to 16	14	Pass
Upper Abdomen Rib Displacement	mm	36 to 47	39	Pass
Lower Abdomen Rib Displacement	mm	33 to 44	38	Pass
Lower Spine (T12) Y Acceleration	G's	9 to 14	10	Pass
		Overall Test Results		Pass

Laboratory Technician

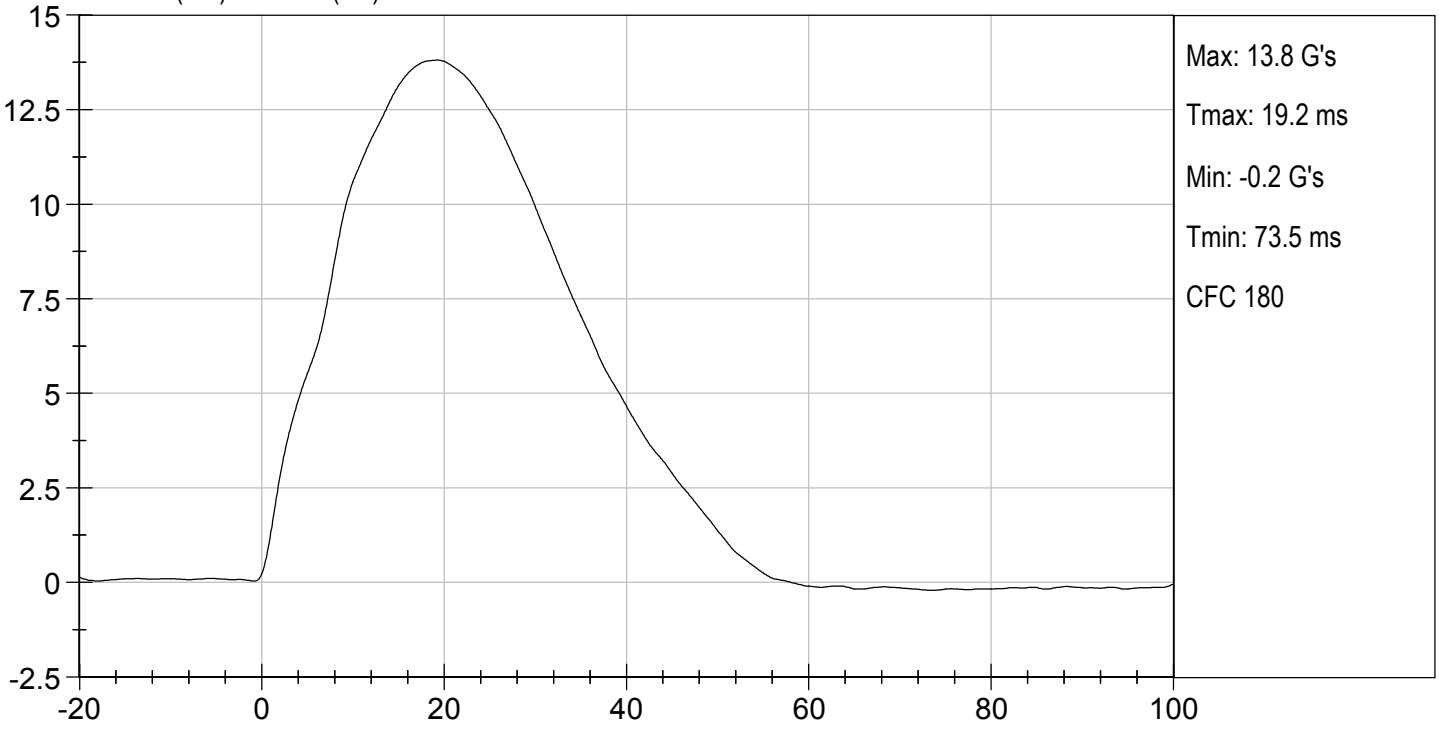
02/04/2021
Test Date

Approved By

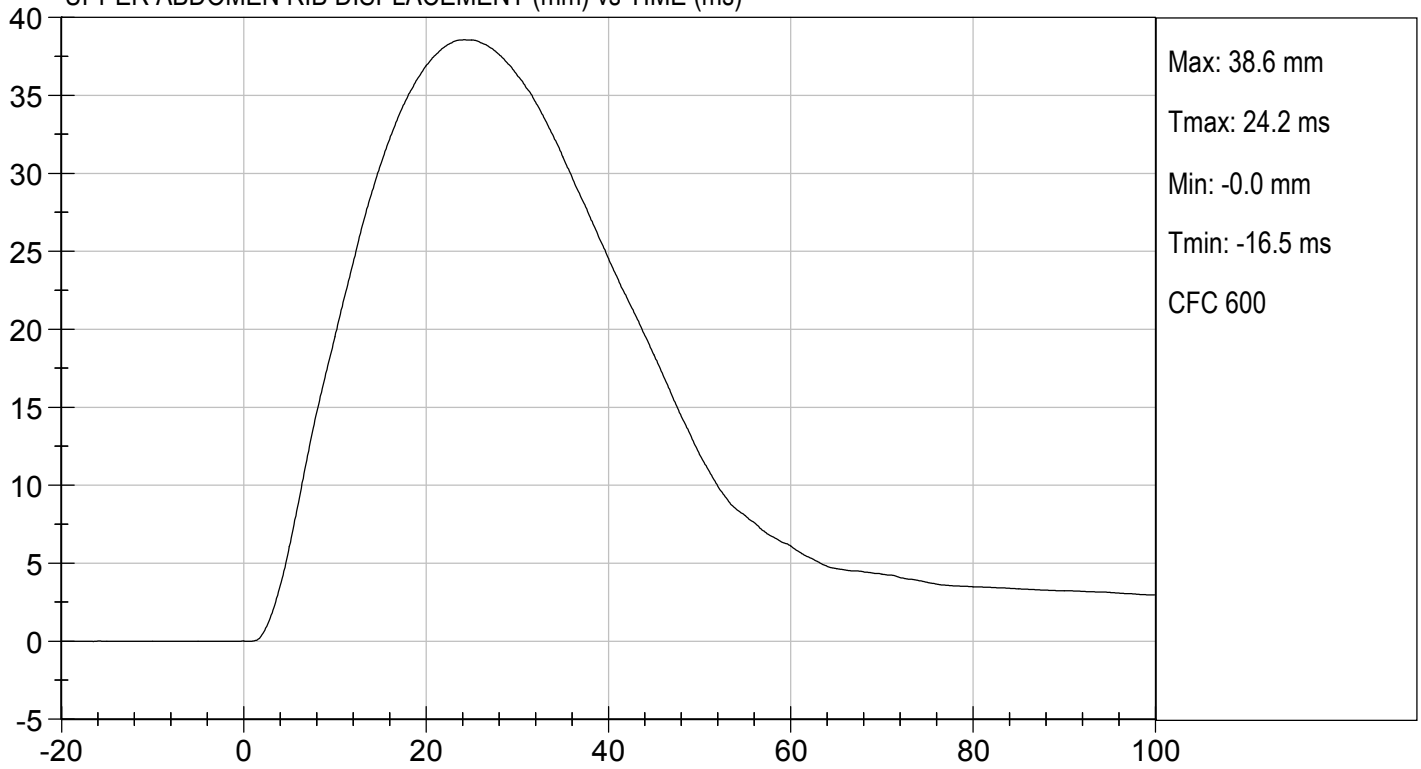
TEST DESC: ABDOMEN IMPACT
VELOCITY: 13.80 ft/s, 4.21 m/s

TEST DATE: 02/04/2021
TEST #: D210256

PROBE (G's) vs TIME (ms)



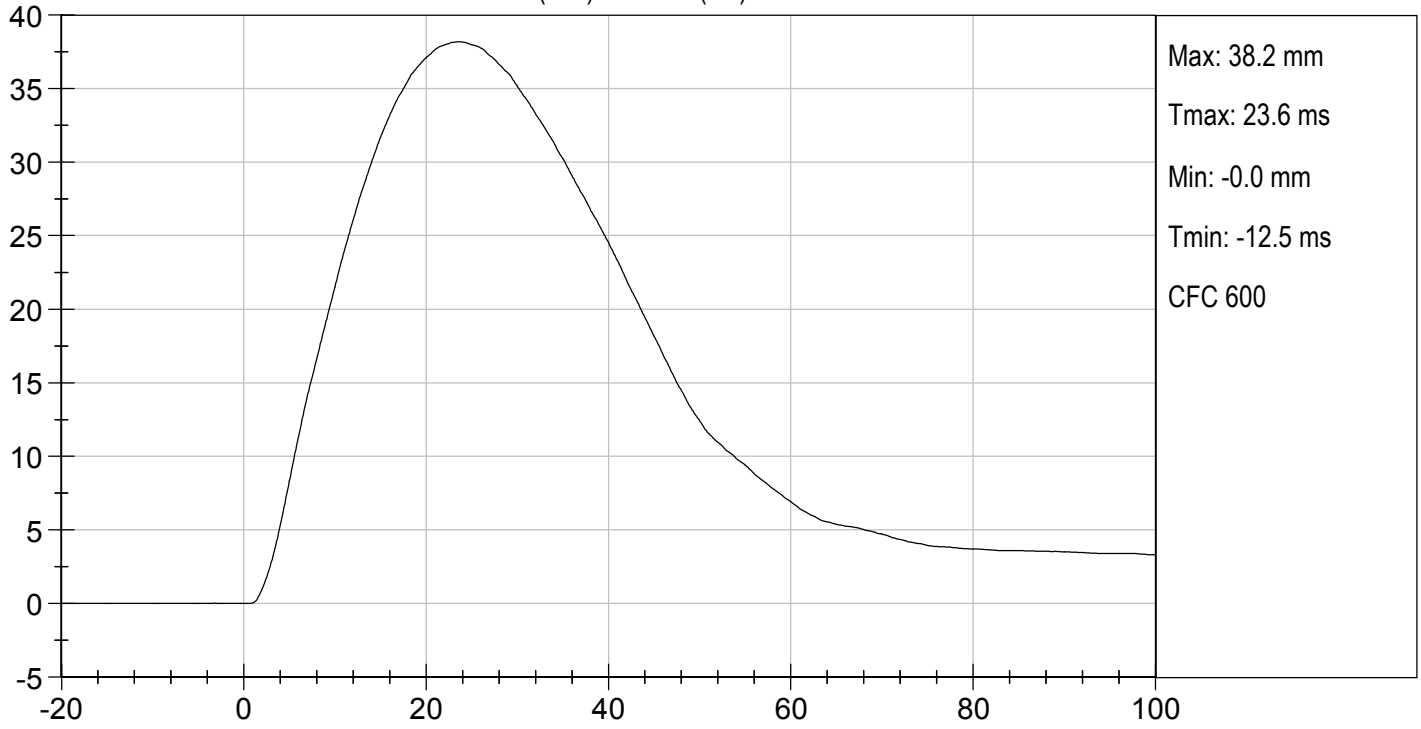
UPPER ABDOMEN RIB DISPLACEMENT (mm) vs TIME (ms)



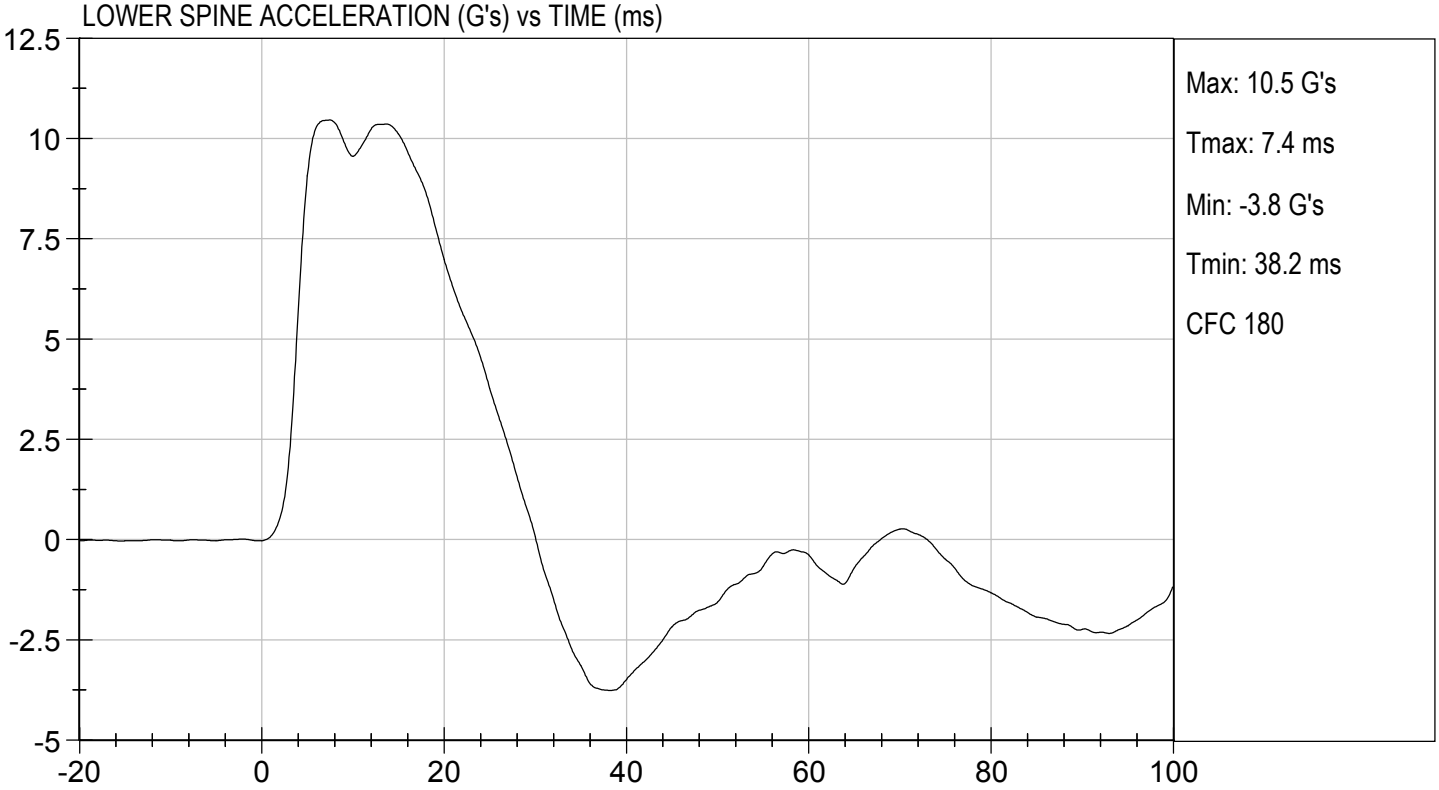
TEST DESC: ABDOMEN IMPACT
VELOCITY: 13.80 ft/s, 4.21 m/s

TEST DATE: 02/04/2021
TEST #: D210256

LOWER ABDOMEN RIB DISPLACEMENT (mm) vs TIME (ms)



LOWER SPINE ACCELERATION (G's) vs TIME (ms)



MGA RESEARCH CORPORATION

PELVIS IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210257

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.0	Pass
Humidity	%	10 to 70	21	Pass
Impact Velocity	m/s	6.60 to 6.80	6.60	Pass
Maximum Probe Acceleration	G's	38 to 47	46	Pass
Pelvis Y Acceleration After 6 ms	G's	34 to 42	37	Pass
Peak Acetabulum Force	N	3600 to 4300	4,037	Pass
		Overall Test Results		Pass

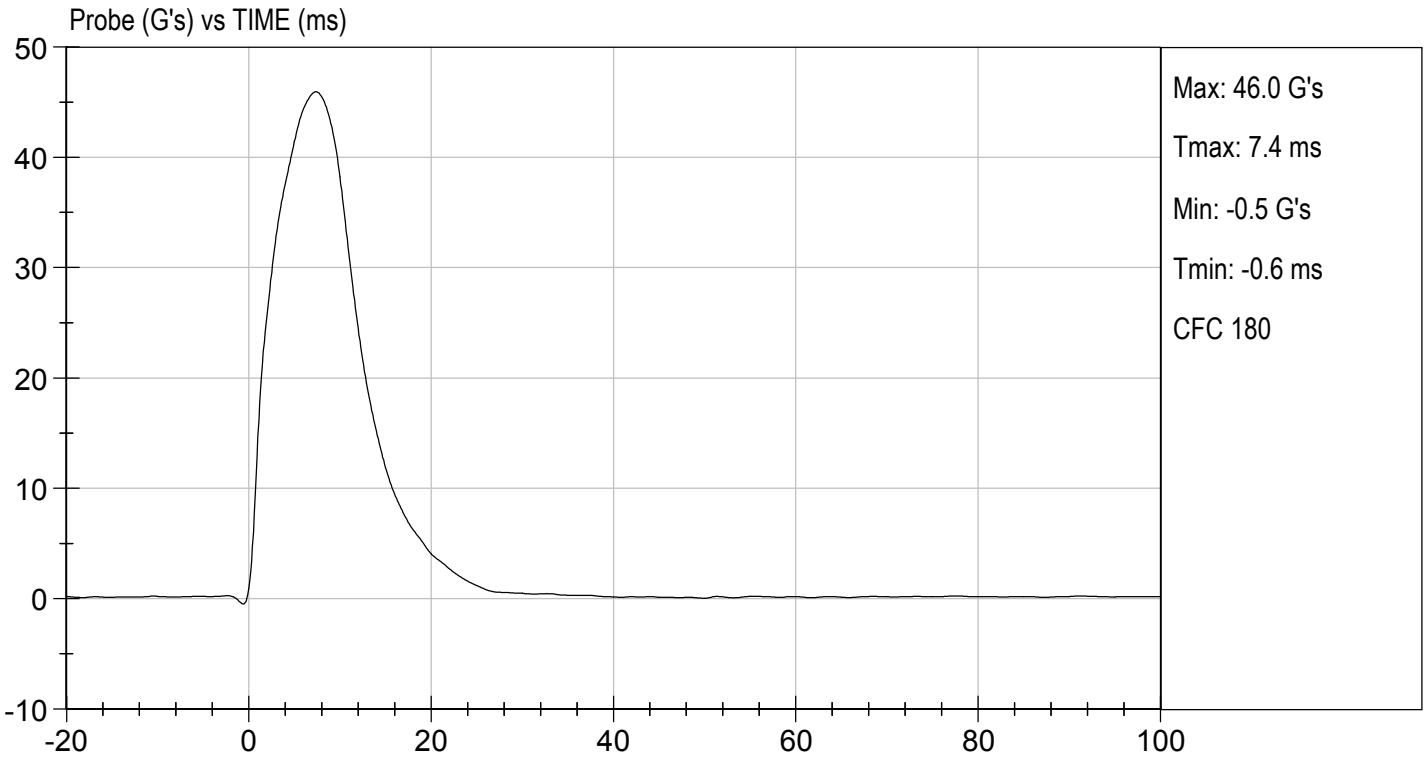
Laboratory Technician

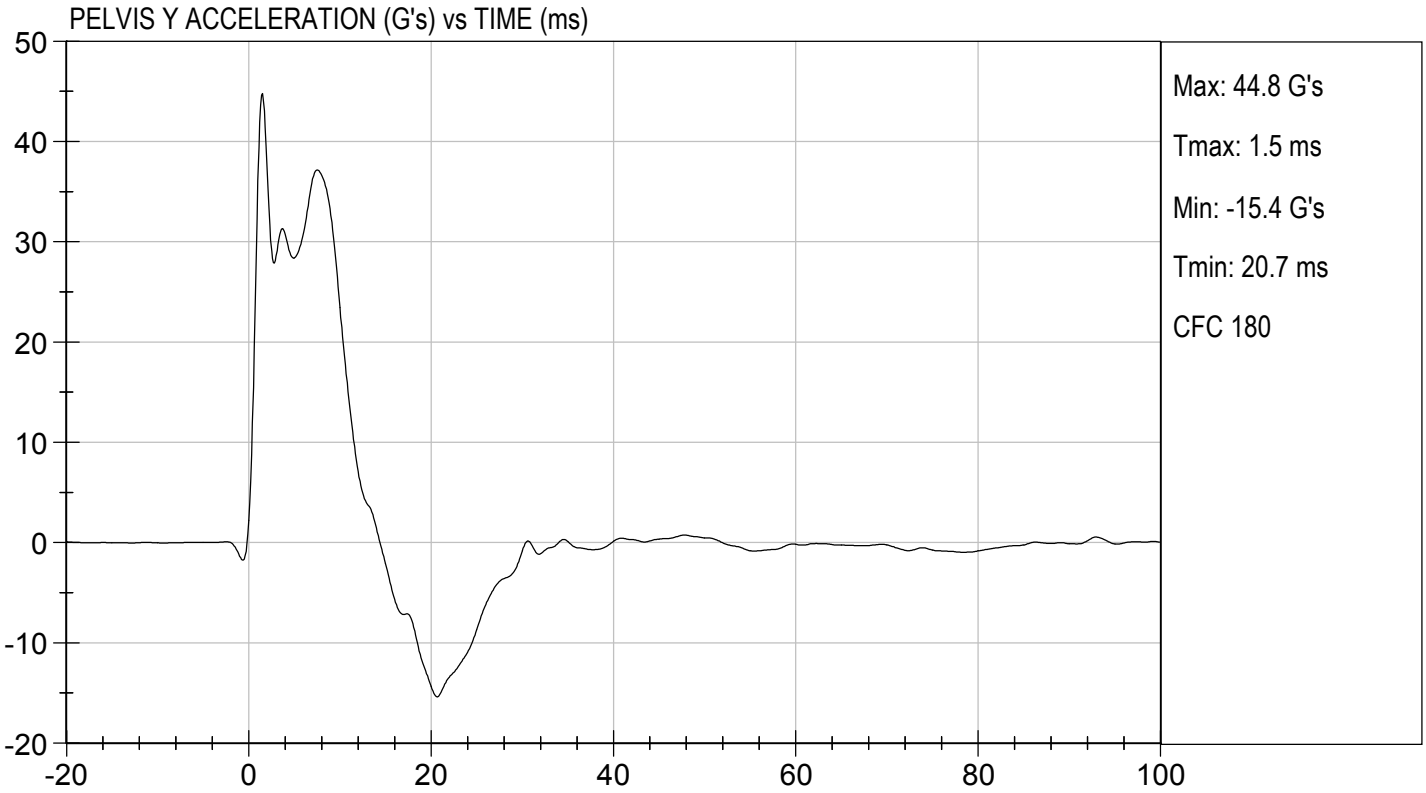
02/04/2021
Test Date

Approved By

TEST DESC: PELVIS IMPACT
VELOCITY: 21.65 ft/s, 6.60 m/s

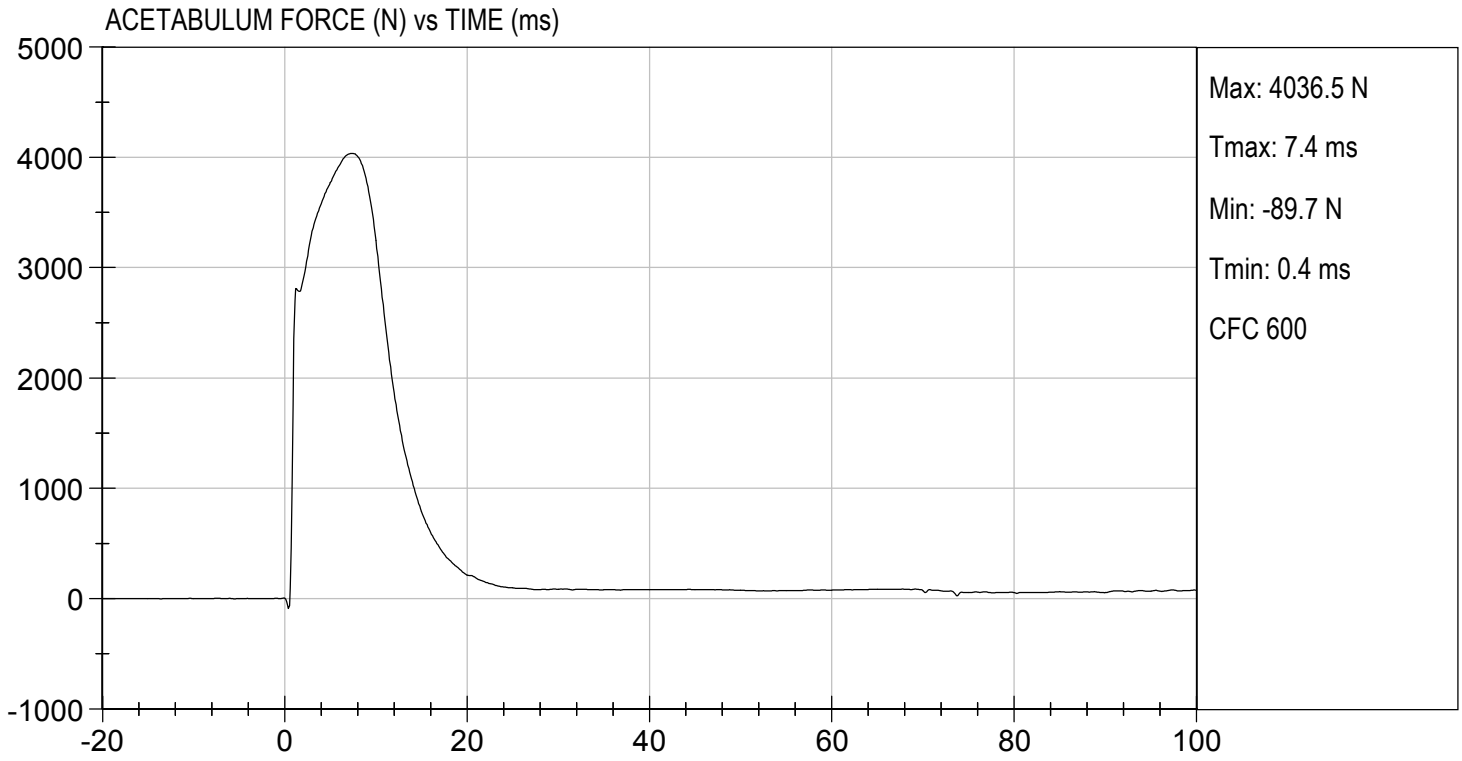
TEST DATE: 02/04/2021
TEST #: D210257





TEST DESC: PELVIS IMPACT
VELOCITY: 21.65 ft/s, 6.60 m/s

TEST DATE: 02/04/2021
TEST #: D210257



MGA RESEARCH CORPORATION

ILIAC IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210258

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.0	Pass
Humidity	%	10 to 70	21	Pass
Impact Velocity	m/s	4.20 to 4.40	4.23	Pass
Maximum Probe Acceleration	G's	36 to 45	42	Pass
Pelvis Y Acceleration	G's	28 to 39	32	Pass
Peak Pelvis Iliac Force	N	4100 to 5100	4,783	Pass
		Overall Test Results		Pass

Laboratory Technician

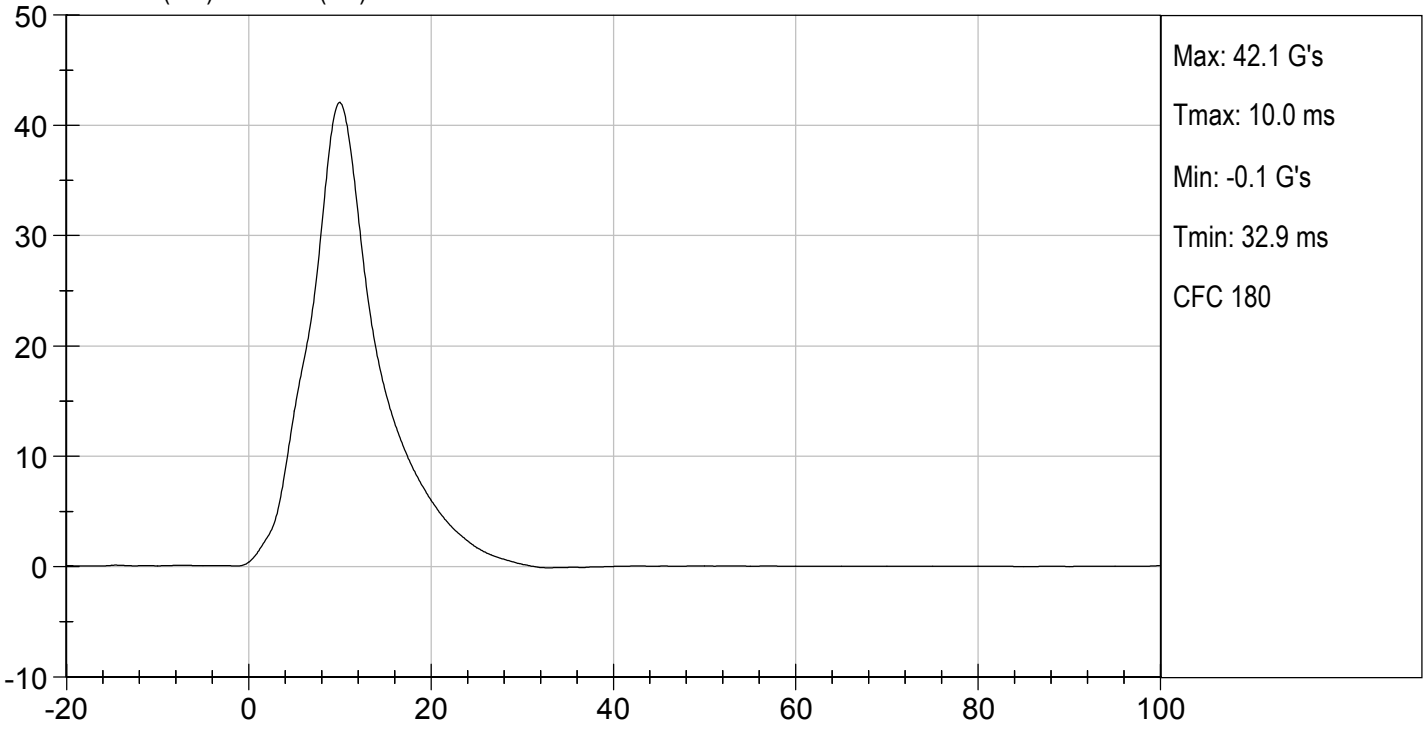
02/03/2021
Test Date

Approved By

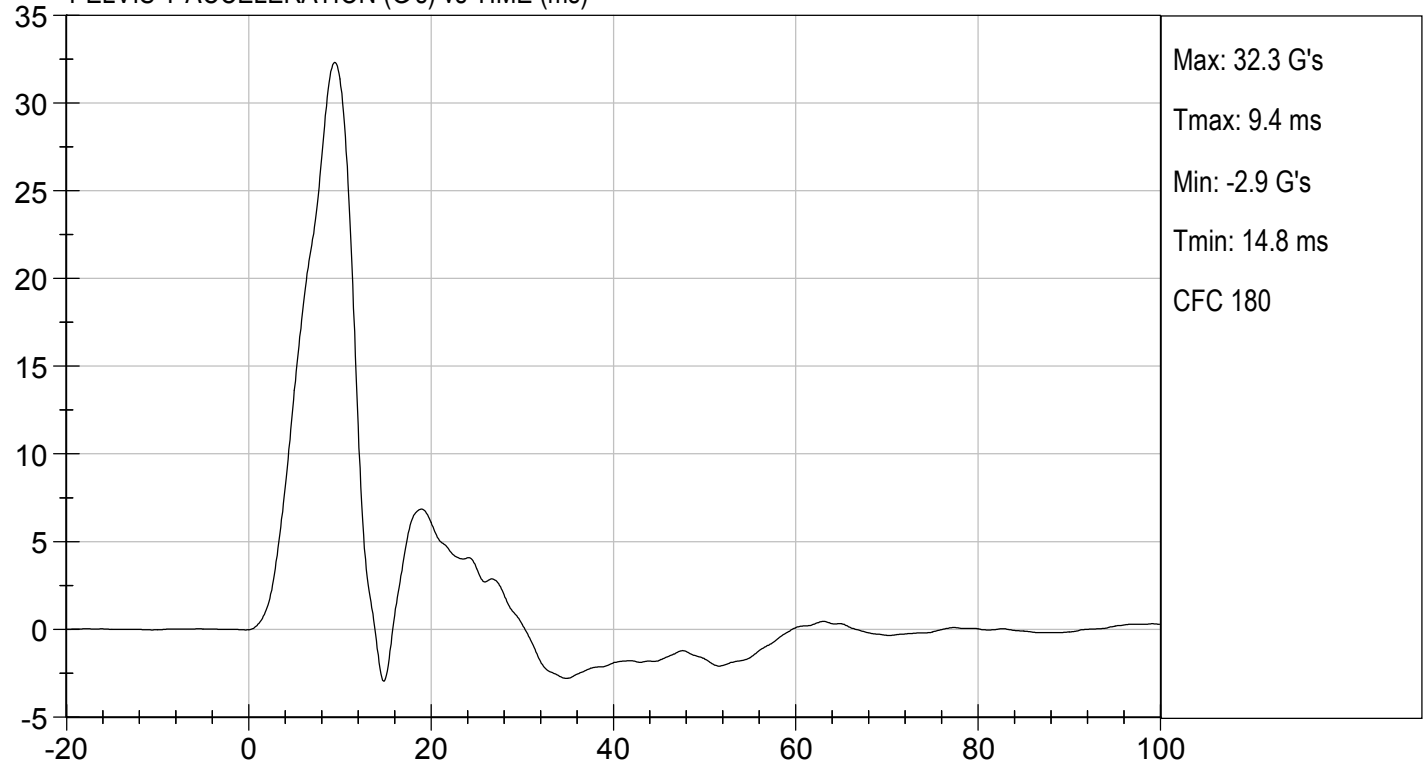
TEST DESC: ILLIAC
VELOCITY: 13.89 ft/s, 4.23 m/s

TEST DATE: 02/03/2021
TEST #: D210258

PROBE (G's) vs TIME (ms)

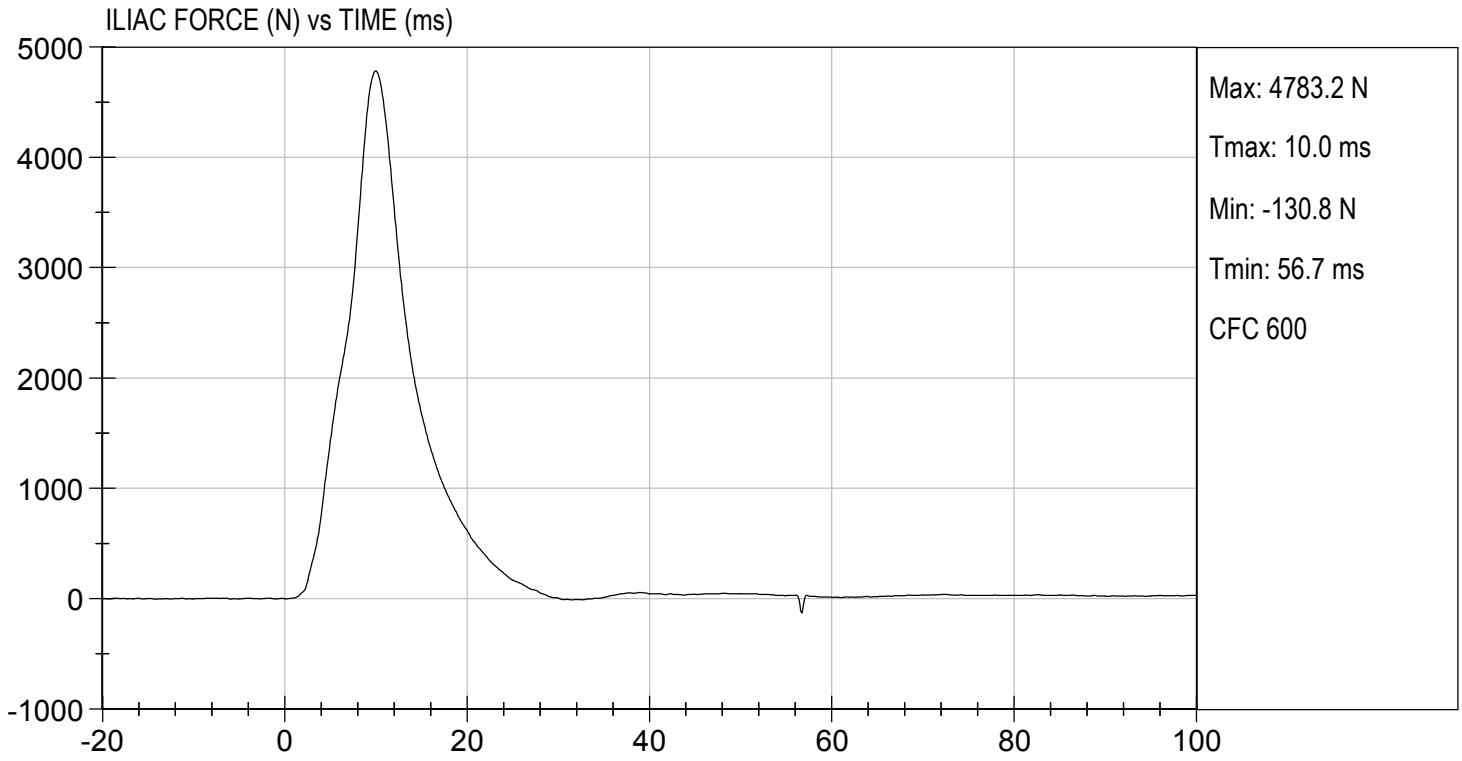


PELVIS Y ACCELERATION (G's) vs TIME (ms)



TEST DESC: ILLIAC
VELOCITY: 13.89 ft/s, 4.23 m/s

TEST DATE: 02/03/2021
TEST #: D210258



CALIBRATION TEST RESULTS

POST-TEST

SID-IIs 5TH PERCENTILE FEMALE ATD

MGA RESEARCH CORPORATION

HEAD DROP TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test ID:** D210421

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	21.2	Pass
Laboratory Relative Humidity	%	10 to 70	22	Pass
Peak Resultant Acceleration	G's	115 to 137	125	Pass
Peak Longitudinal Acceleration	G's	+/- 15	3.1	Pass
Unimodal	N/A	Yes	Yes	Pass
Oscillations	N/A	<15%	Yes	Pass
		Overall Test Results		Pass

Laboratory Technician

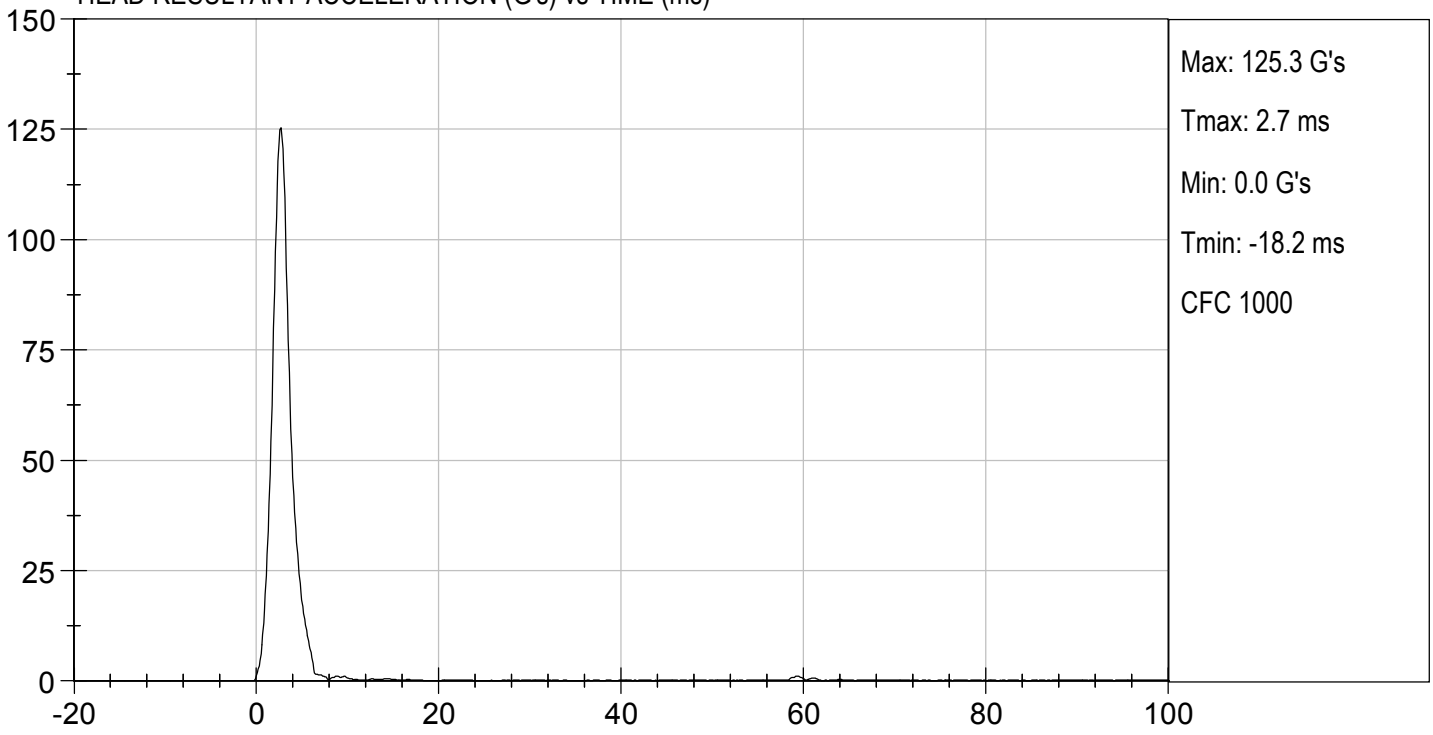
02/16/2021
Test Date

Approved By

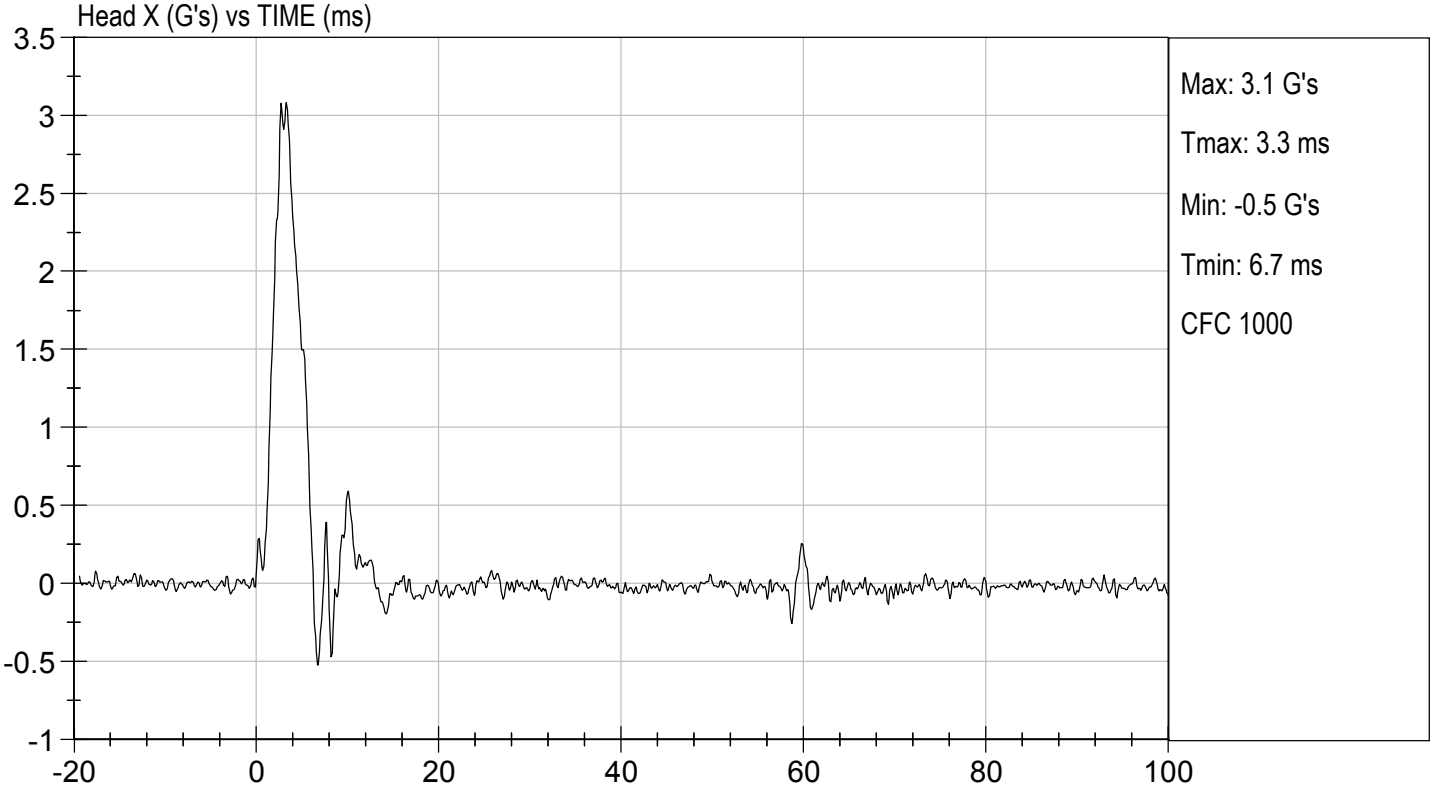
TEST DESC: HEAD DROP

TEST DATE: 02/16/2021
TEST #: D210421

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

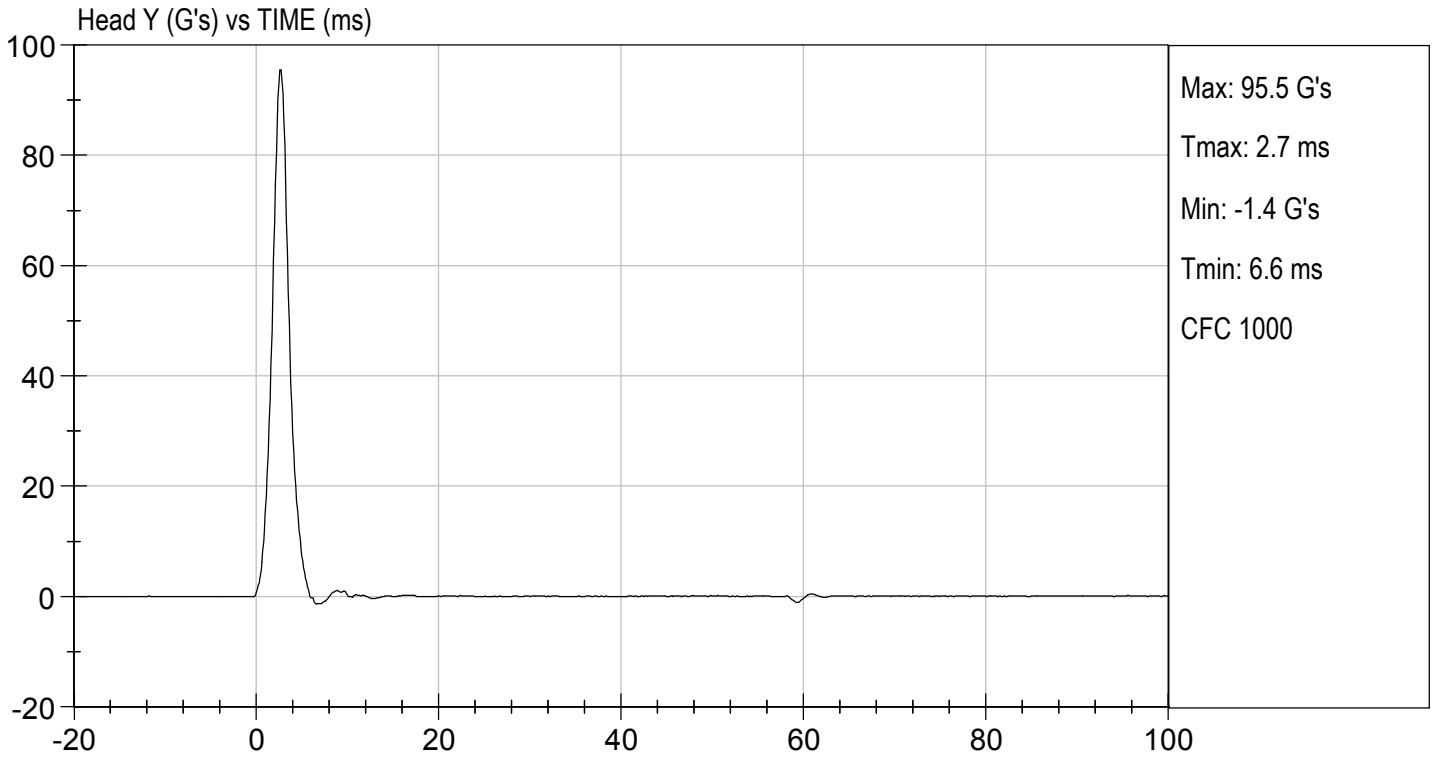


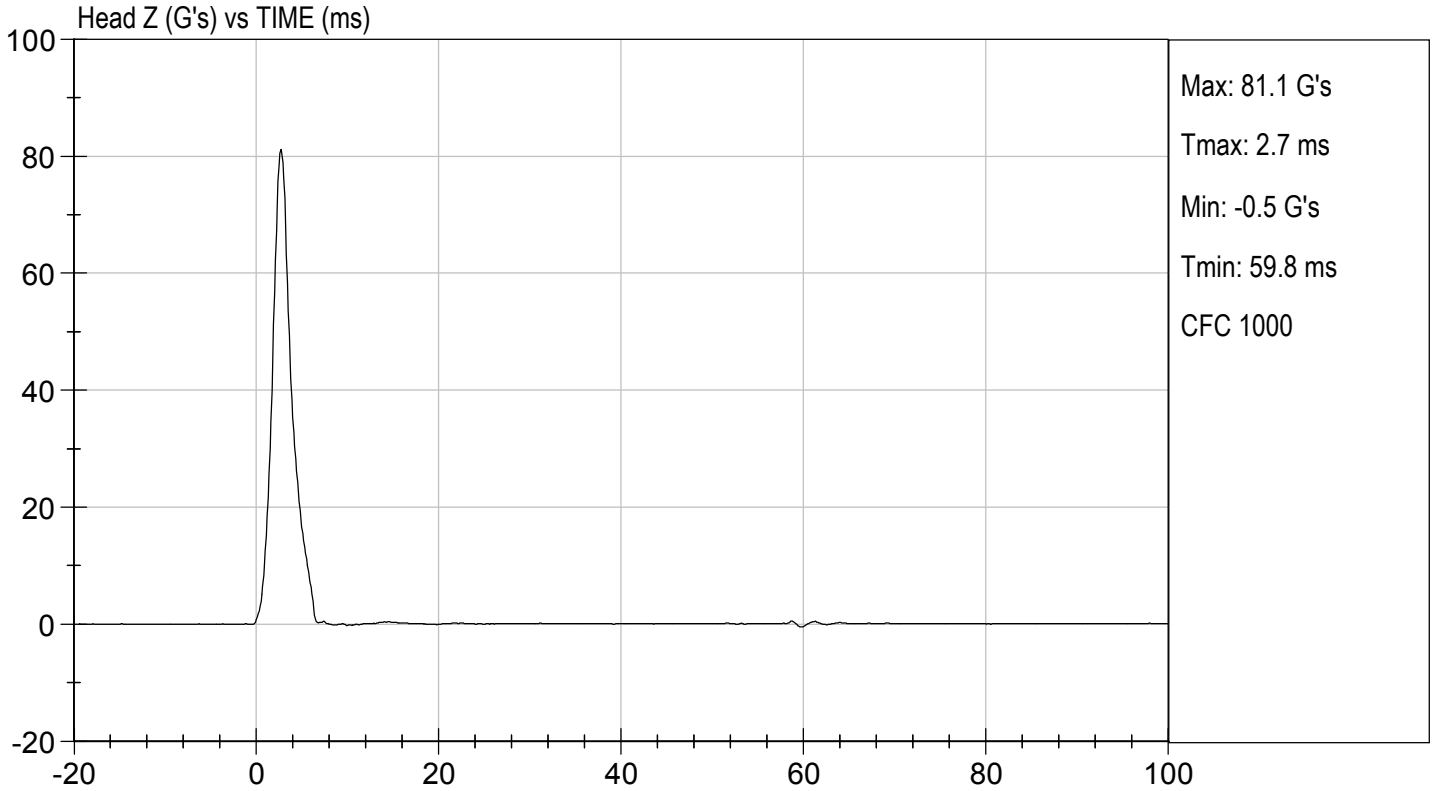
Head X (G's) vs TIME (ms)



TEST DESC: HEAD DROP

TEST DATE: 02/16/2021
TEST #: D210421





MGA RESEARCH CORPORATION

LATERAL NECK PENDULUM TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210422

Tested Parameter		Units	Specification	Result	Pass/Fail
Temperature		deg C	20.6 to 22.2	21.7	Pass
Humidity		%	10 to 70	25	Pass
Impact Velocity		m/s	5.51 to 5.63	5.58	Pass
Pendulum Velocity	10 ms	m/s	2.20 to 2.80	2.63	Pass
	15 ms	m/s	3.30 to 4.10	3.72	Pass
	20 ms	m/s	4.40 to 5.40	5.03	Pass
	25 ms	m/s	5.40 to 6.10	5.67	Pass
	25-100 ms	m/s	5.50 to 6.20	5.68	Pass
Maximum D-Plane Rotation		deg	71 to 81	75	Pass
Time of Maximum D-Plane Rotation		ms	50 to 70	60	Pass
Maximum Occipital Condyle Moment		Nm	-44 to -36	-39	Pass
Time of Moment Decay to 0 Nm		ms	102 to 126	110	Pass
			Overall Test Results		Pass

Gerald Guerrero
Laboratory Technician

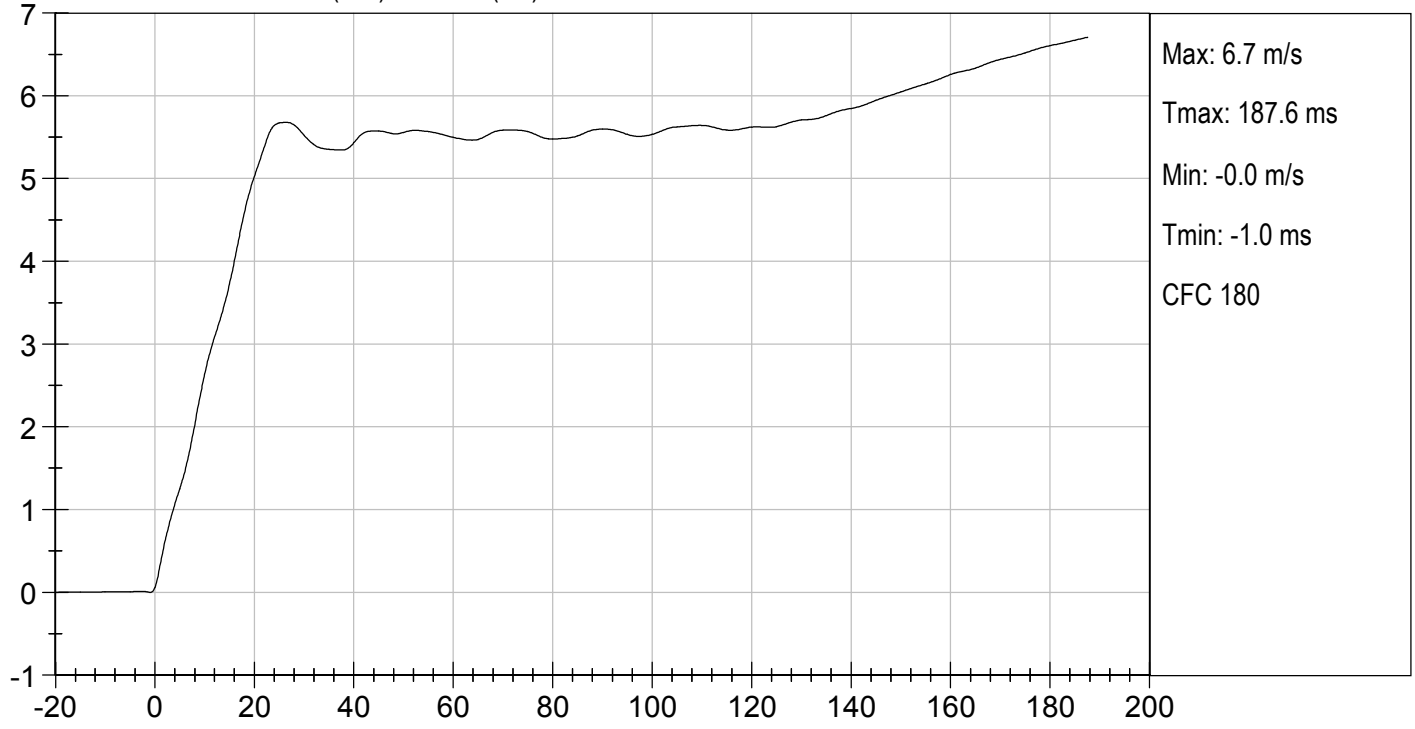
02/16/2021
Test Date

Approved By

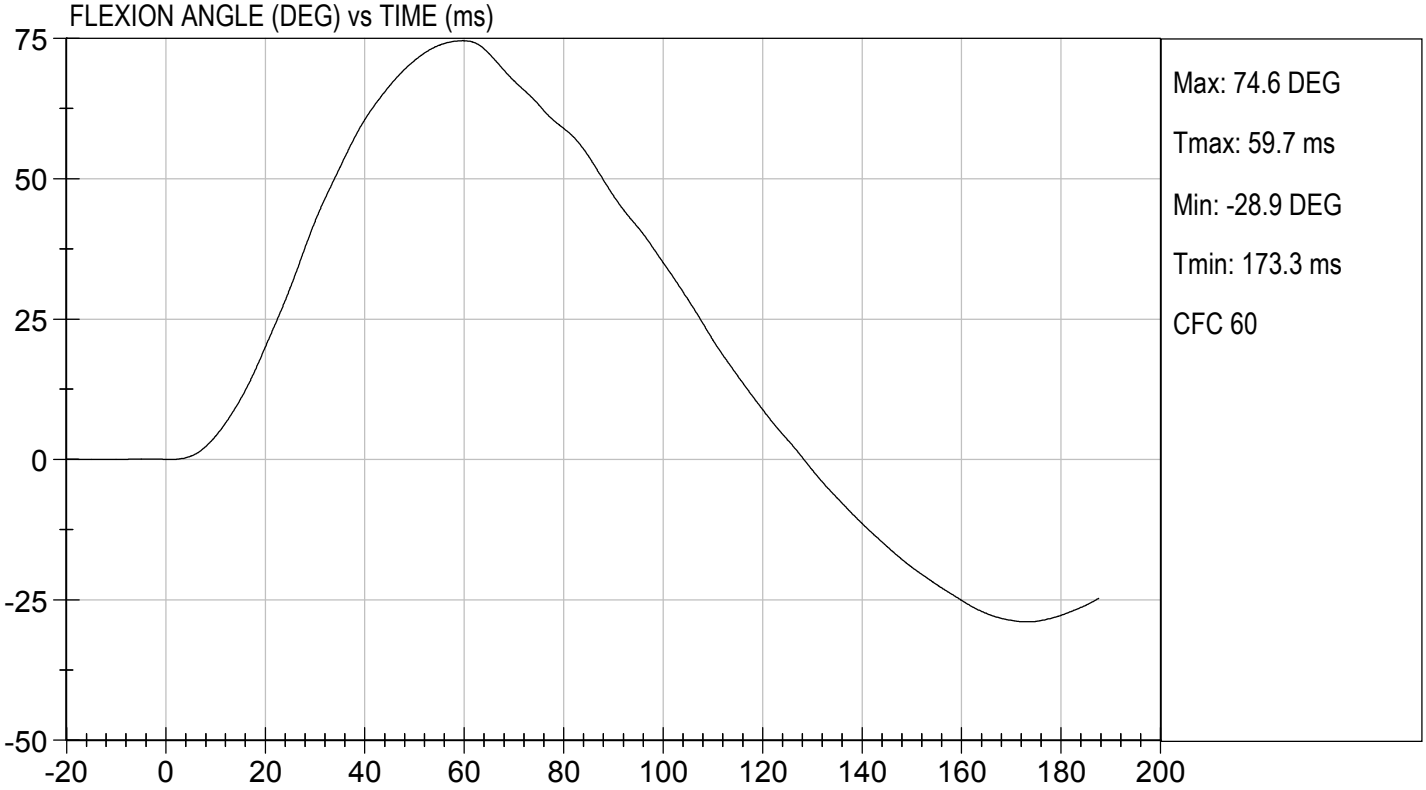
TEST DESC: NECK BENDING
VELOCITY: 18.32 ft/s, 5.58 m/s

TEST DATE: 02/16/2021
TEST #: D210422

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

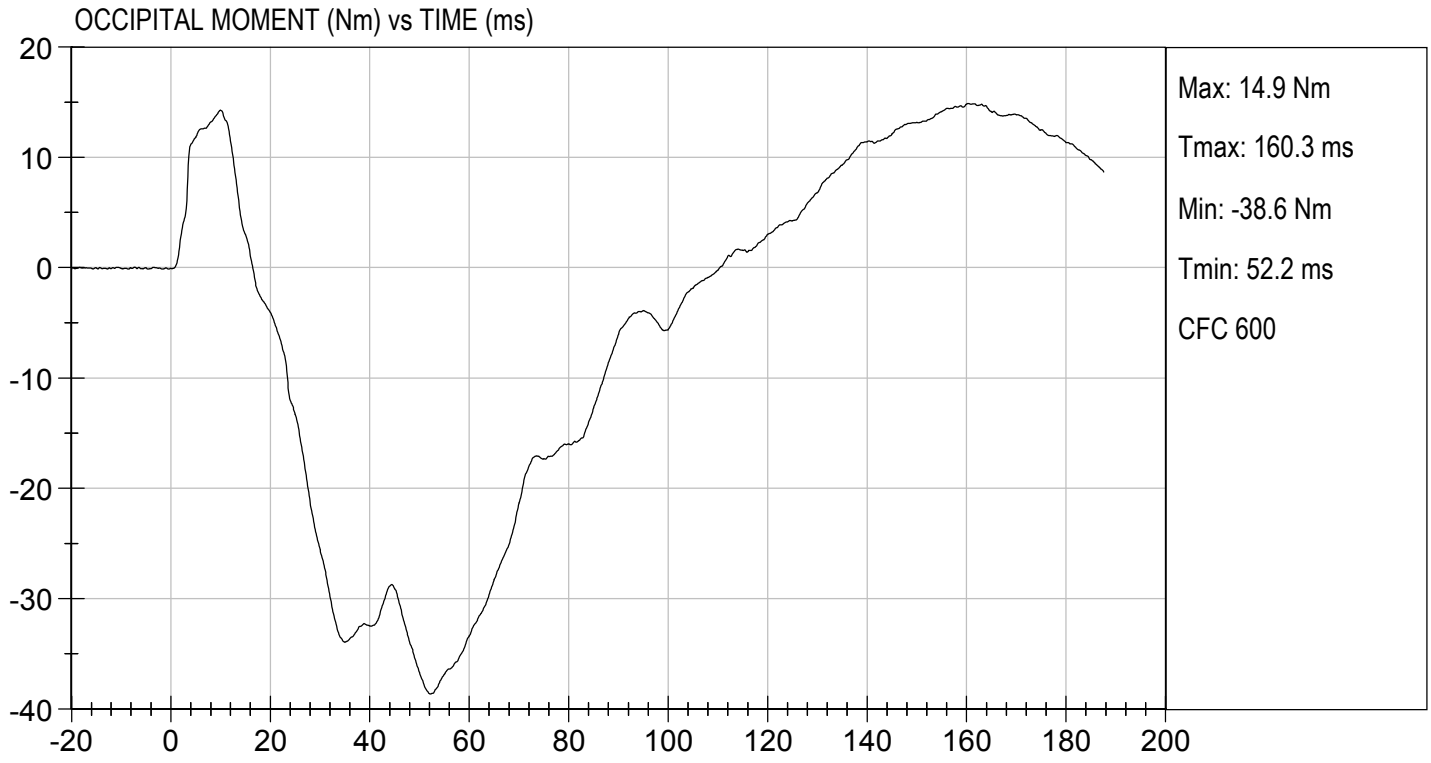


FLEXION ANGLE (DEG) vs TIME (ms)



TEST DESC: NECK BENDING
VELOCITY: 18.32 ft/s, 5.58 m/s

TEST DATE: 02/16/2021
TEST #: D210422



MGA RESEARCH CORPORATION

SHOULDER IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test ID:** D210423

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	20.8	Pass
Laboratory Relative Humidity	%	10 to 70	23	Pass
Impact Velocity	m/s	4.20 to 4.40	4.30	Pass
Maximum Probe Acceleration	G's	13 to 18	16	Pass
Shoulder Displacement	mm	28 to 37	30	Pass
Upper Spine (T1) Y Acceleration	G's	17 to 22	19	Pass
		Overall Test Results		Pass

Gerald Guerrero
Laboratory Technician

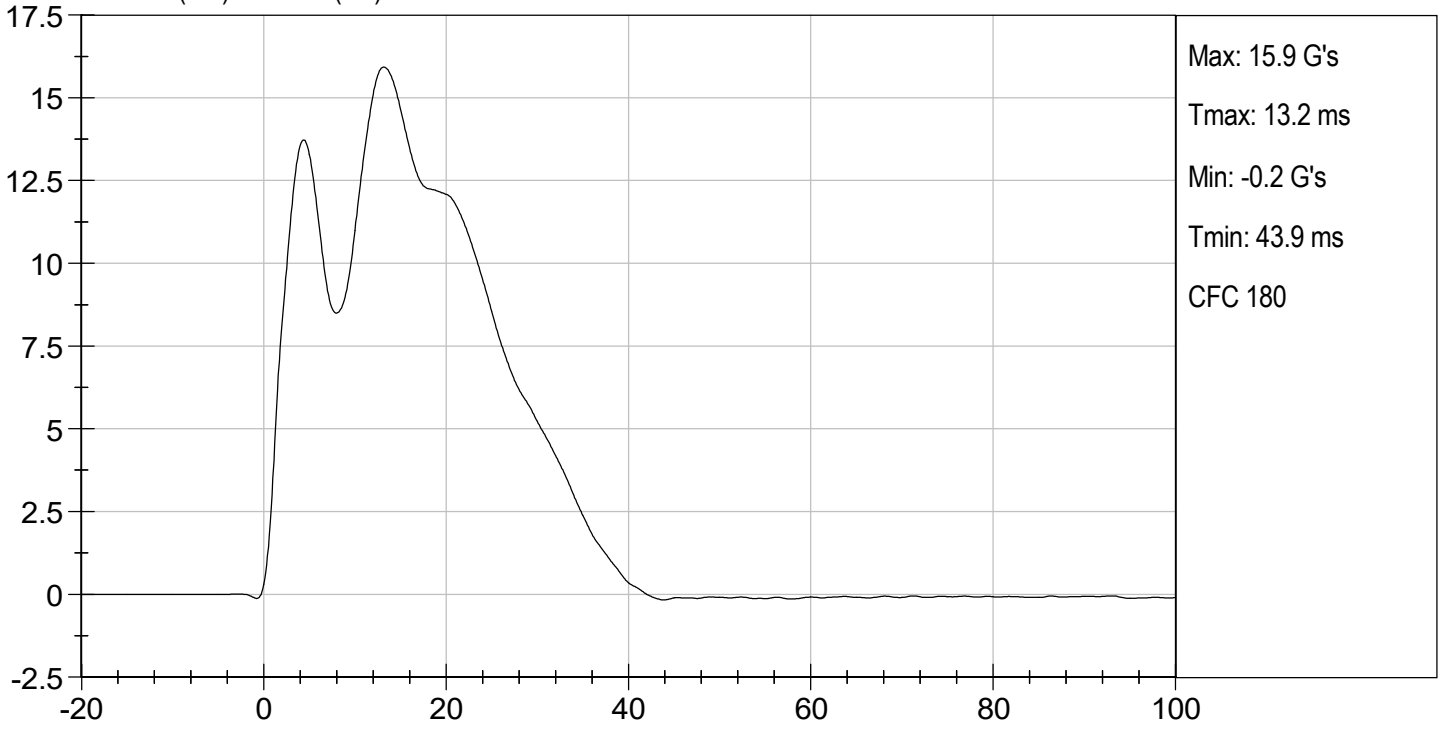
02/16/2021
Test Date

Approved By

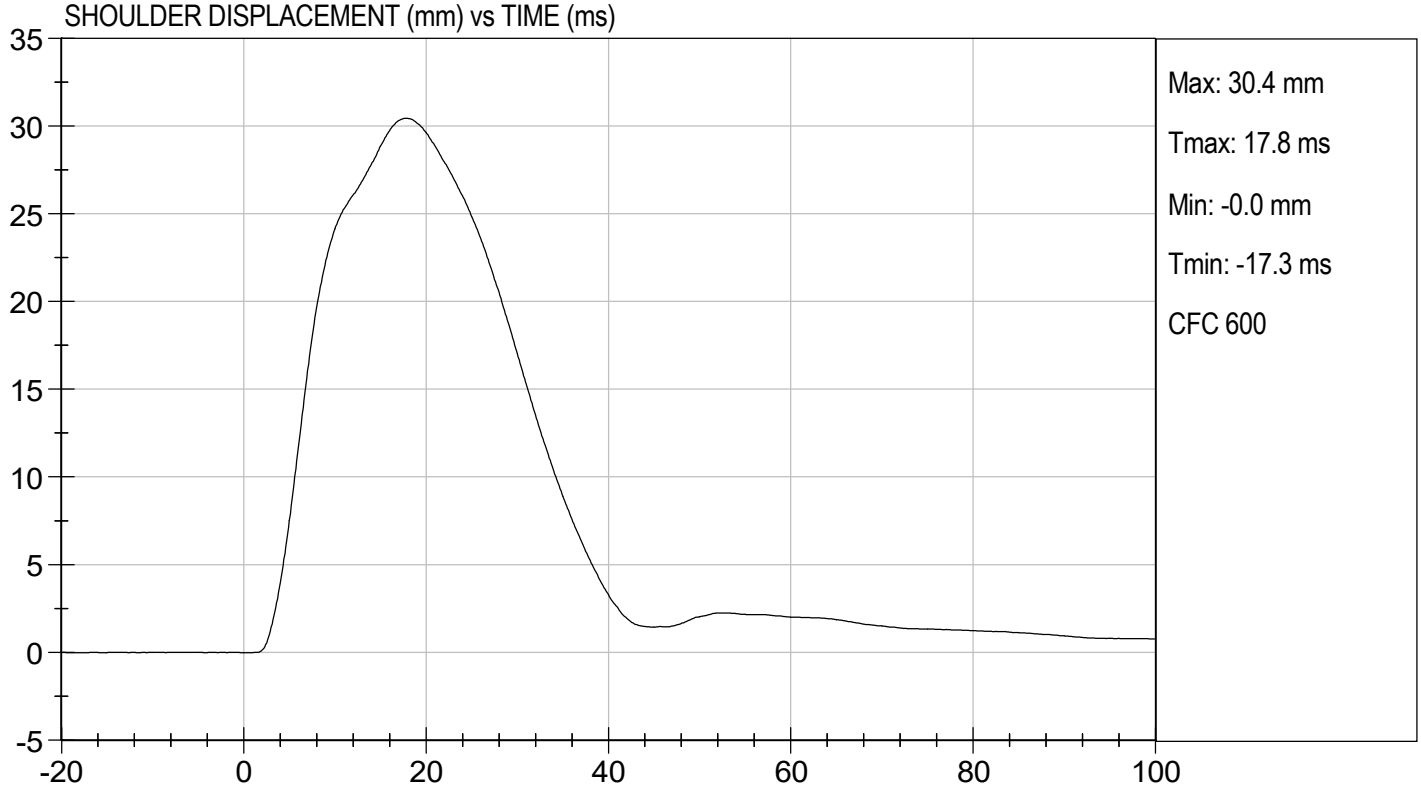
TEST DESC: SHOULDER IMPACT
VELOCITY: 14.12 ft/s, 4.30 m/s

TEST DATE: 02/16/2021
TEST #: D210423

PROBE (G's) vs TIME (ms)

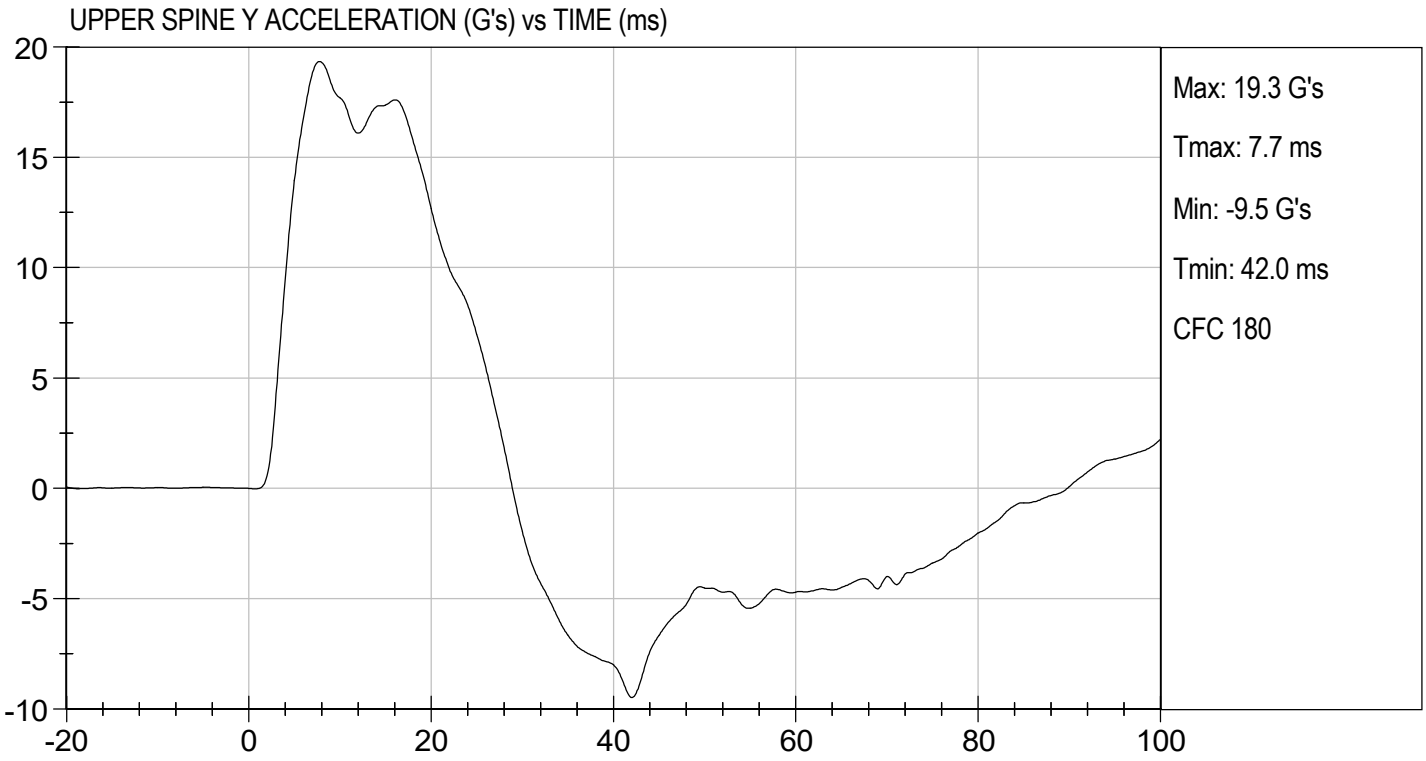


SHOULDER DISPLACEMENT (mm) vs TIME (ms)



TEST DESC: SHOULDER IMPACT
VELOCITY: 14.12 ft/s, 4.30 m/s

TEST DATE: 02/16/2021
TEST #: D210423



MGA RESEARCH CORPORATION

THORAX (WITH ARM) IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210424

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	20.8	Pass
Humidity	%	10 to 70	23	Pass
Impact Velocity	m/s	6.60 to 6.80	6.68	Pass
Maximum Probe Acceleration	G's	30 to 36	36	Pass
Shoulder Displacement	mm	31 to 40	32	Pass
Upper Rib Displacement	mm	25 to 32	27	Pass
Middle Rib Displacement	mm	30 to 36	32	Pass
Lower Rib Displacement	mm	32 to 38	35	Pass
Upper Spine (T1) Y Acceleration	G's	34 to 43	41	Pass
Lower Spine (T12) Y Acceleration	G's	29 to 37	34	Pass
		Overall Test Results		Pass

Gerald Guerrero
Laboratory Technician

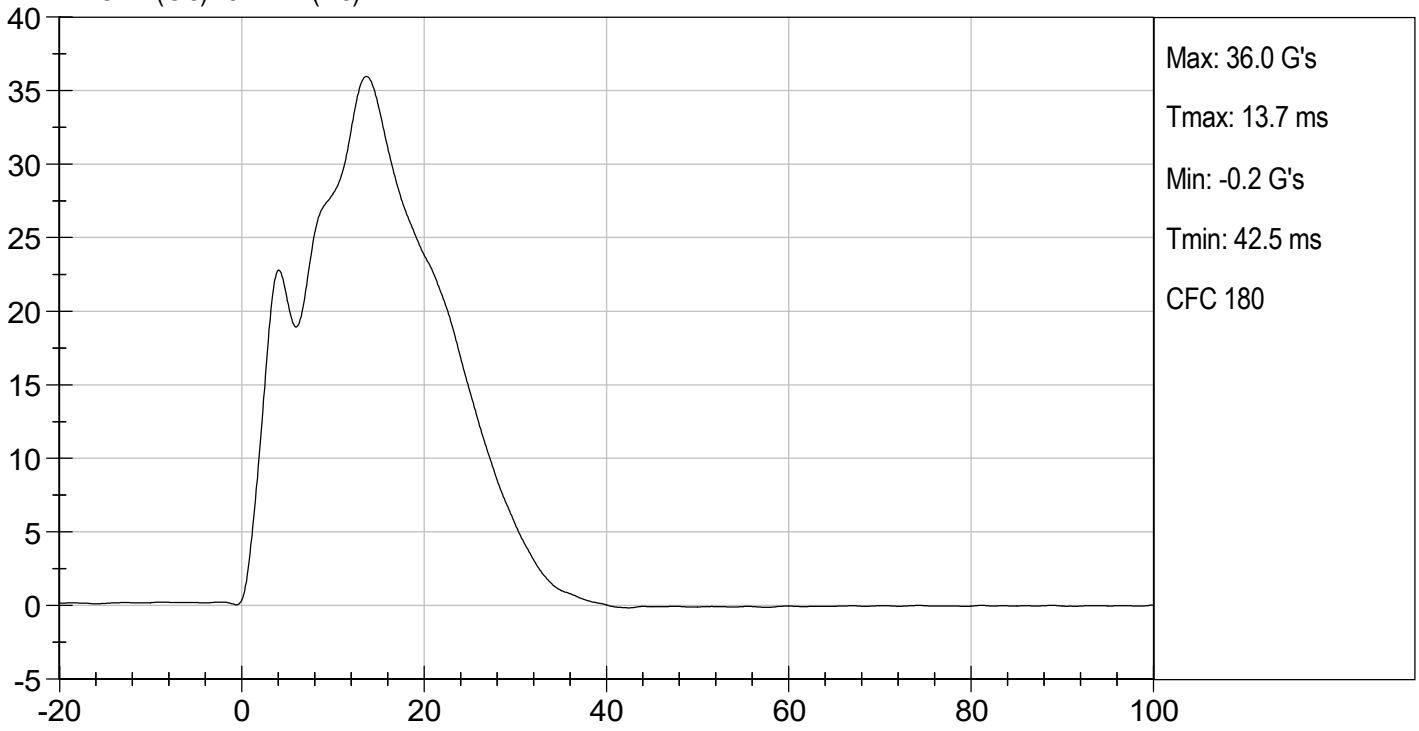
02/16/2021
Test Date

Approved By

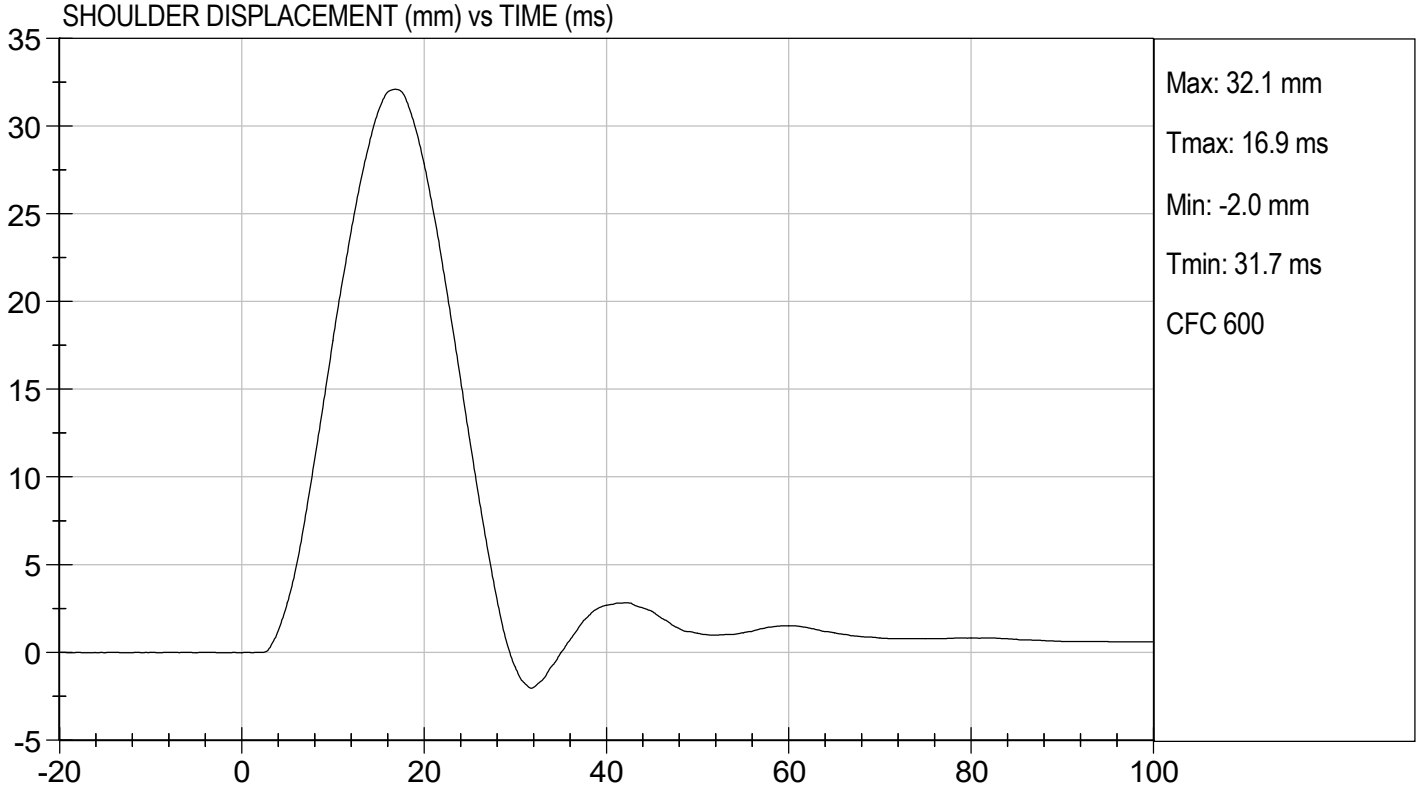
TEST DESC: THORAX IMPACT WITH ARM
VELOCITY: 21.93 ft/s, 6.68 m/s

TEST DATE: 02/16/2021
TEST #: D210424

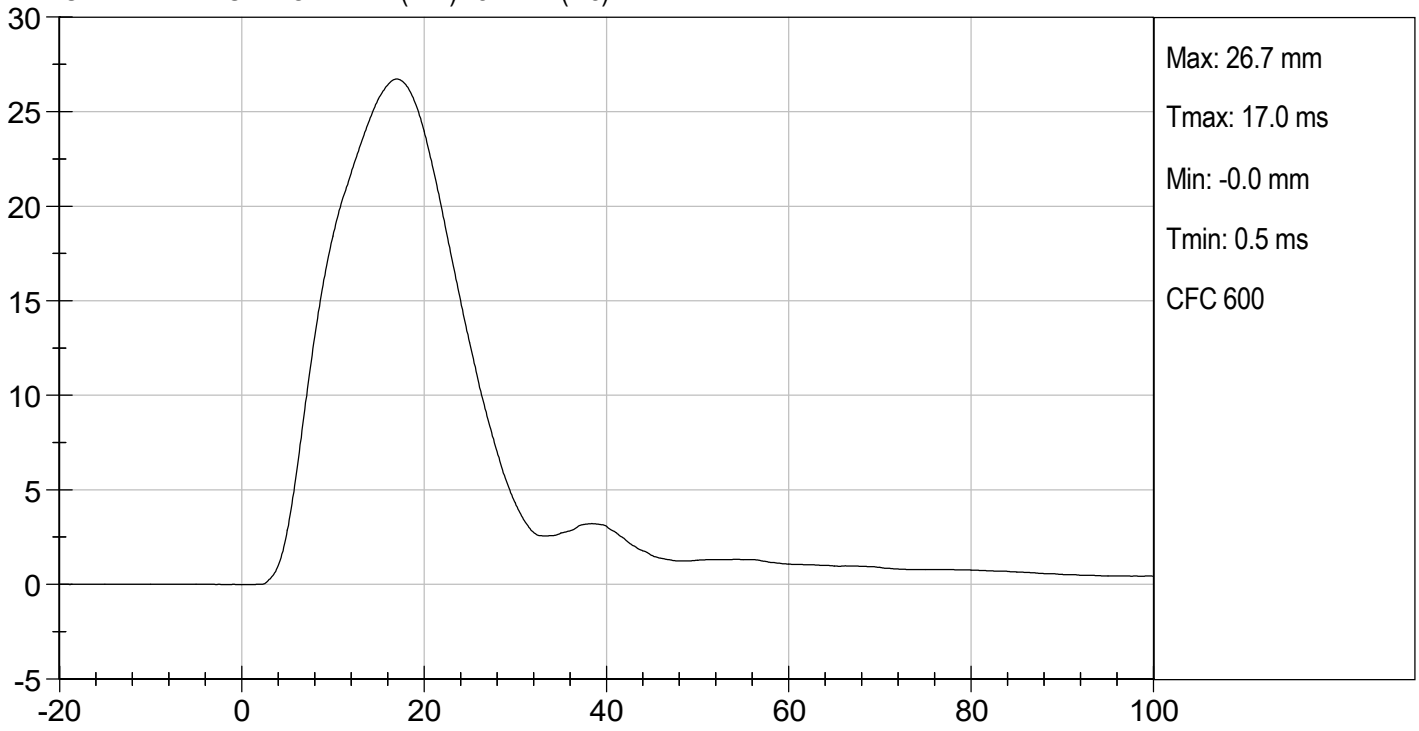
PROBE (G's) vs TIME (ms)



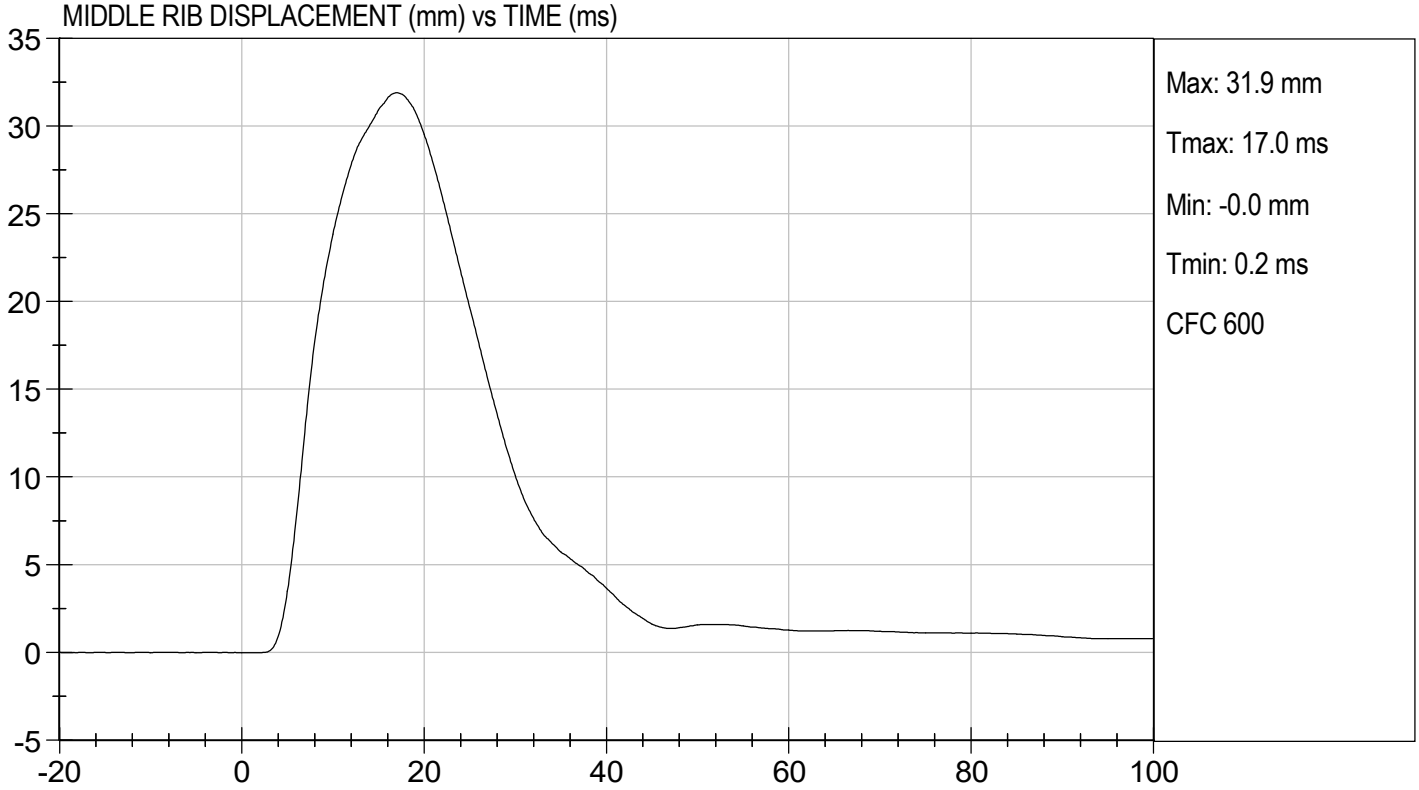
SHOULDER DISPLACEMENT (mm) vs TIME (ms)



UPPER RIB DISPLACEMENT (mm) vs TIME (ms)



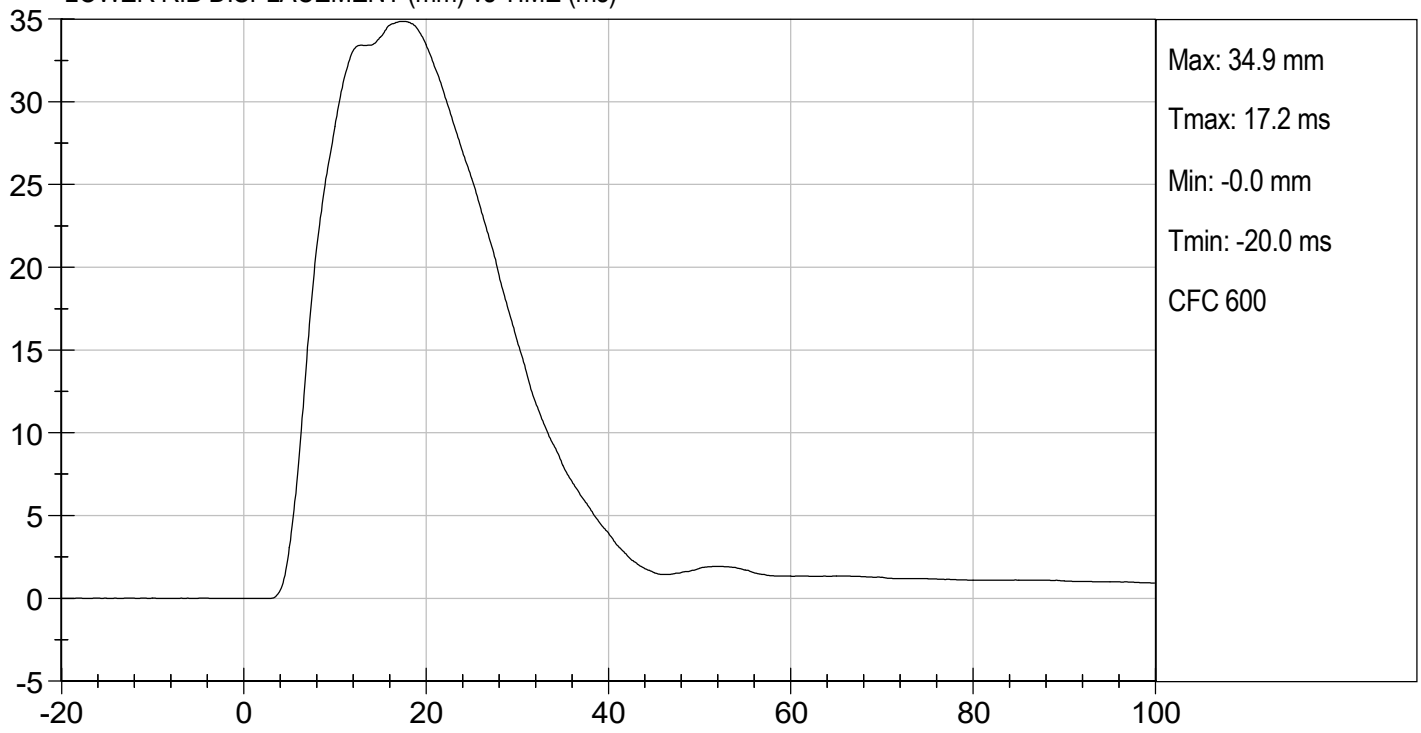
MIDDLE RIB DISPLACEMENT (mm) vs TIME (ms)



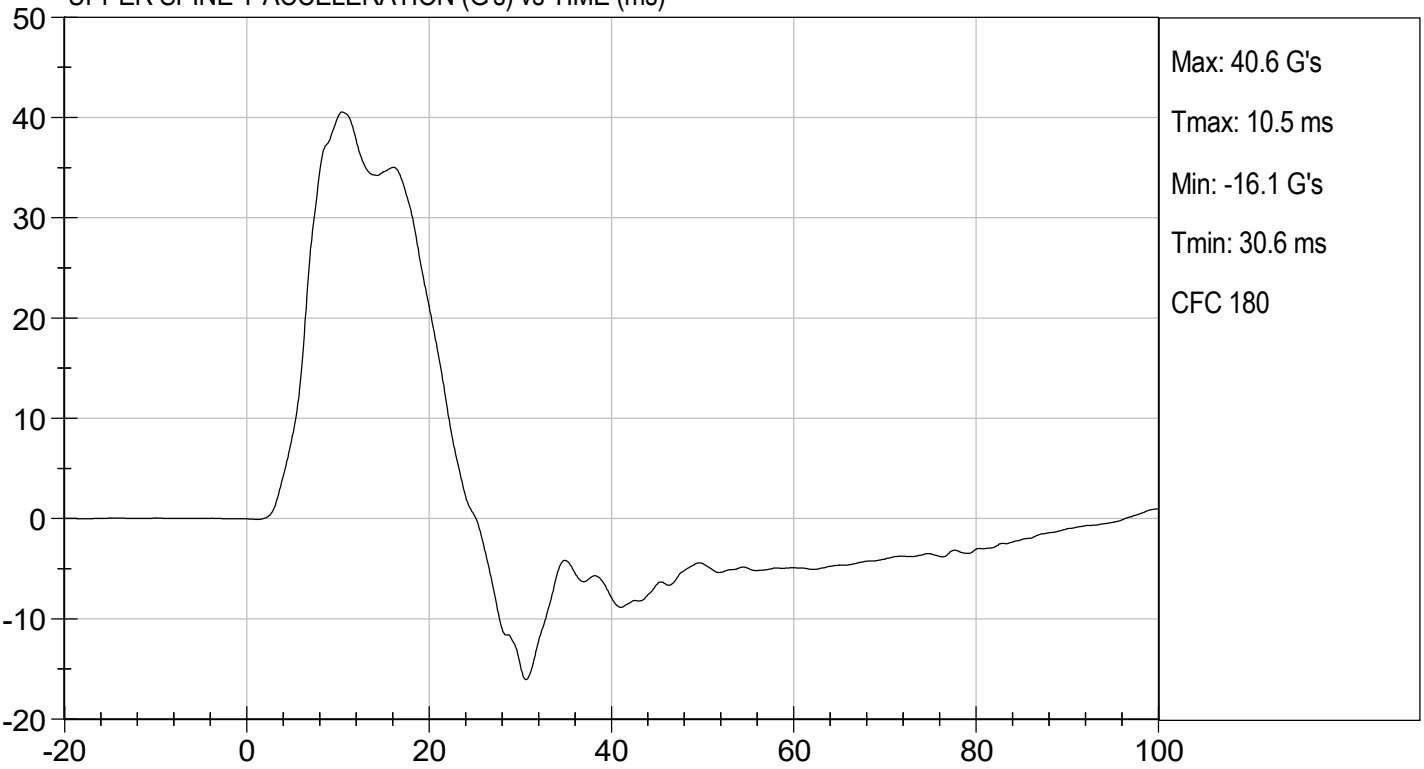
TEST DESC: THORAX IMPACT WITH ARM
VELOCITY: 21.93 ft/s, 6.68 m/s

TEST DATE: 02/16/2021
TEST #: D210424

LOWER RIB DISPLACEMENT (mm) vs TIME (ms)

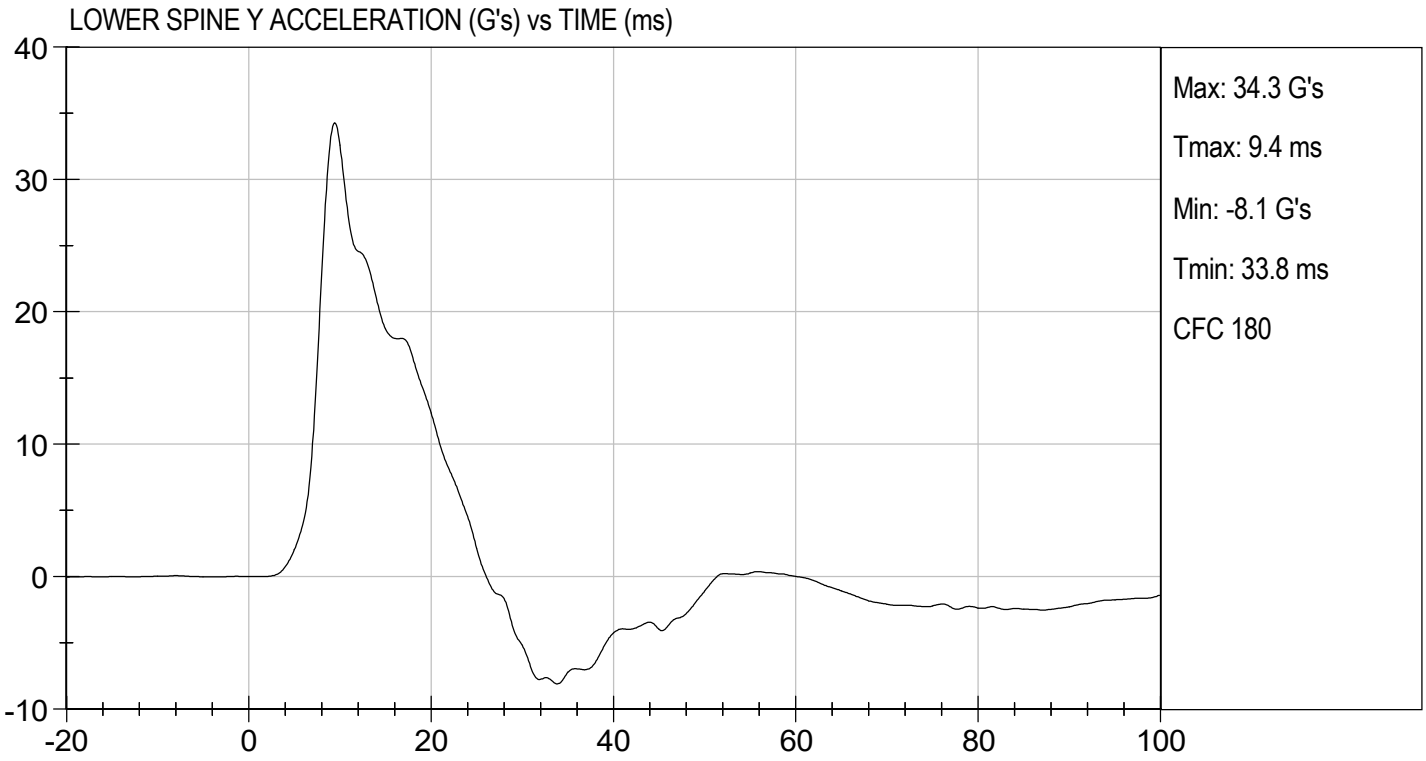


UPPER SPINE Y ACCELERATION (G's) vs TIME (ms)



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

TEST DATE: 02/16/2021
TEST #: D210424



MGA RESEARCH CORPORATION

THORAX (WITHOUT ARM) IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210425

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	20.8	Pass
Humidity	%	10 to 70	23	Pass
Impact Velocity	m/s	4.20 to 4.40	4.34	Pass
Maximum Probe Acceleration	G's	14 to 18	16	Pass
Upper Rib Displacement	mm	32 to 40	34	Pass
Middle Rib Displacement	mm	39 to 45	39	Pass
Lower Rib Displacement	mm	35 to 43	37	Pass
Upper Spine (T1) Y Acceleration	G's	13 to 17	16	Pass
Lower Spine (T12) Y Acceleration	G's	7 to 11	9	Pass
		Overall Test Results		Pass

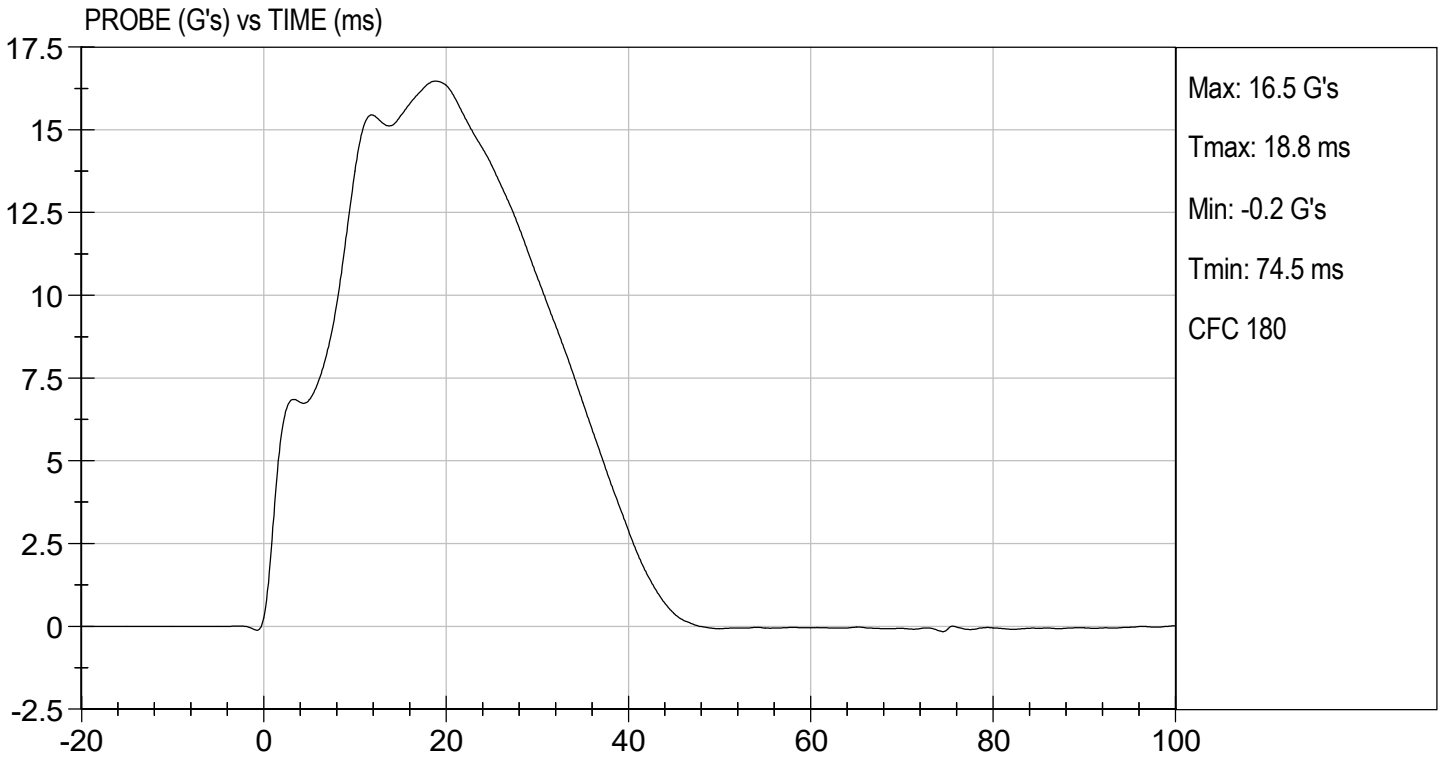
Gerald Guerrero
Laboratory Technician

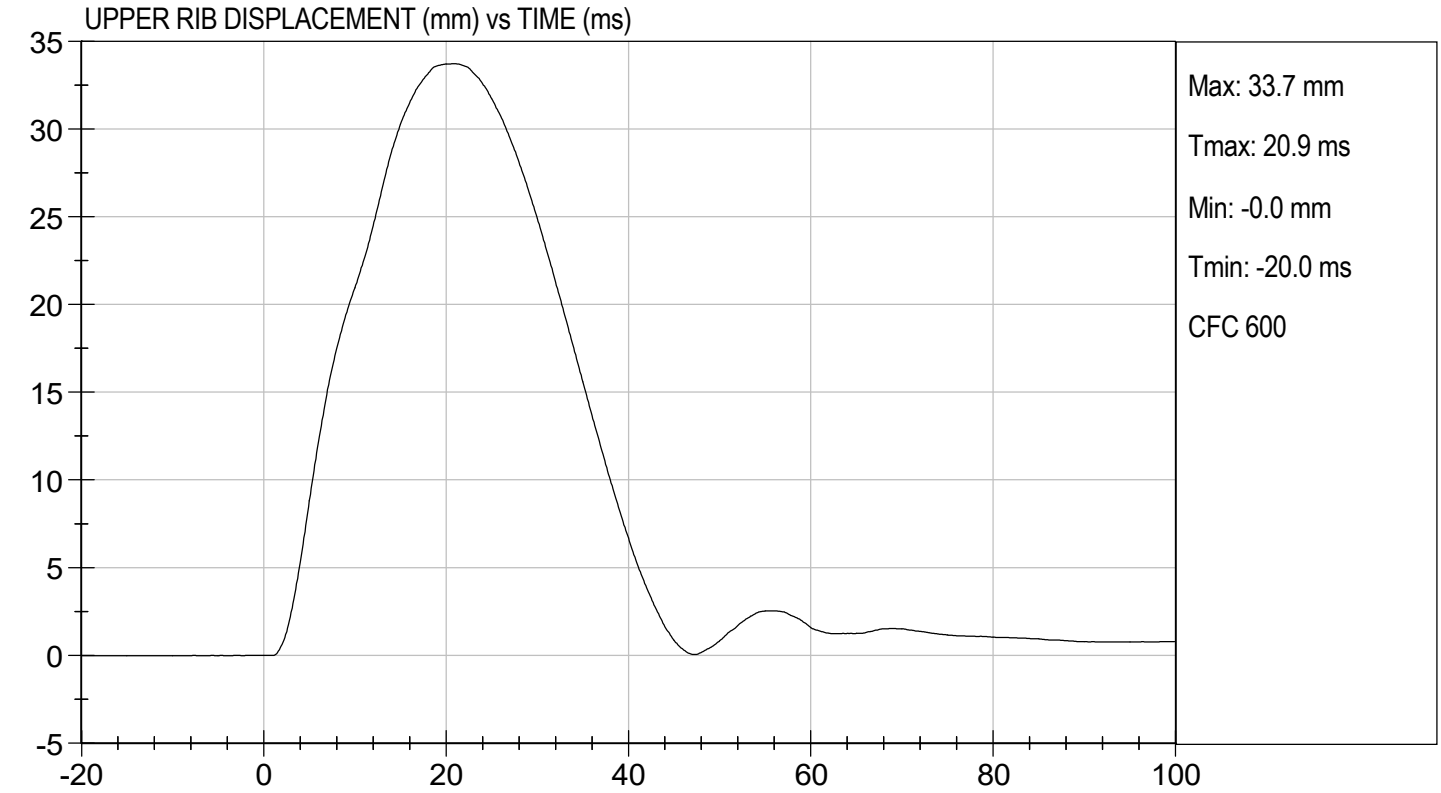
02/16/2021
Test Date

Approved By

TEST DESC: THORAX IMPACT WITHOUT ARM
VELOCITY: 14.24 ft/s, 4.34 m/s

TEST DATE: 02/16/2021
TEST #: D210425

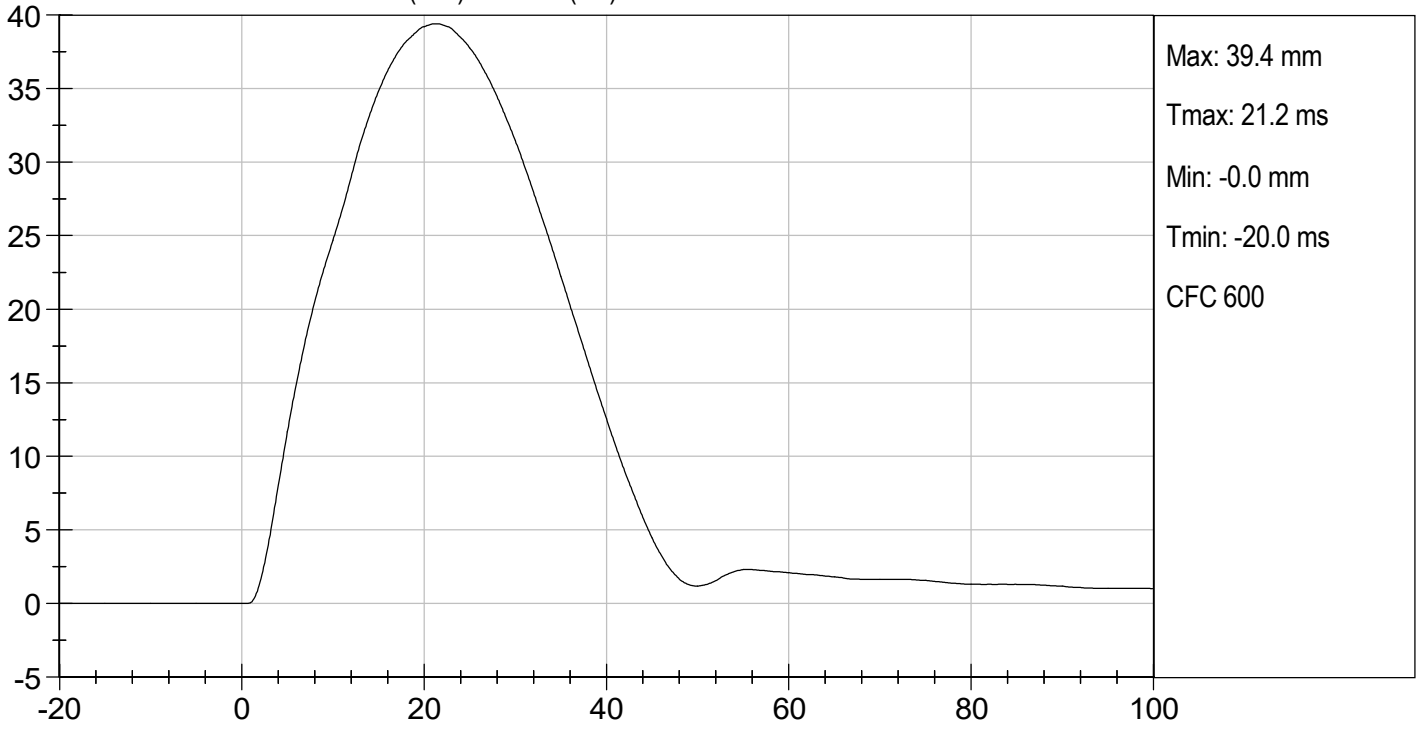




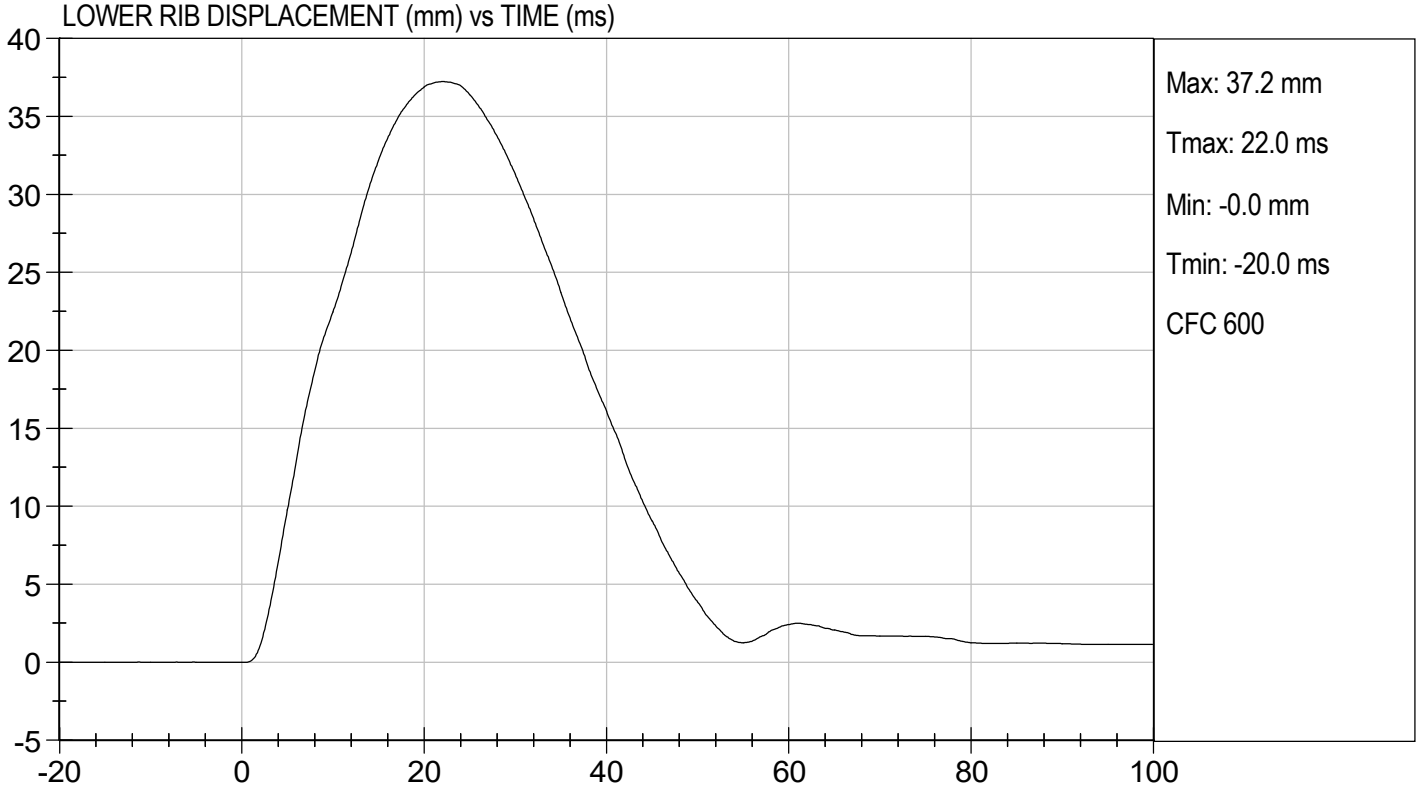
TEST DESC: THORAX IMPACT WITHOUT ARM
VELOCITY: 14.24 ft/s, 4.34 m/s

TEST DATE: 02/16/2021
TEST #: D210425

MIDDLE RIB DISPLACEMENT (mm) vs TIME (ms)



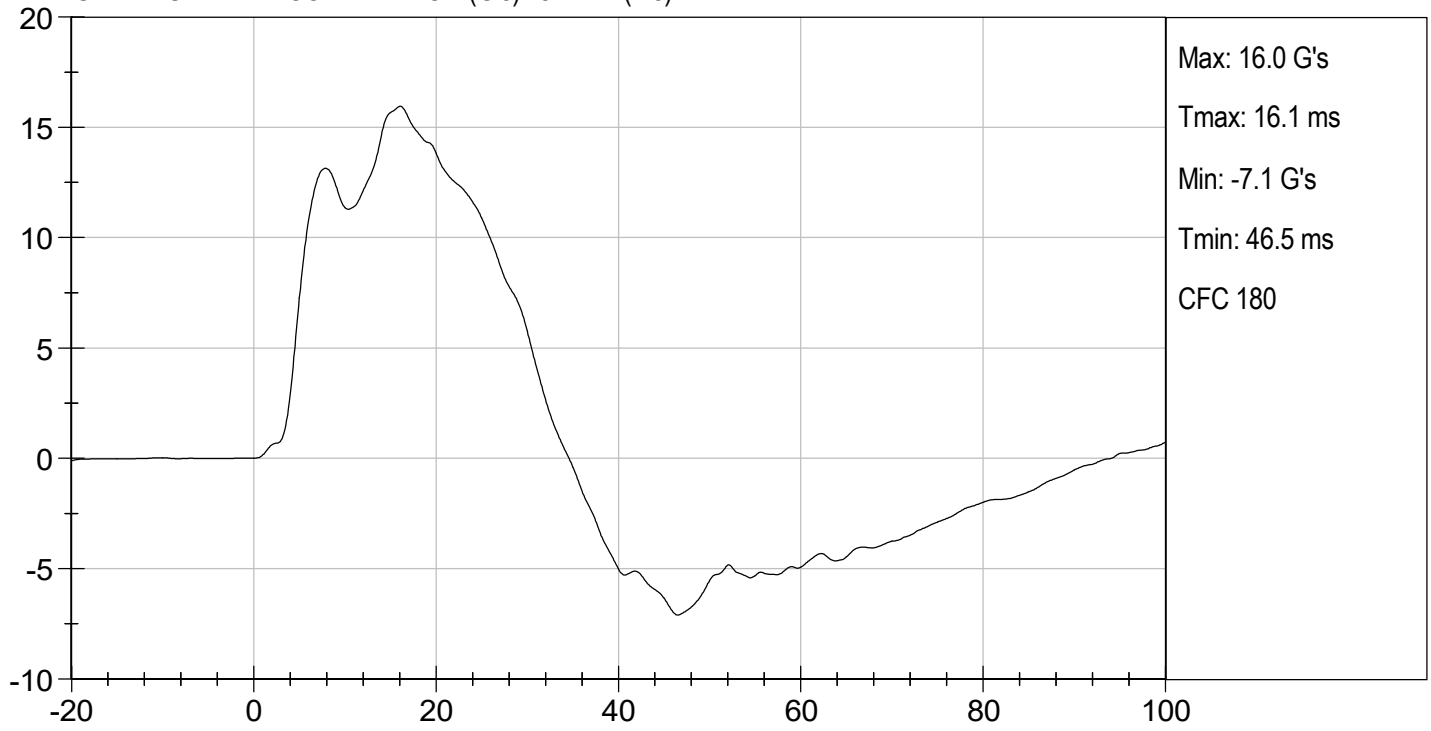
LOWER RIB DISPLACEMENT (mm) vs TIME (ms)



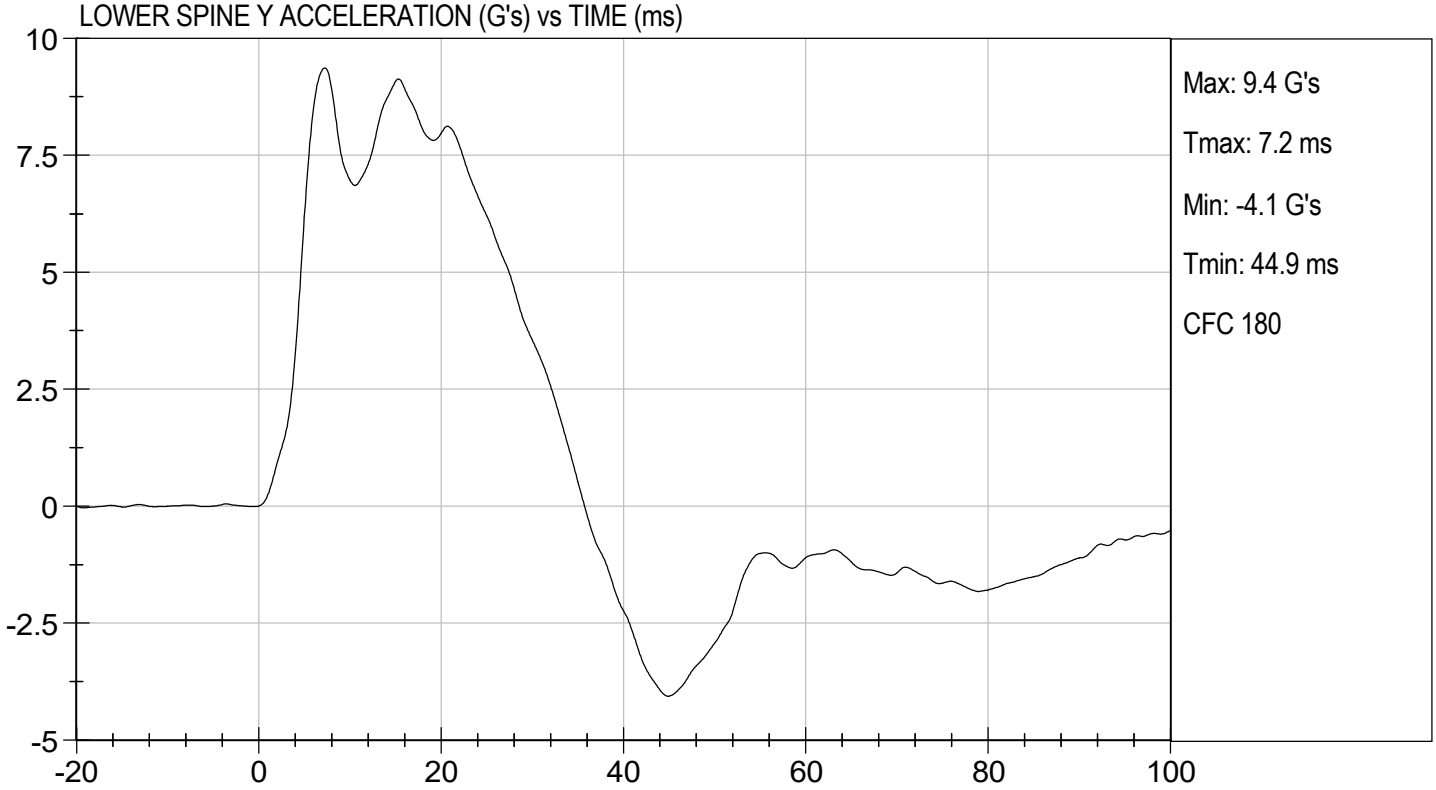
TEST DESC: THORAX IMPACT WITHOUT ARM
VELOCITY: 14.24 ft/s, 4.34 m/s

TEST DATE: 02/16/2021
TEST #: D210425

UPPER SPINE Y ACCELERATION (G's) vs TIME (ms)



LOWER SPINE Y ACCELERATION (G's) vs TIME (ms)



MGA RESEARCH CORPORATION

ABDOMINAL IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210426

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	20.8	Pass
Humidity	%	10 to 70	23	Pass
Impact Velocity	m/s	4.20 to 4.40	4.34	Pass
Maximum Probe Acceleration	G's	12 to 16	16	Pass
Upper Abdomen Rib Displacement	mm	36 to 47	39	Pass
Lower Abdomen Rib Displacement	mm	33 to 44	37	Pass
Lower Spine (T12) Y Acceleration	G's	9 to 14	12	Pass
		Overall Test Results		Pass

Laboratory Technician

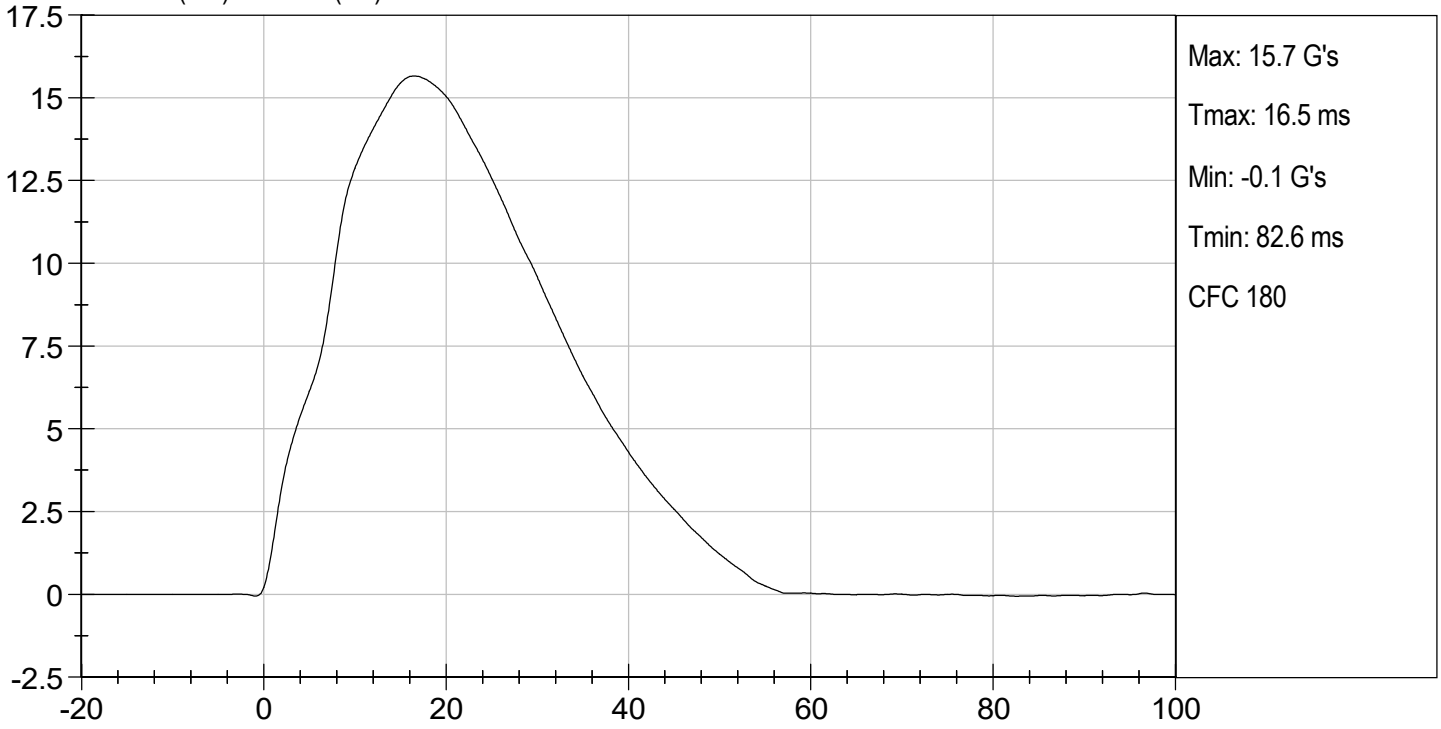
02/16/2021
Test Date

Approved By

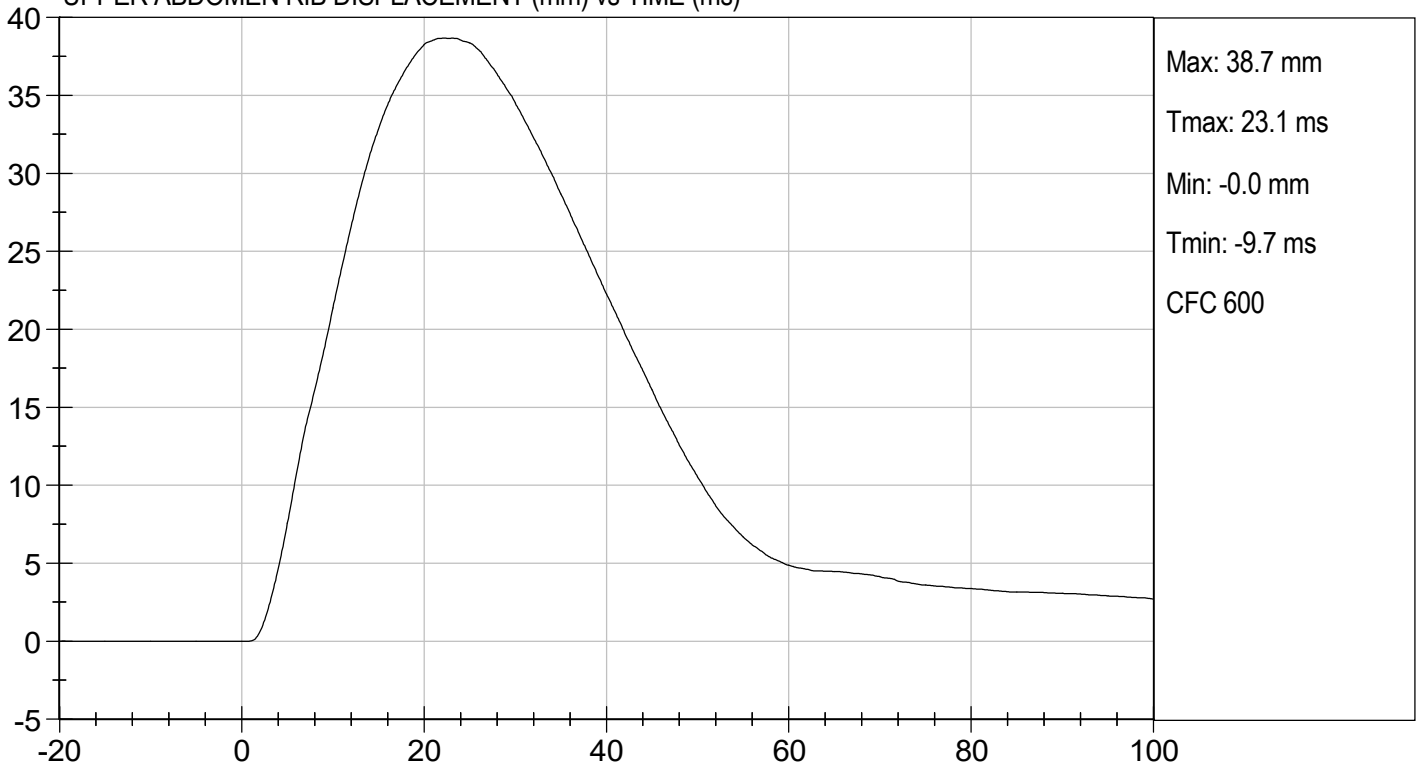
TEST DESC: ABDOMEN IMPACT
VELOCITY: 14.24 ft/s, 4.34 m/s

TEST DATE: 02/16/2021
TEST #: D210426

PROBE (G's) vs TIME (ms)



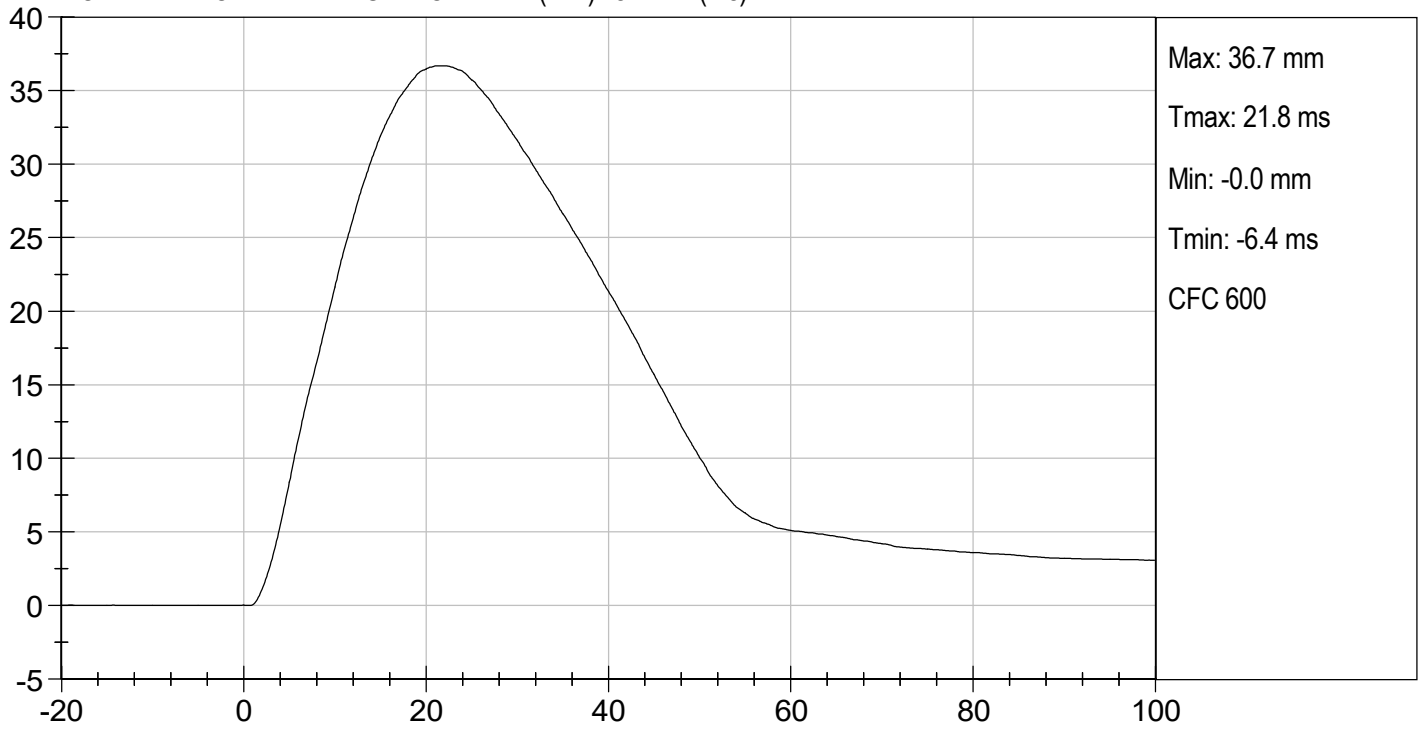
UPPER ABDOMEN RIB DISPLACEMENT (mm) vs TIME (ms)



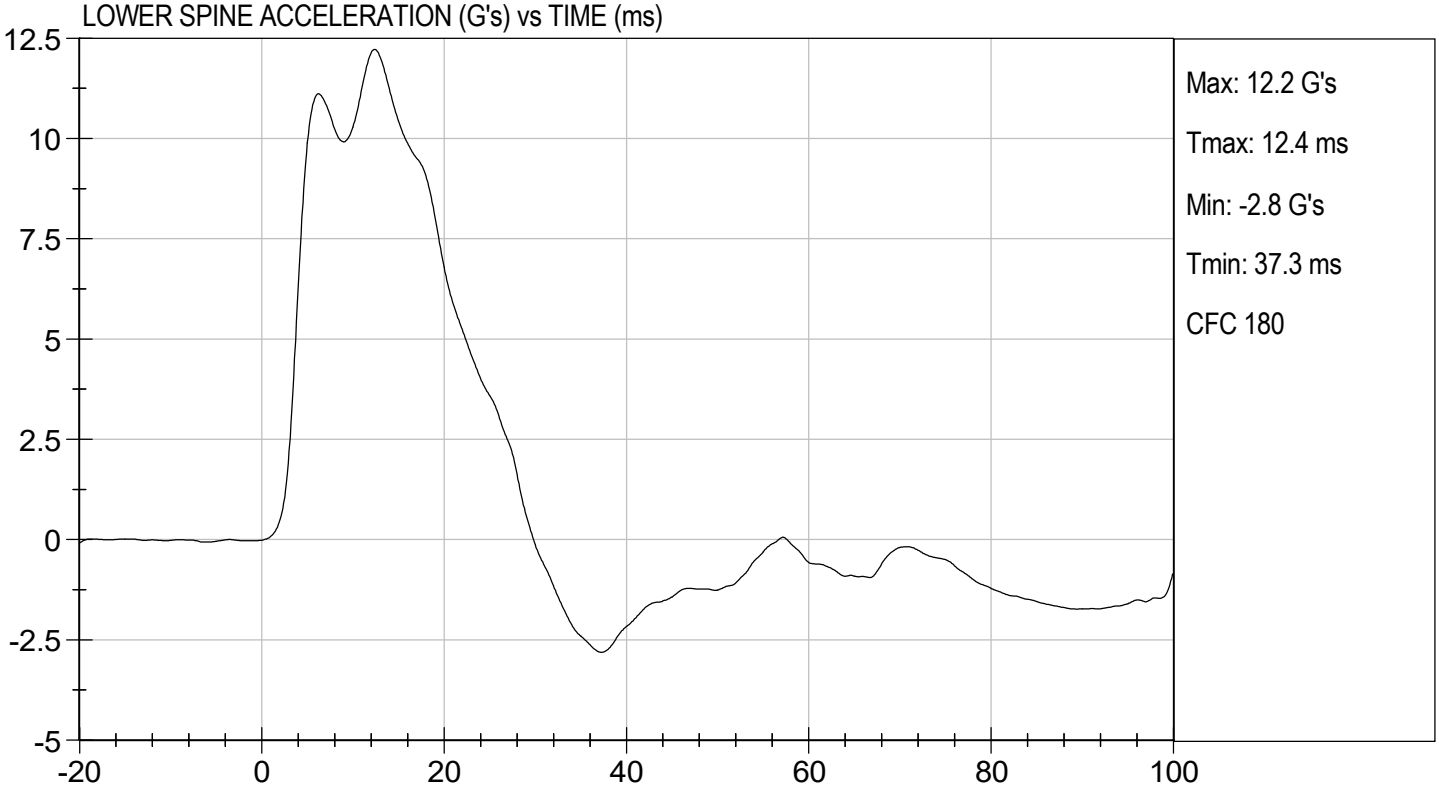
TEST DESC: ABDOMEN IMPACT
VELOCITY: 14.24 ft/s, 4.34 m/s

TEST DATE: 02/16/2021
TEST #: D210426

LOWER ABDOMEN RIB DISPLACEMENT (mm) vs TIME (ms)



LOWER SPINE ACCELERATION (G's) vs TIME (ms)



MGA RESEARCH CORPORATION

PELVIS IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210427

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.5	Pass
Humidity	%	10 to 70	22	Pass
Impact Velocity	m/s	6.60 to 6.80	6.60	Pass
Maximum Probe Acceleration	G's	38 to 47	46	Pass
Pelvis Y Acceleration After 6 ms	G's	34 to 42	36	Pass
Peak Acetabulum Force	N	3600 to 4300	4,133	Pass
		Overall Test Results		Pass

Gerald Guerrero
Laboratory Technician

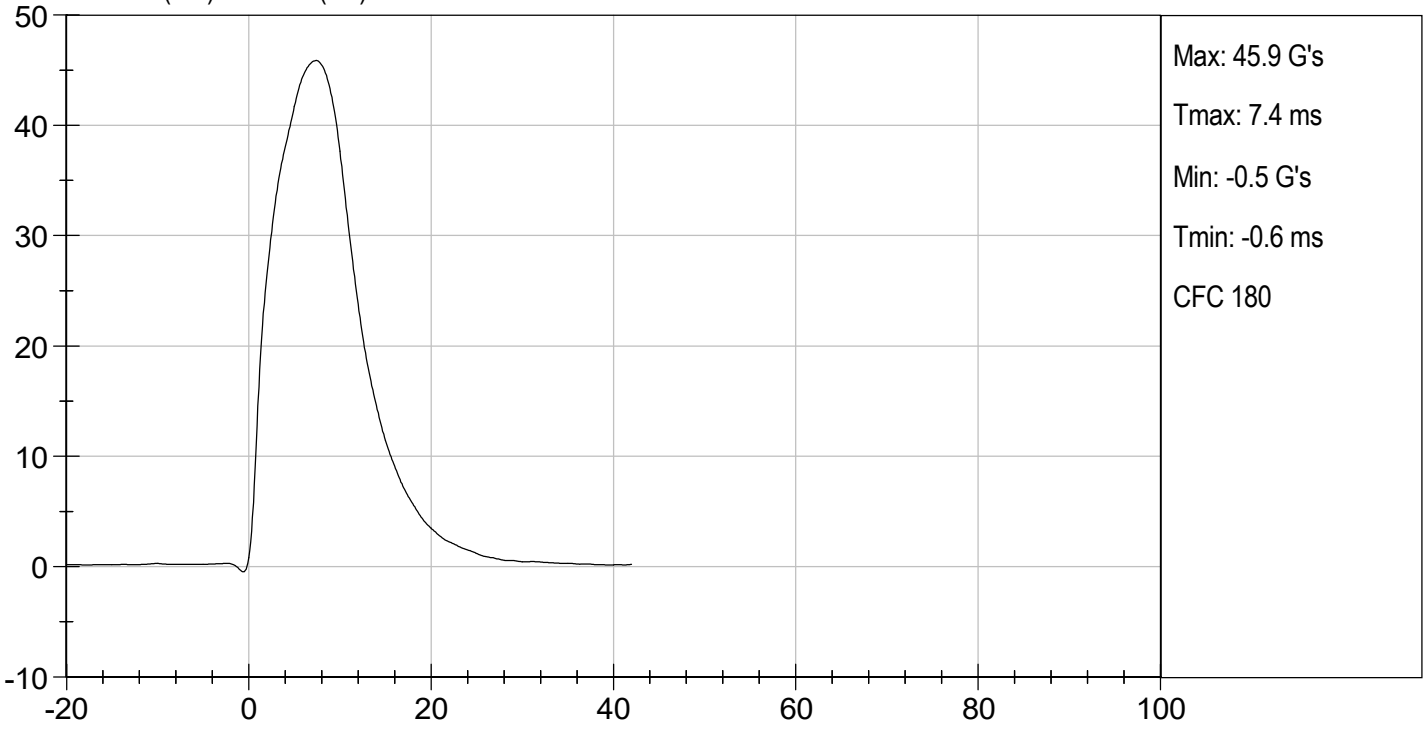
02/16/2021
Test Date

Approved By

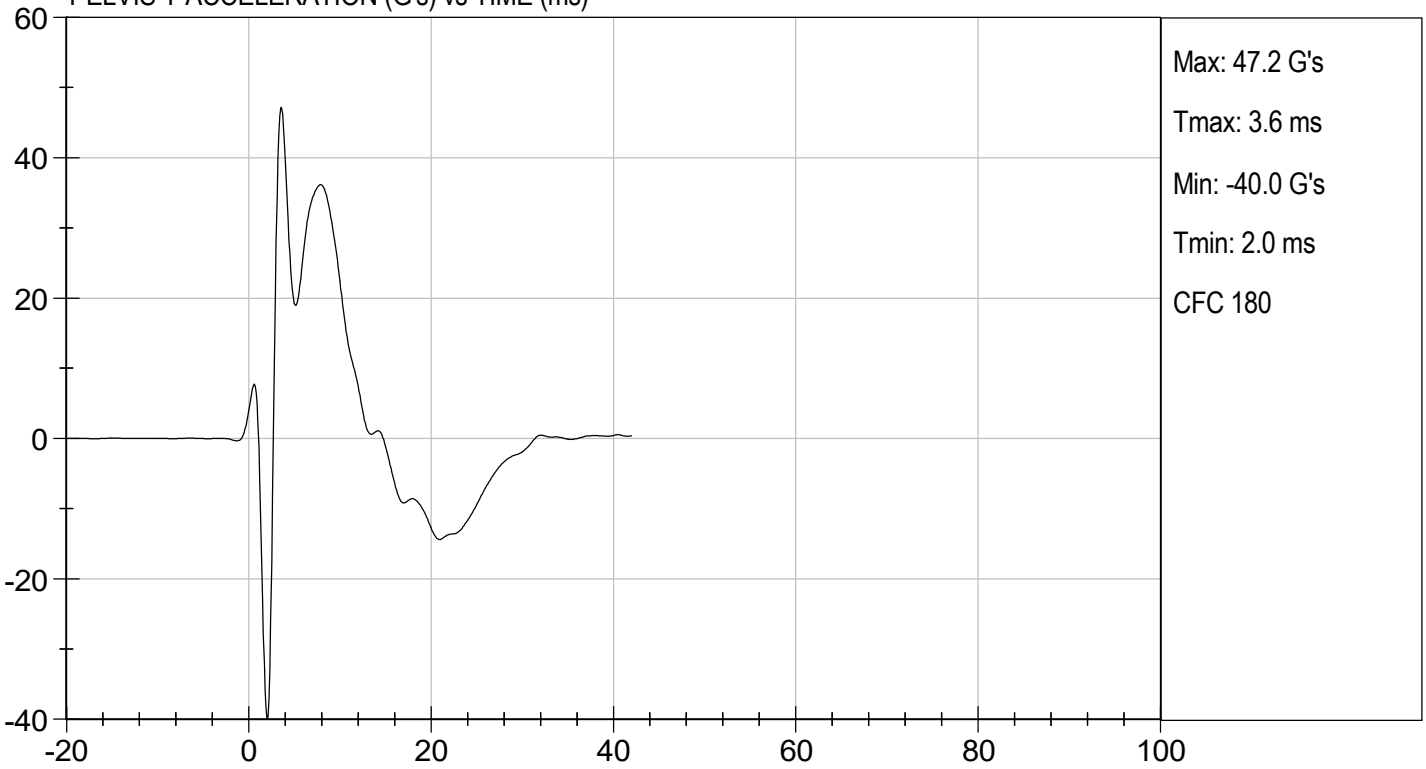
TEST DESC: PELVIS IMPACT
VELOCITY: 21.65 ft/s, 6.60 m/s

TEST DATE: 02/16/2021
TEST #: D210427

PROBE (G's) vs TIME (ms)

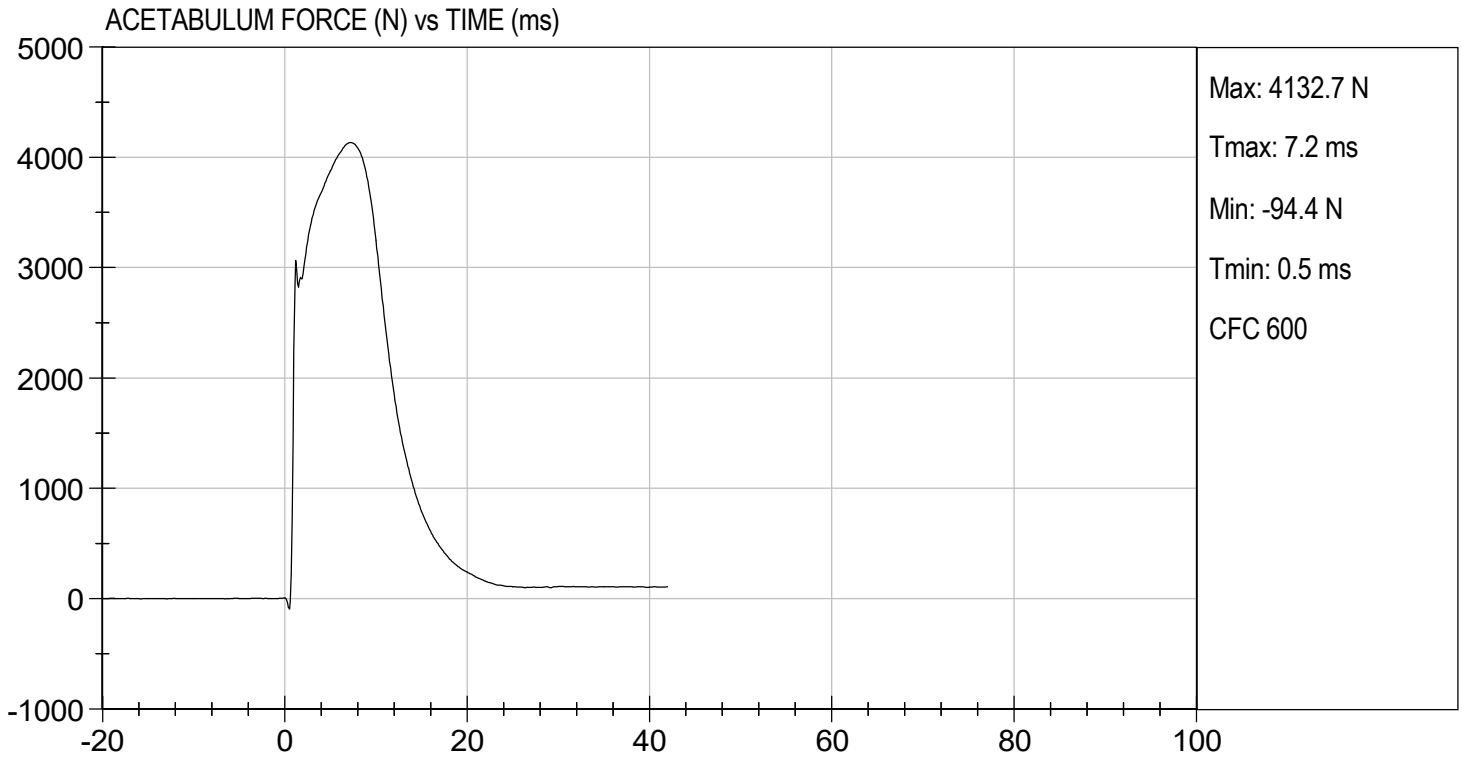


PELVIS Y ACCELERATION (G's) vs TIME (ms)



TEST DESC: PELVIS IMPACT
VELOCITY: 21.65 ft/s, 6.60 m/s

TEST DATE: 02/16/2021
TEST #: D210427



MGA RESEARCH CORPORATION

ILIAC IMPACT TEST

SID-IIs BUILD LEVEL D DUMMY

ATD Serial No: 304 **Test I.D:** D210428

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.7	Pass
Humidity	%	10 to 70	16	Pass
Impact Velocity	m/s	4.20 to 4.40	4.34	Pass
Maximum Probe Acceleration	G's	36 to 45	42	Pass
Pelvis Y Acceleration	G's	28 to 39	31	Pass
Peak Pelvis Iliac Force	N	4100 to 5100	4,747	Pass
		Overall Test Results		Pass

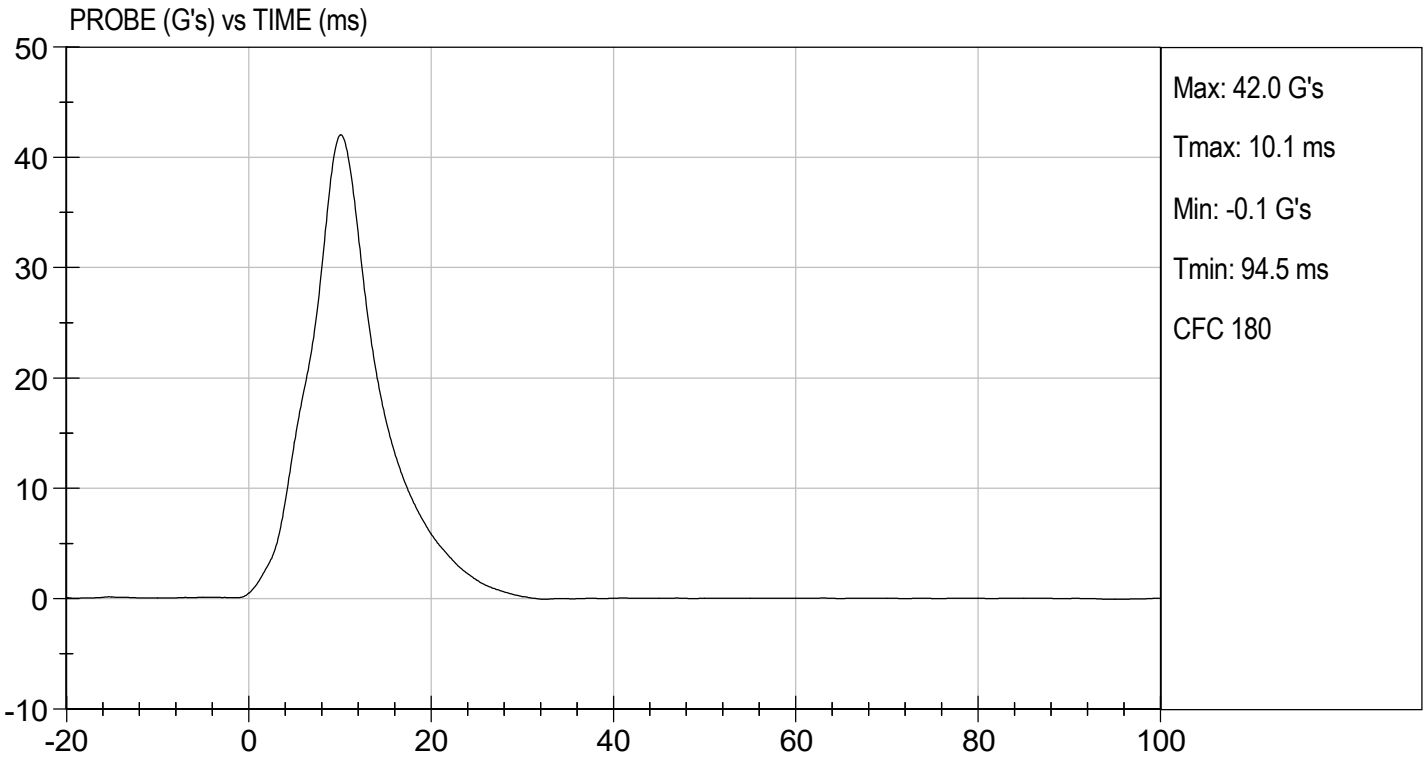
Gerald Guerrero
Laboratory Technician

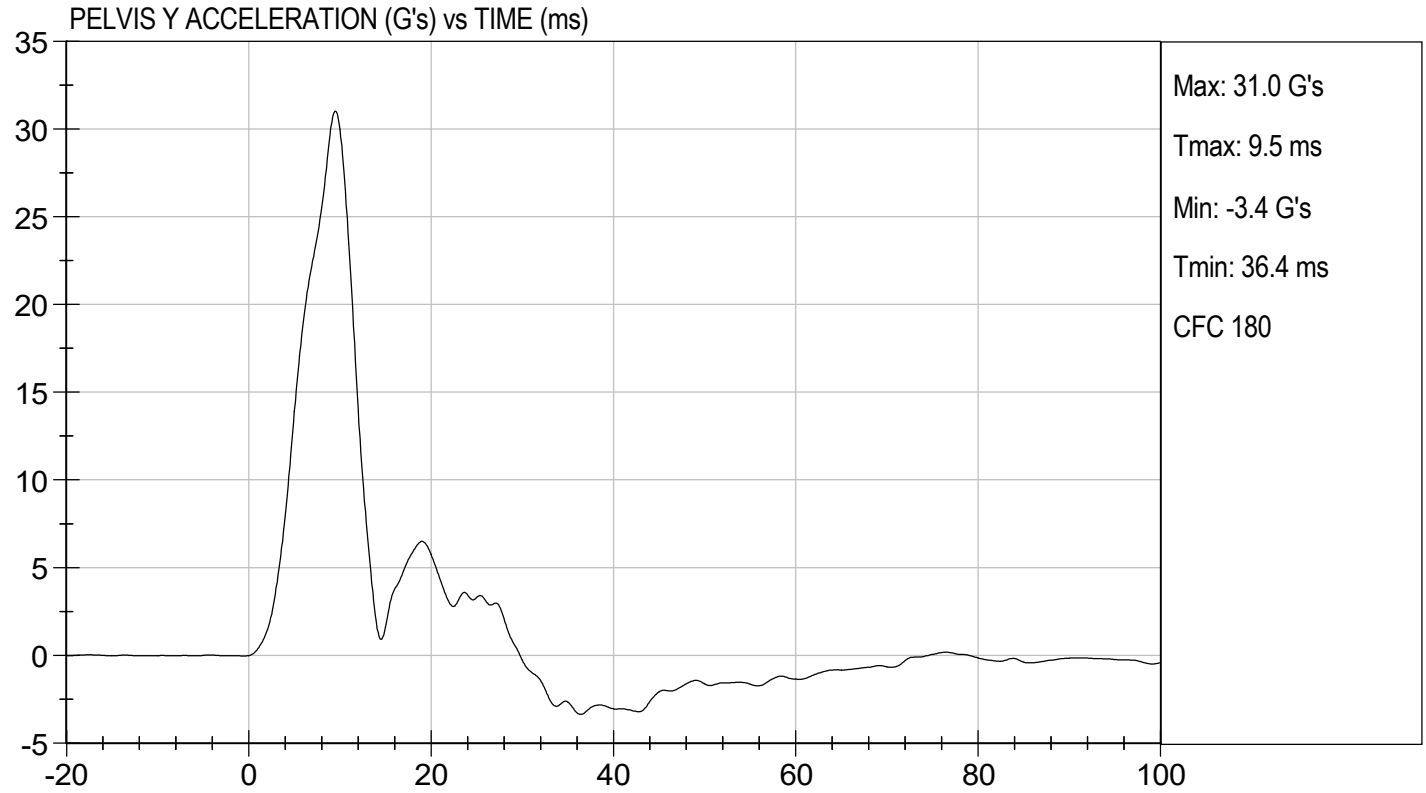
02/15/2021
Test Date

Approved By

TEST DESC: ILLIAC
VELOCITY: 14.25 ft/s, 4.34 m/s

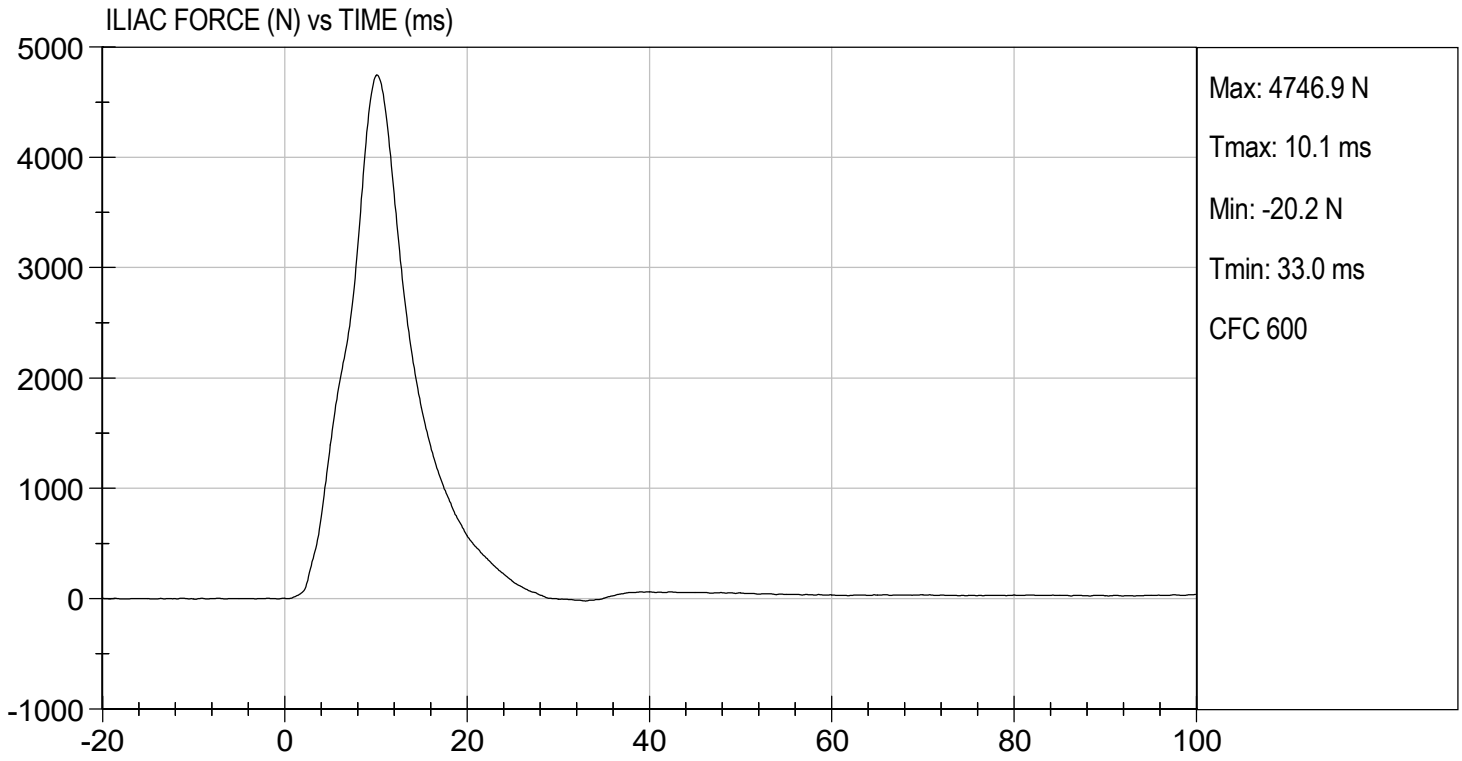
TEST DATE: 02/15/2021
TEST #: D210428





TEST DESC: ILLIAC
VELOCITY: 14.25 ft/s, 4.34 m/s

TEST DATE: 02/15/2021
TEST #: D210428



APPENDIX D
TEST EQUIPMENT AND INSTRUMENTATION CALIBRATION DATA

Table 1 – Dummy Instrumentation

		SID-IIs S/N 304		
		Serial Number	Manufacturer	Calibration Date
Head CG Accelerometers	X	P79001	Endevco	01/28/2021
	Y	P79003	Endevco	01/28/2021
	Z	P79004	Endevco	01/28/2021
	Xr	P83047	Endevco	01/28/2021
	Yr	P83048	Endevco	01/28/2021
	Zr	P83049	Endevco	01/28/2021
Upper Neck Load Cell		NG1911	Denton	07/20/2020
Lower Neck Load Cell		LNGDJ2031	Denton	02/19/2020