REPORT NUMBER: TWG-CAL-20-01

NEW CAR ASSESSMENT PROGRAM (NCAP)
SIDE AIRBAG OUT-OF-POSITION TEST

Subaru Corporation
2020 Subaru WRX
Four Door Sedan

NHTSA NUMBER: M20205502TWG2

PREPARED BY:
CALSPAN CORPORATION
4455 Genesee St.
BUFFALO, NEW YORK 14225

July 9, 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

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Approval Date: July 9, 2021

FINAL REPORT ACCEPTANCE BY OCWS:

Accepted By: _____

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

Date: _____

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COR, New Car Assessment Program
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Date: _____

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16. Abstract

A side air bag out of position test was conducted on the subject 2020 Subaru WRX four door sedan in accordance with the specifications of the Office of Crashworthiness Standards SAB OOP NCAP Laboratory Test Procedure for the generation of consumer information on vehicle side air bag protection. The test was conducted at the Calspan Corporation Test Facility in Buffalo, New York, on August 5, 2020.

The curtain and torso side air bags were deployed and responses were measured on a SID-IIs. Four high-speed cameras recorded the event. The ambient temperature at the time of air bag deployment was 21 °C

Section 3.3.5.3 – SID-IIs – Right Front Passenger Seat			
Measurement Description	**Units**	**IARV**	**Result**
Head Injury Criteria (HIC15)		779	29.20
Nij		1.0	0.415
Upper Neck Tension	N	2070	192.955
Upper Neck Compression	N	2520	-1380.080
Maximum Chest Compression	mm	N/A	N/A
Maximum Chest Compression Rate	m/s	N/A	N/A

17. KEY Words: New Car Assessment Program (NCAP) Side Air Bag Out-of-Position (OOP) Technical Working Group (TWG)	18. Distribution Statement Copies of this report are available from the following: National Highway Traffic Safety Administration Technical Information Services 1200 New Jersey Ave, SE Washington, DC 20590 Email: tis@nhtsa.dot.gov FAX: 202-493-2833

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SECTION 1

PURPOSE AND PROCEDURE OF TEST:

1.1 PURPOSE

The purpose of this test was to obtain data from a static out-of-position side air bag deployment using a vehicle that had previously undergone a New Car Assessment Program (NCAP) sponsored side moving deformable barrier impact test requested by the National Highway Traffic Safety Administration (NHTSA). This test was performed under NHTSA contract No. 693JJ919F000146.

SECTION 2

SUMMARY OF TEST RESULTS

The effects of both a seat-mounted side airbag and a curtain airbag deployment in a 2020 Subaru WRX on an out-of-position SID-IIs ATD were evaluated. The test was performed by Calspan on August 5, 2020. Pre-and post-test photographs of the vehicle and ATD can be found in Appendix A.

The vehicle has previously undergone crash testing as part of the NCAP program. After conducting the crash test and before conducting the air bag deployment test, the vehicle was inspected for damage. The vehicle was found to be in good condition to undergo the air bag deployment test.

Four high-speed digital cameras were used to document the airbag deployment event. High-speed images were recorded at rates of 1000 frames per second. Cameras were placed perpendicular to the right-front passenger seat centerline, oblique, dummy front, and through the passenger window to capture the deployment event from various positions.

The SID-IIs anthropomorphic test device (ATD) was placed in the right front passenger seat facing towards the center of the vehicle with its arm in a horizontal position against the seatback. This placement followed the ATD placement instructions in the NCAP Laboratory Test Procedure as well as 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). 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.

The SID-IIs ATD was instrumented with head x, y and z accelerometers, a six-axis upper neck load cell, and a six-axis lower neck load cell. During the air bag deployment event, a total of 22 channels of data were recorded using an on-board data acquisition system. Appendix B contains the ATD response data traces and Appendix C contains the instrumentation list and calibration information. Appendix D contains the dummy's pre-test qualification performance verification data.

No Injury Reference Values were exceeded during the test. The occupant data is summarized below:

Measurement Description	Units	SID-IIs	
		IARV	Result
Head Injury Criteria (HIC15)		779	29.20
Nij		1.0	0.415
Upper Neck Tension	N	2070	192.955
Upper Neck Compression	N	2520	-1380.080
Thorax Deflection	mm	-	N/A
Thorax Deflection Rate	m/s	-	N/A

SECTION 3
DATA SHEETS

DATA SHEET NO. 1
TEST SUMMARY

Test Vehicle:	2020 Subaru WRX four door sedan	NHTSA No.:	M20205502TWG2
Test Program:	TWG 3.3.5.3	Test Date:	8/5/2020

TEST CONFIGURATION INFORMATION

Seating Position:	P2	Right Front Seating Position
Test:	3.3.5.3	Inboard Facing SID-IIs on Raised Seat
Airbag: 1	Curtain	Roof Rail Mounted – Passenger Side
Airbag: 2	Seat/Torso	Front Passenger Seat Mounted – Outside Seam
Booster Block:	N/A	N/A
ATD Type/Serial No.:	DG8012	SID-IIs
Vehicle	Subaru	WRX
Previous Crash Test	SINCAP	NCAP Side MDB – NHTSA No. M20205502

EQUIPMENT INFORMATION

Number of Data Channels	22
Number of High Speed Video Cameras	4
Number of Real Time Video Cameras	0

VISIBLE DUMMY CONTACT POINTS

Head Contact:	Curtain Airbag
Upper Torso Contact:	Torso/Pelvis Airbag
Lower Torso Contact:	Torso/Pelvis Airbag
Knee Contact:	Passenger Seat Pan
Foot Contact:	Driver Seat Pan

DATA SHEET NO. 2
GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2020 Subaru WRX four door sedan NHTSA No.: M20205502TWG2

Test Program: TWG 3.3.5.3 Test Date: 8/5/2020

TEST VEHICLE INFORMATION AND OPTIONS

NHTSA No.	M20205502TWG2
Model Year	2020
Make	Subaru
Model	WRX
Body Style	Four Door Sedan
VIN	JF1VA1A62L9801577
Body Color	Blue
Odometer Reading (km /mi)	178 mi
Engine Displacement (L)	2.0
Type / No. Cylinders	I4
Engine Placement	Transverse
Transmission Type	Manual
Transmission Speeds	6-Speed
Overdrive	Yes
Final Drive	All Wheel Drive
Roof Rack	No
Sunroof / T-Top	No
Running Boards	No
Tilt Steering Wheel	Yes
Power Seats	No
Anti-Lock Brakes (ABS)	Yes

Traction Control System (TCS)	Yes
Auto-Leveling System	No
Automatic Door Locks (ADLs)	Yes
Power Window Auto-Reverse	No
Other Optional Feature	-
Driver Frontal Airbag	Yes
Driver Curtain Airbag	Yes
Driver Head/Torso Airbag	No
Driver Torso Airbag	No
Driver Torso/Pelvis Airbag	Yes
Driver Pelvis Airbag	No
Driver Knee Airbag	Yes
Rear Pass. Curtain Airbag	Yes
Rear Pass. Head/Torso Airbag	No
Rear Pass. Torso Airbag	No
Rear Pass. Torso/Pelvis Airbag	No
Rear Pass. Pelvis Airbag	No
Driver Pretensioner	Yes
Rear Pass. Pretensioner	No
Driver Load Limiter	Yes
Rear Pass. Load Limiter	No
Other Safety Restraint	-

DATA FROM CERTIFICATION LABEL

Manufactured By	Subaru Corporation
Date of Manufacture	08/19
Vehicle Type	MPV

GVWR (kg)	2000
GAWR Front (kg)	1075
GAWR Rear (kg)	1040

VEHICLE SEATING AND WEIGHT CAPACITY DATA

Measured Parameter	Front	Rear	Third	Total	
Designated Seating Capacity (DSC)	2	3	N/A	5	
Capacity Wt. (VCW) (kg)				385	(A)
DSC x 68.04 (kg)				340.2	(B)
Cargo Wt. (RCLW) (kg)				44.8	(A-B)

VEHICLE SEAT TYPE

Seating Location	Type of Seat Pan				Type of Seatback		
	Bucket	Bench	Split Bench	Contoured	Fixed	Adjustable w/lever	Adjustable w/knob
Front Seat	X					X	
Rear or Second Row			X		X		
Third Row							

DATA SHEET NO. 3
SEAT ADJUSTMENT DATA

Test Vehicle:	2020 Subaru WRX four door sedan	NHTSA No.:	M20205502TWG2
Test Program:	TWG 3.3.5.3	Test Date:	8/5/2020

VEHICLE SEAT FORE / AFT POSITION

Seat Location	Total Fore / Aft Travel		Test Position from Forwardmost Position	
	mm	Detents*	mm	Detent*
Front Right	240	25 (0-24)	120	12
Rear Right	N/A	N/A	N/A	N/A

TWG Seat Fore/Aft Guideline Reference	
Seat Fore/Aft Position Per TWG Guidelines	Should be moved forward to minimize the vertical distance between the ATD's head and the roof-rail module and to maximize the cushion to head interaction
Reason for Deviation from TWG Guidelines	No Deviation from TWG guidelines

VEHICLE SEAT BACK ANGLE ADJUSTMENT

Seat Location	Total Seat Back Angle Range		Test Position from Most Upright (Vertical)	
	Degrees	Detents*	Degrees	Detents*
Front Right	69.6	-	-1.2	5
Rear Right	N/A	N/A	N/A	N/A

TWG Seat Back Guideline Reference	
OEM Seat Back Angle Design Position	5th Detent from forward most position (0)
Method of Measuring Seat Back Angle Position	Headrest Post
Seat Back Angle Position Per TWG Guidelines	-1.2° (5th Detent)
Reason for Deviation from TWG Guidelines	No Deviation from TWG guidelines

VEHICLE SEAT HEIGHT ADJUSTMENT

Seat Location	Total Height Adjustment Range		Test Position from Lowermost Position	
	mm	Detents*	mm	Detent*
Front Right	N/A	N/A	Not Adjustable	N/A
Rear Right	N/A	N/A	N/A	N/A

TWG Seat Vertical Seat Height Guideline Reference	
Seat Height Position Per TWG Guidelines	No Height Adjustment – Lowest Position
Reason for Deviation from TWG Guidelines	No Deviation from TWG guidelines

DATA SHEET NO. 4
DUMMY SETUP AND POSITIONING DATA

Test Vehicle:	2020 Subaru WRX four door sedan	NHTSA No.:	M20205502TWG2
Test Program:	TWG 3.3.5.3	Test Date:	8/5/2020

DUMMY INFORMATION

ATD Type:	SID-IIs
Serial Number:	DG8012
Qualification Date:	July 29, 2020
Qualification Type:	Full Qualification
Clothing:	Cotton knit shirt and pants
Other ATD Prep:	The skullcap seam was taped with 4mm wide electrical tape and the ATD's head was cleaned with alcohol and dusted with baby powder.
ATD Temperature:	21° C

DUMMY POSITIONING INFORMATION

TWG Setup Instructions:	Seat the dummy facing toward the center of the vehicle with its arm against the seatback in a horizontal position. Adjust the seat track position forward to minimize the vertical distance between the dummy's head and the roof-rail module and to maximize the cushion to head interaction. Keeping the head in its neutral orientation, slide the dummy's pelvis outboard until the dummy's back contacted the door trim and the CG of the head was centered in the deployment trajectory of the airbag.
Actual Setup:	The dummy was seated facing toward the center of the vehicle with its arm against the seatback in a horizontal position. The seat track was positioned at mid-track to minimize the vertical distance between the dummy's head and the roof-rail module and to maximize the cushion to head interaction. Keeping the head in its neutral orientation the dummy's pelvis was slid outboard until the dummy's back contacted the door trim and the Head CG was centered in the deployment trajectory of the airbag.

DATA SHEET NO. 5
DUMMY INJURY CRITERIA DATA

Test Vehicle: 2020 Subaru WRX four door sedan NHTSA No.: M20205502TWG2
Test Program: TWG 3.3.5.3 Test Date: 8/5/2020

RECORDED DATA – MINIMUMS AND MAXIMUMS

Channel	Units	Max	Time (ms)	Min	Time (ms)
V1P2 Head x [CFC_1000]	g's	27.75	13.10	-5.62	78.95
V1P2 Head y [CFC_1000]	g's	10.85	11.80	-7.17	12.15
V1P2 Head z [CFC_1000]	g's	54.22	12.00	-14.32	14.20
V1P2 Headform Resultant [CFC_1000]	g's	58.81	12.00	0.00	-33.90
V1P2 Upper Neck Mocy [CFC_600]	Nm	12.75	65.55	-23.39	33.40
V1P2 Upper Neck Ntf [CFC_600]	-	0.10	66.60	0.00	-49.80
V1P2 Upper Neck Nte [CFC_600]	-	0.38	34.65	0.00	-50.00
V1P2 Upper Neck Ncf [CFC_600]	-	0.41	14.65	0.00	-50.00
V1P2 Upper Neck Nce [CFC_600]	-	0.41	32.55	0.00	-50.00
V1P2 Upper Neck Nij [CFC_600]	-	0.41	32.55	0.00	-20.70
V1P2 Upper Neck Fx [CFC_1000]	N	140.58	14.50	-309.32	29.60
V1P2 Upper neck Fy [CFC_1000]	N	147.08	27.95	-56.53	12.45
V1P2 Upper neck Fz [CFC_1000]	N	192.96	47.65	-1380.08	14.70
V1P2 Neck Force Resultant [CFC_1000]	N	1386.94	14.70	0.07	-47.95
V1P2 Upper Neck Mx [CFC_600]	Nm	9.89	19.75	-8.64	30.55
V1P2 Upper Neck My [CFC_600]	Nm	11.19	65.50	-28.38	34.40
V1P2 Upper Neck Mz [CFC_600]	Nm	4.83	19.80	-5.13	76.25
V1P2 Neck Moment Resultant [CFC_600]	Nm	28.87	33.25	0.00	-30.55
V1P2 Lower Neck Fx F [CFC_1000]	N	295.98	32.90	-213.11	18.85
V1P2 Lower Neck Fy F [CFC_1000]	N	228.00	29.15	-152.50	18.05
V1P2 Lower Neck Fz F [CFC_1000]	N	219.80	29.00	-1545.90	14.35
V1P2 Lower Neck Force Resultant [CFC_1000]	N	1548.04	14.35	0.08	-47.10
V1P2 Lower Neck Mx F [CFC_600]	Nm	24.06	29.35	-10.75	96.25
V1P2 Lower Neck My F [CFC_600]	Nm	63.21	14.30	-4.33	10.75
V1P2 Lower Neck Mz F [CFC_600]	Nm	11.75	29.15	-10.76	75.65
V1P2 Lower Neck Moment Resultant [CFC_600]	Nm	63.21	14.30	0.00	-27.95
Curtain Airbag Volts	V	17.40	0.25	-0.00	-36.30
Torso/Pelvis Airbag Volts	V	17.58	0.25	-0.00	-40.55
Front Center Airbag Volts	V	-	-	-	-
Curtain Airbag Current	A	4.62	0.20	-0.05	37.65
Torso/Pelvis Airbag Current	A	3.37	0.20	-0.04	29.50
Front Center Airbag Current	A	-	-	-	-

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

Test Vehicle:	2020 Subaru WRX four door sedan	NHTSA No.:	M20205502TWG2
Test Program:	TWG 3.3.5.3	Test Date:	8/5/2020

HEAD INJURY SUMMARY

H15	T1 (ms)	T2 (ms)	HIC36	T1 (ms)	T2 (ms)
29.20	11.60	26.60	N/A	N/A	N/A

NECK INJURY SUMMARY

Injury Criteria	Units	Value	Time(ms)
Upper Neck NTF		0.098	66.600
Upper Neck NTE		0.380	34.650
Upper Neck NCF		0.408	14.650
Upper Neck NCE		0.415	32.550
Peak Tension	N	192.955	47.65
Peak Compression	N	-1380.080	14.70

CHEST INJURY SUMMARY

Injury Criteria	Units	Value	Time(ms)
Chest/Rib Deflection	mm	N/A	N/A
Deflection Rate[1]	m/s	N/A	N/A

[1](Describe deflection rate calculation method)

RESEARCH INJURY SUMMARY

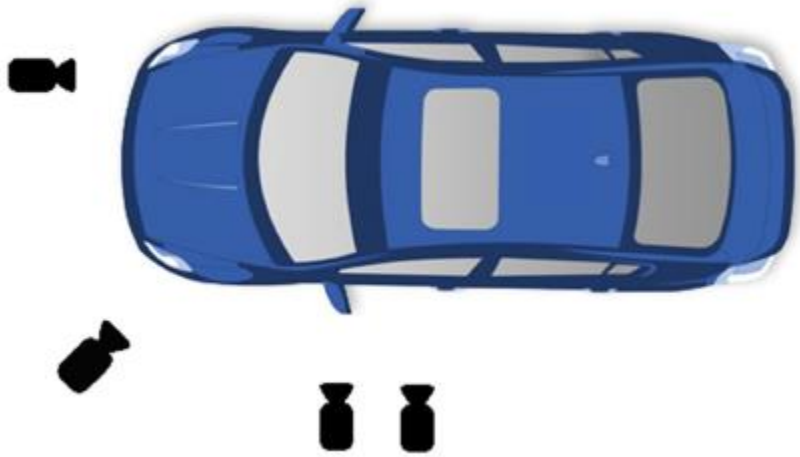
Research Injury Criteria	Units	Value	Time(ms)
Upper Neck Lateral Moment	Nm	9.89	19.75
Upper Neck Twist Moment	Nm	-5.13	76.25
Lower Neck Flexion Moment	Nm	63.21	14.30
Lower Neck Extension Moment	Nm	-4.33	10.75
Lower Neck Lateral Moment	Nm	24.06	29.35
Lower Neck Twist Moment	Nm	11.75	29.15
Lower Neck Tension	N	219.80	29.00
Lower Neck Compression	N	-1545.90	14.35
Spine Acceleration	G	NA	NA

Note: These injury criteria are only monitored and not considered pass/fail

DATA SHEET NO. 6
CAMERA SETUP AND DESCRIPTION

Test Vehicle:	2020 Subaru WRX four door sedan	NHTSA No.:	M20205502TWG2
Test Program:	TWG 3.3.5.3	Test Date:	8/5/2020

CAMERA SETUP DIAGRAM FOR SAB OOP TESTS



CAMERA LOCATIONS

No.	Camera View	Coordinates (mm)			Lens Length (mm)	Speed (fps)
		X	Y	Z		
1	Left View	-2085	-633	-1271	12.5	1000
2	Oblique View	0	-1470	-1536	50	1000
3	Front View	776	0	-1535	50	1000
4	Right View	-2100	1096	-1474	12.5	1000
5	Real Time (Optional)	N/A	N/A	N/A	N/A	N/A

Reference:

+X = To Forward of vehicle
+Y = To Right of vehicle
+Z = Down into ground

Appendix A

PHOTOGRAPHS

TABLE OF PHOTOGRAPHS

Figure A-1: Right Front ¾ View of Test Vehicle As Delivered

Figure A-2: Vehicle Certification Label

Figure A-3: Pre-Test Vehicle Left Side View

Figure A-4: Post-Test Vehicle Left Side View

Figure A-5: Pre-Test Vehicle Location of Airbag 1

Figure A-6: Pre-Test Vehicle Location of Airbag 2

Figure A-7: Pre-Test Vehicle Location of Airbag 3

Figure A-8: Pre-Test Vehicle Seat Back Angle

Figure A-9: Pre-Test Dummy Left Side View

Figure A-10: Post-Test Dummy Left Side View

Figure A-11: Pre-Test Dummy Left Side Close-up View

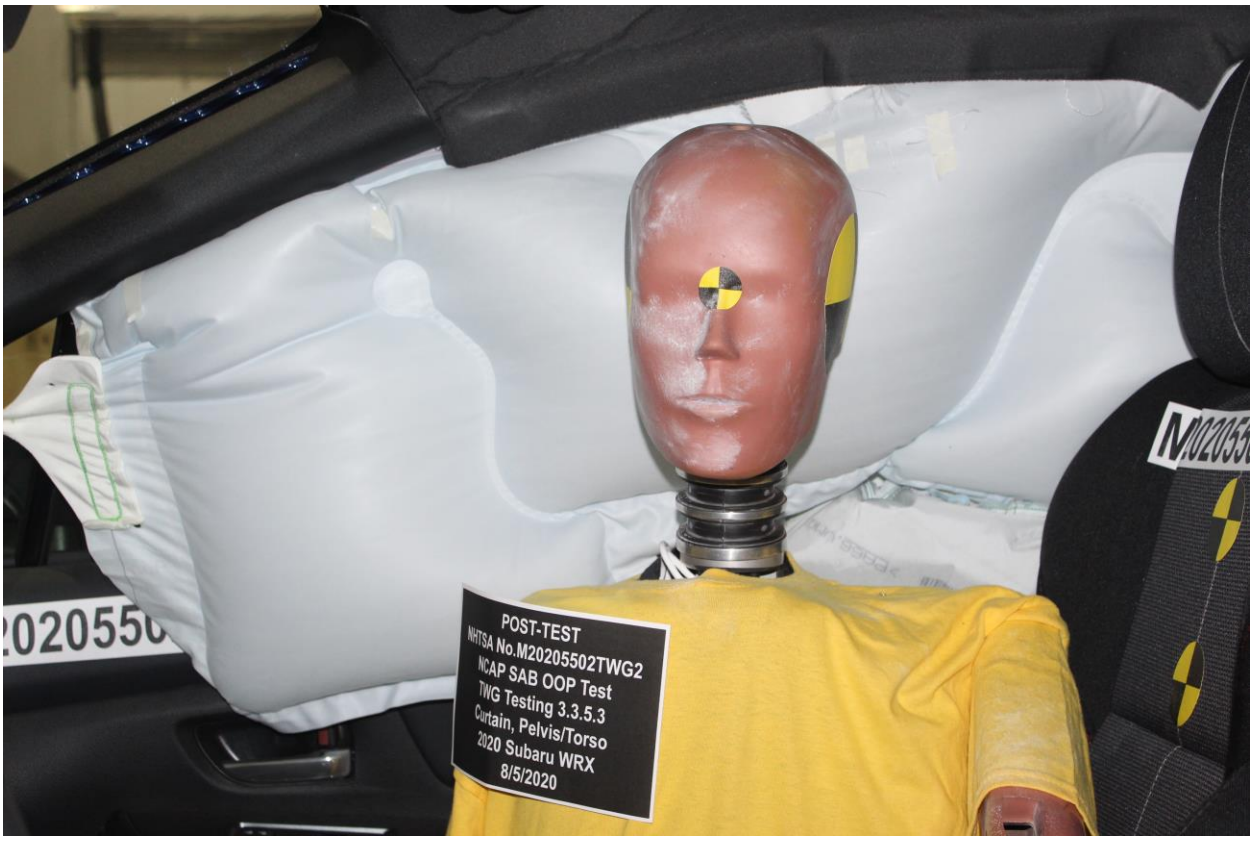


Figure A-12: Post-Test Dummy Left Side Close-up View

Figure A-13: Pre-Test Dummy Left ¾ Front View

Figure A-14: Post-Test Dummy Left ¾ Front View

Figure A-15: Pre-Test Dummy Left ¾ Front Close-up View

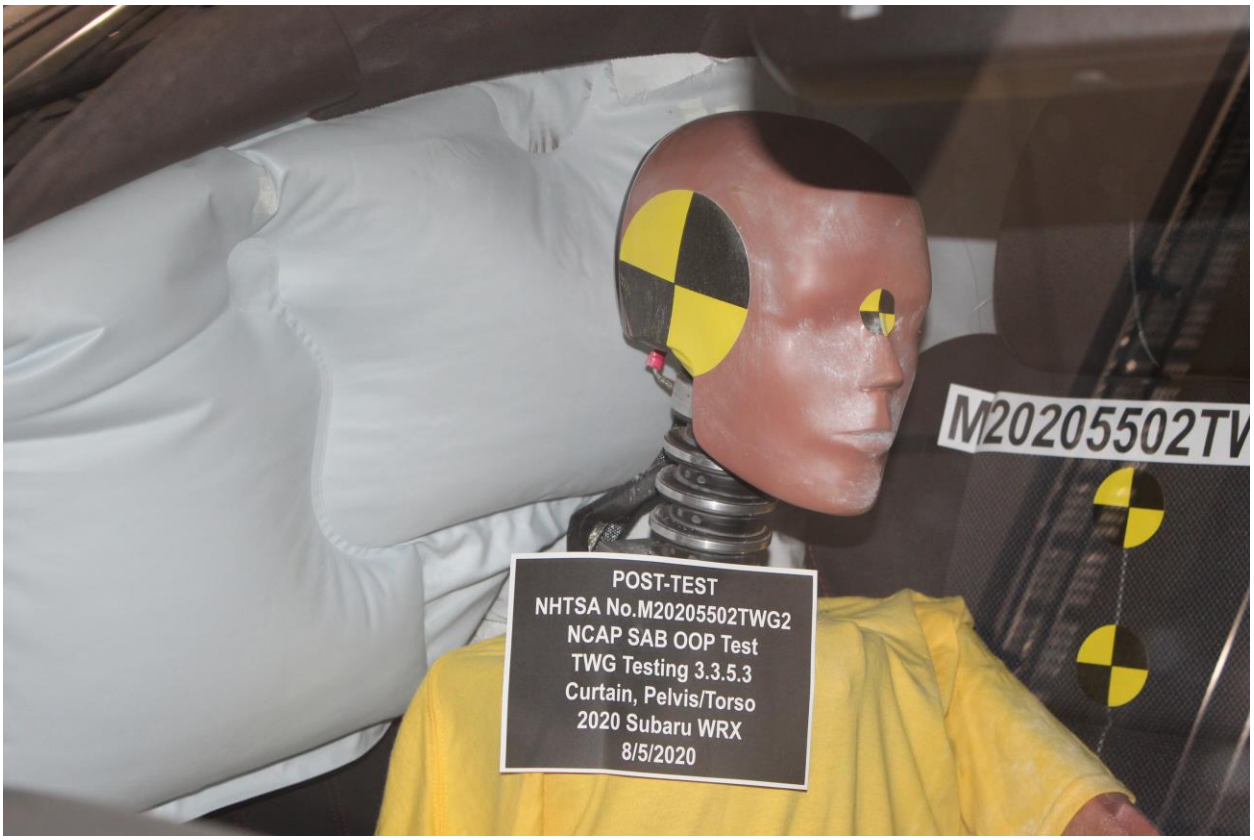


Figure A-16: Post-Test Dummy Left ¾ Front Close-up View

Figure A-17: Pre-Test Dummy Front View

Figure A-18: Post-Test Dummy Front View

Figure A-19: Pre-Test Dummy Front Close-up View

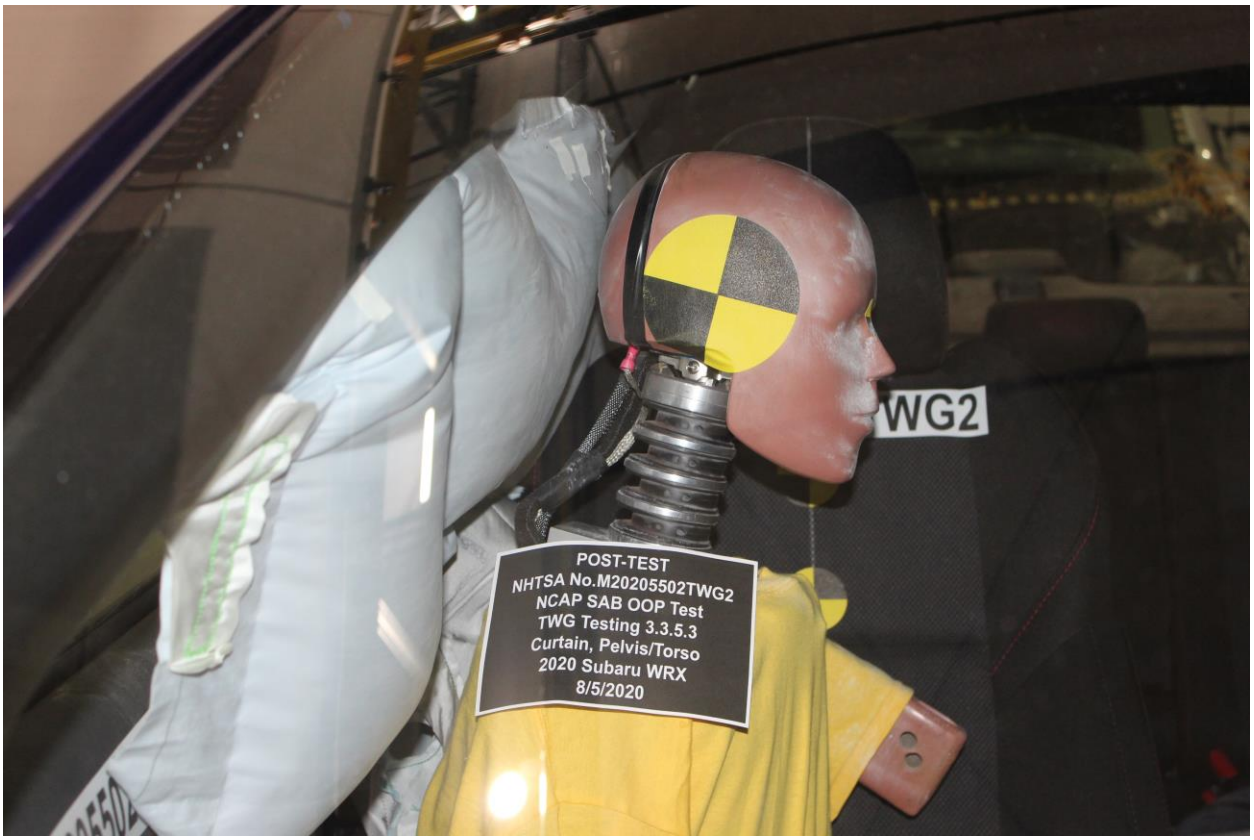


Figure A-20: Post-Test Dummy Front Close-up View

Figure A-21: Pre-Test Dummy Right ¾ Front View

Figure A-22: Post-Test Dummy Right ¾ Front View

Figure A-23: Pre-Test Dummy Right Side View

Figure A-24: Post-Test Dummy Right Side View

Figure A-25: Post-Test Dummy Right Side View (Door Open)

Figure A-26: Post-Test Curtain Air Bag Left Side View

Figure A-27: Post-Test Curtain Air Bag Left ¾ Front View

Figure A-28: Post-Test Curtain Air Bag Front View

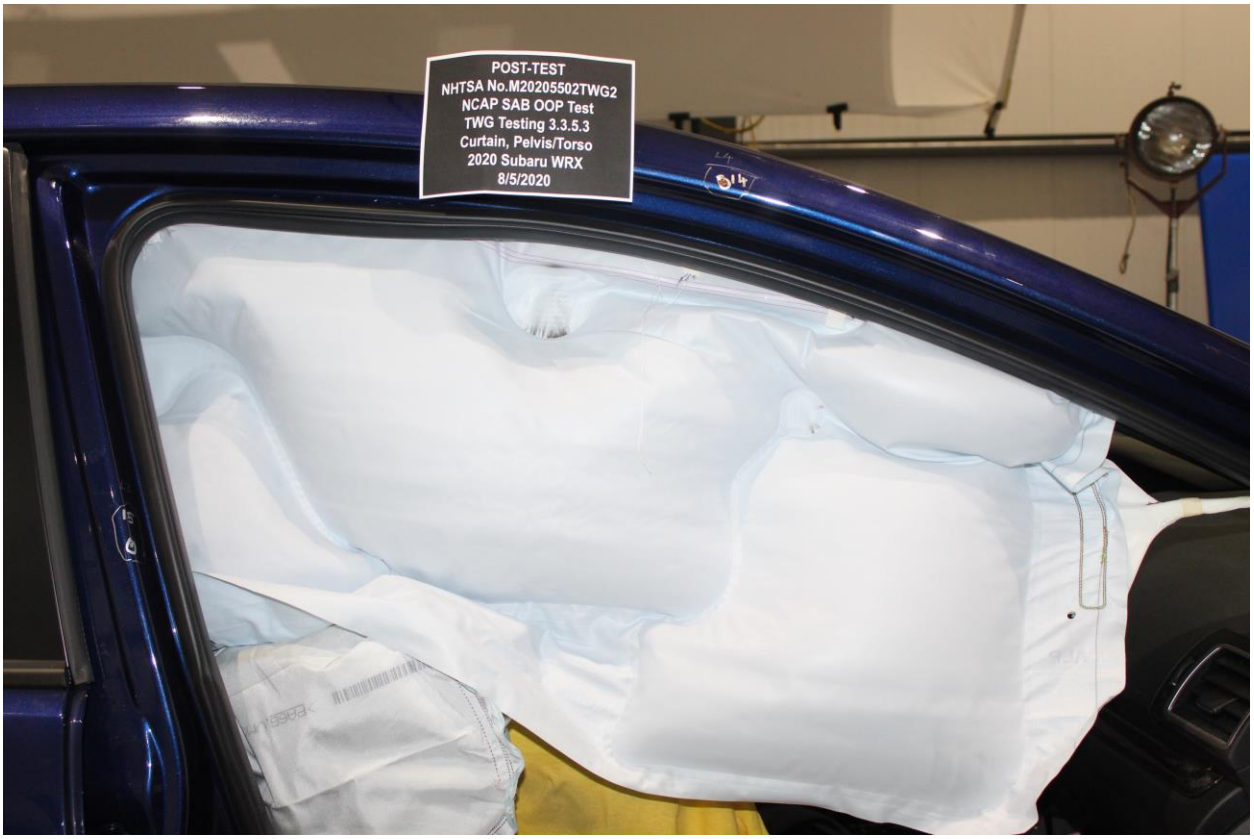


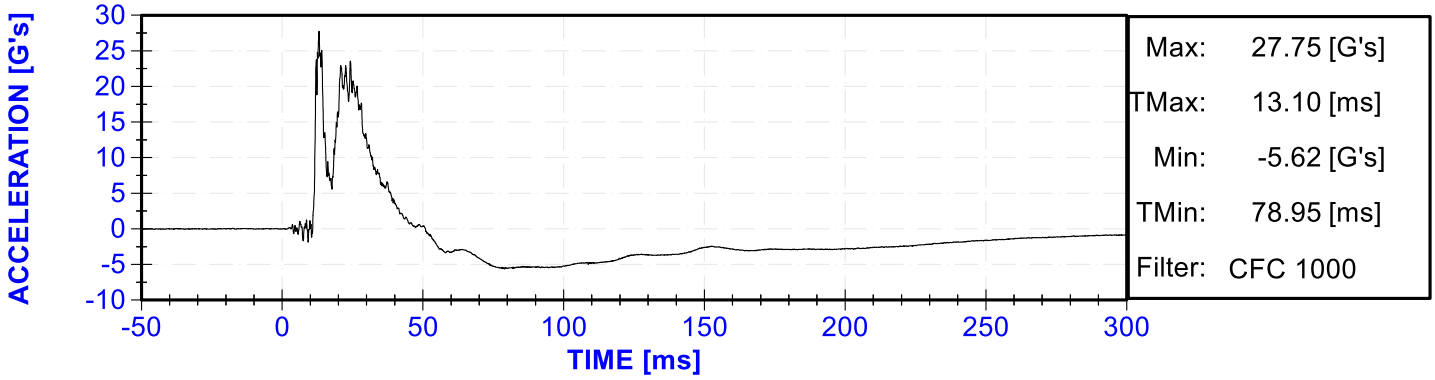
Figure A-29: Post-Test Curtain Air Bag Right Side View (Door Open)

APPENDIX B

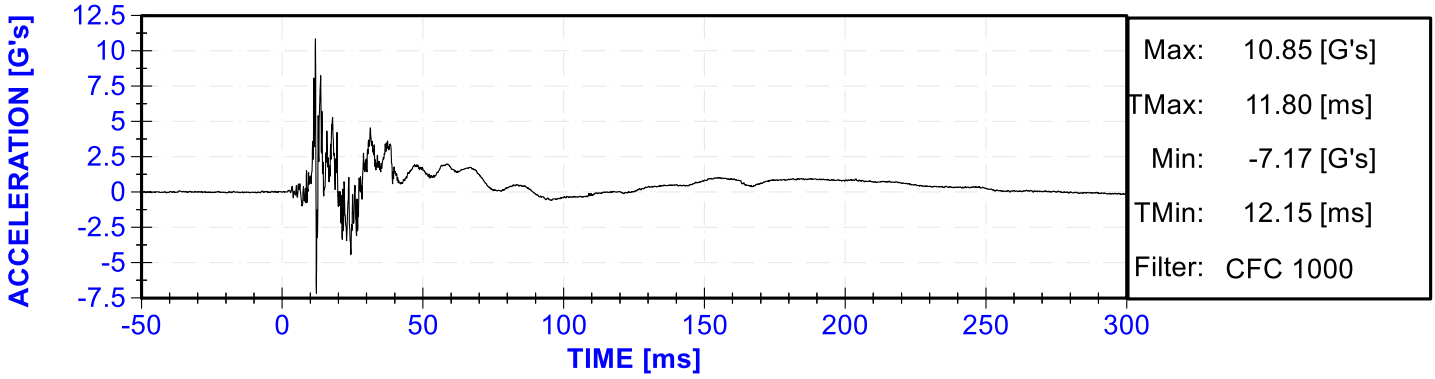
DUMMY RESPONSE DATA PLOTS

Table of Data Plots

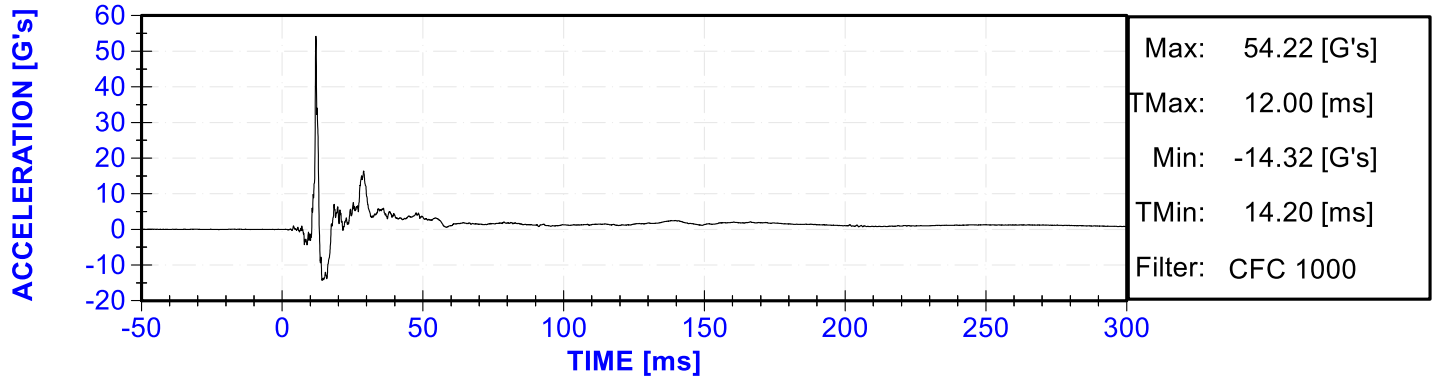
Head CG X Acceleration



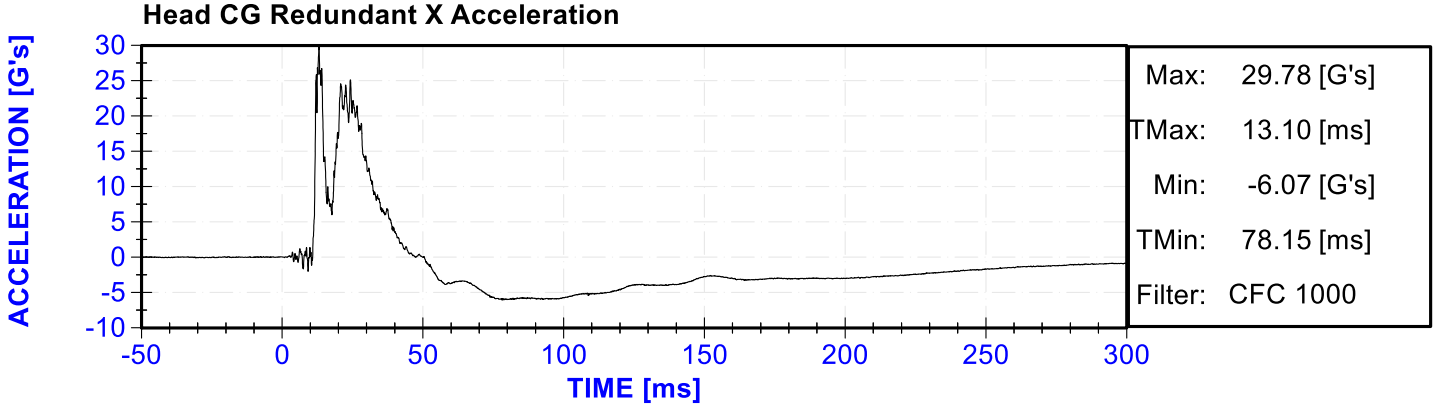
Head CG Y Acceleration



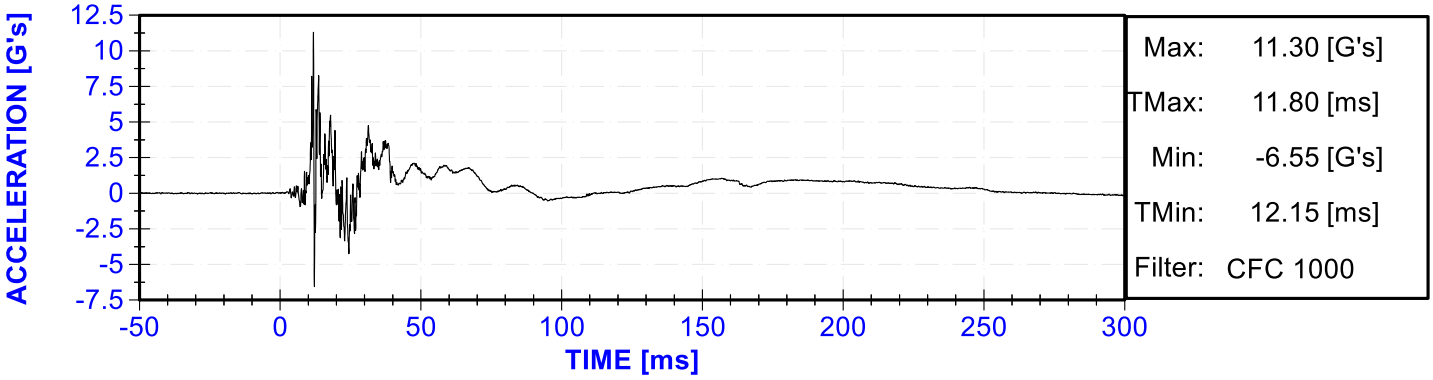
Head CG Z Acceleration



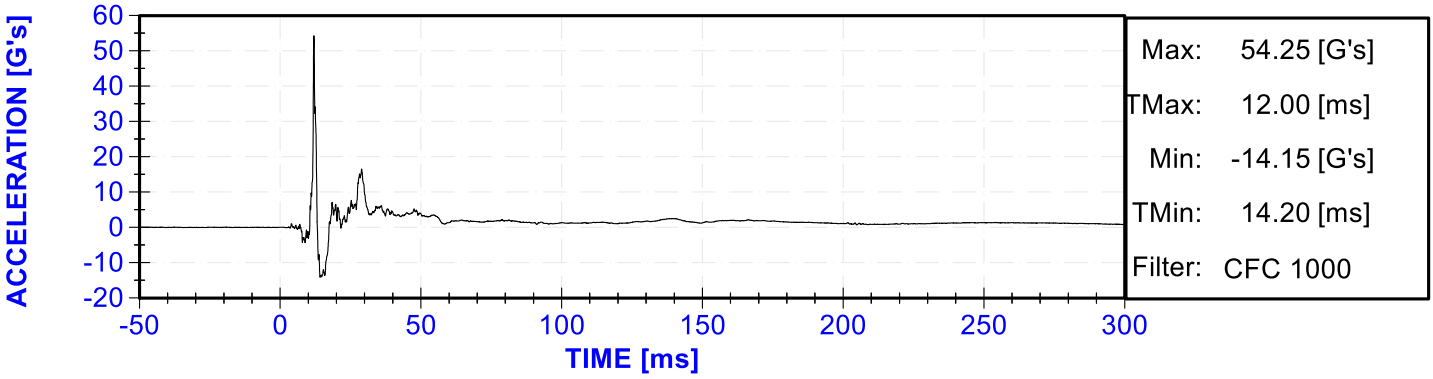
Head CG Redundant X Acceleration



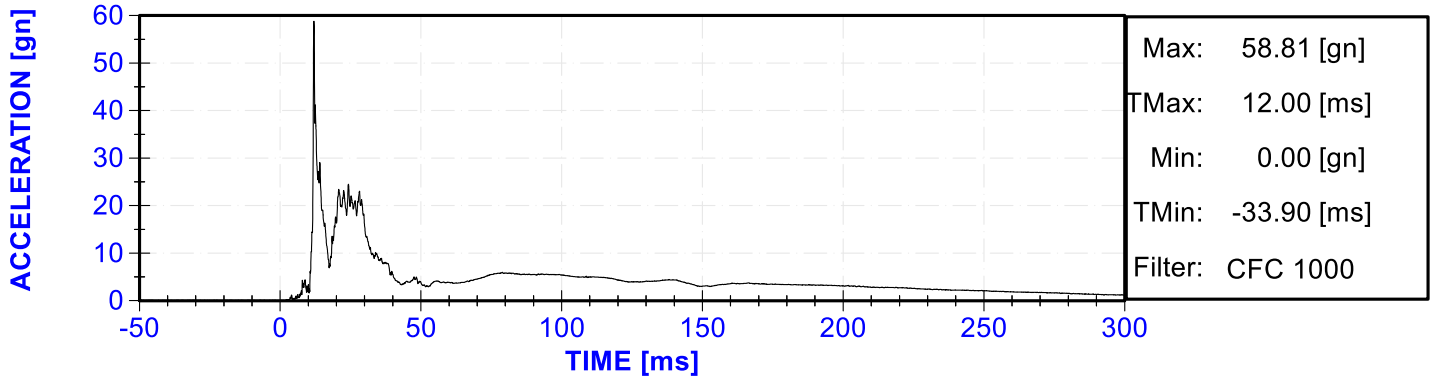
Head CG Redundant Y Acceleration



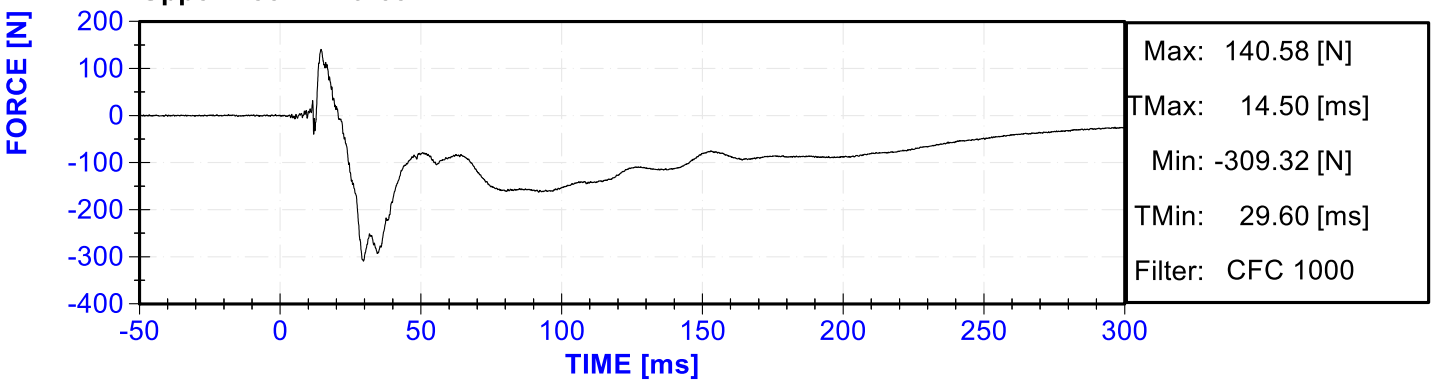
Head CG Redundant Z Acceleration

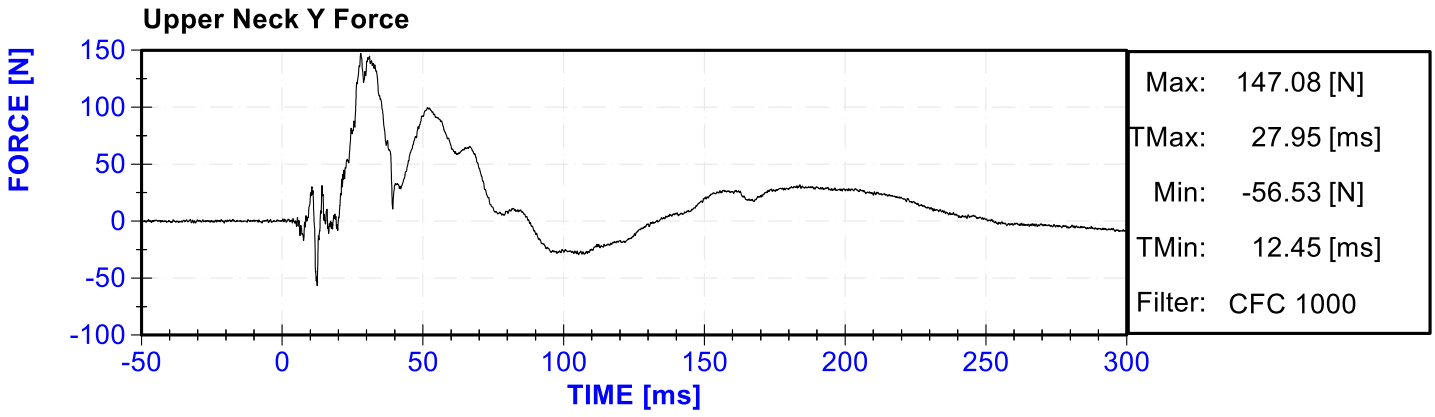


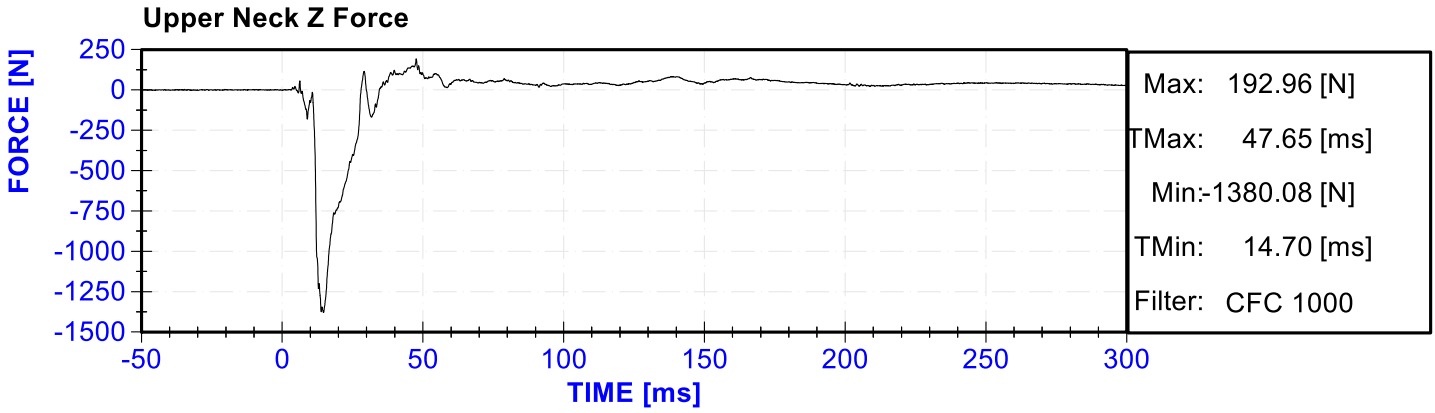
Head CG Acceleration Resultant

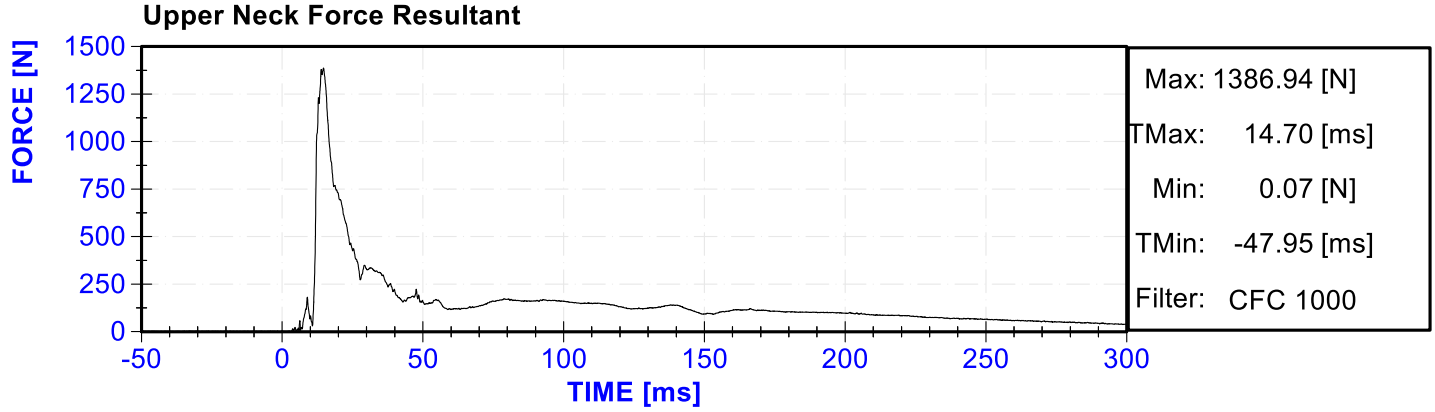


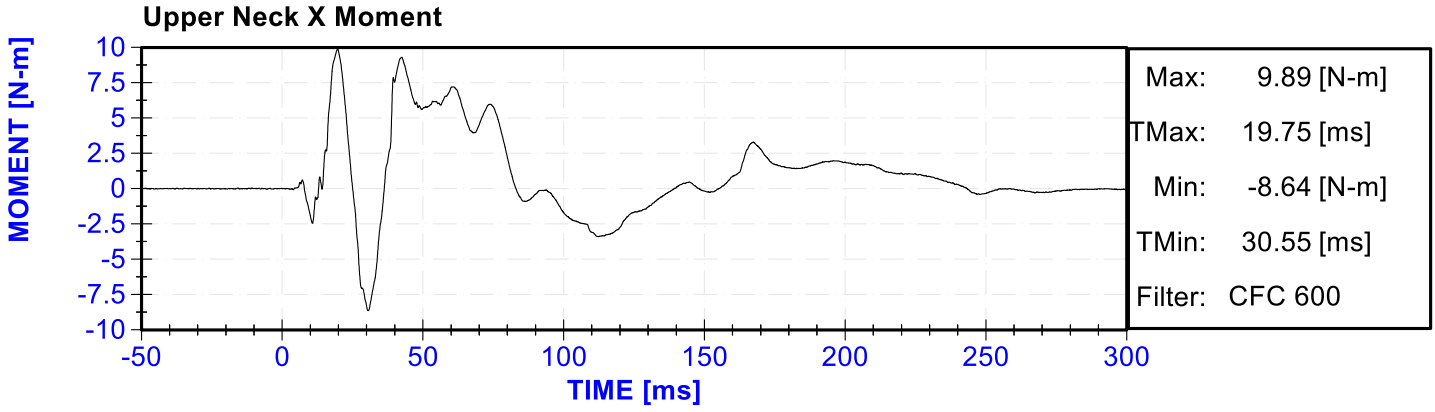
Upper Neck X Force

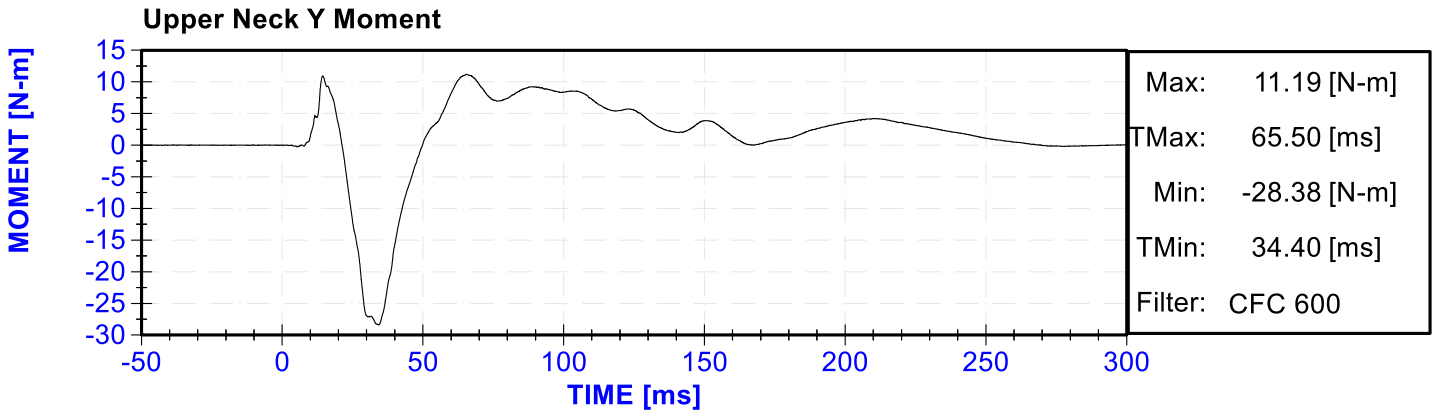


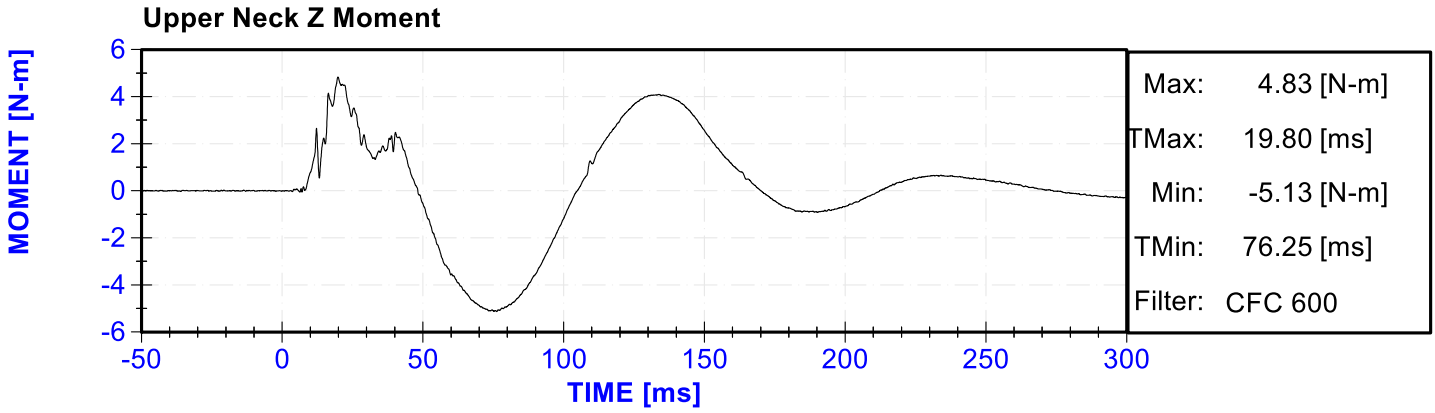

Upper Neck Y Force
FORCE [N]
150
100
50
0
-50
-100
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 147.08 [N]
TMax: 27.95 [ms]
Min: -56.53 [N]
TMin: 12.45 [ms]
Filter: CFC 1000

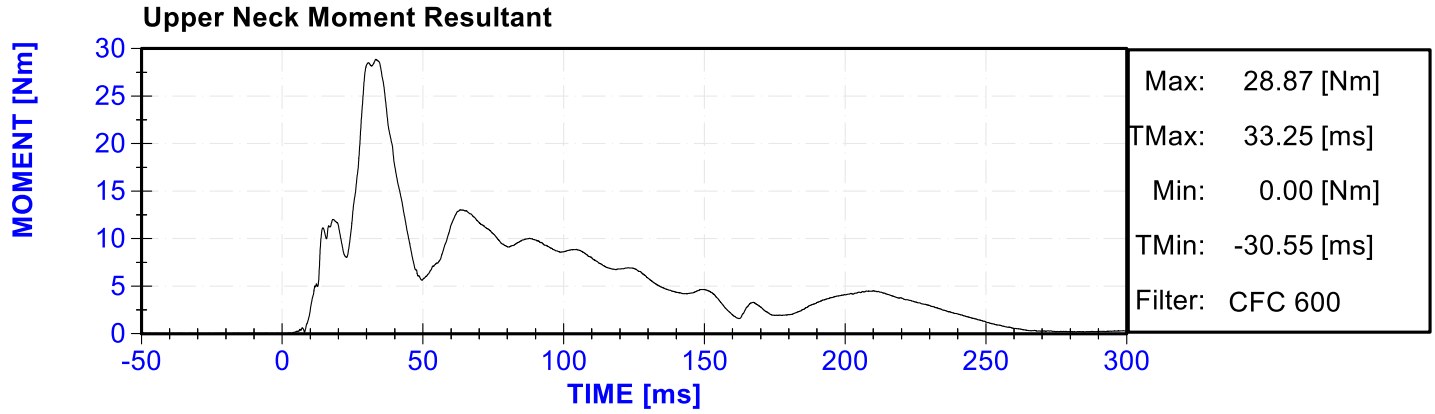

Upper Neck Z Force
FORCE [N]
250
0
-250
-500
-750
-1000
-1250
-1500
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 192.96 [N]
TMax: 47.65 [ms]
Min:-1380.08 [N]
TMin: 14.70 [ms]
Filter: CFC 1000

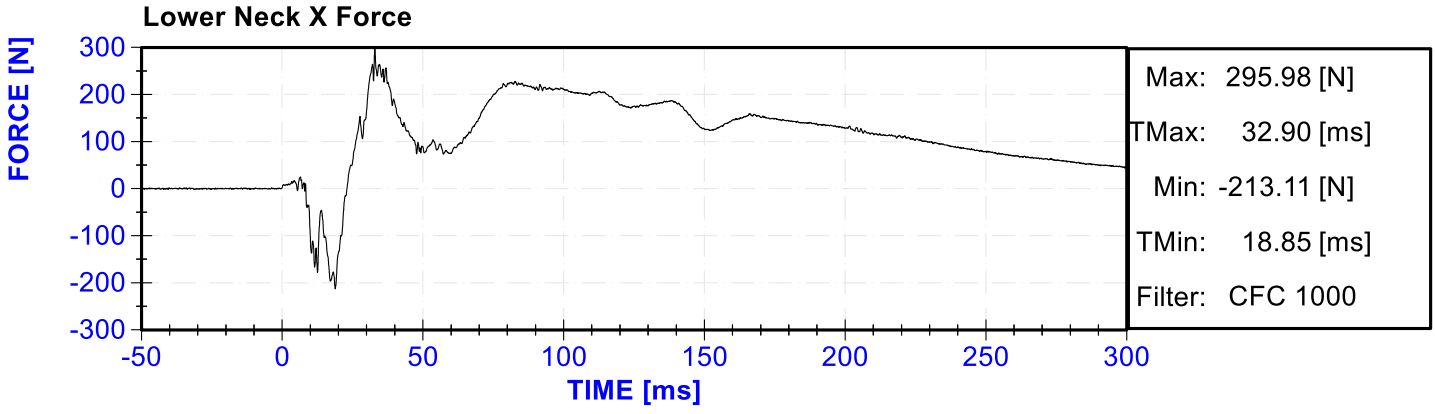

Upper Neck Force Resultant
FORCE [N]
1500
1250
1000
750
500
250
0
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 1386.94 [N]
TMax: 14.70 [ms]
Min: 0.07 [N]
TMin: -47.95 [ms]
Filter: CFC 1000


Upper Neck X Moment
MOMENT [N-m]
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 9.89 [N-m]
TMax: 19.75 [ms]
Min: -8.64 [N-m]
TMin: 30.55 [ms]
Filter: CFC 600

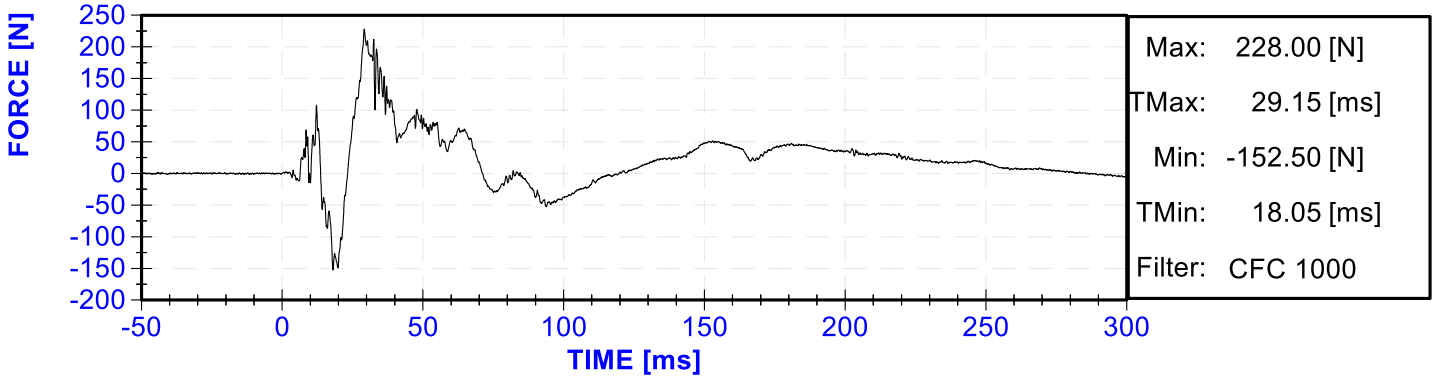

Upper Neck Y Moment
MOMENT [N-m]
15
10
5
0
-5
-10
-15
-20
-25
-30
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 11.19 [N-m]
TMax: 65.50 [ms]
Min: -28.38 [N-m]
TMin: 34.40 [ms]
Filter: CFC 600


Upper Neck Z Moment
MOMENT [N-m]
6
4
2
0
-2
-4
-6
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 4.83 [N-m]
TMax: 19.80 [ms]
Min: -5.13 [N-m]
TMin: 76.25 [ms]
Filter: CFC 600

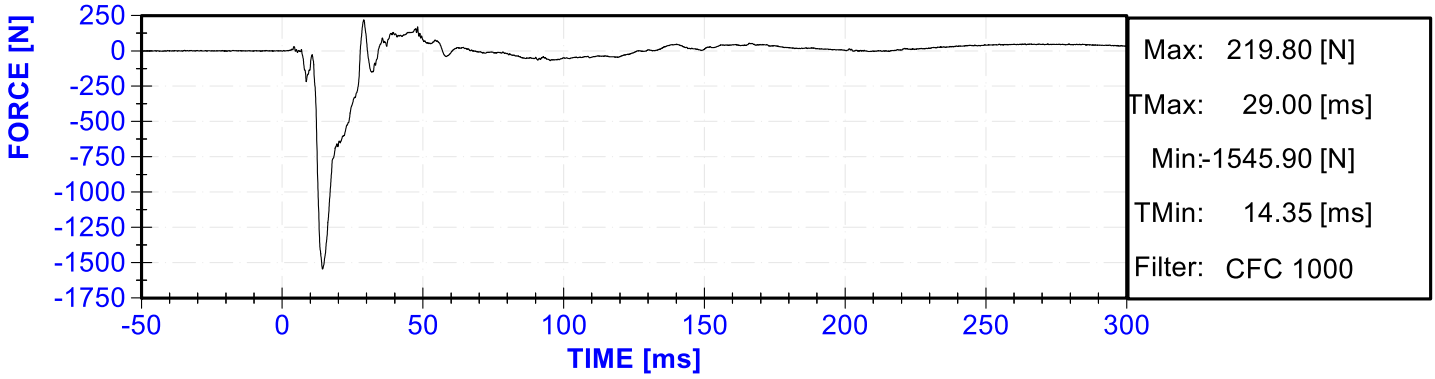

Upper Neck Moment Resultant
MOMENT [Nm]
30
25
20
15
10
5
0
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 28.87 [Nm]
TMax: 33.25 [ms]
Min: 0.00 [Nm]
TMin: -30.55 [ms]
Filter: CFC 600


Lower Neck X Force
FORCE [N]
300
200
100
0
-100
-200
-300
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 295.98 [N]
TMax: 32.90 [ms]
Min: -213.11 [N]
TMin: 18.85 [ms]
Filter: CFC 1000

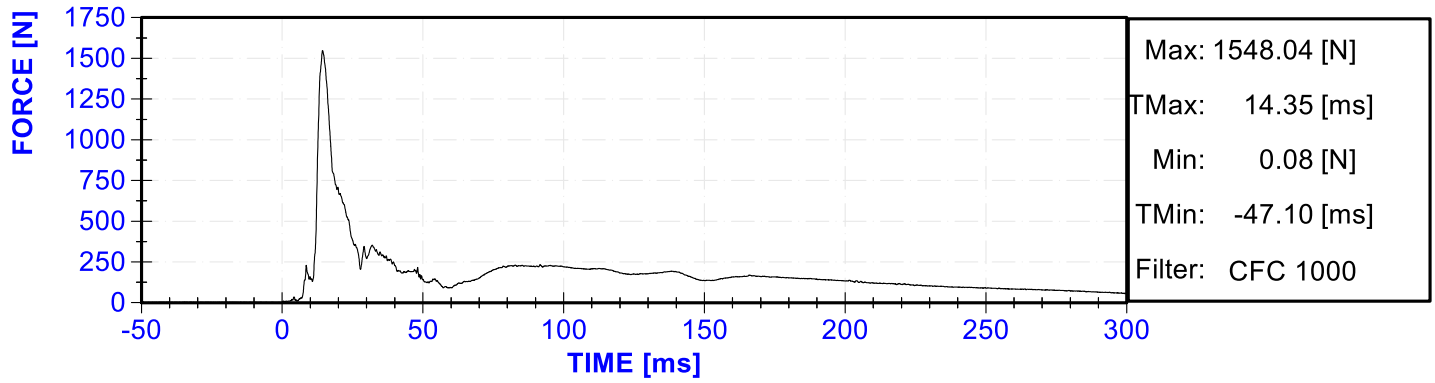
Lower Neck Y Force



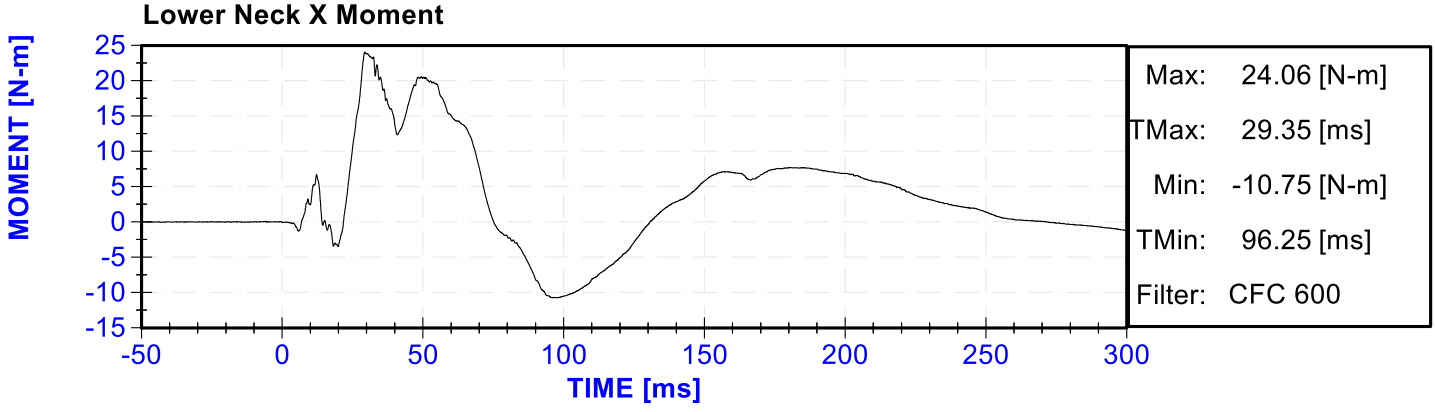
Lower Neck Z Force



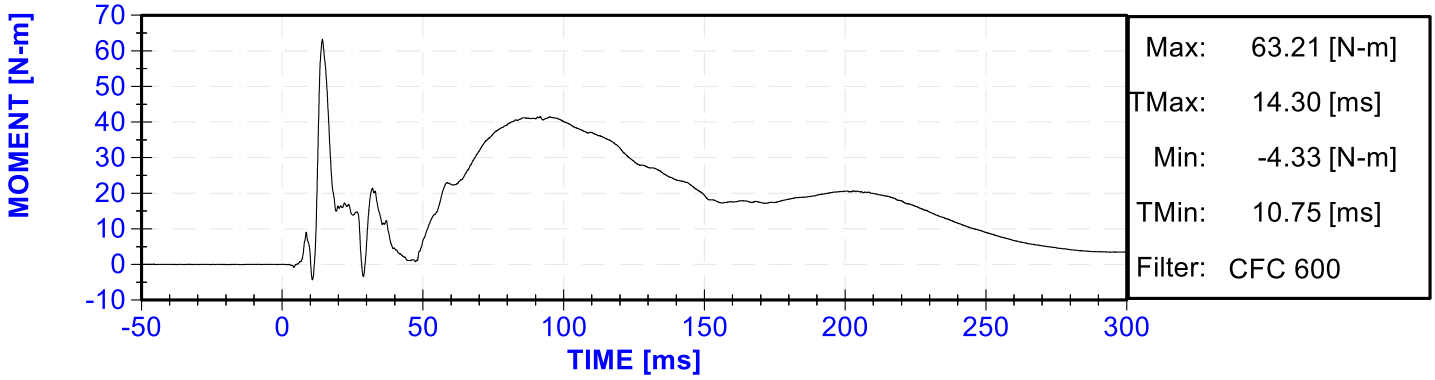
Lower Neck Force Resultant



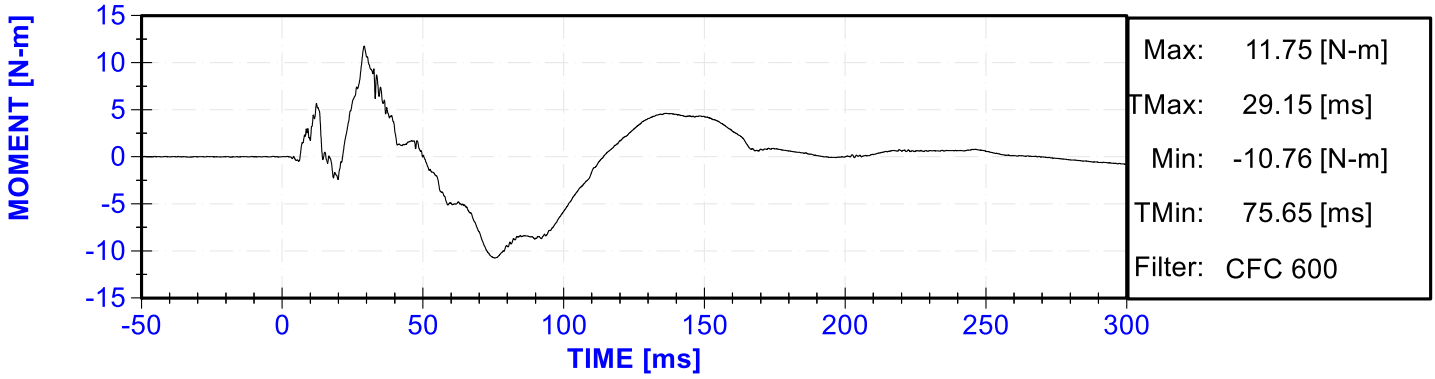
Lower Neck X Moment



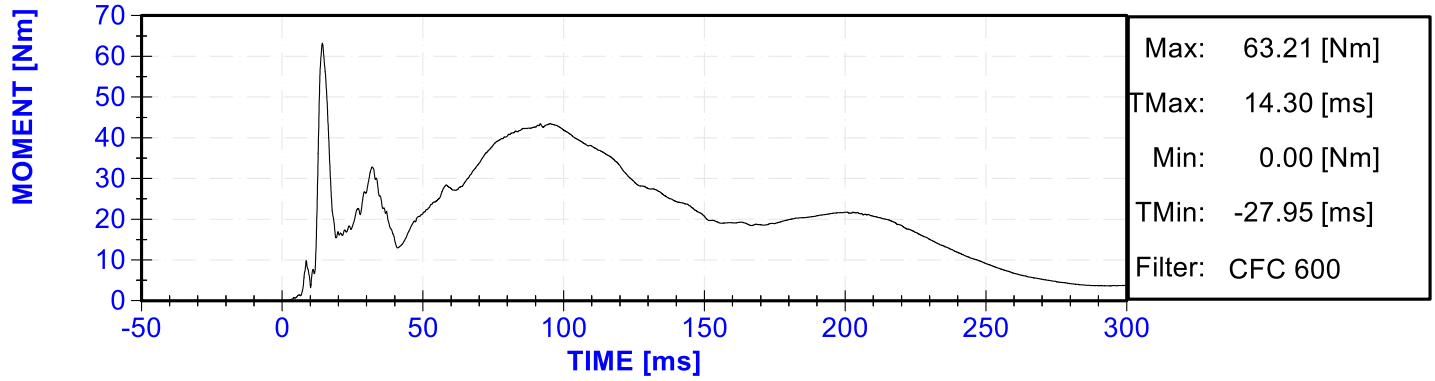
Lower Neck Y Moment



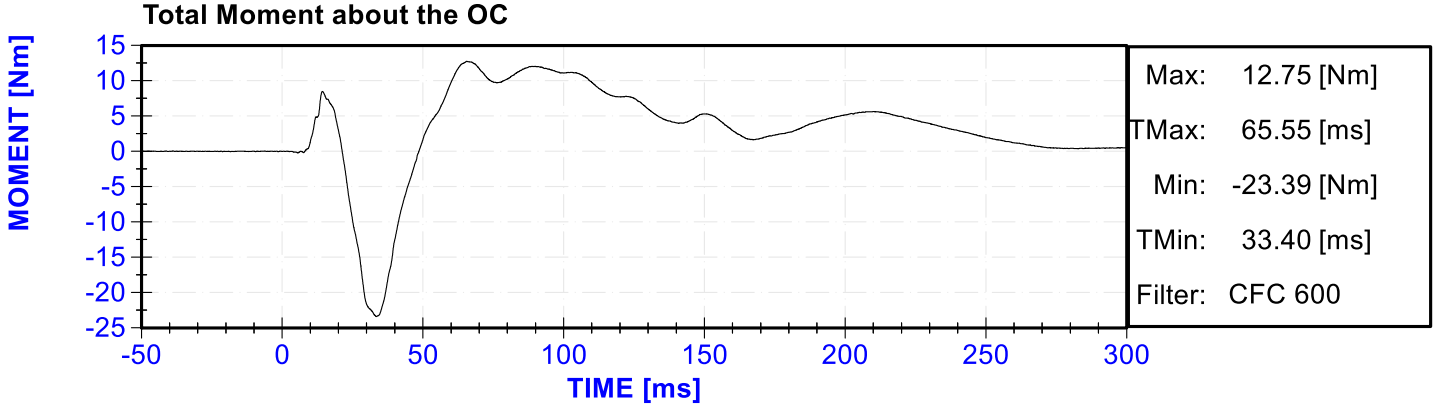
Lower Neck Z Moment



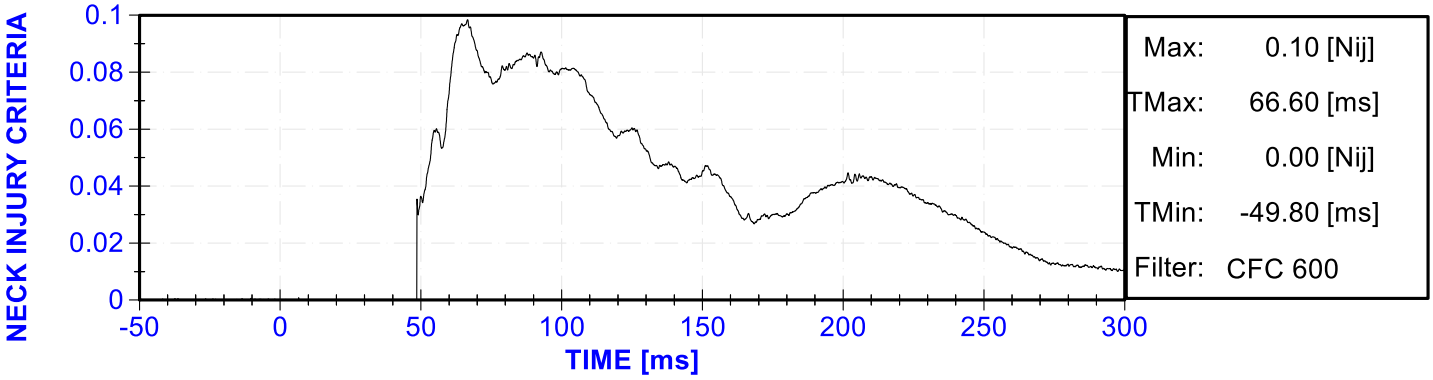
Lower Neck Moment Resultant



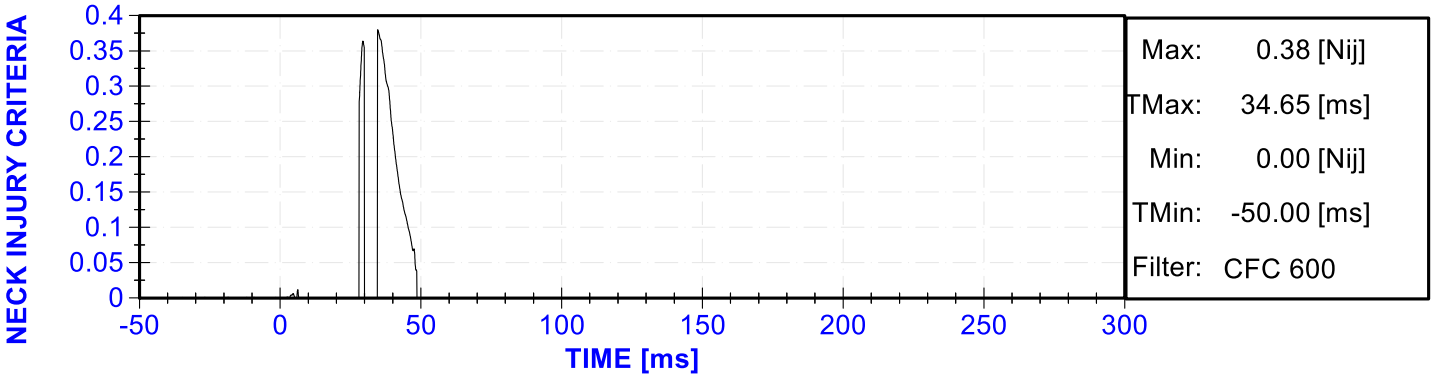
Total Moment about the OC



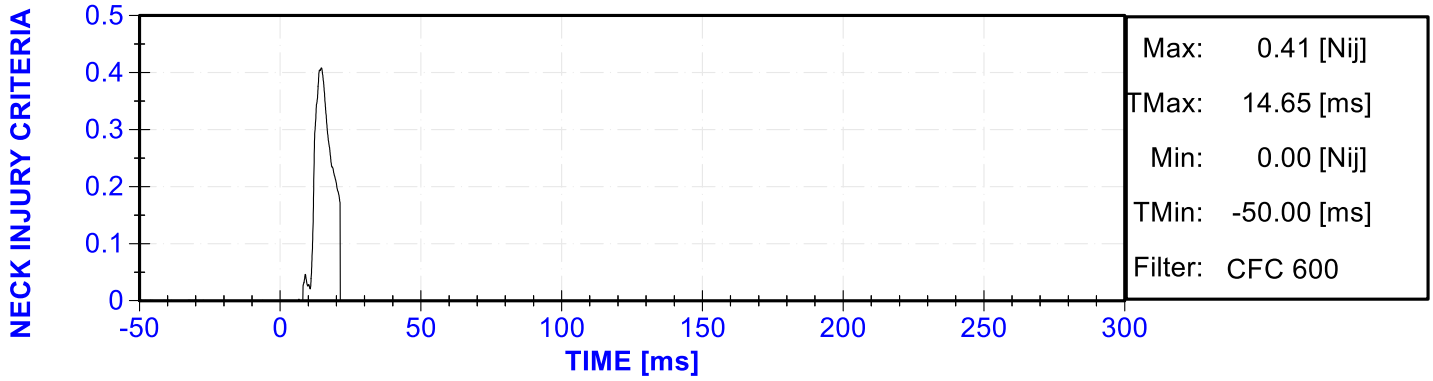
Neck Tension-Flexion Injury



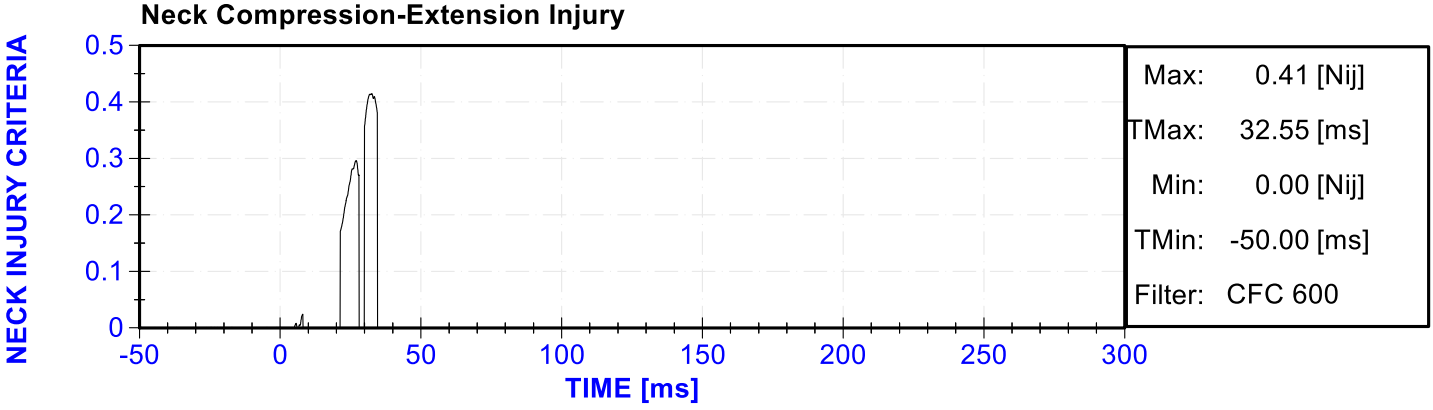
Neck Tension-Extension Injury



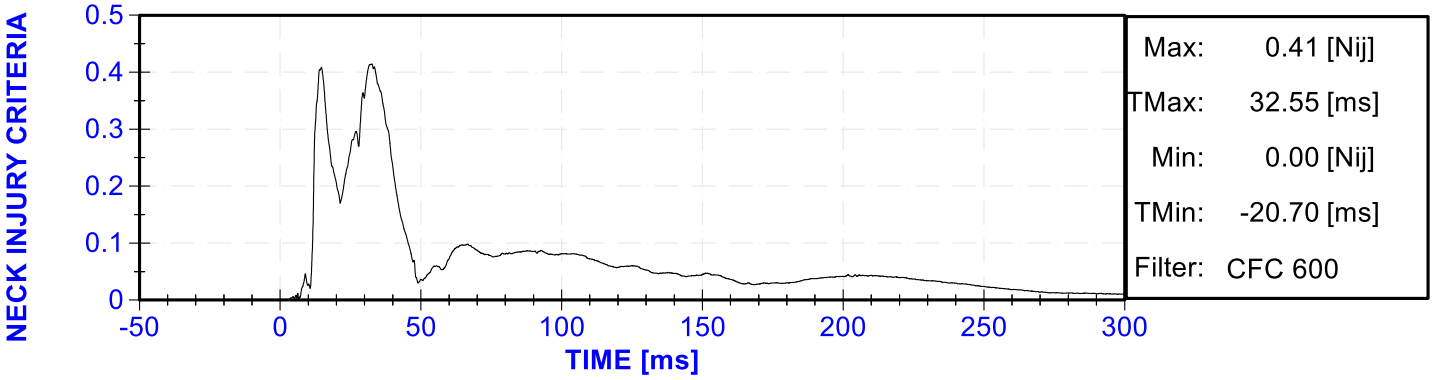
Neck Compression-Flexion Injury



Neck Compression-Extension Injury

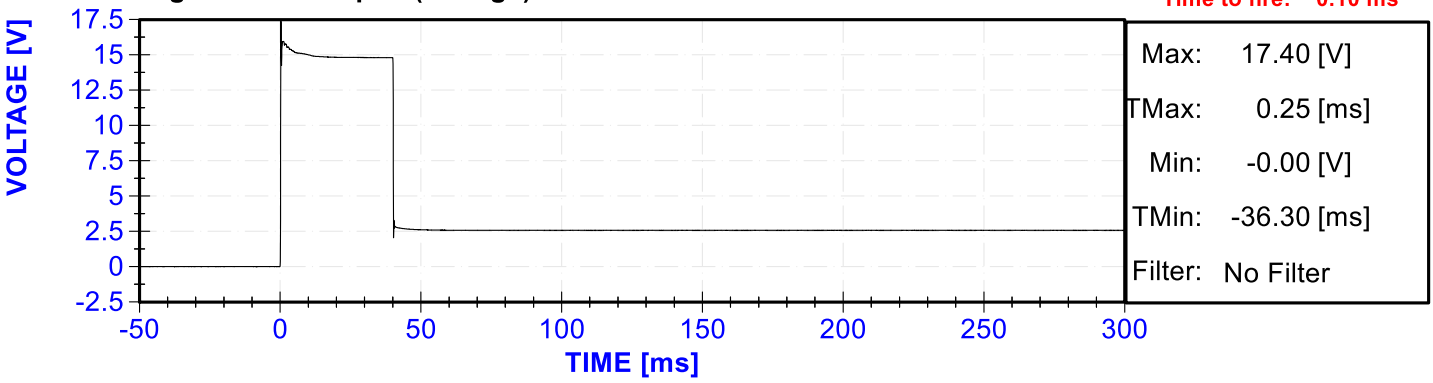


Total Neck Injury



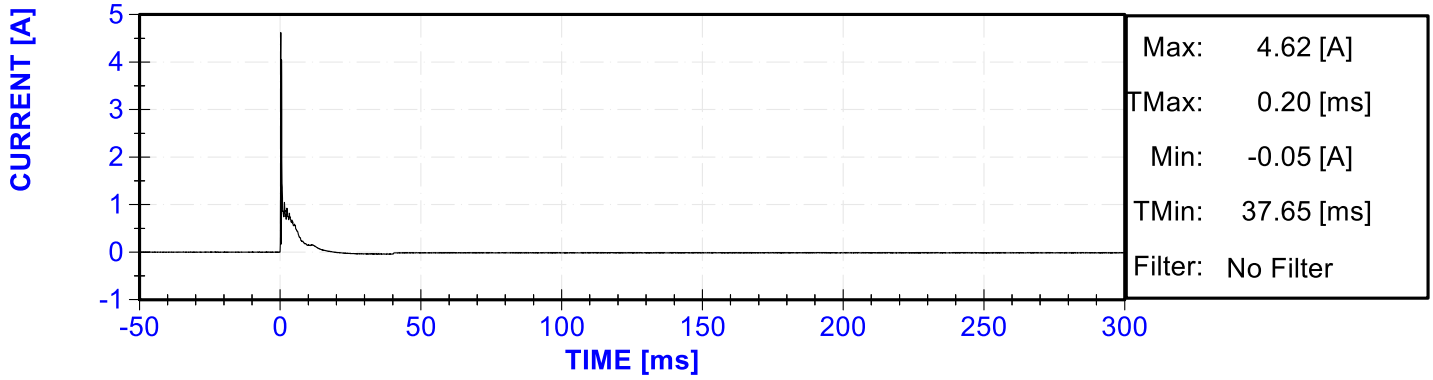
Right Curtain Squib (Voltage)

Time to fire: 0.10 ms



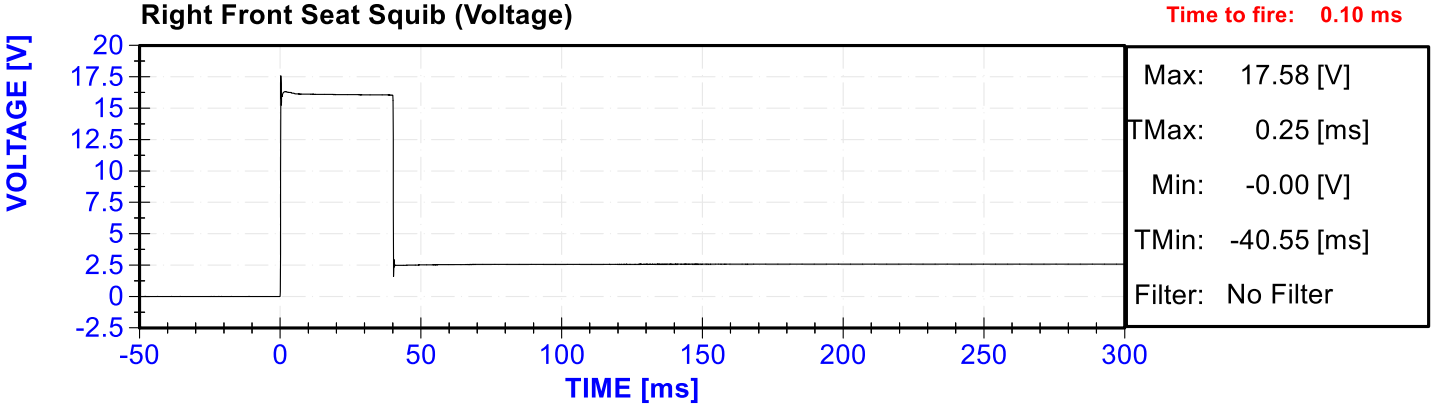
Right Curtain Squib (Current)

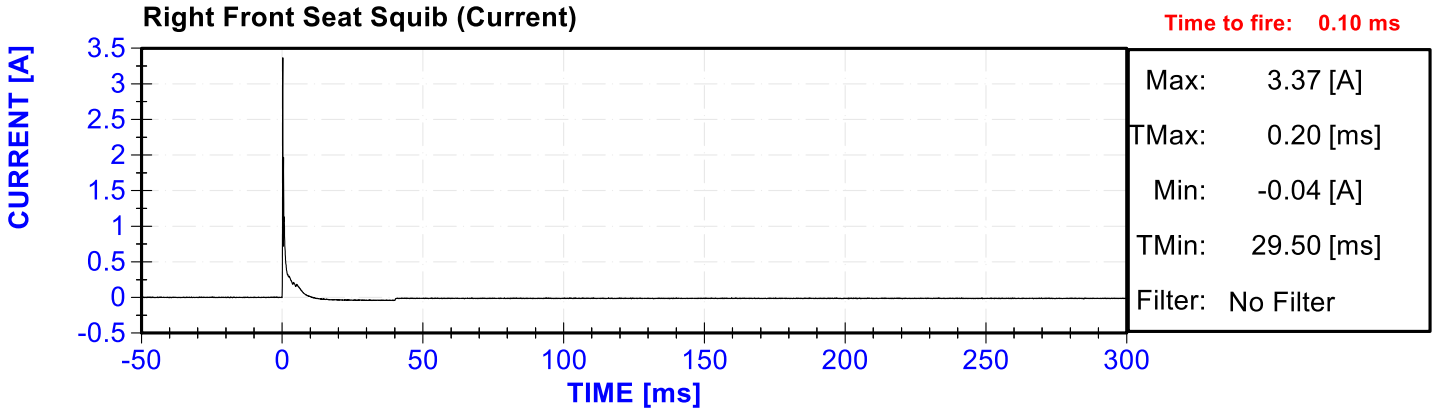
Time to fire: 0.10 ms



Right Front Seat Squib (Voltage)

Time to fire: 0.10 ms




Right Front Seat Squib (Current)
Time to fire: 0.10 ms
CURRENT [A]
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 3.37 [A]
TMax: 0.20 [ms]
Min: -0.04 [A]
TMin: 29.50 [ms]
Filter: No Filter

APPENDIX C

TEST EQUIPMENT AND INSTRUMENTATION CALIBRATION DATA

Table 1 – Dummy Instrumentation

	P2 SID-IIs SERIAL NO.: M20205502TWG2			
	SERIAL NUMBER	**MANUFACTURER**	**CALIBRATION DATE**	**DUE DATE**
Head X Acceleration	AC-P74788	ENDEVCO 7264	4/16/2020	10/15/2020
Head Y Acceleration	AC-P83432	ENDEVCO 7264CT	4/16/2020	10/15/2020
Head Z Acceleration	AC-P83319	ENDEVCO 7264	4/16/2020	10/15/2020
Head Redundant X Acceleration	AC-P80334	ENDEVCO 7264	4/16/2020	10/15/2020
Head Redundant Y Acceleration	AC-P52155	ENDEVCO 7264CT	4/16/2020	10/15/2020
Head Redundant Z Acceleration	AC-P83322	ENDEVCO 7264	4/16/2020	10/15/2020
Upper Neck X Force	LC-2184Fx	Denton 1716A	7/15/2020	7/15/2021
Upper Neck Y Force	LC-2184Fy	Denton 1716A	7/15/2020	7/15/2021
Upper Neck Z Force	LC-2184Fz	Denton 1716A	7/15/2020	7/15/2021
Upper Neck X Moment	LC-2184Mx	Denton 1716A	7/15/2020	7/15/2021
Upper Neck Y Moment	LC-2184My	Denton 1716A	7/15/2020	7/15/2021
Upper Neck Z Moment	LC-2184Mz	Denton 1716A	7/15/2020	7/15/2021
Lower Neck X Force	LC-153 Fx	Humanetics 3166JTF	2/19/2020	2/18/2021
Lower Neck Y Force	LC-153 Fy	Humanetics 3166JTF	2/19/2020	2/18/2021
Lower Neck Z Force	LC-153 Fz	Humanetics 3166JTF	2/19/2020	2/18/2021
Lower Neck X Moment	LC-153 Mx	Humanetics 3166JTF	2/19/2020	2/18/2021
Lower Neck Y Moment	LC-153 My	Humanetics 3166JTF	2/19/2020	2/18/2021
Lower Neck Z Moment	LC-153 Mz	Humanetics 3166JTF	2/19/2020	2/18/2021
Curtain Bag Voltage	ABF011 (Voltage)	-	-	-
Curtain Bag Current	ABF011 (Current)	-	-	-
Seat/Torso Bag Voltage	ABF006 (Voltage)	-	-	-
Seat/Torso Bag Current	ABF006 (Current)	-	-	-

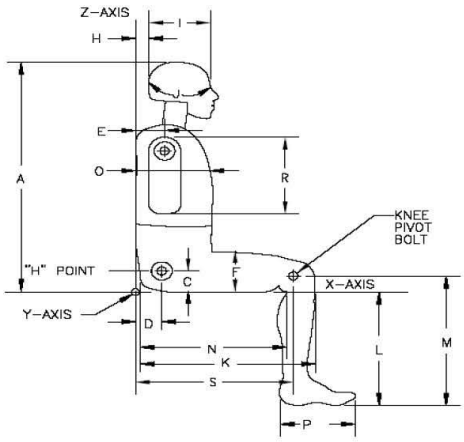
APPENDIX D

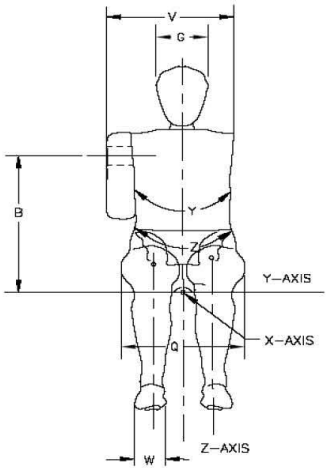
DUMMY QUALIFICATION DATA

External Measurements - SID-IIs

Technician: K. Dutton Date: 07/29/2020

Dummy Serial Number: DG8012





Symbol	Description	Specification (mm)		Result (mm)	Pass/Fail
A	Sitting Height	772	788	779	Pass
B	Shoulder Pivot Height	437	453	446	Pass
C	H-point Height	79	89	84	Pass
D	H-point from seatback	141	151	146	Pass
E	Shoulder Pivot from Backline	97	107	104	Pass
F	Thigh Clearance	119	135	127	Pass
G	Head Breadth	140	148	144	Pass
H	Head Back from Backline	40	46	44	Pass
I	Head Depth	178	188	183	Pass
J	Head Circumference	541	551	547	Pass
K	Buttock to Knee Length	514	540	537	Pass
L	Popliteal Height	343	369	357	Pass
M	Knee Pivot to floor height	392	409	403	Pass
N	Buttock Popliteal Length	416	442	433	Pass
O	Chest Depth w/o jacket	195	211	205	Pass
P	Foot Length	216	232	224	Pass
Q	Hip Breadth (w/pelvic plugs)	313	323	319	Pass
R	Arm Length	249	259	255	Pass
S	Knee Joint to seatback	477	493	487	Pass
V	Shoulder Width	341	357	346	Pass
W	Foot Width	78	94	85	Pass
Y	Chest Circumference w/jacket	851	881	867	Pass
Z	Waist Circumference	761	791	781	Pass

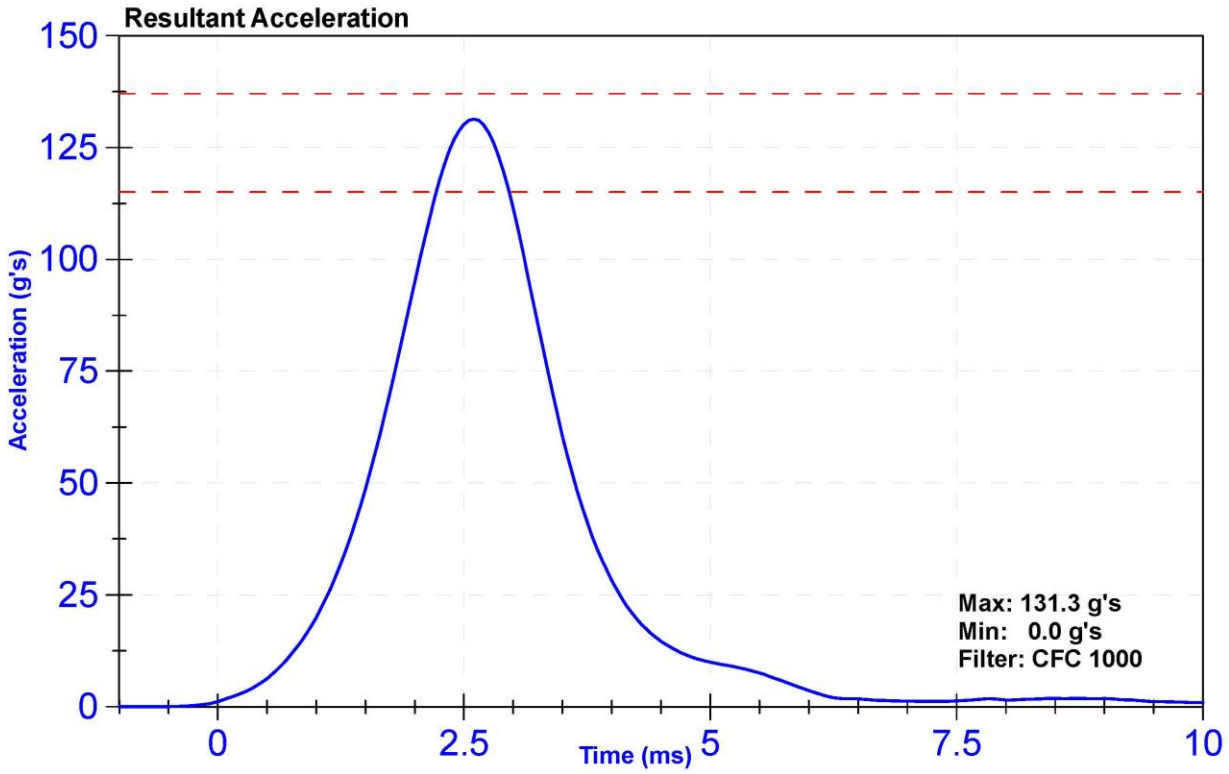
ATD Manufacturer	FTSS	Test Technician	E. Helenbrook
ATD Serial Number	DG8012	Laboratory Supervisor	K. Brogan

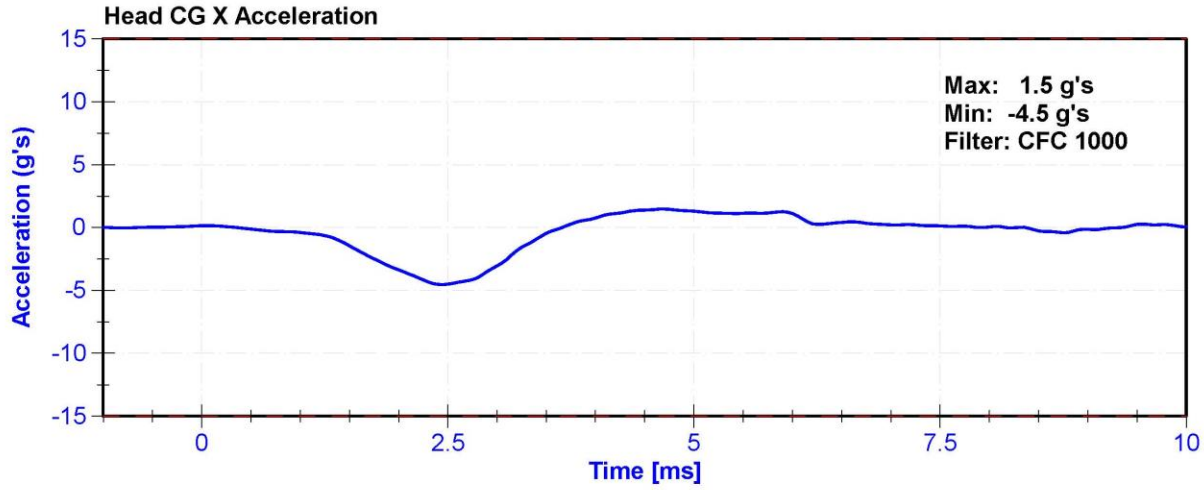
Results

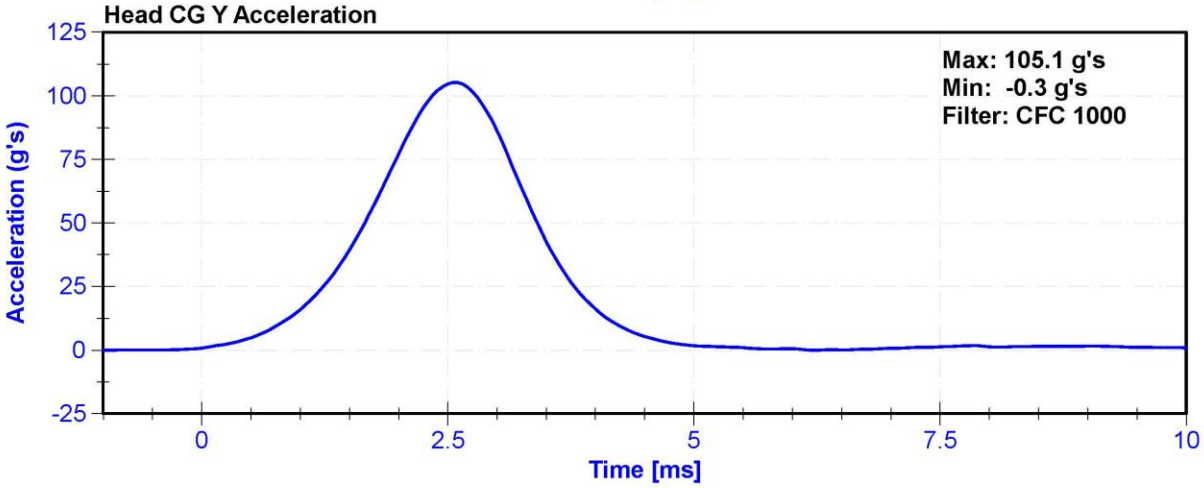
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	64.3	Pass
Resultant Acceleration	115	137	g's	131.3	Pass
Oscillation	0	15	%	1.4	Pass
Fore-Aft Acceleration	-15	15	g's	-4.5	Pass

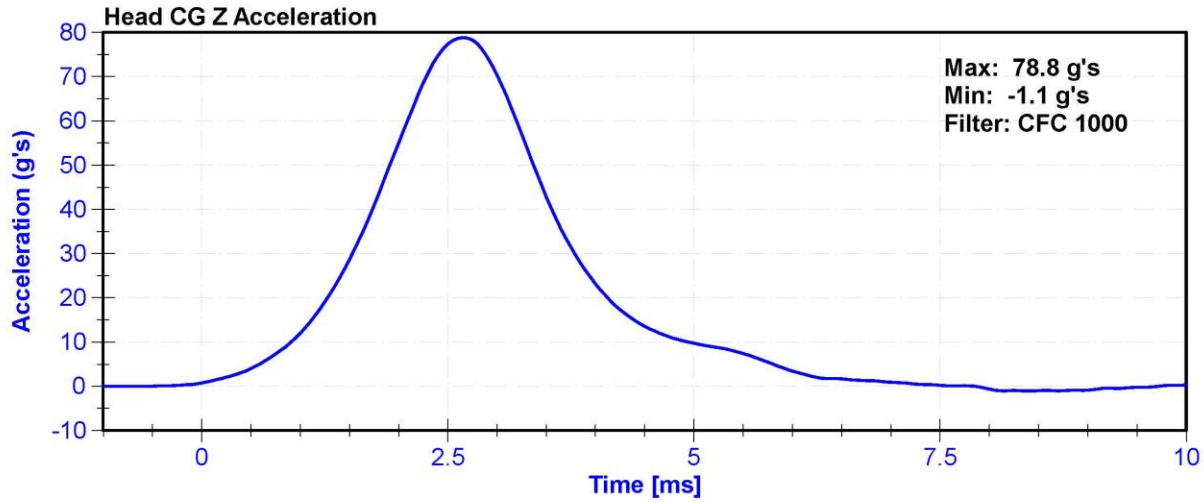
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264	AC-P74788	4/16/2020	10/15/2020
Y Accelerometer	ENDEVCO 7264CT	AC-P83432	4/16/2020	10/15/2020
Z Accelerometer	ENDEVCO 7264	AC-P83319	4/16/2020	10/15/2020




Head CG X Acceleration
Max: 1.5 g's
Min: -4.5 g's
Filter: CFC 1000
Acceleration (g's)
15
10
5
0
-5
-10
-15
0
2.5
5
7.5
10
Time [ms]


Head CG Y Acceleration
Max: 105.1 g's
Min: -0.3 g's
Filter: CFC 1000
Acceleration (g's)
125
100
75
50
25
0
-25
0
2.5
5
7.5
10
Time [ms]


Head CG Z Acceleration
Max: 78.8 g's
Min: -1.1 g's
Filter: CFC 1000
Acceleration (g's)
80
70
60
50
40
30
20
10
0
-10
0
2.5
5
7.5
10
Time [ms]

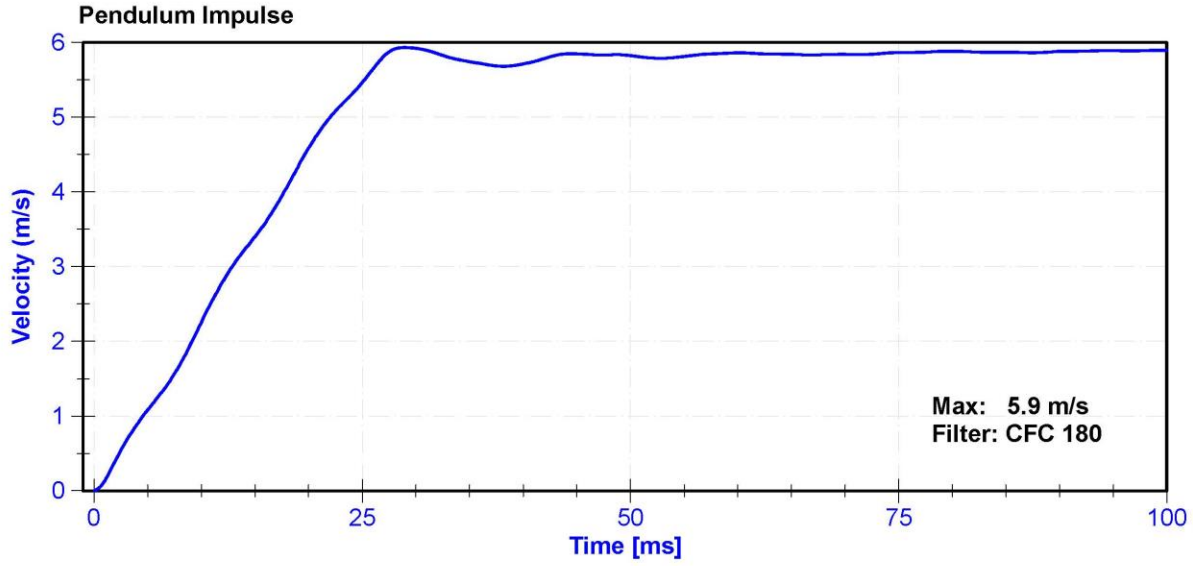
ATD Manufacturer	FTSS	Test Technician	E. Helenbrook
ATD Serial Number	DG8012	Laboratory Supervisor	K. Brogan

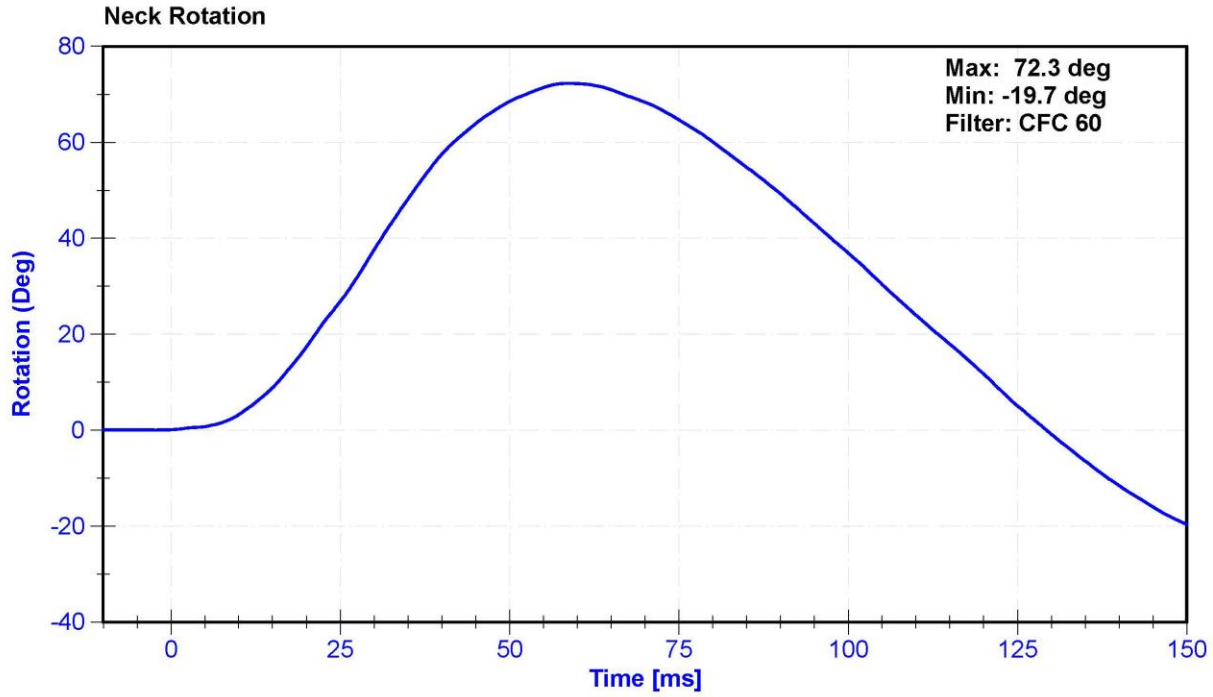
Results

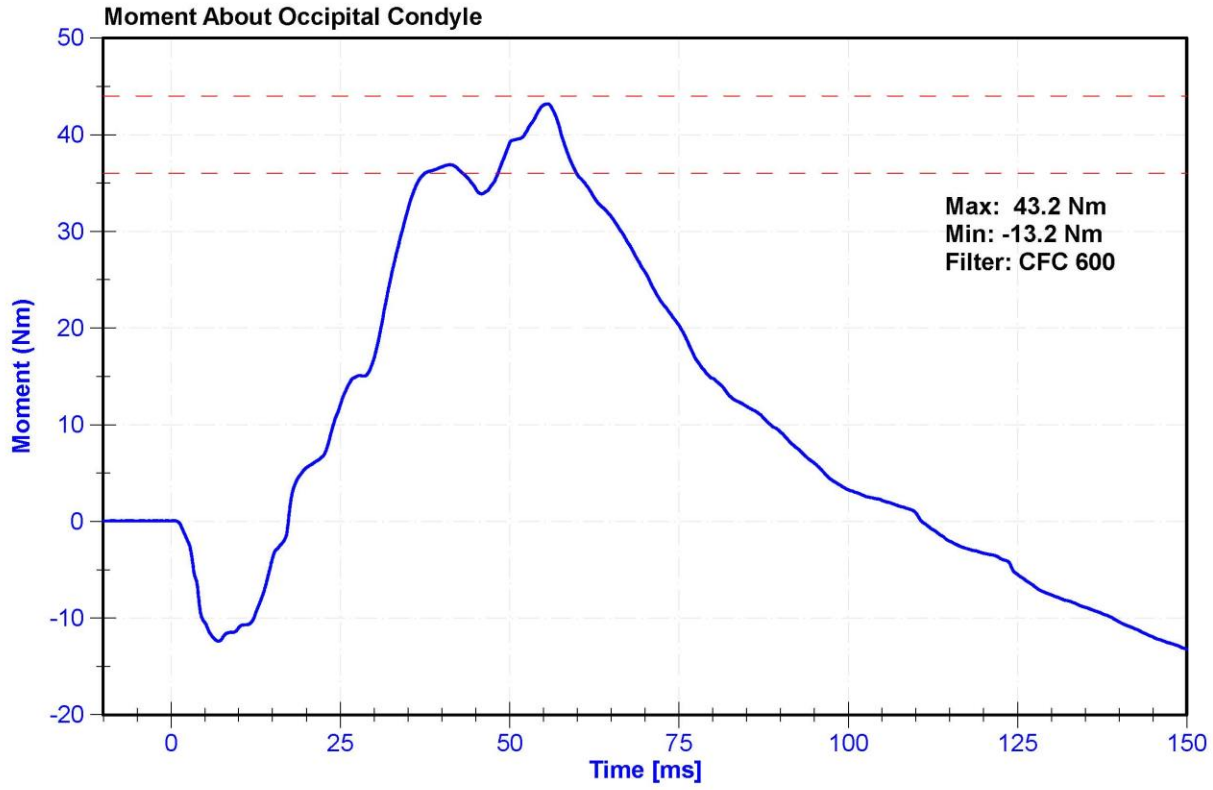
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.9	Pass
Humidity	10	70	%	66.2	Pass
Velocity	5.51	5.63	m/s	5.514	Pass
Pendulum Impulse at 10ms	2.2	2.8	m/s	2.25	Pass
Pendulum Impulse at 15ms	3.3	4.1	m/s	3.40	Pass
Pendulum Impulse at 20ms	4.4	5.4	m/s	4.58	Pass
Pendulum Impulse at 25ms	5.4	6.1	m/s	5.46	Pass
Pendulum Impulse from 25 to 100ms	5.5	6.2	m/s	5.93	Pass
Neck Rotation	71	81	deg	72.3	Pass
Time at Maximum Rotation	50	70	ms	58.6	Pass
Moment about the OC	36	44	Nm	43.2	Pass
Moment Decay to 0 Nm	102	126	ms	110.9	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	Denton 78051-342	DS-184Pend	11/4/2019	11/3/2020
Condyle Potentiometer	Denton 78051-342	DS-185Pend	11/4/2019	11/3/2020
Upper Neck Load Cell	Denton 1716	17162019 FY	3/18/2020	3/18/2021




Neck Rotation
Max: 72.3 deg
Min: -19.7 deg
Filter: CFC 60
Rotation (Deg)
80
60
40
20
0
-20
-40
0
25
50
75
100
125
150
Time [ms]


Moment About Occipital Condyle
Max: 43.2 Nm
Min: -13.2 Nm
Filter: CFC 600
Moment (Nm)
50
40
30
20
10
0
-10
-20
0
25
50
75
100
125
150
Time [ms]

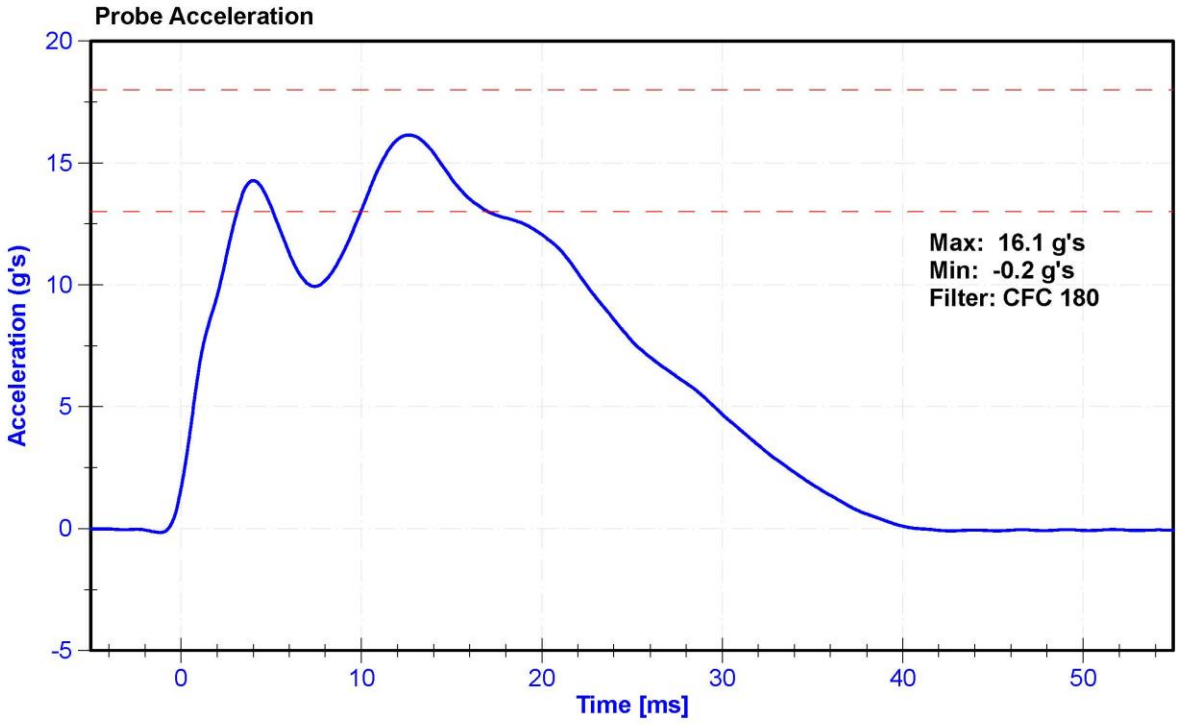
ATD Manufacturer	FTSS	Test Technician	C. Mantell
ATD Serial Number	DG8012	Laboratory Supervisor	K. Brogan

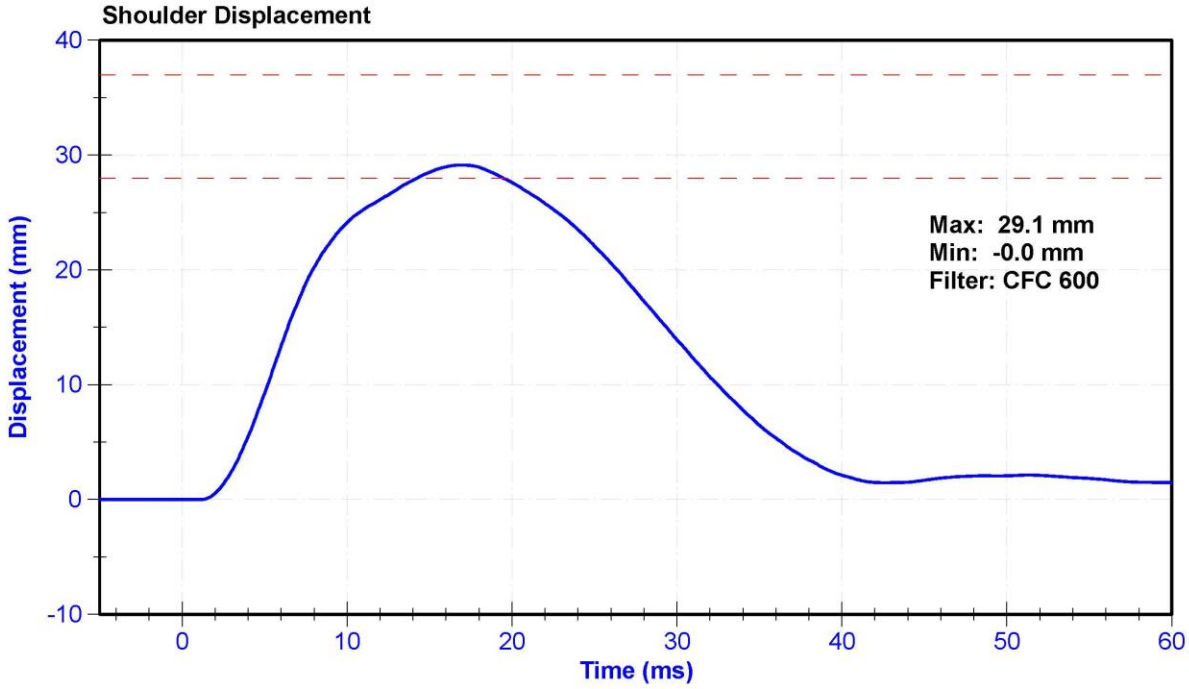
Results

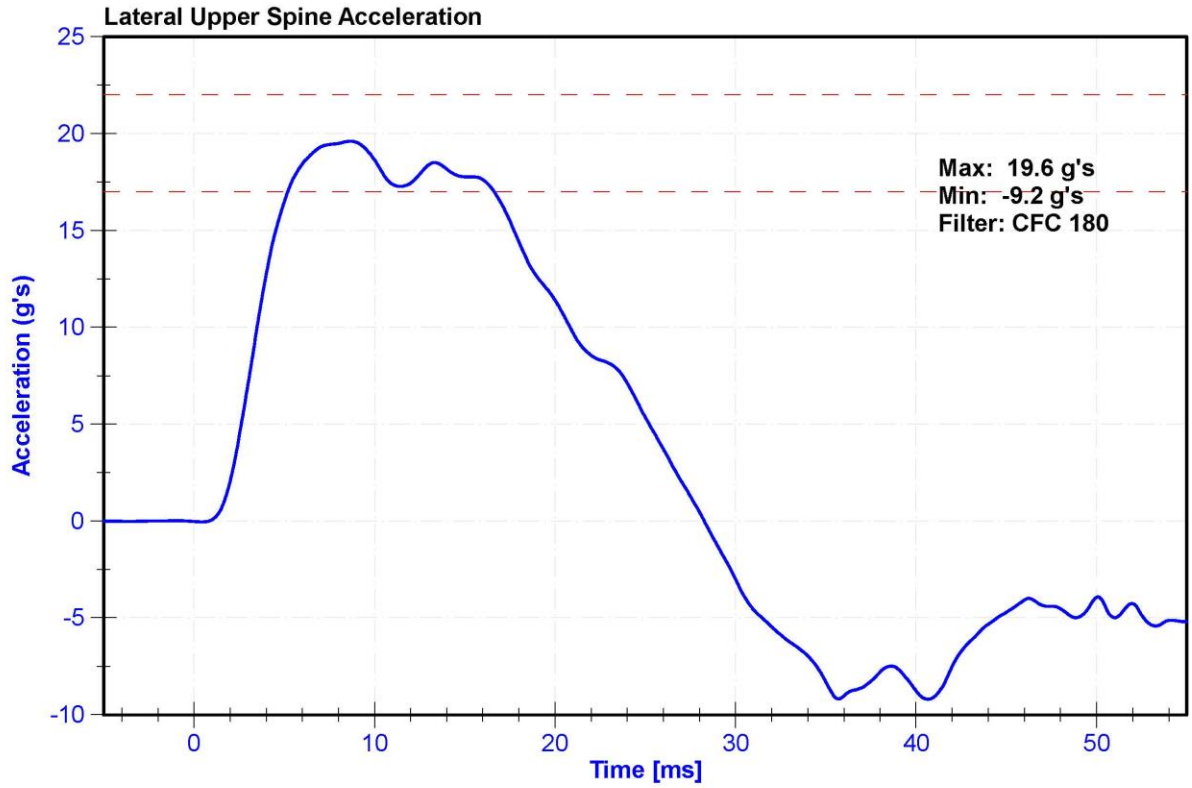
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.4	Pass
Humidity	10	70	%	68.7	Pass
Velocity	4.2	4.4	m/s	4.32	Pass
Probe Acceleration	13	18	g's	16.1	Pass
Shoulder Deflection	28	37	mm	29.1	Pass
Lateral Upper Spine Acceleration	17	22	g's	19.6	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021
Shoulder Potentiometer	Servo 08TC1-3745	DS-1845GFE	5/6/2020	11/4/2020
Upper Spine Y Accelerometer	ENDEVCO 7264CT	AC-P64148	4/16/2020	10/15/2020




Shoulder Displacement
Displacement (mm)
Time (ms)
Max: 29.1 mm
Min: -0.0 mm
Filter: CFC 600


Lateral Upper Spine Acceleration
Acceleration (g's)
Time [ms]
Max: 19.6 g's
Min: -9.2 g's
Filter: CFC 180

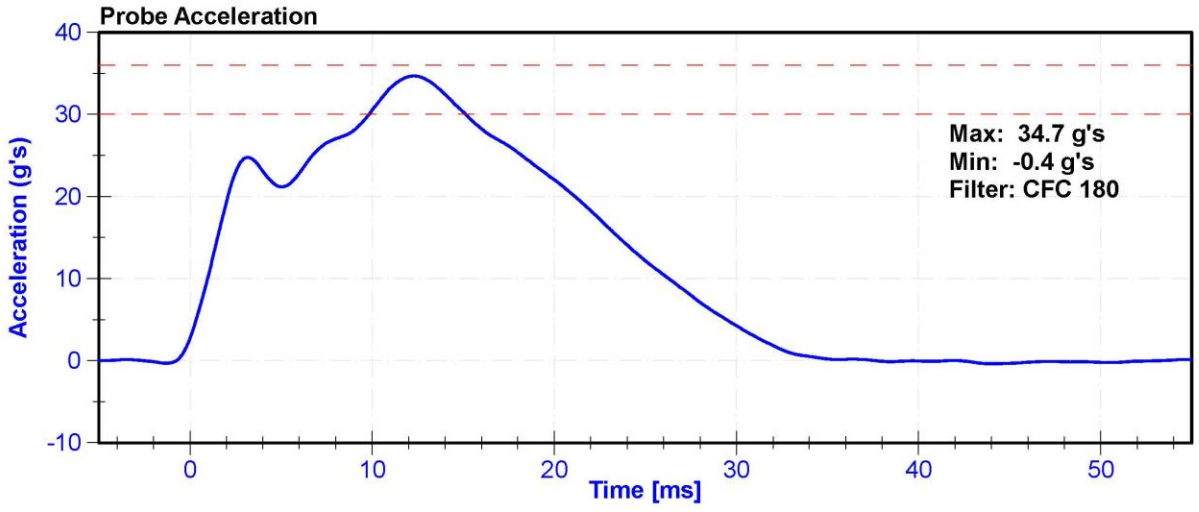
ATD Manufacturer	FTSS	Test Technician	C. Mantell
ATD Serial Number	DG8012	Laboratory Supervisor	K. Brogan

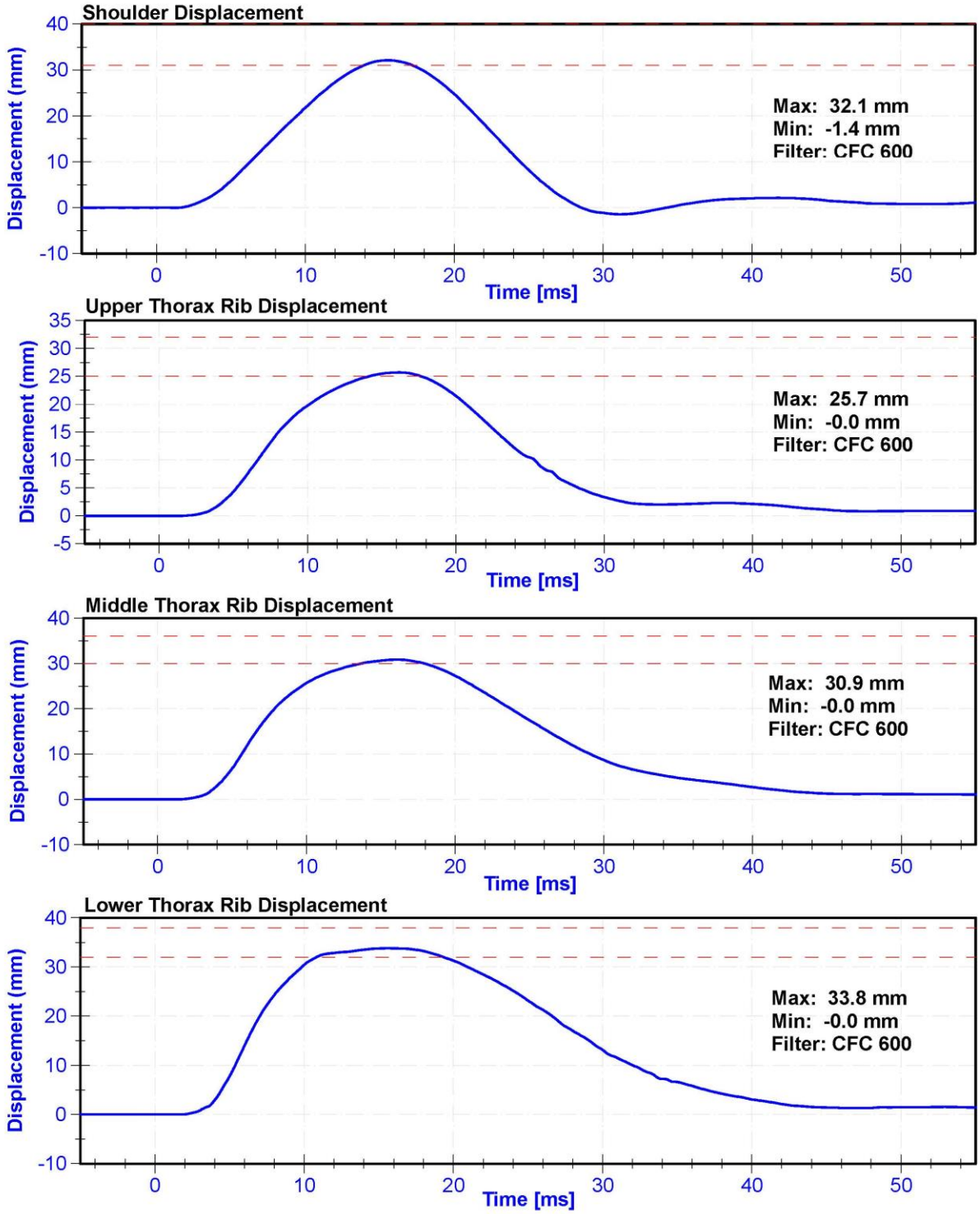
Results

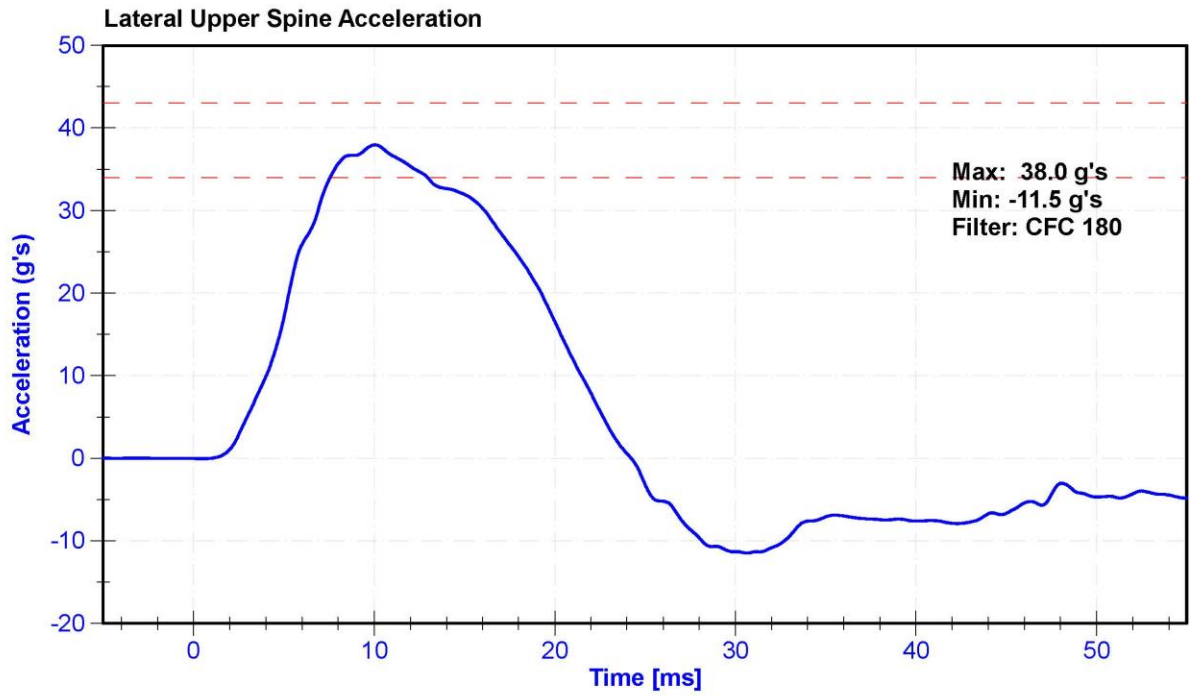
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	67.0	Pass
Velocity	6.6	6.8	m/s	6.66	Pass
Probe Acceleration after 5 ms	30	36	g's	34.7	Pass
Lateral Upper Spine Acceleration	34	43	g's	38.0	Pass
Lateral Lower Spine Acceleration	29	37	g's	32.4	Pass
Shoulder Deflection	31	40	mm	32.1	Pass
Upper Thorax Rib Deflection	25	32	mm	25.7	Pass
Mid Thorax Rib Deflection	30	36	mm	30.9	Pass
Lower Thorax Rib Deflection	32	38	mm	33.8	Pass

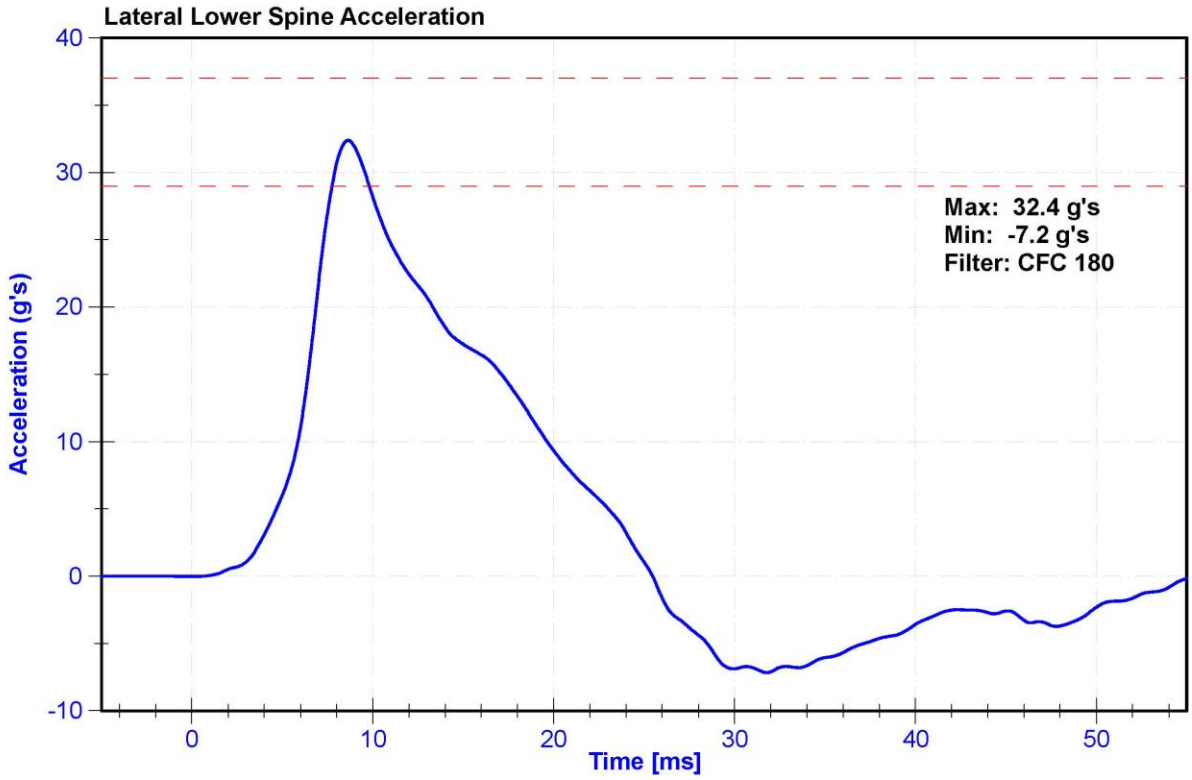
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021
Upper Spine T1 Y Accelerometer	ENDEVCO 7264CT	AC-P64148	4/16/2020	10/15/2020
Upper Spine T12 Y Accelerometer	ENDEVCO 7264C	AC-P51327	4/16/2020	10/15/2020
Shoulder Potentiometer	Servo 08TC1-3745	DS-1845GFE	5/6/2020	11/4/2020
Upper Thorax Rib Potentiometer	Servo 1246	DS-2165GFE	5/6/2020	11/4/2020
Middle Thorax Rib Potentiometer	Servo 08TC1-3621	DS-45 GFE	5/6/2020	11/4/2020
Lower Thorax Rib Potentiometer	Servo 08TC1-3787	DS-011GFE	5/6/2020	11/4/2020




Shoulder Displacement
Displacement (mm)
Time [ms]
Max: 32.1 mm
Min: -1.4 mm
Filter: CFC 600
Upper Thorax Rib Displacement
Displacement (mm)
Time [ms]
Max: 25.7 mm
Min: -0.0 mm
Filter: CFC 600
Middle Thorax Rib Displacement
Displacement (mm)
Time [ms]
Max: 30.9 mm
Min: -0.0 mm
Filter: CFC 600
Lower Thorax Rib Displacement
Displacement (mm)
Time [ms]
Max: 33.8 mm
Min: -0.0 mm
Filter: CFC 600


Lateral Upper Spine Acceleration
Max: 38.0 g's
Min: -11.5 g's
Filter: CFC 180
Acceleration (g's)
Time [ms]
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50


Lateral Lower Spine Acceleration
Max: 32.4 g's
Min: -7.2 g's
Filter: CFC 180
Acceleration (g's)
Time [ms]
40
30
20
10
0
-10
0
10
20
30
40
50

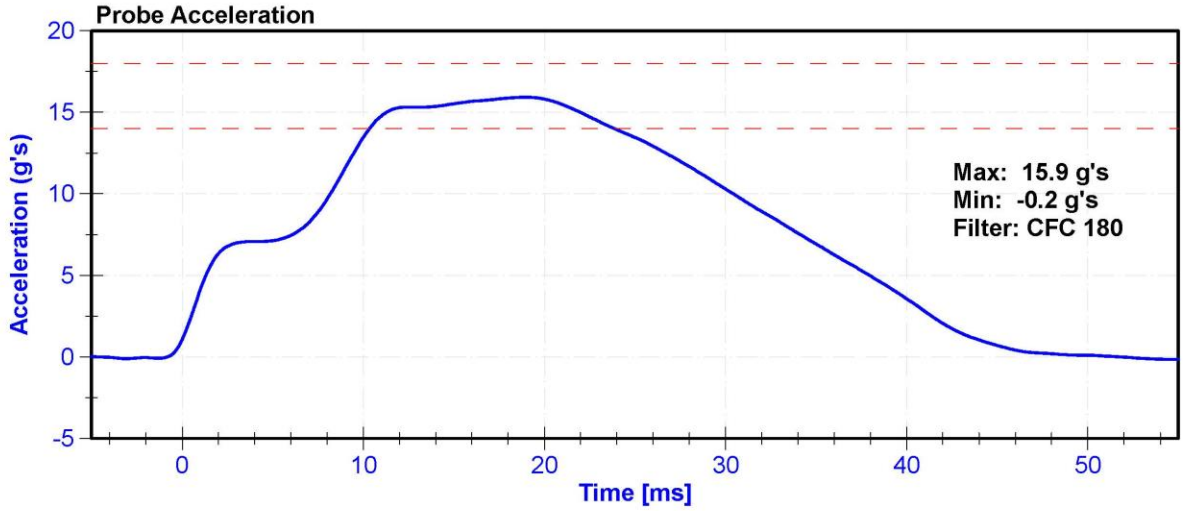
ATD Manufacturer	FTSS	Test Technician	C. Mantell
ATD Serial Number	DG8012	Laboratory Supervisor	K. Brogan

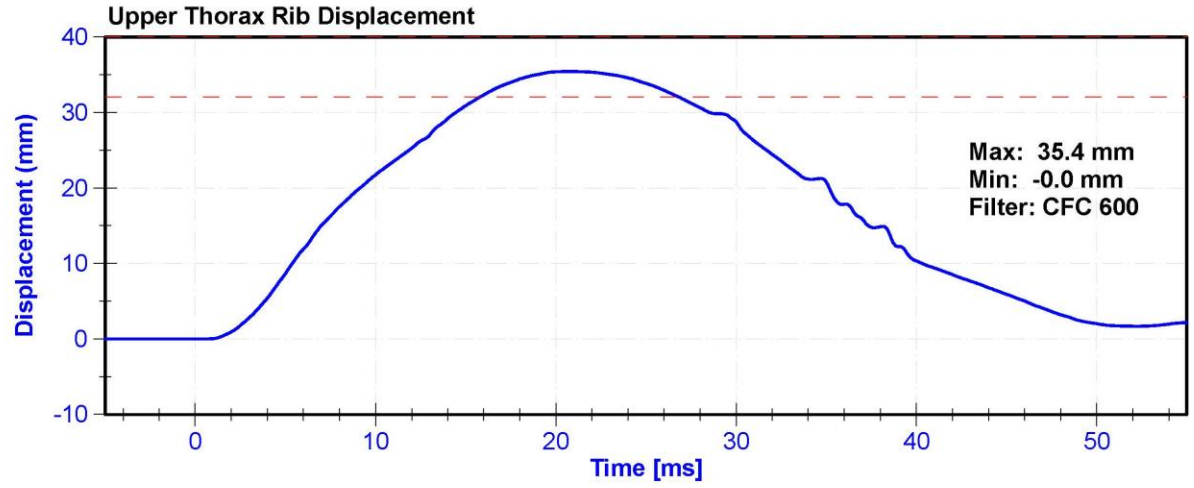
Results

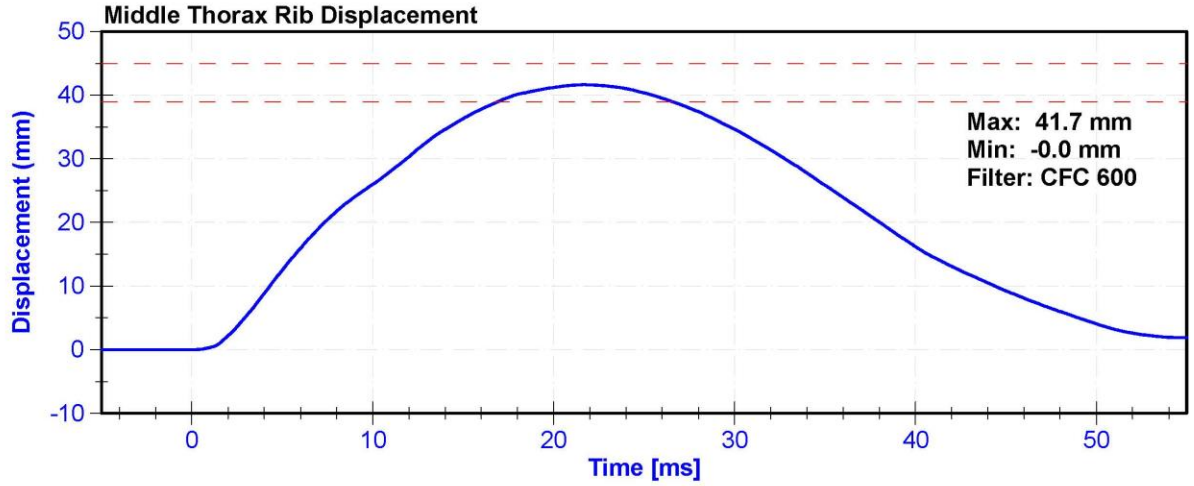
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	69	Pass
Velocity	4.2	4.4	m/s	4.26	Pass
Probe Acceleration	14	18	g's	15.9	Pass
Lateral Upper Spine Acceleration	13	17	g's	14.9	Pass
Lateral Lower Spine Acceleration	7	11	g's	8.9	Pass
Upper Thorax Rib Deflection	32	40	mm	35.4	Pass
Middle Thorax Rib Deflection	39	45	mm	41.7	Pass
Lower Thorax Rib Deflection	35	43	mm	39.7	Pass

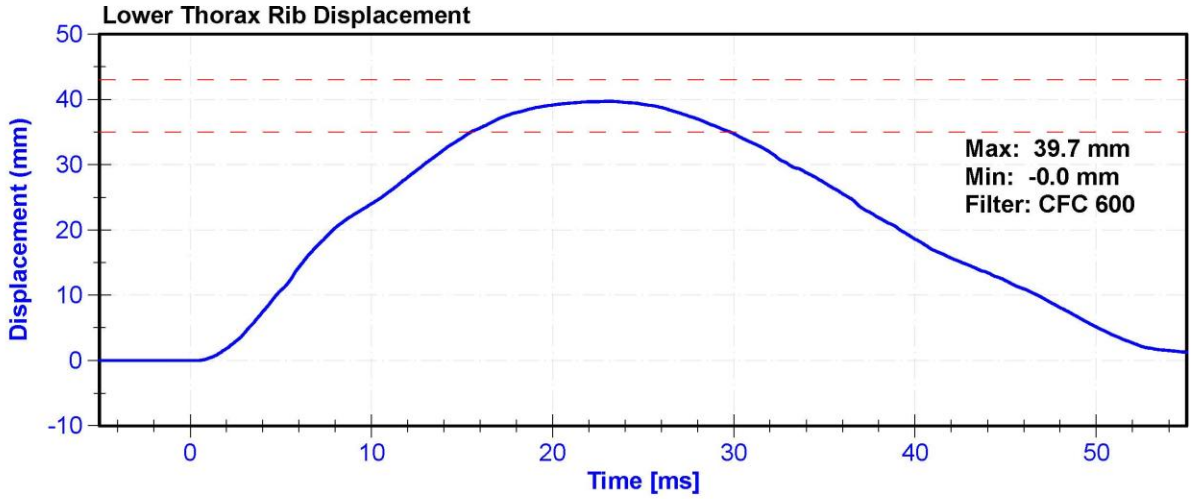
Transducer Calibrations

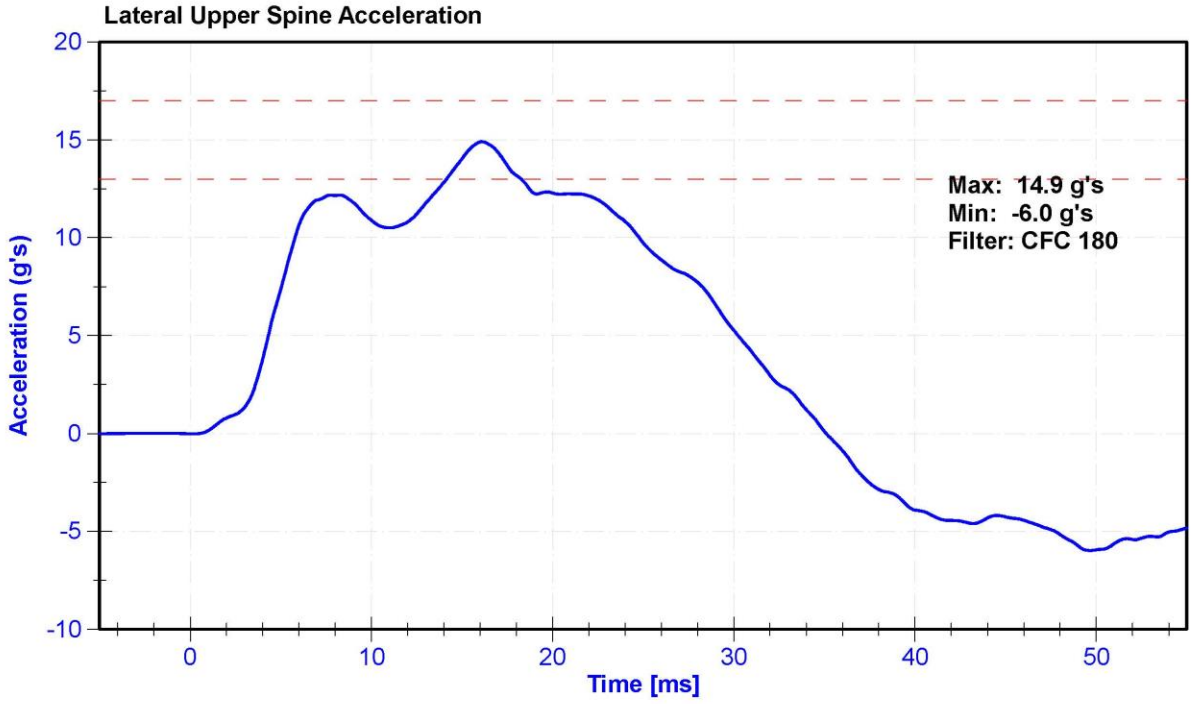
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021
Upper Spine Y Accelerometer	ENDEVCO 7264CT	AC-P64148	4/16/2020	10/15/2020
Lower Spine Y Accelerometer	ENDEVCO 7264C	AC-P51327	4/16/2020	10/15/2020
Upper Thorax Rib Potentiometer	Servo 1246	DS-2165GFE	5/6/2020	11/4/2020
Middle Thorax Rib Potentiometer	Servo 08TC1-3621	DS-45 GFE	5/6/2020	11/4/2020
Lower Thorax Rib Potentiometer	Servo 08TC1-3787	DS-011GFE	5/6/2020	11/4/2020

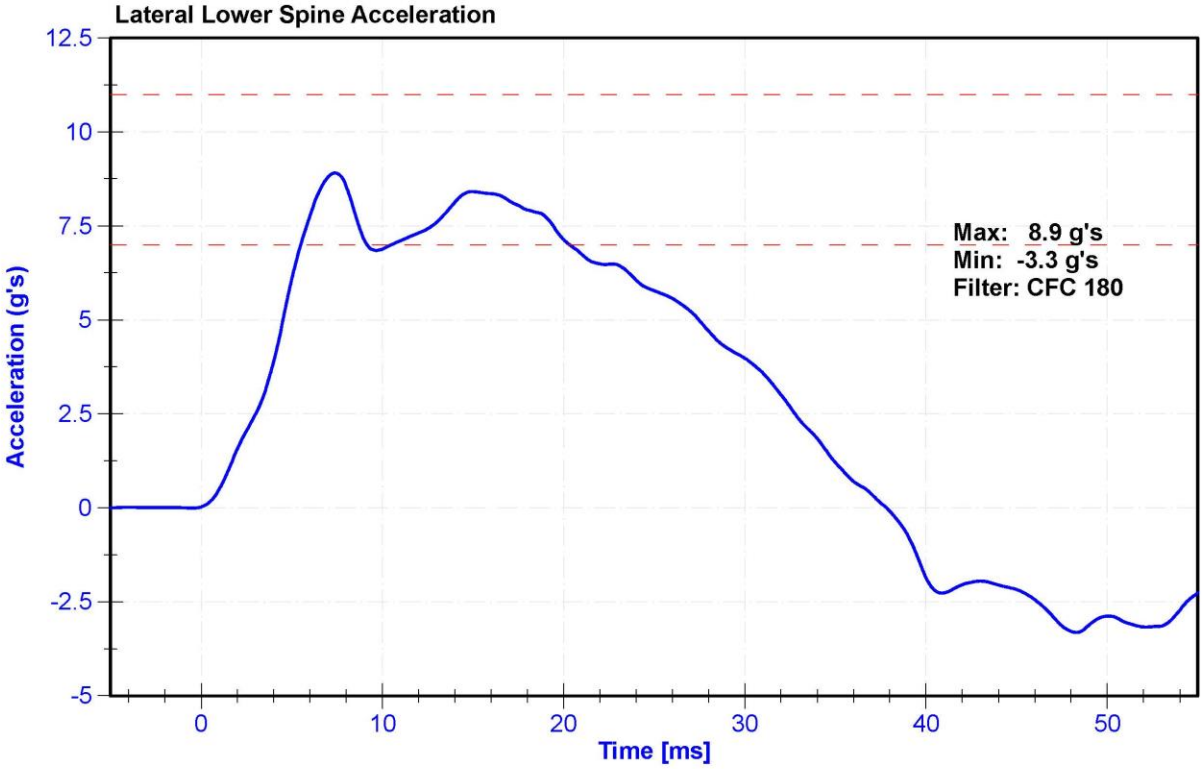



Upper Thorax Rib Displacement
Displacement (mm)
Time [ms]
Max: 35.4 mm
Min: -0.0 mm
Filter: CFC 600


Middle Thorax Rib Displacement
Displacement (mm)
Time [ms]
Max: 41.7 mm
Min: -0.0 mm
Filter: CFC 600


Lower Thorax Rib Displacement
Displacement (mm)
Time [ms]
Max: 39.7 mm
Min: -0.0 mm
Filter: CFC 600


Lateral Upper Spine Acceleration
Acceleration (g's)
Time [ms]
Max: 14.9 g's
Min: -6.0 g's
Filter: CFC 180


Lateral Lower Spine Acceleration
Acceleration (g's)
Time [ms]
Max: 8.9 g's
Min: -3.3 g's
Filter: CFC 180

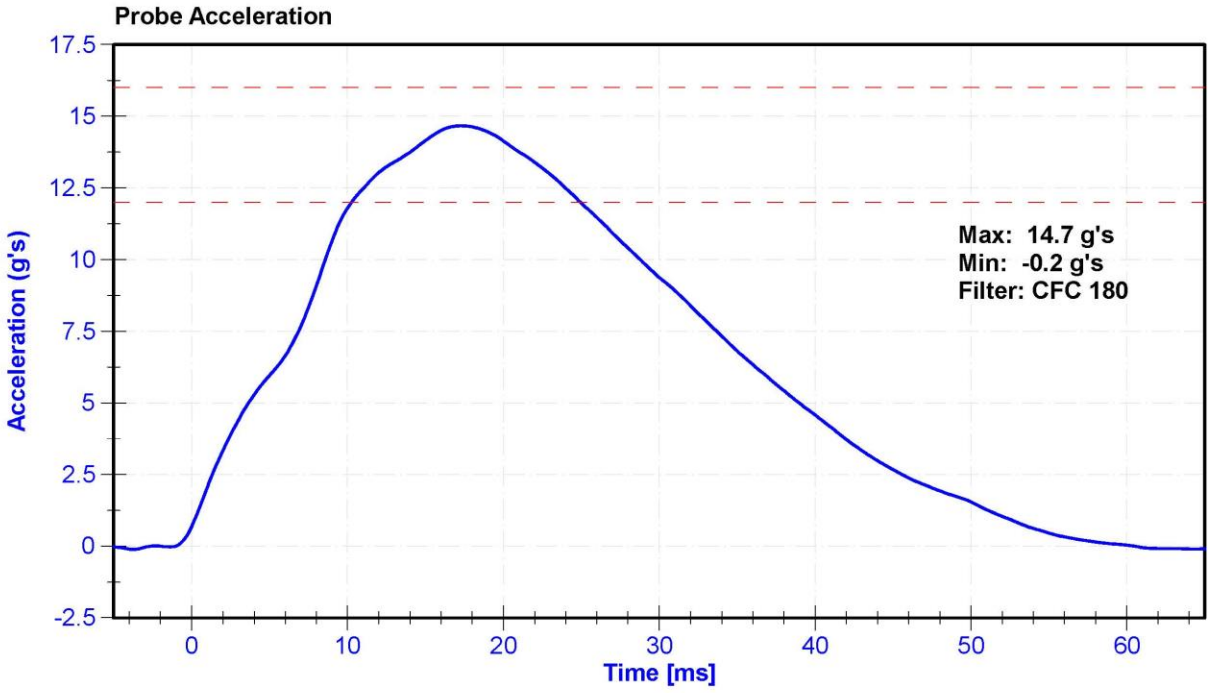
ATD Manufacturer	FTSS	Test Technician	C. Mantell
ATD Serial Number	DG8012	Laboratory Supervisor	K. Brogan

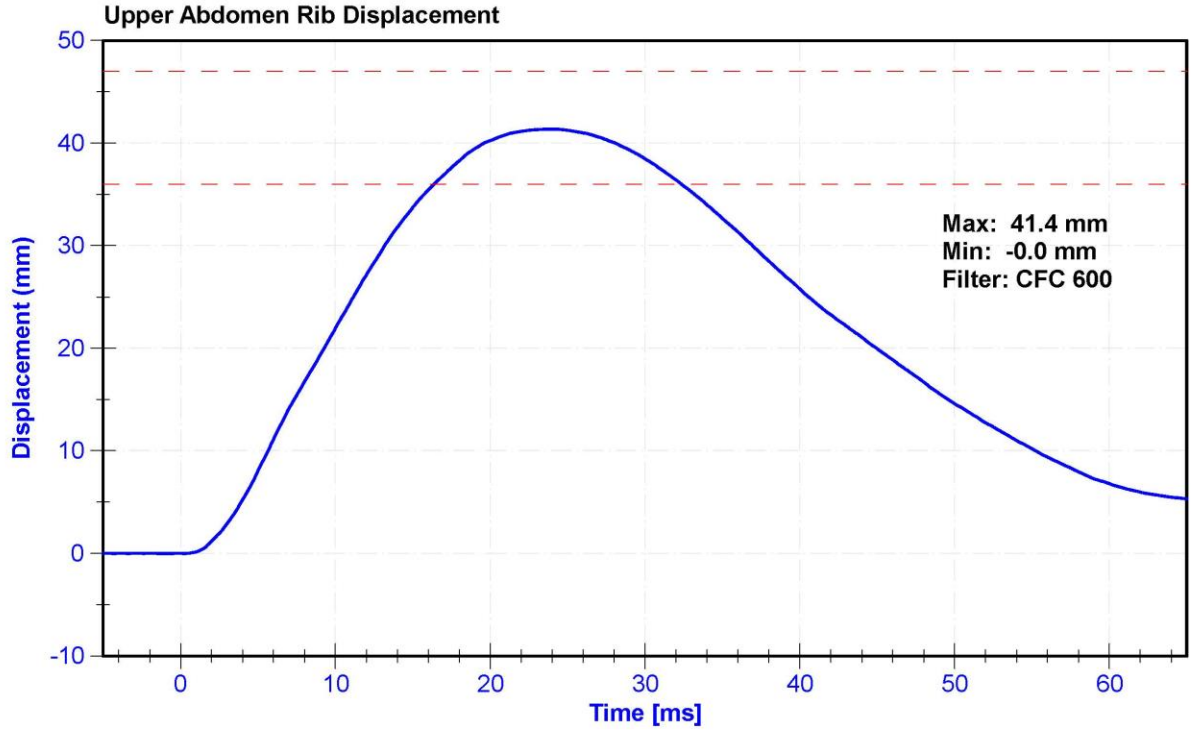
Results

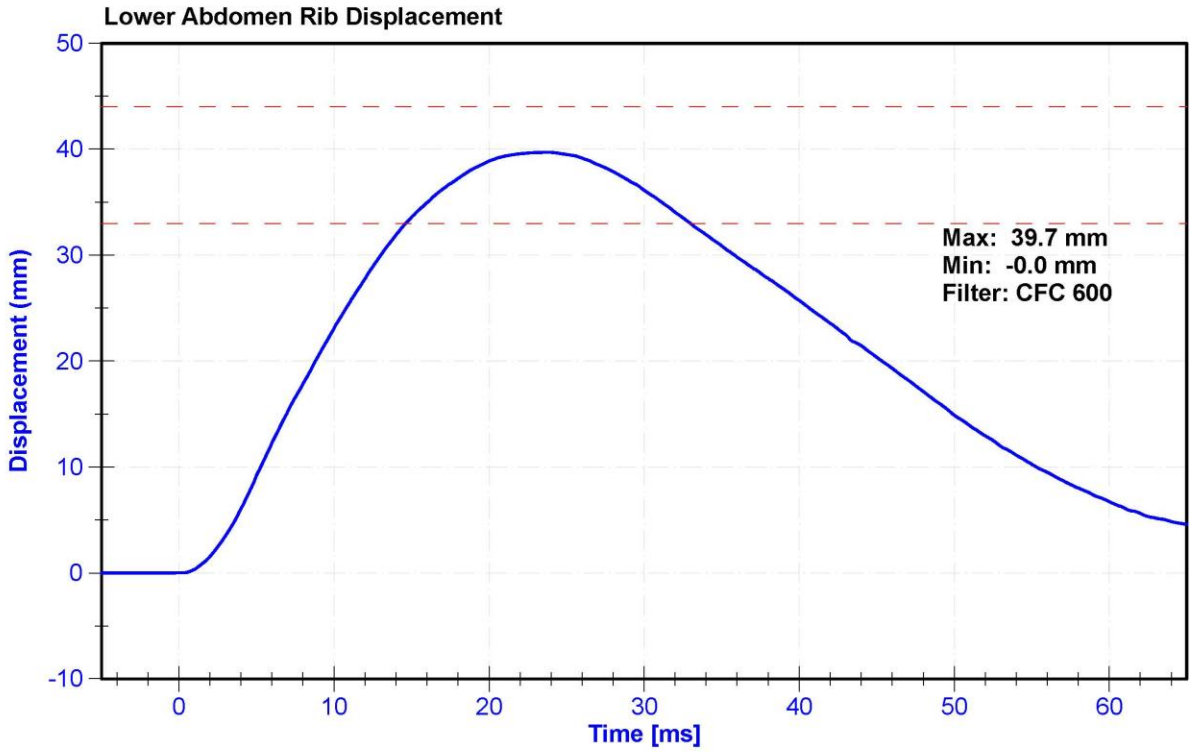
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	68.0	Pass
Velocity	4.2	4.4	m/s	4.26	Pass
Probe Acceleration	12	16	g's	14.7	Pass
Lateral Lower Spine Acceleration	9	14	g's	10.9	Pass
Upper Abdomen Rib Deflection	36	47	mm	41.4	Pass
Lower Abdomen Rib Deflection	33	44	mm	39.7	Pass

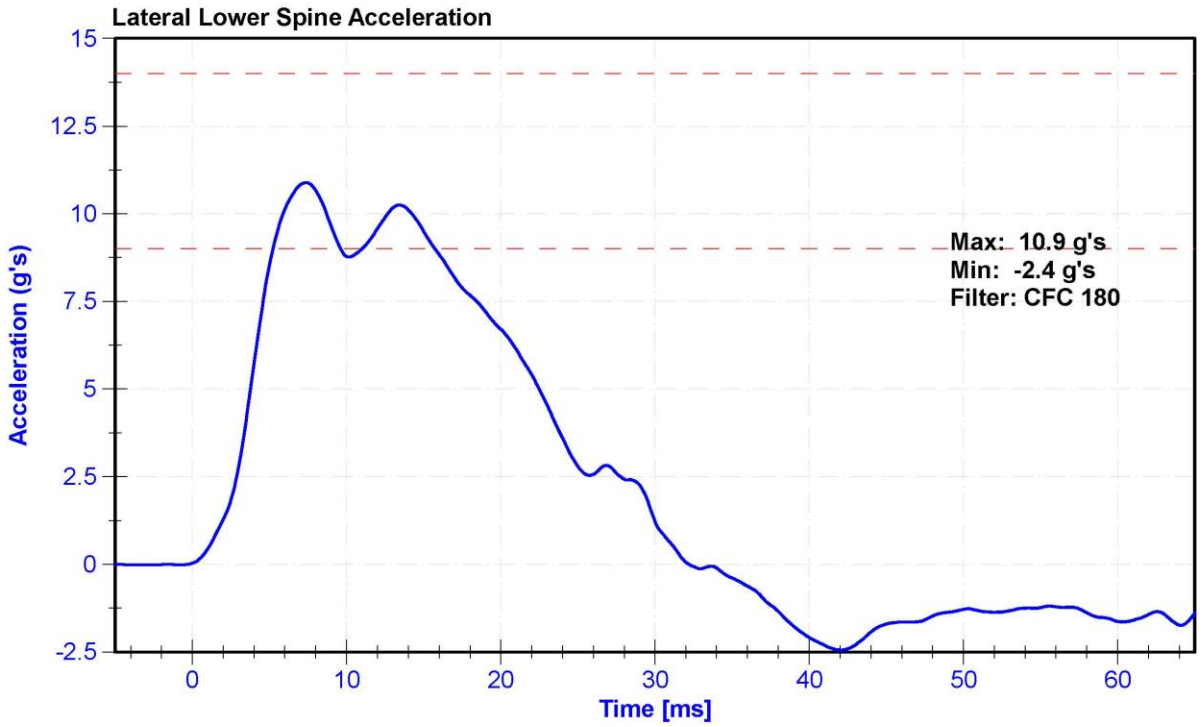
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Probe Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021
Lower Spine Y Accelerometer	ENDEVCO 7264C	AC-P51327	4/16/2020	10/15/2020
Upper Abdomen Rib Potentiometer	Servo 08TC1-3725	DS-008GFE	5/6/2020	11/4/2020
Lower Abdomen Rib Potentiometer	Servo 08TC1-3745	DS-1774GFE	5/6/2020	11/4/2020




Upper Abdomen Rib Displacement
Displacement (mm)
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
Time [ms]
Max: 41.4 mm
Min: -0.0 mm
Filter: CFC 600


Lower Abdomen Rib Displacement
Displacement (mm)
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
Time [ms]
Max: 39.7 mm
Min: -0.0 mm
Filter: CFC 600


Lateral Lower Spine Acceleration
Acceleration (g's)
15
12.5
10
7.5
5
2.5
0
-2.5
0
10
20
30
40
50
60
Time [ms]
Max: 10.9 g's
Min: -2.4 g's
Filter: CFC 180

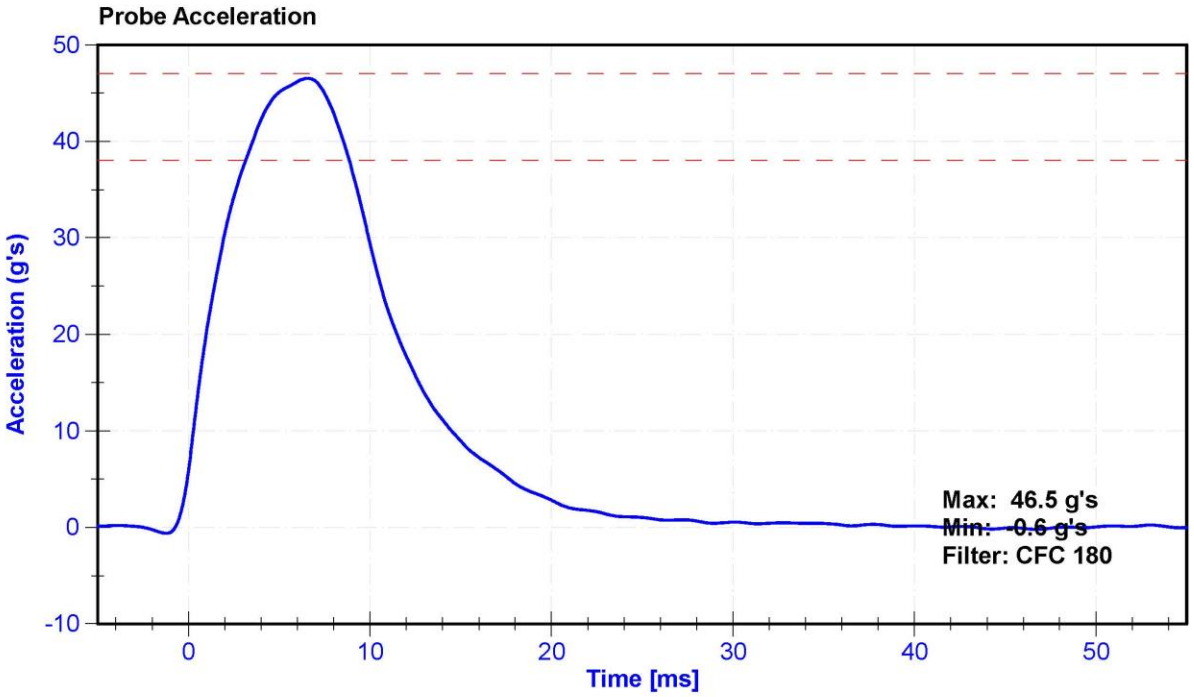
ATD Manufacturer	FTSS	Test Technician	C. Mantell
ATD Serial Number	DG8012	Laboratory Supervisor	K. Brogan

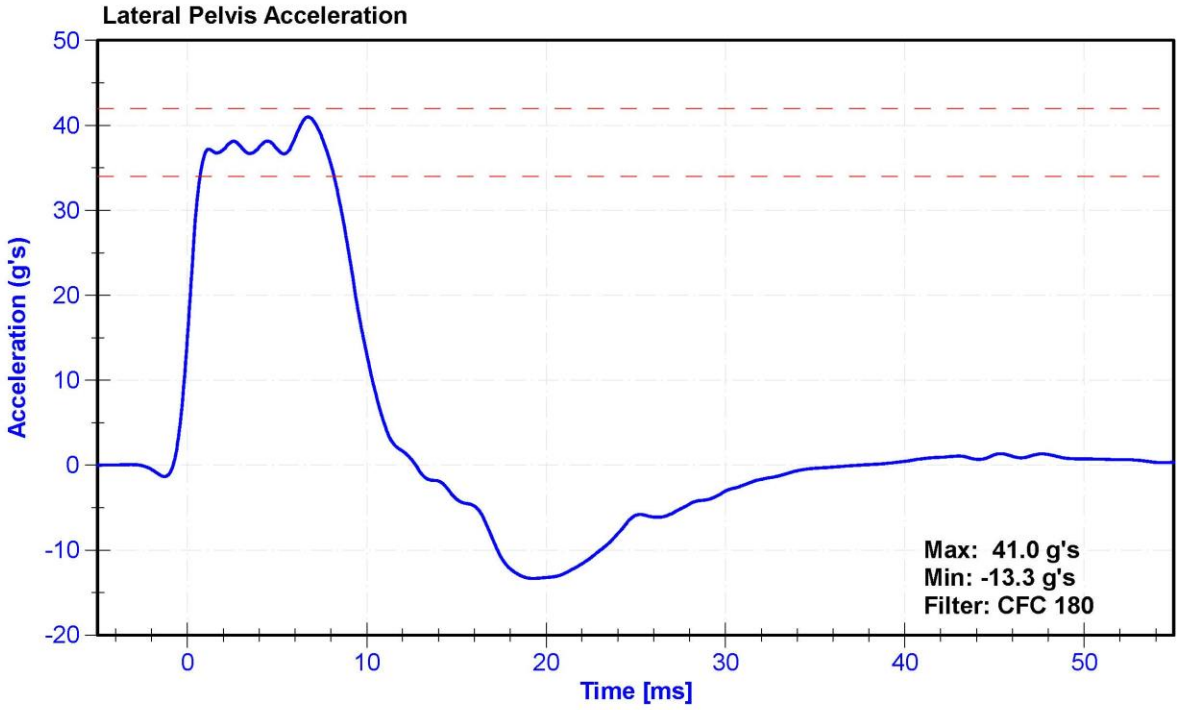
Results

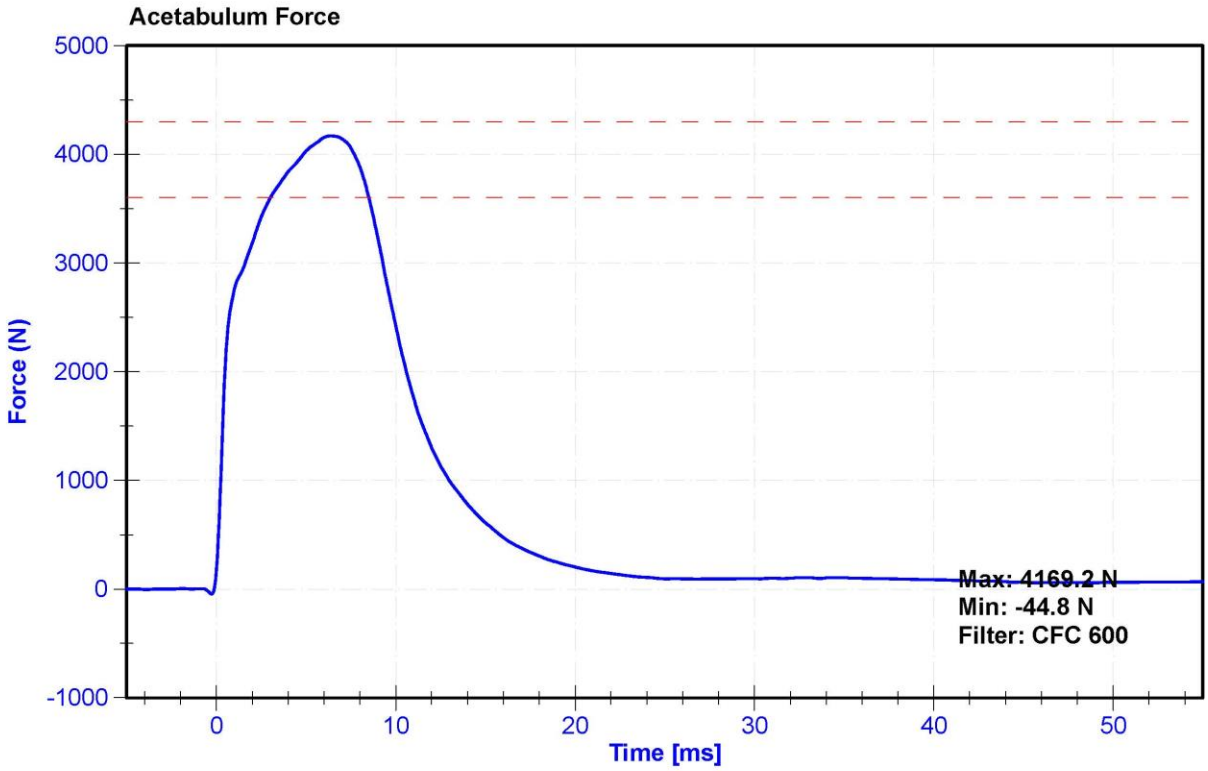
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21	Pass
Humidity	10	70	%	66	Pass
Velocity	6.6	6.8	m/s	6.66	Pass
Probe Acceleration	38	47	g's	46.5	Pass
Lateral Pelvis Acceleration after 6ms	34	42	g's	41.0	Pass
Acetabulum Force	3600	4300	N	4169.2	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021
Pelvis Y Accelerometer	ENDEVCO 7264C	AC-P51875	4/16/2020	10/15/2020
Acetabulum Load Cell	Denton 3249J	LC-267Fy	3/19/2020	3/19/2021
Certification Plug	Humanetics	13214	8-8-2019	N/A
Crash Test Plug	Humanetics	13223	8-12-2019	N/A




Lateral Pelvis Acceleration
Acceleration (g's)
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
Time [ms]
Max: 41.0 g's
Min: -13.3 g's
Filter: CFC 180


Acetabulum Force
Force (N)
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50
Time [ms]
Max: 4169.2 N
Min: -44.8 N
Filter: CFC 600

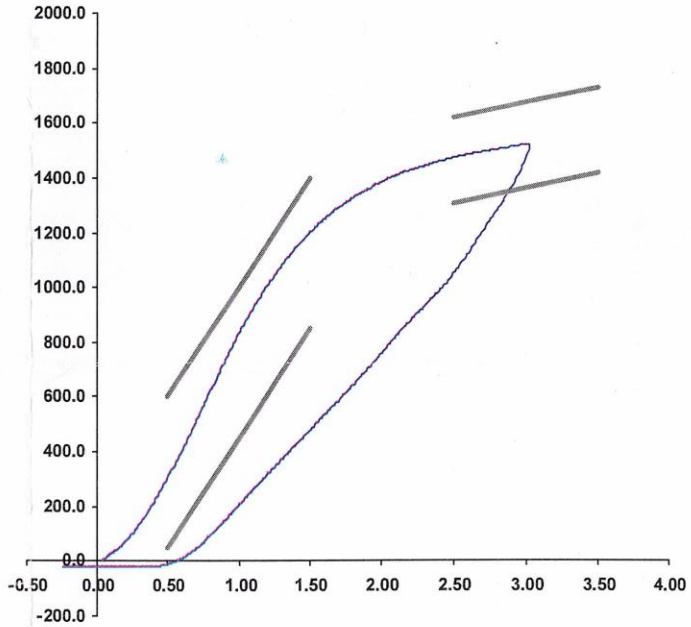
SID-IIs Pelvis Plug Certification Test

Plug S/N 13214
Test Number 10609
Report Number 10644
Test Date 8/8/2019 1:25:47 PM

Cert

	Test Results	Spec Min	Spec Max
Force @ 0.5 mm (N)	317.91	50.00	600.00
Force @ 1.5 mm (N)	1,205.73	850.00	1,400.00
Force @ 2.5 mm (N)	1,474.55	1,306.00	1,618.00
Force @ 3.0 mm (N)	1,521.61	1,361.00	1,673.00

Force (-N) vs Extension (-mm)



Testing Machine STM-20 5965542
Load Cell S/N (FI360947), Units (LBS) 1000

Crosshead Speed (mm / min) or Rate 12.7
Extension or Position Measured by XHD_100 (XHD100)

Notes:

Operator

Part Number 180-4450

Template No 107 **08-Aug-19**
SACO Research

By : DC Date : 8/8/2019

SACO Research 41735 Elm St, #401 Murrieta, CA 92562 Tel 310-694-2082 FAX

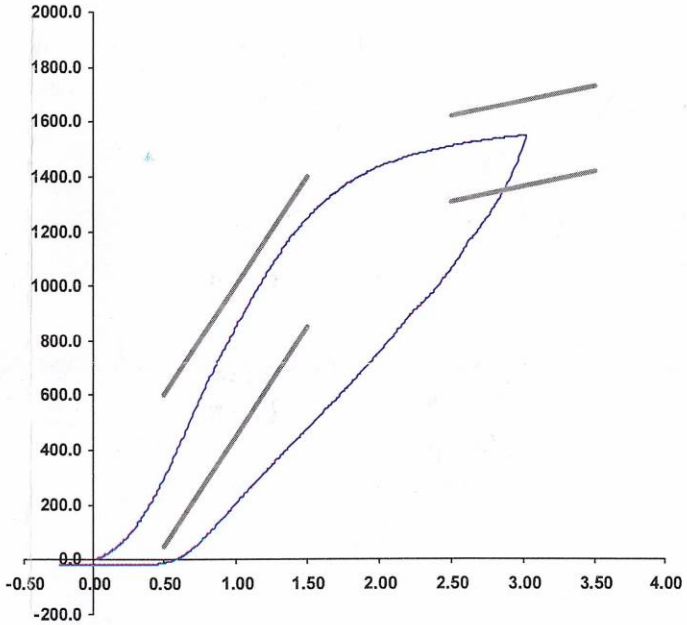
SID-IIs Pelvis Plug Certification Test

Plug S/N 13223
Test Number 10645
Report Number 10681
Test Date 8/12/2019 7:37:44 AM

crush

	Test Results	Spec Min	Spec Max
Force @ 0.5 mm (N)	312.05	50.00	600.00
Force @ 1.5 mm (N)	1,251.10	850.00	1,400.00
Force @ 2.5 mm (N)	1,511.33	1,306.00	1,618.00
Force @ 3.0 mm (N)	1,550.81	1,361.00	1,673.00

Force (-N) vs Extension (-mm)



Testing Machine STM-20 5965542
Load Cell S/N (FI360947), Units (LBS) 1000

Crosshead Speed (mm / min) or Rate 12.7
Extension or Position Measured by XHD_100 (XHD100)

Notes:

Operator

Part Number 180-4450

Template No 107 **12-Aug-19**
SACO Research

By : DC Date : 8/12/2019

SACO Research 41735 Elm St, #401 Murrieta, CA 92562 Tel 310-694-2082 FAX

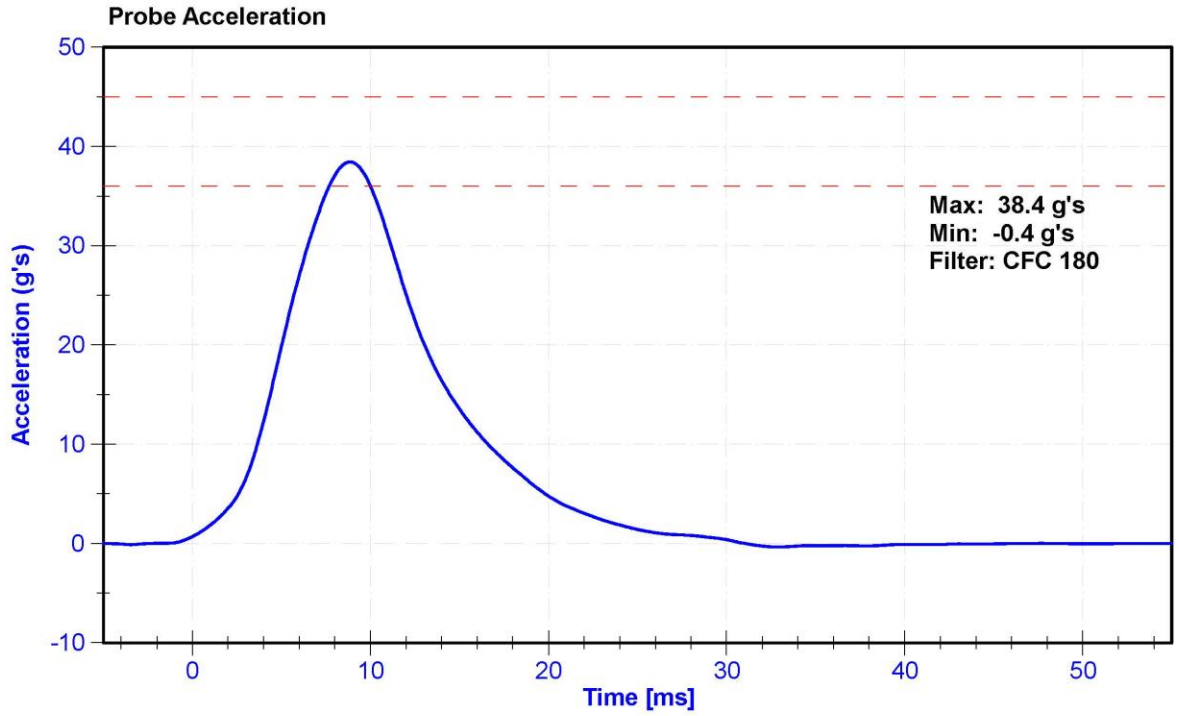
ATD Manufacturer	FTSS	Test Technician	C. Mantell
ATD Serial Number	DG8012	Laboratory Supervisor	K. Brogan

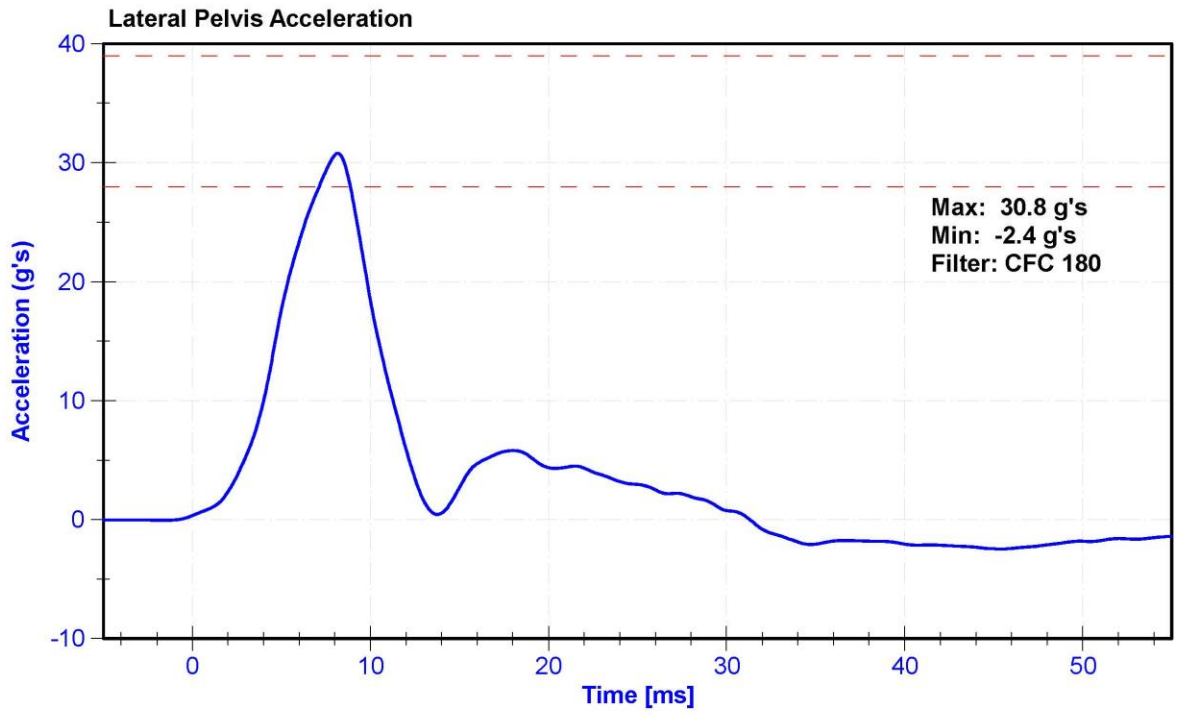
Results

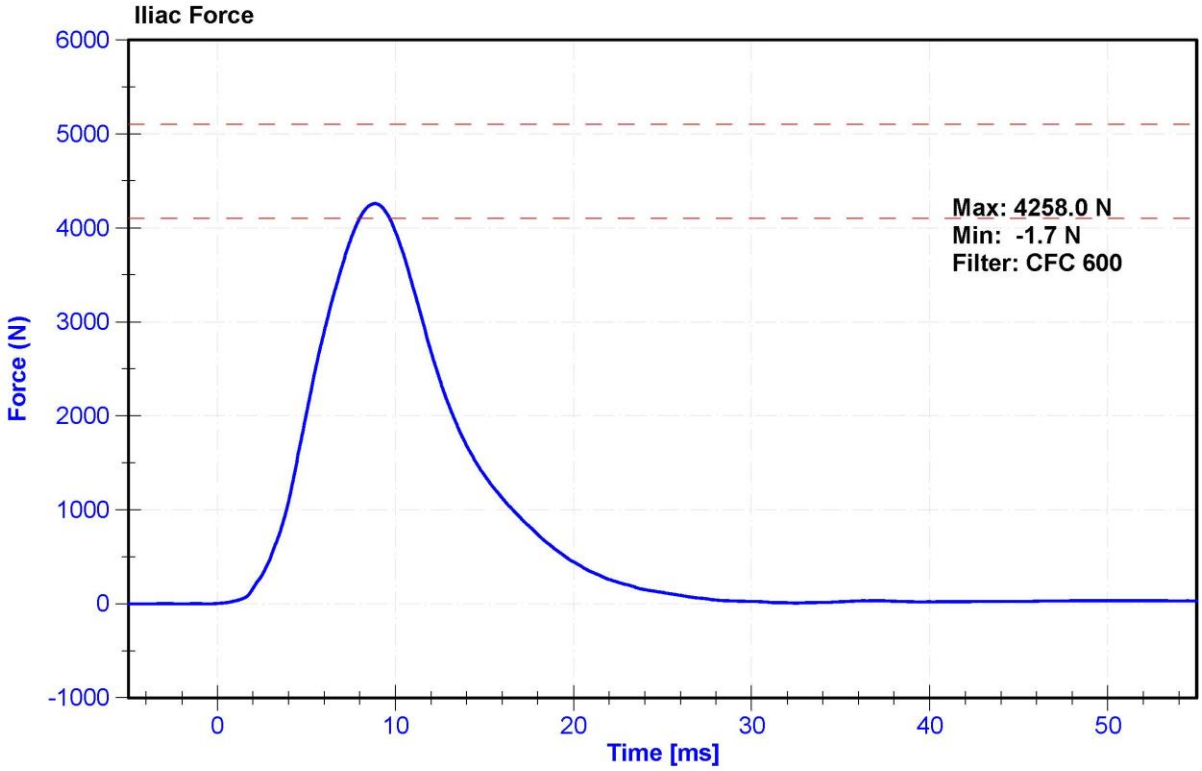
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.4	Pass
Humidity	10	70	%	66.0	Pass
Velocity	4.2	4.4	m/s	4.37	Pass
Probe Acceleration	36	45	g's	38.4	Pass
Lateral Pelvis Acceleration	28	39	g's	30.8	Pass
Iliac Force	4100	5100	N	4258.0	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021
Pelvis Y Accelerometer	ENDEVCO 7264C	AC-P51875	4/16/2020	10/15/2020
Iliac Load Cell	DENTON 3228J	LC-290Fy	9/25/2019	9/24/2020




Lateral Pelvis Acceleration
Acceleration (g's)
Time [ms]
Max: 30.8 g's
Min: -2.4 g's
Filter: CFC 180


Iliac Force
Force (N)
Time [ms]
Max: 4258.0 N
Min: -1.7 N
Filter: CFC 600