REPORT NUMBER: NCAP-CAL-20-010

NEW CAR ASSESSMENT PROGRAM (NCAP)
FRONTAL BARRIER IMPACT TEST

Volvo Car Corporation
2020 Volvo S60
Four Door Sedan

NHTSA No: M20205900

PREPARED BY:
CALSPAN CORPORATION
P.O. BOX 400
BUFFALO, NEW YORK 104625

May 22, 2020

FINAL REPORT

PREPARED FOR:
U. S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
OFFICE OF CRASHWORTHINESS STANDARDS
1200 NEW JERSEY AVE SE, ROOM W43-410
WASHINGTON, D.C. 20590

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Vanessa Hansen, Operations Manager

FINAL REPORT ACCEPTANCE BY OCWS:

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

Date: _____

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

Date: _____

TECHNICAL REPORT DOCUMENTATION PAGE

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12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Office of Crashworthiness Standards 1200 New Jersey Ave., SE, Room W43-410 Washington, D.C. 20590		***13. Type of Report and Period Covered:*** Final Test Report March 12, 2020 - May 22, 2020 ***14. Sponsoring Agency Code*** NRM-110
15. Supplementary Notes		

16. Abstract

A 56.30 km/h (35 mph), NCAP frontal rigid barrier impact test was conducted on a 2020 Volvo S60 four door sedan in accordance with the specifications of the Office of Crashworthiness Standards Laboratory Procedure for NCAP Full Frontal Rigid Barrier Impact Testing. This test was conducted to obtain data related to FMVSS Nos. 208, 212, 219 (partial), 301, and 305 performance. The test was conducted at Calspan Corporation's Transportation Test Operations facility in Buffalo, New York on March 12, 2020.

The impact velocity of the vehicle was 56.15 km/h, and the ambient temperature at the barrier face at the time of impact was 21°C. The target vehicle post-test maximum crush was 409 mm at C4 to the right side of the front bumper. The test vehicle's occupant performance data is as follows:

Measurement Description	Units	Driver ATD (Serial No. 142)		Passenger ATD (Serial No. 288)	
		Threshold	Result	Threshold	Result
Head Injury Criteria (HIC_{15})		700	192.189	700	313.916
Maximum Chest Compression	mm	63	-23.761	52	-16.805
Nij		1	0.257	1	0.300
Neck Tension	N	4,170	838.760	2,620	649.595
Neck Compression	N	4,000	-280.534	2,520	-508.426
Left Femur Force	N	10,008	-1755.810	6,805	-1603.194
Right Femur Force	N	10,008	-2304.629	6,805	-2370.867

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Form DOT F1700.7 (8-69)

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SECTION 1

PURPOSE AND SUMMARY OF TEST

PURPOSE

This 56.3 km/h frontal barrier impact test is part of the Vehicle Barrier Impact Testing Program sponsored by the National Highway Traffic Safety Administration (NHTSA) under Contract No. 693JJ919D000005. The purpose of this test was to obtain vehicle crashworthiness and occupant restraint system performance data for consumer information purposes.

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

SUMMARY

A load cell barrier consisting of 128 load cells was impacted by a 2020 Volvo S60 four door sedan at a velocity of 56.15 km/h. The test was performed at Calspan Corporation's Transportation Test Operations facility in Buffalo, New York on March 12, 2020. Pre- and post-test photographs of the vehicle and dummies to document the test can be found in Appendix A. One real-time camera and 16 high-speed cameras were used to document the frontal barrier impact event. Camera locations and other pertinent camera information can be found in Data Sheet 6 of this report.

One Part 572E, 50th percentile male anthropomorphic test device (ATD), was placed in the driver seating position and one Part 572O 5th percentile female ATD was placed in the right-front passenger seating position according to dummy placement instructions specified in the Laboratory Procedure for NCAP Full Frontal Rigid Barrier Impact Testing. Both ATDs were fully instrumented with head, chest and pelvis tri-axial accelerometers, chest displacement potentiometers, upper neck transducers, femur load cells, and lower leg instrumentation. Seat belt load cells were installed on the driver's and passenger's lap and shoulder belts to measure dummy torso and pelvic section loading. The driver (position 1) ATD (Serial No. 142) and the right-front passenger (position 2) ATD (Serial No. 288) were qualified prior to this test. Certification details, along with instrumentation calibration data, can be found in Appendix C of this report.

The 486 channels of data were recorded on an on-board data acquisition system. Appendix B contains the vehicle, load cell barrier and dummy response data traces.

There was 100 percent windshield retention and no intrusion into the protected zone of the windshield during the event. There was a total of 0.0 grams of stoddard solvent leakage after the event or during any phase of the static rollover. The maximum static crush of the vehicle was 409 mm and both driver and passenger side doors remained closed during the impact event and were operable after the impact.

The driver's visible contact points were as follows: The driver's head contacted the frontal airbag and then the head restraint. The upper torso contacted the frontal airbag. Both knees contacted the knee air bag.

The passenger's visible contact points were as follows: The passenger's head contacted the frontal airbag, head restraint and roof headliner. The upper torso contacted the frontal airbag. Both knees contacted the glove box

The occupant data is summarized below.

ATD Position	HIC_{15}	Nij	Neck Tension (N)	Neck Comp. (N)	3ms Chest Clip (Gs)	Chest Disp. (mm)	Left Femur (N)	Right Femur (N)
Driver (50^{th})	192.189	0.257	838.760	-280.534	36.959	-23.761	-1755.810	-2304.629
Passenger (5^{th})	313.916	0.300	649.595	-508.426	40.255	-16.805	-1603.194	-2370.867

GENERAL COMMENTS:

1. P1 (Driver) serial number - 142
2. P2 (Passenger) serial number - 288

Data Anomalies:

- None

SECTION 2

OCCUPANT AND VEHICLE INFORMATION / DATA SHEETS

This section contains information reporting for the following Data Sheets:

Data Sheet No. 1 – General Test and Vehicle Parameter Data

Data Sheet No. 2 – Seat Adjustment, Fuel System, and Steering Wheel Data

Data Sheet No. 3 – Dummy Longitudinal Clearance Dimensions

Data Sheet No. 4 – Dummy Lateral Clearance Dimensions

Data Sheet No. 5 – Seat Belt Positioning Data

Data Sheet No. 6 – High-Speed Camera Locations and Data

Data Sheet No. 7 – Vehicle Accelerometer Locations

Data Sheet No. 8 – Photographic Reference Target Locations

Data Sheet No. 9 – Load Cell Locations on Fixed Barrier

Data Sheet No. 10 – Test Vehicle Summary of Results

Data Sheet No. 11 – Post-Test Observations

Data Sheet No. 12 – Vehicle Profile Measurements

Data Sheet No. 13 – Accident Investigation Division Data

Data Sheet No. 14 – Vehicle Intrusion Measurements

Data Sheet No. 15 – Summary of Indicant FMVSS No. 212 and FMVSS No. 219 (Partial)

Data Sheet No. 16 – FMVSS 301 Barrier Impact and Static Rollover Results

Data Sheet No. 17 – Dummy/Vehicle Temperature Stabilization Chart

DATA SHEET NO. 1
GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2020 Volvo S60 four door sedan
NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test
Test Date: 3/12/2020

TEST VEHICLE INFORMATION AND OPTIONS

NHTSA No.	M20205900
Model Year	2020
Make	Volvo
Model	S60
Body Style	Four Door Sedan
VIN	7JRA22TKXLG044902
Body Color	Blue
Odometer Reading (km /mi)	29 miles
Engine Displacement (L)	2.0
Type / No. Cylinders	I4
Engine Placement	Transverse
Transmission Type	Automatic
Transmission Speeds	8-Speed
Overdrive	Yes
Final Drive	All Wheel Drive
Roof Rack	No
Sunroof / T-Top	Yes
Running Boards	No
Tilt Steering Wheel	Yes
Power Seats	Yes
Anti-Lock Brakes (ABS)	Yes
Automatic Door Locks (ADLs)	Yes

Traction Control System (TCS)	Yes
Power Steering	Yes
Power Window Auto-Reverse	No
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
Front Pass. Frontal Airbag	Yes
Front Pass. Curtain Airbag	Yes
Front Pass. Head/Torso Airbag	No
Front Pass. Torso Airbag	No
Front Pass. Torso/Pelvis Airbag	Yes
Front Pass. Pelvis Airbag	No
Front Pass. Knee Airbag	No
Driver Pretensioner	Yes
Driver Load Limiter	Yes
Front Pass. Pretensioner	Yes
Front Pass. Load Limiter	Yes
Other –	-

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

DATA FROM CERTIFICATION LABEL

Manufactured By	Volvo Car Corporation
Date of Manufacture	09/19

GVWR (kg)	2282
GAWR Front (kg)	1150
GAWR Rear (kg)	1159

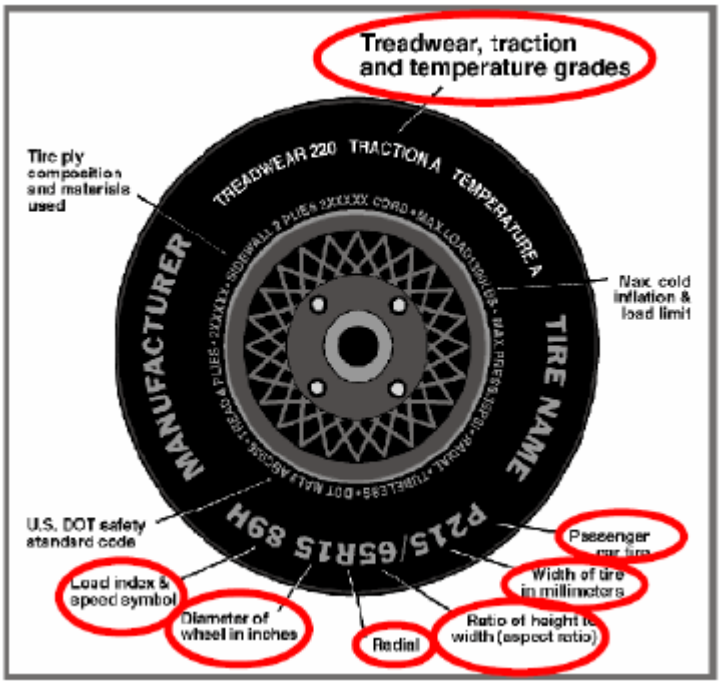
VEHICLE SEATING AND WEIGHT CAPACITY DATA

Measured Parameter	Front	Rear	Third	Total
Type of Seats	Bucket	Bench	N/A	
Number of Occupants	2	3	N/A	5
Capacity Wt. (VCW) (kg)				405
Cargo Wt. (RCLW) (kg)				64.8

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

Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020

Collect items circled in red, tire manufacturer, and tire name.



VEHICLE TIRE INFORMATION

Measured Parameter	Front	Rear
Maximum Tire Pressure (kPa)	350	350
Cold Pressure (kPa)	250	250
Recommended Tire Size	235/45R18	235/45R18
Tire Size on Vehicle	235/45R18	235/45R18
Tire Manufacturer	Continental	Continental
Tire Model	ProContact	ProContact
Treadwear	500	500
Traction	A	A
Temperature Grades	A	A
Tire Plies Sidewall	2 Polyester	2 Polyester
Tire Plies Body	1 Polyester, 2 Steel, 1 Polyamide	1 Polyester, 2 Steel, 1 Polyamide
Load Index / Speed Symbol	98H	98H
Tire Material	Rubber	Rubber
DOT Safety Code Left	VYFUWCC03419	VYFUWCC03419
DOT Safety Code Right	VYFUWCC03519	VYFUWCC03519

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

Test Vehicle: 2020 Volvo S60 four door sedan NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/12/2020

TEST VEHICLE WEIGHTS

	Units	As Delivered Weights (UVW)			As Tested Weights (ATW)		
		Front Axle	Rear Axle	Total	Front Axle	Rear Axle	Total
Left	kg	508	400		537	479	
Right	kg	504	384		527	453	
Ratio	%	56.3	43.7		53.3	46.7	
Totals	kg	1012	784	1796	1064	932	1996

TARGET TEST WEIGHT CALCULATION

Measured Parameter	Units	Value	
Total Delivered Weight (UVW)	kg	1796	(A)
Weight of 1 P572E ATD & 1 P572O ATD	kg	142	(B)
Rated Cargo / Luggage Weight (RCLW)	kg	64.8	(C)
Calculated Vehicle Target Weight (TVTW)	kg	2002.8	(A+B+C)

TEST VEHICLE ATTITUDES AND CG

Condition	Units	LF	RF	LR	RR	CG (aft of front axle)
As Delivered	mm	704	708	713	719	1255
As Tested	mm	696	700	694	703	1342
Post-Test	mm	738	757	687	701	

GENERAL TEST VEHICLE DATA

Measurement Description	Units	Value
Total Vehicle Wheel Base	mm	2874
Total Vehicle Length at Left Side	mm	4678
Total Vehicle Length at Centerline	mm	4762
Total Vehicle Length at Right Side	mm	4678
Weight of Ballast in Cargo Area	kg	31.8
Weight of Vehicle Components Removed	kg	26
Amount of Stoddard Solvent in Fuel Tank	L	55.8

LIST OF COMPONENTS REMOVED TO MEET TEST WEIGHT:

Trunk carpeting, spare tire, jack,

DATA SHEET NO.1 … (CONTINUED932)
GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2020 Volvo S60 four door sedan NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/12/2020

TARGET VEHICLE STRUCTURAL MEASUREMENT

No.	Description	Pre-Test
1	Total Length	4762
2	Total Width	1851
3*	Bumper Top Height	538
4*	Bumper Bottom Height	373
5*	Longitudinal Member Top Height	634
6	Distance Between Longitudinal Members	1027
7	Longitudinal Member Width	58
8*	Engine Top Height	854
9*	Engine Bottom Height	400
10	Engine and Gearbox Width	415
11	Front Bumper-Engine Distance	637
12*	Front Shock Absorber Fixing Height	851
13*	Bonnet Leading Edge Height	792
14	Front Shock Absorber Fixing Width	1028
15	Front Bumper – Front Axle Distance	848
16	Front Axle – A Pillar Distance	687
17	A-Pillar – B-Pillar Distance	1099
18	B-Pillar – Rear Axle Distance	1088
19	B-Pillar – C-Pillar Distance	1005
20*	Roof Sill Bottom Height	1322
21*	Roof Sill Top Height	1368
22*	Floor Sill Bottom Height	295
23*	Floor Sill Top Height	385

*Height Measurements are taken from the ground
Note: All measurements are in millimeters

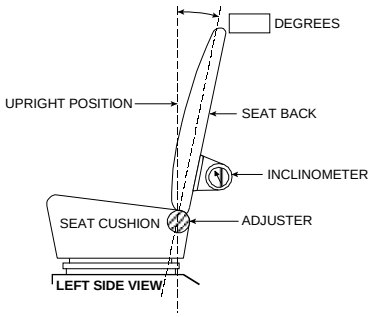
DATA SHEET NO. 2
SEAT ADJUSTMENT, FUEL SYSTEM, AND STEERING WHEEL DATA

Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020

NOMINAL DESIGN RIDING POSITION

The driver's seat back was set to the manufacturer's designated angle. The passenger's seat back was positioned in a similar manner as the driver's seat back. Seat back angles are measured at the headrest post bezel using a digital inclinometer.

Seating Position	Degrees
Driver Seat Back Angle	23.1
Passenger Seat Back Angle	18.9



FRONT SEAT ASSEMBLY

SEAT FORE / AFT POSITIONS

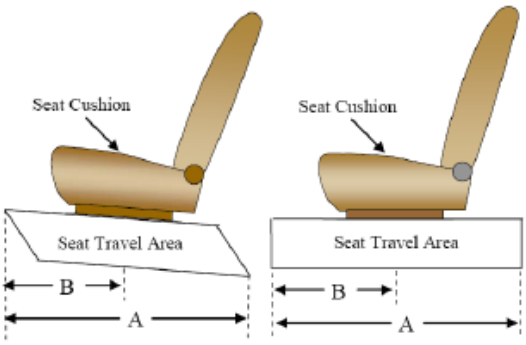
The driver's seat was positioned at the mid-point of fore/aft travel at its lowest position. The passenger's seat was positioned at the most forward position of fore/aft travel. Zero is defined as the forward most position.

Seating Position	Total Fore / Aft Travel	Placed in Position #
Driver Seat	328	164
Passenger Seat	262	0

SEAT BELT UPPER ANCHORAGE

The driver's seat belt anchorage was positioned according to the manufacturer's designated positioning for a 50th percentile adult male ATD. The passenger's seat belt anchorage was positioned according to the manufacturer's designated positioning for a 5th percentile adult female ATD. For this test zero is defined as the uppermost position.

Seating Position	Total # of Positions	Placed in Position #
Driver Seat	4(0-3)	0
Passenger Seat	4(0-3)	0



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

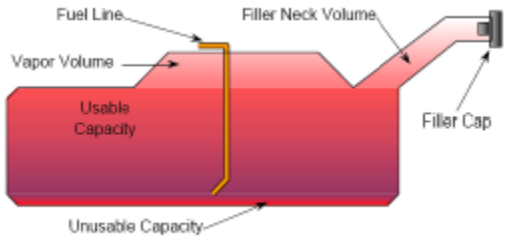
Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020

FUEL TANK CAPACITY

Description	Liters
Usable Capacity of "Standard Tank"	60
Usable Capacity of "Optional Tank"	N/A
92%-94% of Usable Capacity	55.2 – 56.4
Actual Amount of Solvent Used	55.8
1/3 of Usable Capacity	20

FUEL PUMP

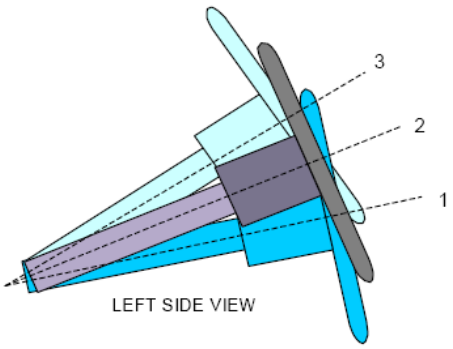
The vehicle is equipped with an electric fuel pump. The fuel filler neck is on the right side of the vehicle. The pump creates positive pressure in the fuel lines, pushing the gasoline to the engine. See form 1 for more information.



VEHICLE FUEL TANK ASSEMBLY

STEERING COLUMN ADJUSTMENT

Steering wheel and column adjustments are made so that the steering wheel hub is at the geometric center of the locus it describes when moved through its full range of motion. For angular measurements, a digital inclinometer was used to measure a plate which was placed across the steering wheel rim. A tape measure was used to measure the telescoping steering wheel travel.



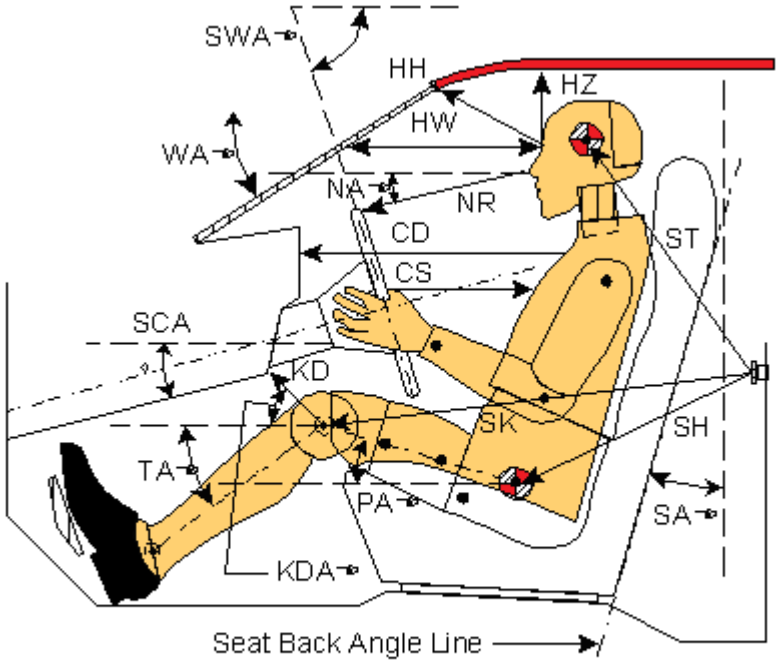
STEERING COLUMN ASSEMBLY

STEERING COLUMN POSITIONS

Description	Degrees	Fore / Aft Position (mm)
Lowermost position No. 1	17.1	
Geometric center position No. 2	20	
Uppermost position No. 3	22.9	
Telescoping Steering Wheel Travel		50
Test Position	20	25

DATA SHEET NO. 3
DUMMY LONGITUDINAL CLEARANCE DIMENSIONS

Test Vehicle: 2020 Volvo S60 four door sedan
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20205900
Test Date: 3/12/2020

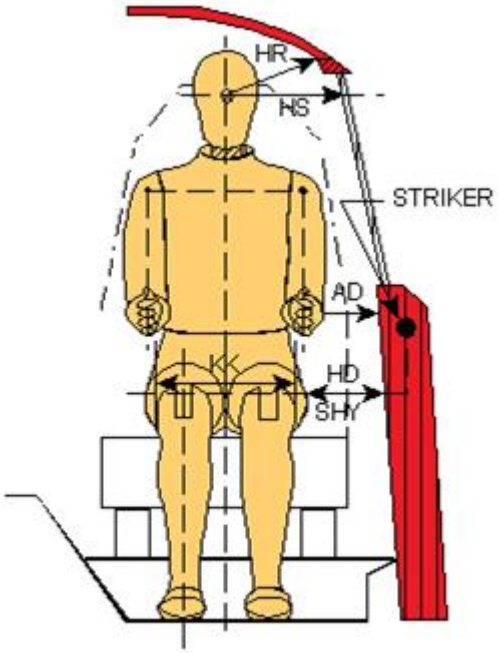


Left Side View

Code	Measurement Description	Driver (SN: 142)		Passenger (SN: 288)	
		Length (mm)	Angle (°)	Length (mm)	Angle (°)
WA°	Windshield Angle		26.2		
SWA°	Steering Wheel Angle		19.6		
SCA°	Steering Column Angle		70.4		
SA°	Seat Back Angle (on headrest post)		23.1		18.9
HZ	Head to Roof (Z)	170	90	178	90
HH	Head to Header	390	25.8	290	44.2
HW	Head to Windshield	697	0	602	0
NR	Nose to Rim / Dash	414	6.3	410	31.8
CD	Chest to Dash	536		354	
CS	Chest to Steering Hub	320	0		
RA	Rim to Abdomen	226	0		
KDL	Left Knee to Dash	270	16.2	93	34.8
KDR	Right Knee to Dash	278	11.2	93	38.2
PA°	Pelvic Angle		24.5		20.4
TA°	Tibia Angle		27.1		38.7
SK	Striker to Knee	535	12.5	665	9.0
ST	Striker to Head	438	37.2	438	60.2
SH	Striker to H-Point	273	53.2	414	26.0

DATA SHEET NO. 4
DUMMY LATERAL CLEARANCE DIMENSIONS

Test Vehicle: 2020 Volvo S60 four door sedan
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20205900
Test Date: 3/12/2020

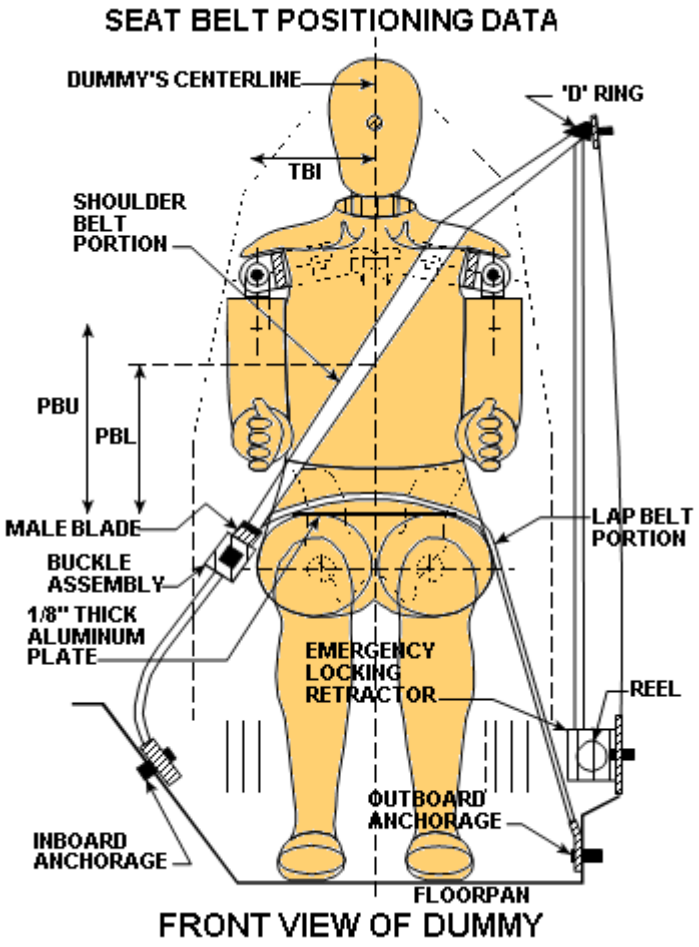


Front View

Code	Description	Driver (mm)	Passenger (mm)
AD	Arm to Door	124	75
HD	H-Point to Door	142	250
HR	Head to Side Header	190	207
HS	Head to Side Window	342	364
KK	Knee to Knee	335	210
SHY	Striker to H-Point (Y Direction)	235	245
AA	Ankle to Ankle	345	165

DATA SHEET NO. 5
SEAT BELT POSITIONING DATA

Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020



SEAT BELT POSITIONING MEASUREMENTS

Measurement Description	Units	Driver	Passenger
PBU — Top surface of reference to belt upper edge	mm	320	290
PBL — Top surface of reference to belt lower edge	mm	245	215

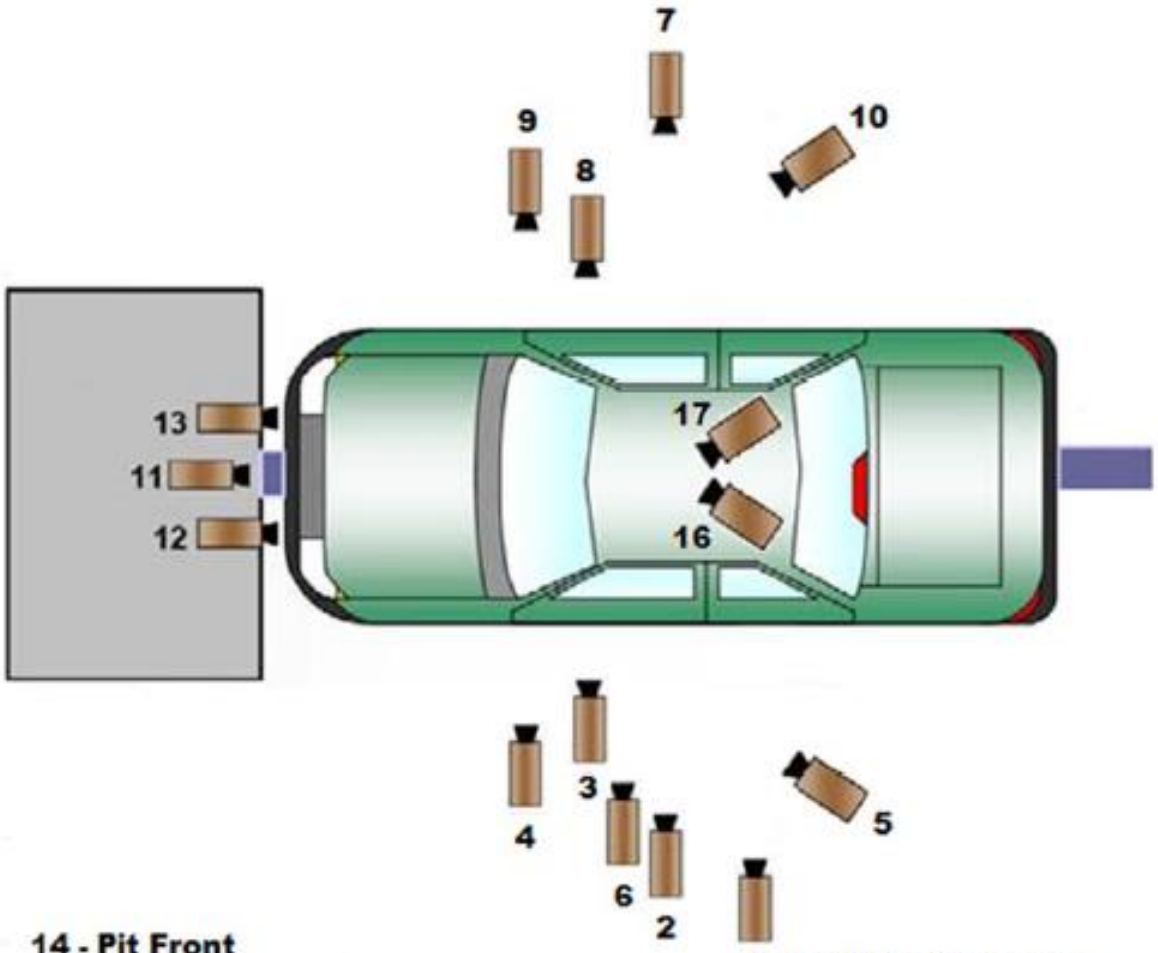
BELT LENGTH DATA

Measurement Description	Units	Driver	Passenger
Shoulder belt length as measured on ATD	mm	895	940
Lap Belt Length as measured on ATD	mm	605	565
Remainder of belt on reel	mm	1100	1095
Total belt length for continuous webbing systems	mm	2600	2600

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

Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020

CAMERA POSITIONS FOR FRONTAL IMPACTS



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

Test Vehicle: 2020 Volvo S60 four door sedan NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/12/2020

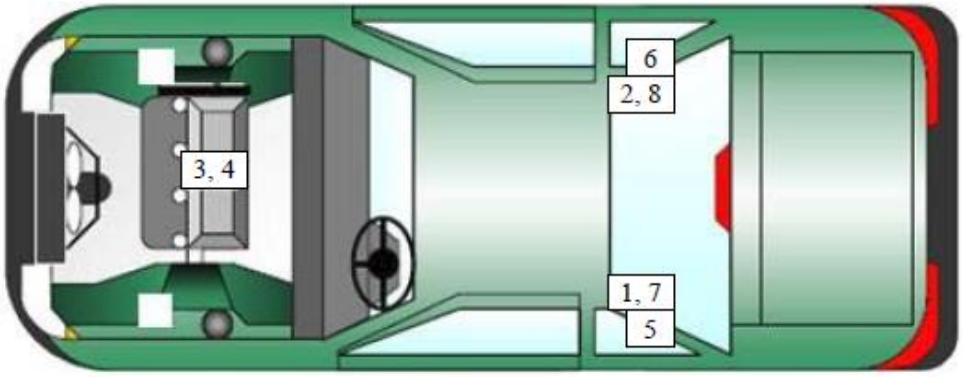
CAMERA LOCATIONS

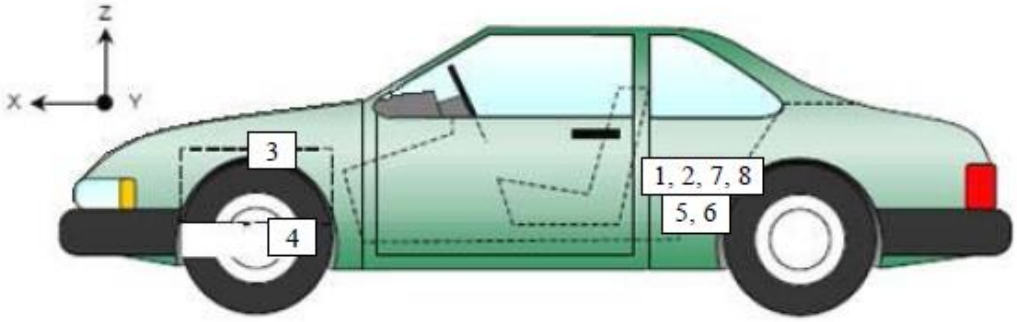
No.	Camera View	Location (mm)			Lens (mm)	Speed (fps)
		X	Y	Z		
1	Real-Time Left Overall	-	-	-		60
2	Left Overall	-2151	-7186	-1213	24	1000
3	Driver Close-Up	-1463	-6736	-1359	50	1000
4	Left Front Half	-799	-6444	-1270	28	1000
5	Left Angle	-4141	-4989	-2350	50	1000
6	Steering Column	-1463	-6548	-1804	50	1000
7	Right Overall	-1870	7949	-1269	24	1000
8	Passenger Close-Up	-1336	7163	-1379	50	1000
9	Right Front Half	-723	6596	-1209	28	1000
10	Right Angle	-4220	5066	-2623	50	1000
11	Windshield	1250	0	-3471	25	1000
12	Driver Windshield	814	-400	-2431	25	1000
13	Passenger Windshield	814	400	-2431	25	1000
14	Pit Front	-906	0	2413	12.5	1000
15	Pit Rear	-3260	0	2413	12.5	1000
16	Onboard Driver Airbag (Optional)				8	1000
17	Onboard Passenger Airbag (Optional)				8	1000

** COORDINATES:* *+X = forward of impact plane*
+Y = right of monorail center
+Z = into ground

DATA SHEET NO. 7
VEHICLE ACCELEROMETER LOCATIONS

Test Vehicle: 2020 Volvo S60 four door sedan NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/12/2020





VEHICLE ACCELEROMETER PRE-TEST LOCATIONS

No.	Accelerometer Location	Measurements (mm)		
		X	Y	Z
1	Left Rear Accelerometer – X Direction	1900	-352	117
2	Right Rear Accelerometer – X Direction	1902	316	60
3	Engine Top X	3972	373	-399
4	Engine Bottom X	4397	-101	135
5	Left Rear Accelerometer – Z Direction	1900	-352	117
6	Right Rear Accelerometer – Z Direction	1902	316	60
7	Left Rear Accelerometer – X Direction Redundant	1900	-352	117
8	Right Rear Accelerometer – X Direction Redundant	1902	316	60

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

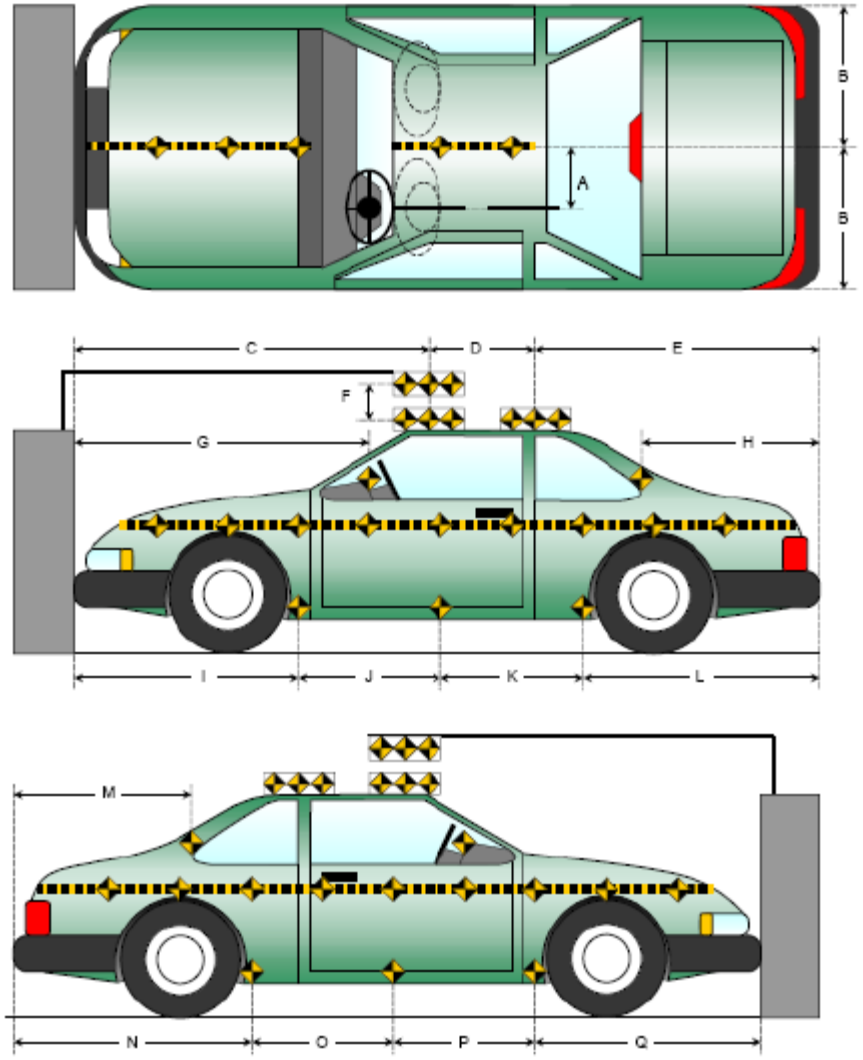
DATA SHEET NO. 8
PHOTOGRAPHIC REFERENCE TARGET LOCATIONS

Test Vehicle: 2020 Volvo S60 four door sedan
Test Program: NCAP Frontal Barrier Impact Test

NHTSA No.: M20205900
Test Date: 3/12/2020

Item	Value
A	398
B	925
C	2659
D	609
E	1494
F	150
G	1854
H	1055
I	1304
J	995
K	990
L	1473
M	1055
N	1471
O	995
P	1000
Q	1295

All units in millimeters



DATA SHEET NO. 9
LOAD CELL LOCATIONS ON FIXED BARRIER

Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020

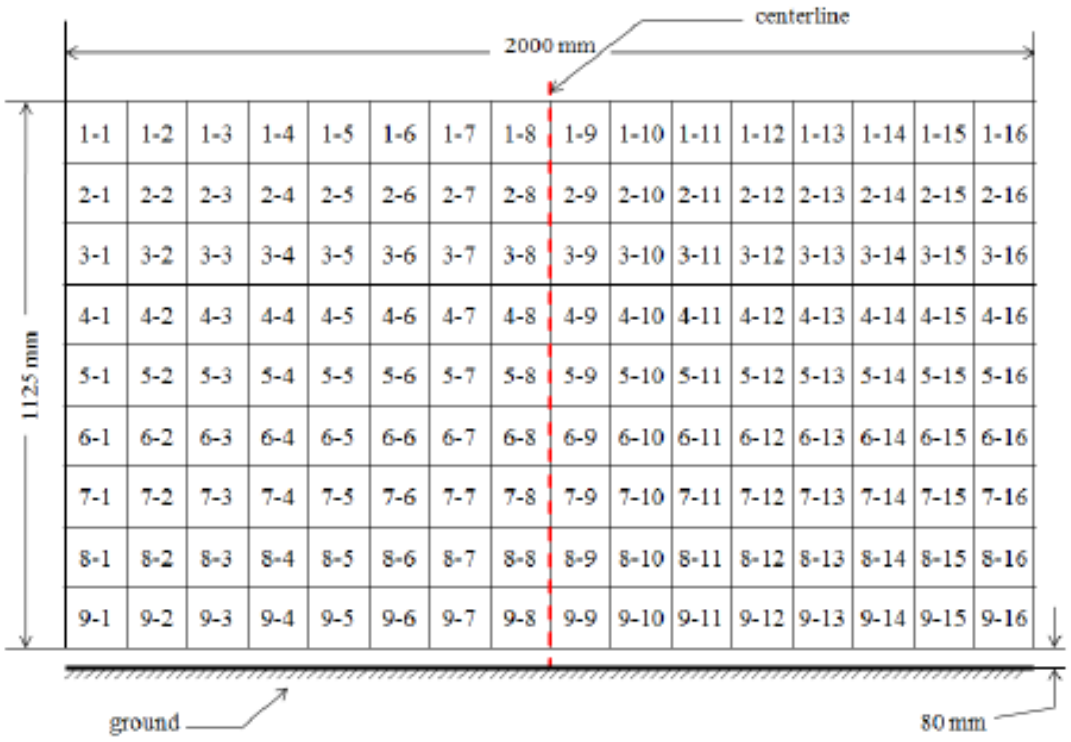


Figure 1 - Load Cell Locations on a 128-Load Cell Barrier with Plywood Height Extension*
Please note above diagram is not actual representation of load cell barrier used.

DATA SHEET NO. 10
TEST VEHICLE SUMMARY OF RESULTS

Test Vehicle: 2020 Volvo S60 four door sedan NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/12/2020

INSTRUMENTATION

Instrumentation	Number of Channels Collected
Driver Dummy Accelerometers	47
Passenger Dummy Accelerometers	47
Vehicle Structure Accelerometers	8
Load Cell Barrier	384
Total	486

CAMERA COVERAGE

Type of Camera	Number Used in this Test
High-Speed Vehicle Onboard	2
High-Speed Offboard	14
Real-Time Panning	1
Total	17

DATA SHEET NO. 11
POST-TEST OBSERVATIONS

Test Vehicle: 2020 Volvo S60 four door sedan NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/12/2020

TEST DUMMY INFORMATION AND CONTACT LOCATIONS

Description	Driver	Passenger
Dummy Type / Serial No.	P572E 50th Male / 142	P5720 5th Female / 288
Head Contact	Frontal Airbag & Headrest	Frontal Airbag, Headrest & Roof Headliner
Upper Torso Contact	Frontal Airbag	Frontal Airbag
Lower Torso Contact	None	None
Left Knee Contact	Knee Airbag	Knee Bolster
Right Knee Contact	Knee Airbag	Knee Bolster

DOOR OPENING AND SEAT TRACK INFORMATION

Description	Driver	Passenger	Other
Locked / Unlocked Doors	Unlocked	Unlocked	
Front Door Opening	Closed & Operational	Closed & Operational	
Rear Door Opening	Closed & Operational	Closed & Operational	
Trunk/Hatch/Tailgate Opening			Operational
Seat Track Shift (mm)	0	0	
Seat Back Movement from Initial Position	None	None	

POST-TEST STRUCTURAL OBSERVATIONS

Critical Areas of Performance	Observations and Conclusions
Windshield Damage	None
Window Damage	None
Other	None

VEHICLE REBOUND FROM BARRIER

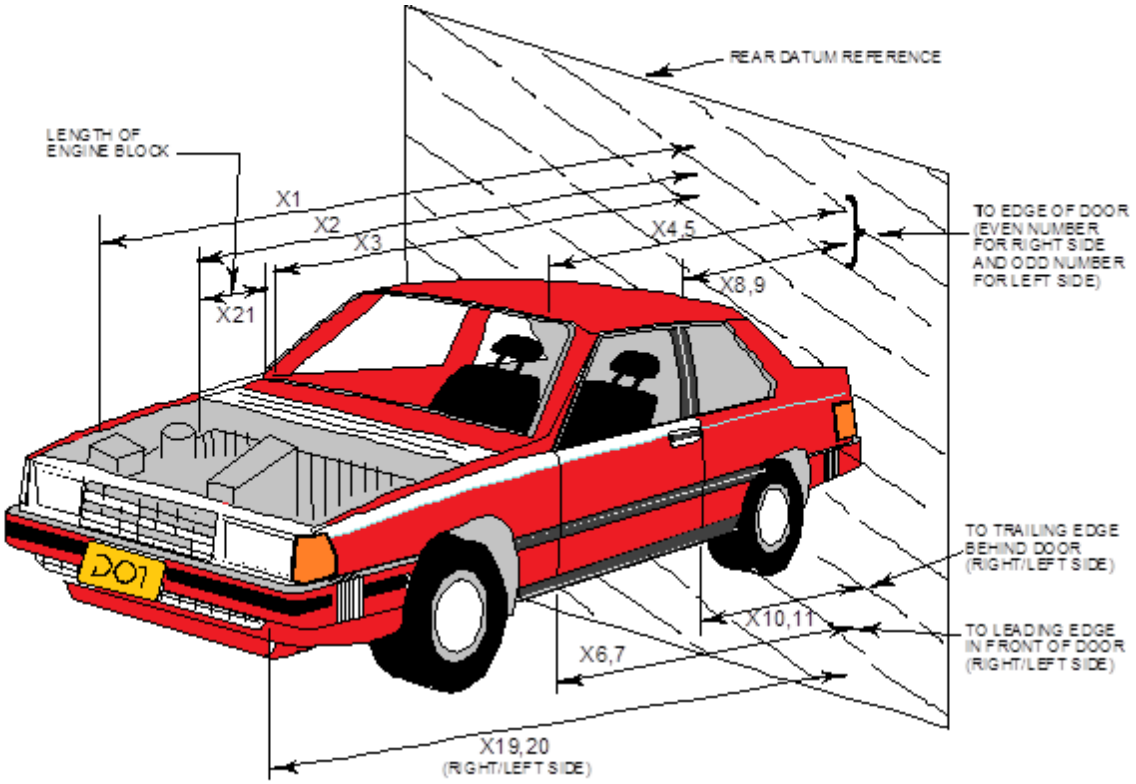
Measured Parameter	Units	Value
Left Side	mm	1287
Center	mm	1274
Right Side	mm	1347
Average	mm	1303

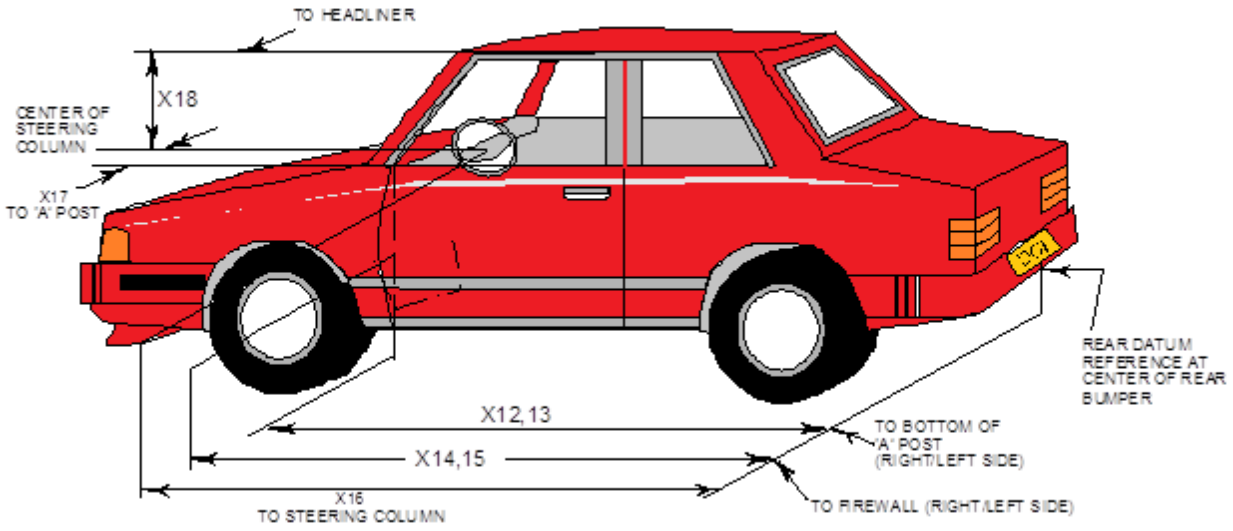
SUPPLEMENTAL RESTRAINT SYSTEM INFORMATION

Restraint Type	Driver		Passenger	
	Installed	Deployed	Installed	Deployed
Front Airbag	Yes	Yes	Yes	Yes
Side Airbag 1 - Curtain	Yes	No	Yes	No
Side Airbag 2 - Torso/Pelvis Airbag	Yes	No	Yes	No
Knee Airbag	Yes	Yes	No	N/A
Seat Belt Pretensioner	Yes	Yes	Yes	Yes
Seat Belt Load Limiter	Yes	Yes	Yes	Yes
Other				

DATA SHEET NO. 12
VEHICLE PROFILE MEASUREMENTS

Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020





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

Test Vehicle: 2020 Volvo S60 four door sedan NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/12/2020

No.	Measurement Description	Pre-Test	Post-Test	Difference
1	Total Length of Vehicle at Centerline	4762	4363	-399
2	Rear Surface of Vehicle (RSOV) to Front of Engine	4125	3960	-165
3	RSOV to Firewall	3752	3622	-130
4	RSOV to Upper Leading Edge of Right Door	3228	3228	0
5	RSOV to Upper Leading Edge of Left Door	3229	3228	-1
6	RSOV to Lower Leading Edge of Right Door	3247	3246	-1
7	RSOV to Lower Leading Edge of Left Door	3250	3250	0
8	RSOV to Upper Trailing Edge of Right Door	2135	2137	2
9	RSOV to Upper Trailing Edge of Left Door	2135	2135	0
10	RSOV to Lower Trailing Edge of Right Door	2207	2205	-2
11	RSOV to Lower Trailing Edge of Left Door	2208	2207	-1
12	RSOV to Bottom of “A” Post of Right Side	3256	3251	-5
13	RSOV to Bottom of “A” Post of Left Side	3253	3251	-2
14	RSOV to Firewall, Right Side	3726	3504	-222
15	RSOV to Firewall, Left Side	3755	3497	-258
16	RSOV to Steering Column	2735	2822	87
17	Center of Steering Column to “A” Post	276	279	3
18	Center of Steering Column to Headliner	422	430	8
19	RSOV to Right Side of Front Bumper	4717	4252	-465
20	RSOV to Left Side of Front Bumper	4717	4265	-452
21	Length of Engine Block	346	346	0
RD	RSOV to Right Side of Dash Panel	2907	2910	3
CD	RSOV to Center of Dash Panel	2935	2941	6
LD	RSOV to Left Side of Dash Panel	2909	2908	-1

*UR= Unrecoverable data point
All Dimensions in mm

DATA SHEET NO. 13
ACCIDENT INVESTIGATION DIVISION DATA

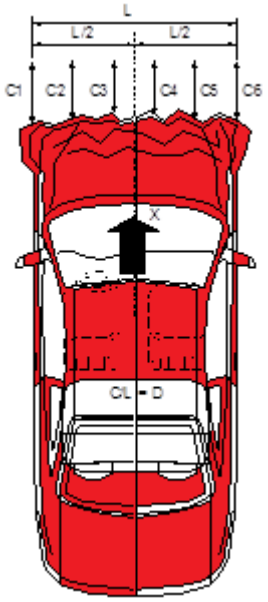
Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020

VEHICLE INFORMATION

VIN:	7JRA22TKXLG044902	Wheelbase (mm):	2874
Vehicle Size Category:	Passenger Car	Test Weight (kg):	1,996

ACCELEROMETER DATA

Accelerometer Locations:	Please See Data Sheet No. 7
Cal. Procedure / Interval:	Calspan Procedure / 6 month
Integration Algorithm:	Trapezoidal
Linearity:	> 99%
Impact Velocity (km/h):	56.15
Velocity Change (km/h):	65.23
Time of Separation (ms):	123



CRUSH PROFILE

Collision Deformation Classification:	12FDEW2
Midpoint of Damage:	C4
Damage Region Length (mm):	1427
Impact Mode:	Frontal

No.	Measurement Description	Units	Pre-Test	Post-Test	Difference
C1	Crush Zone 1 at Left Side	mm	4584	4375	209
C2	Crush Zone 2 at Left Side	mm	4704	4338	366
C3	Crush Zone 3 at Left Side	mm	4751	4352	399
C4	Crush Zone 4 at Right Side	mm	4750	4341	409
C5	Crush Zone 5 at Right Side	mm	4679	4292	387
C6	Crush Zone 6 at Right Side	mm	4541	4309	232
L	C1 to C6	mm	1427	1489	-62

DATA SHEET NO. 14
VEHICLE INTRUSION MEASUREMENTS

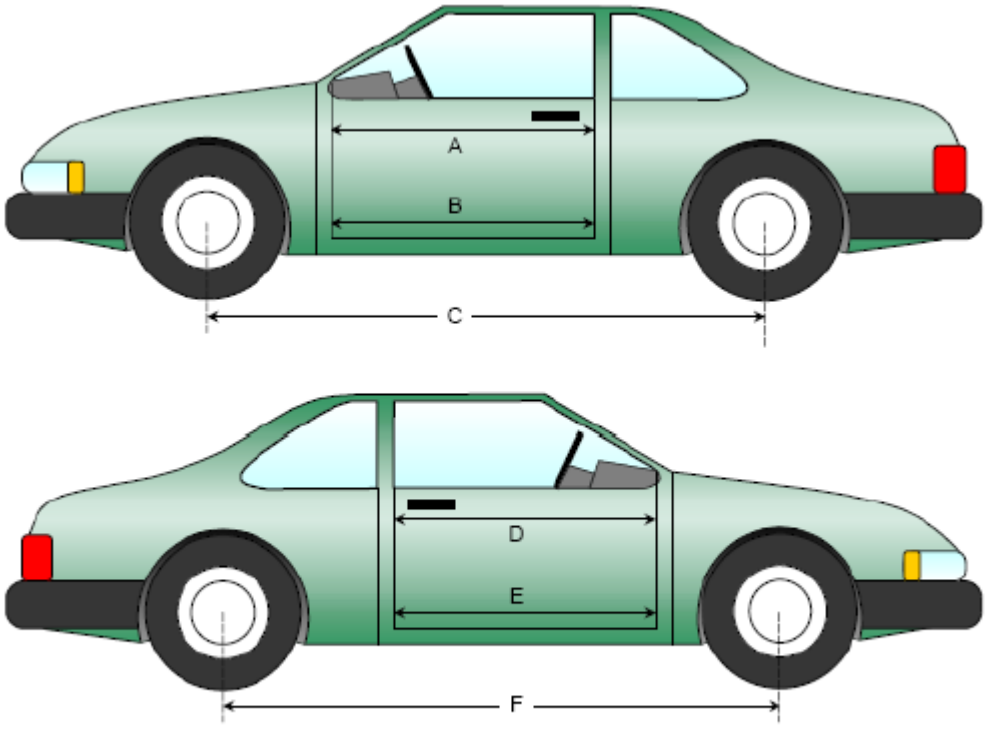
Test Vehicle: 2020 Volvo S60 four door sedan
NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test
Test Date: 3/12/2020

DOOR OPENING WIDTH

Item	Description	Units	Pre-Test	Post-Test	Difference
A	Left Side Upper	mm	962	960	-2
B	Left Side Lower	mm	781	781	0
D	Right Side Upper	mm	961	959	-2
E	Right Side Lower	mm	770	771	1

WHEELBASE MEASUREMENTS

Item	Description	Units	Pre-Test	Post-Test	Difference
C	Left Side Wheelbase	mm	2874	2806	-68
F	Right Side Wheelbase	mm	2874	2794	-80



Left & Right Side Views

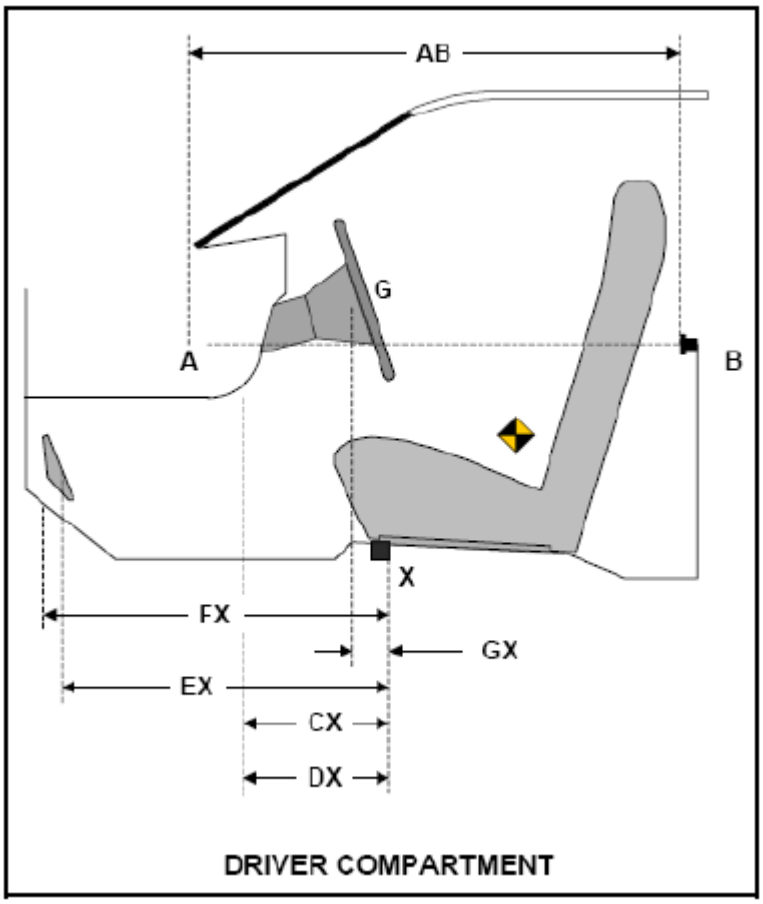
DATA SHEET NO.14 … (CONTINUED)
VEHICLE INTRUSION MEASUREMENTS

Test Vehicle: 2020 Volvo S60 four door sedan NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/12/2020

DRIVER COMPARTMENT INTRUSION

Item	Description	Units	Pre-Test	Post-Test	Difference
AB	Door Opening (Inside Window Jam)	mm	758	758	0
CX	Left Knee Bolster to X	mm	329	332	3
DX	Right Knee Bolster to X	mm	309	307	-2
EX	Brake Pedal to X	mm	564	621	57
FX	Foot Rest to X	mm	582	584	2
GX	Center of Steering Column Wheel Hub to X	mm	27	117	90

X = Front of Seat Track (Stationary)



DATA SHEET NO. 15
SUMMARY OF FMVSS 212, 219 (PARTIAL), AND 301 DATA

Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020

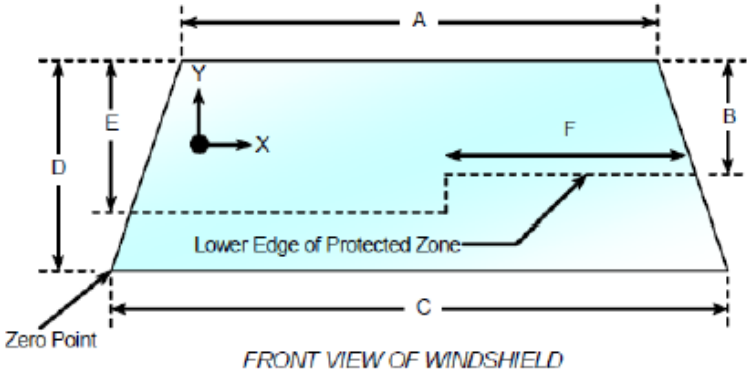
Windshield Mounting Details: A 0.8 mm trim surrounds the top and side of windshield while a plastic shroud is on the bottom.

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

Temperature of windshield molding during test: 21 ° C

WINDSHIELD PERIPHERY MEASUREMENTS

Measurement	Pre-Test (mm)	Post-Test (mm)	% Retention
Left Side	2189	2189	100
Right Side	2189	2189	100
Total	4378	4379	100



FRONT VIEW OF WINDSHIELD

Item	Units	Value
A	mm	1223
B	mm	420
C	mm	1501
D	mm	827
E	mm	452
F	mm	545

AREAS OF PROTECTED ZONE FAILURES

A. *Provide coordinates of the area that the protected zone was penetrated more than .25 inches by a vehicle component other than one that is normally in contact with the windshield.*
- No Penetration

X	Y

B. *Provide coordinates of the area beneath the protected zone that the inner surface of the windshield was penetrated by a vehicle component.*
- No Penetration

X	Y

DATA SHEET NO. 15 … (CONTINUED)
SUMMARY OF FMVSS 212, 219 (PARTIAL), AND 301 DATA

Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020

FMVSS 301 FUEL SYSTEM INTEGRITY POST IMPACT DATA

Temperature at Time of Impact: 21 ° C Test Time: 10:18 AM

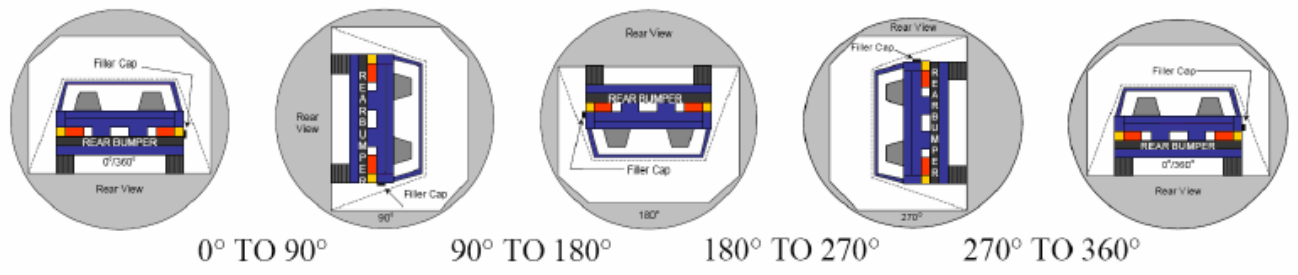
STODDARD SOLVENT SPILLAGE MEASUREMENTS

A. From impact until vehicle motion ceases: (Maximum allowable is 1 oz.)	0	oz.
B. For the 5-minute period after motion ceases: (Maximum allowable is 5 oz.)	0	oz.
C. For the following 25 minutes: (Maximum allowable is 1 oz./minute)	0	oz.

D. Spillage: No Spillage Occurred

DATA SHEET NO. 16
FMVSS 301 STATIC ROLLOVER RESULTS

Test Vehicle: 2020 Volvo S60 four door sedan
NHTSA No.: M20205900
Test Program: NCAP Frontal Barrier Impact Test
Test Date: 3/12/2020



1. The specified fixture rollover rate for each 90°of rotation is 60 to 180 seconds.
2. The position hold time at each position is 300 seconds (minimum).
3. Details of Stoddard Solvent Spillage: No Spillage Occurred

SOLVENT COLLECTION TIME TABLE IN SECONDS

Test Phase	Rotation Time	Hold Time	Total Time
0° to 90°	69	300	369
90° to 180°	63	300	363
180° to 270°	61	300	361
270° to 360°	66	300	366

FMVSS 301 SPILLAGE TABLE

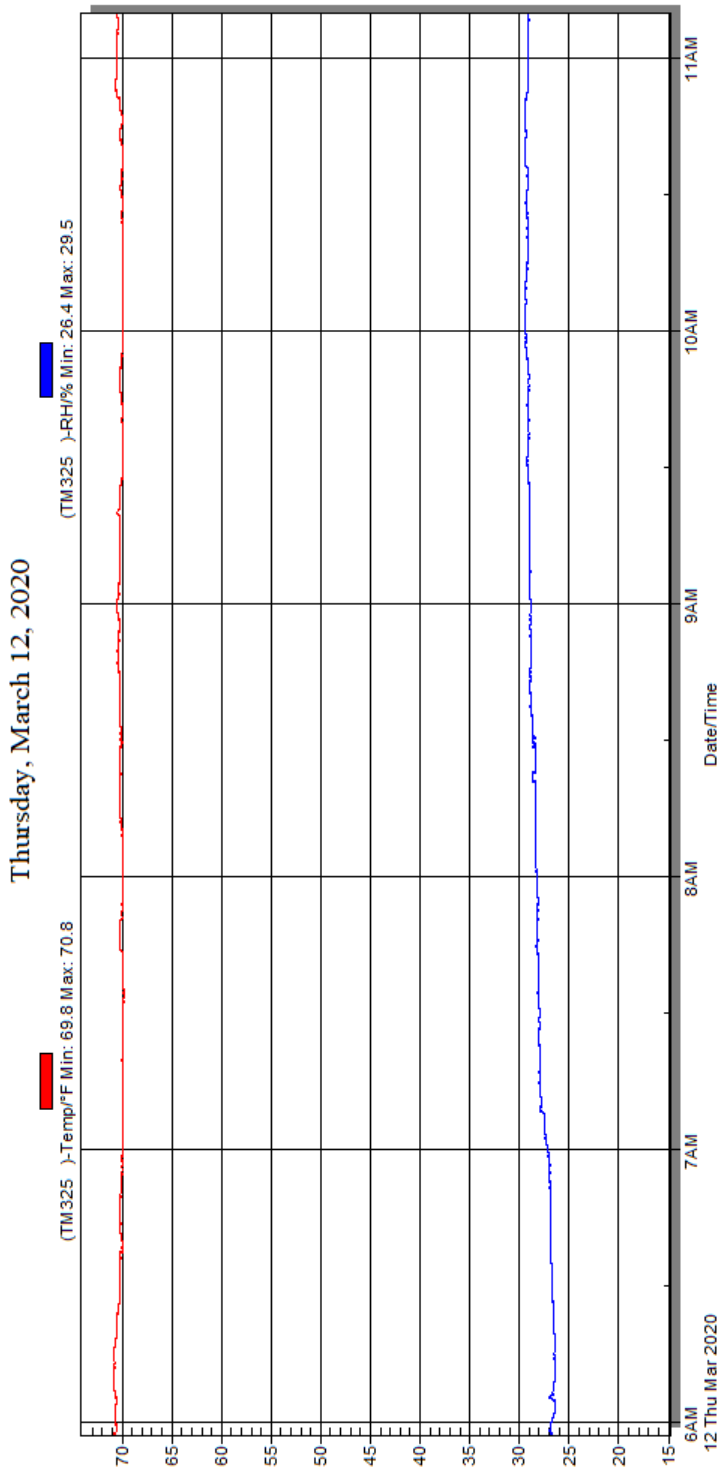
Test Phase	First 5 Minutes	Sixth Minute	Seventh Minute	Eighth Minute
0° to 90°	0	0	0	
90° to 180°	0	0	0	
180° to 270°	0	0	0	
270° to 360°	0	0	0	

SOLVENT SPILLAGE LOCATION TABLE

Test Phase	Spillage Location
0° to 90°	None
90° to 180°	None
180° to 270°	None
270° to 360°	None

DATA SHEET NO. 17
DUMMY / VEHICLE TEMPERATURE STABILIZATION CHART

Test Vehicle:	2020 Volvo S60 four door sedan	NHTSA No.:	M20205900
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/12/2020



Temperature and Humidity Stabilization Chart/Data for Dummies and Test Vehicle

APPENDIX A

PHOTOGRAPHS

TABLE OF PHOTOGRAPHS

[1]**NOTE**: *The underbody views should include the following vehicle components: fuel pump, fuel lines, sender unit, fuel tank filler pipe and any other visible system components.*

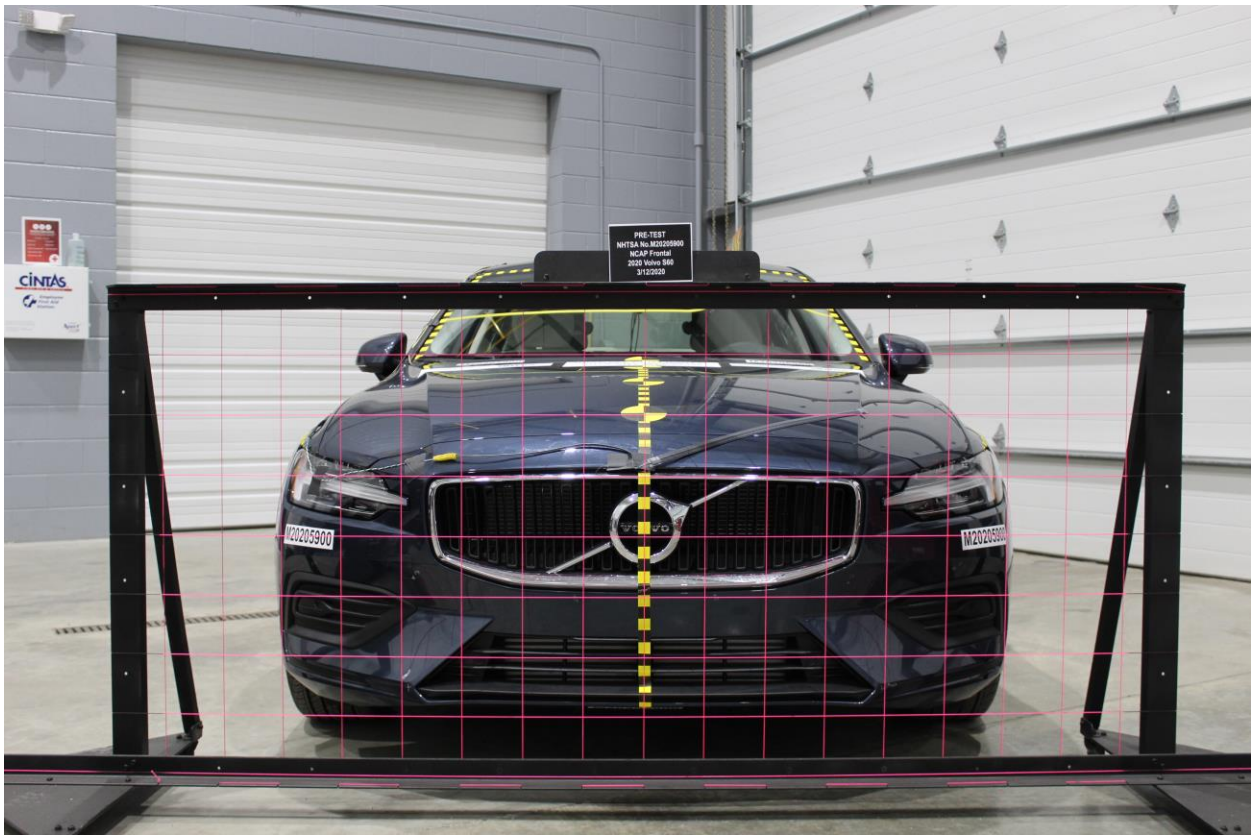


Figure A-1: Load Cell Location

Figure A-2: Pre-Test Load Cell Wall

Figure A-3: Post-Test Load Cell Wall

Figure A-4: Manufacturer's Label

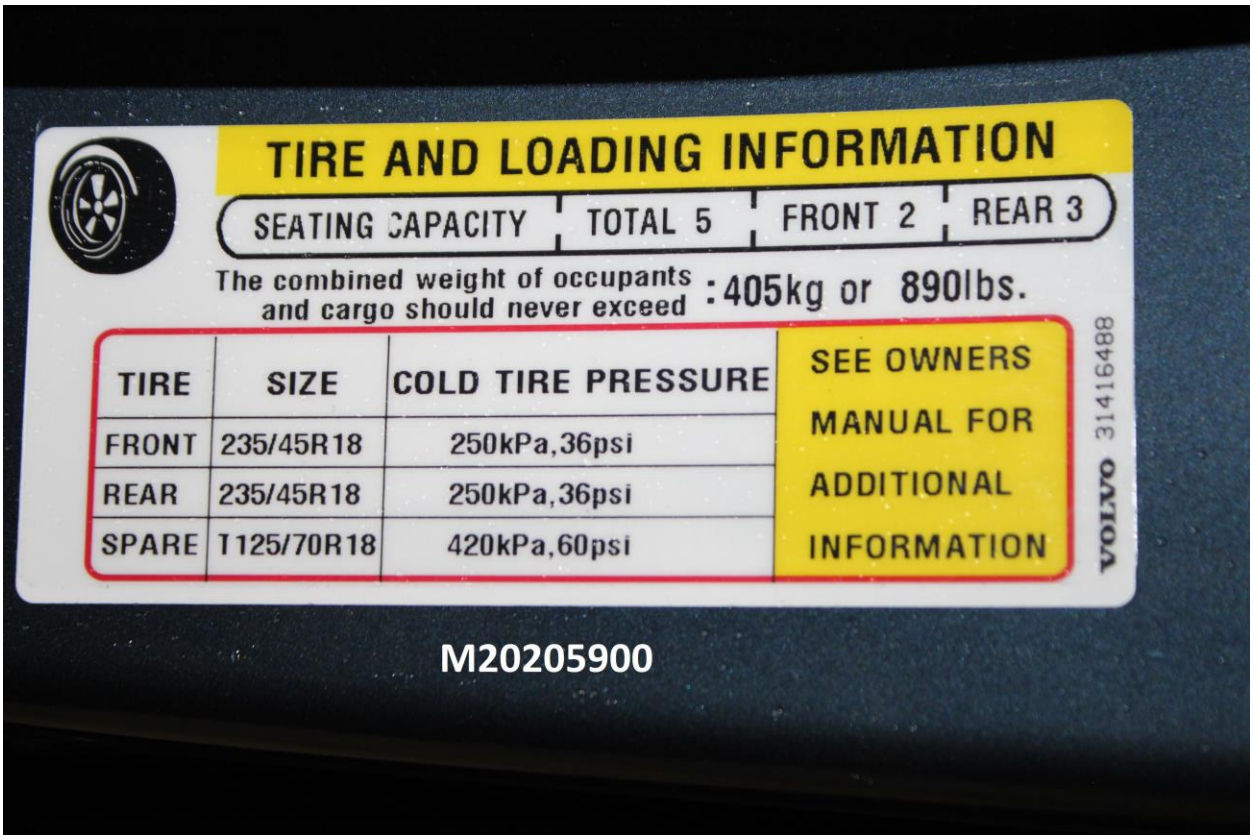


Figure A-5: Tire Placard

Figure A-6: 2020 Volvo S60 Frontal As Delivered

Figure A-7: Left Rear 3-4 View, As Received

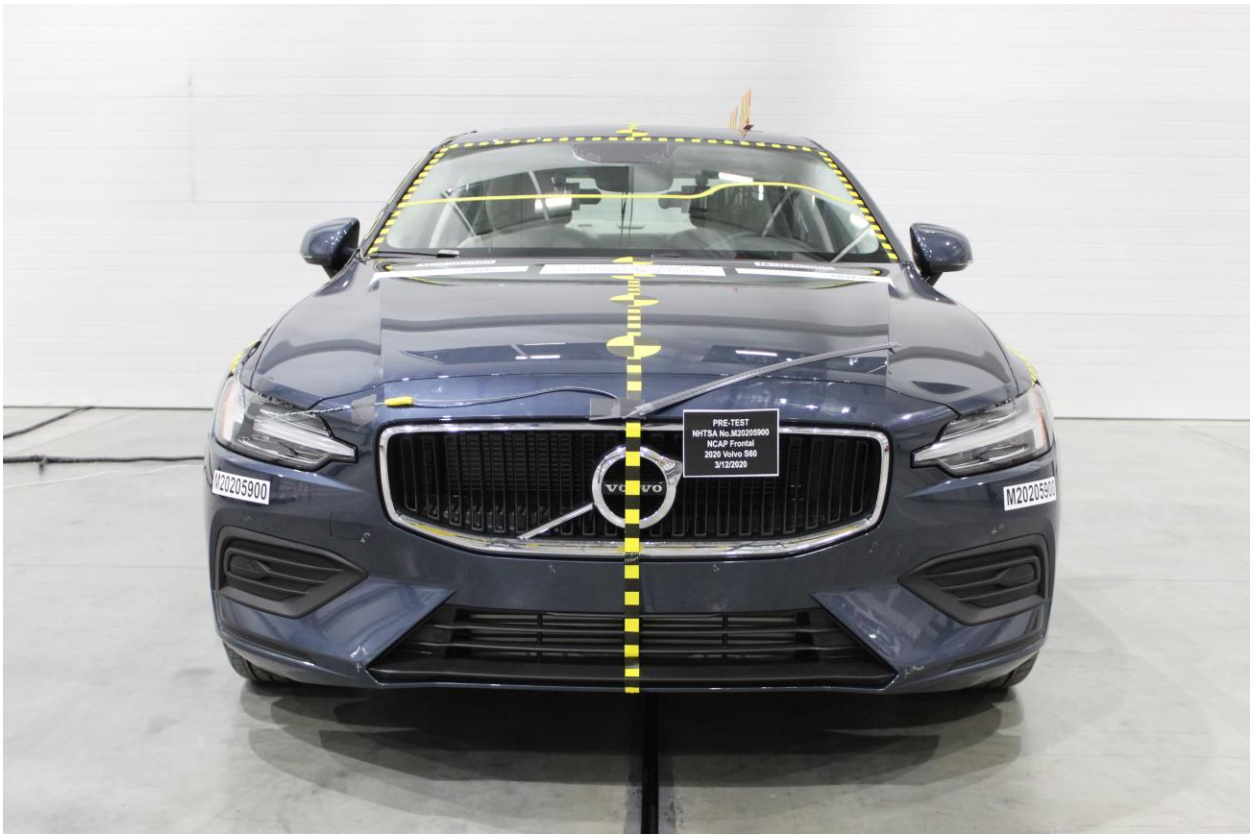


Figure A-8: Pre-Test Front View of Test Vehicle

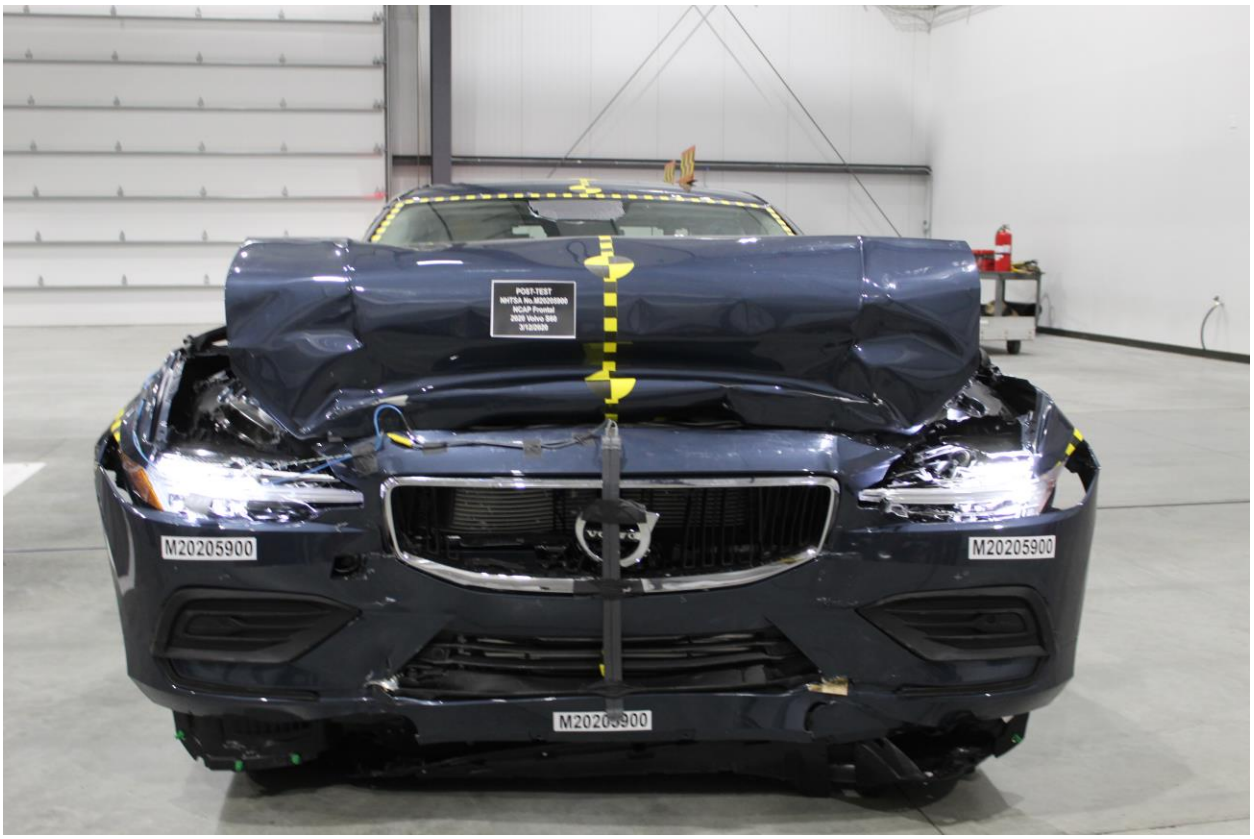


Figure A-9: Post-Test Front View of Test Vehicle

Figure A-10: Pre-Test Left View of Test Vehicle

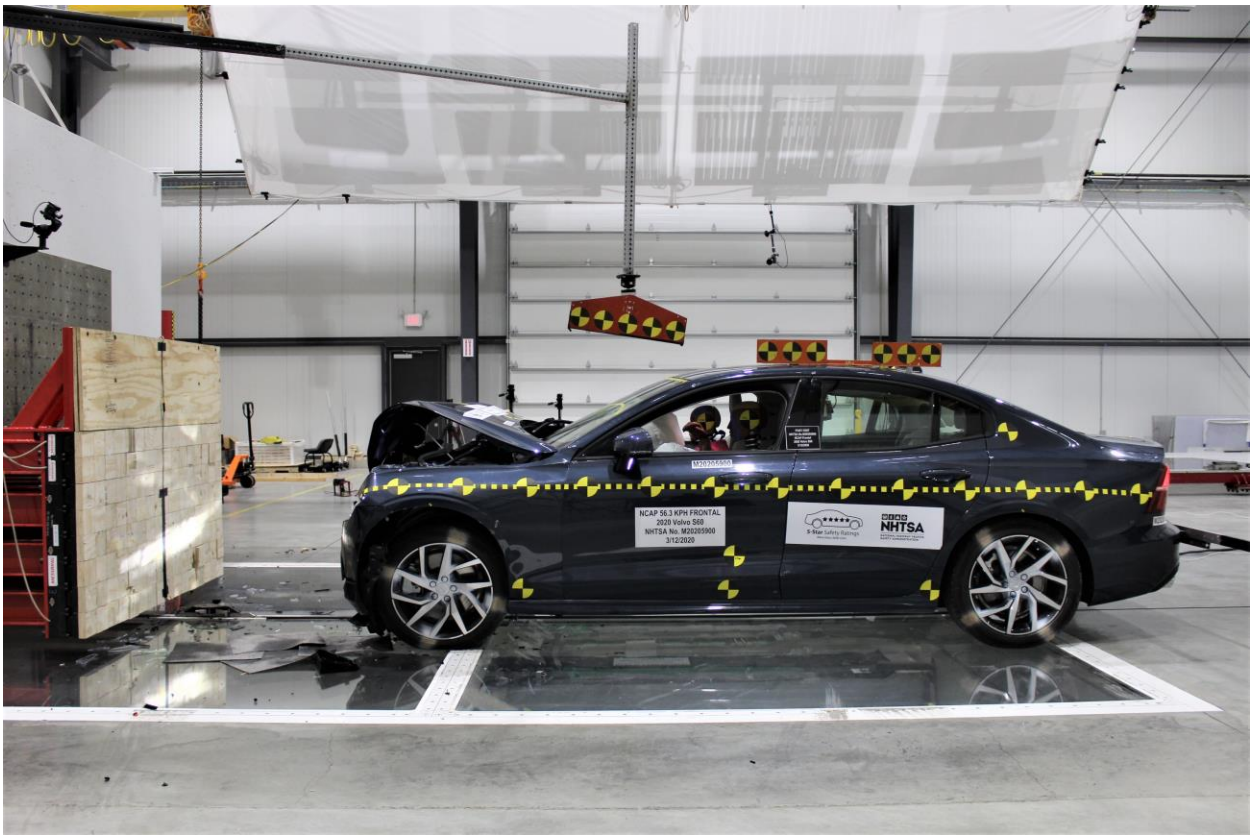


Figure A-11: Post-Test Left View of Test Vehicle

Figure A-12: Pre-Test Right View of Test Vehicle

Figure A-13: Post-Test Right View of Test Vehicle

Figure A-14: Pre-Test Right Front 3-4 View

Figure A-15: Post-Test Right Front 3-4 View

Figure A-16: Pre-Test Left Rear 3-4 View

Figure A-17: Post-Test Left Rear 3-4 View

Figure A-18: Pre-Test Windshield View

Figure A-19: Post-Test Windshield View

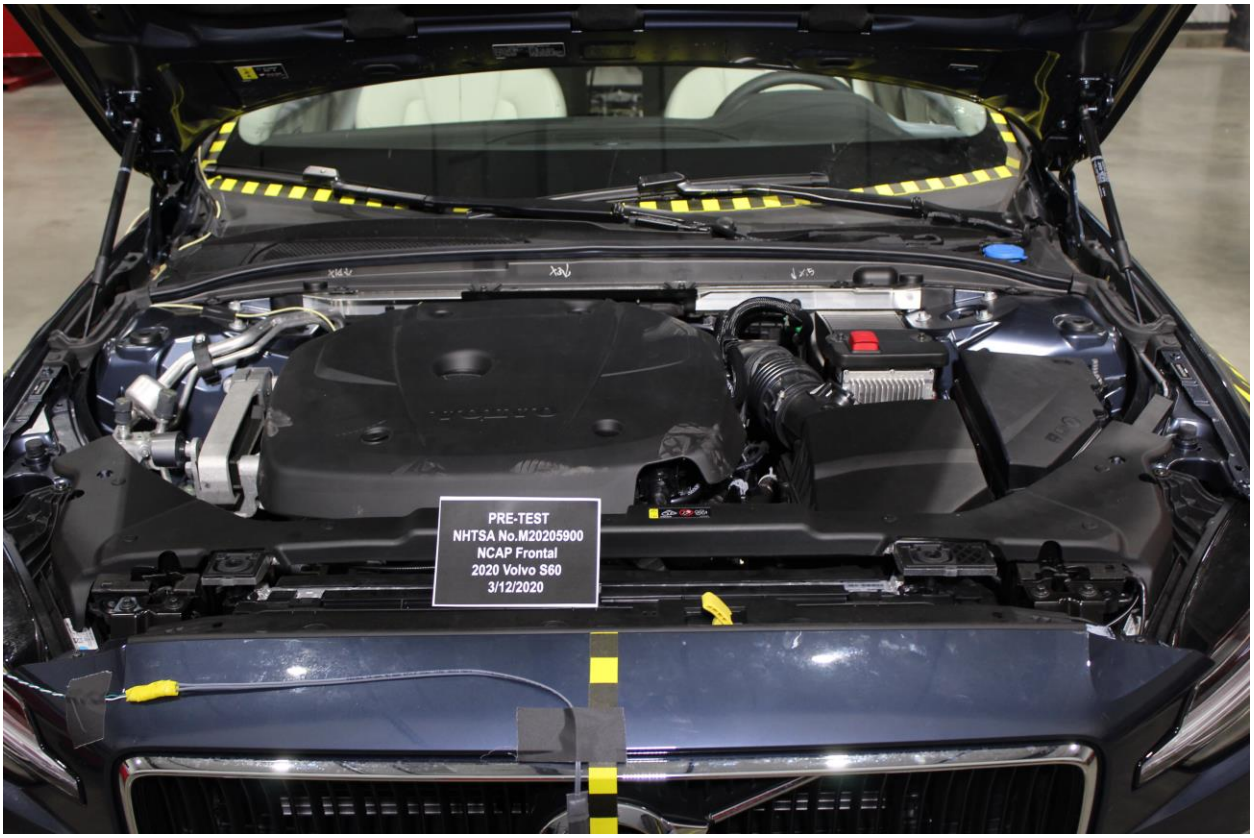


Figure A-20: Pre-Test Engine Compartment View

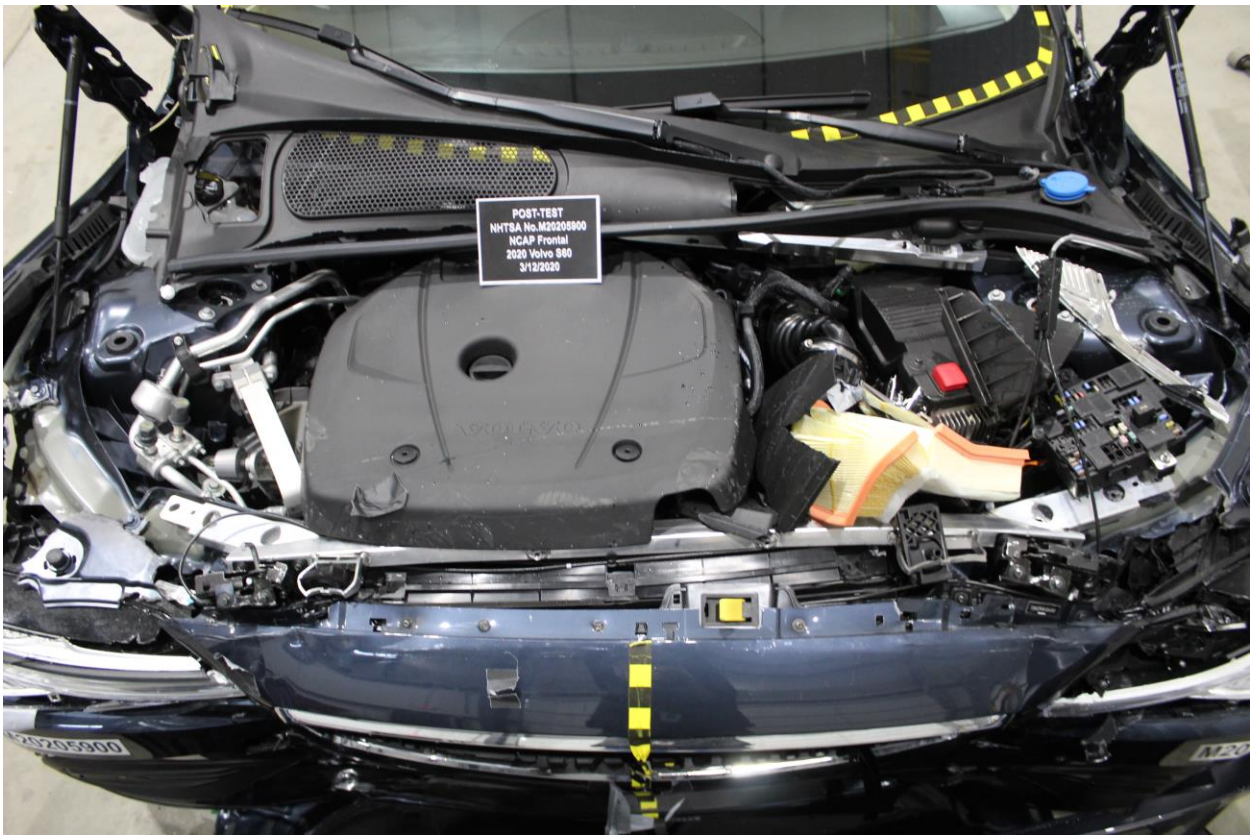


Figure A-21: Post-Test Engine Compartment View

Figure A-22: Pre-Test Fuel Filler Cap View

Figure A-23: Post-Test Fuel Filler Cap View

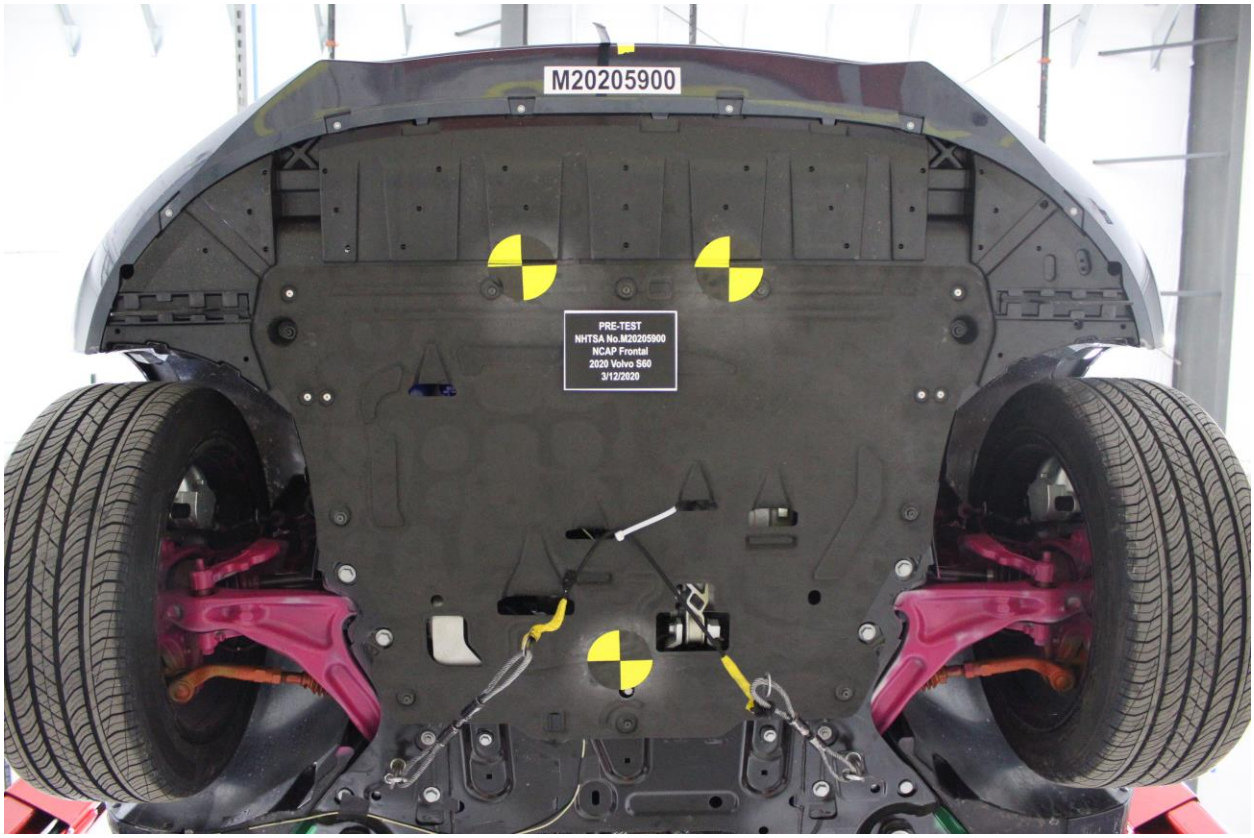


Figure A-24: Pre-Test Front Underbody View

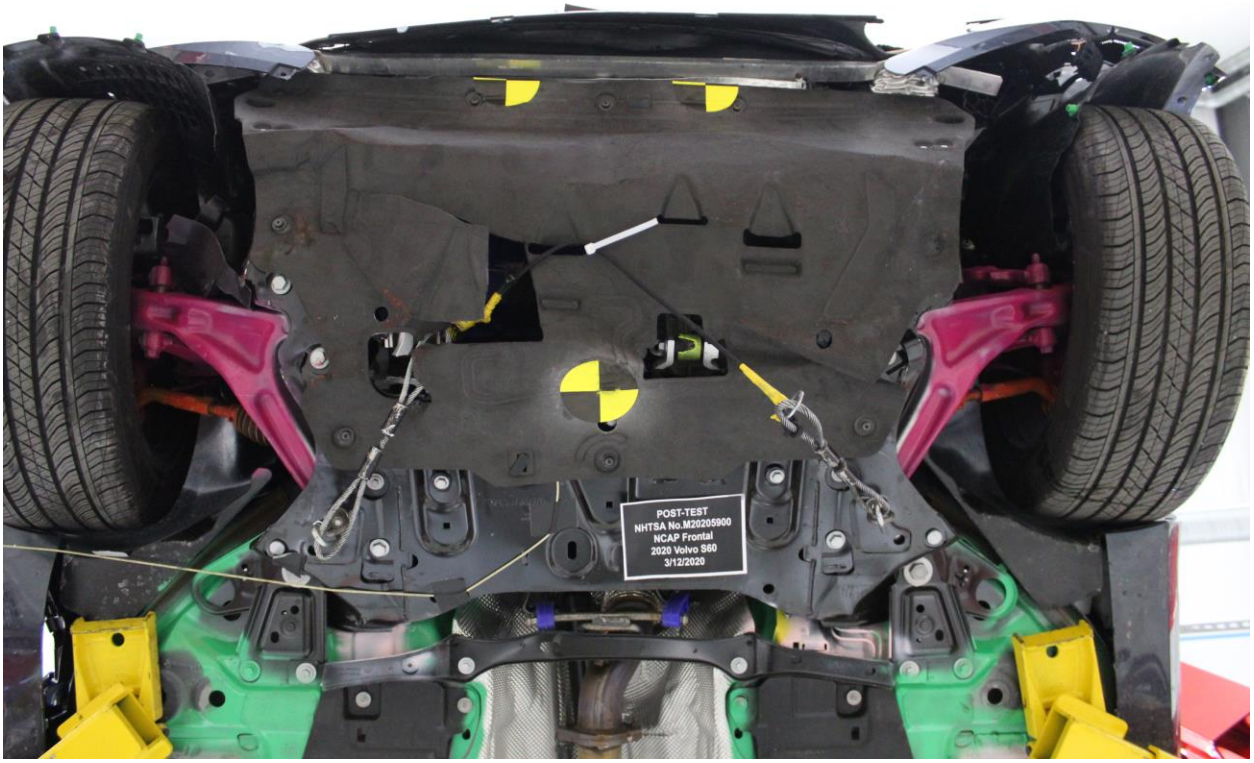


Figure A-25: Post-Test Front Underbody View

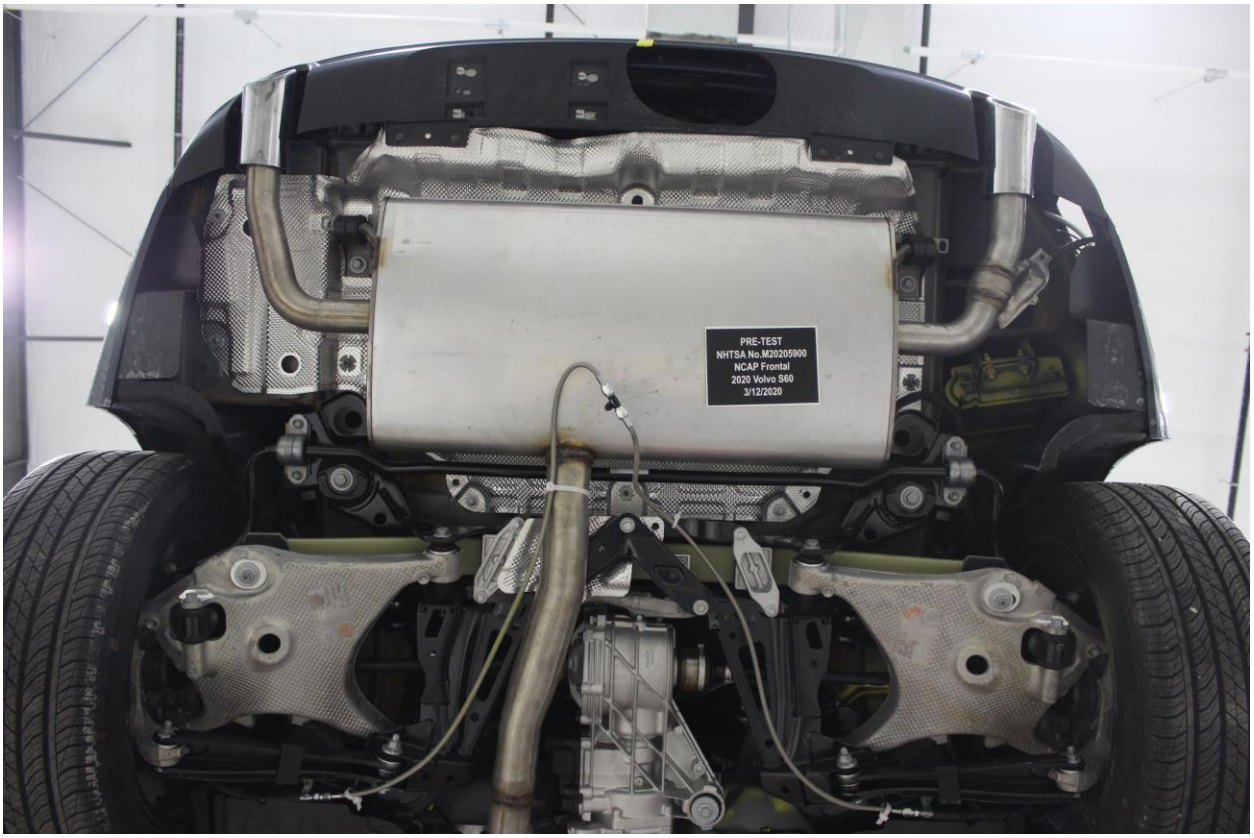


Figure A-26: Pre-Test Rear Underbody View

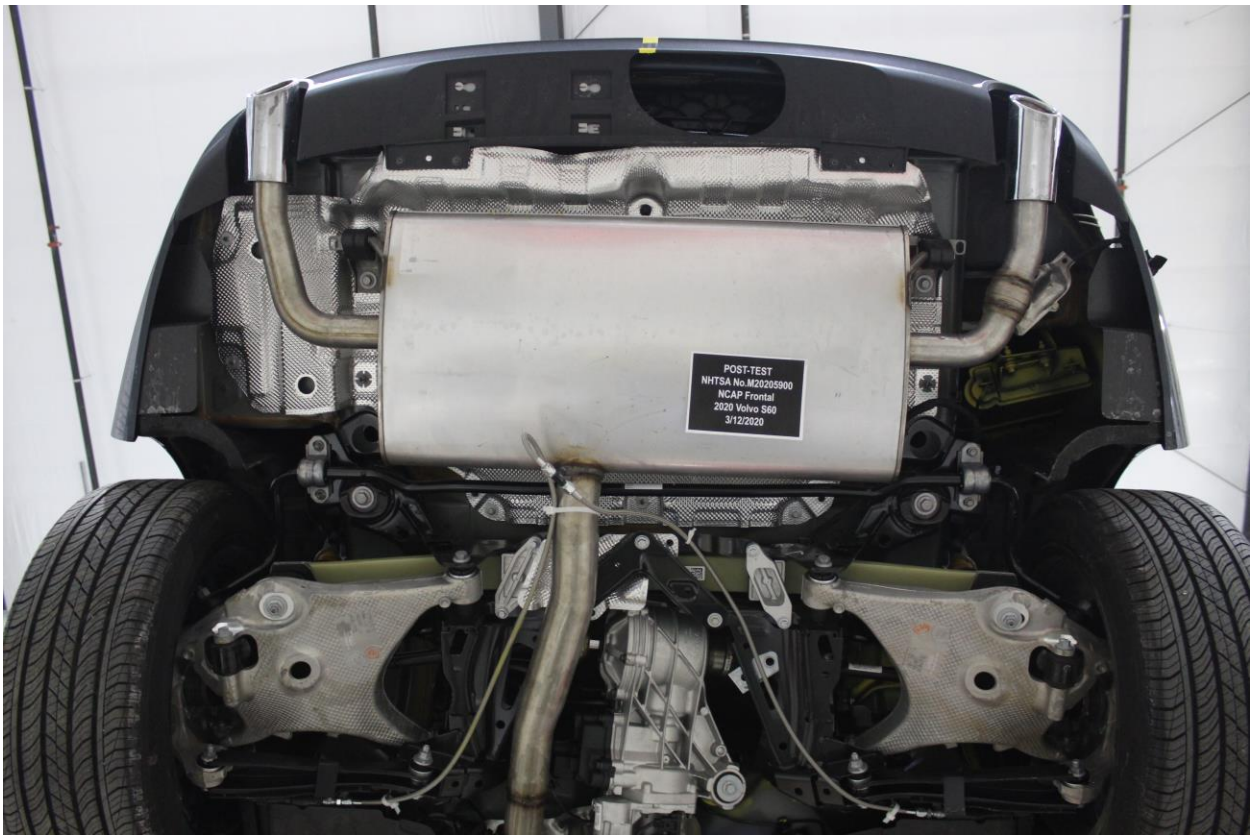


Figure A-27: Post-Test Rear Underbody View

Figure A-28: Pre-Test Dummy Cable Routing

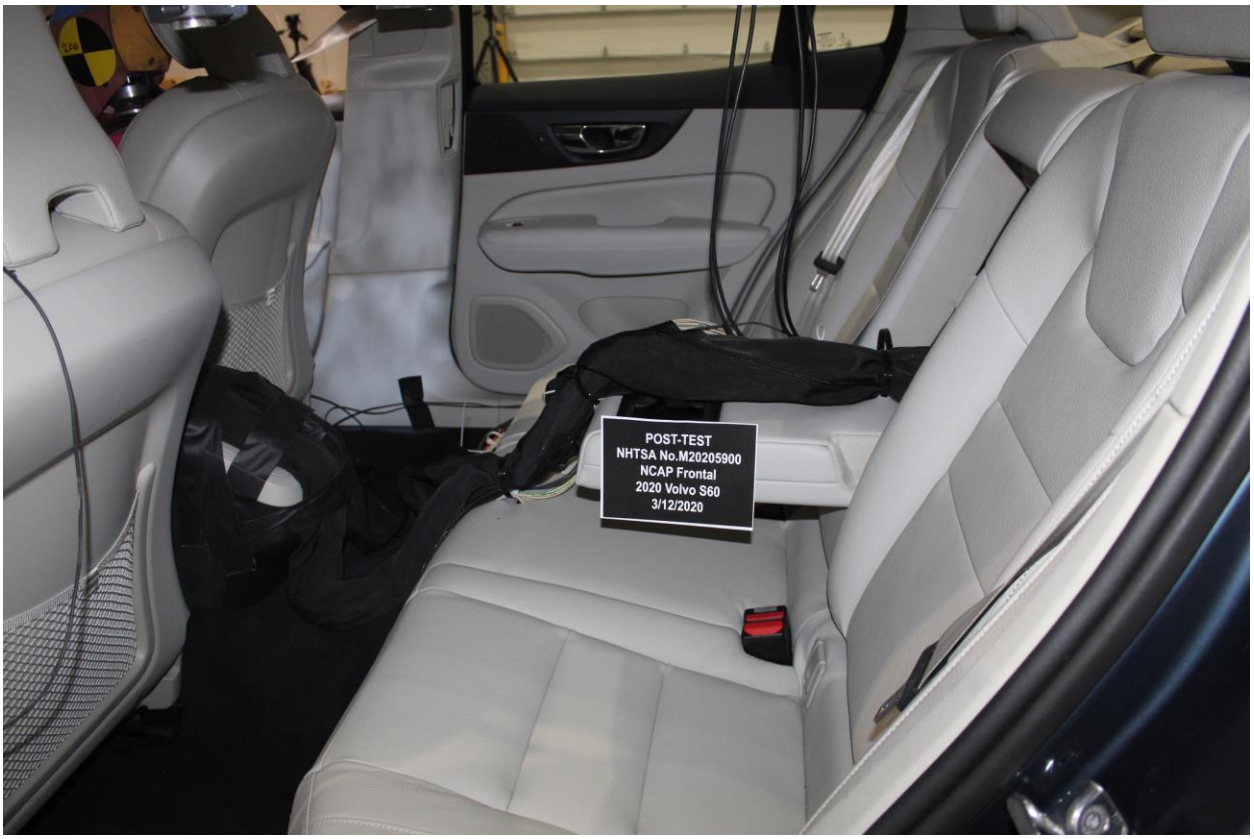


Figure A-29: Post-Test Dummy Cable Routing

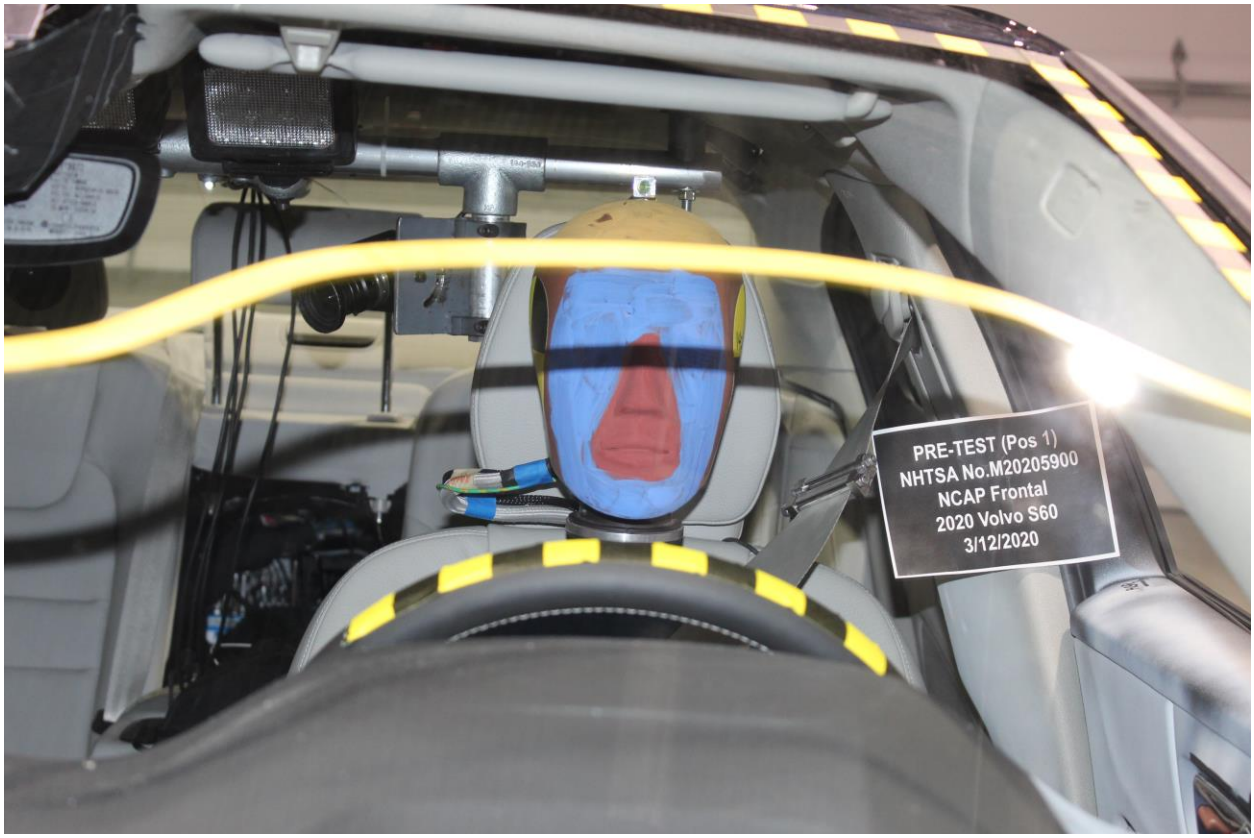


Figure A-30: Pre-Test Driver Dummy Front View

Figure A-31: Post-Test Driver Dummy Front View

Figure A-32: Pre-Test Driver Dummy Window View

Figure A-33: Post-Test Driver Dummy Window View

Figure A-34: Pre-Test Driver Dummy and Vehicle Interior View

Figure A-35: Post-Test Driver Dummy and Vehicle Interior View

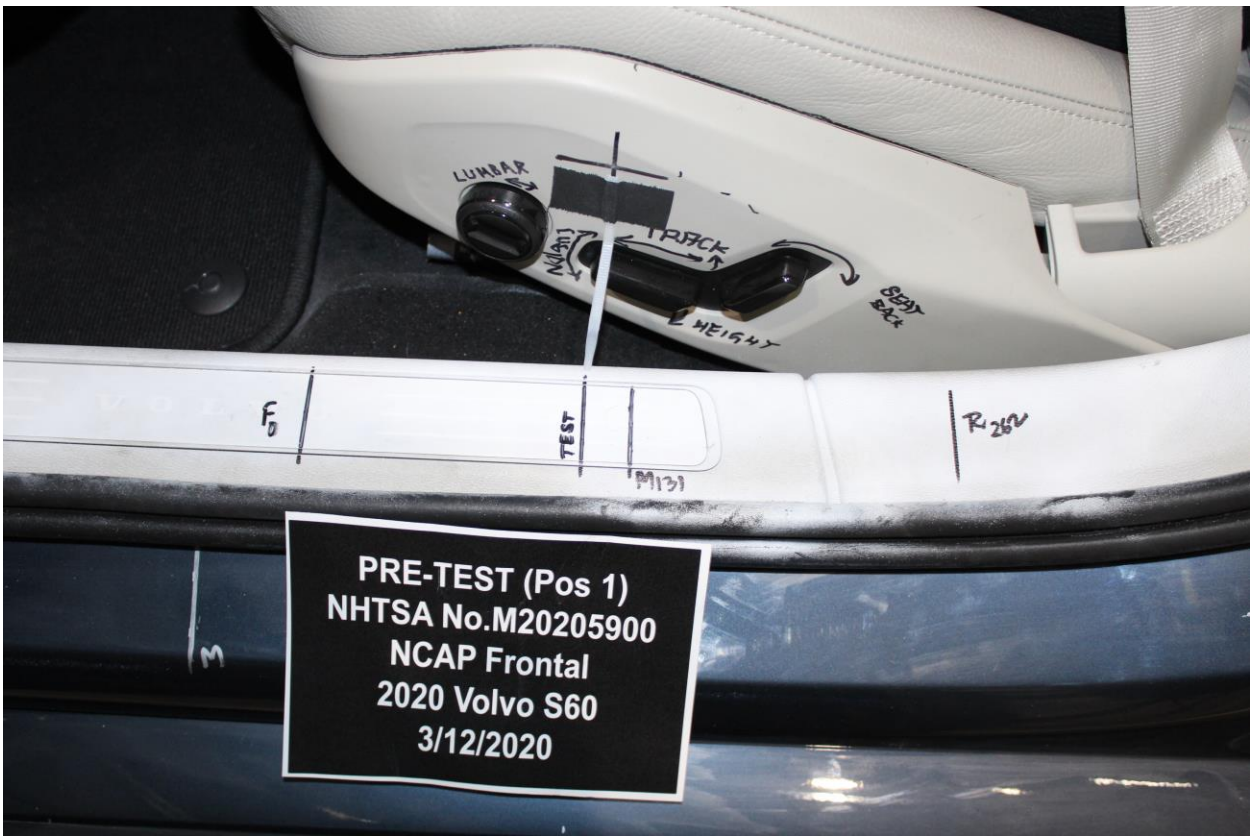


Figure A-36: Pre-Test Driver's Seat Fore-Aft Markings

Figure A-37: Post-Test Driver's Seat Fore-Aft Markings

Figure A-38: Pre-Test View of Belt Anchorage for Driver Dummy

Figure A-39: Post-Test View of Belt Anchorage for Driver Dummy

Figure A-40: Pre-Test View of Belt Buckle and Latch Plate for Driver Dummy

Figure A-41: Post-Test View of Belt Buckle and Latch Plate for Driver Dummy

Figure A-42: Pre-Test Driver Dummy Feet

Figure A-43: Post-Test Driver Dummy Feet

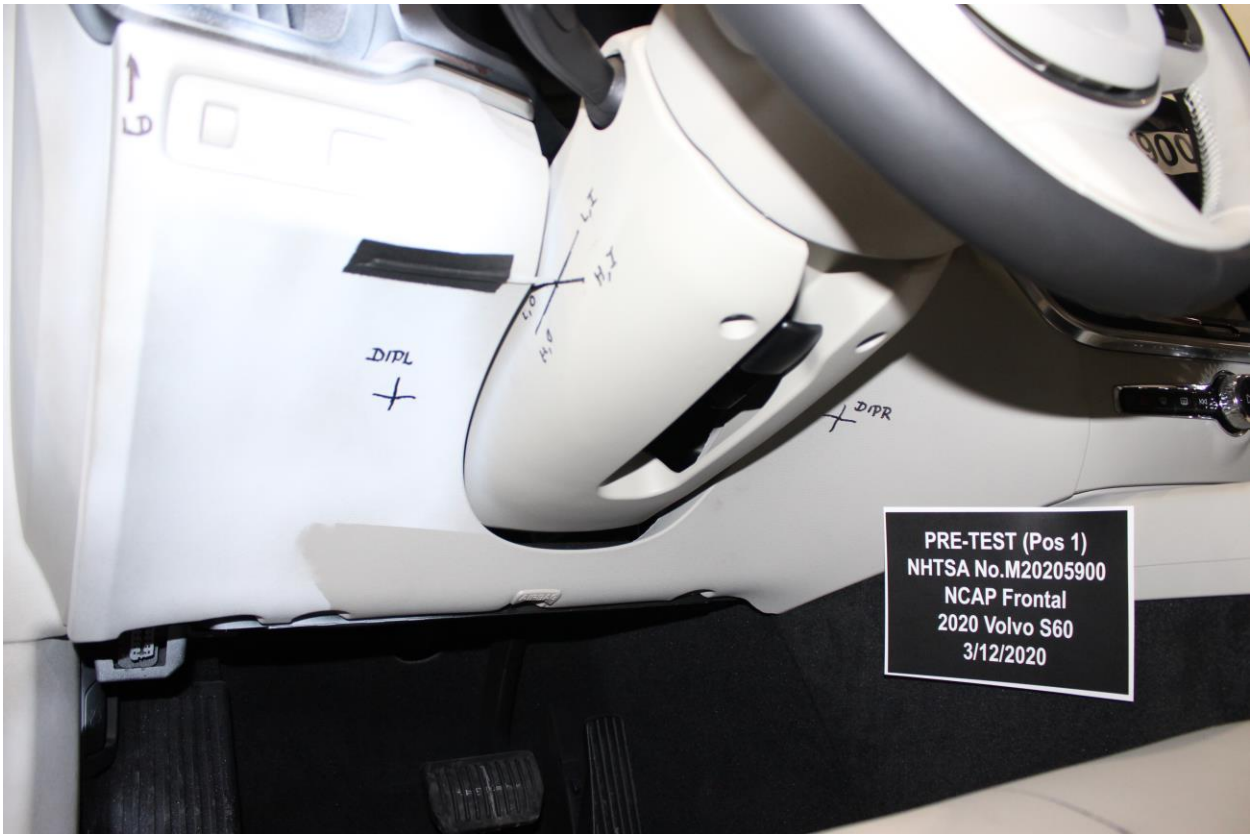


Figure A-44: Pre-Test Driver's Side Knee Bolster

Figure A-45: Post-Test Driver's Side Knee Bolster

Figure A-46: Pre-Test Driver's Side Floorpan

Figure A-47: Post-Test Driver's Side Floorpan

Figure A-48: Post-Test Driver Dummy Face

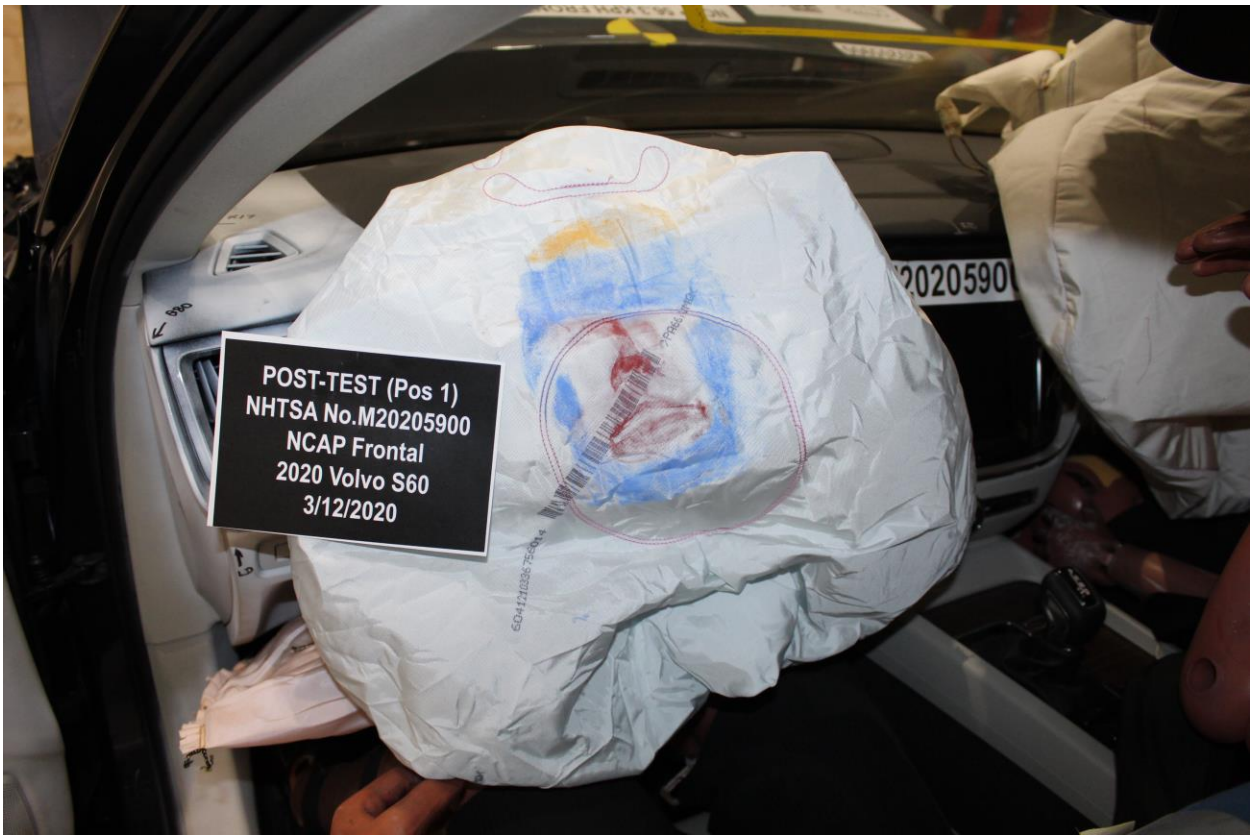


Figure A-49: Post-Test Driver Dummy Contact With Airbag

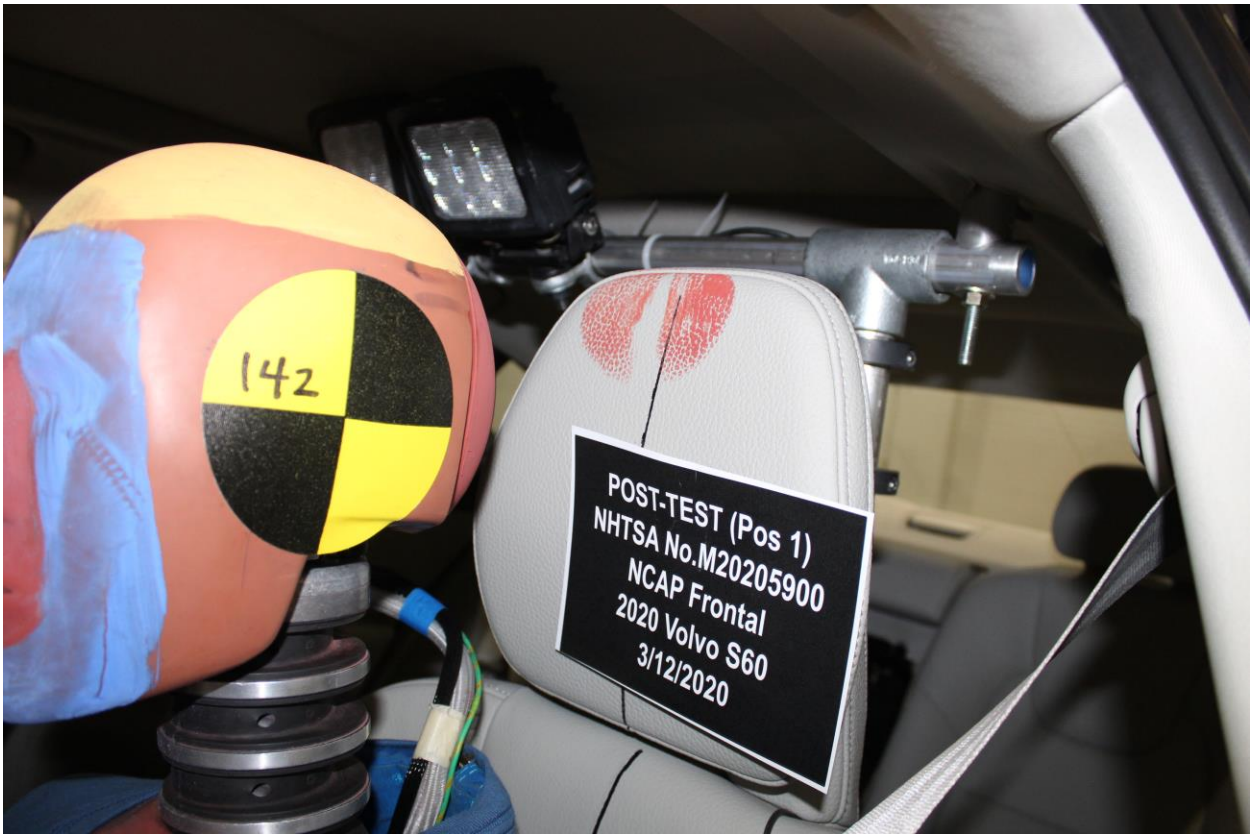


Figure A-50: Post-Test Driver Dummy Contact With Headrest

Figure A-51: Pre-Test View of the Steering Wheel

Figure A-52: Post-Test View of the Steering Wheel

Figure A-53: Pre-Test Passenger Dummy Front View

Figure A-54: Post-Test Passenger Dummy Front View

Figure A-55: Pre-Test Passenger Dummy Window View

Figure A-56: Post-Test Passenger Dummy Window View

Figure A-57: Pre-Test Passenger Dummy and Vehicle Interior View

Figure A-58: Post-Test Passenger Dummy and Vehicle Interior View

Figure A-59: Pre-Test Passenger's Seat Fore-Aft Markings

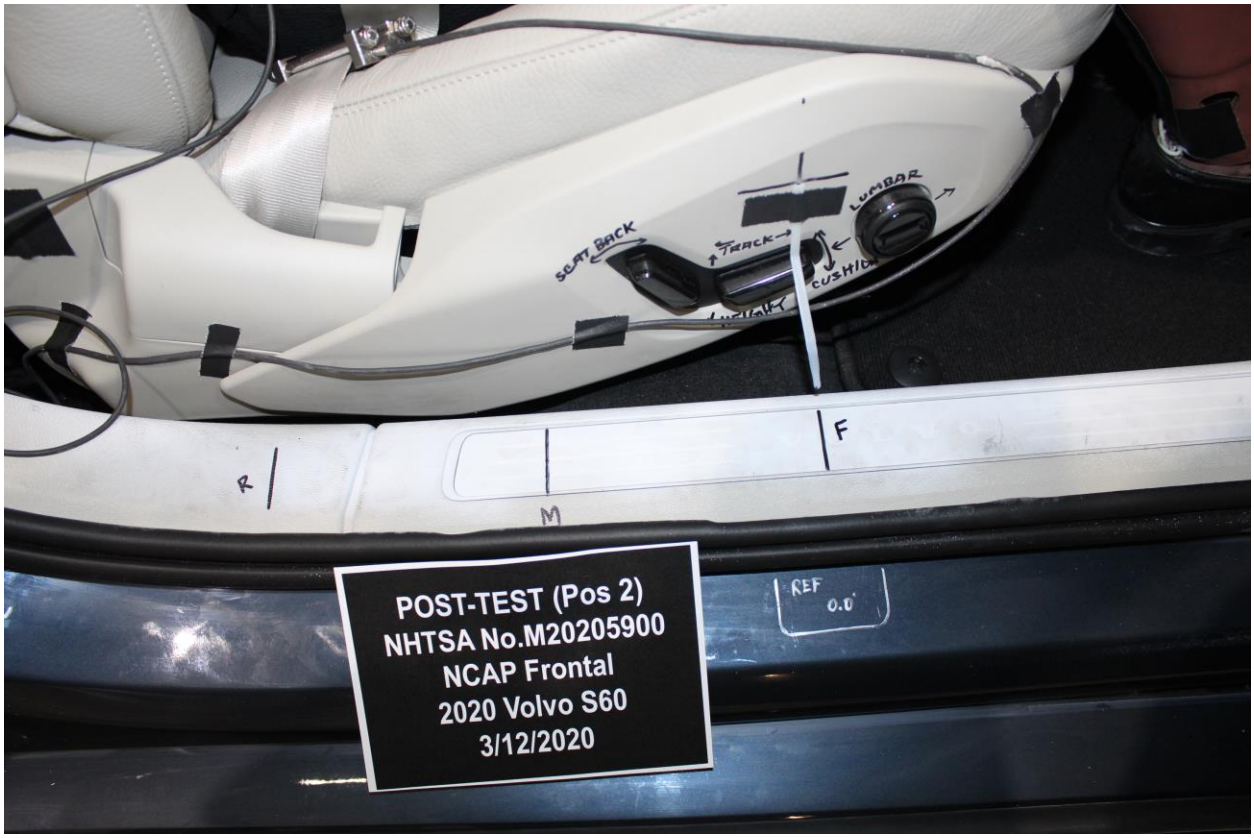


Figure A-60: Post-Test Passenger's Seat Fore-Aft Markings

Figure A-61: Pre-Test View of Belt Anchorage for Passenger Dummy

Figure A-62: Post-Test View of Belt Anchorage for Passenger Dummy

Figure A-63: Pre-Test View of Belt Buckle and Latch Plate for Passenger Dummy

Figure A-64: Post-Test View of Belt Buckle and Latch Plate for Passenger Dummy

Figure A-65: Pre-Test Passenger Dummy Feet

Figure A-66: Post-Test Passenger Dummy Feet

Figure A-67: Pre-Test Passenger's Side Knee Bolster

Figure A-68: Post-Test Passenger's Side Knee Bolster

Figure A-69: Pre-Test Passenger's Side Floorpan

Figure A-70: Post-Test Passenger's Side Floorpan

Figure A-71: Post-Test Passenger Dummy Face

Figure A-72: Post-Test Passenger Dummy Contact With Airbag

Figure A-73: Post-Test Passenger Dummy Contact With Headrest

Figure A-74: Photograph of Ballast Installed in Vehicle

Photo Not Applicable

Figure A-75: Post-Test Stoddard Solvent Spillage Location View, If Required

Figure A-76: Post-Test Speed Trap Read-Out

Figure A-77: Vehicle at 0º on Static Rollover Device

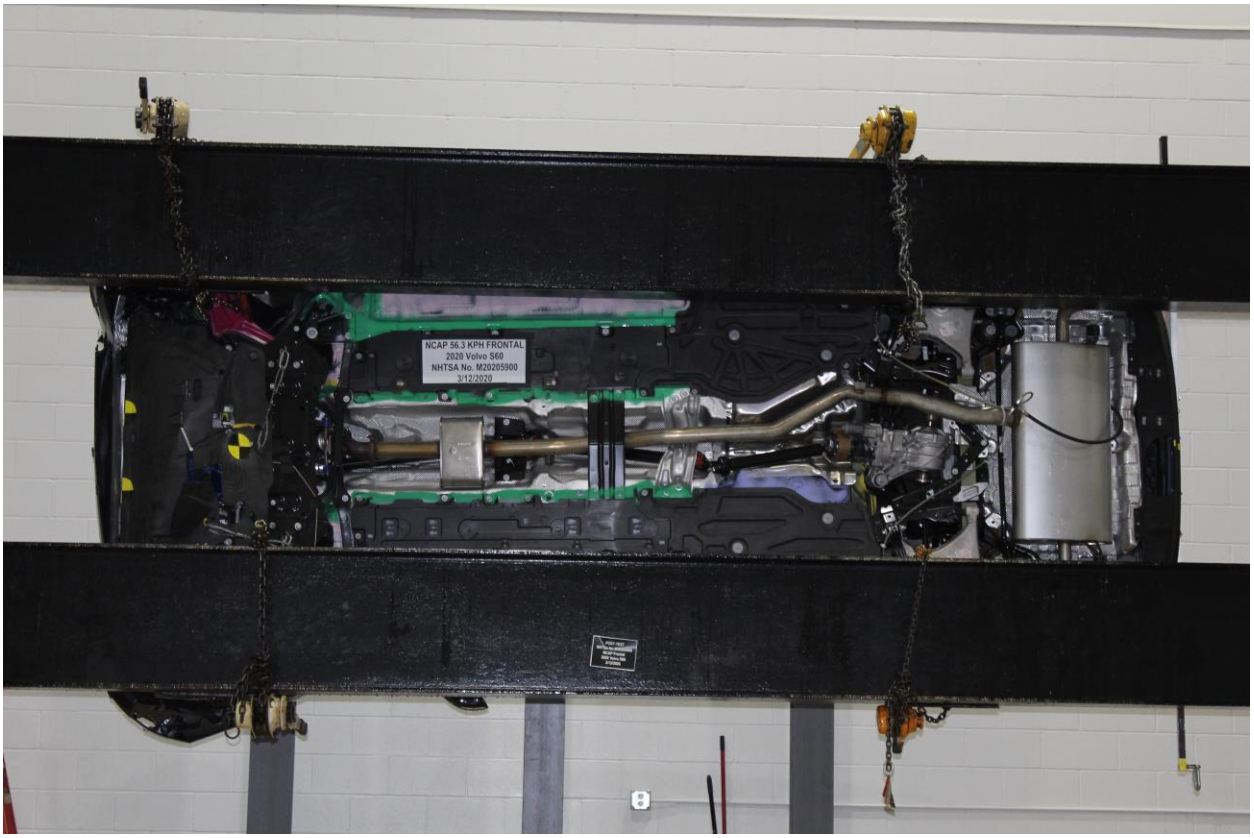


Figure A-78: Vehicle at 90º on Static Rollover Device

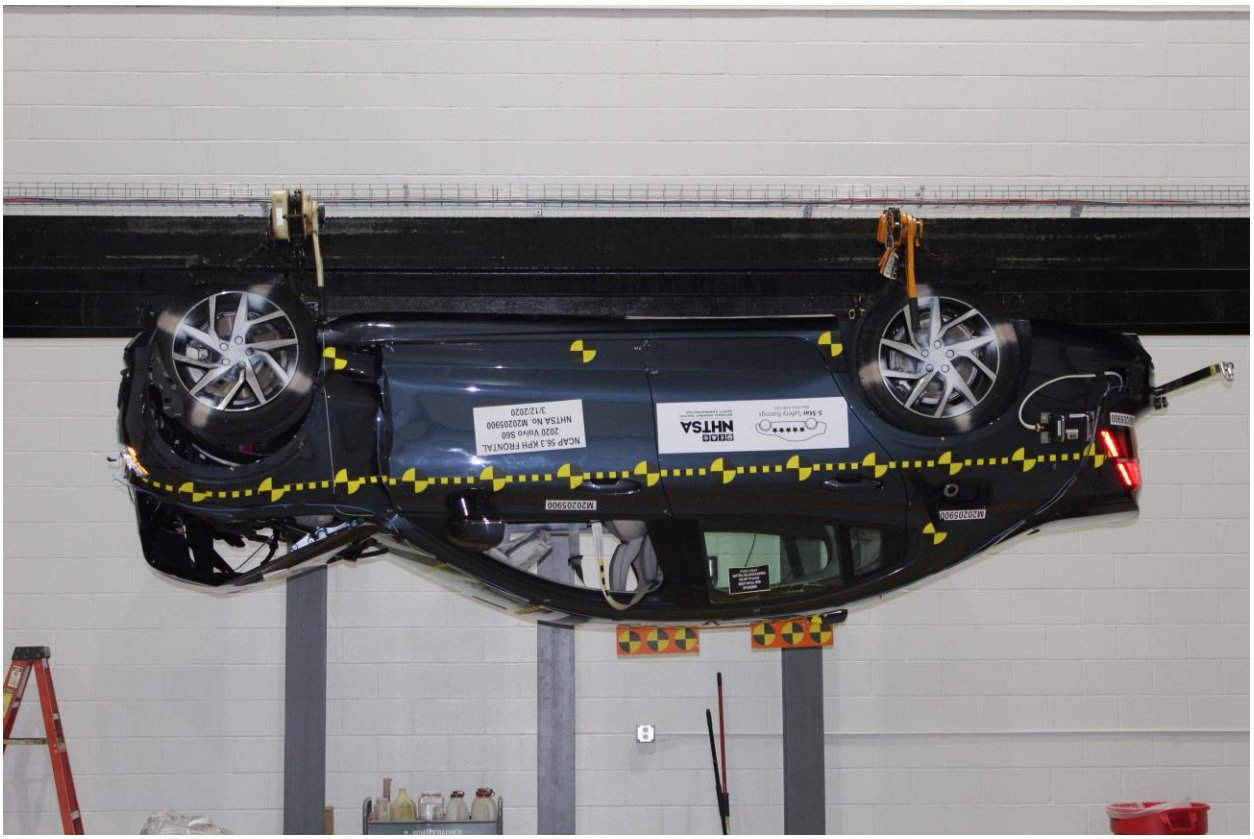


Figure A-79: Vehicle at 180º on Static Rollover Device

Figure A-80: Vehicle at 270º on Static Rollover Device

Figure A-81: Vehicle at 360º on Static Rollover Device

Figure A-82: 2020 Volvo S60 Frontal Impact Event

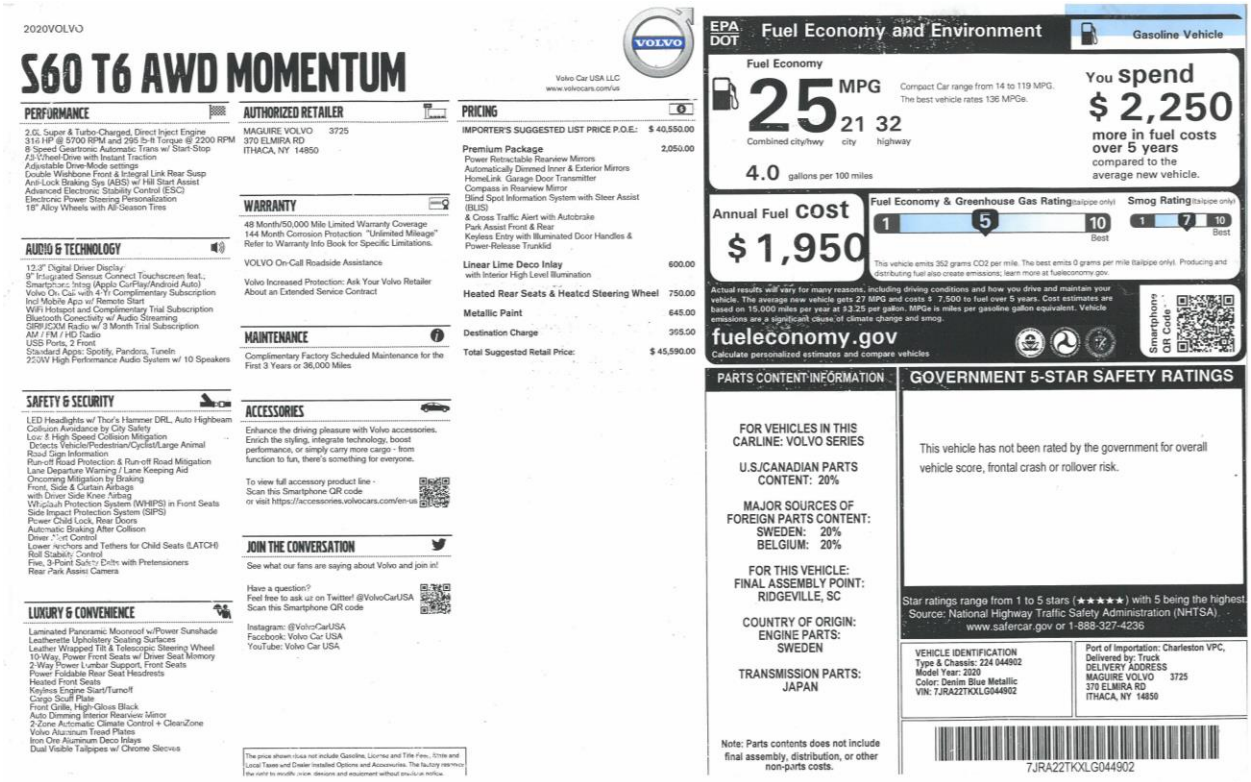


Figure A-83: Monroney Label Photograph

APPENDIX B
VEHICLE & DUMMY RESPONSE DATA TRACES

Table of Data Plots

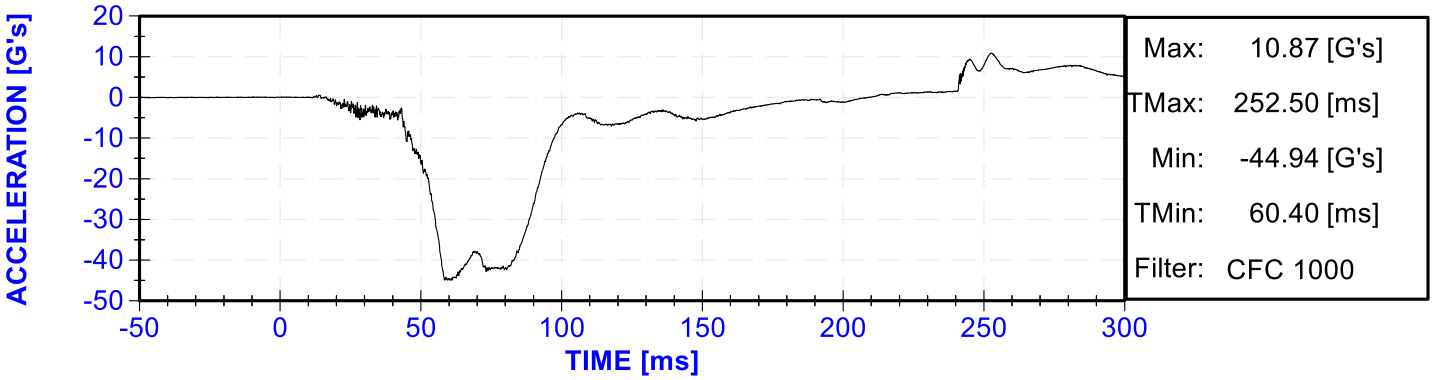
The following additional dummy and vehicle response data can be found in the R&D section of the NHTSA website at www.NHTSA.gov

Driver Head X Acceleration Redundant
Driver Head Y Acceleration Redundant
Driver Head Z Acceleration Redundant
Driver Upper Neck Force Y
Driver Upper Neck Moment X
Driver Upper Neck Moment Z
Driver Chest X Acceleration Redundant
Driver Chest Y Acceleration Redundant
Driver Chest Z Acceleration Redundant
Driver Pelvis X
Driver Pelvis Y
Driver Pelvis Z
Driver Left Femur Redundant
Driver Right Femur Redundant
Driver Left Upper Tibia Moment X
Driver Left Upper Tibia Moment Y

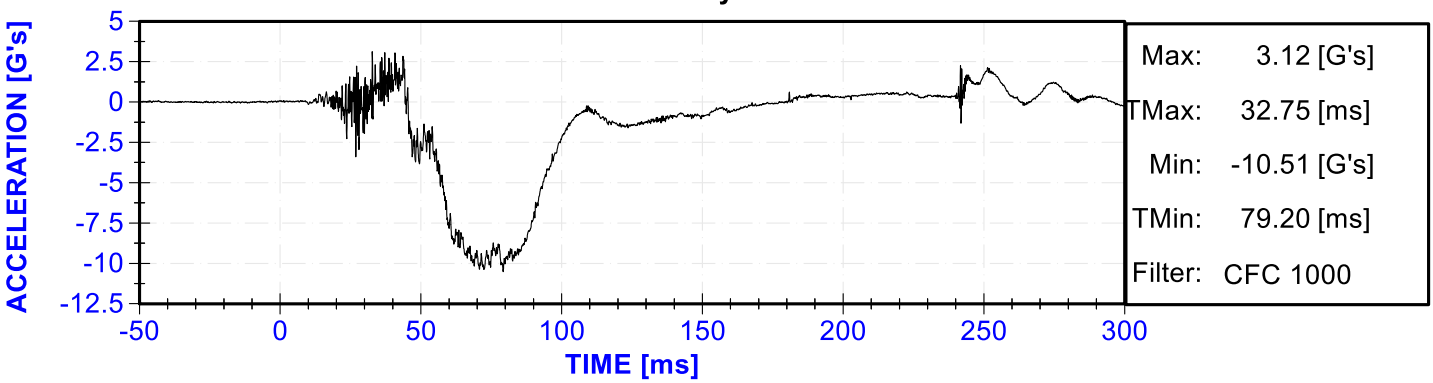
Driver Left Upper Tibia Force Z
Driver Left Lower Tibia Moment X
Driver Left Lower Tibia Moment Y
Driver Left Lower Tibia Force Z
Driver Right Upper Tibia Moment X
Driver Right Upper Tibia Moment Y
Driver Right Upper Tibia Force Z
Driver Right Lower Tibia Moment X
Driver Right Lower Tibia Moment Y
Driver Right Lower Tibia Force Z
Driver Left Foot Fore Z
Driver Left Foot Aft X
Driver Left Foot Aft Z
Driver Right Foot Fore Z
Driver Right Foot Aft X
Driver Right Foot Aft Z
Driver Shoulder Belt Force
Driver Lap Belt Force
Driver Head Angular Velocity X
Driver Head Angular Velocity Y
Driver Head Angular Velocity Z
Passenger Head X Acceleration Redundant
Passenger Head Y Acceleration Redundant
Passenger Head Z Acceleration Redundant
Passenger Upper Neck Force X
Passenger Upper Neck Force Z
Passenger Upper Neck Moment Y
Passenger Chest X Acceleration Redundant
Passenger Chest Y Acceleration Redundant
Passenger Chest Z Acceleration Redundant
Passenger Pelvis X
Passenger Pelvis Y
Passenger Pelvis Z
Passenger Left Femur Redundant
Passenger Right Femur Redundant
Passenger Left Upper Tibia Moment X
Passenger Left Upper Tibia Moment Y
Passenger Left Upper Tibia Force Z
Passenger Left Lower Tibia Moment X
Passenger Left Lower Tibia Moment Y
Passenger Left Lower Tibia Force Z
Passenger Right Upper Tibia Moment X
Passenger Right Upper Tibia Moment Y
Passenger Right Upper Tibia Force Z
Passenger Right Lower Tibia Moment X
Passenger Right Lower Tibia Moment Y
Passenger Right Lower Tibia Force Z
Passenger Left Foot Fore Z
Passenger Left Foot Aft X
Passenger Left Foot Aft Z

Passenger Right Food Fore Z
Passenger Right Foot Aft X
Passenger Right Foot Aft Z
Passenger Shoulder Belt Force
Passenger Lap Belt Force
Passenger Head Angular Velocity X
Passenger Head Angular Velocity Y
Passenger Head Angular Velocity Z
Left Rear Seat Crossmember X
Left Rear Seat Crossmember Z
Right Rear Seat Crossmember X
Right Rear Seat Crossmember Z
Left Rear Seat Crossmember X Redundant
Right Rear Seat Crossmember X Redundant
Vehicle Engine Top X
Vehicle Engine Bottom X
Load Cell Barrier Forces and Moments

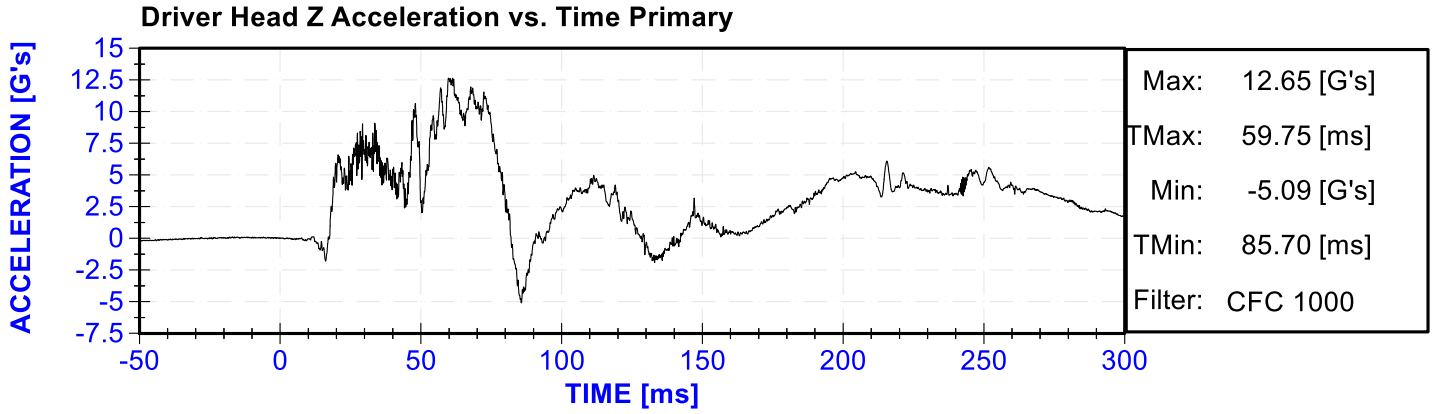
Driver Head X Acceleration vs. Time Primary



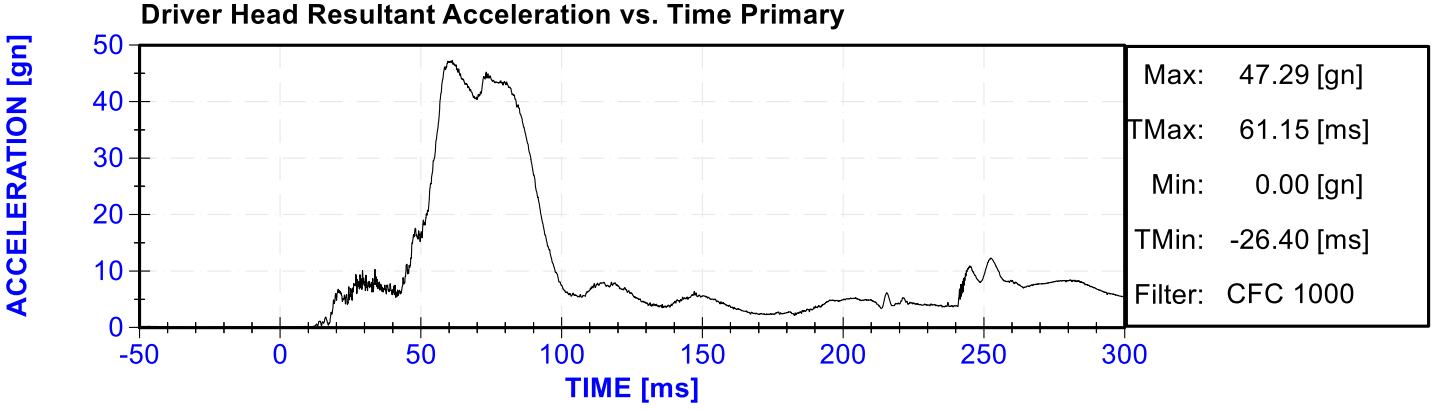
Driver Head Y Acceleration vs. Time Primary



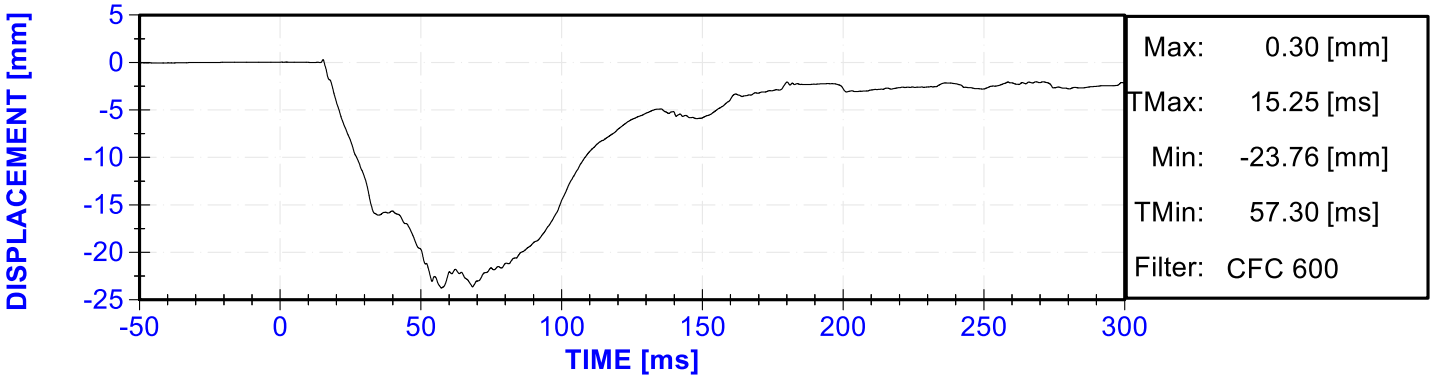
Driver Head Z Acceleration vs. Time Primary



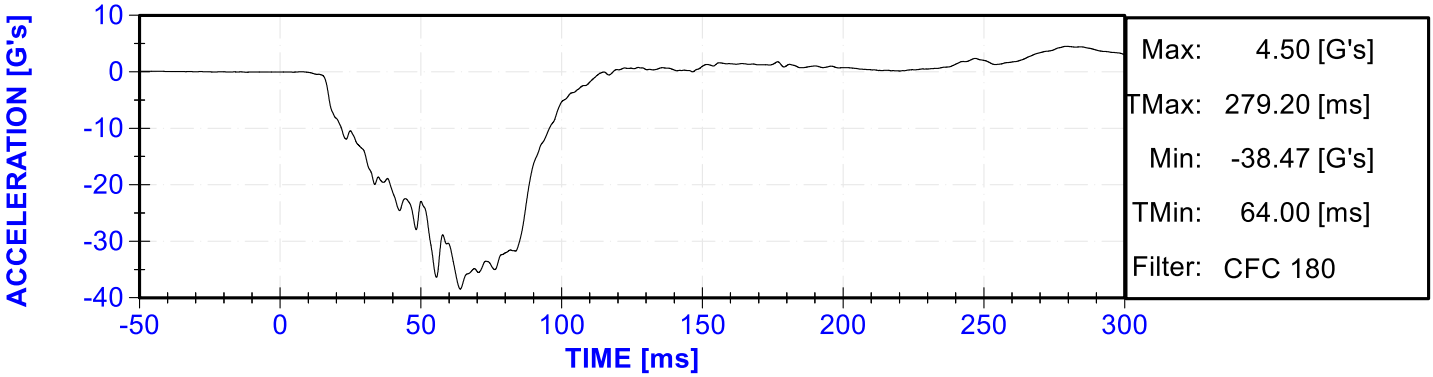
Driver Head Resultant Acceleration vs. Time Primary



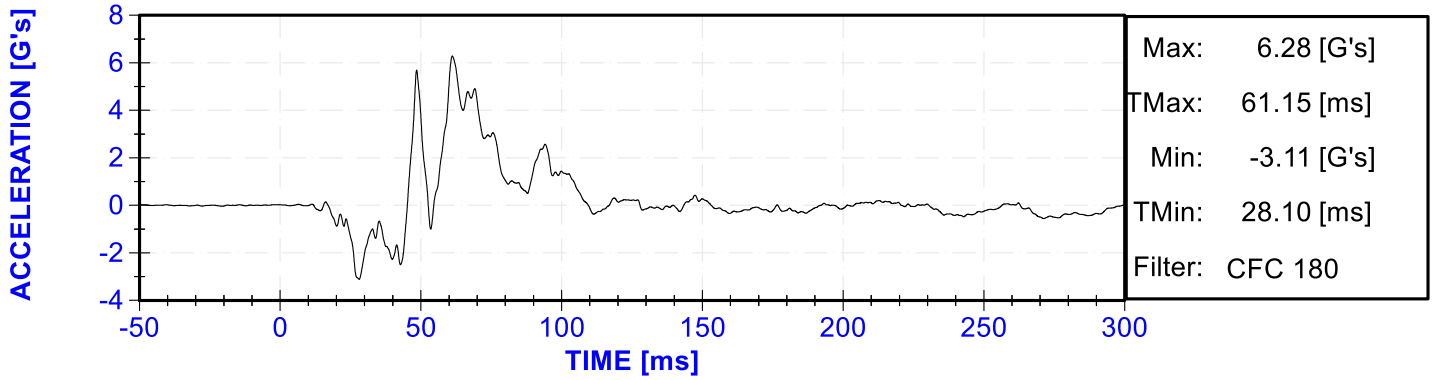
Driver Chest X Deflection vs. Time



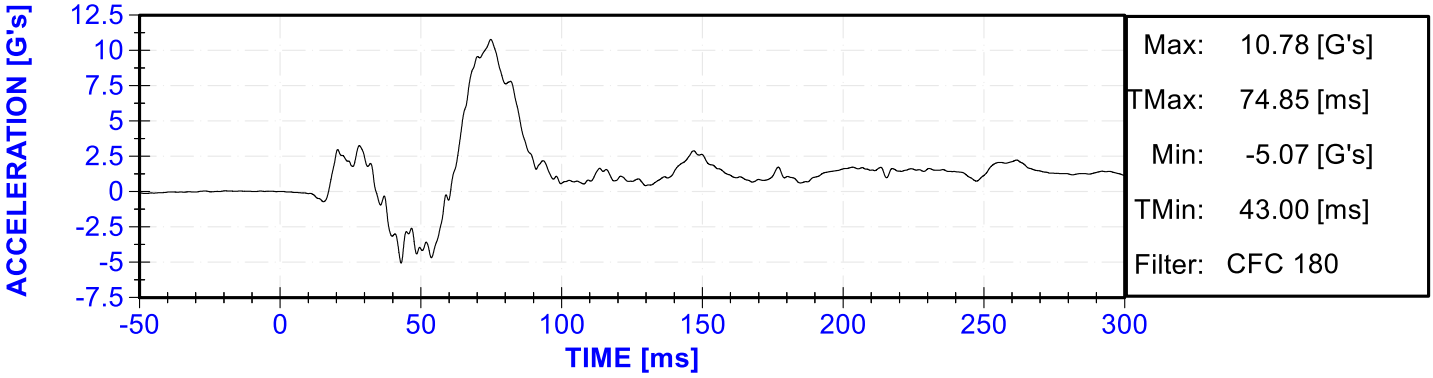
Driver Chest X Acceleration vs. Time Primary



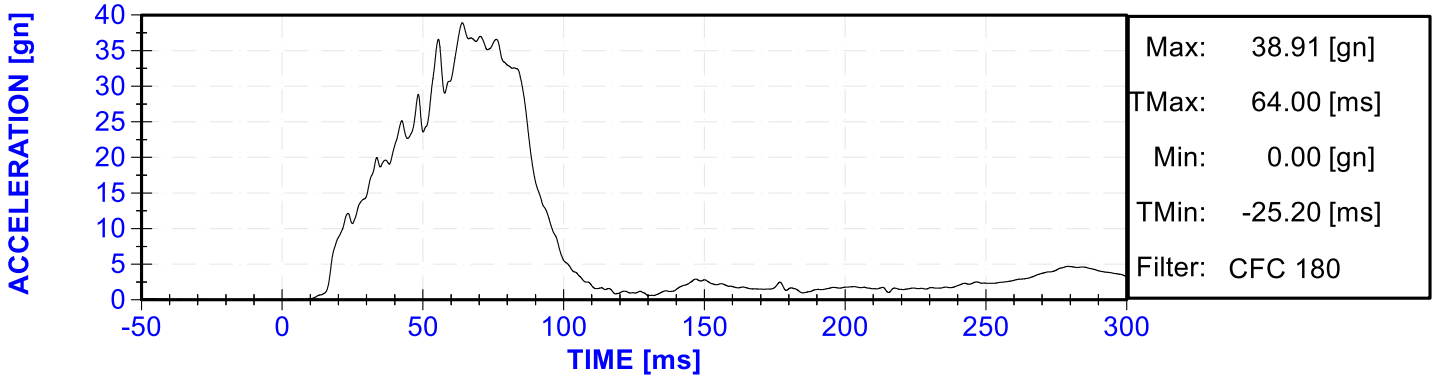
Driver Chest Y Acceleration vs. Time Primary



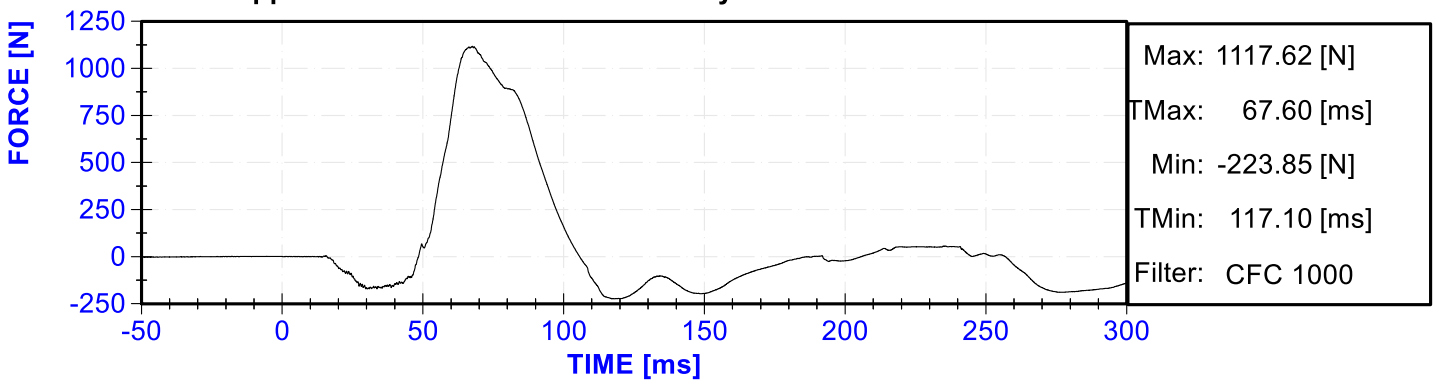
Driver Chest Z Acceleration vs. Time Primary



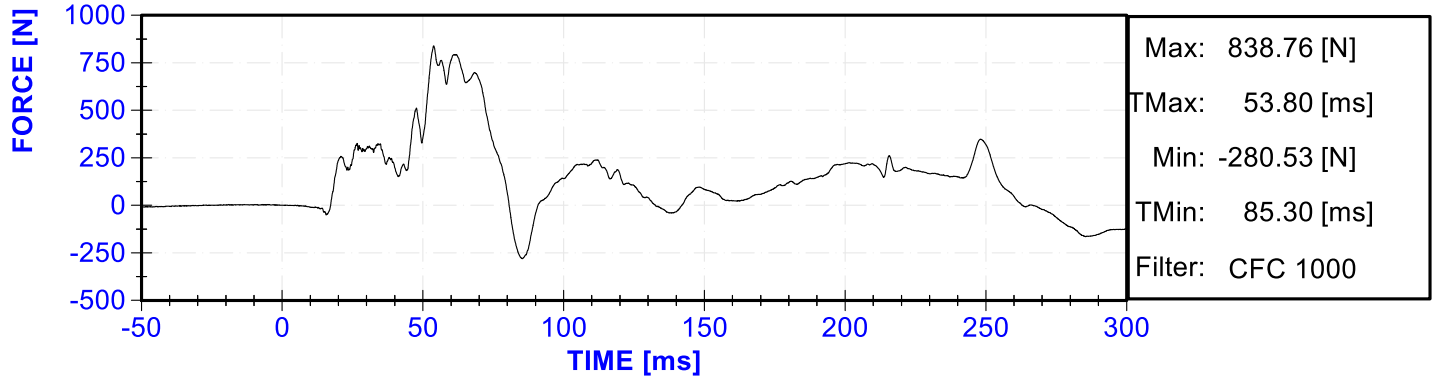
Driver Chest Resultant Acceleration vs. Time Primary



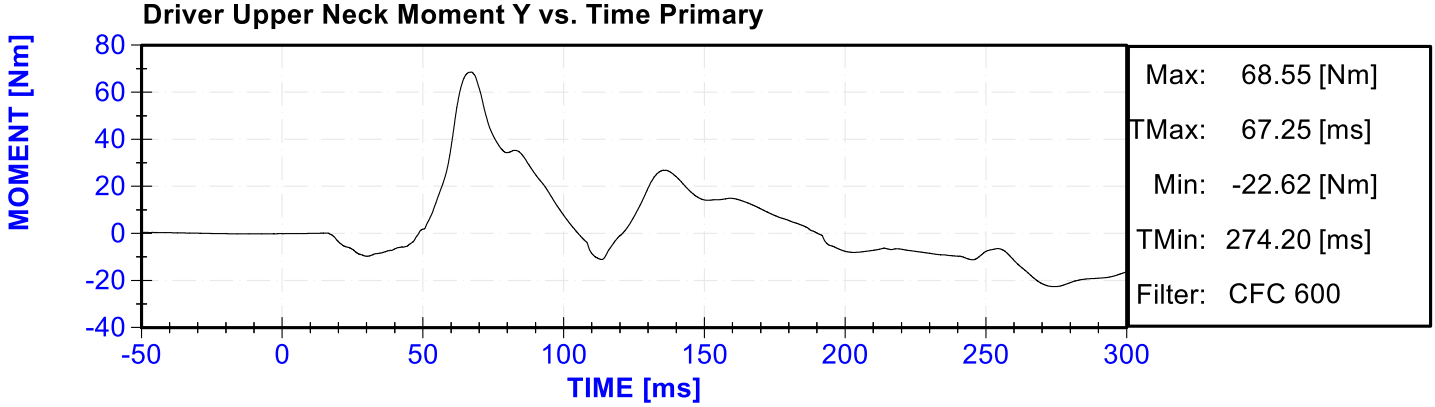
Driver Upper Neck Force X vs. Time Primary



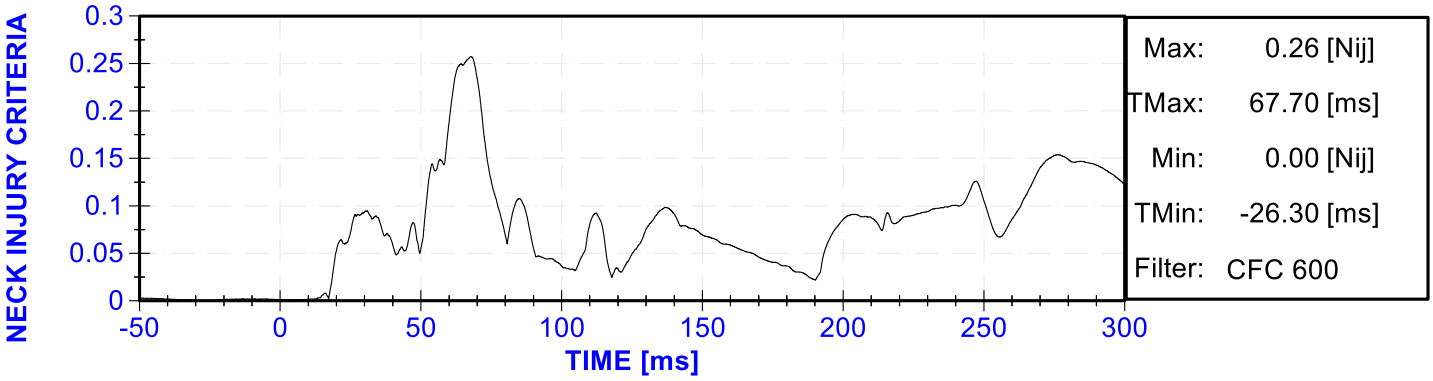
Driver Upper Neck Force Z vs. Time Primary



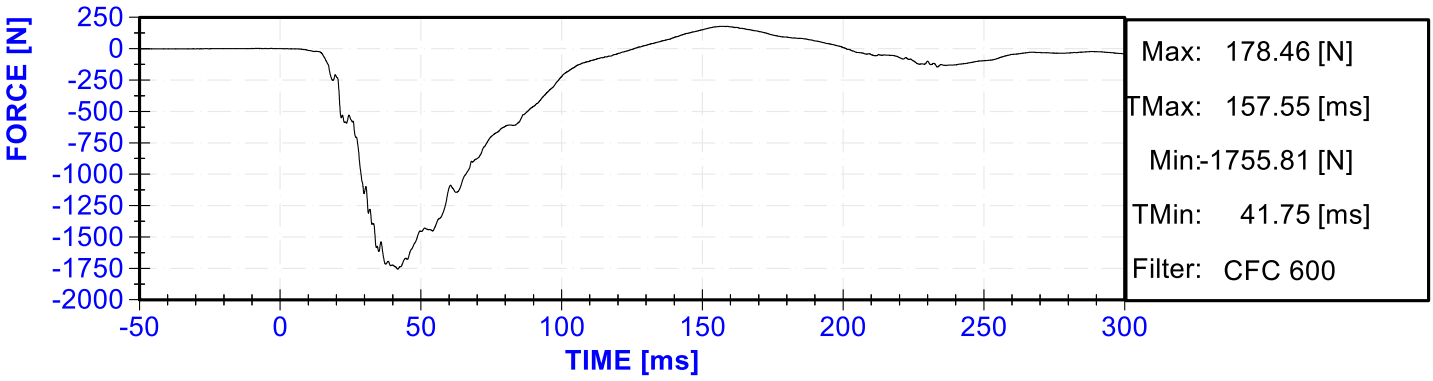
Driver Upper Neck Moment Y vs. Time Primary



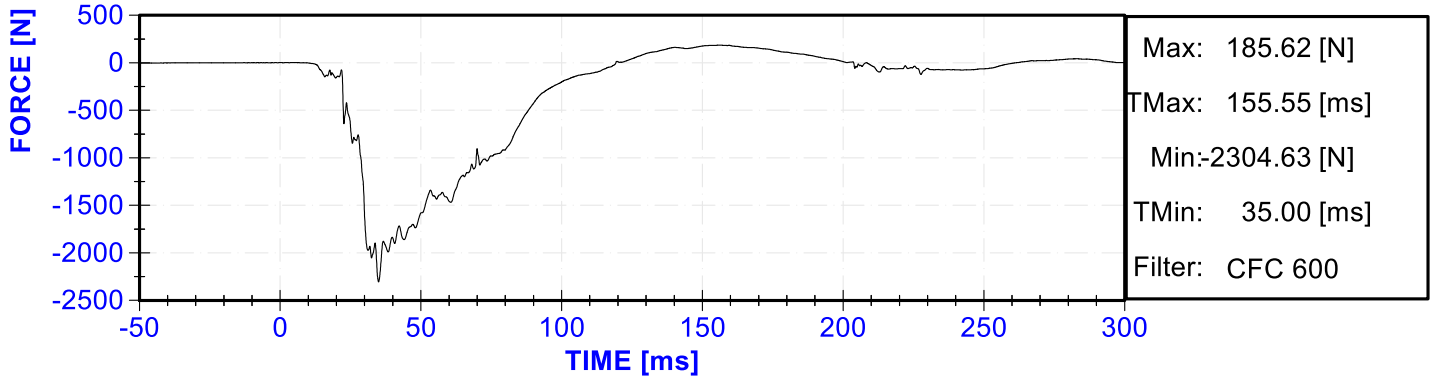
Driver Nij vs. Time Primary



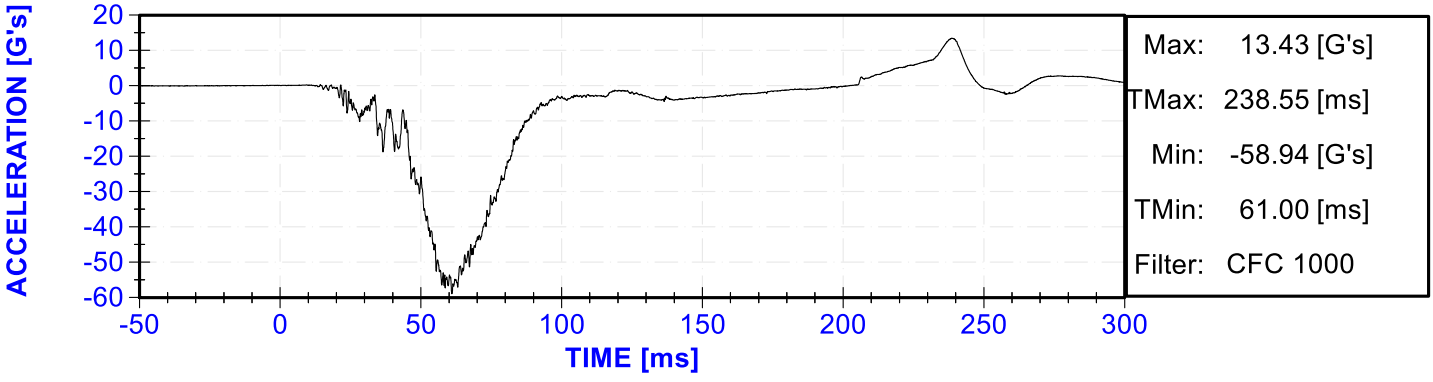
Driver Left Femur Force vs. Time



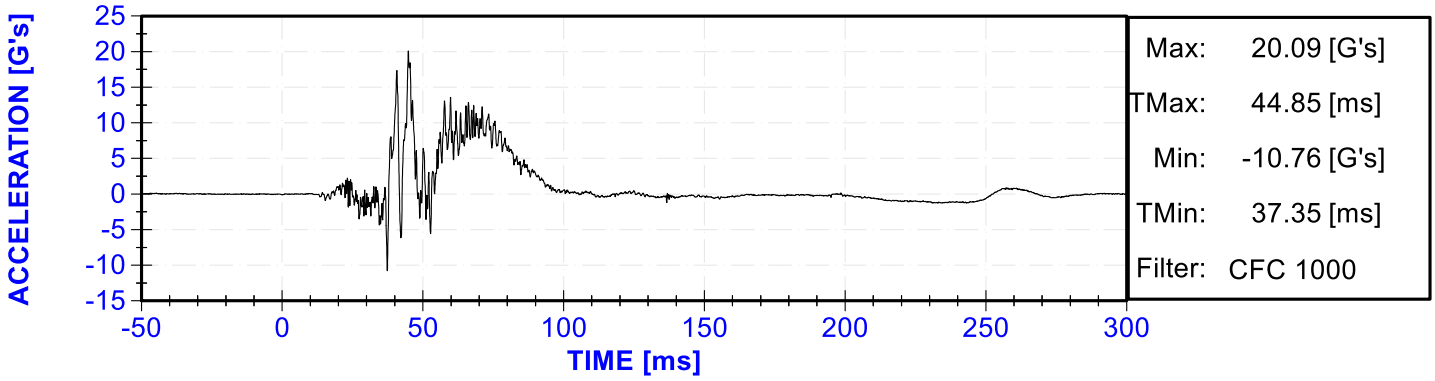
Driver Right Femur Force vs. Time



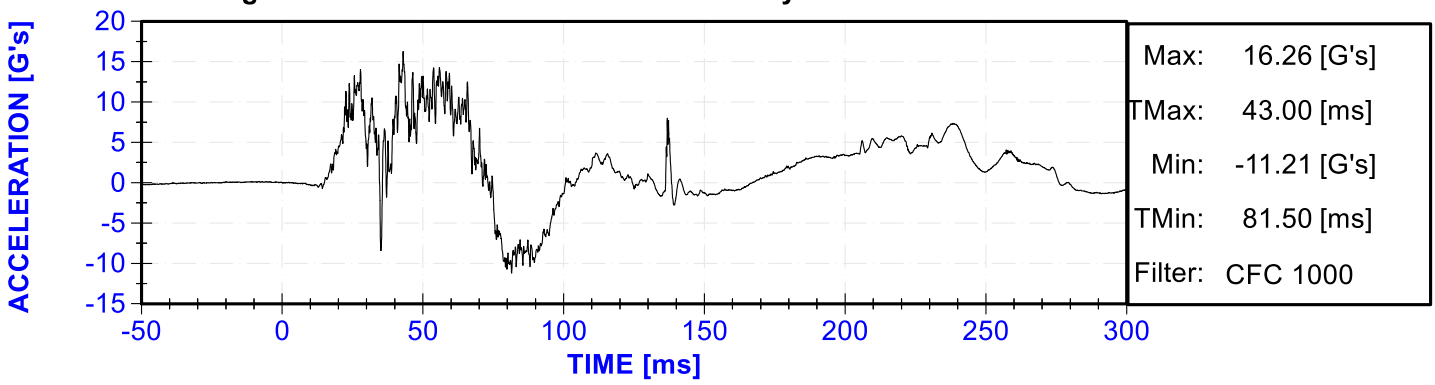
Passenger Head X Acceleration vs. Time Primary



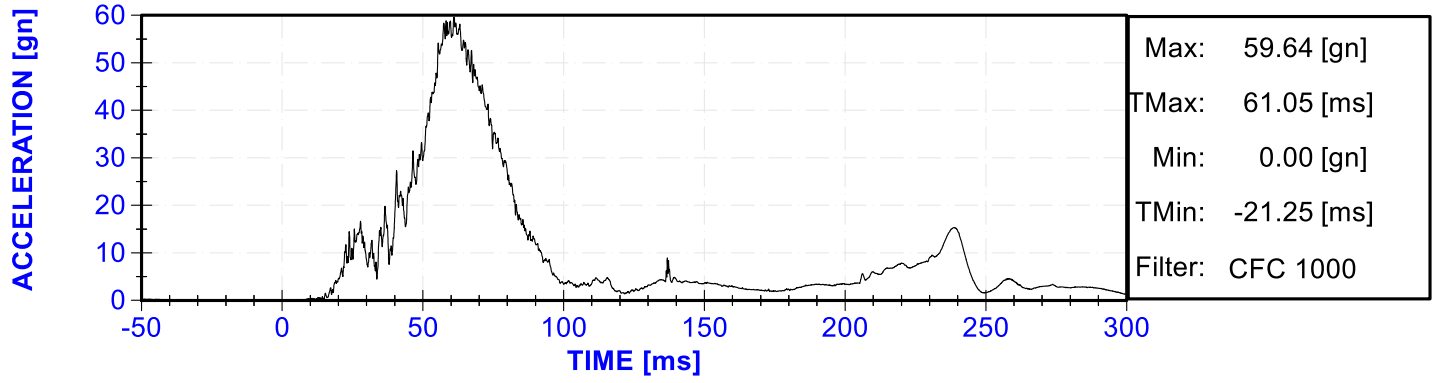
Passenger Head Y Acceleration vs. Time Primary



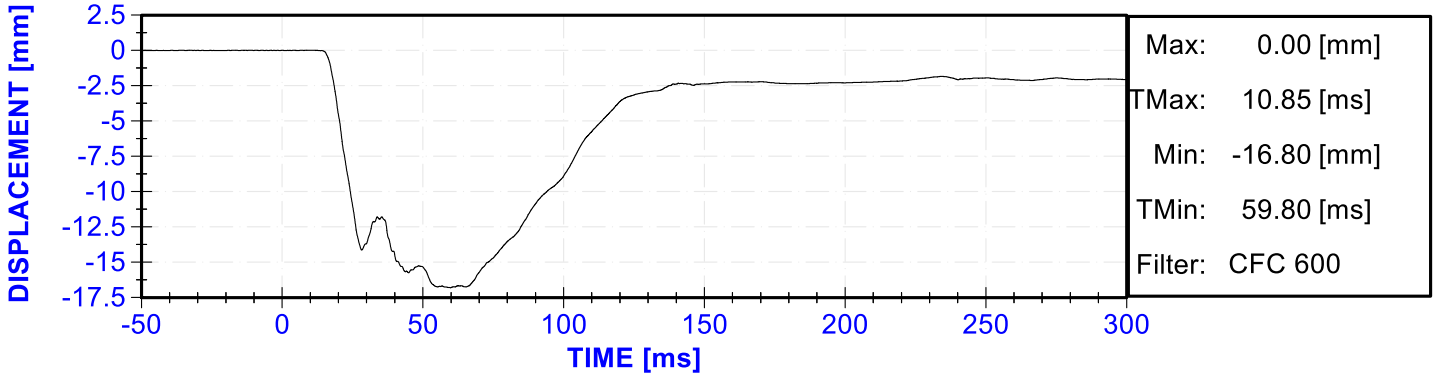
Passenger Head Z Acceleration vs. Time Primary



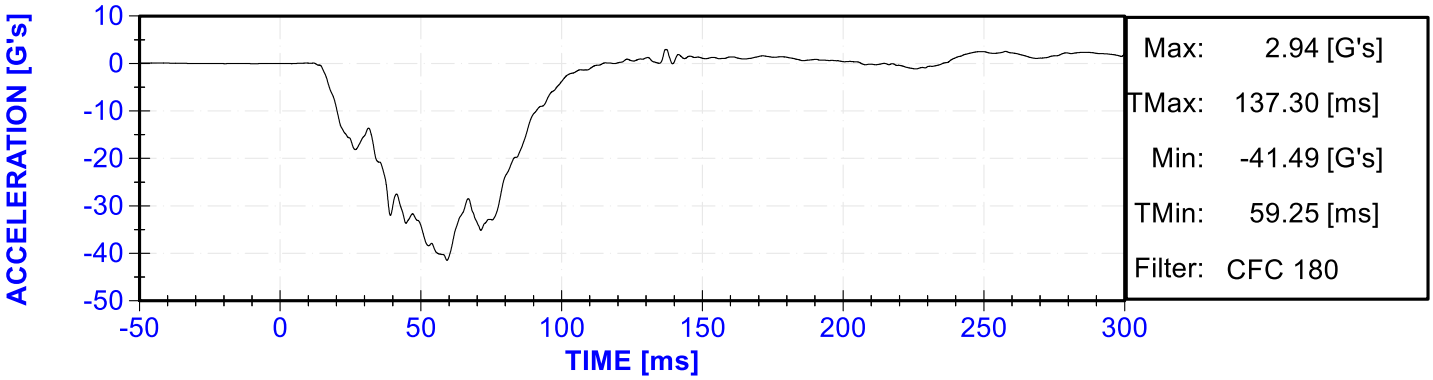
Passenger Head Resultant Acceleration vs. Time Primary



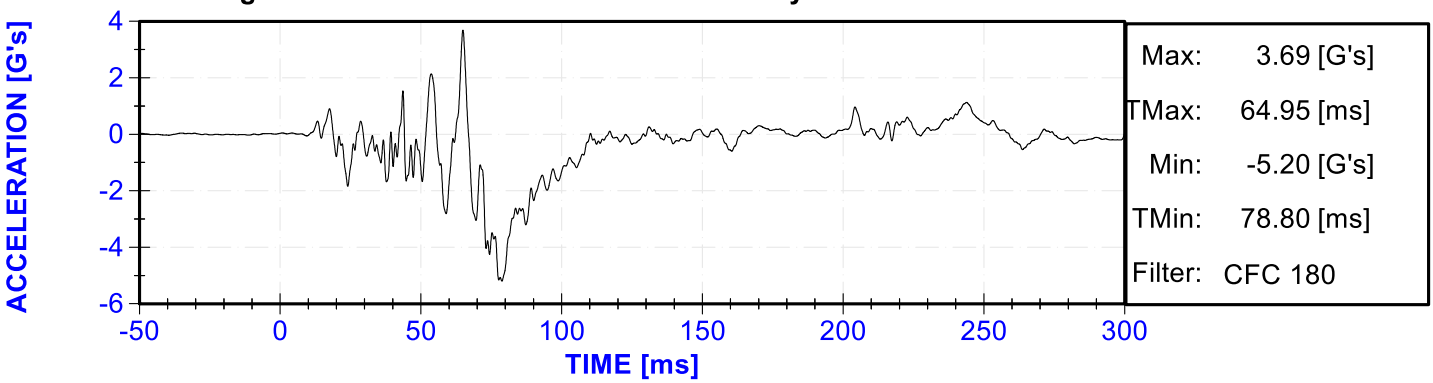
Passenger Chest X Deflection vs. Time



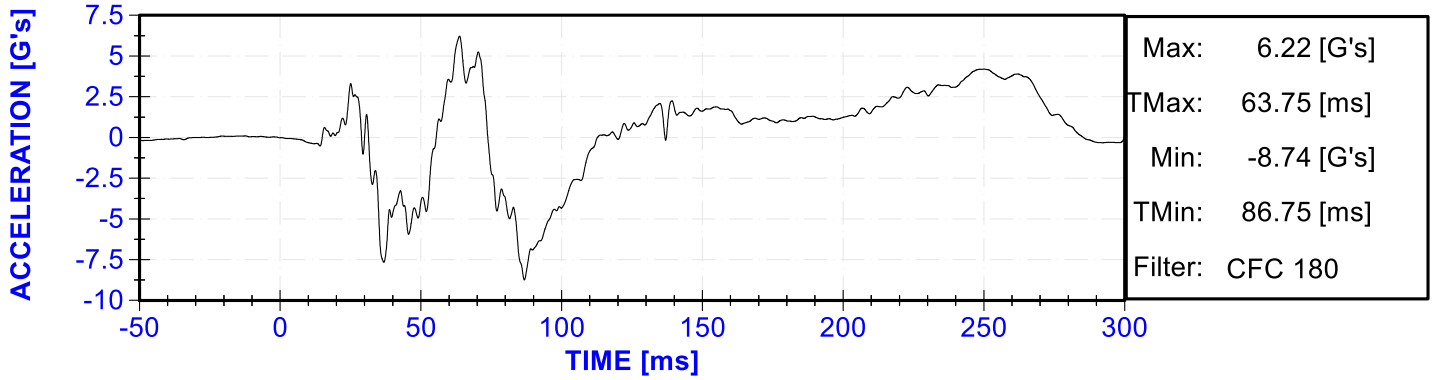
Passenger Chest X Acceleration vs. Time Primary



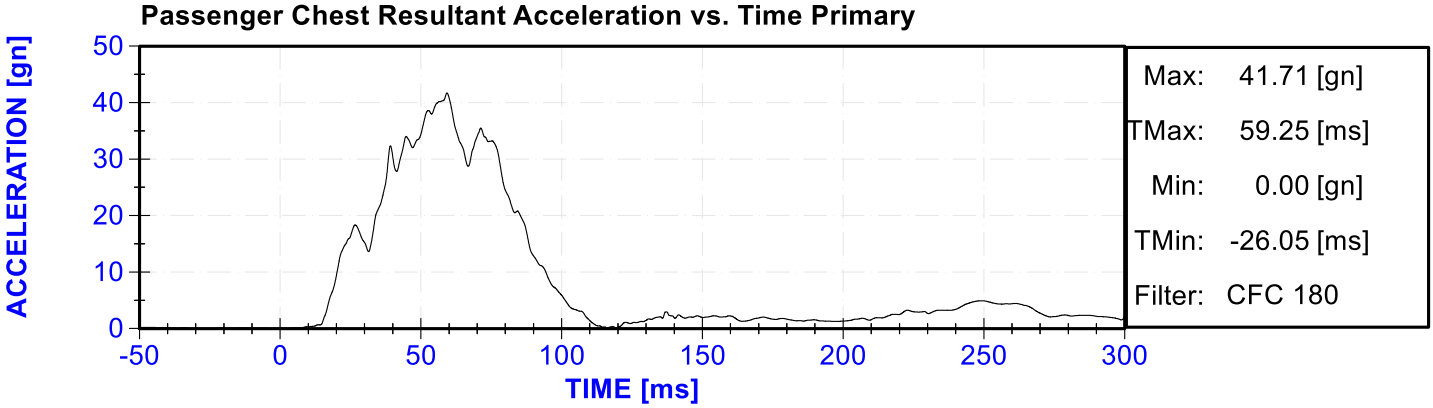
Passenger Chest Y Acceleration vs. Time Primary



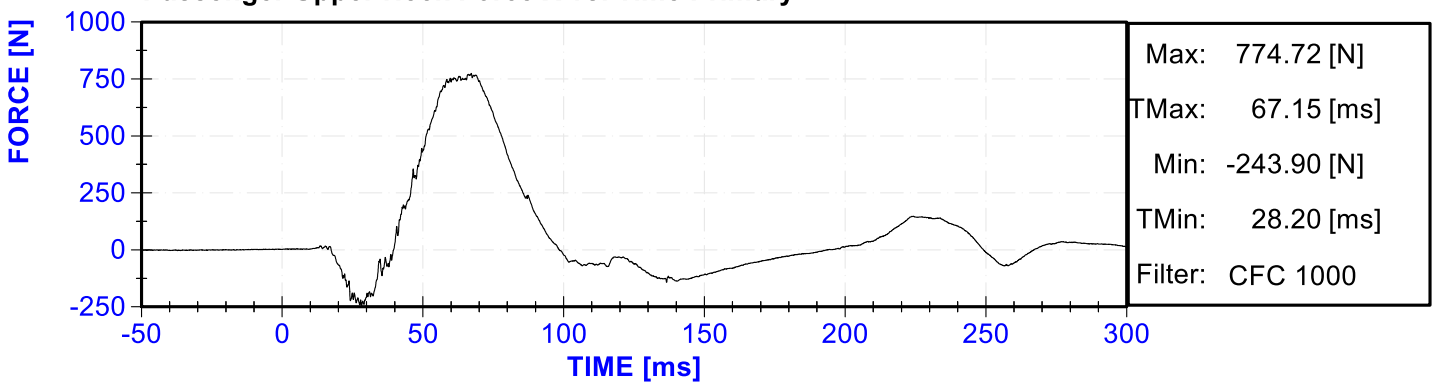
Passenger Chest Z Acceleration vs. Time Primary



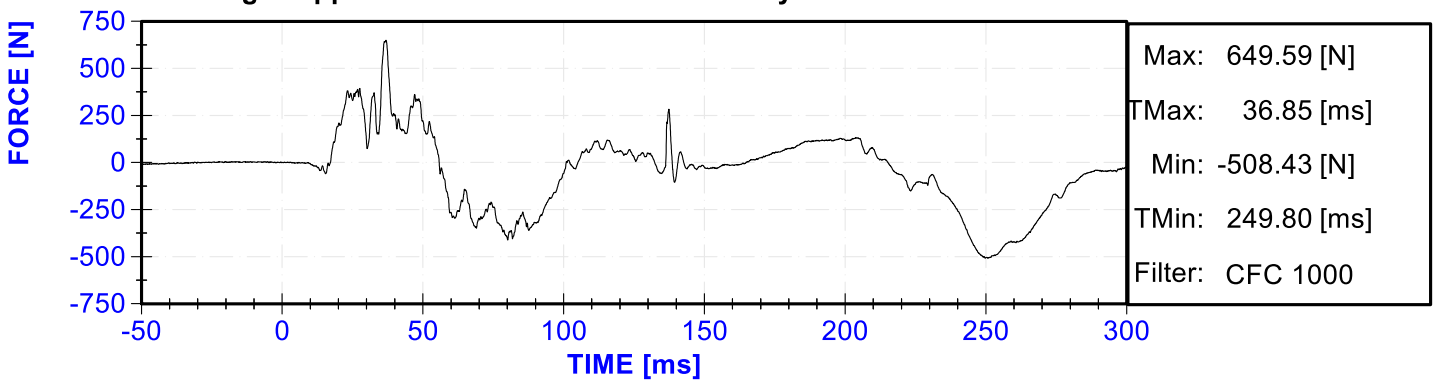
Passenger Chest Resultant Acceleration vs. Time Primary



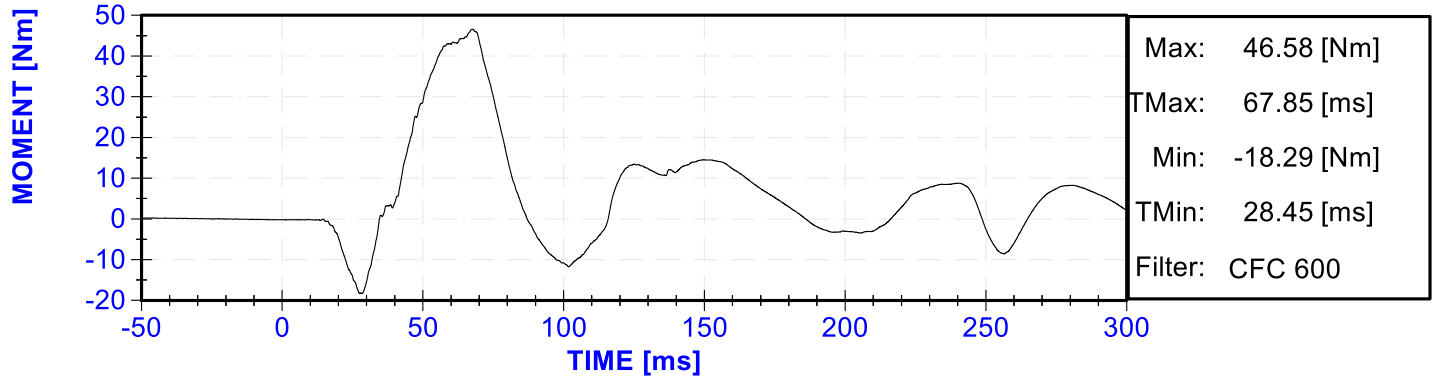
Passenger Upper Neck Force X vs. Time Primary



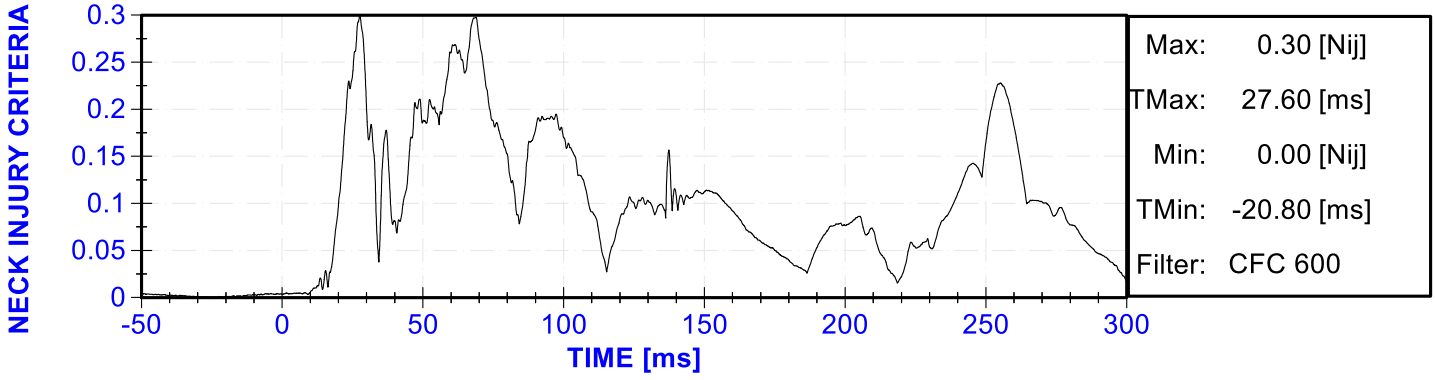
Passenger Upper Neck Force Z vs. Time Primary

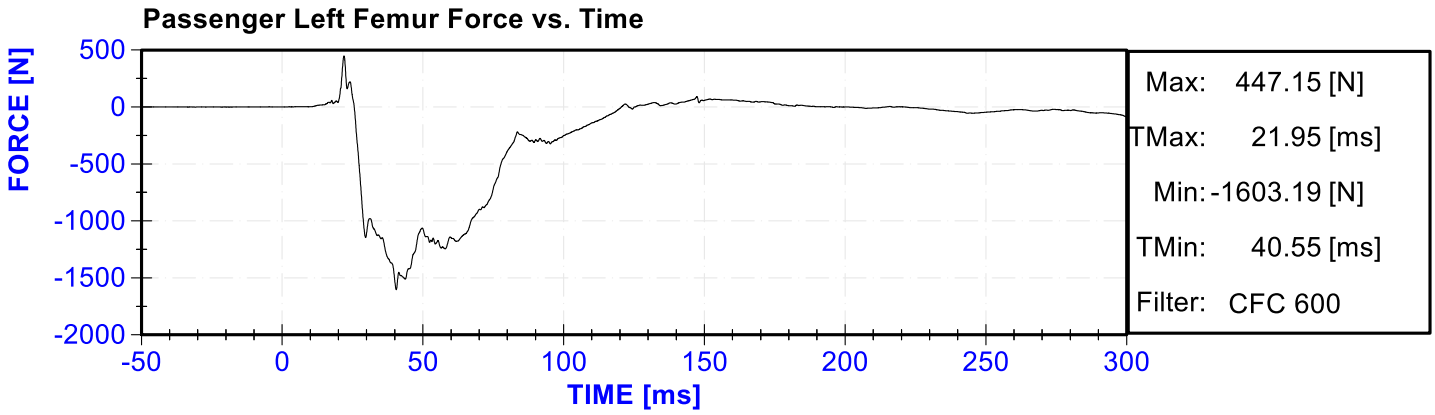


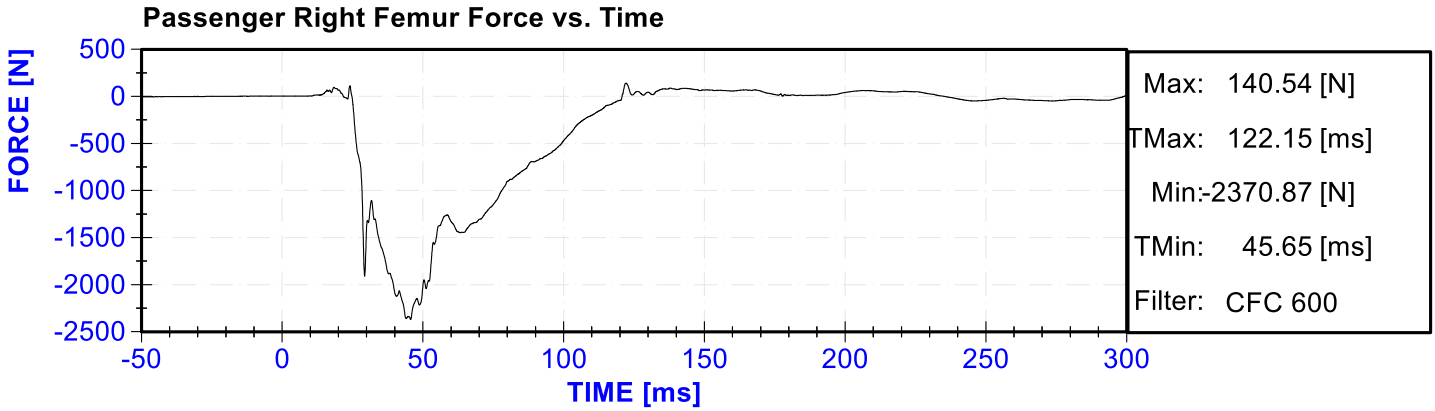
Passenger Upper Neck Moment Y vs. Time Primary



Passenger Nij vs. Time Primary




Passenger Left Femur Force vs. Time
FORCE [N]
500
0
-500
-1000
-1500
-2000
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 447.15 [N]
TMax: 21.95 [ms]
Min: -1603.19 [N]
TMin: 40.55 [ms]
Filter: CFC 600


Passenger Right Femur Force vs. Time
FORCE [N]
500
0
-500
-1000
-1500
-2000
-2500
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 140.54 [N]
TMax: 122.15 [ms]
Min: -2370.87 [N]
TMin: 45.65 [ms]
Filter: CFC 600

APPENDIX C

DUMMY CALIBRATION AND PERFORMANCE VERIFICATION DATA

CALIBRATION TEST RESULTS

PRE-TEST

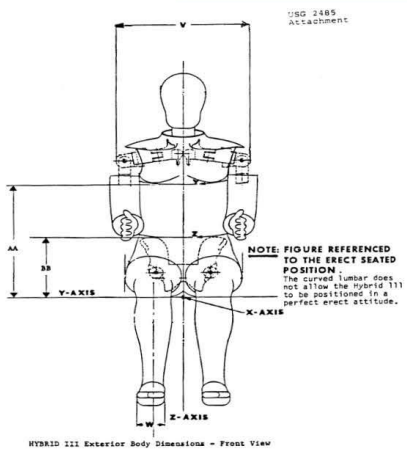
HYBRID III 50TH PERCENTILE MALE - DRIVER ATD

SERIAL NO: 142

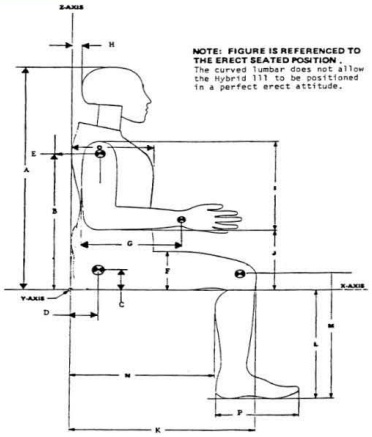
External Measurements - Hybrid 3 - 50th Male

Technician: K. Dutton Date: 03/04/2020

Dummy Serial Number: 142



HYBRID III Exterior Body Dimensions - Front View



HYBRID III Exterior Body Dimensions - Side View

Symbol	Description	Specification (in)		Result (in)	Pass/Fail
A	Sitting Height	34.6	35.0	34.8	Pass
B	Shoulder Pivot Height	19.9	20.5	20.2	Pass
C	H-Point Height	3.3	3.5	3.4	Pass
D	H-Point from Backline	5.3	5.5	5.4	Pass
E	Shoulder Pivot from Backline	3.3	3.7	3.6	Pass
F	Thigh Clearance	5.5	6.1	5.8	Pass
G	Back of Elbow to Wrist Pivot	11.4	12.0	11.6	Pass
H	Head Back to Backline	1.6	1.8	1.7	Pass
I	Shoulder to Elbow Length	13.0	13.6	13.4	Pass
J	Elbow Rest Height	7.5	8.3	8.0	Pass
K	Buttock to Knee Length	22.8	23.8	23.4	Pass
L	Popliteal Height	16.9	17.9	17.4	Pass
M	Knee Pivot Height	19.1	19.7	19.5	Pass
N	Buttock Popliteal Length	17.8	18.8	18.4	Pass
O	Chest Depth without Jacket	8.4	9.0	8.7	Pass
P	Foot Length (right)	9.9	10.5	10.3	Pass
V	Shoulder Breadth	16.3	17.2	16.9	Pass
W	Foot Breadth	3.6	4.2	3.8	Pass
Y	Chest Circumference with Jacket	38.2	39.4	38.8	Pass
Z	Waist Circumference	32.9	34.1	33.7	Pass
AA	Reference Location (Chest Circumference)	16.9	17.1	17.0	Pass
BB	Reference Location (Waist Circumference)	8.9	9.1	9.0	Pass

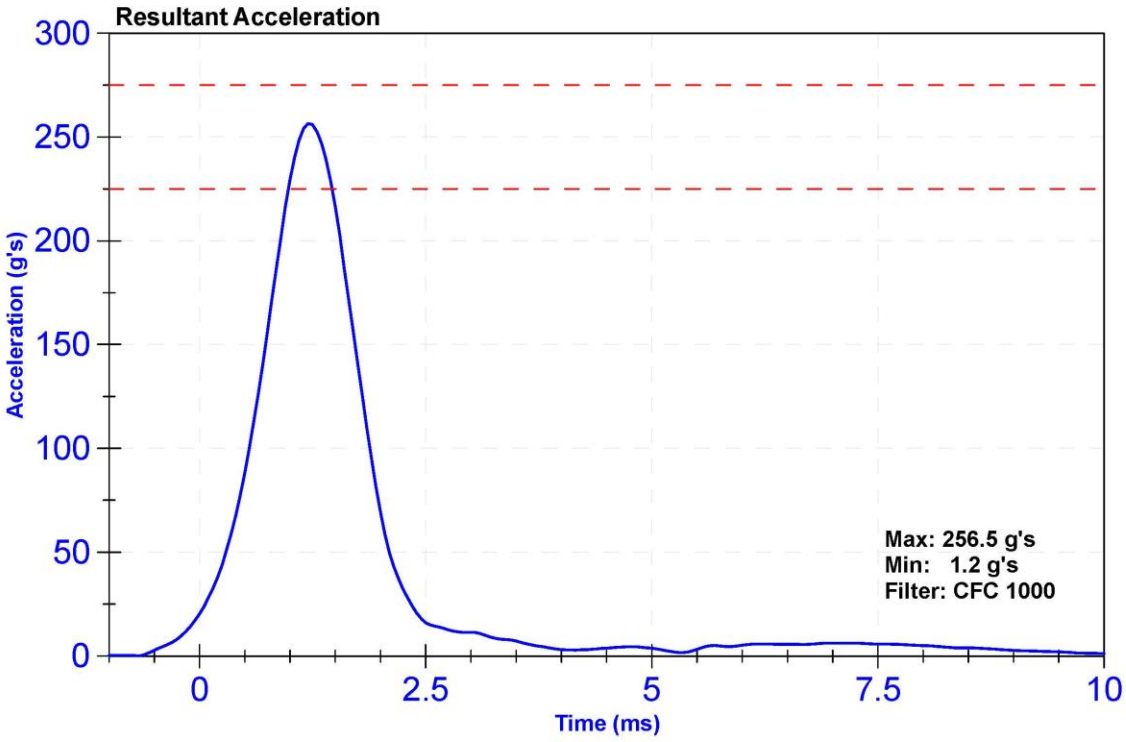
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

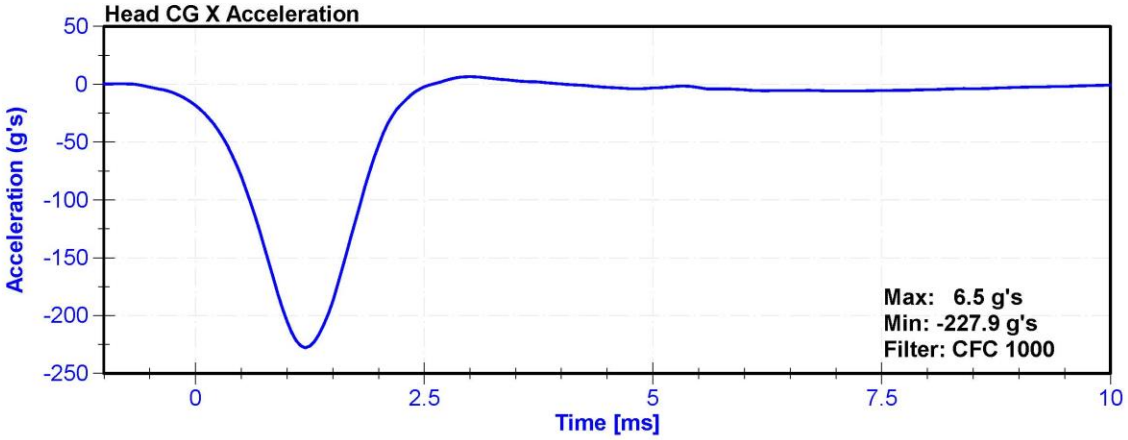
Results

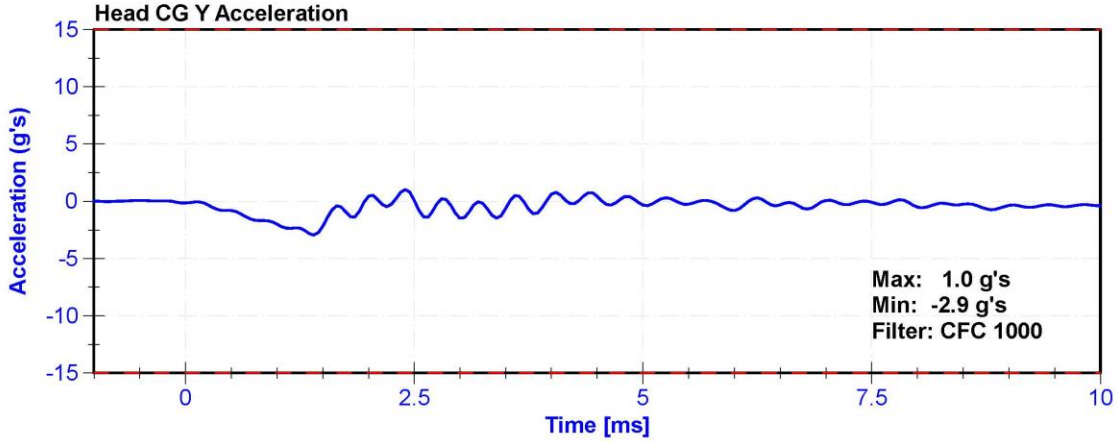
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.0	Pass
Humidity	10	70	%	22.7	Pass
Resultant Acceleration	225	275	g's	256.5	Pass
Oscillation	0	10	%	4.4	Pass
Lateral Acceleration	-15	15	g's	-2.9	Pass

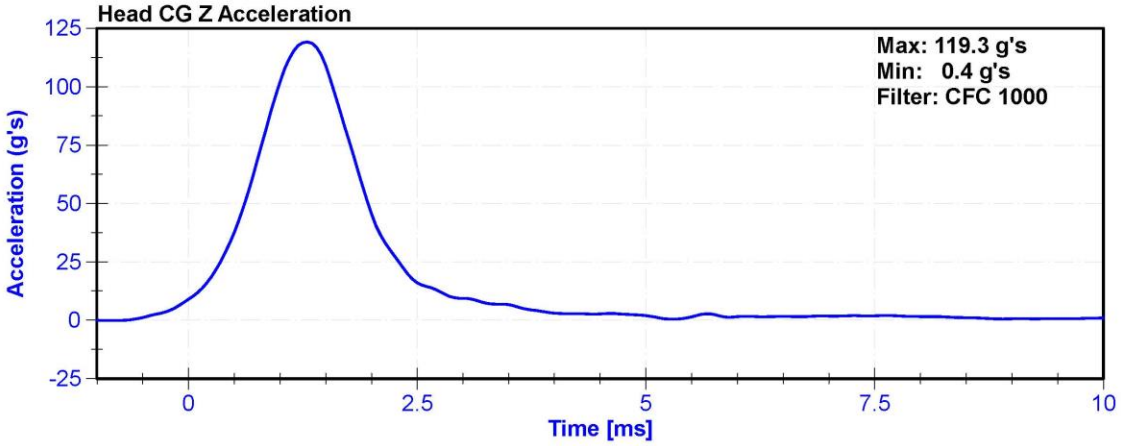
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264	P51681	2/10/2020	8/10/2020
Y Accelerometer	ENDEVCO 7264	P64151	2/10/2020	8/10/2020
Z Accelerometer	ENDEVCO 7264	P52114	2/10/2020	8/10/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 6.5 g's
Min: -227.9 g's
Filter: CFC 1000


Head CG Y Acceleration
Acceleration (g's)
15
10
5
0
-5
-10
-15
0
2.5
5
7.5
10
Time [ms]
Max: 1.0 g's
Min: -2.9 g's
Filter: CFC 1000


Head CG Z Acceleration
Acceleration (g's)
125
100
75
50
25
0
-25
0
2.5
5
7.5
10
Time [ms]
Max: 119.3 g's
Min: 0.4 g's
Filter: CFC 1000

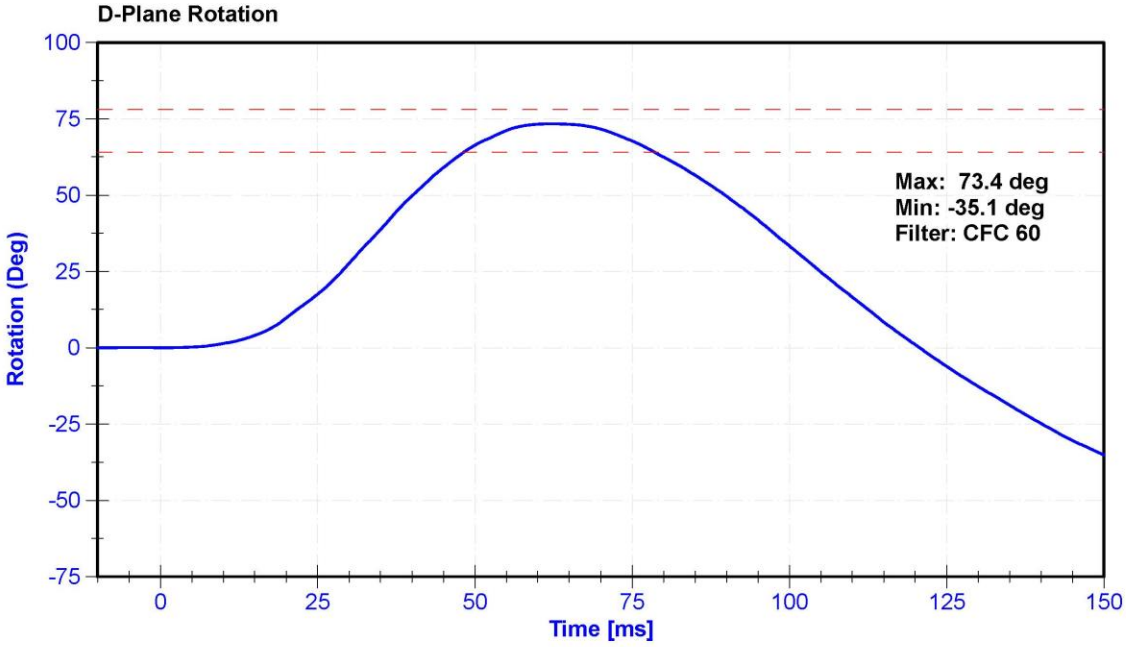
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

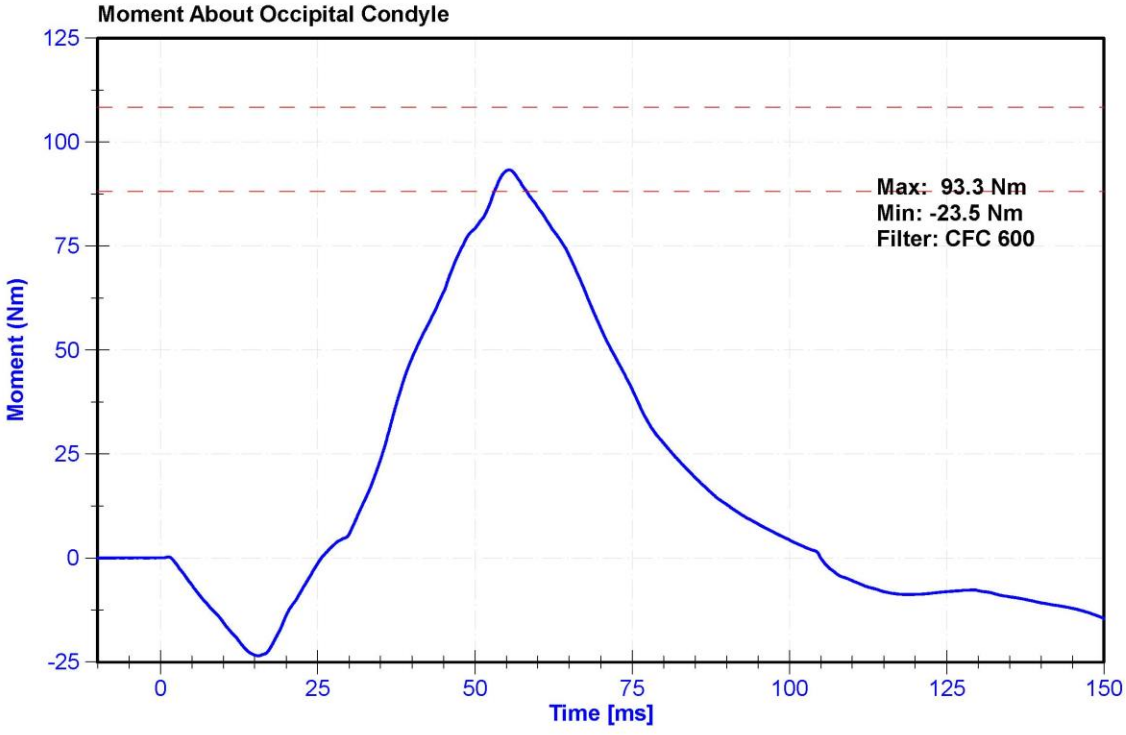
Results

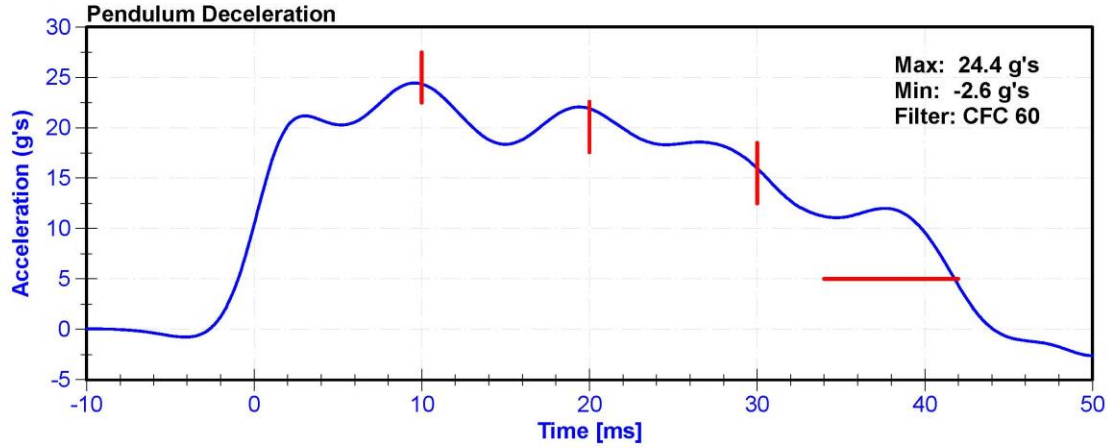
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.3	Pass
Humidity	10	70	%	24.9	Pass
Velocity	6.89	7.13	m/s	6.903	Pass
Pendulum Deceleration at 10ms	22.5	27.5	g's	24.35	Pass
Pendulum Deceleration at 20ms	17.6	22.6	g's	21.90	Pass
Pendulum Deceleration at 30ms	12.5	18.5	g's	15.99	Pass
Max. Pendulum Deceleration After 30ms	0	29	g's	24.4	Pass
Pendulum Deceleration Time to 5 g's	34	42	ms	41.8	Pass
Maximum D Plane Rotation	64	78	deg	73.4	Pass
Time to Maximum Rotation	57	64	ms	62.1	Pass
Rotation Decay to Zero	113	127	ms	120.7	Pass
Moment About Occipital Condyle	88.1	108.4	Nm	93.29	Pass
Time to Maximum Moment	47	58	ms	55.4	Pass
Moment Decay to Zero	97	107	ms	105.0	Pass

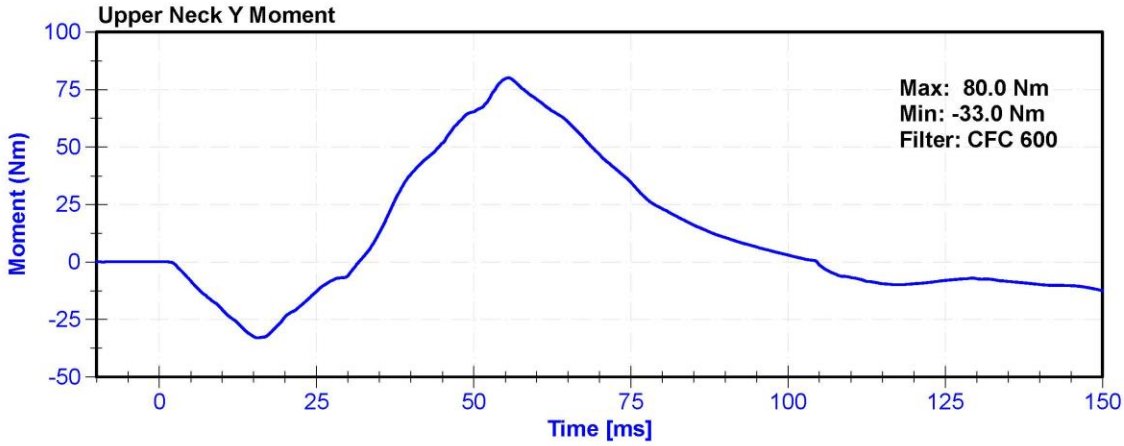
Transducer Calibrations

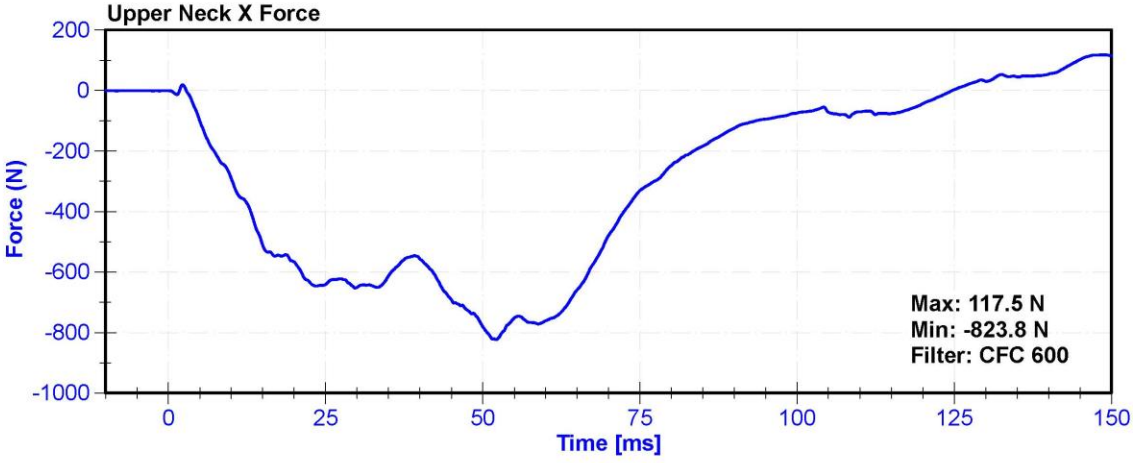
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton IF-205	LC-280FxGFE	10/3/2019	10/2/2020


D-Plane Rotation
Rotation (Deg)
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150
Time [ms]
Max: 73.4 deg
Min: -35.1 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
125
100
75
50
25
0
-25
0
25
50
75
100
125
150
Time [ms]
Max: 93.3 Nm
Min: -23.5 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 24.4 g's
Min: -2.6 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 80.0 Nm
Min: -33.0 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 117.5 N
Min: -823.8 N
Filter: CFC 600
Force (N)
Time [ms]

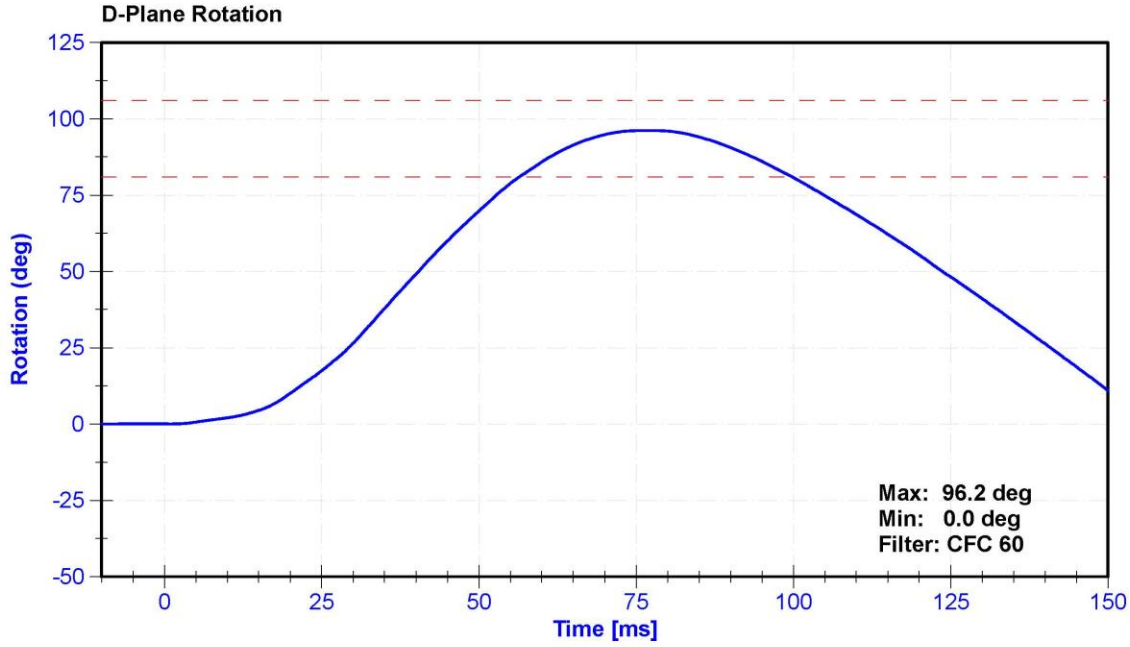
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

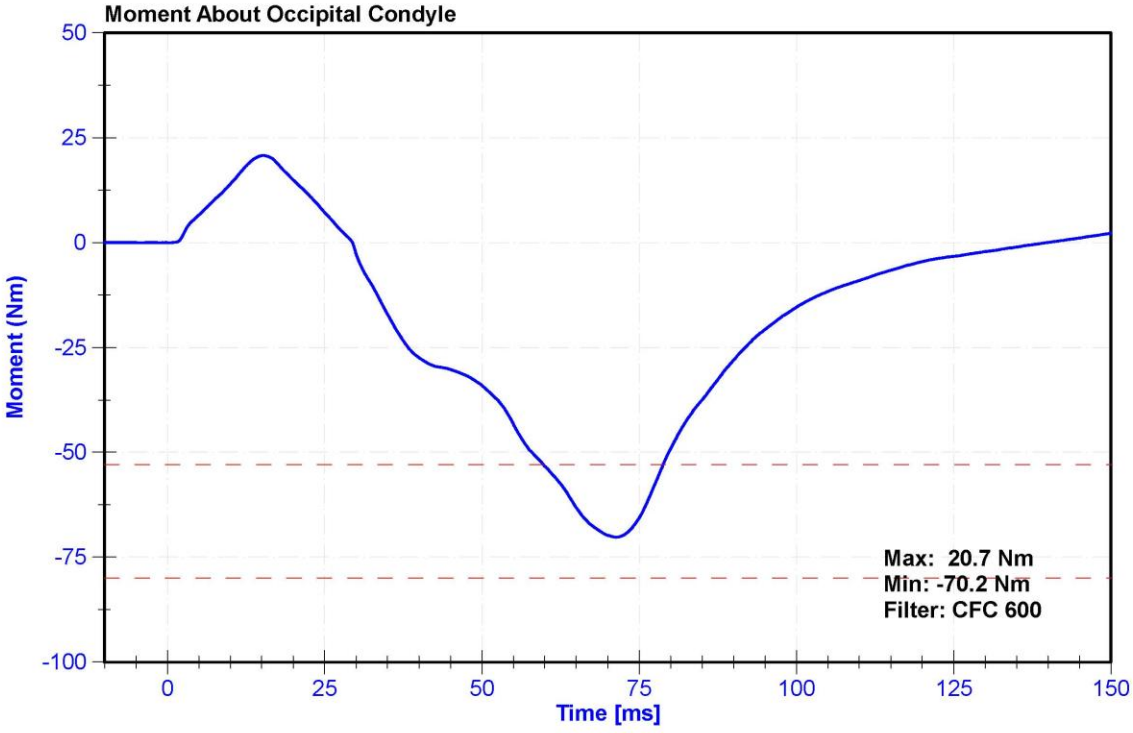
Results

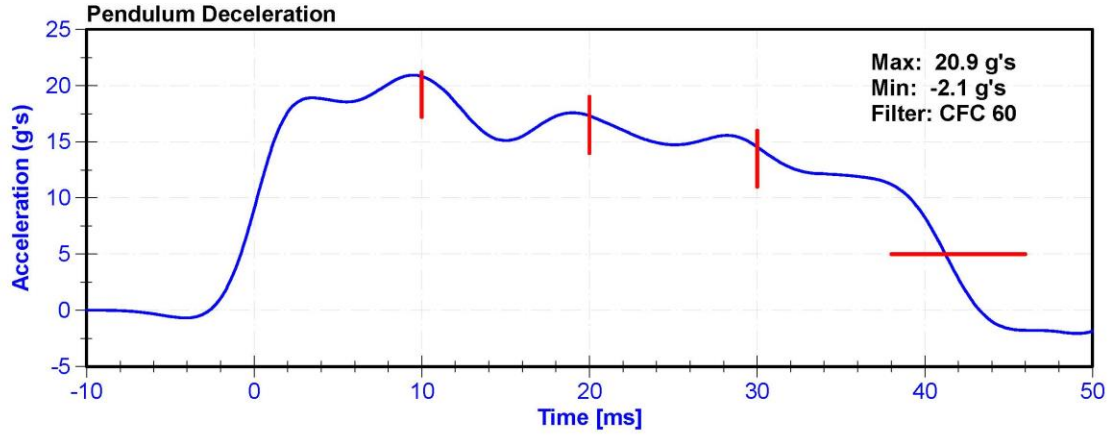
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.6	Pass
Humidity	10	70	%	28.1	Pass
Velocity	5.94	6.19	m/s	6.005	Pass
Pendulum Deceleration at 10ms	17.2	21.2	g's	20.82	Pass
Pendulum Deceleration at 20ms	14	19	g's	17.3	Pass
Pendulum Deceleration at 30ms	11	16	g's	14.5	Pass
Max. Pendulum Deceleration After 30ms	0	22	g's	20.9	Pass
Pendulum Deceleration Time to 5 g's	38	46	ms	41.3	Pass
Maximum D Plane Rotation	81	106	deg	96.2	Pass
Time to Maximum Rotation	72	82	ms	76.9	Pass
Rotation Decay to Zero	147	174	ms	157.4	Pass
Minimum Moment About OC	-80	-52.9	Nm	-70.24	Pass
Time to Minimum Moment	65	79	ms	71.4	Pass
Moment Decay to Zero	120	148	ms	140.0	Pass

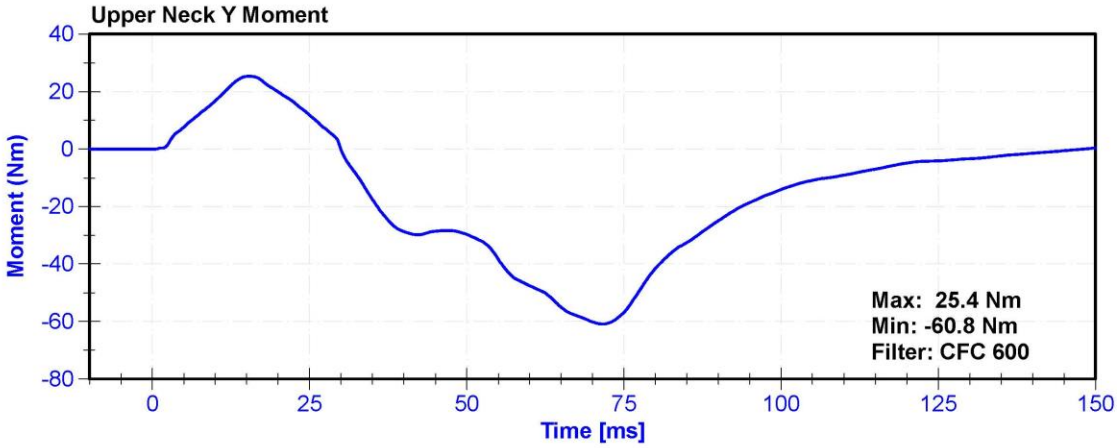
Transducer Calibrations

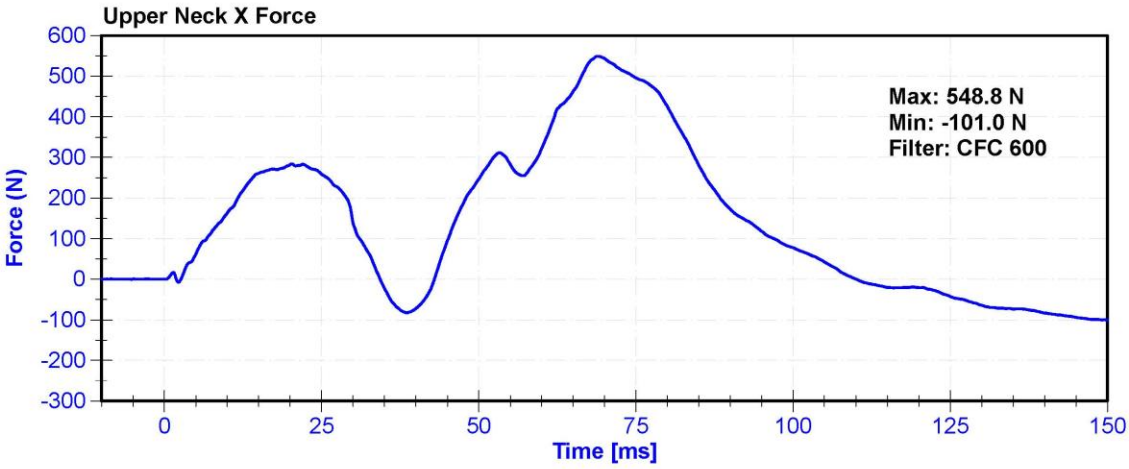
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton IF-205	LC-280FxGFE	10/3/2019	10/2/2020


D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 96.2 deg
Min: 0.0 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
50
25
0
-25
-50
-75
-100
0
25
50
75
100
125
150
Time [ms]
Max: 20.7 Nm
Min: -70.2 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 20.9 g's
Min: -2.1 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 25.4 Nm
Min: -60.8 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 548.8 N
Min: -101.0 N
Filter: CFC 600
Force (N)
Time [ms]

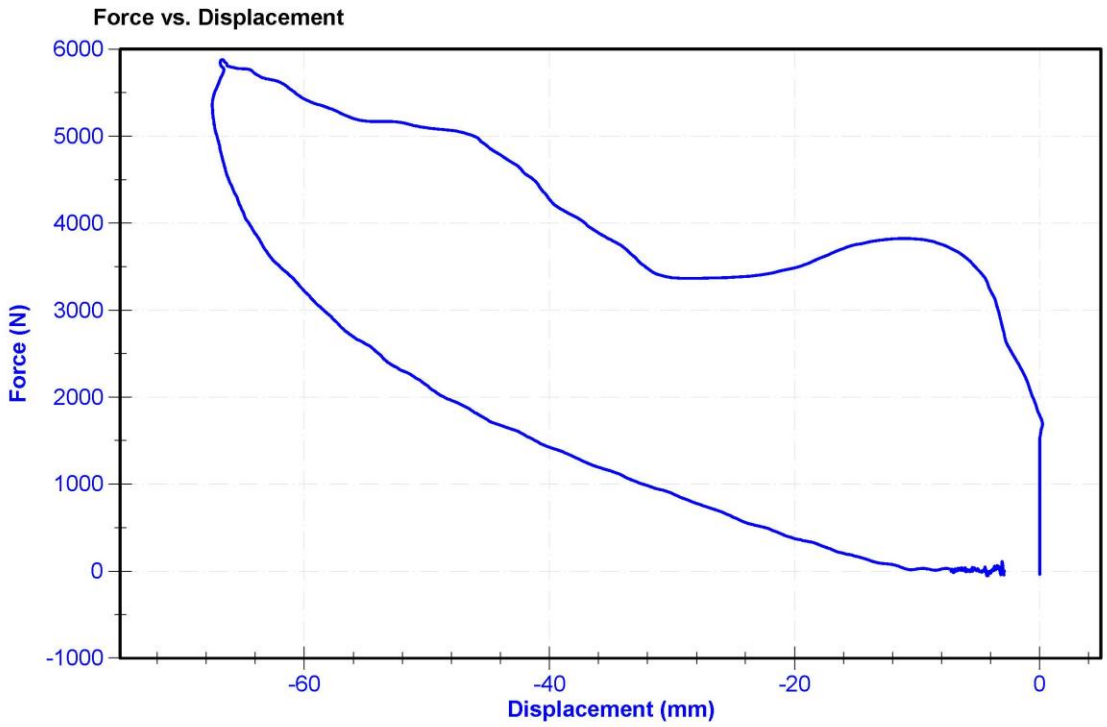
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

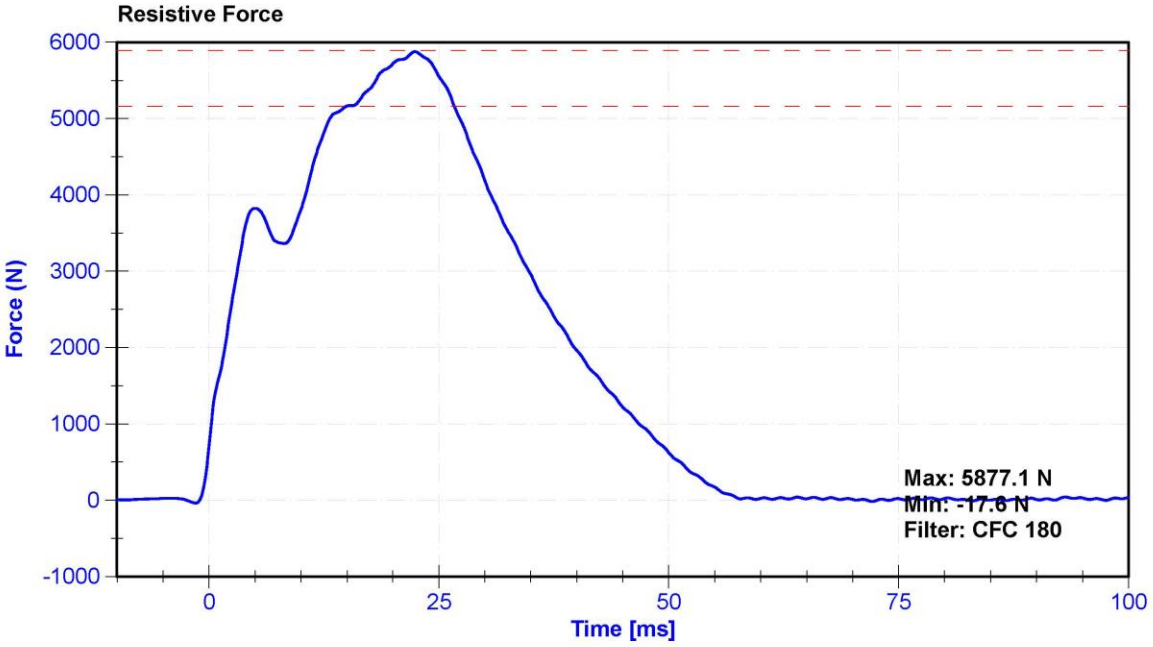
Results

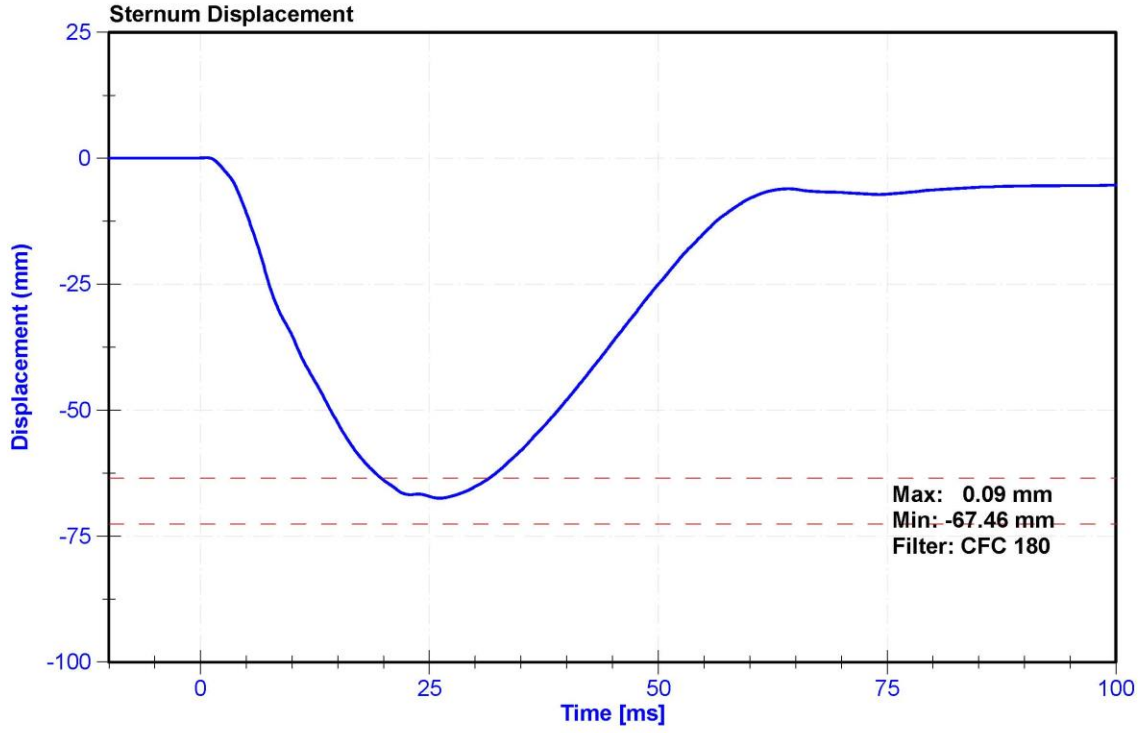
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.6	Pass
Humidity	10	70	%	24	Pass
Velocity	6.59	6.83	m/s	6.714	Pass
Chest Displacement	-72.6	-63.5	mm	-67.46	Pass
Resistive Force	5160	5894	N	5877.1	Pass
Hysteresis	65	85	%	67.3	Pass

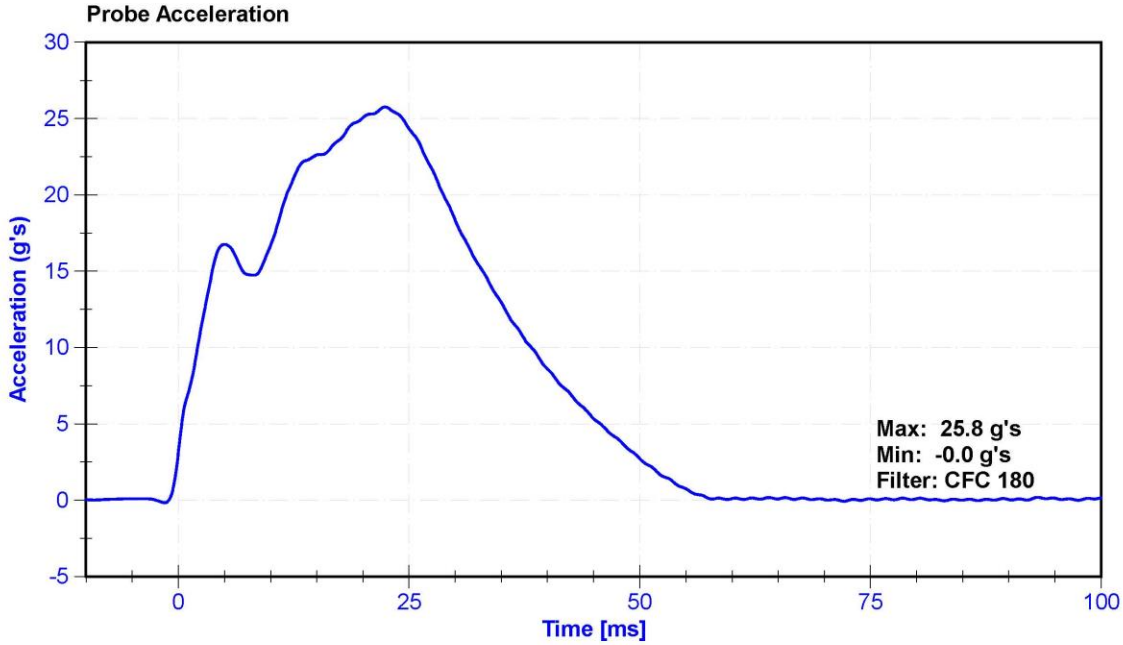
Transducer Calibrations

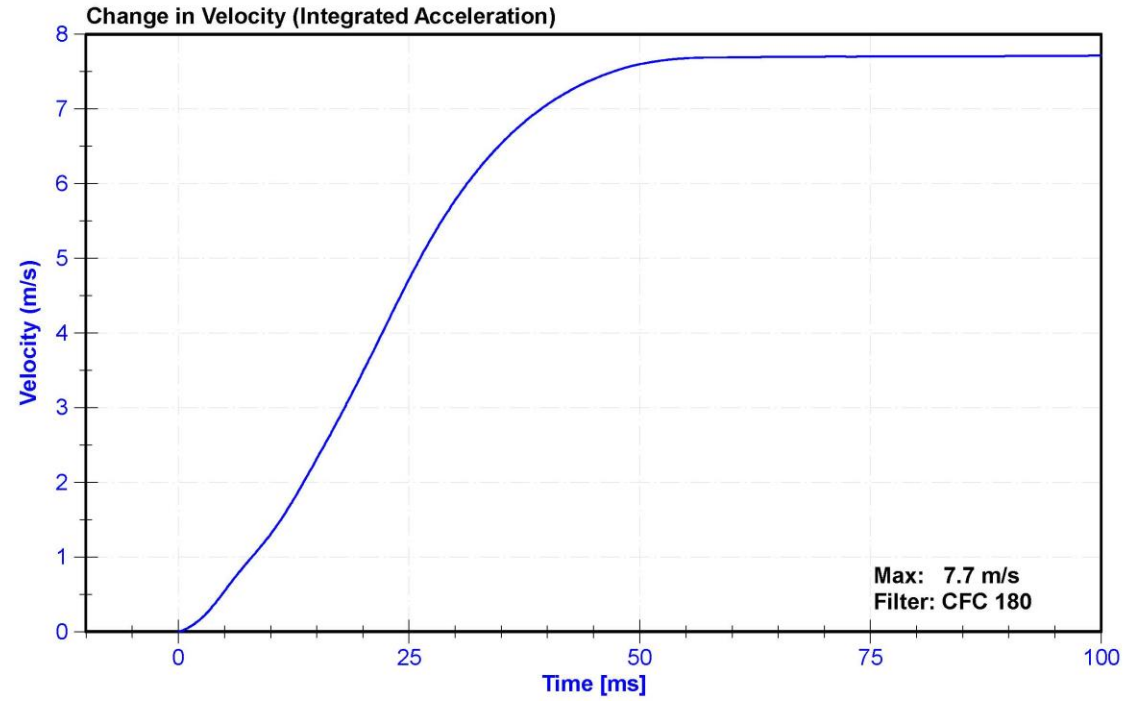
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020
Chest Potentiometer	JDK 6209-2038	DS-142	9/12/2019	9/11/2020




Resistive Force
Force (N)
6000
5000
4000
3000
2000
1000
0
-1000
0
25
50
75
100
Time [ms]
Max: 5877.1 N
Min: -17.6 N
Filter: CFC 180


Sternum Displacement
Displacement (mm)
25
0
-25
-50
-75
-100
0
25
50
75
100
Time [ms]
Max: 0.09 mm
Min: -67.46 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
30
25
20
15
10
5
0
-5
0
25
50
75
100
Time [ms]
Max: 25.8 g's
Min: -0.0 g's
Filter: CFC 180


Change in Velocity (Integrated Acceleration)
Velocity (m/s)
8
7
6
5
4
3
2
1
0
0
25
50
75
100
Time [ms]
Max: 7.7 m/s
Filter: CFC 180

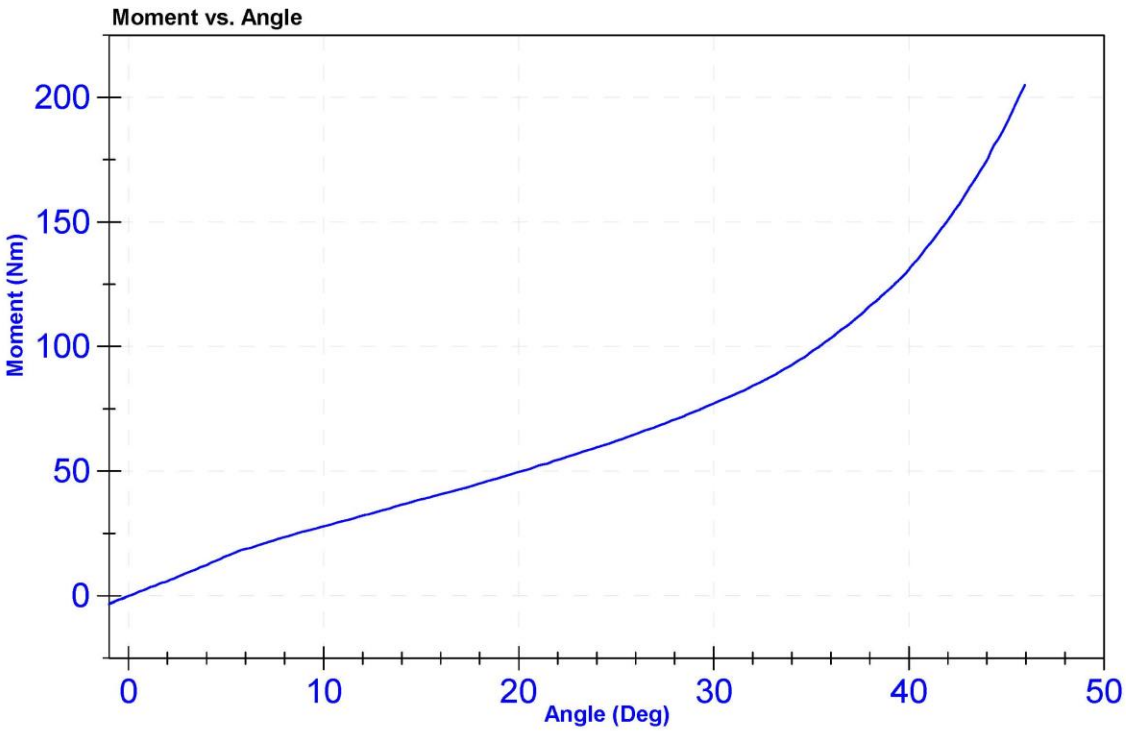
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.0	Pass
Humidity	10	70	%	27.0	Pass
Average Velocity	5	10	deg/s	7.0	Pass
Angle at 203Nm	40	50	deg	45.8	Pass
Moment at 30 degrees	0	94.9	Nm	77.2	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	ETI SP22	DS-0008	2019-09-18	2020-09-17
Load Cell	Key Trans 2301-02	LC-115 My	2019-09-12	2020-09-11



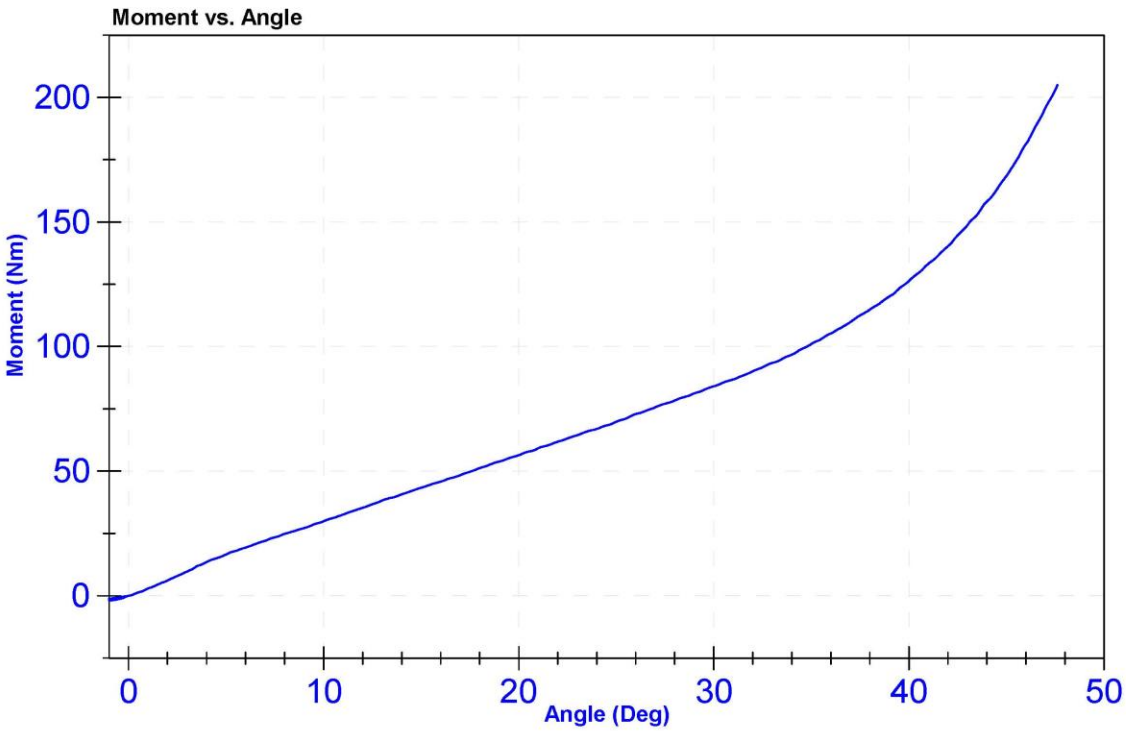
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.7	Pass
Humidity	10	70	%	27.0	Pass
Average Velocity	5	10	deg/s	7.0	Pass
Angle at 203Nm	40	50	deg	47.5	Pass
Moment at 30 degrees	0	94.9	Nm	84.1	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	ETI SP22	DS-0008	2019-09-18	2020-09-17
Load Cell	Key Trans 2301-02	LC-115 My	2019-09-12	2020-09-11



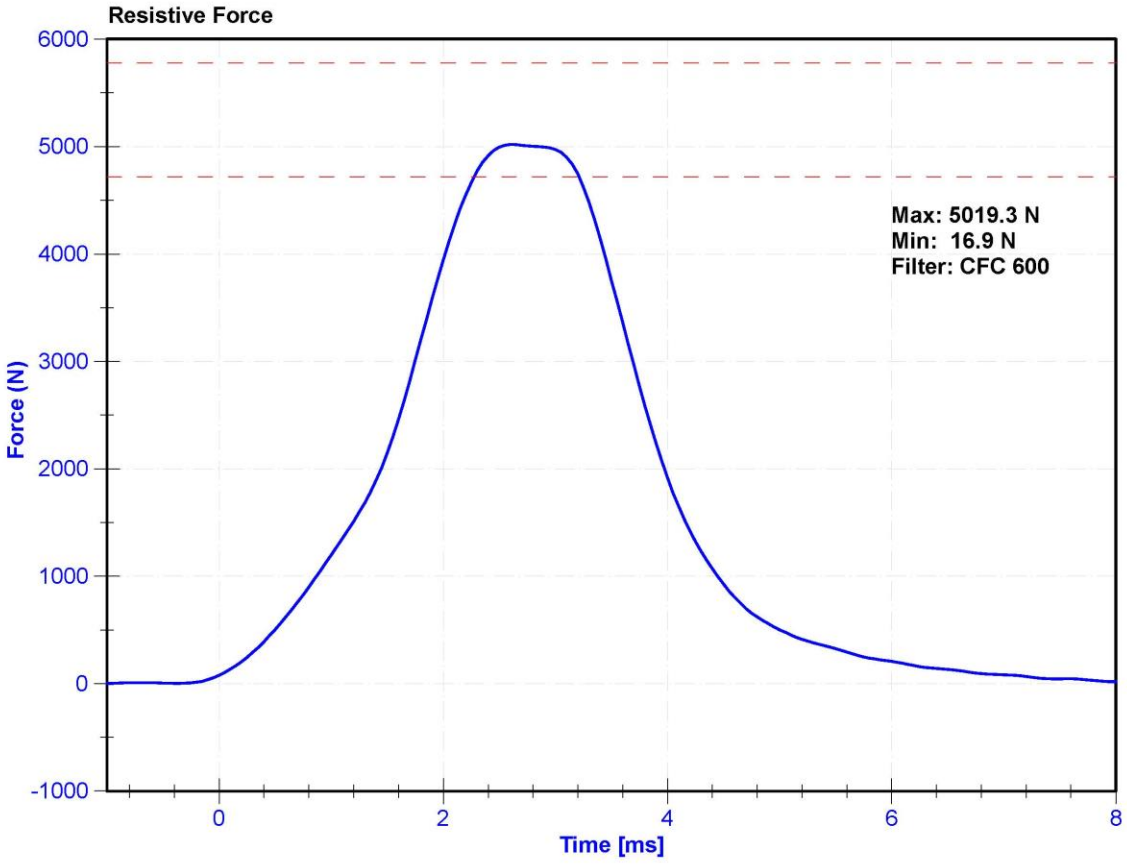
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

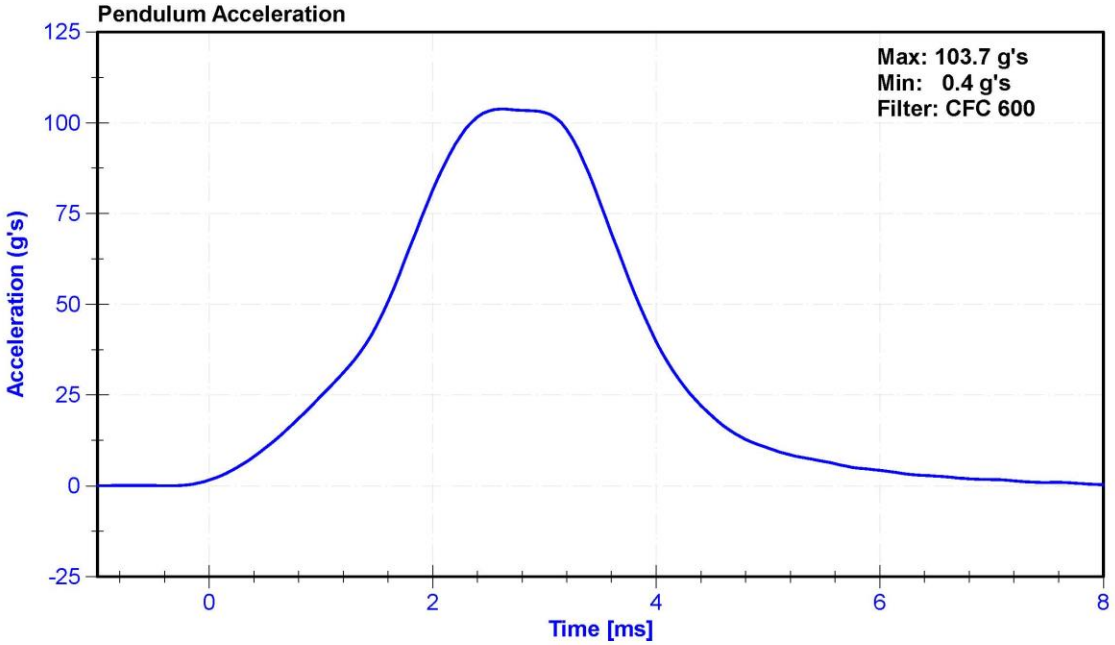
Results

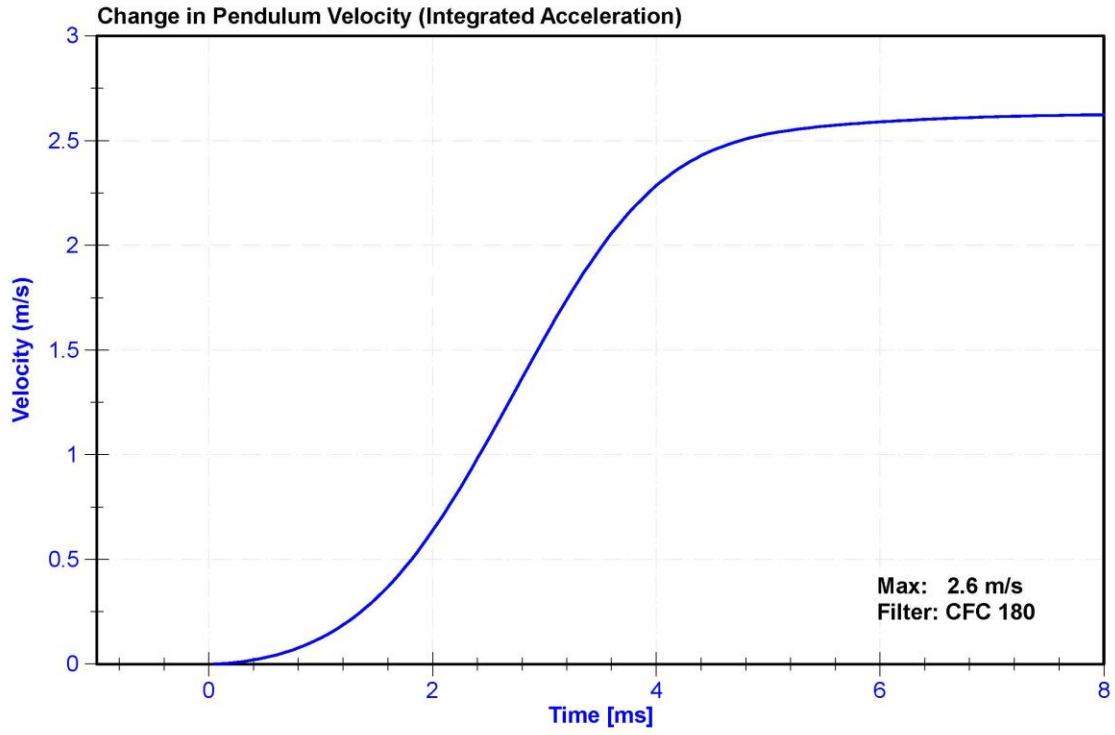
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.3	Pass
Humidity	10	70	%	19.4	Pass
Velocity	2.07	2.13	m/s	2.099	Pass
Maximum Resistive Force	4720	5780	N	5019.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	1/28/2021




Pendulum Acceleration
Max: 103.7 g's
Min: 0.4 g's
Filter: CFC 600
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]


Change in Pendulum Velocity (Integrated Acceleration)
Max: 2.6 m/s
Filter: CFC 180
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]

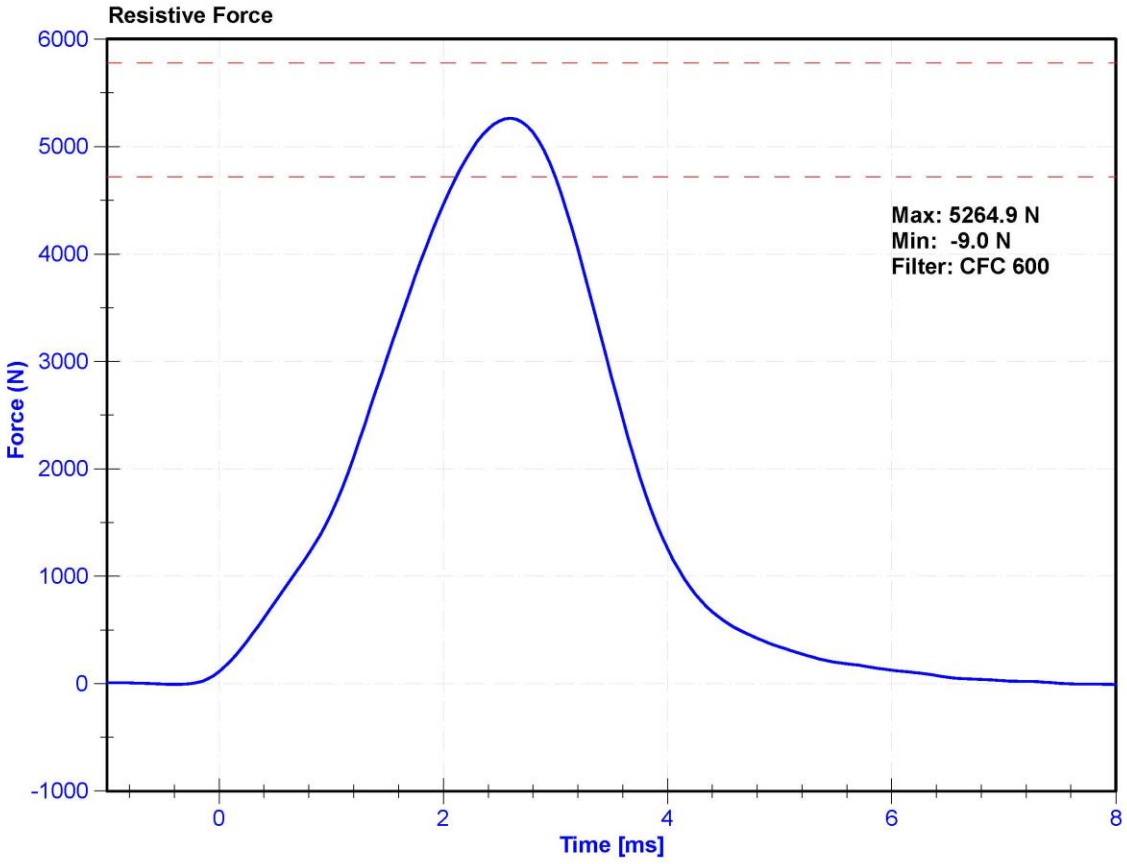
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

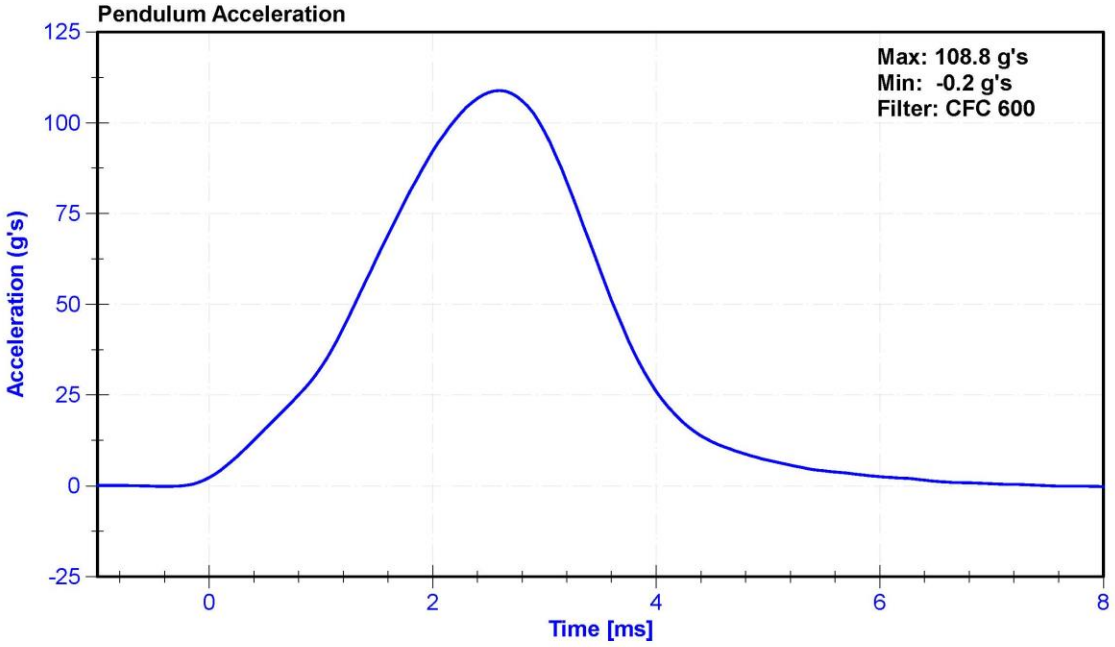
Results

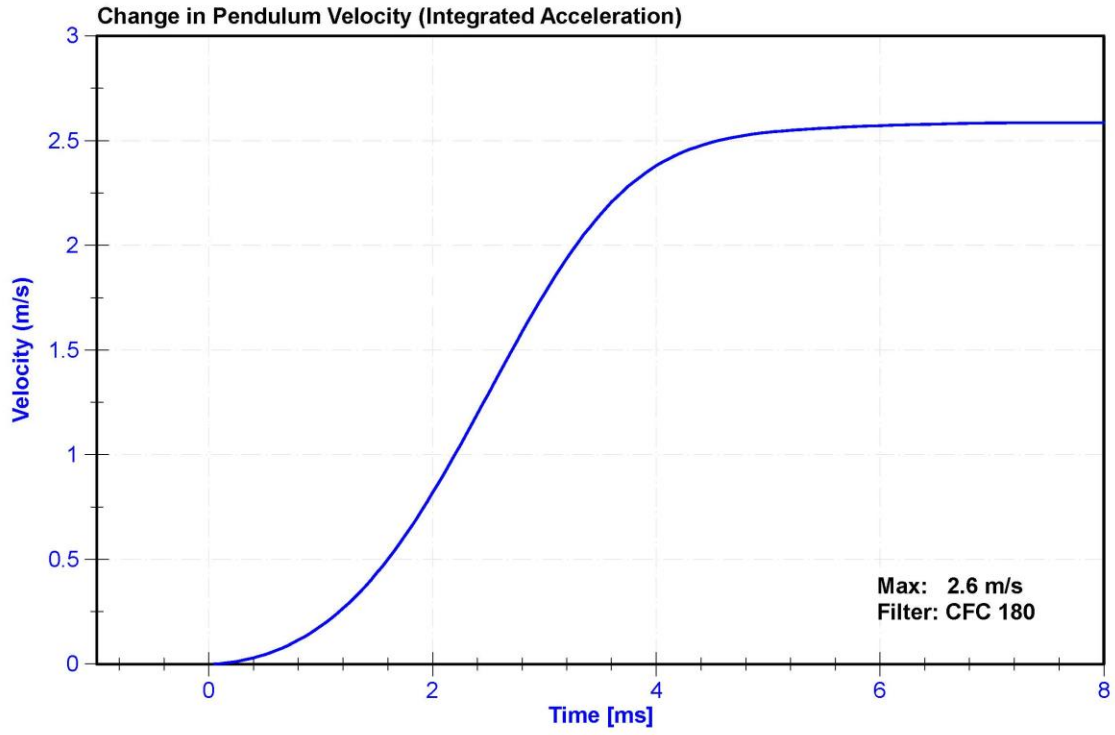
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	19.4	Pass
Velocity	2.07	2.13	m/s	2.104	Pass
Maximum Resistive Force	4720	5780	N	5264.9	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	1/28/2021




Pendulum Acceleration
Max: 108.8 g's
Min: -0.2 g's
Filter: CFC 600
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]


Change in Pendulum Velocity (Integrated Acceleration)
Max: 2.6 m/s
Filter: CFC 180
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]

CALIBRATION TEST RESULTS

PRE-TEST

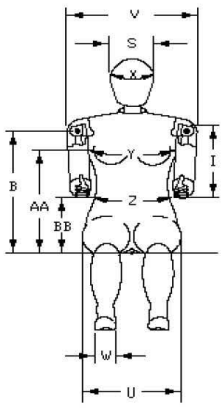
HYBRID III 5TH PERCENTILE - PASSENGER ATD

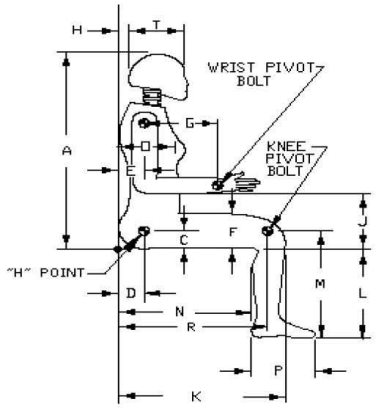
SERIAL NO: 288

External Measurements - Hybrid 3 - 5th Female

Technician: K. Dutton Date: 02/28/2020

Dummy Serial Number: 288





Symbol	Description	Specification (mm)		Result (mm)	Pass/Fail
A	Sitting Height	775	800	787	Pass
B	Shoulder Pivot Height	432	457	450	Pass
C	H-Point Height	81	86	85	Pass
D	H-Point from Backline	145	150	148	Pass
E	Shoulder Pivot from Backline	69	84	77	Pass
F	Thigh Clearance	119	135	127	Pass
G	Back of Elbow to Wrist Pivot	244	259	256	Pass
H	Head Back to Backline	43	48	45	Pass
I	Shoulder to Elbow Length	277	297	284	Pass
J	Elbow Rest Height	183	203	192	Pass
K	Buttock to Knee Length	521	546	538	Pass
L	Popliteal Height	356	376	365	Pass
M	Knee Pivot Height	394	419	407	Pass
N	Buttock Popliteal Length	414	439	429	Pass
O	Chest Depth without Jacket	175	191	182	Pass
P	Foot Length (right)	219	234	221	Pass
R	Buttock To Knee Pivot Length	457	483	465	Pass
S	Head Breadth	137	147	142	Pass
T	Head Depth	178	188	183	Pass
U	Hip Breadth	300	315	310	Pass
V	Shoulder Breadth	351	366	361	Pass
W	Foot Breadth	79	94	85	Pass
X	Head Circumference	528	549	537	Pass
Y	Chest Circumference with Jacket	851	881	865	Pass
Z	Waist Circumference	460	790	777	Pass
AA	Reference Location (Chest Circumference)	333	358	345	Pass
BB	Reference Location (Waist Circumference)	160	170	164	Pass

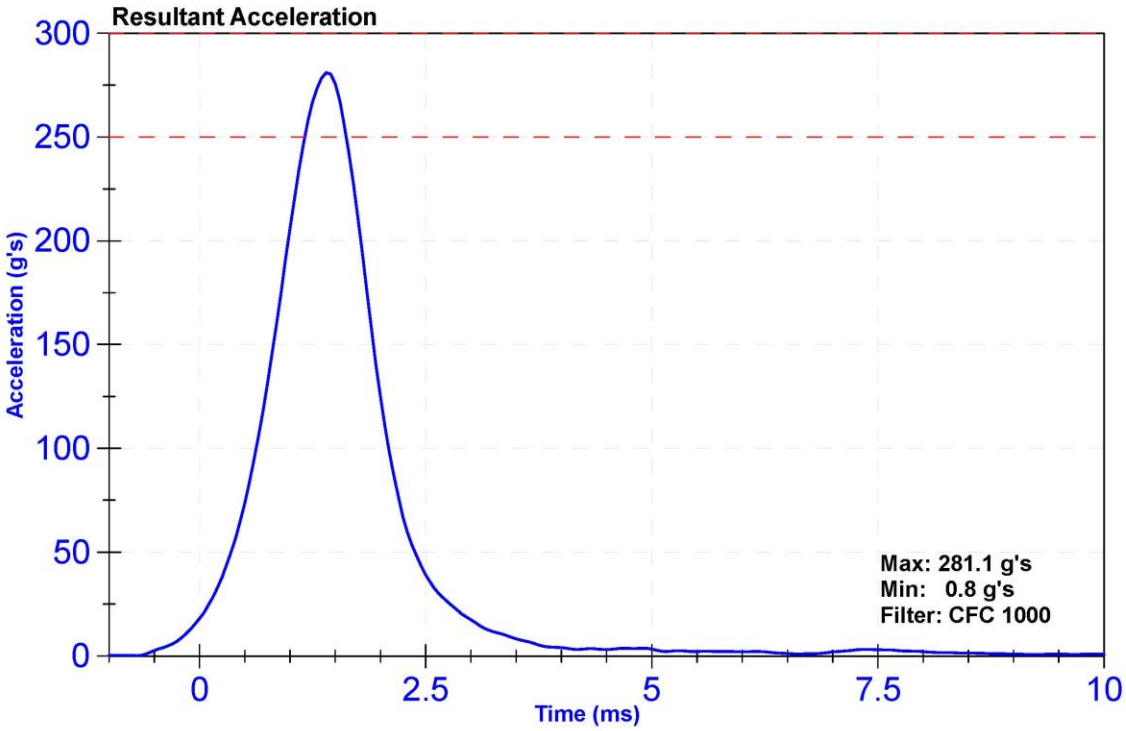
ATD Manufacturer	FTSS	Test Technician	D.Reinhard
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

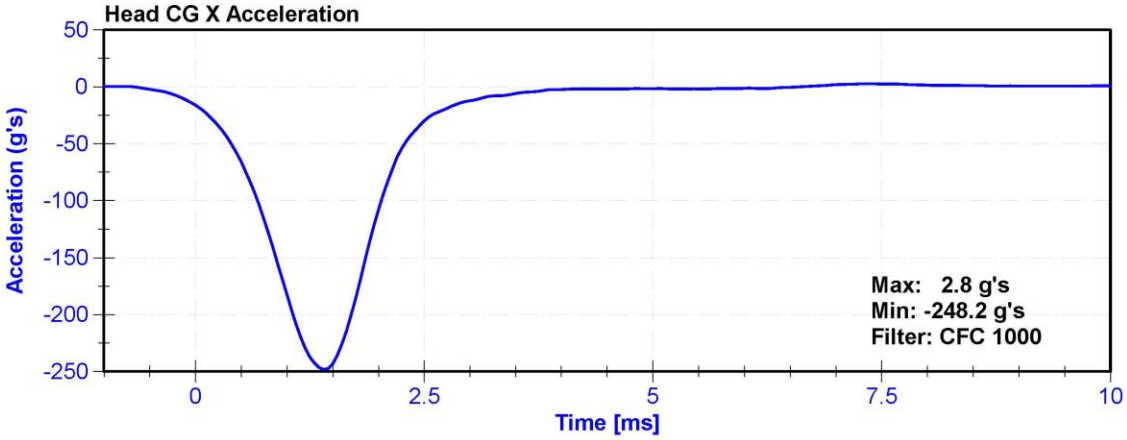
Results

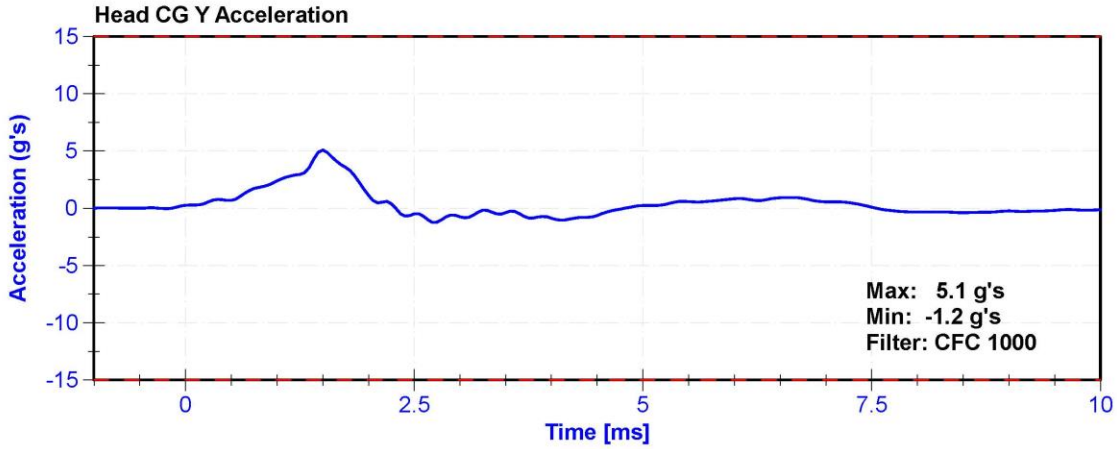
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21	Pass
Humidity	10	70	%	39	Pass
Resultant Acceleration	250	300	g's	281.1	Pass
Oscillation	0	10	%	1.3	Pass
Lateral Acceleration	-15	15	g's	5.1	Pass

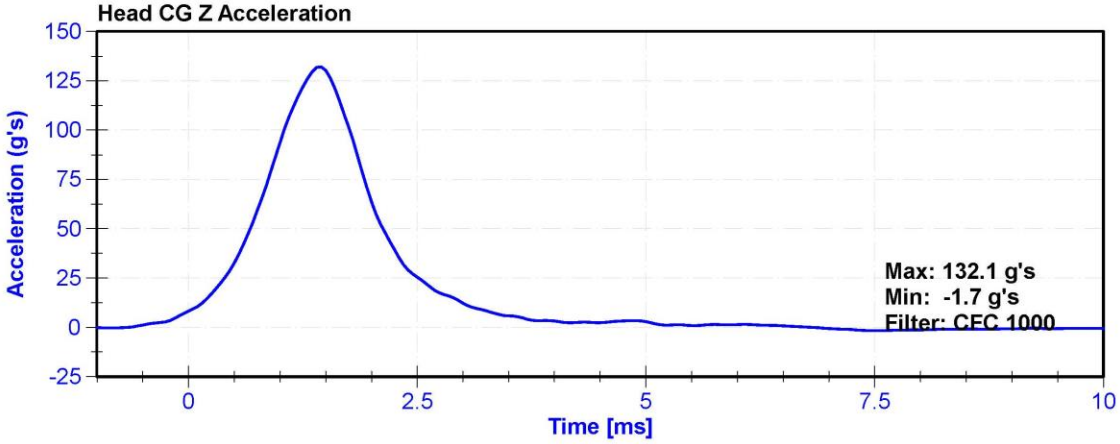
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264CT	AC-P58998	3/3/2020	9/1/2020
Y Accelerometer	ENDEVCO 7264CT	AC-P51722	3/3/2020	9/1/2020
Z Accelerometer	ENDEVCO 7264CT	AC-P58997	3/3/2020	9/1/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 2.8 g's
Min: -248.2 g's
Filter: CFC 1000


Head CG Y Acceleration
Acceleration (g's)
15
10
5
0
-5
-10
-15
0
2.5
5
7.5
10
Time [ms]
Max: 5.1 g's
Min: -1.2 g's
Filter: CFC 1000


Head CG Z Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2.5
5
7.5
10
Time [ms]
Max: 132.1 g's
Min: -1.7 g's
Filter: CFC 1000

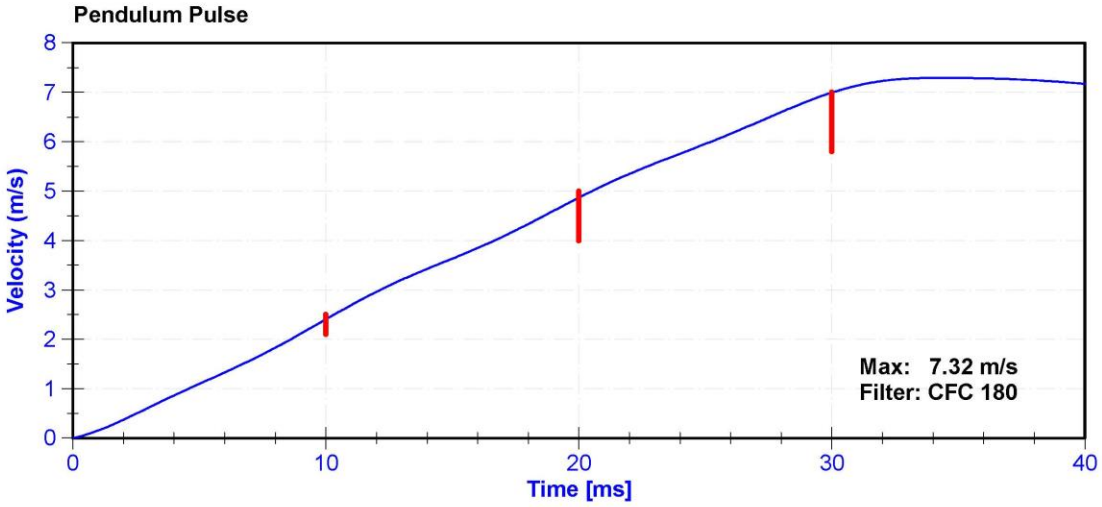
ATD Manufacturer	FTSS	Test Technician	D.Reinhard
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

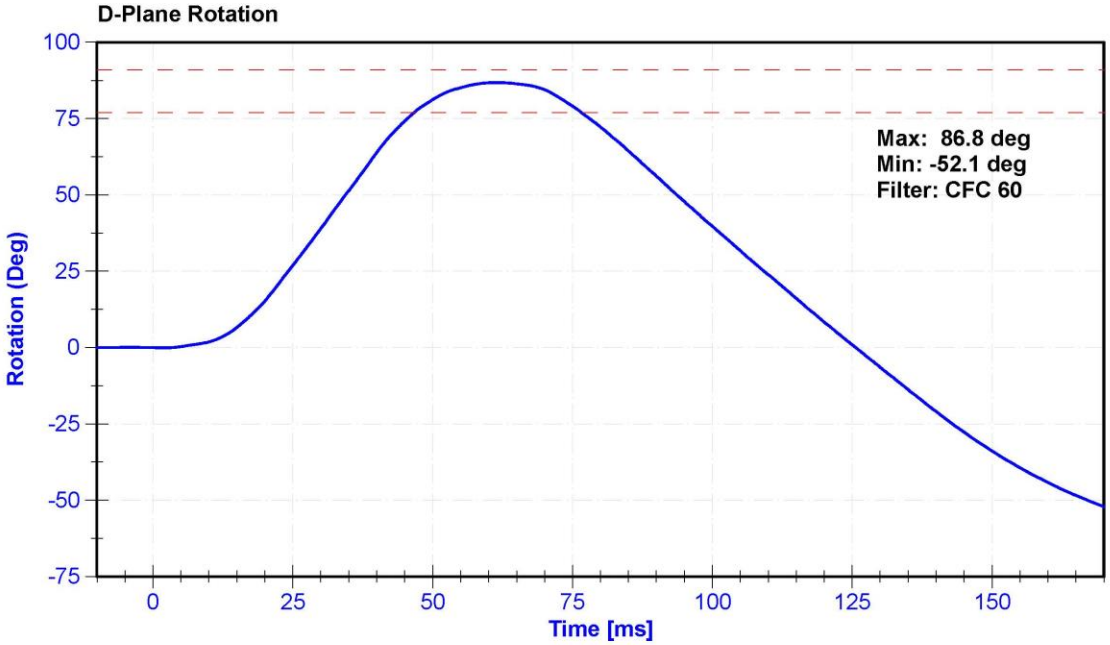
Results

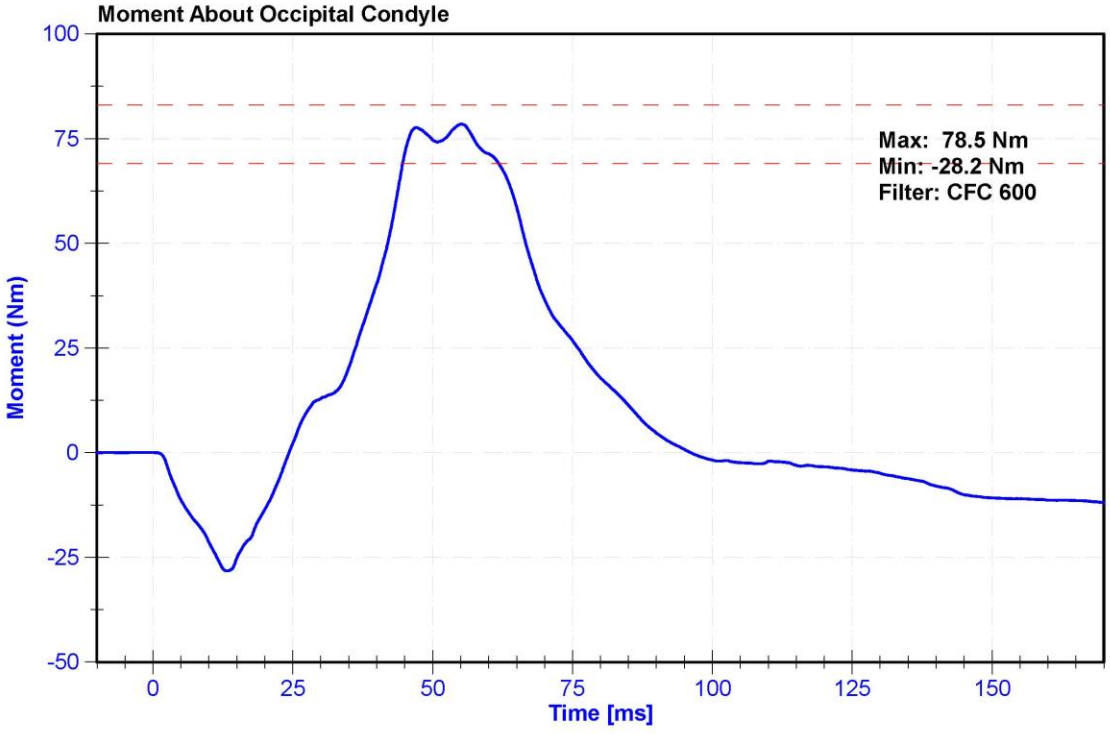
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	37.0	Pass
Velocity	6.89	7.13	m/s	6.958	Pass
Pendulum Impulse at 10ms	2.1	2.5	m/s	2.40	Pass
Pendulum Impulse at 20ms	4.0	5.0	m/s	4.87	Pass
Pendulum Impulse at 30ms	5.8	7.0	m/s	7.00	Pass
Max D Plane Rotation	77	91	deg	86.8	Pass
Max Moment During Rotation Interval	69	83	Nm	78.5	Pass
Moment Decay to 10.0 Nm	80	100	ms	85.9	Pass

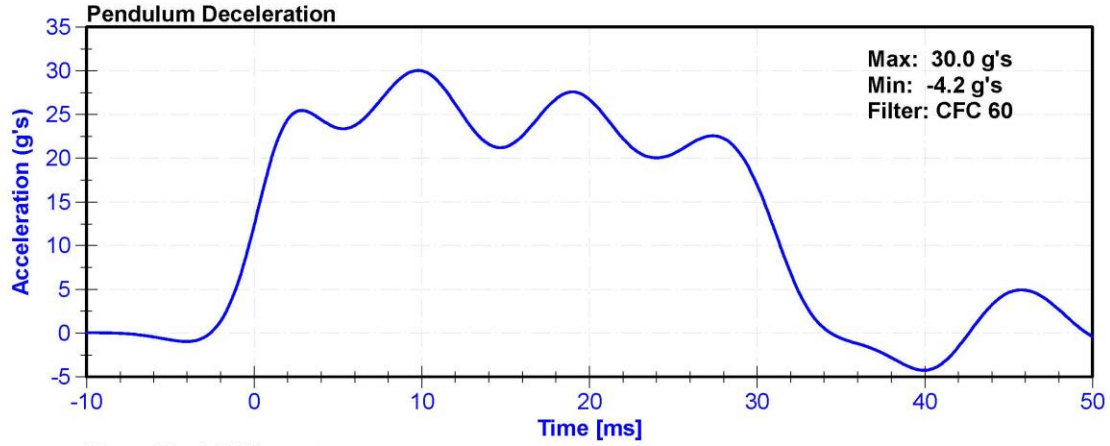
Transducer Calibrations

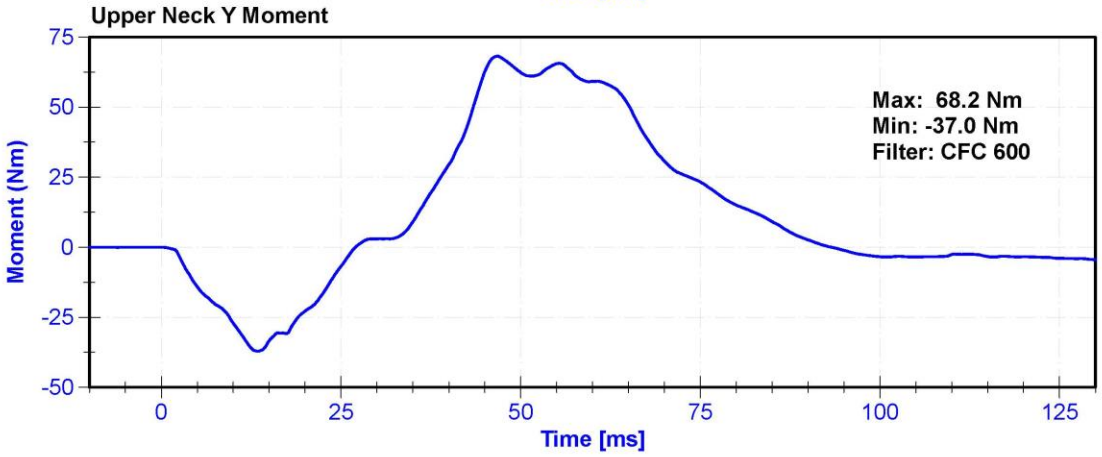
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton 1716	LC-1872 FX	10/5/2019	10/4/2020

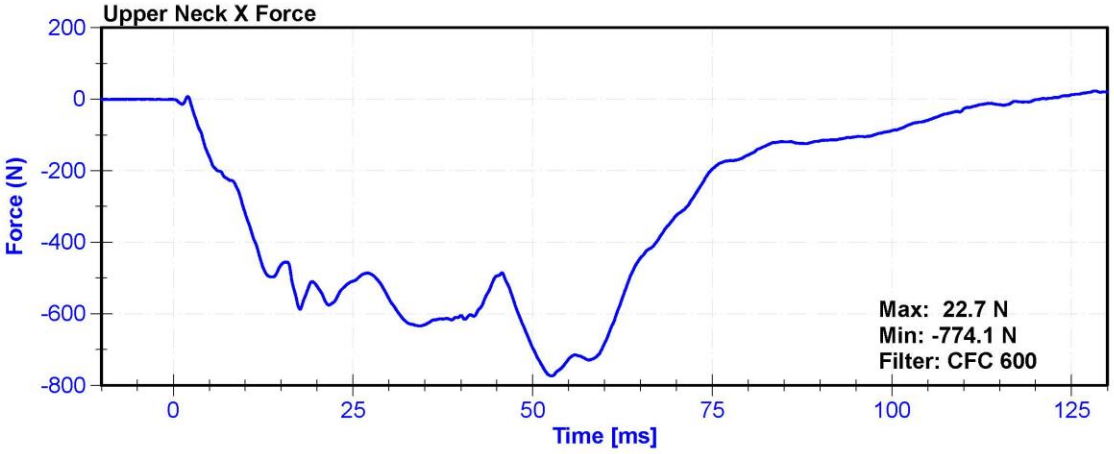



D-Plane Rotation
Rotation (Deg)
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150
Time [ms]
Max: 86.8 deg
Min: -52.1 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 78.5 Nm
Min: -28.2 Nm
Filter: CFC 600


Pendulum Deceleration
Acceleration (g's)
Time [ms]
Max: 30.0 g's
Min: -4.2 g's
Filter: CFC 60


Upper Neck Y Moment
Moment (Nm)
Time [ms]
Max: 68.2 Nm
Min: -37.0 Nm
Filter: CFC 600


Upper Neck X Force
Force (N)
Time [ms]
Max: 22.7 N
Min: -774.1 N
Filter: CFC 600

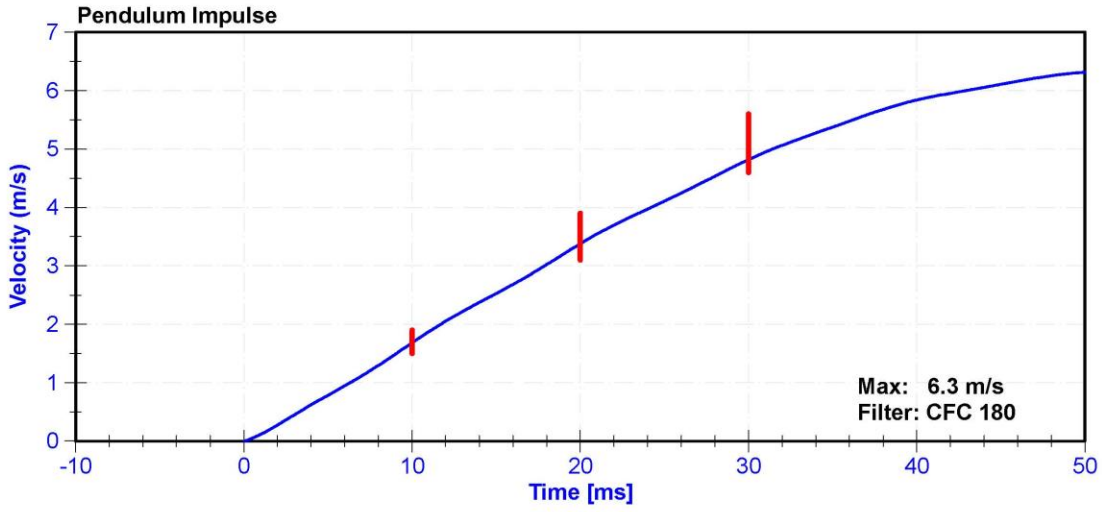
ATD Manufacturer	FTSS	Test Technician	D.Reinhard
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

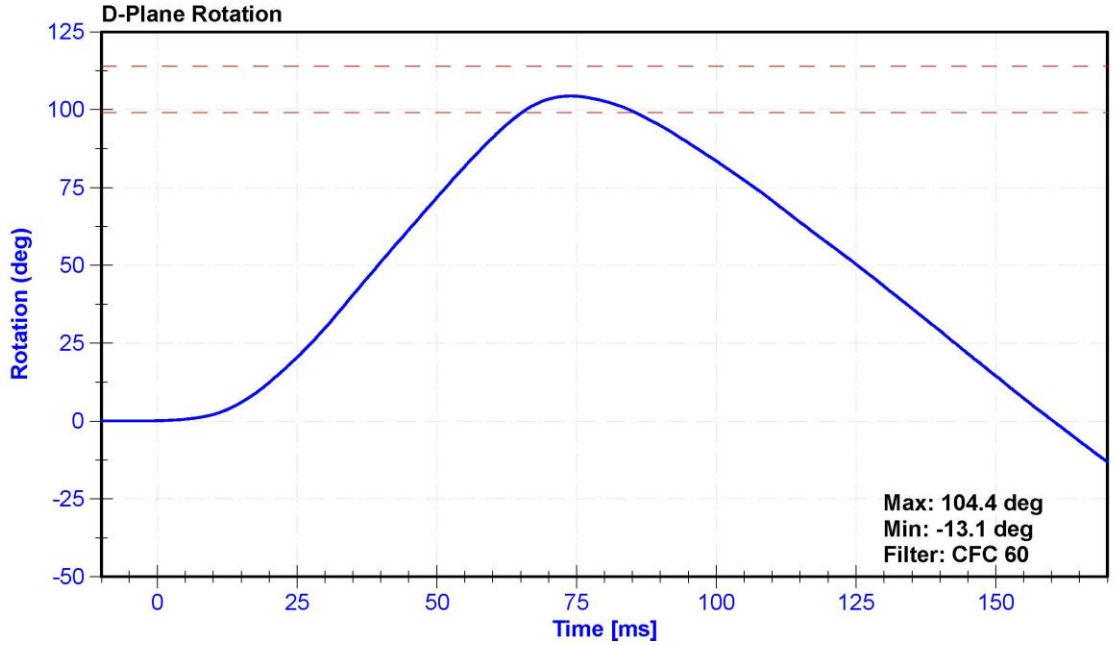
Results

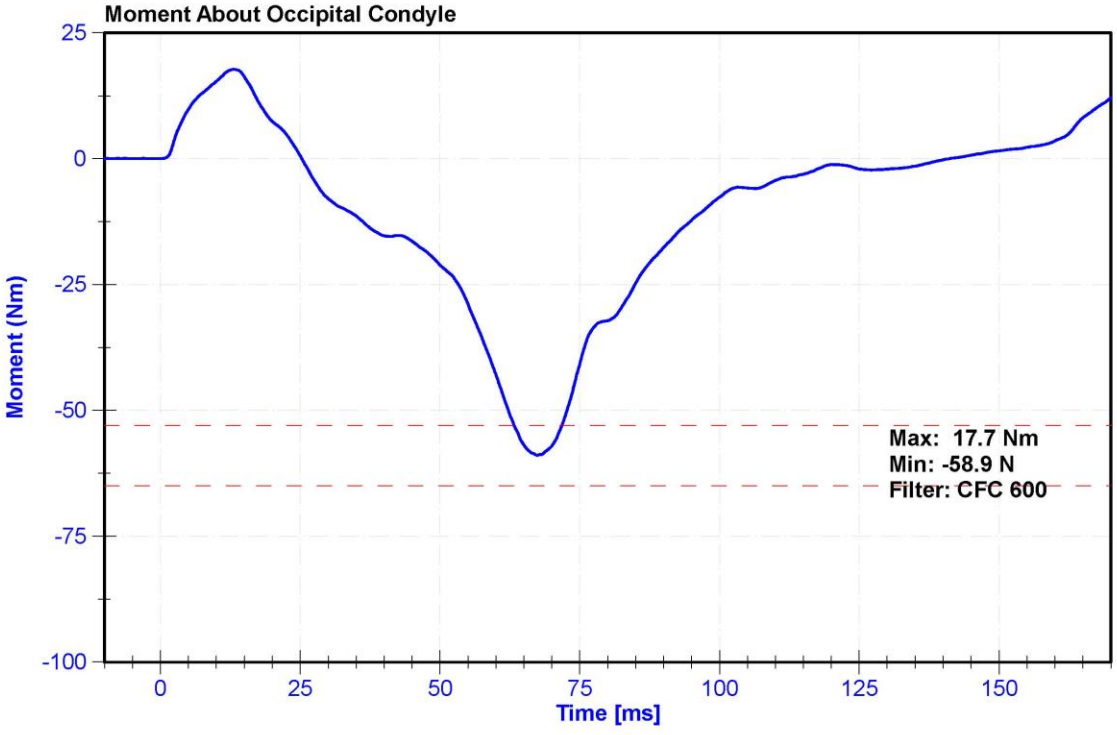
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	38.0	Pass
Velocity	5.95	6.19	m/s	6.046	Pass
Pendulum Impulse at 10ms	1.5	1.9	m/s	1.68	Pass
Pendulum Impulse at 20ms	3.1	3.9	m/s	3.38	Pass
Pendulum Impulse at 30ms	4.6	5.6	m/s	4.82	Pass
D Plane Rotation	99	114	deg	104.4	Pass
Moment During Rotation Interval	-65	-53	Nm	-58.9	Pass
Moment Decay to -10Nm	94	114	ms	97.4	Pass

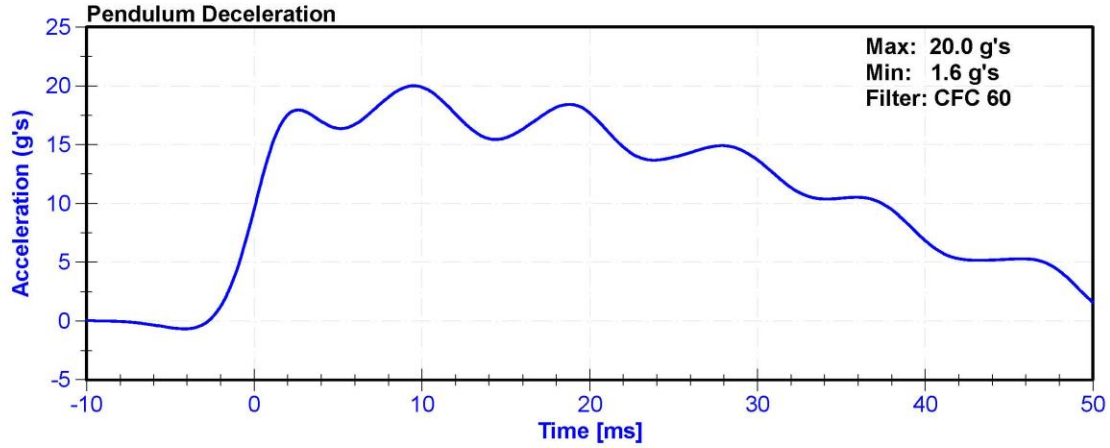
Transducer Calibrations

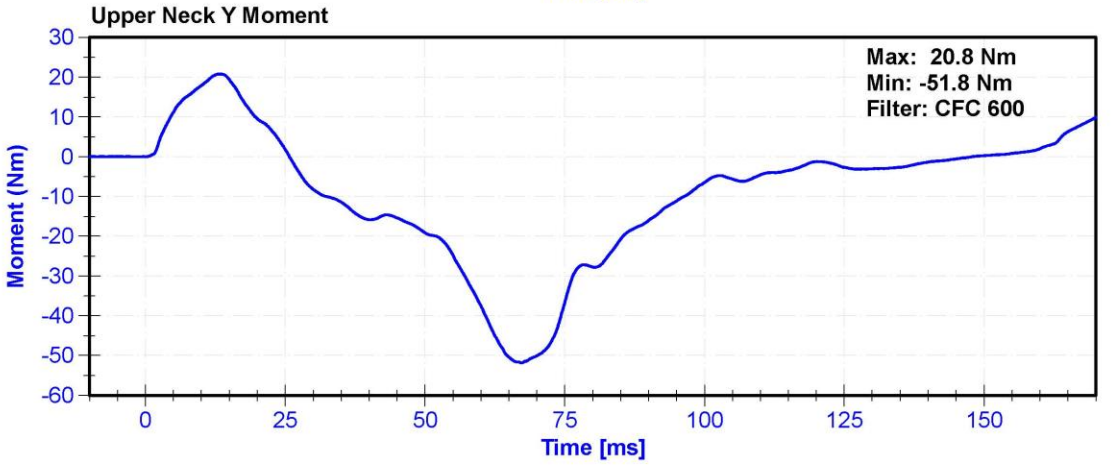
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton 1716	LC-1872 FX	10/5/2019	10/4/2020

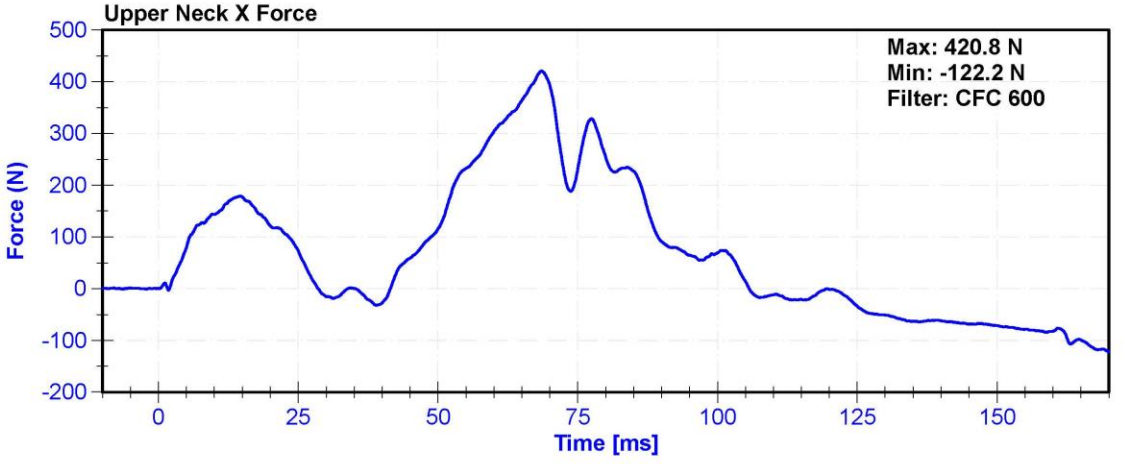



D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 104.4 deg
Min: -13.1 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
25
0
-25
-50
-75
-100
0
25
50
75
100
125
150
Time [ms]
Max: 17.7 Nm
Min: -58.9 N
Filter: CFC 600


Pendulum Deceleration
Max: 20.0 g's
Min: 1.6 g's
Filter: CFC 60
Acceleration (g's)
25
20
15
10
5
0
-5
-10
0
10
20
30
40
50
Time [ms]


Upper Neck Y Moment
Max: 20.8 Nm
Min: -51.8 Nm
Filter: CFC 600
Moment (Nm)
30
20
10
0
-10
-20
-30
-40
-50
-60
0
25
50
75
100
125
150
Time [ms]


Upper Neck X Force
Max: 420.8 N
Min: -122.2 N
Filter: CFC 600
Force (N)
500
400
300
200
100
0
-100
-200
0
25
50
75
100
125
150
Time [ms]

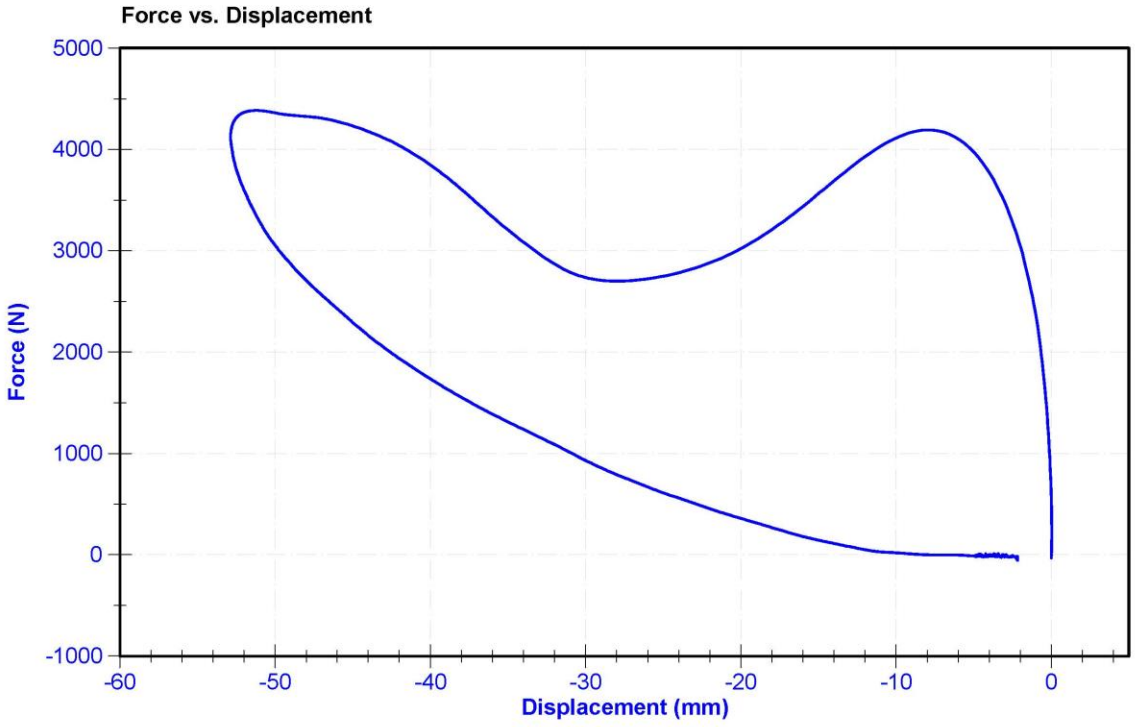
ATD Manufacturer	FTSS	Test Technician	D.Reinhard
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

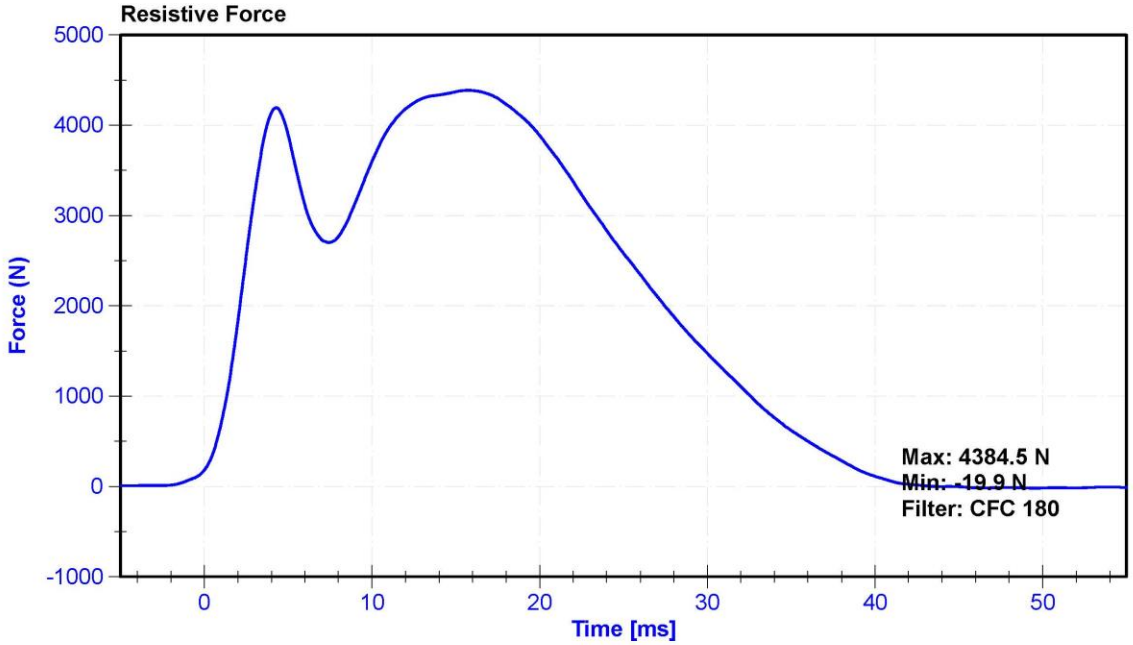
Results

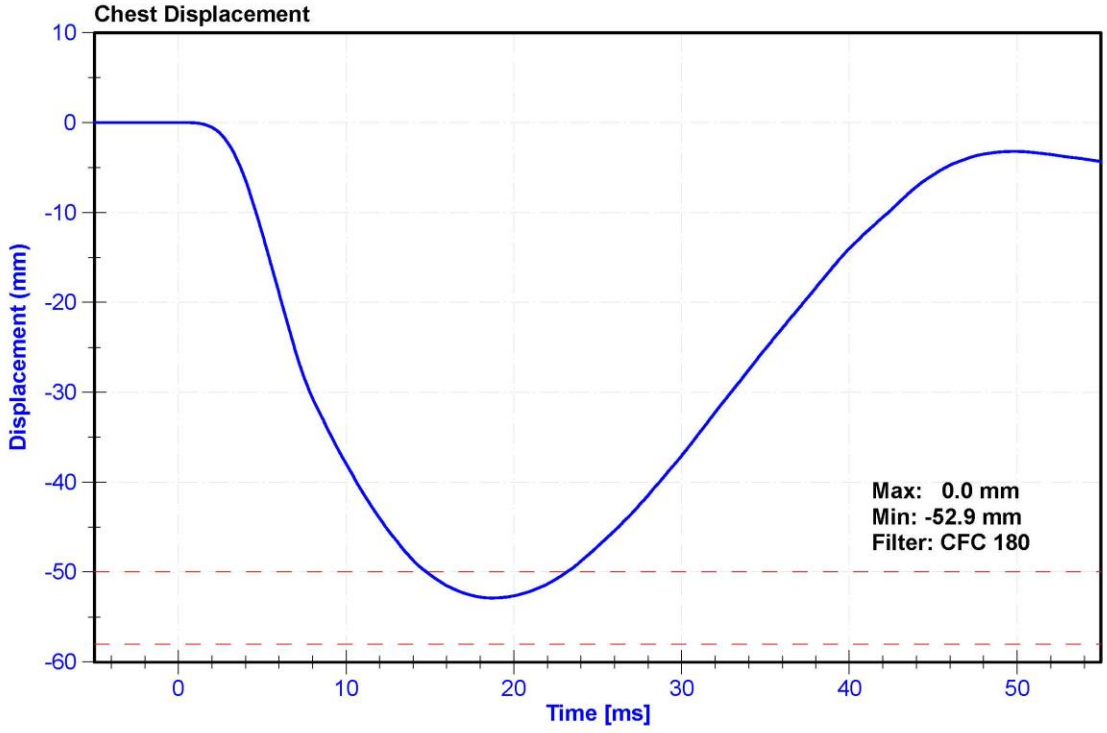
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	43	Pass
Velocity	6.59	6.83	m/s	6.670	Pass
Chest Deflection	-58	-50	mm	-52.9	Pass
Maximum Resistive Force (50 to 58mm)	3900	4400	N	4384.5	Pass
Maximum Resistive Force (18 to 50mm)	0	4600	N	4360.4	Pass
Hysteresis	69	85	%	70.9	Pass

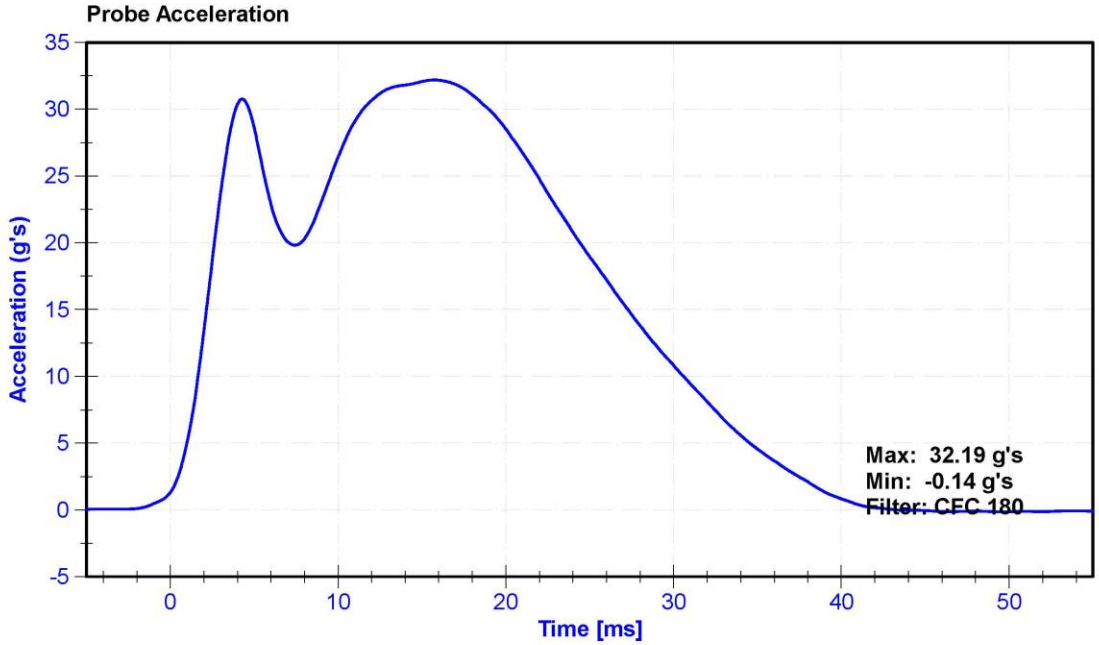
Transducer Calibrations

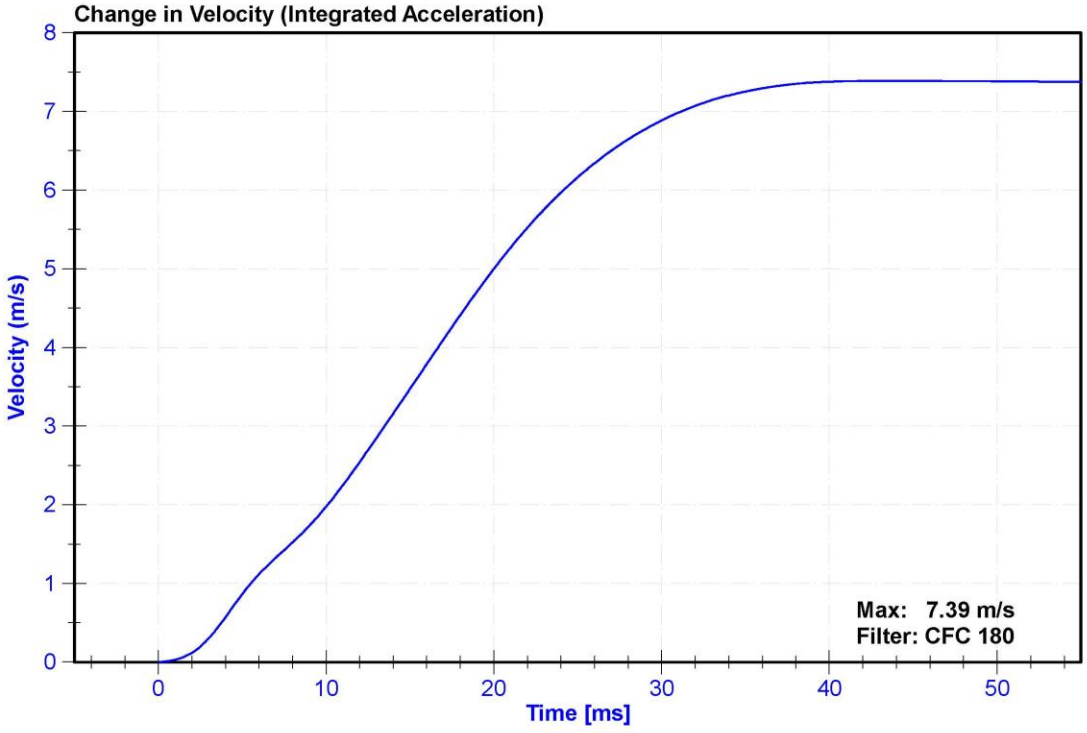
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020
Chest Potentiometer	SERVO 14CBI-3615	DS-140GFE	6/21/2019	6/20/2020




Resistive Force
Force (N)
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50
Time [ms]
Max: 4384.5 N
Min: -19.9 N
Filter: CFC 180


Chest Displacement
Displacement (mm)
10
0
-10
-20
-30
-40
-50
-60
0
10
20
30
40
50
Time [ms]
Max: 0.0 mm
Min: -52.9 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
35
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
Time [ms]
Max: 32.19 g's
Min: -0.14 g's
Filter: CFC 180


Change in Velocity (Integrated Acceleration)
Velocity (m/s)
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
Time [ms]
Max: 7.39 m/s
Filter: CFC 180

ATD Manufacturer	FTSS	Test Technician	D.Reinhard
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

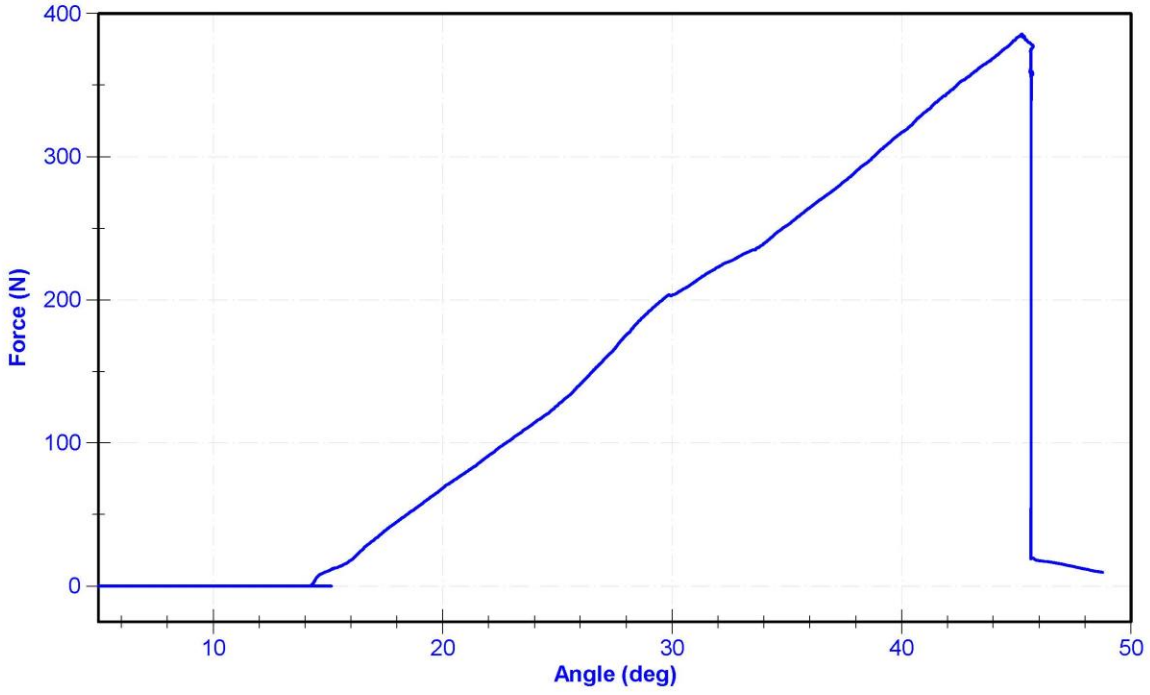
Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.6	25.6	ºC	21.5	Pass
Humidity	10	70	%	33	Pass
Initial Angle	0	20	deg	14.0	Pass
Force at 45 Degrees	320	390	N	385.7	Pass
Return Angle Relative to Initial	0	8	deg	2.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	Rieker N4C-1	DS-13051548	12/9/2019	12/8/2020
Load Cell	Interface SML-200	LC-493319	1/10/2020	1/9/2021

Force vs. Displacement



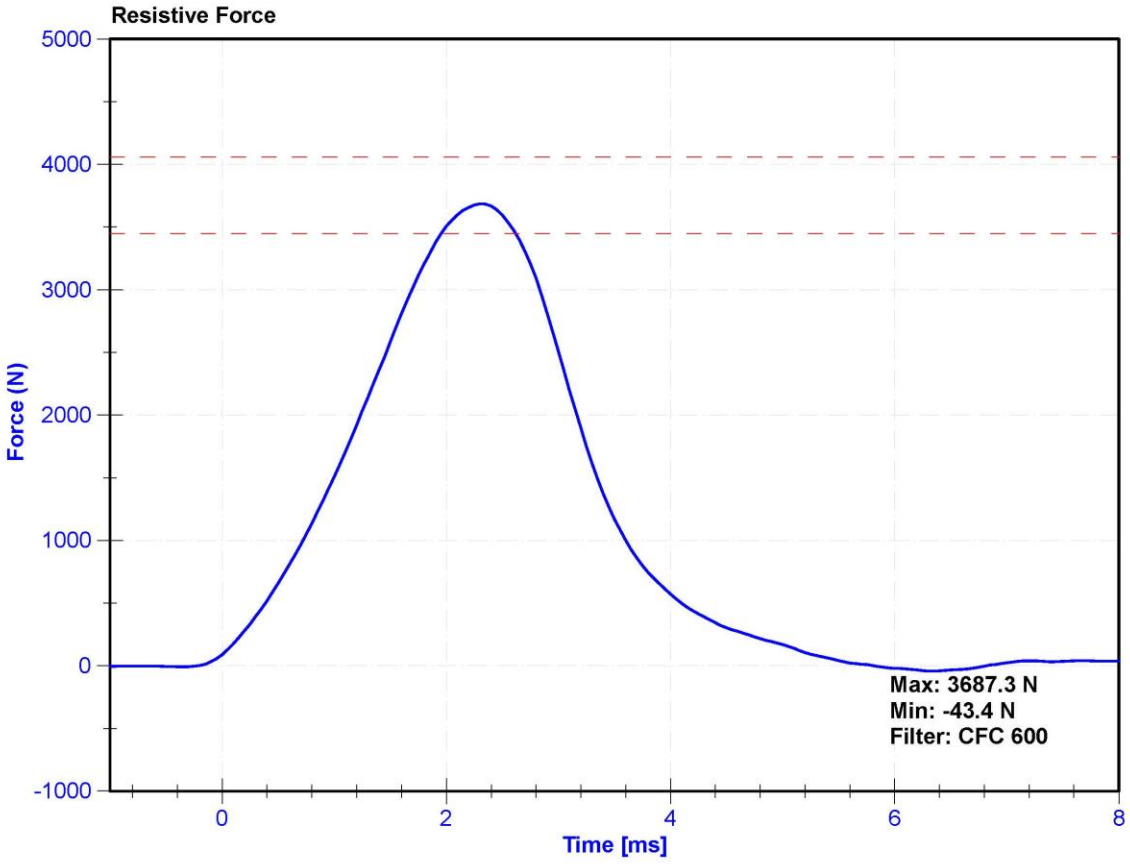
ATD Manufacturer	FTSS	Test Technician	M. Dudek
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

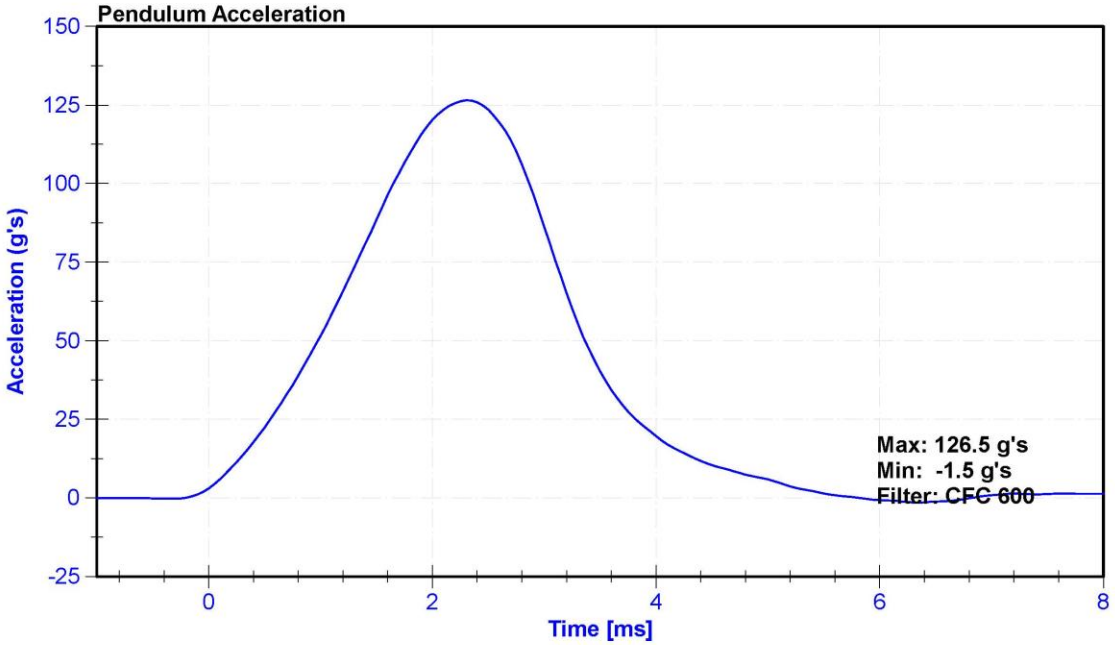
Results

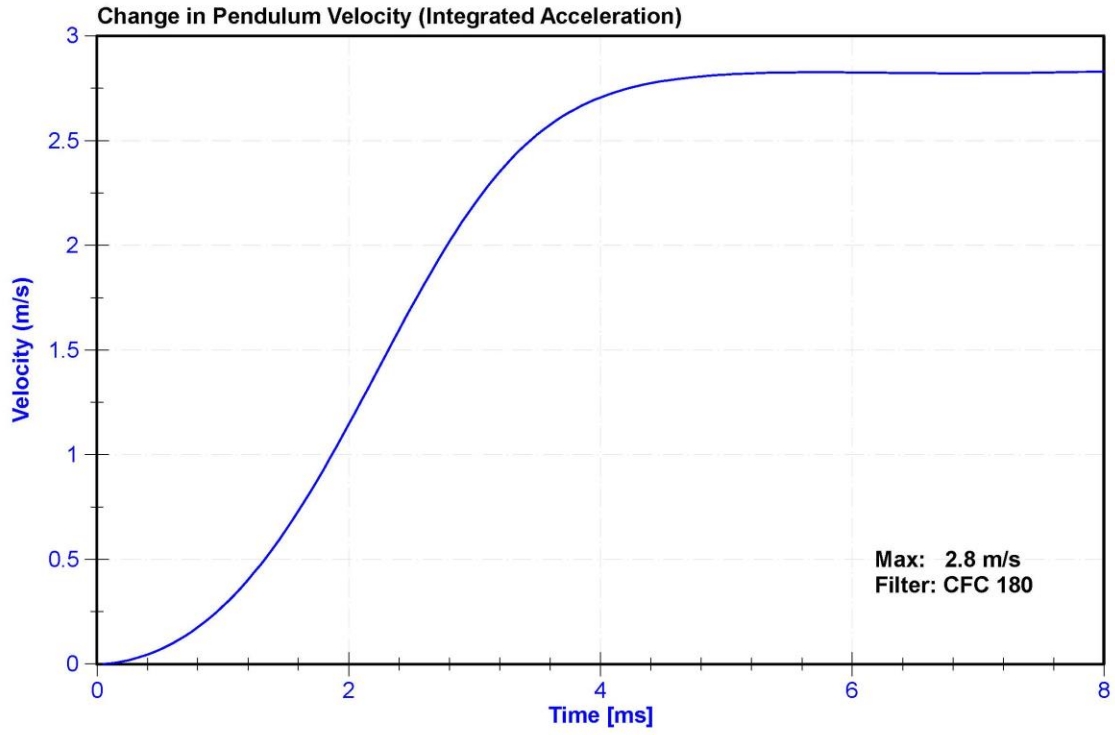
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.0	Pass
Humidity	10	70	%	40.3	Pass
Velocity	2.07	2.13	m/s	2.117	Pass
Resistive Force	3450	4060	N	3687.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 126.5 g's
Min: -1.5 g's
Filter: CFC 600


Change in Pendulum Velocity (Integrated Acceleration)
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]
Max: 2.8 m/s
Filter: CFC 180

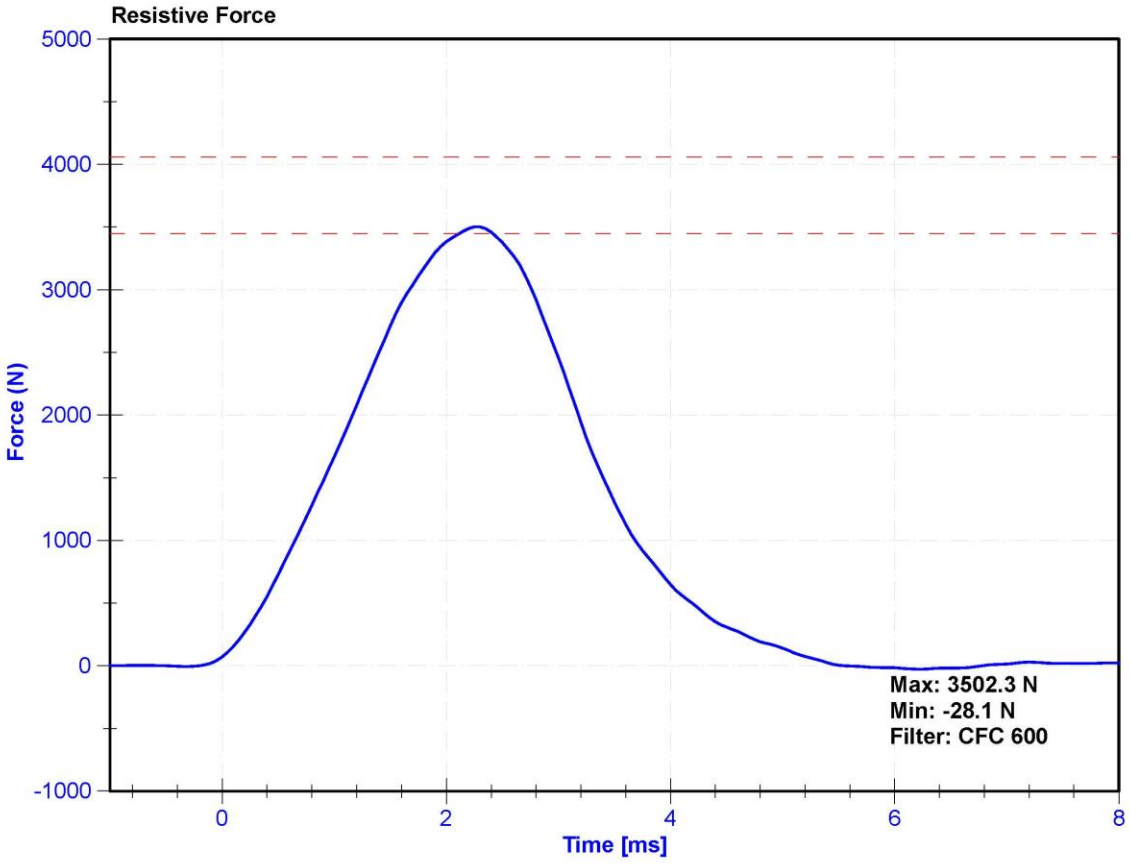
ATD Manufacturer	FTSS	Test Technician	M. Dudek
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

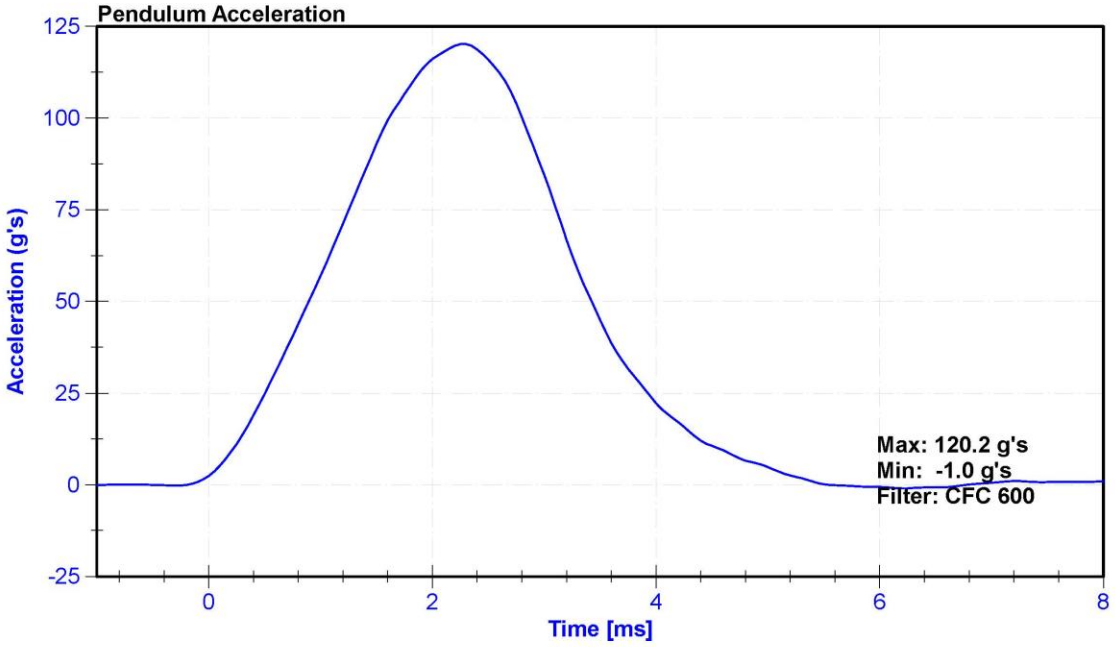
Results

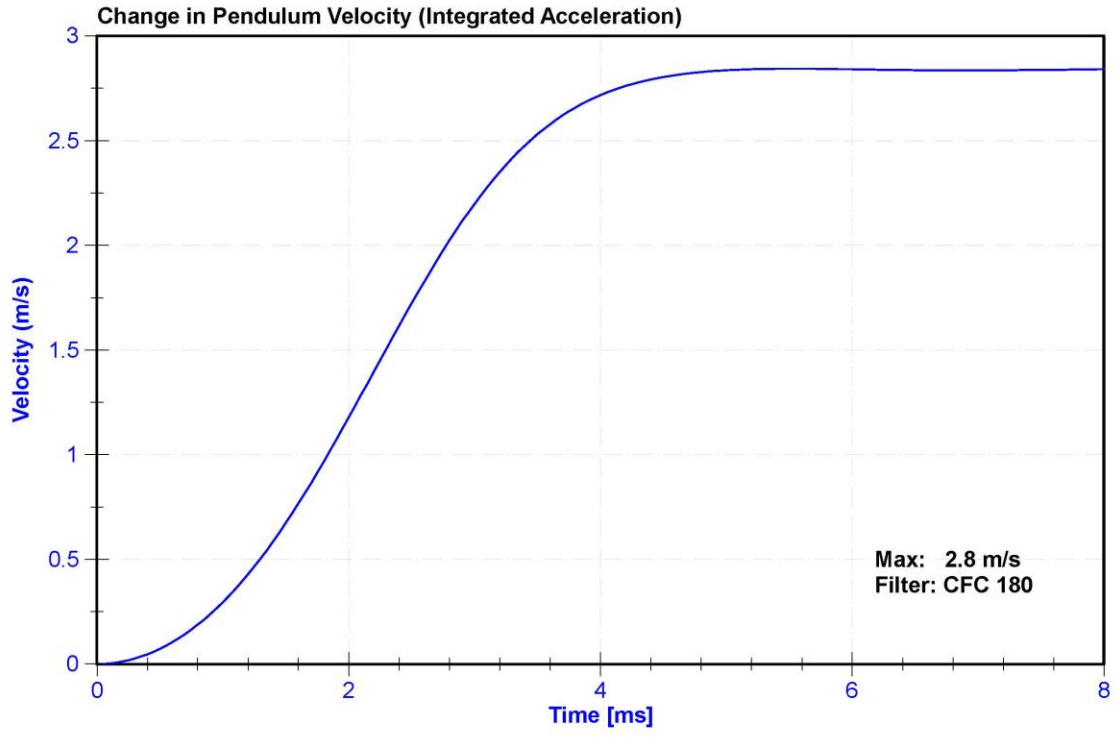
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.9	Pass
Humidity	10	70	%	38.2	Pass
Velocity	2.07	2.13	m/s	2.104	Pass
Resistive Force	3450	4060	N	3502.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020




Pendulum Acceleration
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 120.2 g's
Min: -1.0 g's
Filter: CFC 600


Change in Pendulum Velocity (Integrated Acceleration)
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]
Max: 2.8 m/s
Filter: CFC 180

CALIBRATION TEST RESULTS

POST-TEST

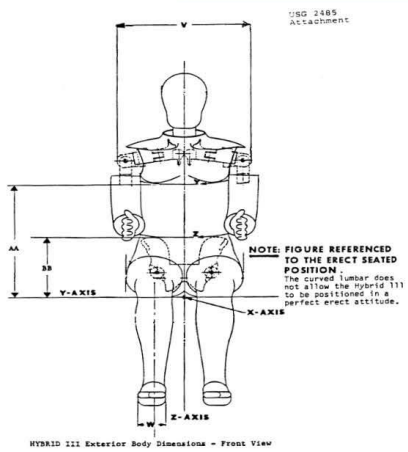
HYBRID III 50TH PERCENTILE MALE - DRIVER ATD

SERIAL NO: 142

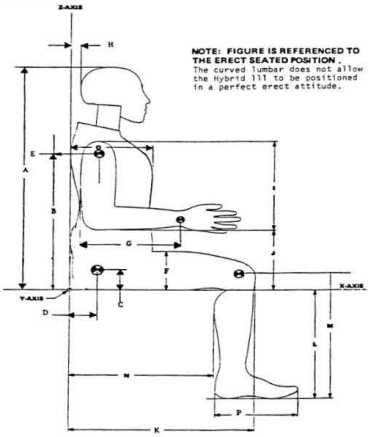
External Measurements - Hybrid 3 - 50th Male

Technician: K. Dutton Date: 03/13/2020

Dummy Serial Number: 142



HYBRID III Exterior Body Dimensions - Front View



HYBRID III Exterior Body Dimensions - Side View

Symbol	Description	Specification (in)		Result (in)	Pass/Fail
A	Sitting Height	34.6	35.0	34.8	Pass
B	Shoulder Pivot Height	19.9	20.5	20.2	Pass
C	H-Point Height	3.3	3.5	3.4	Pass
D	H-Point from Backline	5.3	5.5	5.4	Pass
E	Shoulder Pivot from Backline	3.3	3.7	3.6	Pass
F	Thigh Clearance	5.5	6.1	5.8	Pass
G	Back of Elbow to Wrist Pivot	11.4	12.0	11.6	Pass
H	Head Back to Backline	1.6	1.8	1.7	Pass
I	Shoulder to Elbow Length	13.0	13.6	13.4	Pass
J	Elbow Rest Height	7.5	8.3	8.0	Pass
K	Buttock to Knee Length	22.8	23.8	23.5	Pass
L	Popliteal Height	16.9	17.9	17.4	Pass
M	Knee Pivot Height	19.1	19.7	19.5	Pass
N	Buttock Popliteal Length	17.8	18.8	18.4	Pass
O	Chest Depth without Jacket	8.4	9.0	8.7	Pass
P	Foot Length (right)	9.9	10.5	10.3	Pass
V	Shoulder Breadth	16.3	17.2	16.9	Pass
W	Foot Breadth	3.6	4.2	3.8	Pass
Y	Chest Circumference with Jacket	38.2	39.4	38.8	Pass
Z	Waist Circumference	32.9	34.1	33.7	Pass
AA	Reference Location (Chest Circumference)	16.9	17.1	17.0	Pass
BB	Reference Location (Waist Circumference)	8.9	9.1	9.0	Pass

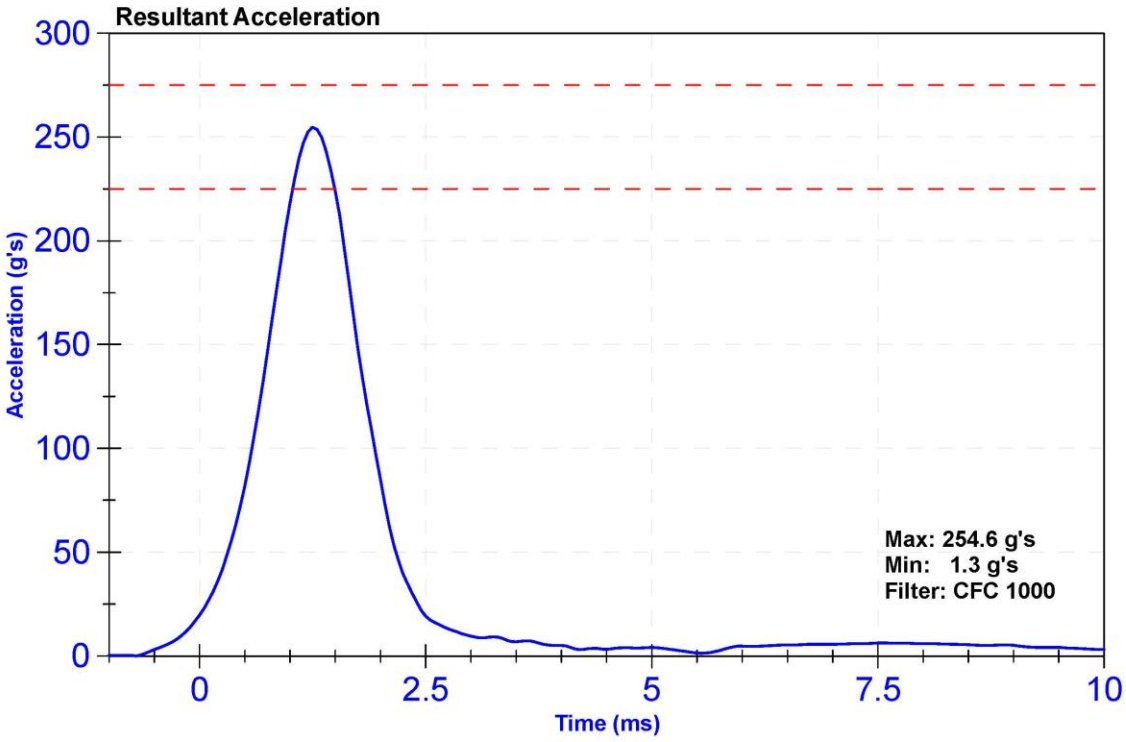
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K.Brogan

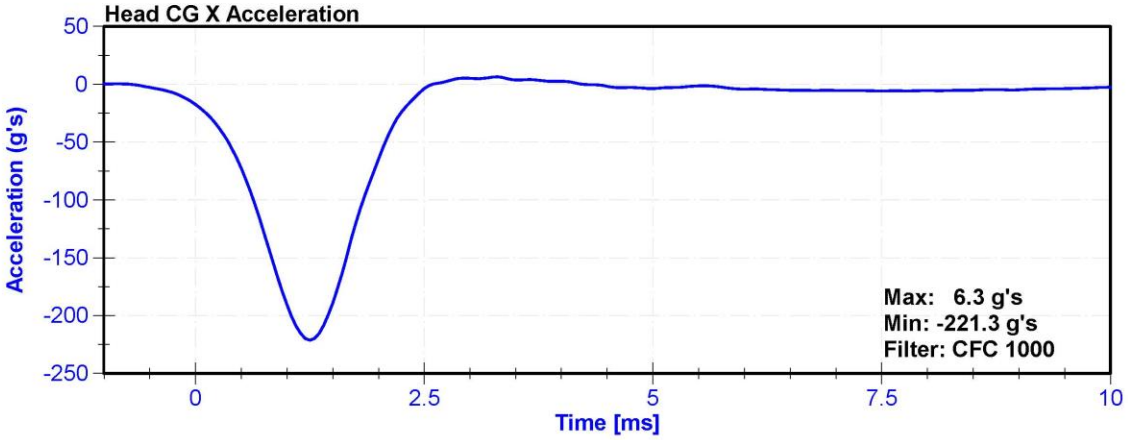
Results

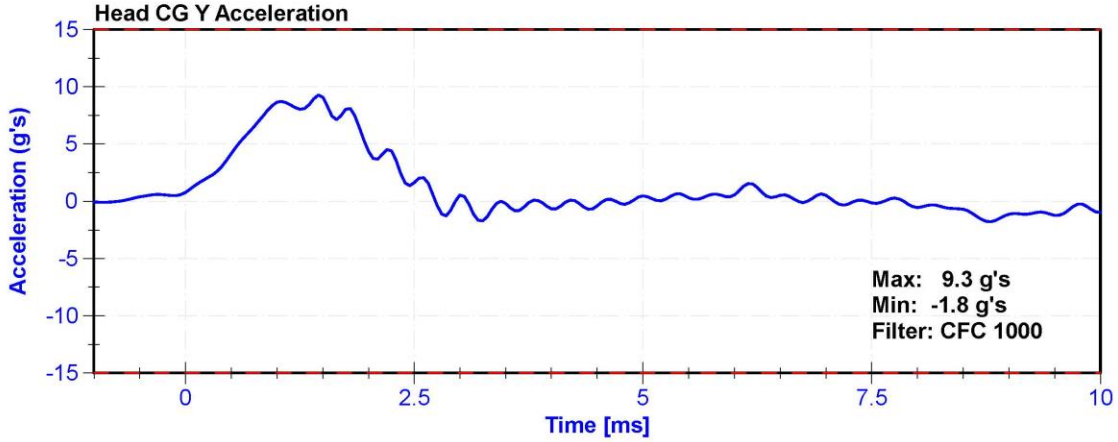
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.9	Pass
Humidity	10	70	%	19.7	Pass
Resultant Acceleration	225	275	g's	254.6	Pass
Oscillation	0	10	%	3.6	Pass
Lateral Acceleration	-15	15	g's	9.3	Pass

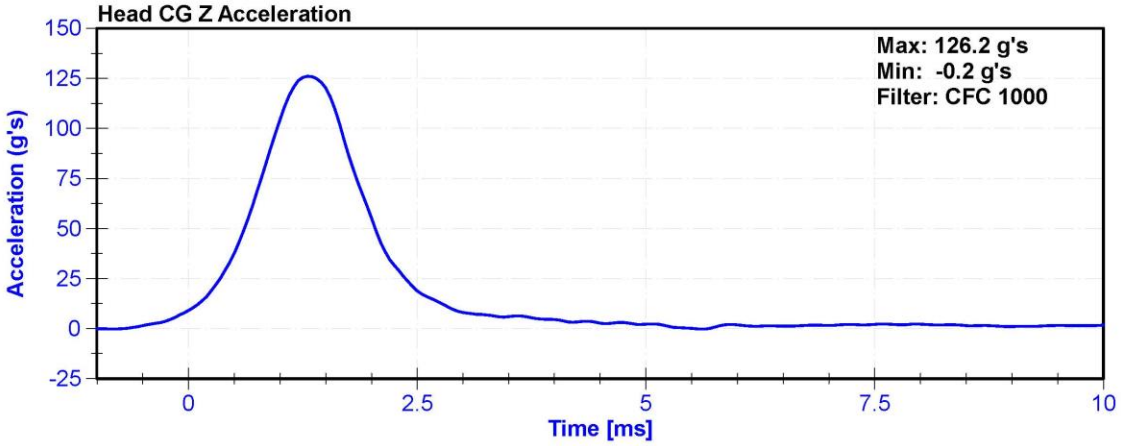
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264	P51681	2/10/2020	8/10/2020
Y Accelerometer	ENDEVCO 7264	P64151	2/10/2020	8/10/2020
Z Accelerometer	ENDEVCO 7264	P52114	2/10/2020	8/10/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 6.3 g's
Min: -221.3 g's
Filter: CFC 1000


Head CG Y Acceleration
Acceleration (g's)
15
10
5
0
-5
-10
-15
0
2.5
5
7.5
10
Time [ms]
Max: 9.3 g's
Min: -1.8 g's
Filter: CFC 1000


Head CG Z Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2.5
5
7.5
10
Time [ms]
Max: 126.2 g's
Min: -0.2 g's
Filter: CFC 1000

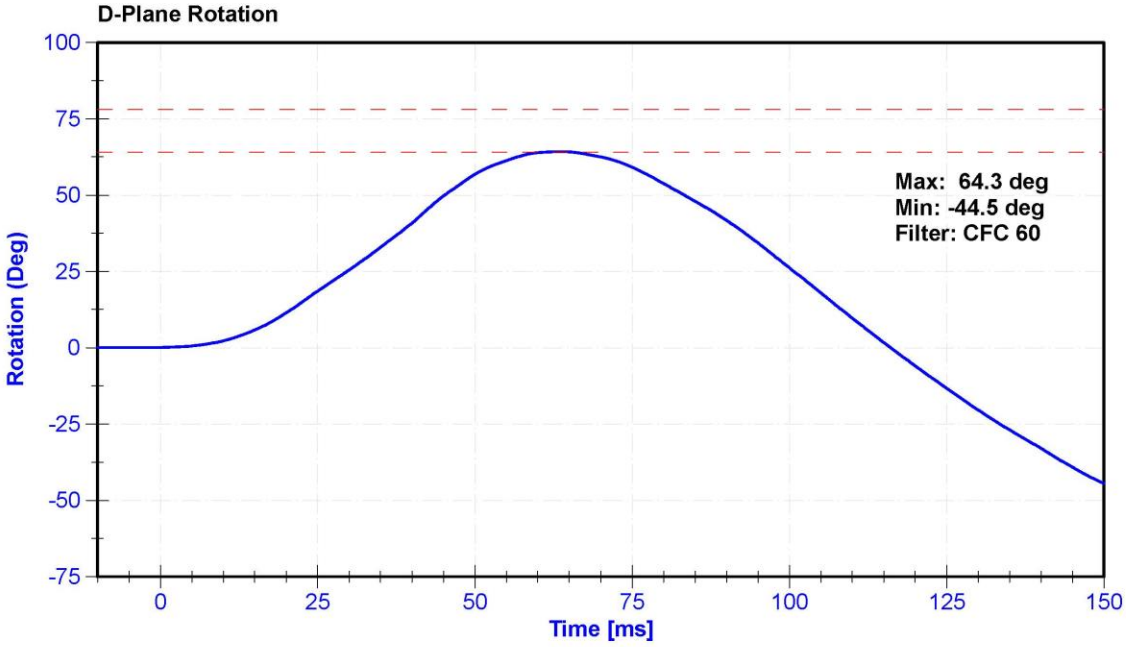
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

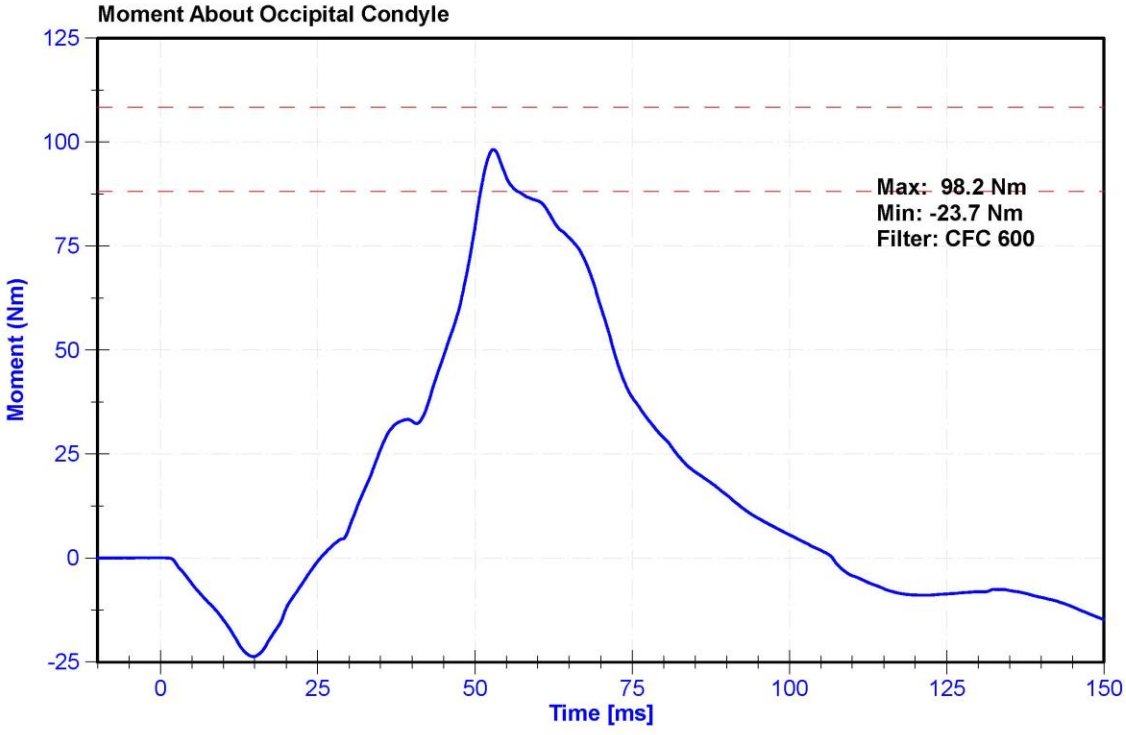
Results

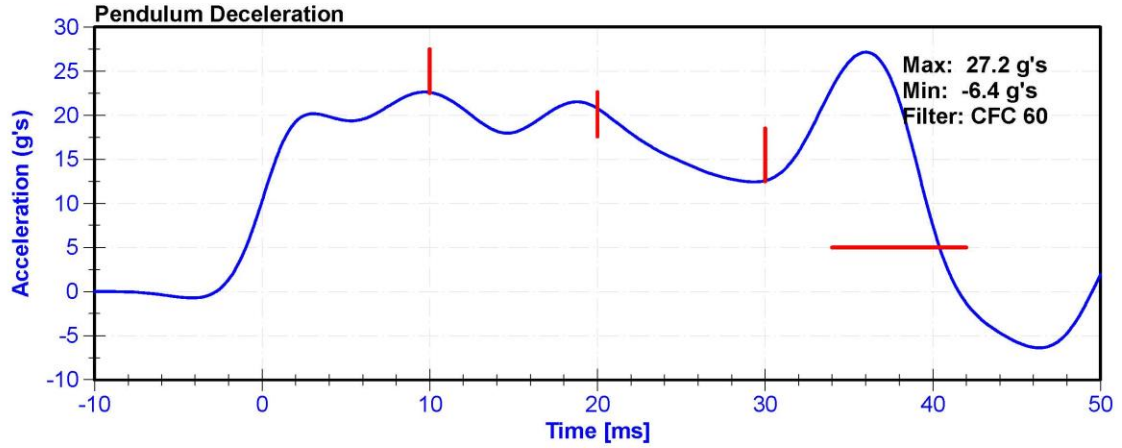
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.3	Pass
Humidity	10	70	%	30.0	Pass
Velocity	6.89	7.13	m/s	6.903	Pass
Pendulum Deceleration at 10ms	22.5	27.5	g's	22.59	Pass
Pendulum Deceleration at 20ms	17.6	22.6	g's	20.77	Pass
Pendulum Deceleration at 30ms	12.5	18.5	g's	12.58	Pass
Max. Pendulum Deceleration After 30ms	0	29	g's	27.2	Pass
Pendulum Deceleration Time to 5 g's	34	42	ms	40.4	Pass
Maximum D Plane Rotation	64	78	deg	64.3	Pass
Time to Maximum Rotation	57	64	ms	63.6	Pass
Rotation Decay to Zero	113	127	ms	116.1	Pass
Moment About Occipital Condyle	88.1	108.4	Nm	98.17	Pass
Time to Maximum Moment	47	58	ms	52.9	Pass
Moment Decay to Zero	97	107	ms	106.9	Pass

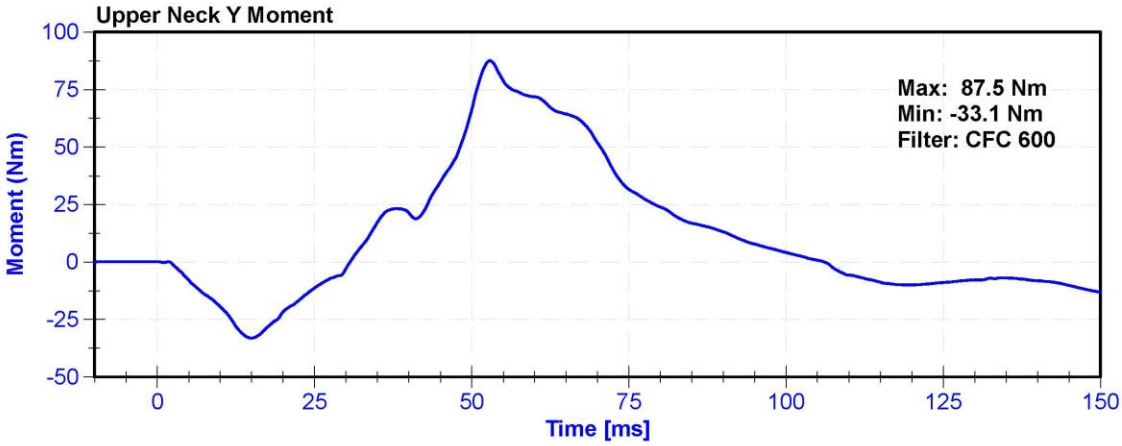
Transducer Calibrations

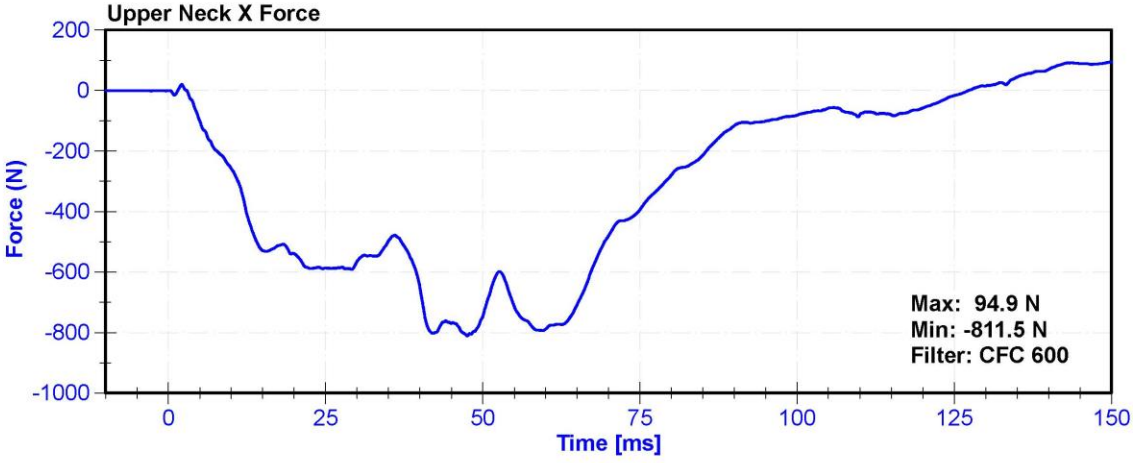
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton IF-205	LC-280FxGFE	10/3/2019	10/2/2020


D-Plane Rotation
Rotation (Deg)
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150
Time [ms]
Max: 64.3 deg
Min: -44.5 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
125
100
75
50
25
0
-25
0
25
50
75
100
125
150
Time [ms]
Max: 98.2 Nm
Min: -23.7 Nm
Filter: CFC 600


Pendulum Deceleration
Acceleration (g's)
Time [ms]
Max: 27.2 g's
Min: -6.4 g's
Filter: CFC 60


Upper Neck Y Moment
Moment (Nm)
Time [ms]
Max: 87.5 Nm
Min: -33.1 Nm
Filter: CFC 600


Upper Neck X Force
Force (N)
Time [ms]
Max: 94.9 N
Min: -811.5 N
Filter: CFC 600

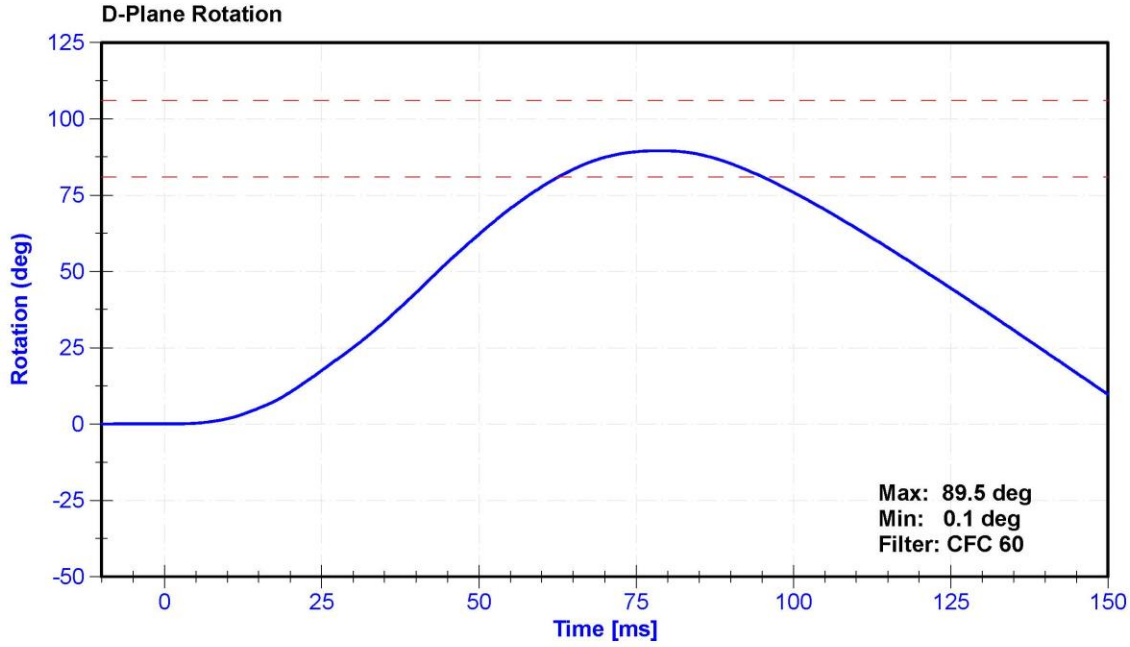
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

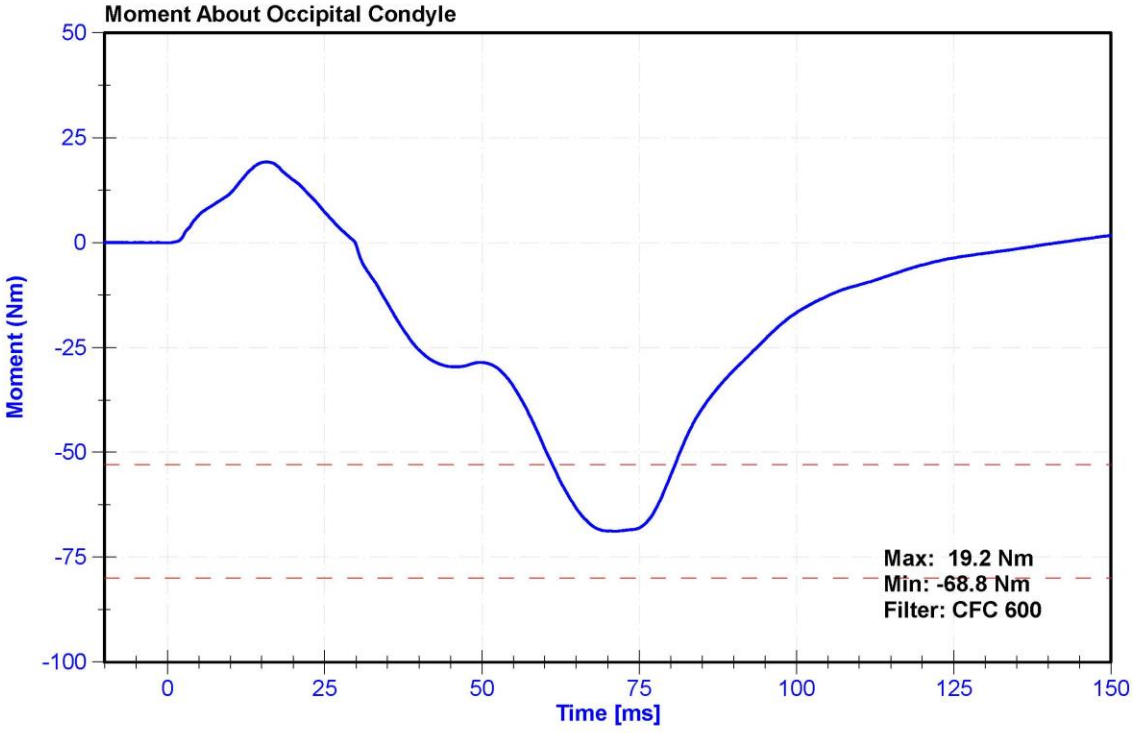
Results

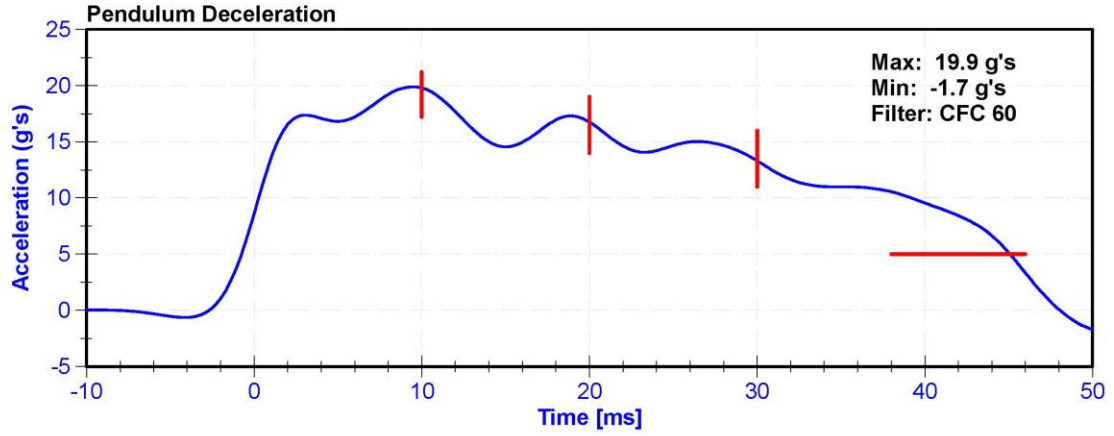
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.2	Pass
Humidity	10	70	%	29	Pass
Velocity	5.94	6.19	m/s	5.964	Pass
Pendulum Deceleration at 10ms	17.2	21.2	g's	19.80	Pass
Pendulum Deceleration at 20ms	14	19	g's	16.8	Pass
Pendulum Deceleration at 30ms	11	16	g's	13.3	Pass
Max. Pendulum Deceleration After 30ms	0	22	g's	19.9	Pass
Pendulum Deceleration Time to 5 g's	38	46	ms	45.1	Pass
Maximum D Plane Rotation	81	106	deg	89.5	Pass
Time to Maximum Rotation	72	82	ms	78.7	Pass
Rotation Decay to Zero	147	174	ms	157.4	Pass
Minimum Moment About OC	-80	-52.9	Nm	-68.77	Pass
Time to Minimum Moment	65	79	ms	71.4	Pass
Moment Decay to Zero	120	148	ms	141.8	Pass

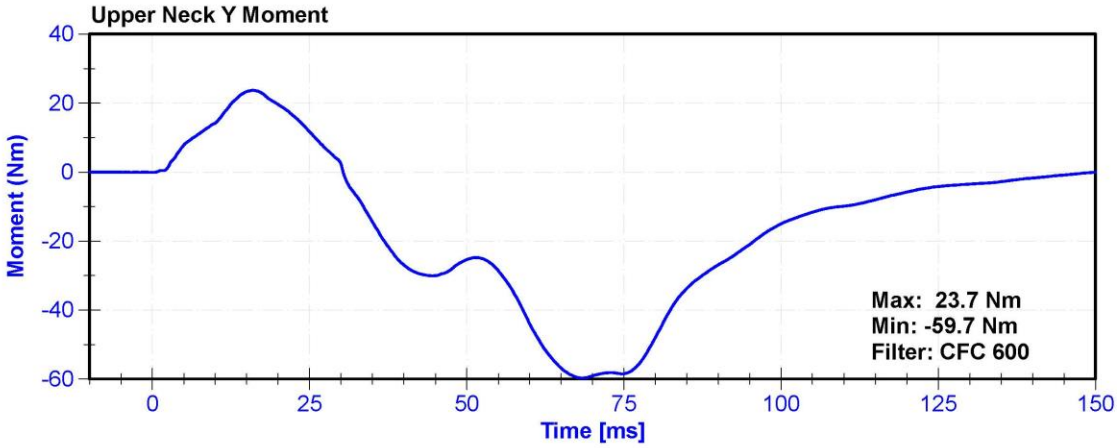
Transducer Calibrations

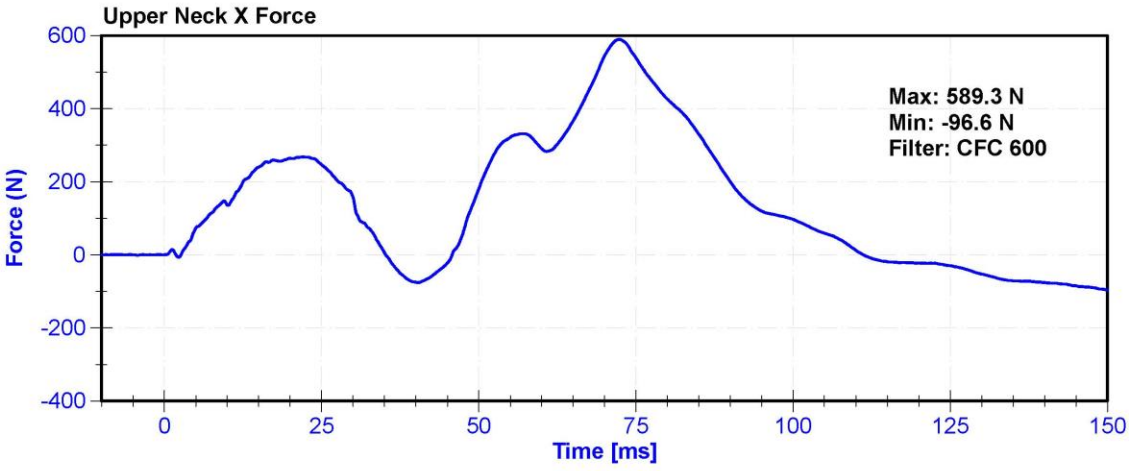
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton IF-205	LC-280FxGFE	10/3/2019	10/2/2020


D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 89.5 deg
Min: 0.1 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
50
25
0
-25
-50
-75
-100
0
25
50
75
100
125
150
Time [ms]
Max: 19.2 Nm
Min: -68.8 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 19.9 g's
Min: -1.7 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 23.7 Nm
Min: -59.7 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 589.3 N
Min: -96.6 N
Filter: CFC 600
Force (N)
Time [ms]

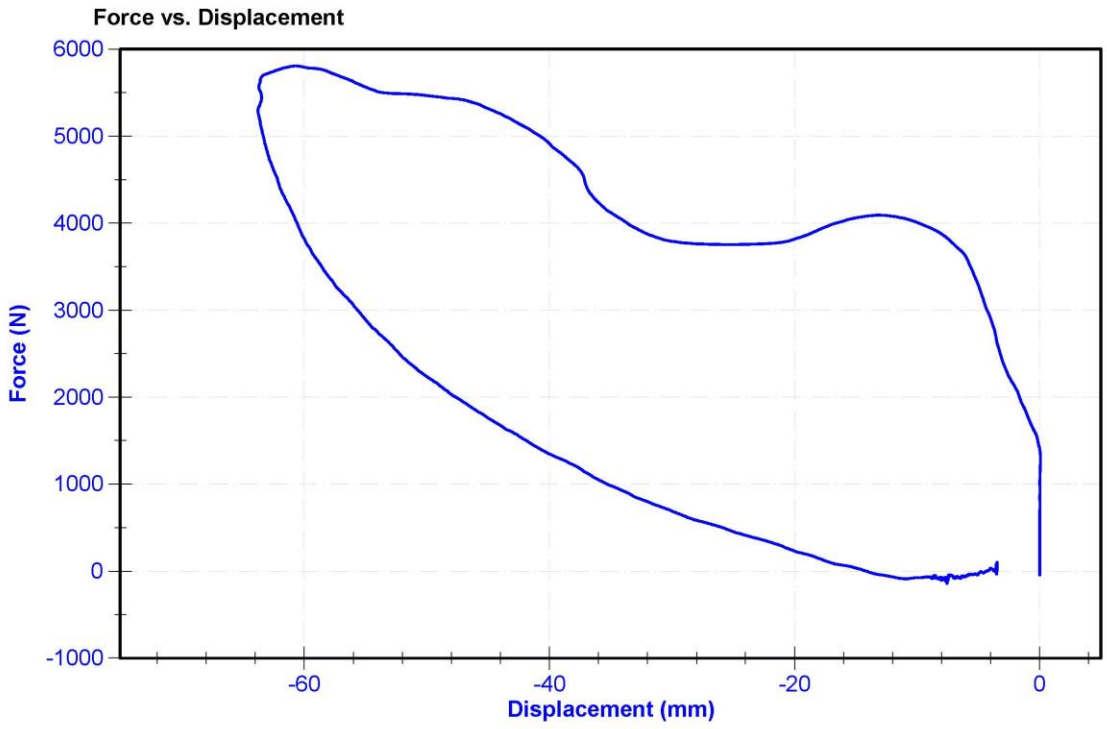
ATD Manufacturer	Humanetics	Test Technician	C. Mantell
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

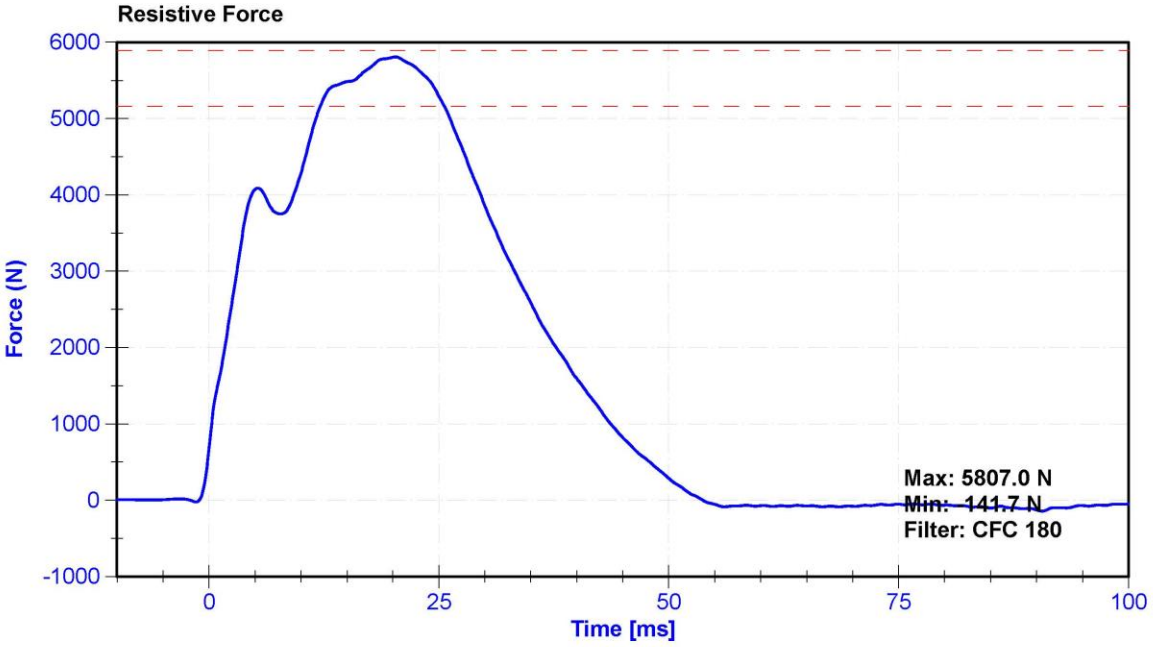
Results

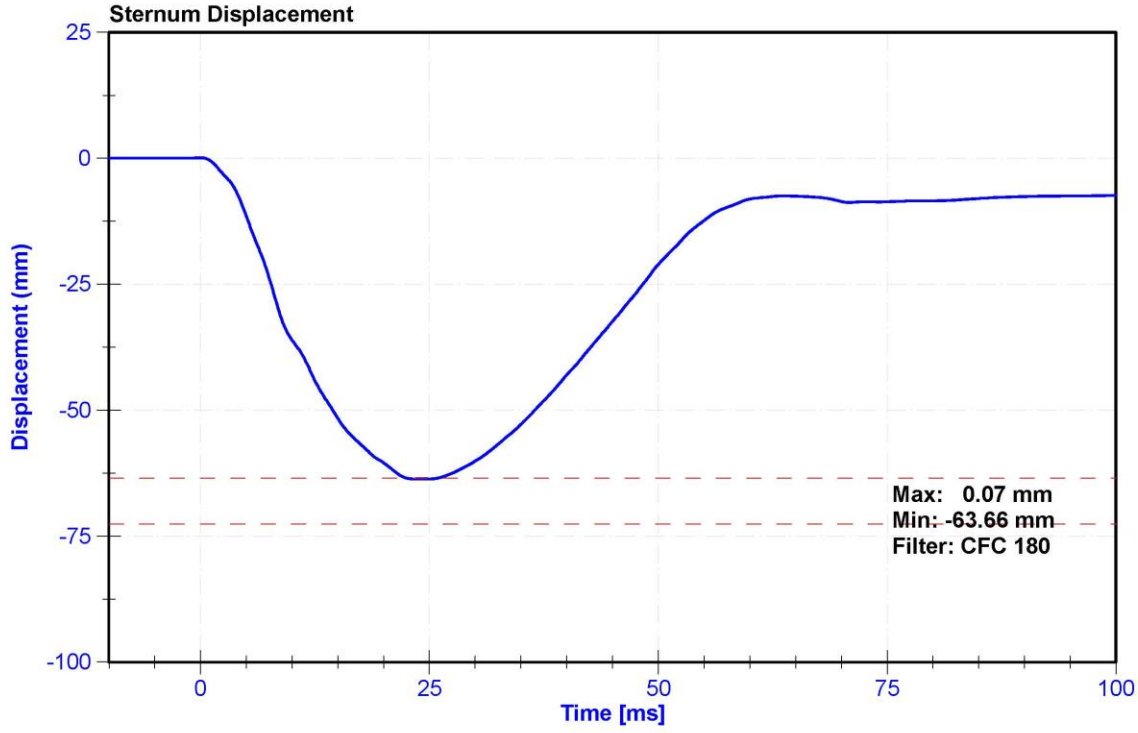
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.3	Pass
Humidity	10	70	%	29.6	Pass
Velocity	6.59	6.83	m/s	6.788	Pass
Chest Displacement	-72.6	-63.5	mm	-63.66	Pass
Resistive Force	5160	5894	N	5807.0	Pass
Hysteresis	65	85	%	72.0	Pass

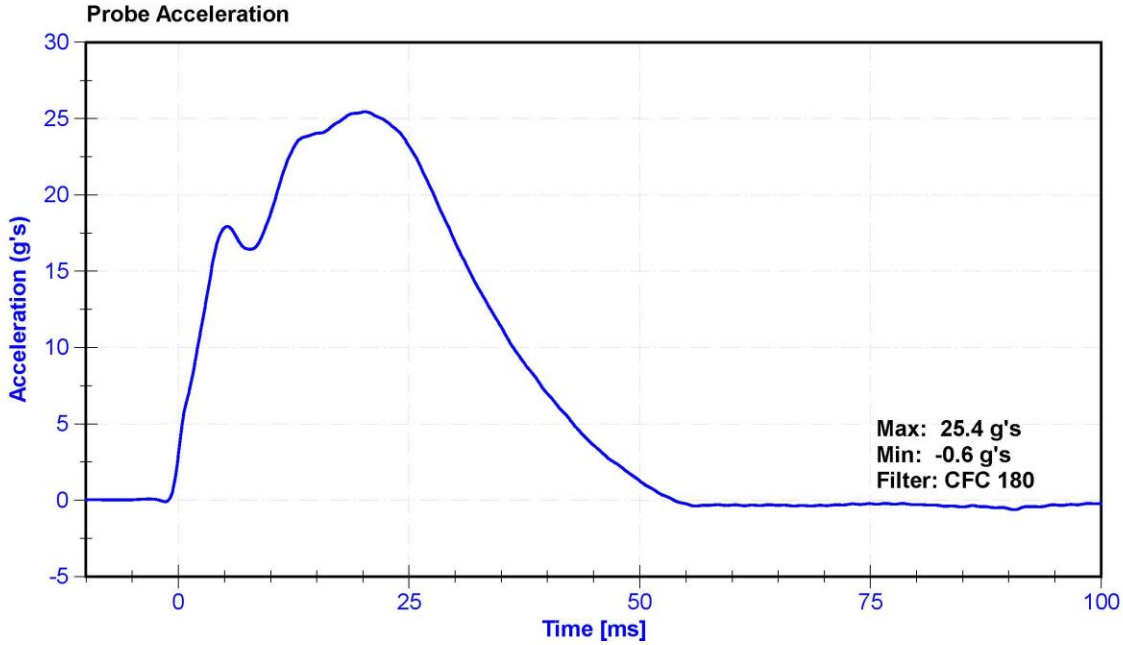
Transducer Calibrations

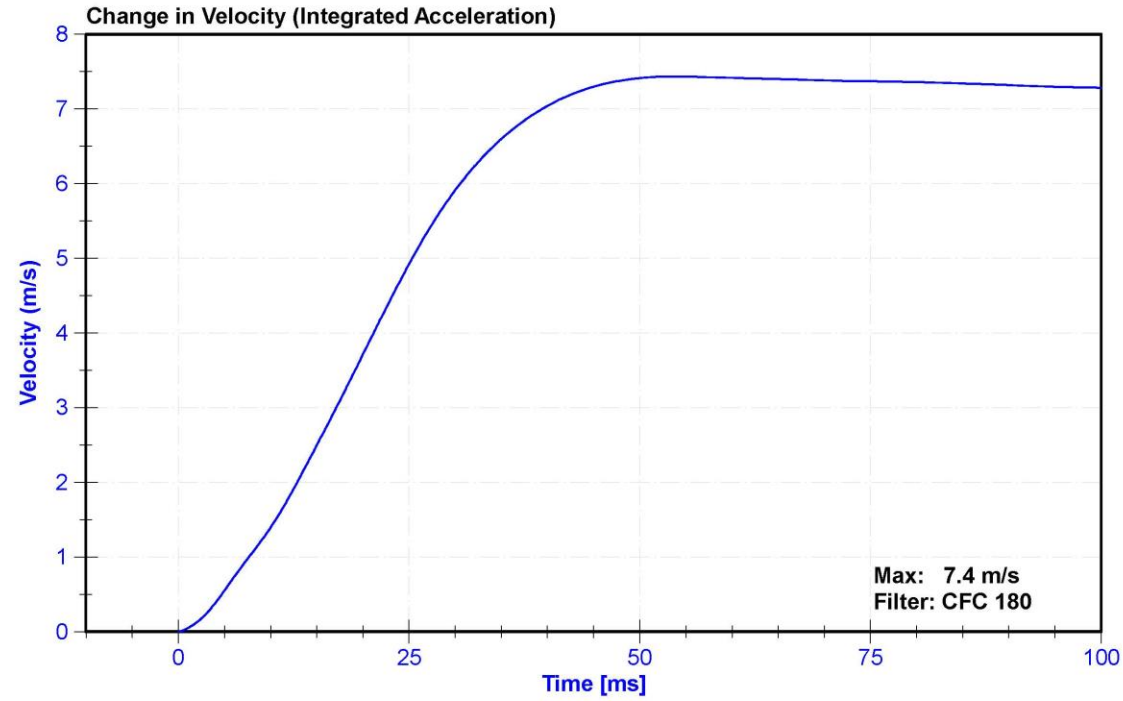
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020
Chest Potentiometer	JDK 6209-2038	DS-142	9/12/2019	9/11/2020




Resistive Force
Force (N)
6000
5000
4000
3000
2000
1000
0
-1000
0
25
50
75
100
Time [ms]
Max: 5807.0 N
Min: -141.7 N
Filter: CFC 180


Sternum Displacement
Displacement (mm)
25
0
-25
-50
-75
-100
0
25
50
75
100
Time [ms]
Max: 0.07 mm
Min: -63.66 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
30
25
20
15
10
5
0
-5
0
25
50
75
100
Time [ms]
Max: 25.4 g's
Min: -0.6 g's
Filter: CFC 180


Change in Velocity (Integrated Acceleration)
Velocity (m/s)
8
7
6
5
4
3
2
1
0
0
25
50
75
100
Time [ms]
Max: 7.4 m/s
Filter: CFC 180

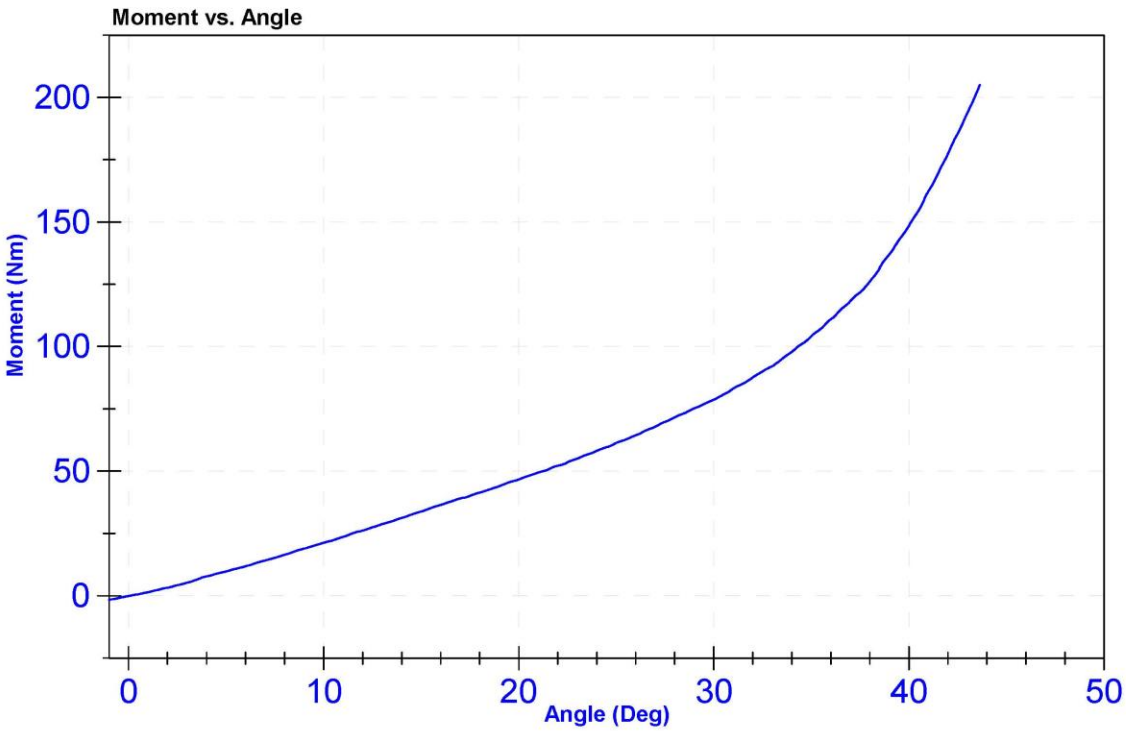
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	22.0	Pass
Humidity	10	70	%	24.2	Pass
Average Velocity	5	10	deg/s	7.0	Pass
Angle at 203Nm	40	50	deg	43.5	Pass
Moment at 30 degrees	0	94.9	Nm	78.7	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	ETI SP22	DS-0008	9/18/2019	9/17/2020
Load Cell	Key Trans 2301-02	LC-115 My	9/12/2019	9/11/2020



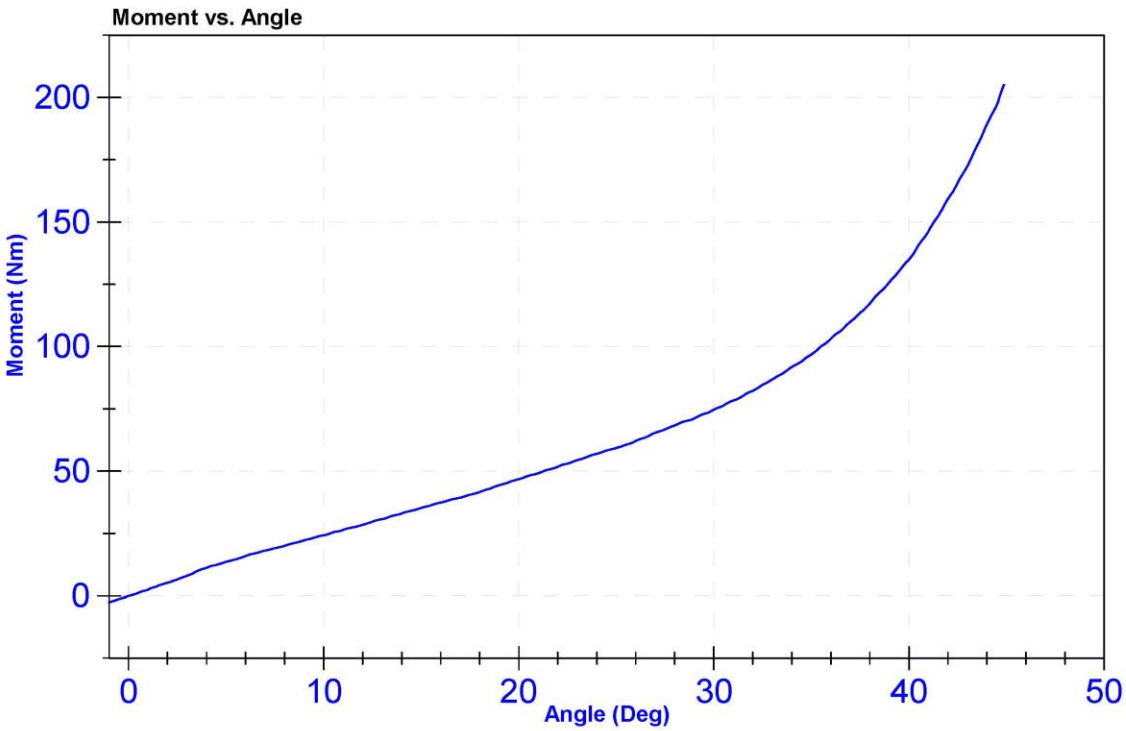
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	22.0	Pass
Humidity	10	70	%	24.2	Pass
Average Velocity	5	10	deg/s	7.0	Pass
Angle at 203Nm	40	50	deg	44.8	Pass
Moment at 30 degrees	0	94.9	Nm	74.8	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	ETI SP22	DS-0008	9/18/2019	9/17/2020
Load Cell	Key Trans 2301-02	LC-115 My	9/12/2019	9/11/2020



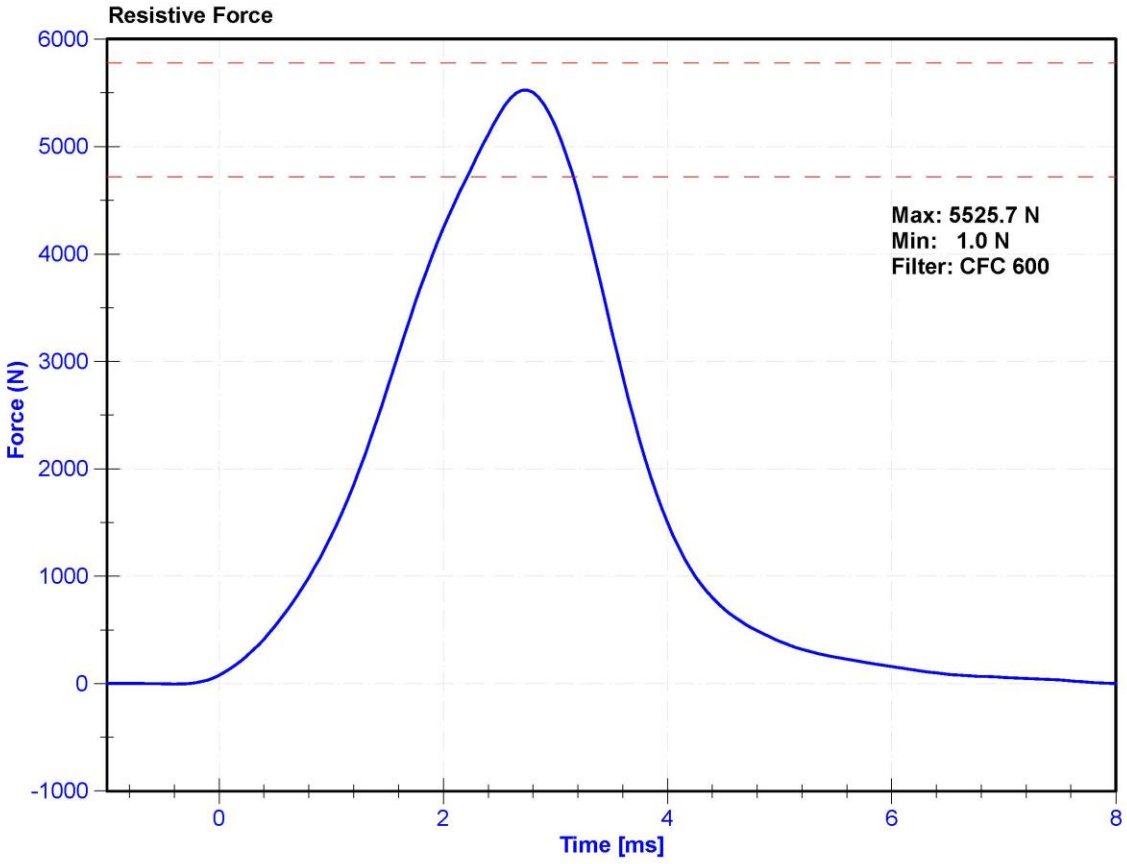
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

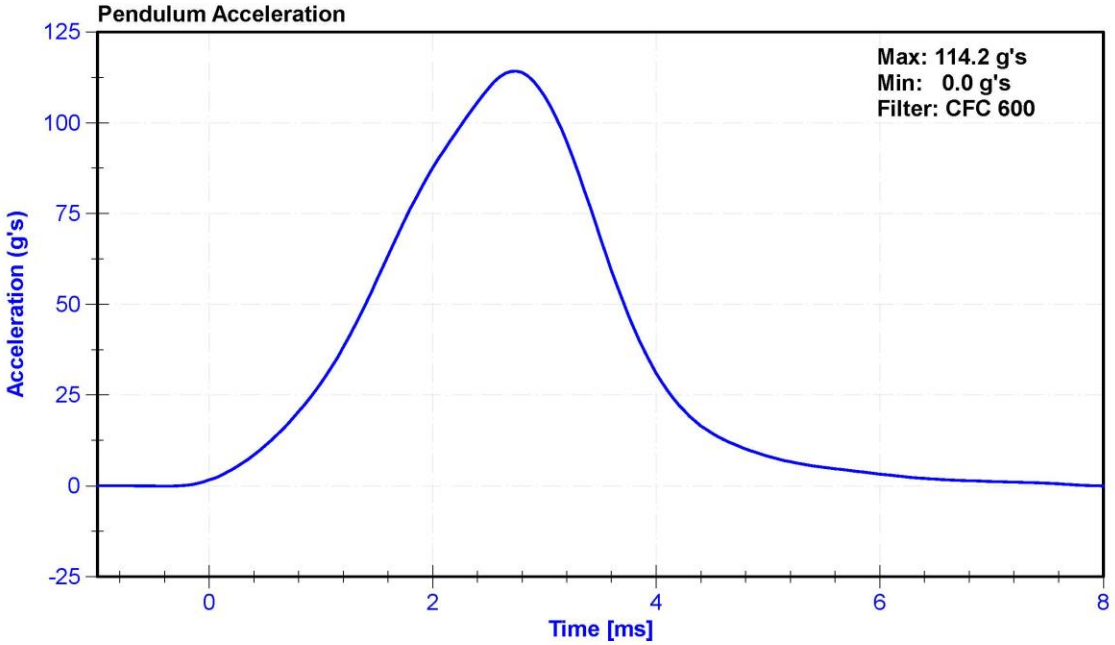
Results

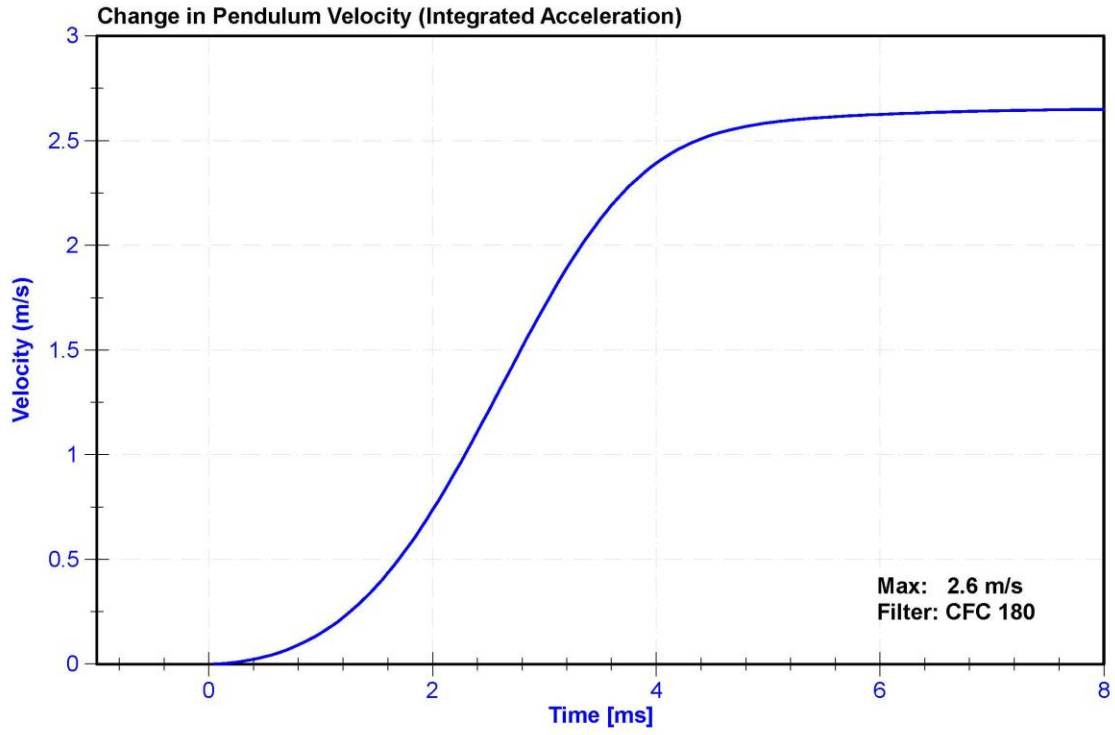
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.7	Pass
Humidity	10	70	%	31.4	Pass
Velocity	2.07	2.13	m/s	2.126	Pass
Maximum Resistive Force	4720	5780	N	5525.7	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020




Pendulum Acceleration
Max: 114.2 g's
Min: 0.0 g's
Filter: CFC 600
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]


Change in Pendulum Velocity (Integrated Acceleration)
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
Max: 2.6 m/s
Filter: CFC 180
0
2
4
6
8
Time [ms]

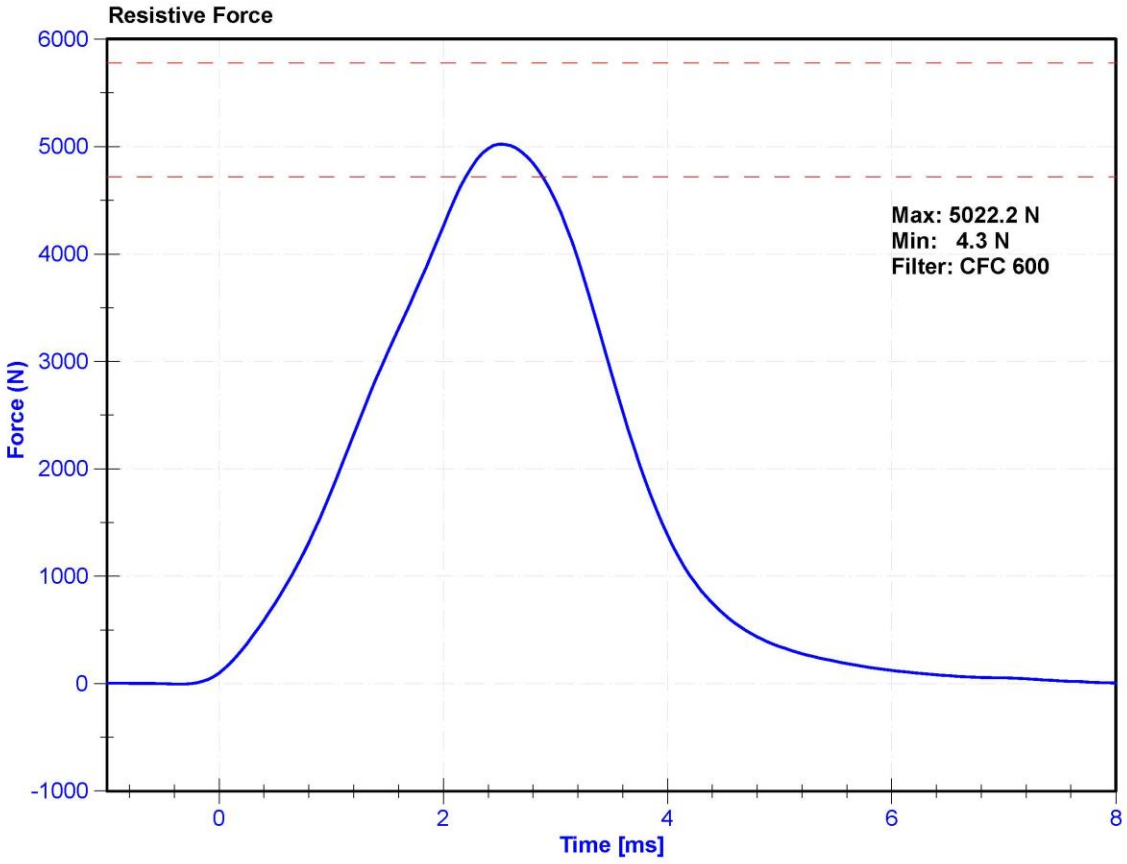
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

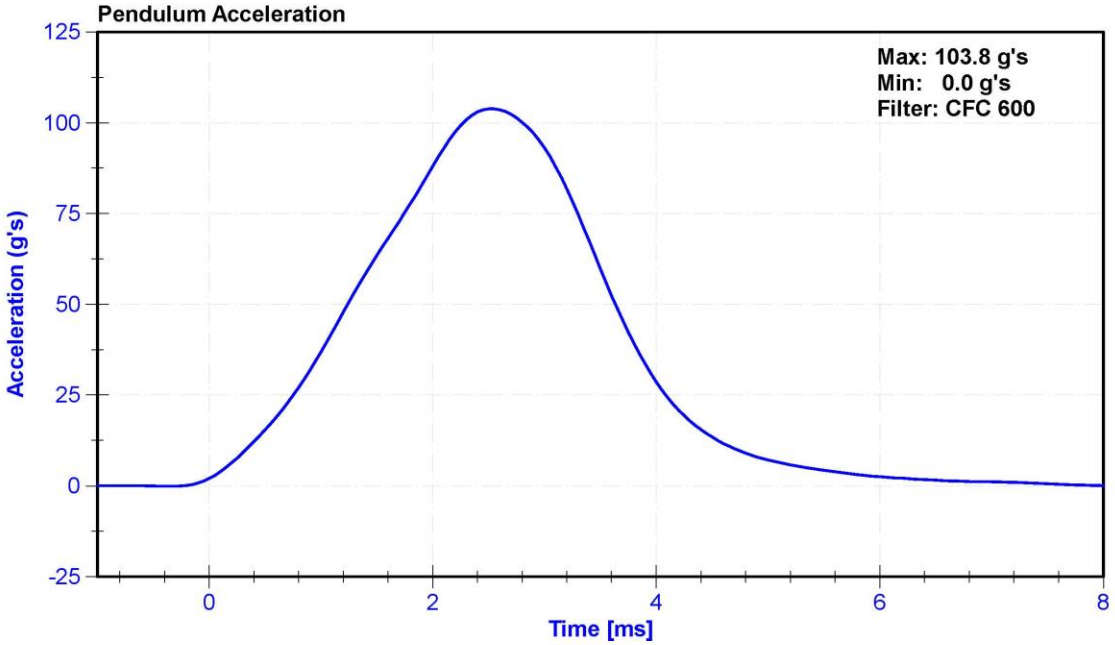
Results

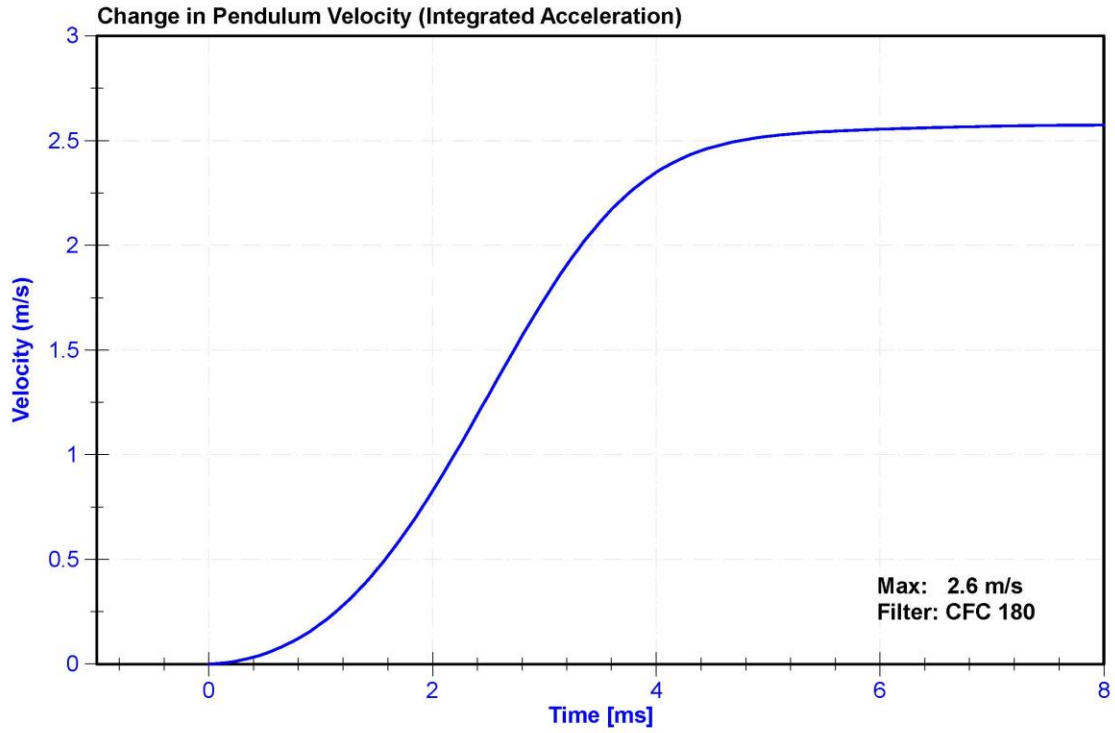
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.8	Pass
Humidity	10	70	%	31.4	Pass
Velocity	2.07	2.13	m/s	2.126	Pass
Maximum Resistive Force	4720	5780	N	5022.2	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020




Pendulum Acceleration
Max: 103.8 g's
Min: 0.0 g's
Filter: CFC 600
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]


Change in Pendulum Velocity (Integrated Acceleration)
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
Max: 2.6 m/s
Filter: CFC 180
0
2
4
6
8
Time [ms]

CALIBRATION TEST RESULTS

POST-TEST

HYBRID III 5TH PERCENTILE FEMALE - PASSENGER ATD

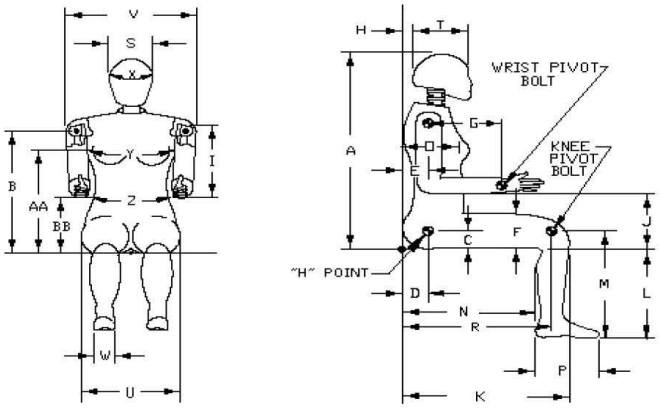
SERIAL NO: 288

Calspan

External Measurements - Hybrid 3 - 5th Female

Technician: K. Dutton Date: 03/13/2020

Dummy Serial Number: 288



Symbol	Description	Specification (mm)		Result (mm)	Pass/Fail
A	Sitting Height	775	800	787	Pass
B	Shoulder Pivot Height	432	457	450	Pass
C	H-Point Height	81	86	85	Pass
D	H-Point from Backline	145	150	148	Pass
E	Shoulder Pivot from Backline	69	84	77	Pass
F	Thigh Clearance	119	135	127	Pass
G	Back of Elbow to Wrist Pivot	244	259	256	Pass
H	Head Back to Backline	43	48	45	Pass
I	Shoulder to Elbow Length	277	297	284	Pass
J	Elbow Rest Height	183	203	192	Pass
K	Buttock to Knee Length	521	546	538	Pass
L	Popliteal Height	356	376	365	Pass
M	Knee Pivot Height	394	419	410	Pass
N	Buttock Popliteal Length	414	439	429	Pass
O	Chest Depth without Jacket	175	191	182	Pass
P	Foot Length (right)	219	234	221	Pass
R	Buttock To Knee Pivot Length	457	483	465	Pass
S	Head Breadth	137	147	141	Pass
T	Head Depth	178	188	183	Pass
U	Hip Breadth	300	315	310	Pass
V	Shoulder Breadth	351	366	361	Pass
W	Foot Breadth	79	94	85	Pass
X	Head Circumference	528	549	537	Pass
Y	Chest Circumference with Jacket	851	881	865	Pass
Z	Waist Circumference	460	790	777	Pass
AA	Reference Location (Chest Circumference)	333	358	345	Pass
BB	Reference Location (Waist Circumference)	160	170	164	Pass

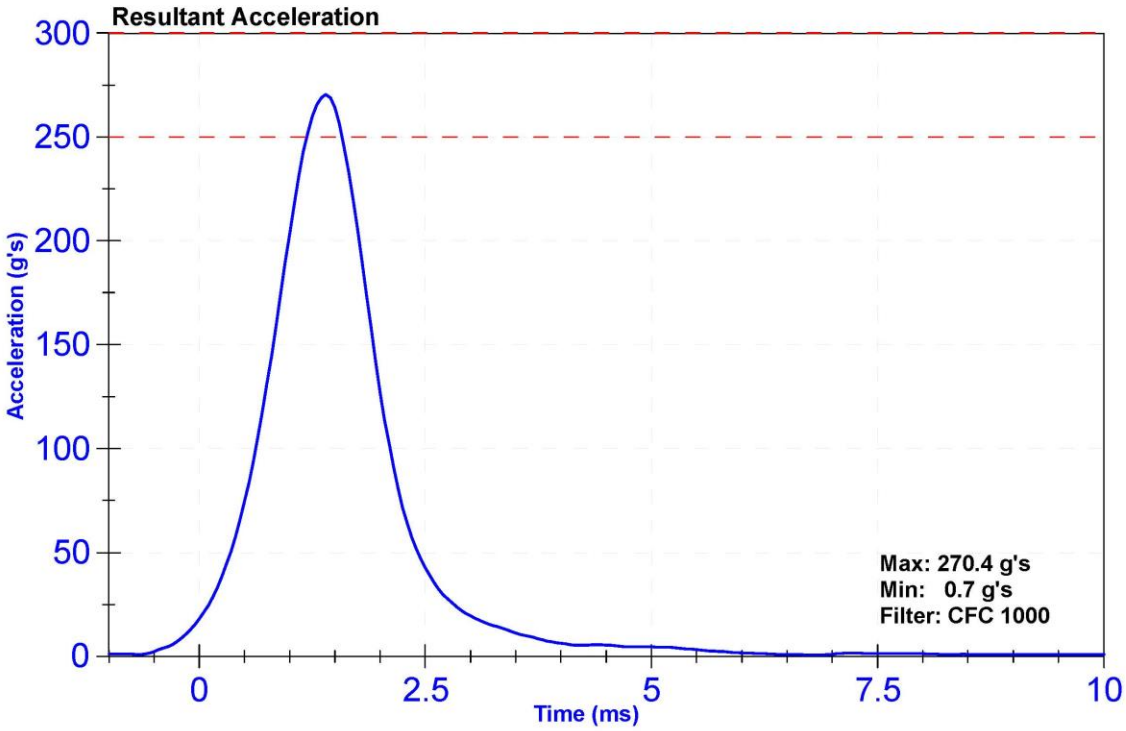
ATD Manufacturer	FTSS	Test Technician	D.Reinhard
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

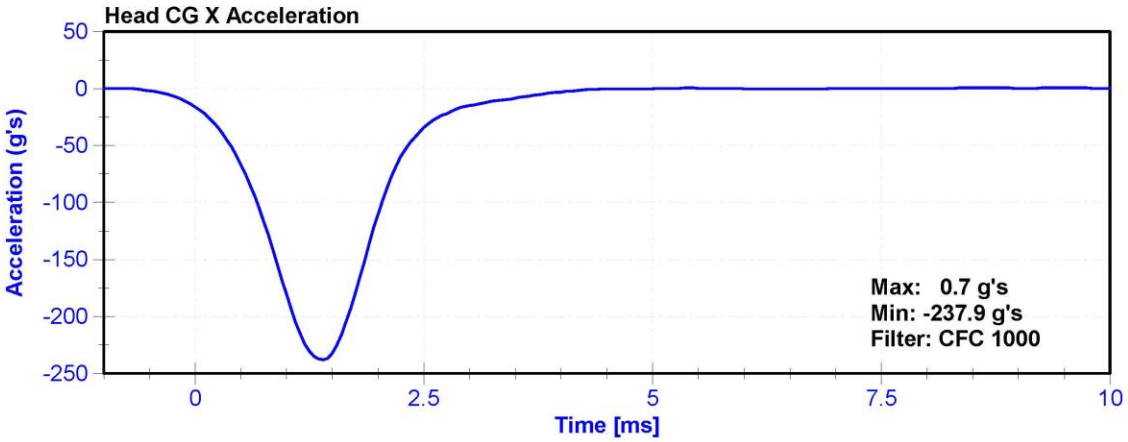
Results

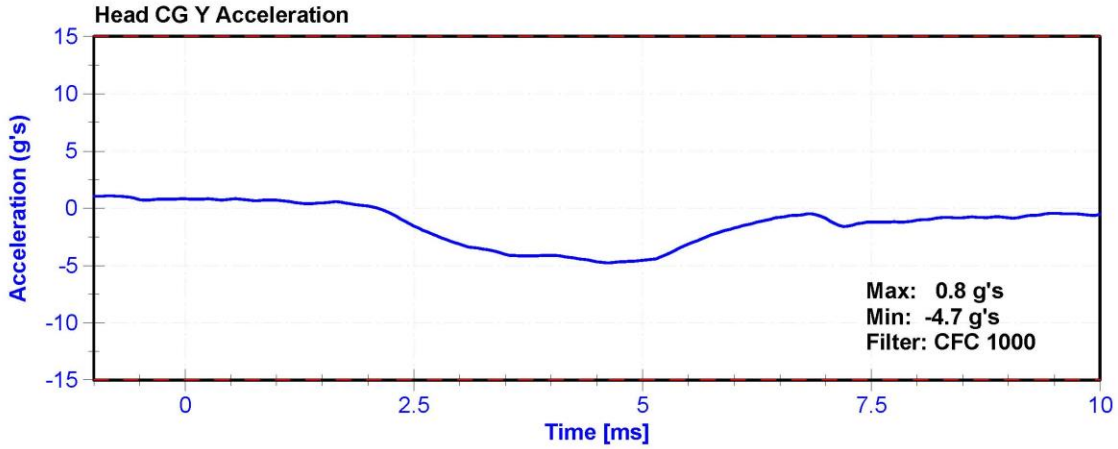
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	22	Pass
Humidity	10	70	%	29	Pass
Resultant Acceleration	250	300	g's	270.4	Pass
Oscillation	0	10	%	2.0	Pass
Lateral Acceleration	-15	15	g's	-4.7	Pass

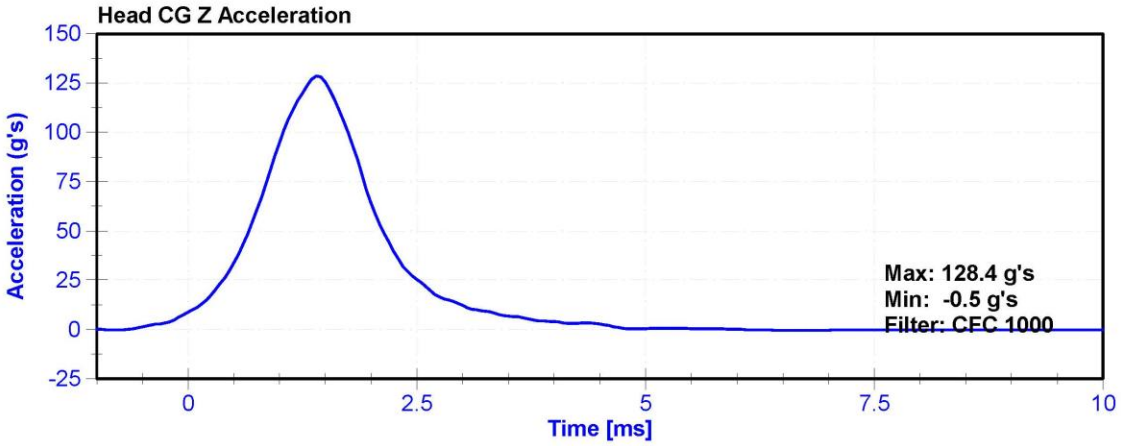
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264CT	AC-P58998	3/3/2020	9/1/2020
Y Accelerometer	ENDEVCO 7264CT	AC-P51722	3/3/2020	9/1/2020
Z Accelerometer	ENDEVCO 7264CT	AC-P58997	3/3/2020	9/1/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 0.7 g's
Min: -237.9 g's
Filter: CFC 1000


Head CG Y Acceleration
Acceleration (g's)
15
10
5
0
-5
-10
-15
0
2.5
5
7.5
10
Time [ms]
Max: 0.8 g's
Min: -4.7 g's
Filter: CFC 1000


Head CG Z Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2.5
5
7.5
10
Time [ms]
Max: 128.4 g's
Min: -0.5 g's
Filter: CFC 1000

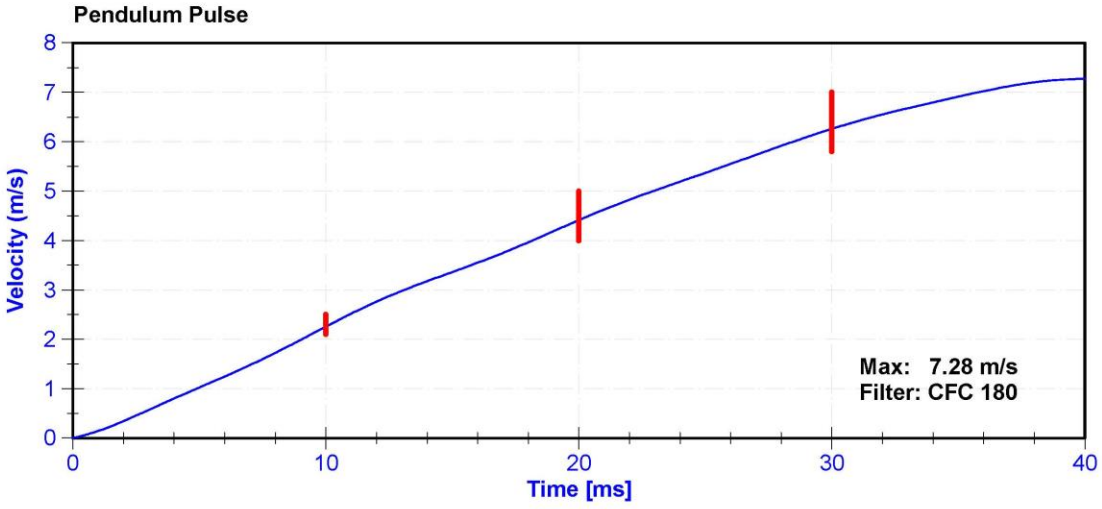
ATD Manufacturer	FTSS	Test Technician	M. Dudek
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

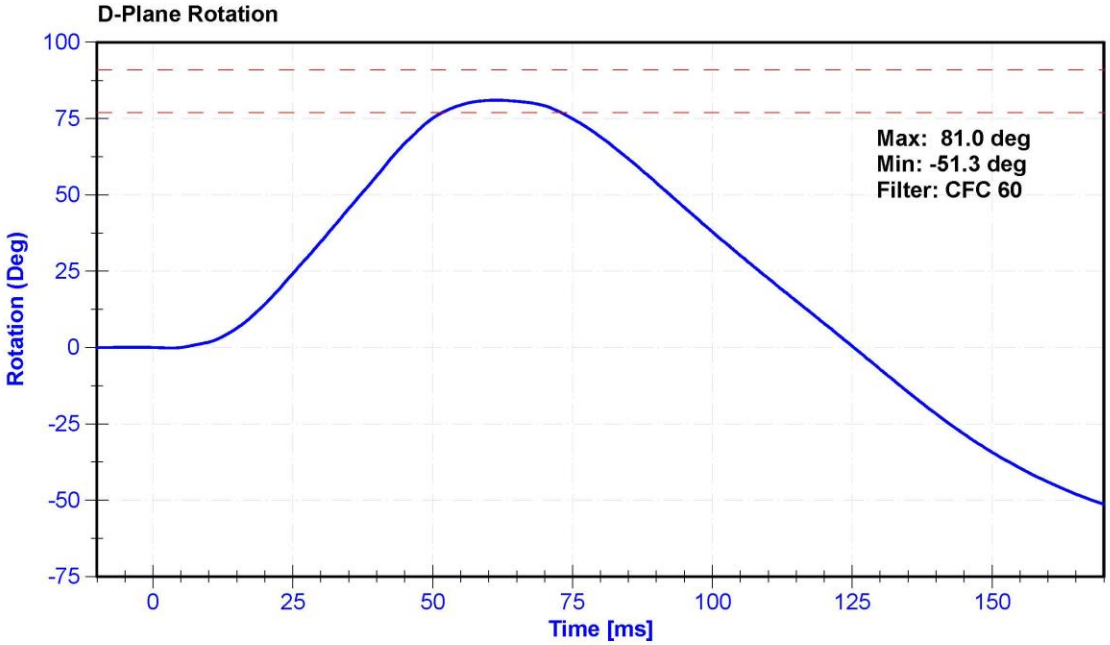
Results

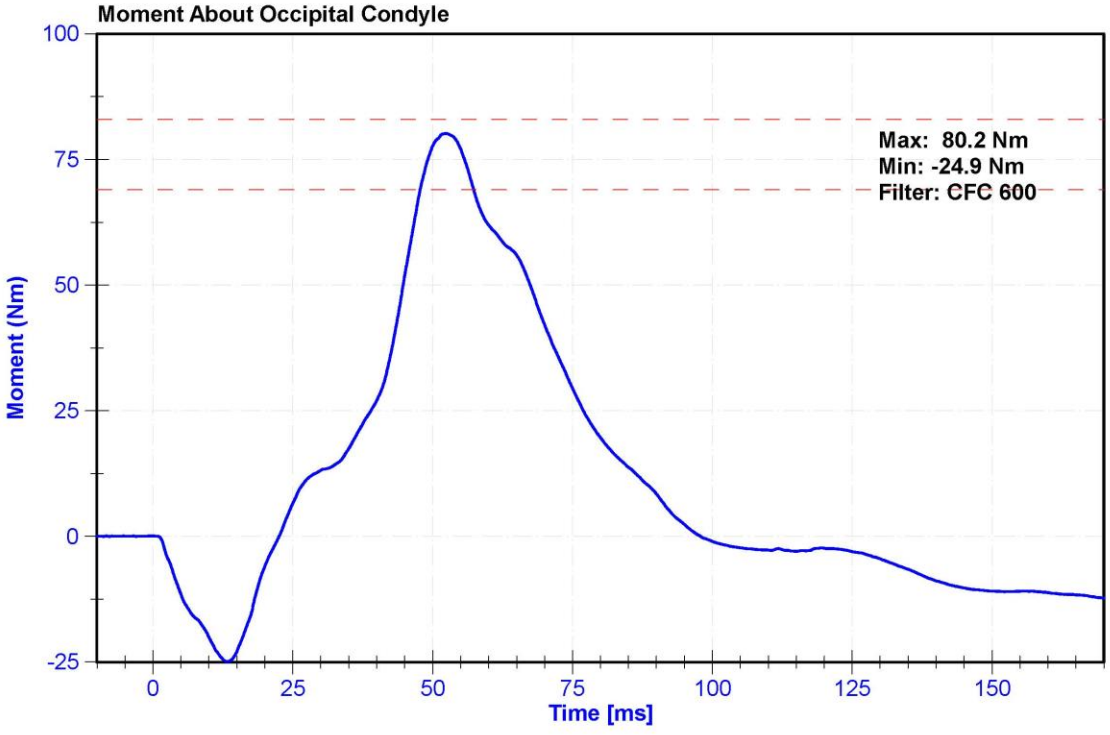
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	27.1	Pass
Velocity	6.89	7.13	m/s	6.903	Pass
Pendulum Impulse at 10ms	2.1	2.5	m/s	2.26	Pass
Pendulum Impulse at 20ms	4.0	5.0	m/s	4.41	Pass
Pendulum Impulse at 30ms	5.8	7.0	m/s	6.26	Pass
Max D Plane Rotation	77	91	deg	81.0	Pass
Max Moment During Rotation Interval	69	83	Nm	80.2	Pass
Moment Decay to 10.0 Nm	80	100	ms	88.7	Pass

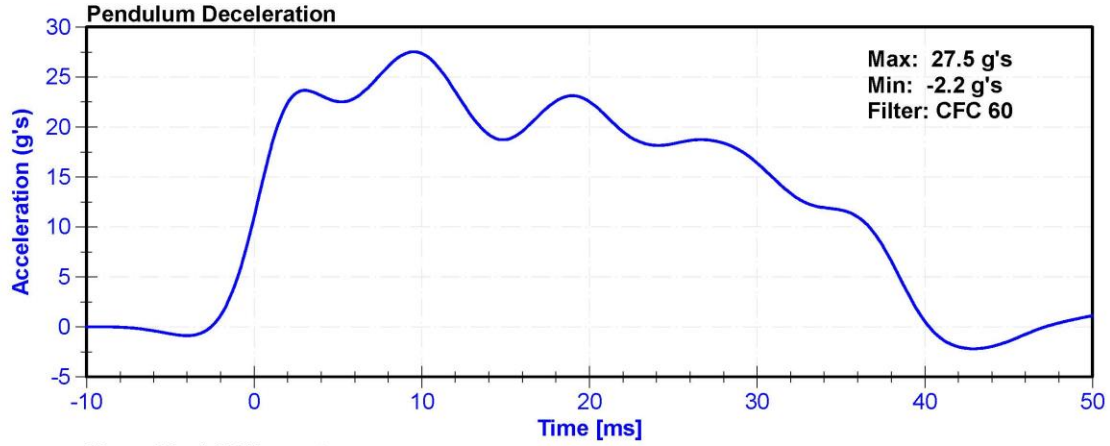
Transducer Calibrations

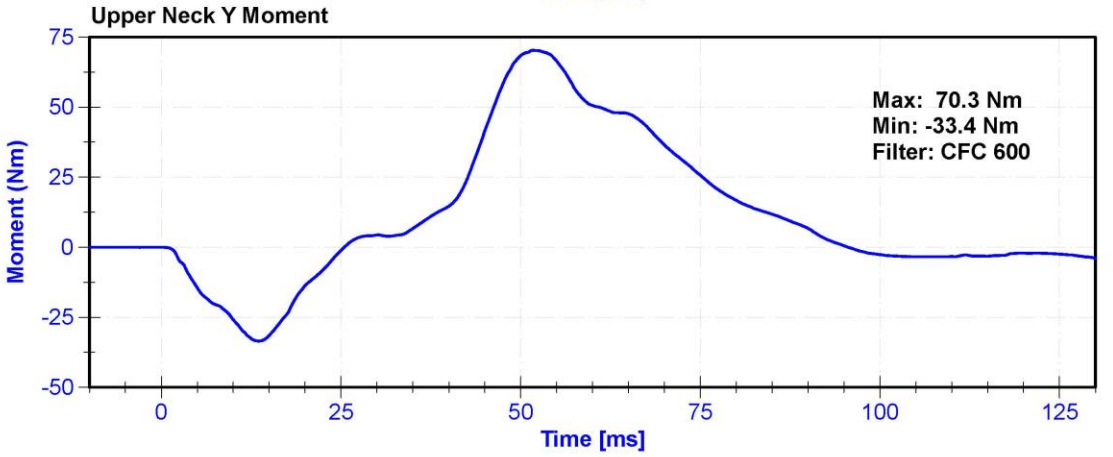
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton 1716	LC-1872 FX	10/5/2019	10/4/2020

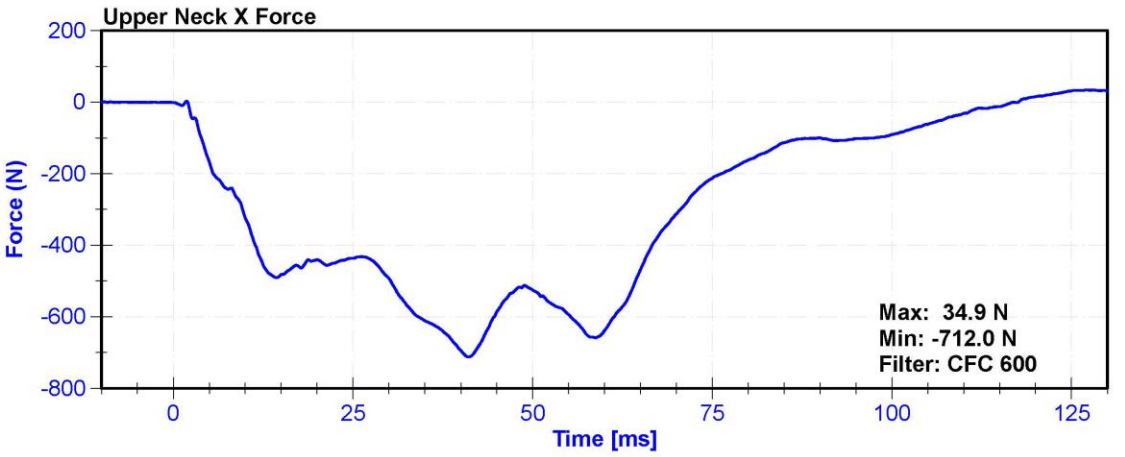



D-Plane Rotation
Max: 81.0 deg
Min: -51.3 deg
Filter: CFC 60
Rotation (Deg)
Time [ms]
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150


Moment About Occipital Condyle
Max: 80.2 Nm
Min: -24.9 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]
100
75
50
25
0
-25
0
25
50
75
100
125
150


Pendulum Deceleration
Max: 27.5 g's
Min: -2.2 g's
Filter: CFC 60
Acceleration (g's)
30
25
20
15
10
5
0
-5
-10
0
10
20
30
40
50
Time [ms]


Upper Neck Y Moment
Max: 70.3 Nm
Min: -33.4 Nm
Filter: CFC 600
Moment (Nm)
75
50
25
0
-25
-50
0
25
50
75
100
125
Time [ms]


Upper Neck X Force
Max: 34.9 N
Min: -712.0 N
Filter: CFC 600
Force (N)
200
0
-200
-400
-600
-800
0
25
50
75
100
125
Time [ms]

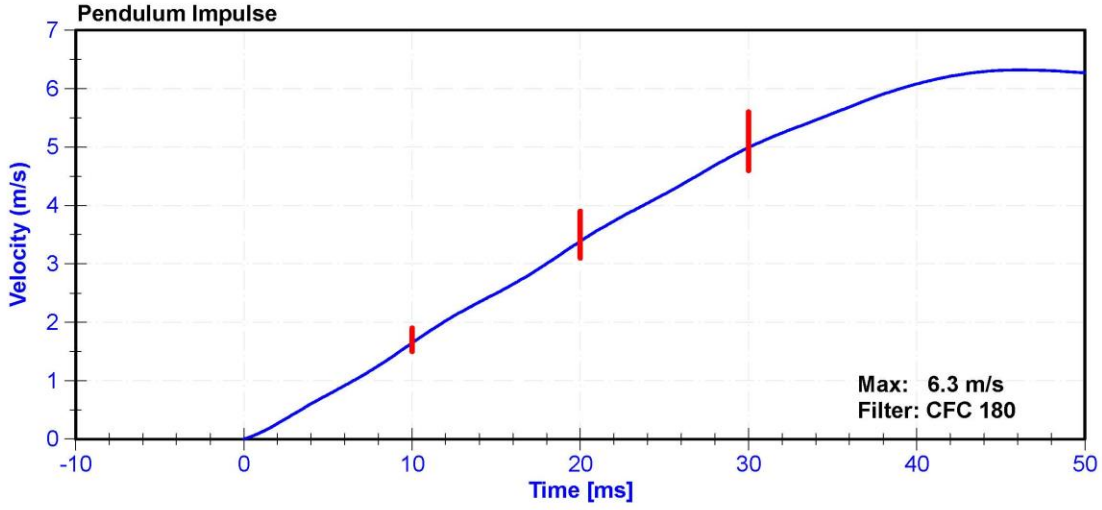
ATD Manufacturer	FTSS	Test Technician	E. Helenbrook
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

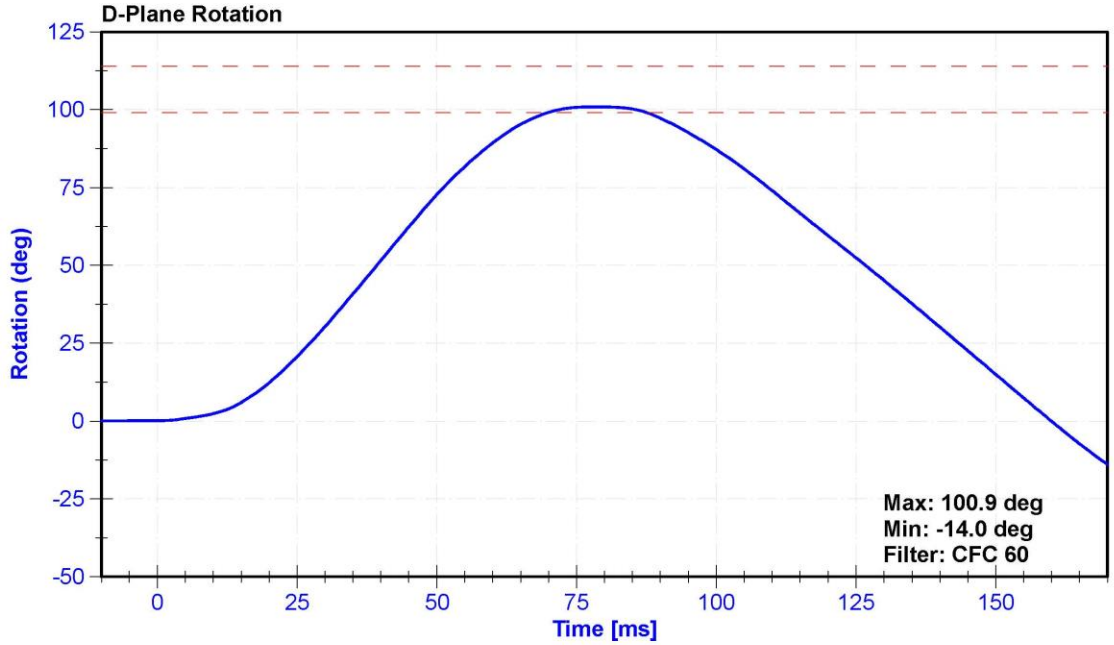
Results

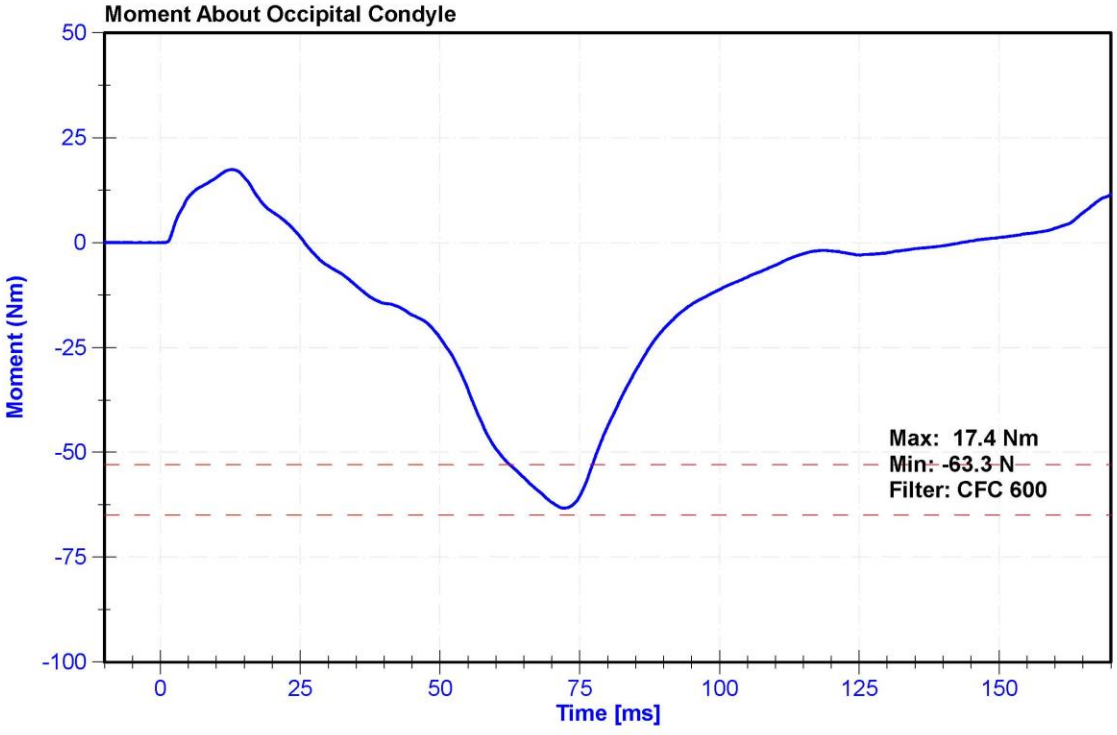
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.0	Pass
Humidity	10	70	%	29.5	Pass
Velocity	5.95	6.19	m/s	6.046	Pass
Pendulum Impulse at 10ms	1.5	1.9	m/s	1.64	Pass
Pendulum Impulse at 20ms	3.1	3.9	m/s	3.39	Pass
Pendulum Impulse at 30ms	4.6	5.6	m/s	4.99	Pass
D Plane Rotation	99	114	deg	100.9	Pass
Moment During Rotation Interval	-65	-53	Nm	-63.3	Pass
Moment Decay to -10Nm	94	114	ms	102.0	Pass

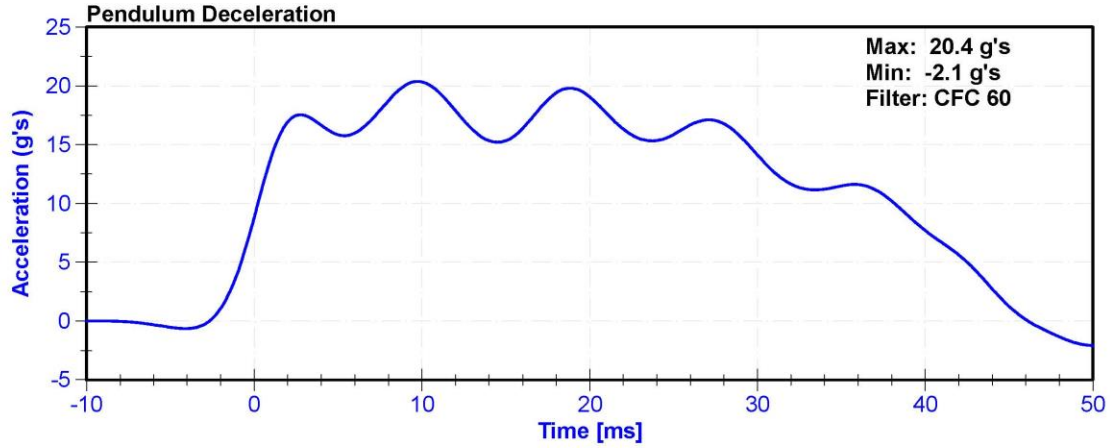
Transducer Calibrations

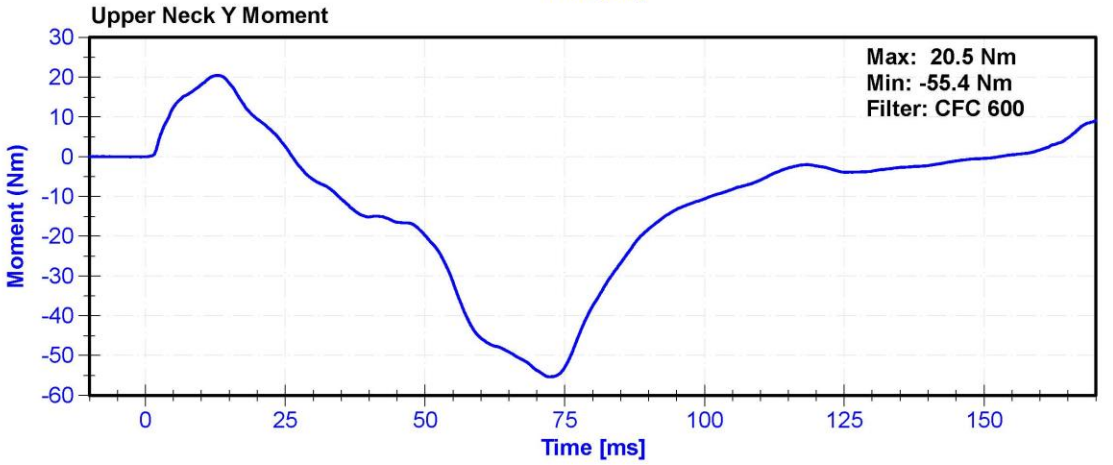
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton 1716	LC-1872 FX	10/5/2019	10/4/2020

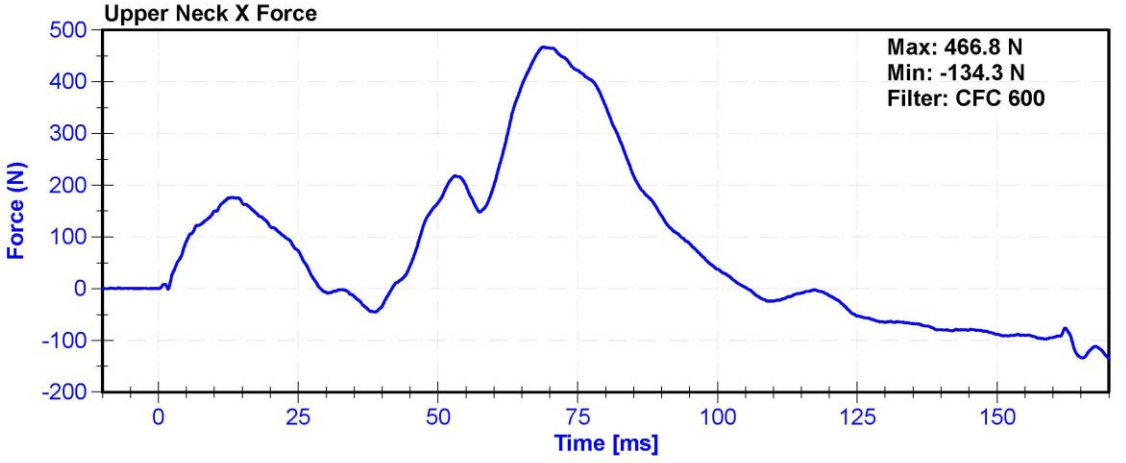



D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 100.9 deg
Min: -14.0 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
50
25
0
-25
-50
-75
-100
0
25
50
75
100
125
150
Time [ms]
Max: 17.4 Nm
Min: -63.3 N
Filter: CFC 600


Pendulum Deceleration
Max: 20.4 g's
Min: -2.1 g's
Filter: CFC 60
Acceleration (g's)
25
20
15
10
5
0
-5
-10
0
10
20
30
40
50
Time [ms]


Upper Neck Y Moment
Max: 20.5 Nm
Min: -55.4 Nm
Filter: CFC 600
Moment (Nm)
30
20
10
0
-10
-20
-30
-40
-50
-60
0
25
50
75
100
125
150
Time [ms]


Upper Neck X Force
Max: 466.8 N
Min: -134.3 N
Filter: CFC 600
Force (N)
500
400
300
200
100
0
-100
-200
0
25
50
75
100
125
150
Time [ms]

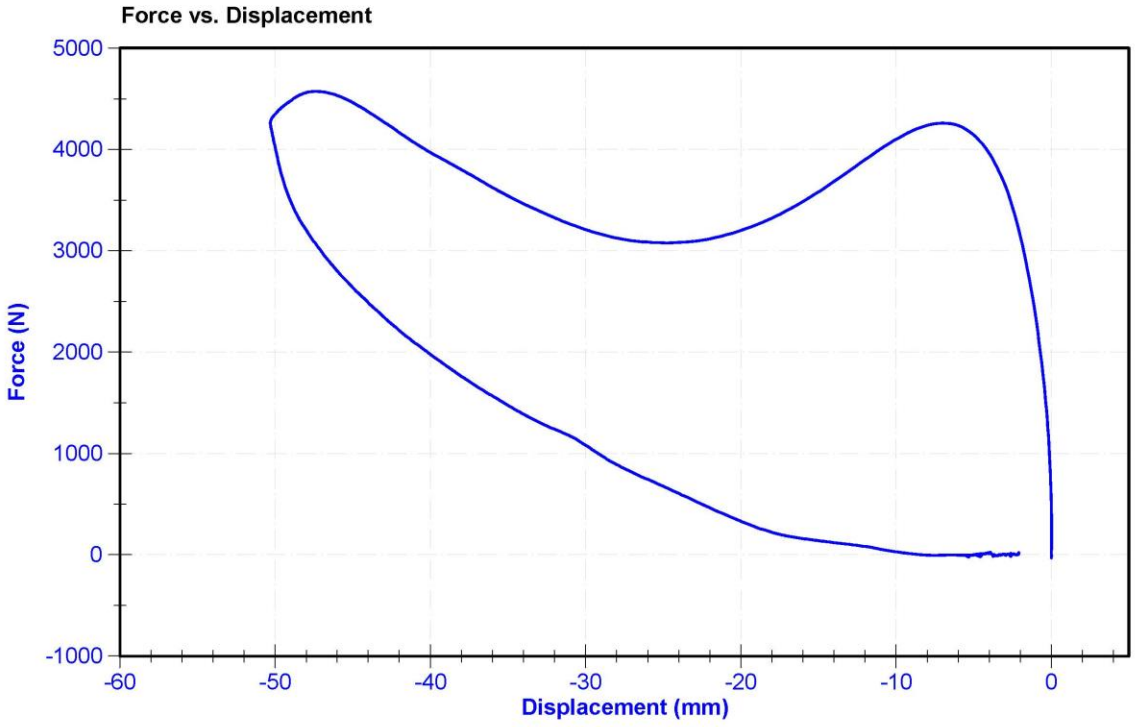
ATD Manufacturer	FTSS	Test Technician	C. Mantell
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

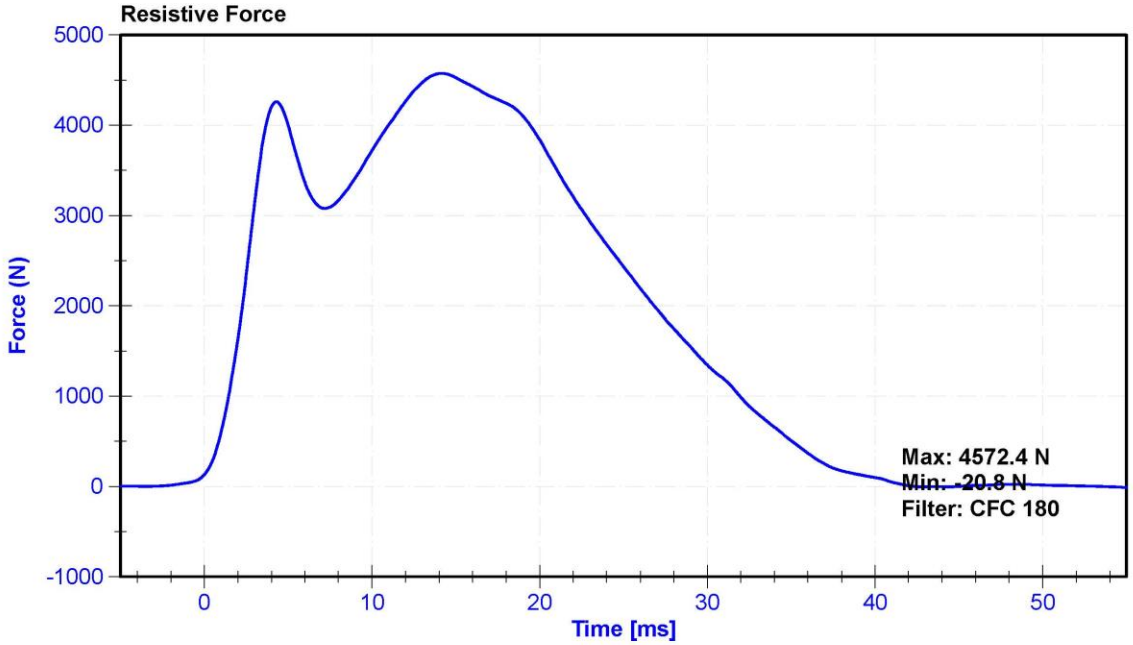
Results

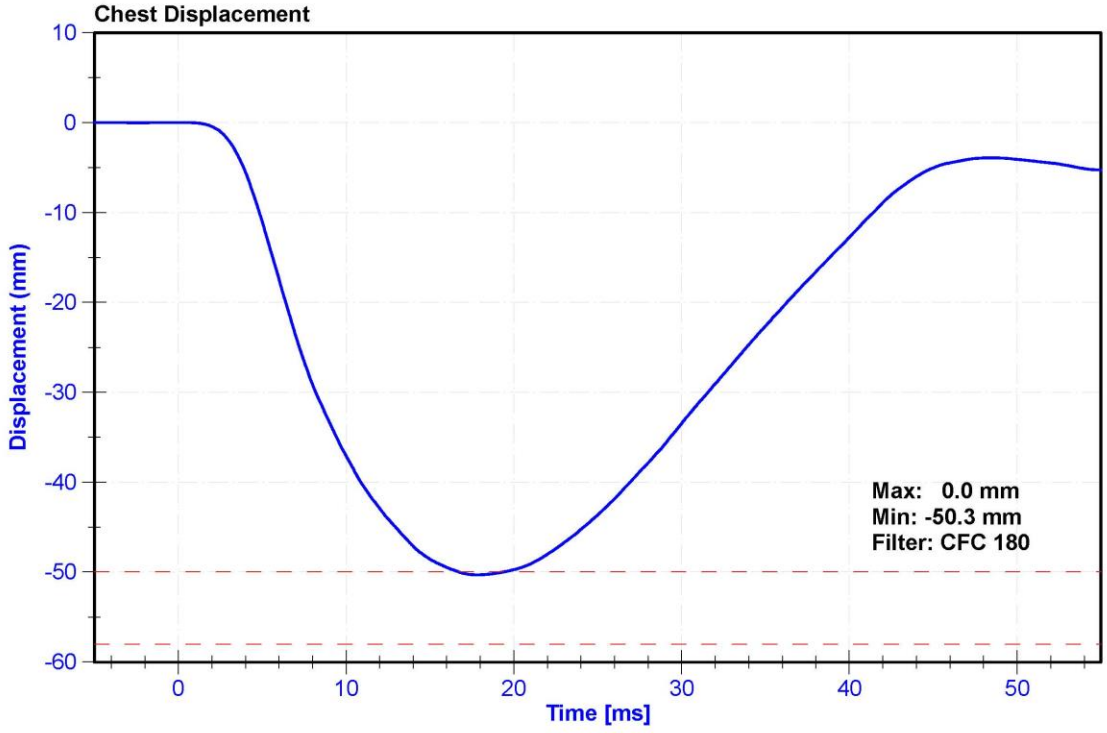
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.4	Pass
Humidity	10	70	%	22.7	Pass
Velocity	6.59	6.83	m/s	6.728	Pass
Chest Deflection	-58	-50	mm	-50.3	Pass
Maximum Resistive Force (50 to 58mm)	3900	4400	N	4353.8	Pass
Maximum Resistive Force (18 to 50mm)	0	4600	N	4572.4	Pass
Hysteresis	69	85	%	72.0	Pass

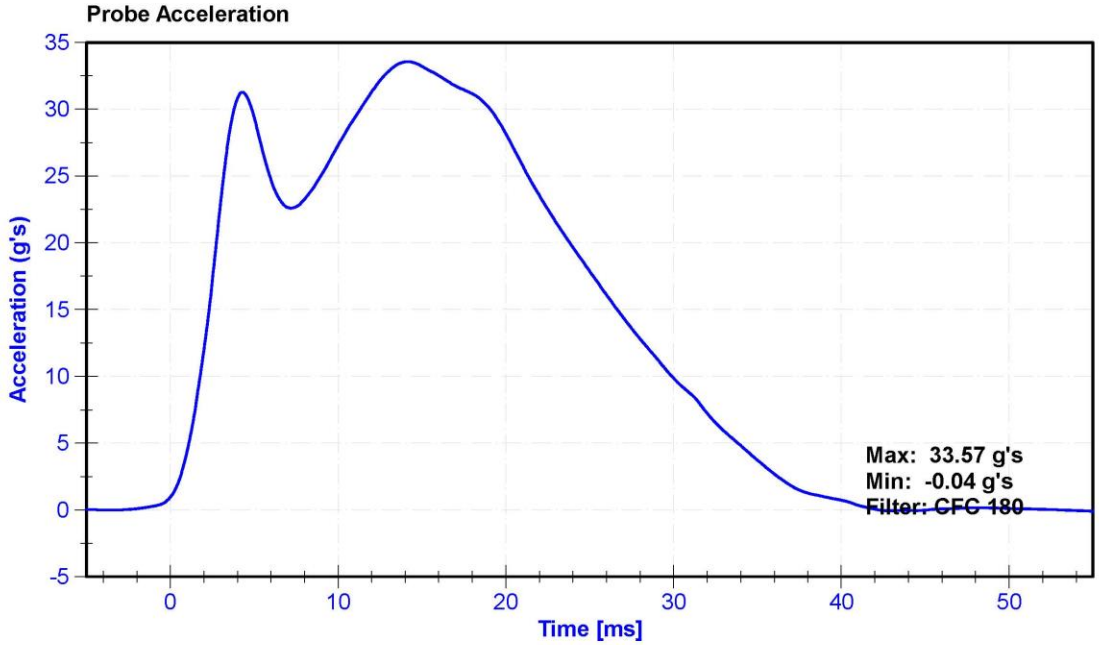
Transducer Calibrations

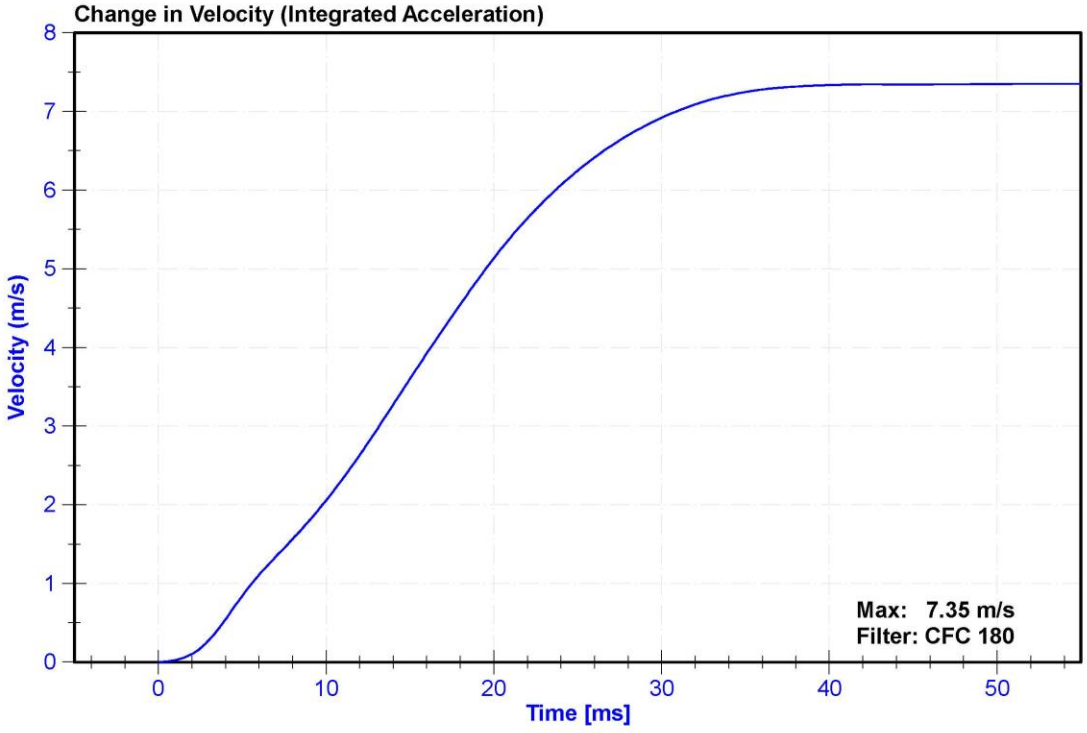
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020
Chest Potentiometer	SERVO 14CBI-3615	DS-140GFE	6/21/2019	6/20/2020




Resistive Force
Force (N)
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50
Time [ms]
Max: 4572.4 N
Min: -20.8 N
Filter: CFC 180


Chest Displacement
Displacement (mm)
10
0
-10
-20
-30
-40
-50
-60
0
10
20
30
40
50
Time [ms]
Max: 0.0 mm
Min: -50.3 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
35
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
Time [ms]
Max: 33.57 g's
Min: -0.04 g's
Filter: CFC 180


Change in Velocity (Integrated Acceleration)
Velocity (m/s)
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
Time [ms]
Max: 7.35 m/s
Filter: CFC 180

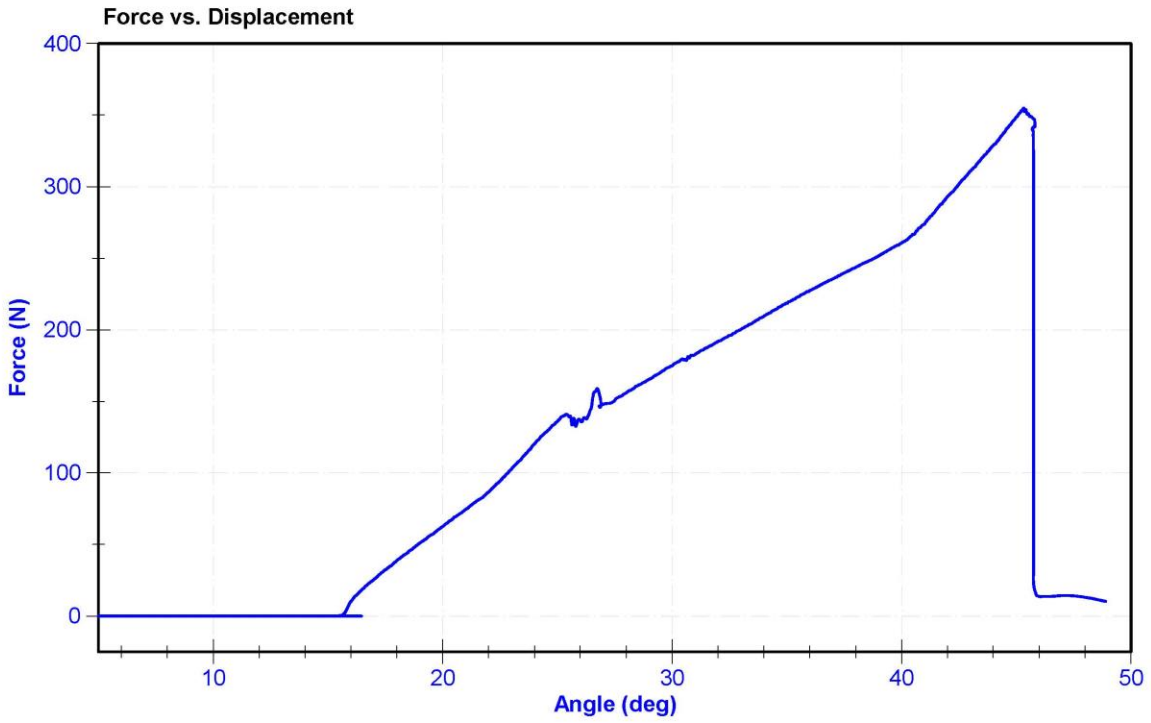
ATD Manufacturer	FTSS	Test Technician	D.Reinhard
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.6	25.6	ºC	21.2	Pass
Humidity	10	70	%	30	Pass
Initial Angle	0	20	deg	15.3	Pass
Force at 45 Degrees	320	390	N	355.0	Pass
Return Angle Relative to Initial	0	8	deg	6.7	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	Rieker N4C-1	DS-13051548	2019-12-09	2020-12-08
Load Cell	Interface SML-200	LC-493319	2020-01-10	2021-01-09



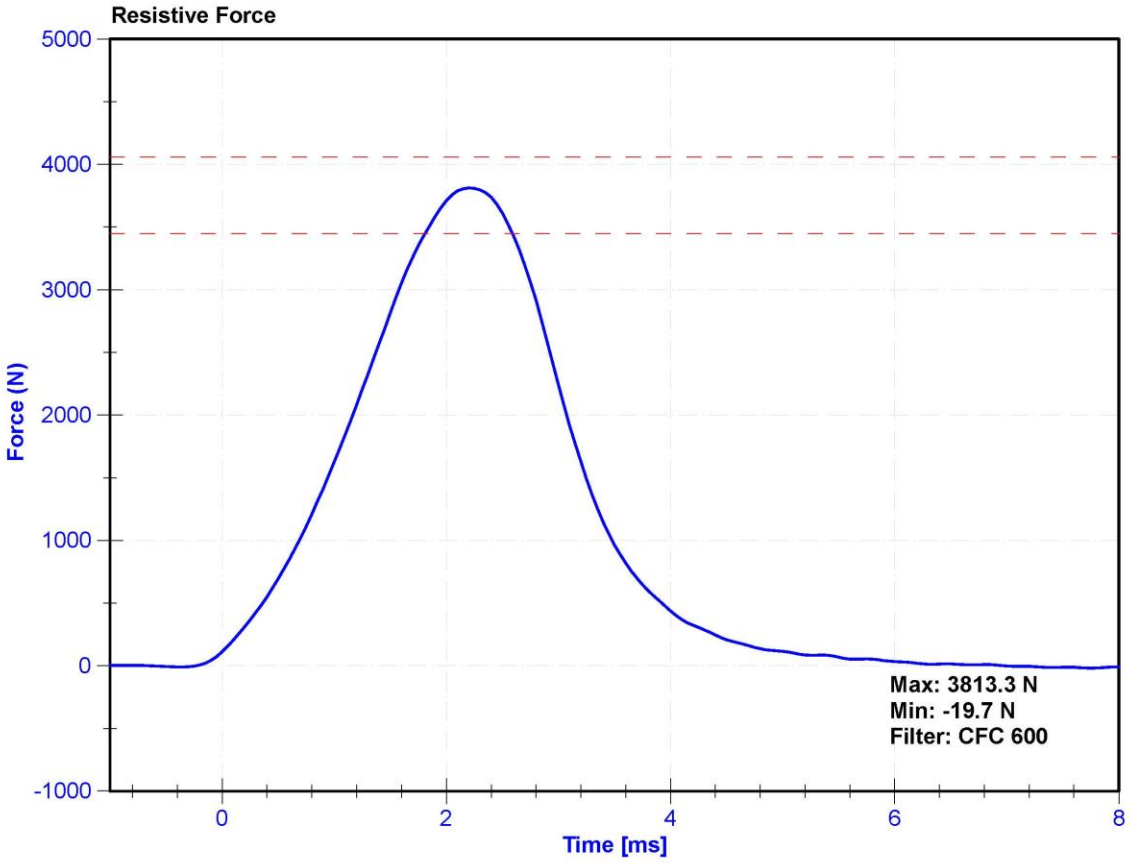
ATD Manufacturer	FTSS	Test Technician	M. Dudek
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

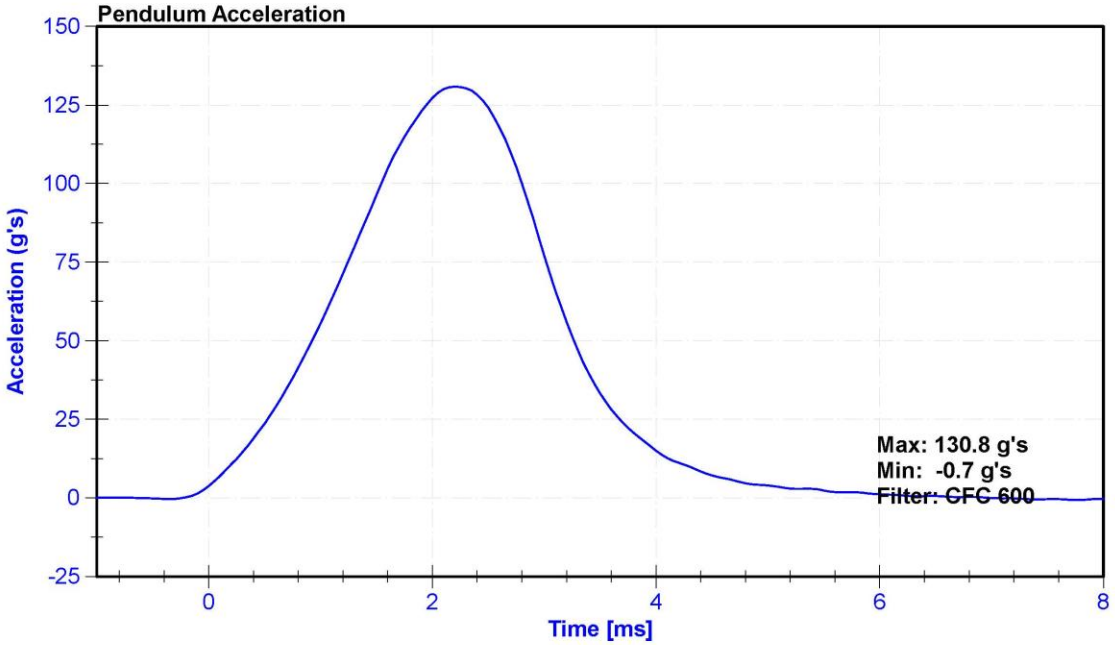
Results

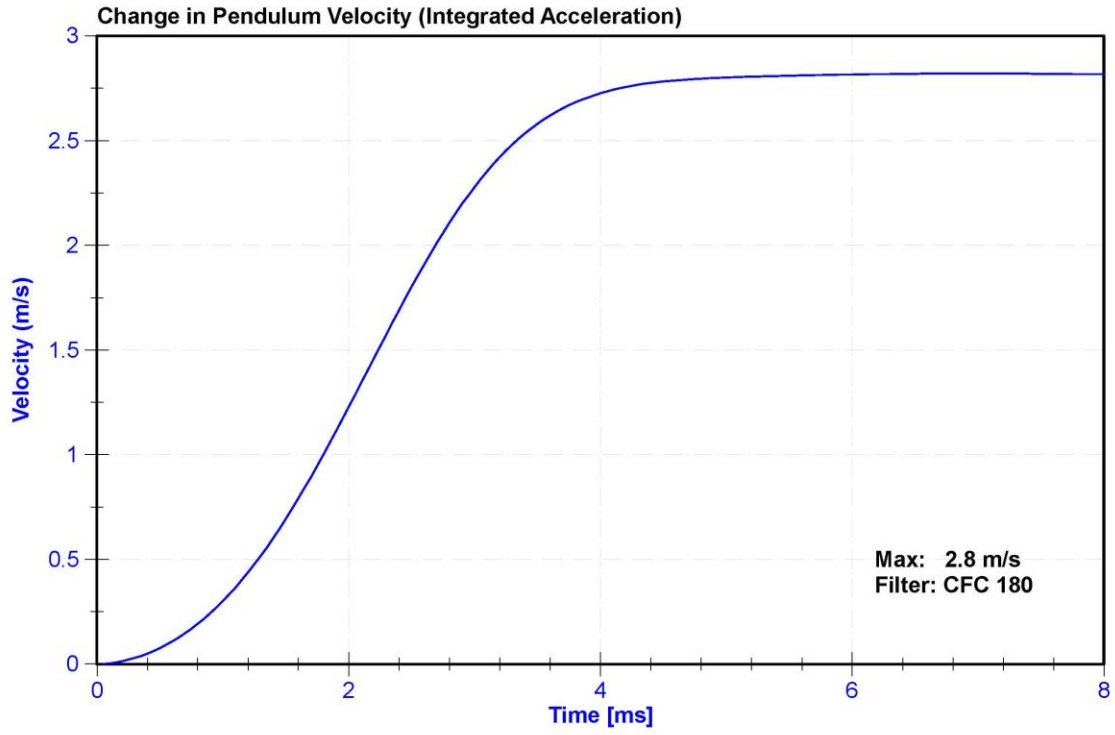
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	31.3	Pass
Velocity	2.07	2.13	m/s	2.128	Pass
Resistive Force	3450	4060	N	3813.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 130.8 g's
Min: -0.7 g's
Filter: CFC 600


Change in Pendulum Velocity (Integrated Acceleration)
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]
Max: 2.8 m/s
Filter: CFC 180

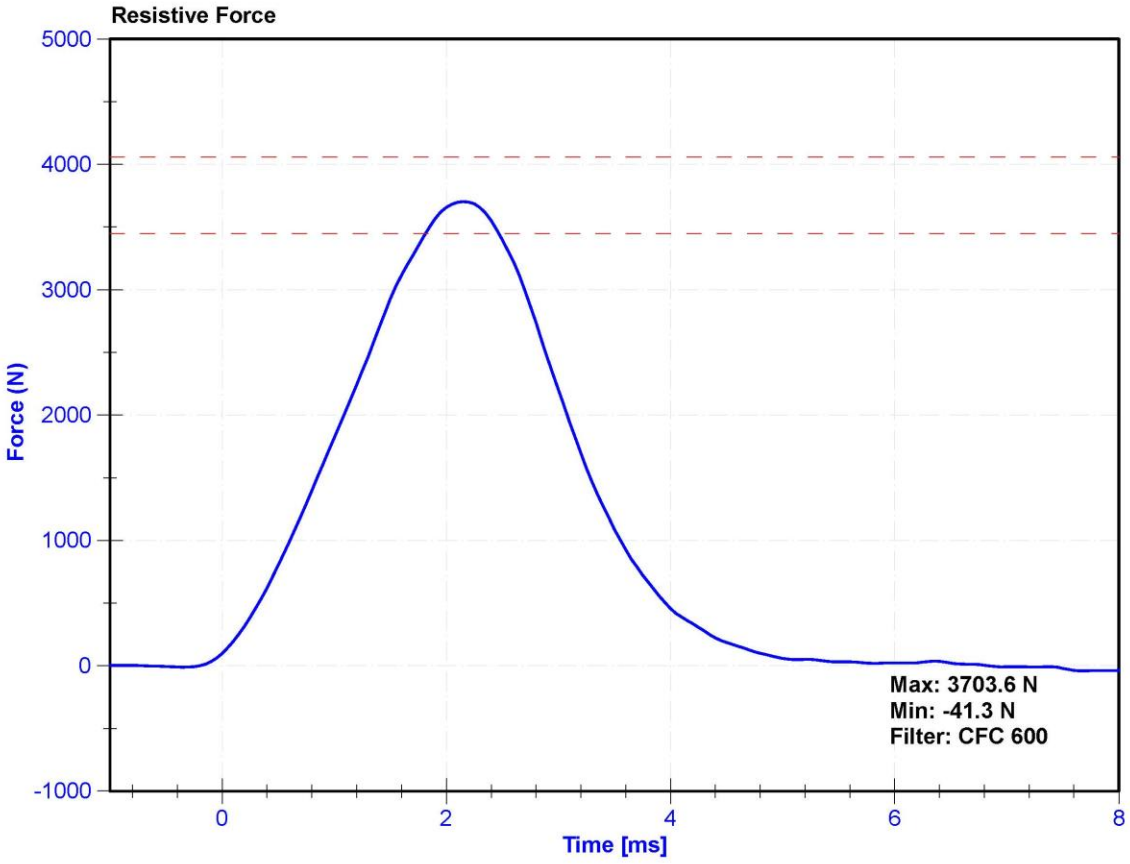
ATD Manufacturer	FTSS	Test Technician	M. Dudek
ATD Serial Number	288	Laboratory Supervisor	K. Brogan

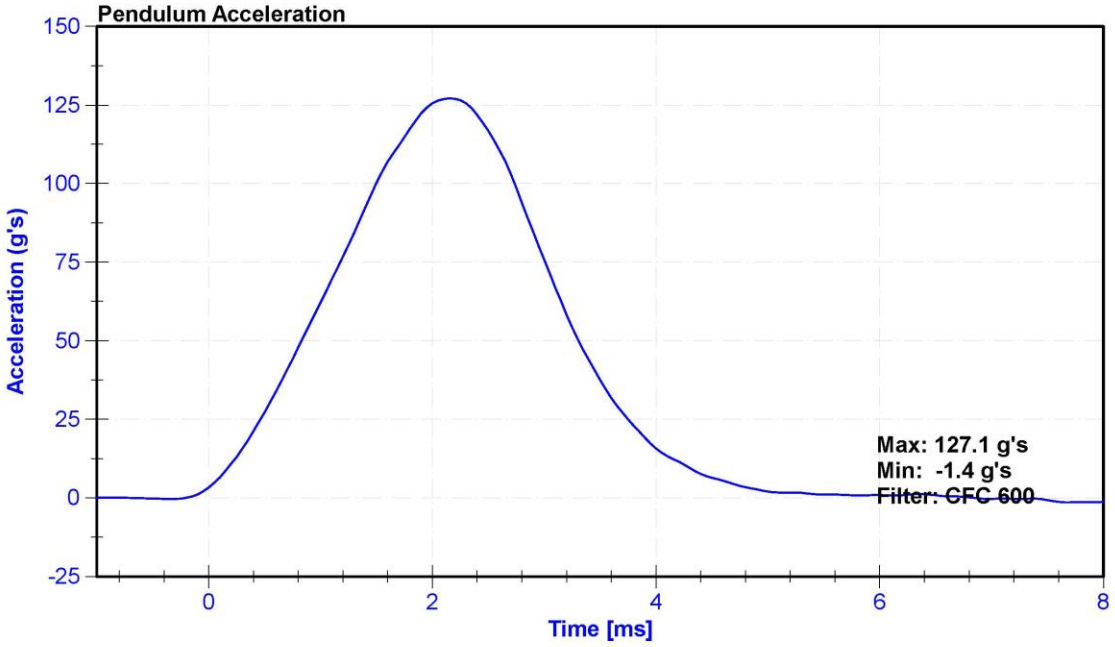
Results

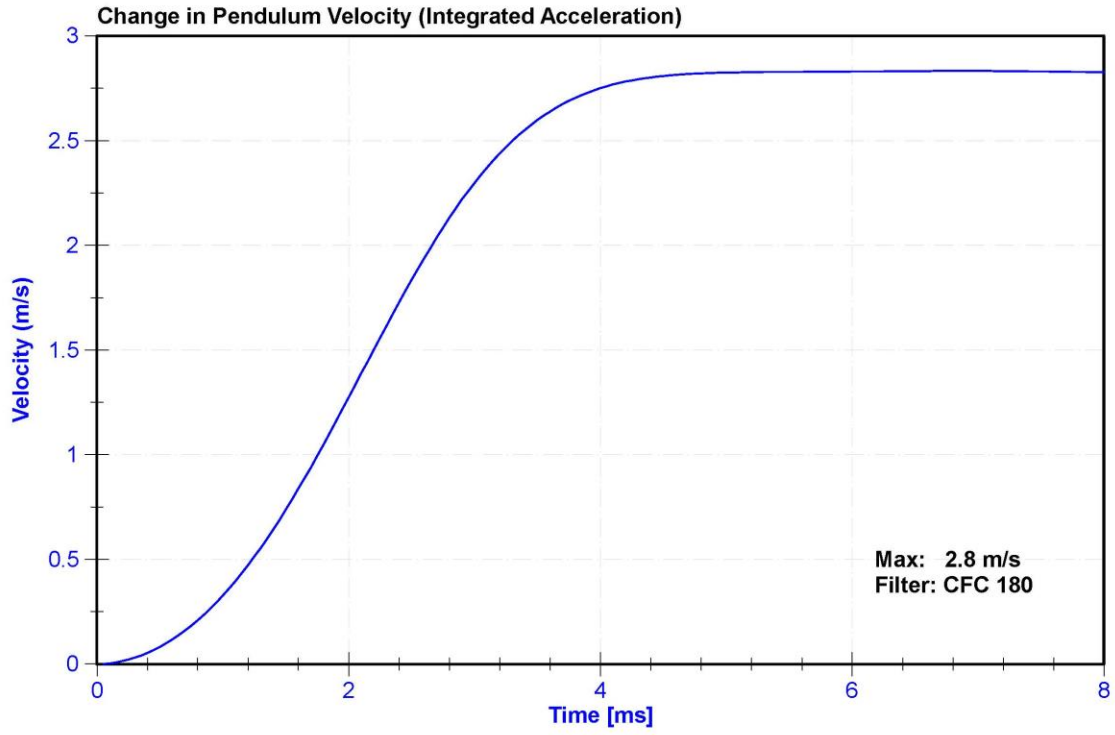
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	30.8	Pass
Velocity	2.07	2.13	m/s	2.096	Pass
Resistive Force	3450	4060	N	3703.6	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	1/29/2020	7/29/2020




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 127.1 g's
Min: -1.4 g's
Filter: CFC 600


Change in Pendulum Velocity (Integrated Acceleration)
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]
Max: 2.8 m/s
Filter: CFC 180

APPENDIX D

DUMMY CALIBRATION AND PERFORMANCE VERIFICATION DATA

Table 1 – Driver Dummy Instrumentation

Instrumentation		Axis/Location	Hybrid III 50th S/N: 142		
			Serial Number	Manufacturer	Calibration Date
Head Accelerometers	Primary	X	P51681	ENDEVCO	2/10/2020
		Y	P64151	ENDEVCO	2/10/2020
		Z	P52114	ENDEVCO	2/10/2020
	Redundant	X	P58833	ENDEVCO	2/10/2020
		Y	P58905	ENDEVCO	2/10/2020
		Z	P63996	ENDEVCO	2/10/2020
Head Angular Rate Sensors		X	ARS-5941 GFE	DTS	7/8/2019
		Y	ARS-6014 GFE	DTS	7/8/2019
		Z	ARS-5990	DTS	7/8/2019
Upper Neck Load Cell		FX, Fy, Fz MX,MY, MZ	LC-280FxGFE	Denton	10/3/2019
Chest Accelerometers	Primary	X	AC-P51994	ENDEVCO	2/17/2020
		Y	AC-P51991	ENDEVCO	2/17/2020
		Z	AC-P49185	ENDEVCO	2/17/2020
	Redundant	X	AC-P51713	ENDEVCO	2/17/2020
		Y	AC-P68059	ENDEVCO	2/17/2020
		Z	AC-P78824	ENDEVCO	2/17/2020
Chest Potentiometer		X	DS-142	JDK 6209-2038	9/12/2019
Pelvis Accelerometer		X	AC-P58800	ENDEVCO	2/17/2020
		Y	AC-P52157	ENDEVCO	2/17/2020
		Z	AC-P52156	ENDEVCO	2/17/2020
Femur Load Cells - Left	Primary	Z	LC-115-1 Fz	Denton	10/3/2019
	Redundant	Z	LC-115-2 Fz	Denton	10/3/2019
Femur Load Cells - Right	Primary	Z	LC-DI4210FZ1	Denton	10/3/2019
	Redundant	Z	LC-DI4210FZ2	Denton	10/3/2019
Tibia Load Cells - Left	Upper	MX, MY, FZ	LC-404Fx	Denton 3644	9/25/2019
	Lower	MX, MY, FZ	LC-396Fz	Denton 3644	9/25/2019
Tibia Load Cells – Right	Upper	MX, MY, FZ	LC-364Fz	Denton 3643	10/3/2019
	Lower	MX, MY, FZ	36440364 FZ	Denton 3644	9/25/2019
Foot Accelerometers - Left	Rear	X	AC-P50084	ENDEVCO	2/17/2020
	Front	Z	AC-P58779	ENDEVCO	2/17/2020
Foot Accelerometers - Right	Rear	X	AC-P51872	ENDEVCO	2/17/2020
	Front	Z	AC-P58893	ENDEVCO	2/17/2020
Seat belt Load Cells	Lap		LC-278	FTSS IF-964	11/2/2019
	Shoulder		LC-290	FTSS IF-964	11/2/2019

Table 2 – Front Passenger Dummy Instrumentation

Instrumentation		Axis/Location	Hybrid III 5th S/N: 288		
			Serial Number	Manufacturer	Calibration Date
Head Accelerometers	Primary	X	AC-P58998	ENDEVCO	3/3/2020
		Y	AC-P51722	ENDEVCO	3/3/2020
		Z	AC-P58997	ENDEVCO	3/3/2020
	Redundant	X	AC-P58780	ENDEVCO	3/3/2020
		Y	AC-P58749	ENDEVCO	3/3/2020
		Z	AC-P58909	ENDEVCO	3/3/2020
Head Angular Rate Sensors		X	ARS16992	DTS	5/28/2019
		Y	ARS-4712 GFE	DTS	7/8/2019
		Z	ARS11293	DTS	5/28/2019
Upper Neck Load Cell		FX, Fy, Fz MX,MY, MZ	LC-1872 FX	DENTON	10/5/2019
Chest Accelerometers	Primary	X	AC-P59019	ENDEVCO	3/3/2020
		Y	AC-P51965	ENDEVCO	3/3/2020
		Z	AC-P58981	ENDEVCO	3/3/2020
	Redundant	X	AC-P64000	ENDEVCO	3/3/2020
		Y	AC-P51970	ENDEVCO	3/3/2020
		Z	AC-P51689	ENDEVCO	3/3/2020
Chest Potentiometer		X	DS-140GFE	SERVO	6/21/2019
Pelvis Accelerometer		X	AC-P58912	ENDEVCO	10/21/2019
		Y	AC-P51220	ENDEVCO	10/21/2019
		Z	AC-P51989	ENDEVCO	10/21/2019
Femur Load Cells - Left	Primary	Z	LC-135Fz1	DENTON	10/3/2019
	Redundant	Z	LC-135Fz2	DENTON	10/3/2019
Femur Load Cells - Right	Primary	Z	LC-124Fz1	DENTON	10/3/2019
	Redundant	Z	LC-124Fz2	DENTON	10/3/2019
Tibia Load Cells - Left	Upper	MX, MY, FZ	3643-93 Fz	DENTON	10/3/2019
	Lower	MX, MY, FZ	LC-490Fz	DENTON	10/3/2019
Tibia Load Cells – Right	Upper	MX, MY, FZ	LC-91Fz	DENTON	10/3/2019
	Lower	MX, MY, FZ	LC-398Fz	DENTON	10/3/2019
Foot Accelerometers - Left	Rear	X	AC-P64005	ENDEVCO	10/21/2019
	Front	Z	AC-P64006	ENDEVCO	10/21/2019
Foot Accelerometers - Right	Rear	X	AC-P78669	ENDEVCO	10/21/2019
	Front	Z	AC-P52054	ENDEVCO	2/12/2020
Seat belt Load Cells	Lap		LC-174	FTSS	5/4/2019
	Shoulder		LC-DK1753	FTSS	5/4/2019

Table 3 – Vehicle Instrumentation

Instrumentation			Axis	Serial Number	Manufacturer	Calibration Date
Crossmember/Rear Seat Accelerometers	Left	Primary	X	AC-A280967	MSI	11/1/2019
			Z	A284374	MSI	9/22/2019
		Redundant	X	A282707	MSI	10/30/2019
	Right	Primary	X	AC-A280886	MSI	10/1/2019
			Z	A280962	MSI	2/20/2020
		Redundant	X	AC-A280951	MSI	2/20/2020
Engine Accelerometers	Top		X	AC-A279980	MSI	2/26/2020
	Bottom		X	AC-A280318	MSI	2/26/2020