REPORT NUMBER: NCAP-CAL-20-016

NEW CAR ASSESSMENT PROGRAM (NCAP)
FRONTAL BARRIER IMPACT TEST

Toyota Motor Manufacturing, Indiana, INC
2020 Toyota Highlander
Five Door SUV

NHTSA No: M20205100

PREPARED BY:
CALSPAN CORPORATION
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November 6, 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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Prepared by: Matthew Pronko Date: November 6, 2020
Matthew Pronko, Test Engineer

Approved by: Vanessa Hansen Date: November 6, 2020
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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15. Supplementary Notes		

16. Abstract

A 56.30 km/h (35 mph), NCAP frontal rigid barrier impact test was conducted on a 2020 Toyota Highlander SUV 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 August 10, 2020.

The impact velocity of the vehicle was 56.25 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 434 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. 139)	
		Threshold	Result	Threshold	Result
Head Injury Criteria (HIC_{15})		700	292.498	700	328.030
Maximum Chest Compression	mm	63	-29.280	52	-15.301
Nij		1	0.382	1	0.284
Neck Tension	N	4,170	1542.619	2,620	798.060
Neck Compression	N	4,000	-245.639	2,520	-402.015
Left Femur Force	N	10,008	-1428.248	6,805	-2426.356
Right Femur Force	N	10,008	-1082.209	6,805	-1437.981

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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 Toyota Highlander SUV at a velocity of 56.25 km/h. The test was performed at Calspan Corporation's Transportation Test Operations facility in Buffalo, New York on August 10, 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 not installed on the driver's and passenger's lap and shoulder belts to measure dummy torso and pelvic section loading per OEM request. The driver (position 1) ATD (Serial No. 142) and the right-front passenger (position 2) ATD (Serial No. 139) 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 434 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 and then the head restraint. 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})	292.498	0.382	1542.619	-245.639	47.248	-29.280	-1428.248	-1082.209
Passenger (5^{th})	328.030	0.284	798.060	-402.015	48.577	-15.301	-2426.356	-1437.981

GENERAL COMMENTS:

1. P1 (Driver) serial number - 142
2. P2 (Passenger) serial number – 139
3. Seatbelt load cells were not used for Driver or Passenger

Data Anomalies:

- Driver Left Foot AFT Z Acceleration – Accelerometer was inadvertently mounted in the Y-axis

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 Toyota Highlander SUV
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20205100
Test Date: 8/10/2020

TEST VEHICLE INFORMATION AND OPTIONS

NHTSA No.	M20205100
Model Year	2020
Make	Toyota
Model	Highlander
Body Style	SUV
VIN	5TDCZRBH7LS505321
Body Color	Silver
Odometer Reading (km /mi)	62 miles
Engine Displacement (L)	3.5
Type / No. Cylinders	V6
Engine Placement	Transverse
Transmission Type	Automatic
Transmission Speeds	8-Speed
Overdrive	Yes
Final Drive	All Wheel Drive
Roof Rack	No
Sunroof / T-Top	No
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
Passenger Cushion Airbag	Yes

Does owner's manual provide instructions to turn off automatic door locks? Yes

DATA FROM CERTIFICATION LABEL

Manufactured By	Toyota Motor Manufacturing, Indiana, INC.
Date of Manufacture	02/20

GVWR (kg)	2690
GAWR Front (kg)	1635
GAWR Rear (kg)	1635

VEHICLE SEATING AND WEIGHT CAPACITY DATA

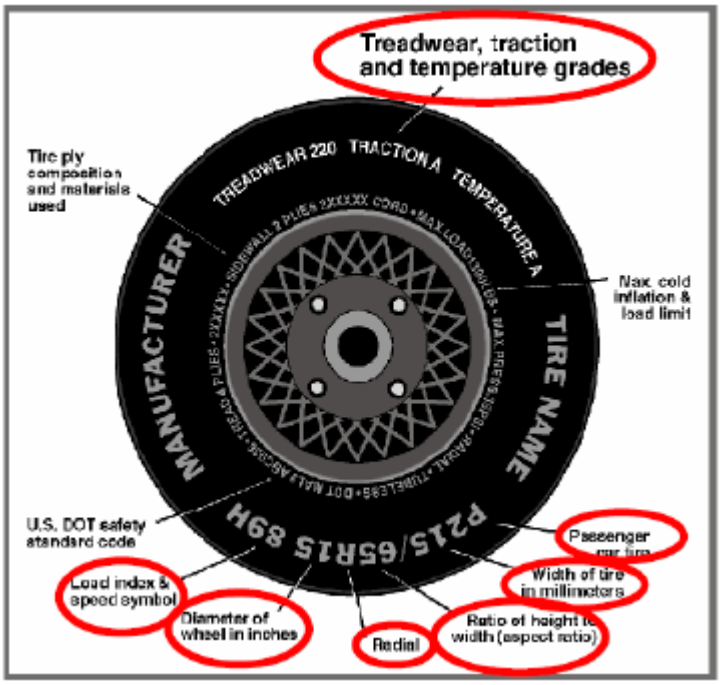
Measured Parameter	Front	Rear	Third	Total
Type of Seats	Bucket	Bench	Bench	
Number of Occupants	2	3	3	8
Capacity Wt. (VCW) (kg)				622*
Cargo Wt. (RCLW) (kg)				93.68

*Vehicle had a load reduction of 8kg

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

Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020

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	235/65R18	235/65R18
Tire Size on Vehicle	235/65R18	235/65R18
Tire Manufacturer	Bridgestone	Bridgestone
Tire Model	Alenza	Alenza
Treadwear	500	500
Traction	A	A
Temperature Grades	A	A
Tire Plies Sidewall	2 Polyester	2 Polyester
Tire Plies Body	2 Polyester, 2 Steel, 1 Nylon	2 Polyester, 2 Steel, 1 Nylon
Load Index / Speed Symbol	106V	106V
Tire Material	Rubber	Rubber
DOT Safety Code Left	IW2LMALA14419	IW2LMALA14619
DOT Safety Code Right	IW2LMALA10120	IW2LMALA10120

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

Test Vehicle: 2020 Toyota Highlander SUV NHTSA No.: M20205100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 8/10/2020

TEST VEHICLE WEIGHTS

	Units	As Delivered Weights (UVW)			As Tested Weights (ATW)		
		Front Axle	Rear Axle	Total	Front Axle	Rear Axle	Total
Left	kg	552	436		612	491	
Right	kg	546	414		547	511	
Ratio	%	56	44		54	46	
Totals	kg	1098	850	1948	1159	1002	2161

TARGET TEST WEIGHT CALCULATION

Measured Parameter	Units	Value	
Total Delivered Weight (UVW)	kg	1948	(A)
Weight of 1 P572E ATD & 1 P572O ATD	kg	142	(B)
Rated Cargo / Luggage Weight (RCLW)	kg	77.68	(C)
Calculated Vehicle Target Weight (TVTW)	kg	2167.68	(A+B+C)

TEST VEHICLE ATTITUDES AND CG

Condition	Units	LF	RF	LR	RR	CG (aft of front axle)
As Delivered	mm	886	887	900	908	1245
As Tested	mm	877	880	870	879	1323
Post-Test	mm	860	885	863	888	

GENERAL TEST VEHICLE DATA

Measurement Description	Units	Value
Total Vehicle Wheel Base	mm	2854
Total Vehicle Length at Left Side	mm	4889
Total Vehicle Length at Centerline	mm	4948
Total Vehicle Length at Right Side	mm	4889
Weight of Ballast in Cargo Area	kg	35.5
Weight of Vehicle Components Removed	kg	43
Amount of Stoddard Solvent in Fuel Tank	L	63.3

LIST OF COMPONENTS REMOVED TO MEET TEST WEIGHT:

Trunk carpeting, jack, third row seats

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

Test Vehicle: 2020 Toyota Highlander SUV NHTSA No.: M20205100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 8/10/2020

TARGET VEHICLE STRUCTURAL MEASUREMENT

No.	Description	Pre-Test
1	Total Length	4948
2	Total Width	1907
3*	Bumper Top Height	640
4*	Bumper Bottom Height	506
5*	Longitudinal Member Top Height	632
6	Distance Between Longitudinal Members	1044
7	Longitudinal Member Width	47
8*	Engine Top Height	963
9*	Engine Bottom Height	228
10	Engine and Gearbox Width	507
11	Front Bumper-Engine Distance	655
12*	Front Shock Absorber Fixing Height	1002
13*	Bonnet Leading Edge Height	1027
14	Front Shock Absorber Fixing Width	1237
15	Front Bumper – Front Axle Distance	984
16	Front Axle – A Pillar Distance	524
17	A-Pillar – B-Pillar Distance	1075
18	B-Pillar – Rear Axle Distance	1256
19	B-Pillar – C-Pillar Distance	1050
20*	Roof Sill Bottom Height	1601
21*	Roof Sill Top Height	1652
22*	Floor Sill Bottom Height	394
23*	Floor Sill Top Height	478

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

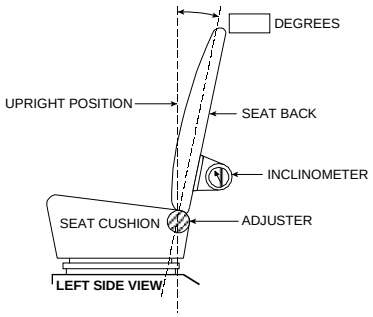
DATA SHEET NO. 2
SEAT ADJUSTMENT, FUEL SYSTEM, AND STEERING WHEEL DATA

Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020

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	1.2
Passenger Seat Back Angle	1.1



FRONT SEAT ASSEMBLY

SEAT FORE / AFT POSITIONS

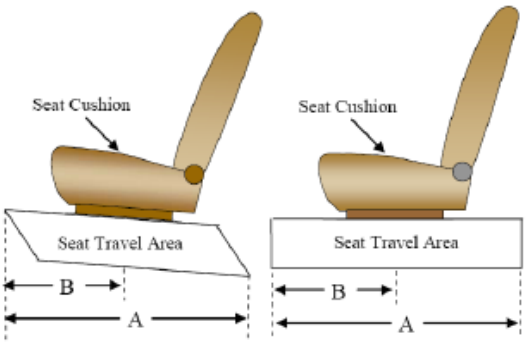
The driver's seat was positioned at the mid-point of fore/aft travel at its lowest position. The passenger's seat was positioned at the most forward position of fore/aft travel. Zero is defined as the forward most position.

Seating Position	Total Fore / Aft Travel	Placed in Position #
Driver Seat	285	143
Passenger Seat	240 (0-24)	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

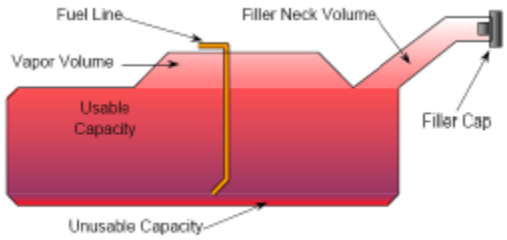
Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020

FUEL TANK CAPACITY

Description	Liters
Usable Capacity of "Standard Tank"	68.13
Usable Capacity of "Optional Tank"	N/A
92%-94% of Usable Capacity	62.68 – 64.04
Actual Amount of Solvent Used	63.3
1/3 of Usable Capacity	22.6

FUEL PUMP

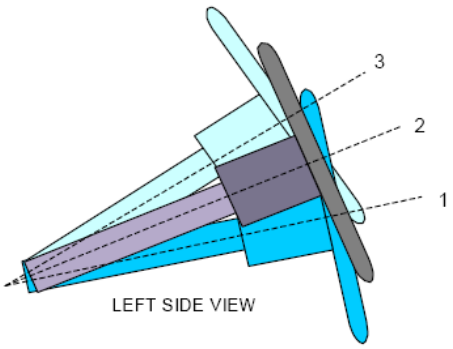
The vehicle is equipped with an electric fuel pump. The fuel filler neck is on the left side of the vehicle. The pump creates positive pressure in the fuel lines, pushing the gasoline to the engine. See form 1 for more information.



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.



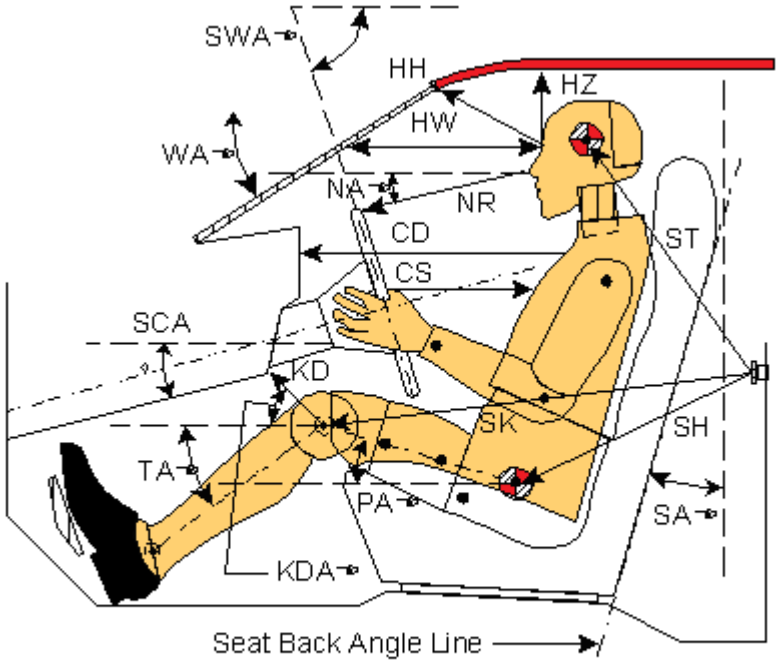
STEERING COLUMN ASSEMBLY

STEERING COLUMN POSITIONS

Description	Degrees	Fore / Aft Position (mm)
Lowermost position No. 1	22.0	
Geometric center position No. 2	24.0	
Uppermost position No. 3	26.2	
Telescoping Steering Wheel Travel		58
Test Position	24.0	29

DATA SHEET NO. 3
DUMMY LONGITUDINAL CLEARANCE DIMENSIONS

Test Vehicle: 2020 Toyota Highlander SUV
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20205100
Test Date: 8/10/2020



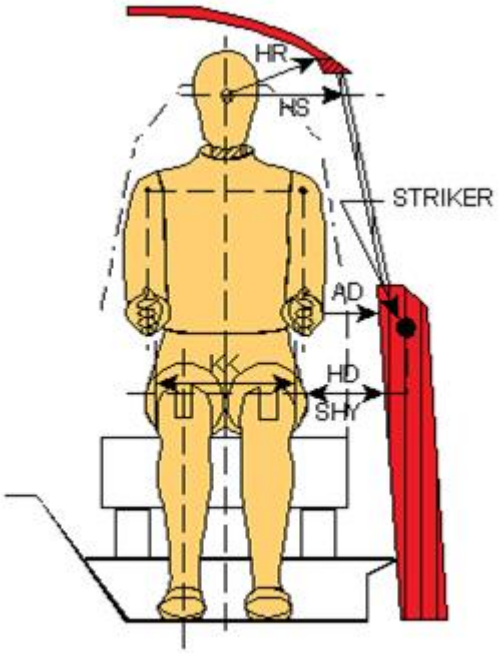
Left Side View

Code	Measurement Description	Driver (SN: 142)		Passenger (SN: 139)	
		Length (mm)	Angle (°)	Length (mm)	Angle (°)
WA°	Windshield Angle		30.2		
SWA°	Steering Wheel Angle		23.7		
SCA°	Steering Column Angle		66.3		
SA°	Seat Back Angle (on headrest post)		1.2		1.1
HZ	Head to Roof (Z)	230	90	245	0
HH	Head to Header	375	31.2	334	51.4
HW	Head to Windshield	668	0	657	0
NR	Nose to Rim / Dash	410	12.4	457	21.8
CD	Chest to Dash	544		395	
CS	Chest to Steering Hub	315	2.1		
RA	Rim to Abdomen	208	0		
KDL	Left Knee to Dash	206	23.2	115	8.2
KDR	Right Knee to Dash	188	16.4	115	26.4
PA°	Pelvic Angle		22.2		19.3
TA°	Tibia Angle		35.1		53.2
SK	Striker to Knee	586	11.7	693	13.2
ST	Striker to Head	438	80.2	438	53.7
SH	Striker to H-Point	294	51.4	415	31.8

DATA SHEET NO. 4
DUMMY LATERAL CLEARANCE DIMENSIONS

Test Vehicle: 2020 Toyota Highlander SUV
Test Program: NCAP Frontal Barrier Impact Test

NHTSA No.: M20205100
Test Date: 8/10/2020

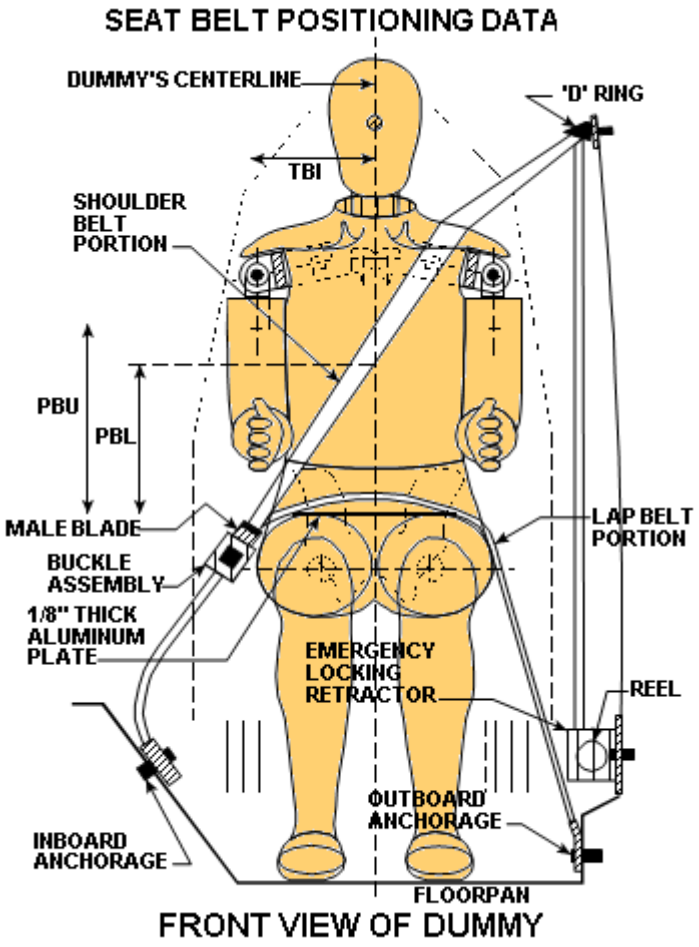


Front View

Code	Description	Driver (mm)	Passenger (mm)
AD	Arm to Door	150	101
HD	H-Point to Door	175	188
HR	Head to Side Header	248	288
HS	Head to Side Window	378	395
KK	Knee to Knee	330	165
SHY	Striker to H-Point (Y Direction)	265	305
AA	Ankle to Ankle	328	166

DATA SHEET NO. 5
SEAT BELT POSITIONING DATA

Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020



SEAT BELT POSITIONING MEASUREMENTS

Measurement Description	Units	Driver	Passenger
PBU — Top surface of reference to belt upper edge	mm	365	315
PBL — Top surface of reference to belt lower edge	mm	270	235

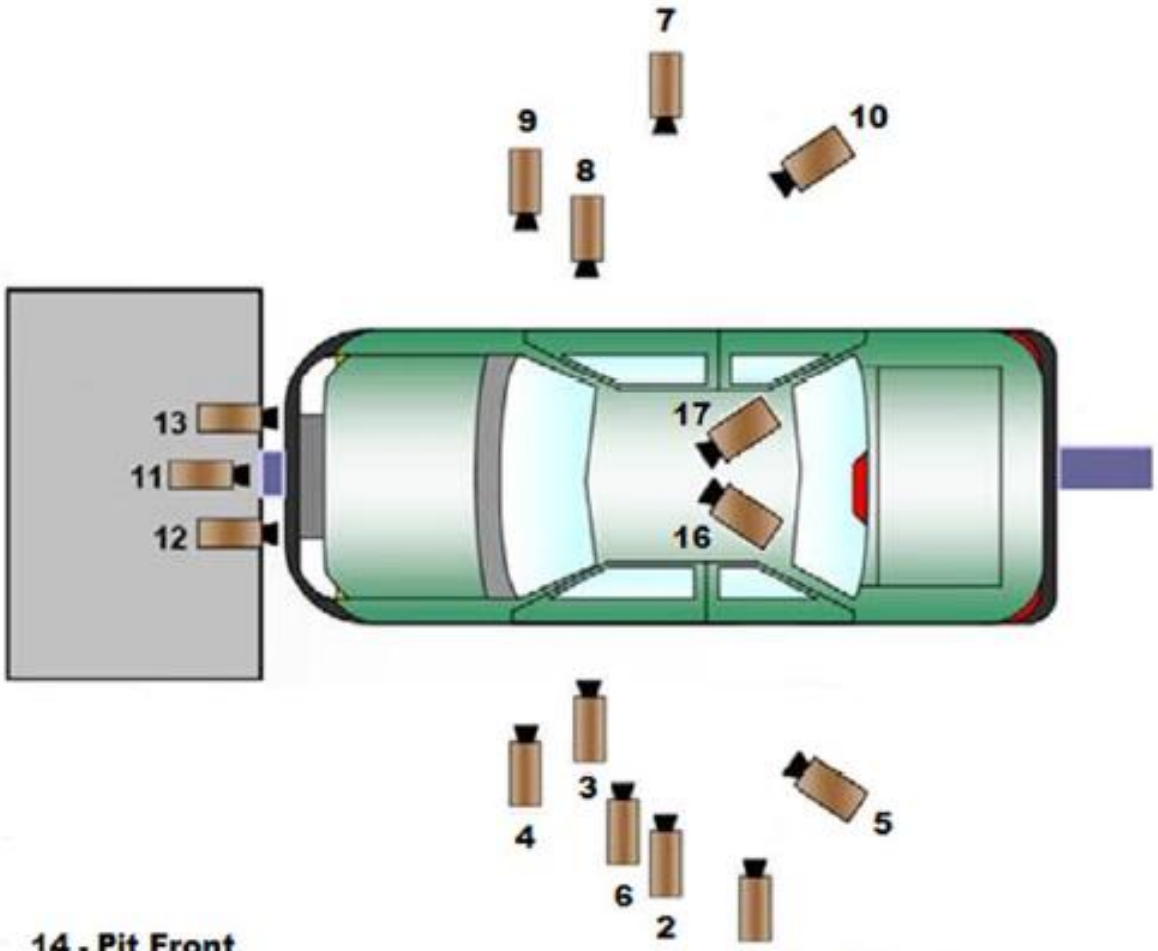
BELT LENGTH DATA

Measurement Description	Units	Driver	Passenger
Shoulder belt length as measured on ATD	mm	838	930
Lap Belt Length as measured on ATD	mm	700	760
Remainder of belt on reel	mm	962	910
Total belt length for continuous webbing systems	mm	2500	2600

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

Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020

CAMERA POSITIONS FOR FRONTAL IMPACTS



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

Test Vehicle: 2020 Toyota Highlander SUV NHTSA No.: M20205100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 8/10/2020

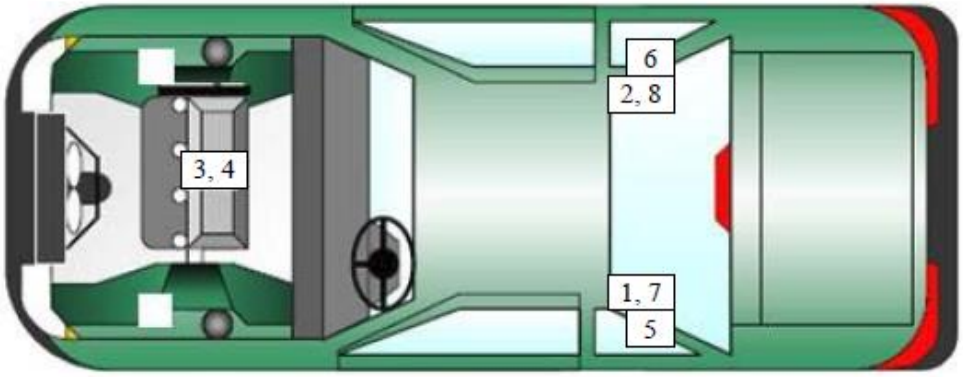
CAMERA LOCATIONS

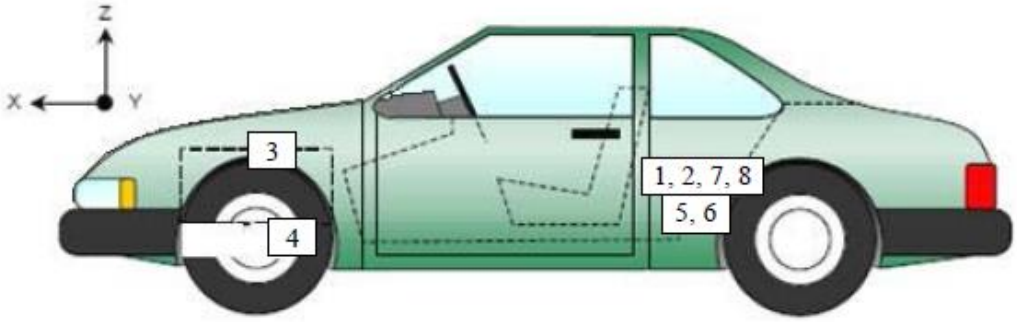
No.	Camera View	Location (mm)			Lens (mm)	Speed (fps)
		X	Y	Z		
1	Real-Time Left Overall	-	-	-		60
2	Left Overall	-2465	-7805	-1363	25	1000
3	Driver Close-Up	-1779	-7335	-1457	50	1000
4	Left Front Half	-1228	-7042	-1420	28	1000
5	Left Angle	-4775	-5059	-2549	50	1000
6	Steering Column	-1722	-7603	-2458	50	1000
7	Right Overall	-2186	8355	-1463	24	1000
8	Passenger Close-Up	-1581	7407	-1387	50	1000
9	Right Front Half	-1126	6903	-1425	28	1000
10	Right Angle	-4774	4898	-2556	50	1000
11	Windshield	1116	0	-3471	12.5	1000
12	Driver Windshield	741	-341	-2732	25	1000
13	Passenger Windshield	741	437	-2732	25	1000
14	Pit Front	-1183	0	2614	12.5	1000
15	Pit Rear	-2969	0	2686	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 Toyota Highlander SUV NHTSA No.: M20205100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 8/10/2020





VEHICLE ACCELEROMETER PRE-TEST LOCATIONS

No.	Accelerometer Location	Measurements (mm)		
		X	Y	Z
1	Left Rear Accelerometer – X Direction	2061	-383	205
2	Right Rear Accelerometer – X Direction	2060	382	206
3	Engine Top X	3993	175	-306
4	Engine Bottom X	4153	239	442
5	Left Rear Accelerometer – Z Direction	2061	-383	205
6	Right Rear Accelerometer – Z Direction	2060	382	206
7	Left Rear Accelerometer – X Direction Redundant	2061	-394	205
8	Right Rear Accelerometer – X Direction Redundant	2060	372	204

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

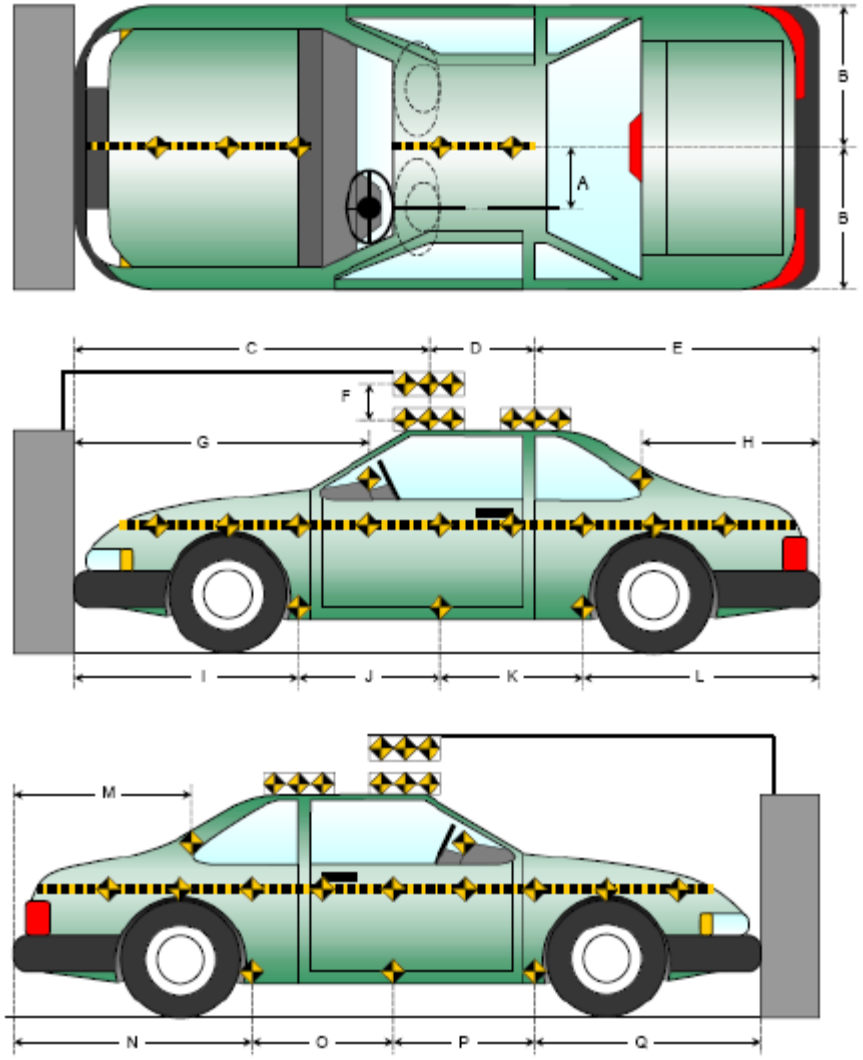
DATA SHEET NO. 8
PHOTOGRAPHIC REFERENCE TARGET LOCATIONS

Test Vehicle: 2020 Toyota Highlander SUV
Test Program: NCAP Frontal Barrier Impact Test

NHTSA No.: M20205100
Test Date: 8/10/2020

Item	Value
A	357
B	954
C	2718
D	607
E	1623
F	190
G	1779
H	1318
I	1506
J	919
K	915
L	1608
M	1316
N	1608
O	923
P	908
Q	1509

All units in millimeters



DATA SHEET NO. 9
LOAD CELL LOCATIONS ON FIXED BARRIER

Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020

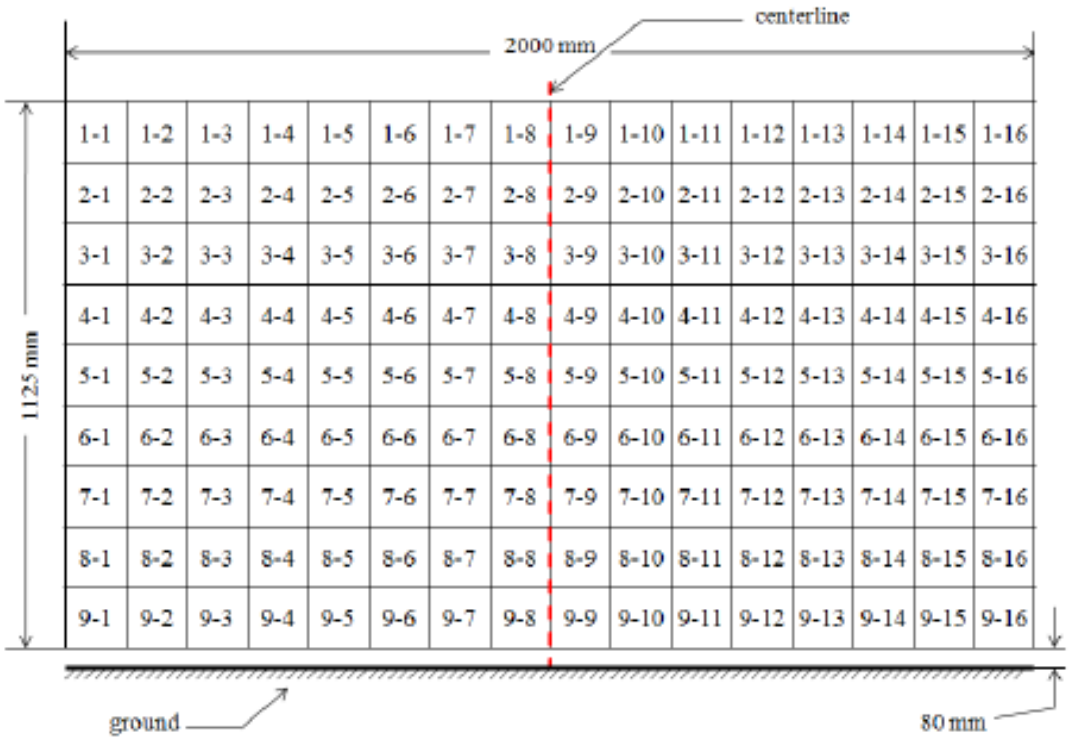


Figure 1 - Load Cell Locations on a 128-Load Cell Barrier with Plywood Height Extension*
Please note above diagram is not actual representation of load cell barrier used.

DATA SHEET NO. 10
TEST VEHICLE SUMMARY OF RESULTS

Test Vehicle: 2020 Toyota Highlander SUV NHTSA No.: M20205100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 8/10/2020

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 Toyota Highlander SUV NHTSA No.: M20205100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 8/10/2020

TEST DUMMY INFORMATION AND CONTACT LOCATIONS

Description	Driver	Passenger
Dummy Type / Serial No.	P572E 50th Male / 142	P5720 5th Female / 139
Head Contact	Frontal Airbag & Headrest	Frontal Airbag & Headrest
Upper Torso Contact	Frontal Airbag	Frontal Airbag
Lower Torso Contact	None	None
Left Knee Contact	Knee Airbag	Glove Box
Right Knee Contact	Knee Airbag	Glove Box

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			Closed & Operational
Seat Track Shift (mm)	0	0	
Seat Back Movement from Initial Position	None	None	

**NOTE: Indicate "No", "N/A, or "Yes" described

POST-TEST STRUCTURAL OBSERVATIONS

Critical Areas of Performance	Observations and Conclusions
Windshield Damage	Corners of hood penetrated windshield, cracks throughout
Window Damage	None
Other	None

VEHICLE REBOUND FROM BARRIER

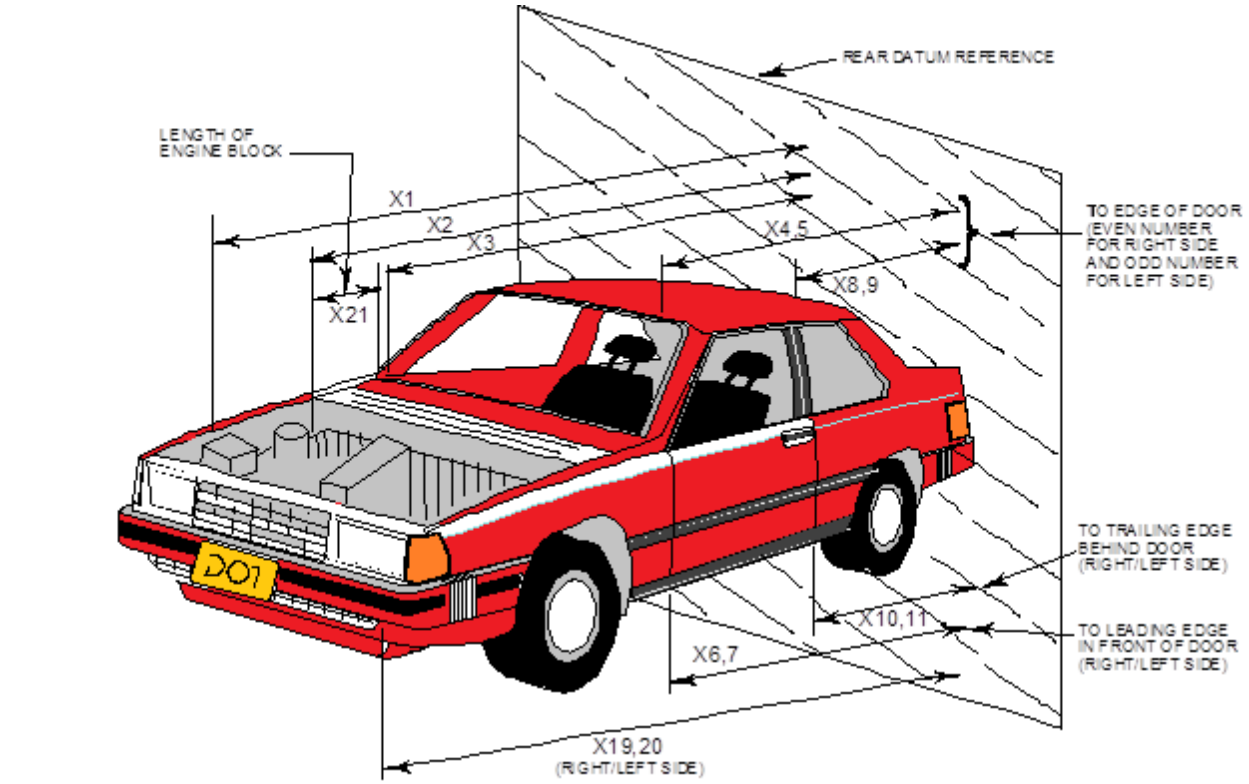
Measured Parameter	Units	Value
Left Side	mm	1018
Center	mm	1055
Right Side	mm	1120
Average	mm	1064

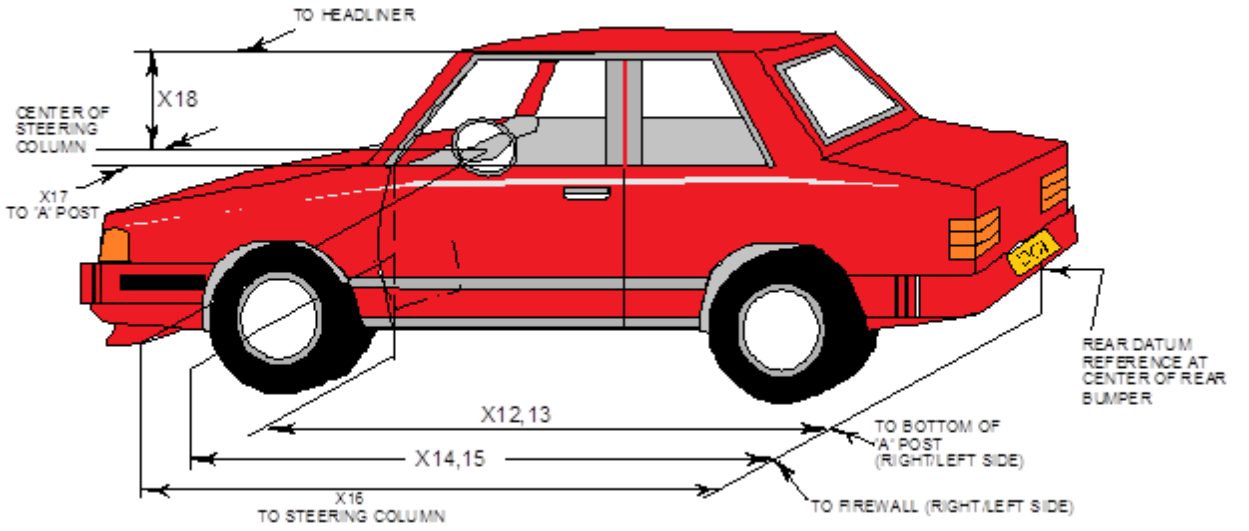
SUPPLEMENTAL RESTRAINT SYSTEM INFORMATION

Restraint Type	Driver		Passenger	
	Installed	Deployed	Installed	Deployed
Front Airbag	Yes	Yes	Yes	Yes
Side Airbag 1 - Curtain	Yes	Yes	Yes	Yes
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 – Seat Cushion Airbag			Yes	Yes

DATA SHEET NO. 12
VEHICLE PROFILE MEASUREMENTS

Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020





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

Test Vehicle: 2020 Toyota Highlander SUV NHTSA No.: M20205100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 8/10/2020

No.	Measurement Description	Pre-Test	Post-Test	Difference
1	Total Length of Vehicle at Centerline	4948	4531	-417
2	Rear Surface of Vehicle (RSOV) to Front of Engine	4293	4102	-191
3	RSOV to Firewall	3948	3926	-22
4	RSOV to Upper Leading Edge of Right Door	3447	3447	0
5	RSOV to Upper Leading Edge of Left Door	3448	3446	-2
6	RSOV to Lower Leading Edge of Right Door	3390	3387	-3
7	RSOV to Lower Leading Edge of Left Door	3389	3391	2
8	RSOV to Upper Trailing Edge of Right Door	2370	2369	-1
9	RSOV to Upper Trailing Edge of Left Door	2372	2368	-4
10	RSOV to Lower Trailing Edge of Right Door	2380	2377	-3
11	RSOV to Lower Trailing Edge of Left Door	2381	2381	0
12	RSOV to Bottom of “A” Post of Right Side	3434	3431	-3
13	RSOV to Bottom of “A” Post of Left Side	3435	3433	-2
14	RSOV to Firewall, Right Side	3768	3748	-20
15	RSOV to Firewall, Left Side	3768	3746	-22
16	RSOV to Steering Column	2983	3046	63
17	Center of Steering Column to “A” Post	295	294	-1
18	Center of Steering Column to Headliner	453	463	10
19	RSOV to Right Side of Front Bumper	4918	4495	-423
20	RSOV to Left Side of Front Bumper	4916	4550	-366
21	Length of Engine Block	262	262	0
RD	RSOV to Right Side of Dash Panel	3194	3195	1
CD	RSOV to Center of Dash Panel	3125	3118	-7
LD	RSOV to Left Side of Dash Panel	3193	3194	1

*UR= Unrecoverable data point
All Dimensions in mm

DATA SHEET NO. 13
ACCIDENT INVESTIGATION DIVISION DATA

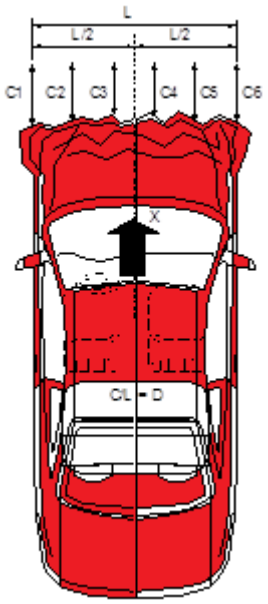
Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020

VEHICLE INFORMATION

VIN:	5TDCZRBH7LS505321	Wheelbase (mm):	2854
Vehicle Size Category:	MPV	Test Weight (kg):	2161

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):	56.25
Velocity Change (km/h):	66.04
Time of Separation (ms):	115



CRUSH PROFILE

Collision Deformation Classification:	12FDEW2
Midpoint of Damage:	C4
Damage Region Length (mm):	1541
Impact Mode:	Frontal

No.	Measurement Description	Units	Pre-Test	Post-Test	Difference
C1	Crush Zone 1 at Left Side	mm	4715	4465	250
C2	Crush Zone 2 at Left Side	mm	4904	4533	371
C3	Crush Zone 3 at Left Side	mm	4937	4523	414
C4	Crush Zone 4 at Right Side	mm	4938	4504	434
C5	Crush Zone 5 at Right Side	mm	4904	4473	431
C6	Crush Zone 6 at Right Side	mm	4710	4359	351
L	C1 to C6	mm	1541	1638	-97

DATA SHEET NO. 14
VEHICLE INTRUSION MEASUREMENTS

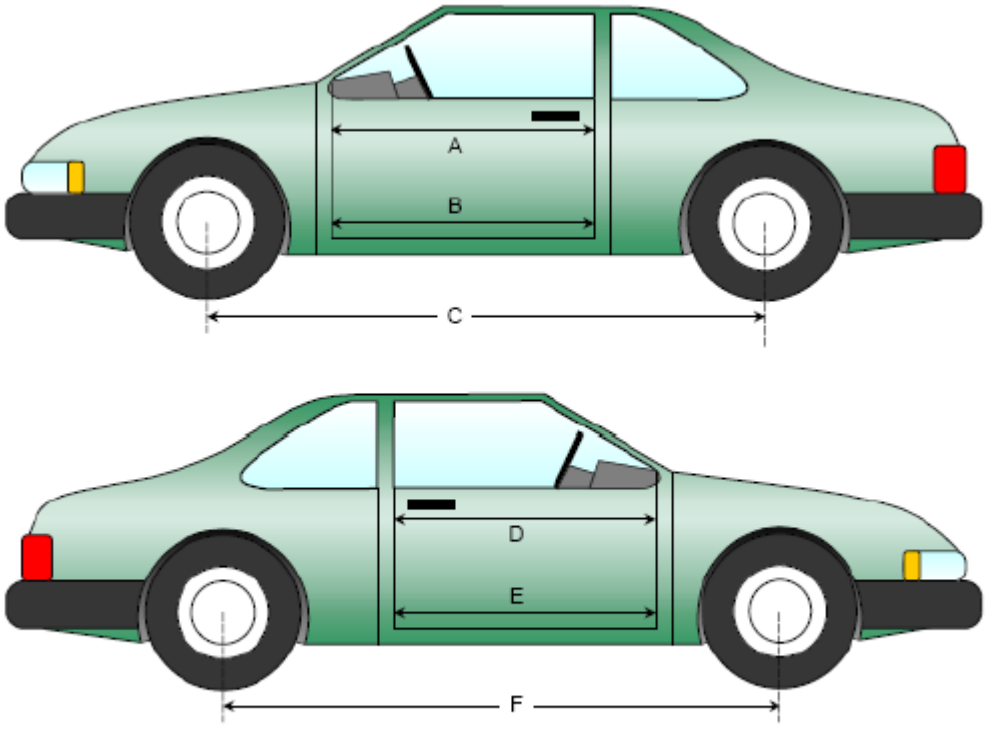
Test Vehicle: 2020 Toyota Highlander SUV
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20205100
Test Date: 8/10/2020

DOOR OPENING WIDTH

Item	Description	Units	Pre-Test	Post-Test	Difference
A	Left Side Upper	mm	975	973	-2
B	Left Side Lower	mm	786	785	-1
D	Right Side Upper	mm	975	973	-2
E	Right Side Lower	mm	779	779	0

WHEELBASE MEASUREMENTS

Item	Description	Units	Pre-Test	Post-Test	Difference
C	Left Side Wheelbase	mm	2854	2811	-43
F	Right Side Wheelbase	mm	2854	2871	18



Left & Right Side Views

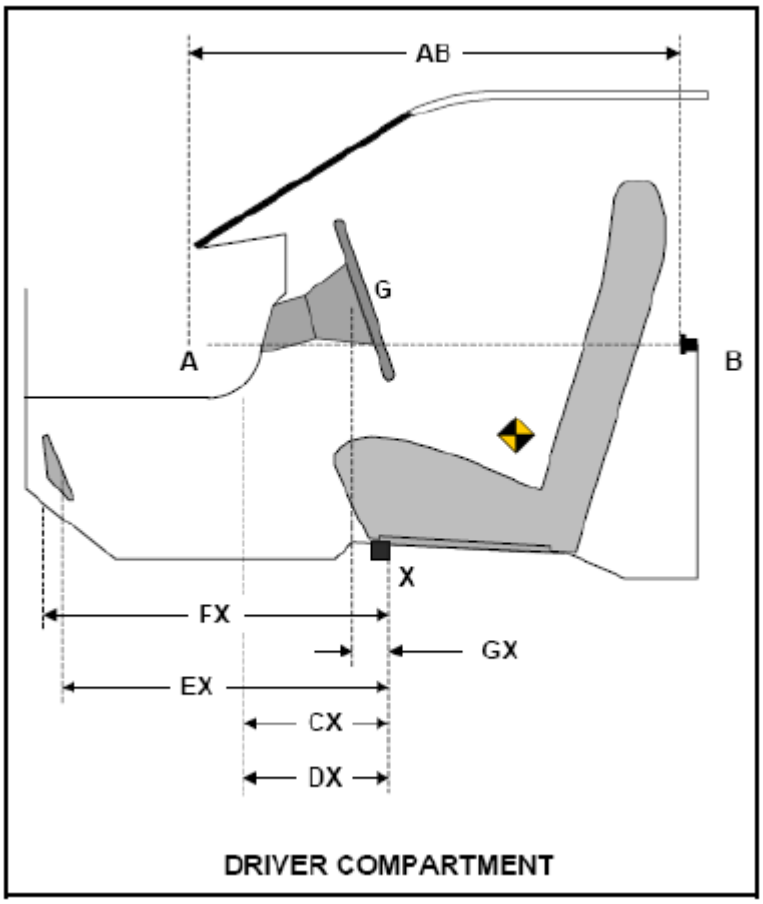
DATA SHEET NO.14 … (CONTINUED)
VEHICLE INTRUSION MEASUREMENTS

Test Vehicle: 2020 Toyota Highlander SUV NHTSA No.: M20205100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 8/10/2020

DRIVER COMPARTMENT INTRUSION

Item	Description	Units	Pre-Test	Post-Test	Difference
AB	Door Opening (Inside Window Jam)	mm	772	771	-1
CX	Left Knee Bolster to X	mm	319	321	2
DX	Right Knee Bolster to X	mm	304	296	-8
EX	Brake Pedal to X	mm	528	502	-26
FX	Foot Rest to X	mm	548	542	-6
GX	Center of Steering Column Wheel Hub to X	mm	44	110	66

X = Front of Seat Track (Stationary)



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

Test Vehicle: 2020 Toyota Highlander SUV NHTSA No.: M20205100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 8/10/2020

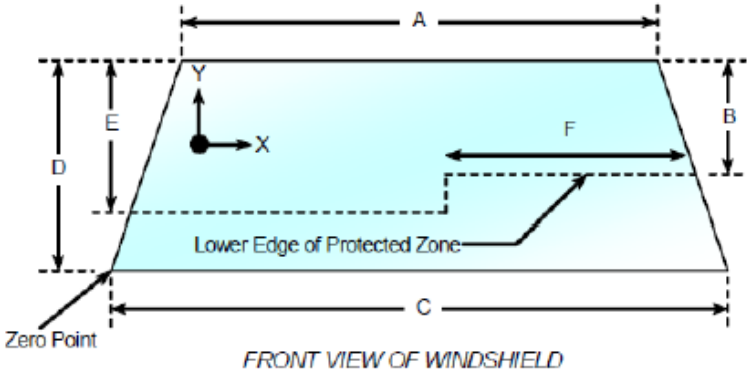
Windshield Mounting Details: A 0.8 mm trim surrounds the top and side of windshield while a plastic shroud is on the bottom.

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	2228	2228	100
Right Side	2228	2228	100
Total	4456	4465	100



FRONT VIEW OF WINDSHIELD

Item	Units	Value
A	mm	1250
B	mm	415
C	mm	1584
D	mm	811
E	mm	469
F	mm	526

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.*
- Hood corners penetrated windshield

X	Y
1485	95
85	102

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

Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020

FMVSS 301 FUEL SYSTEM INTEGRITY POST IMPACT DATA

Temperature at Time of Impact: 21 ° C Test Time: 11:21 AM

STODDARD SOLVENT SPILLAGE MEASUREMENTS

A. From impact until vehicle motion ceases: 0 oz.
(Maximum allowable is 1 oz.)

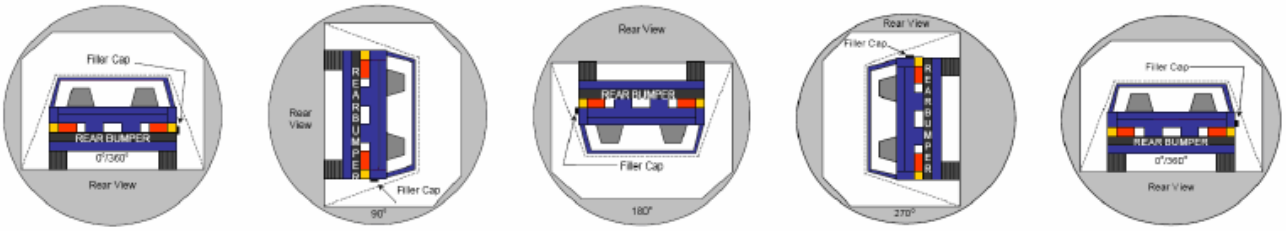
B. For the 5-minute period after motion ceases: 0 oz.
(Maximum allowable is 5 oz.)

C. For the following 25 minutes: 0 oz.
(Maximum allowable is 1 oz./minute)

D. Spillage: No Spillage Occurred

DATA SHEET NO. 16
FMVSS 301 STATIC ROLLOVER RESULTS

Test Vehicle:	2020 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020



0° TO 90° 90° TO 180° 180° TO 270° 270° TO 360°

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°	71	300	371
90° to 180°	68	300	368
180° to 270°	67	300	367
270° to 360°	73	300	373

FMVSS 301 SPILLAGE TABLE

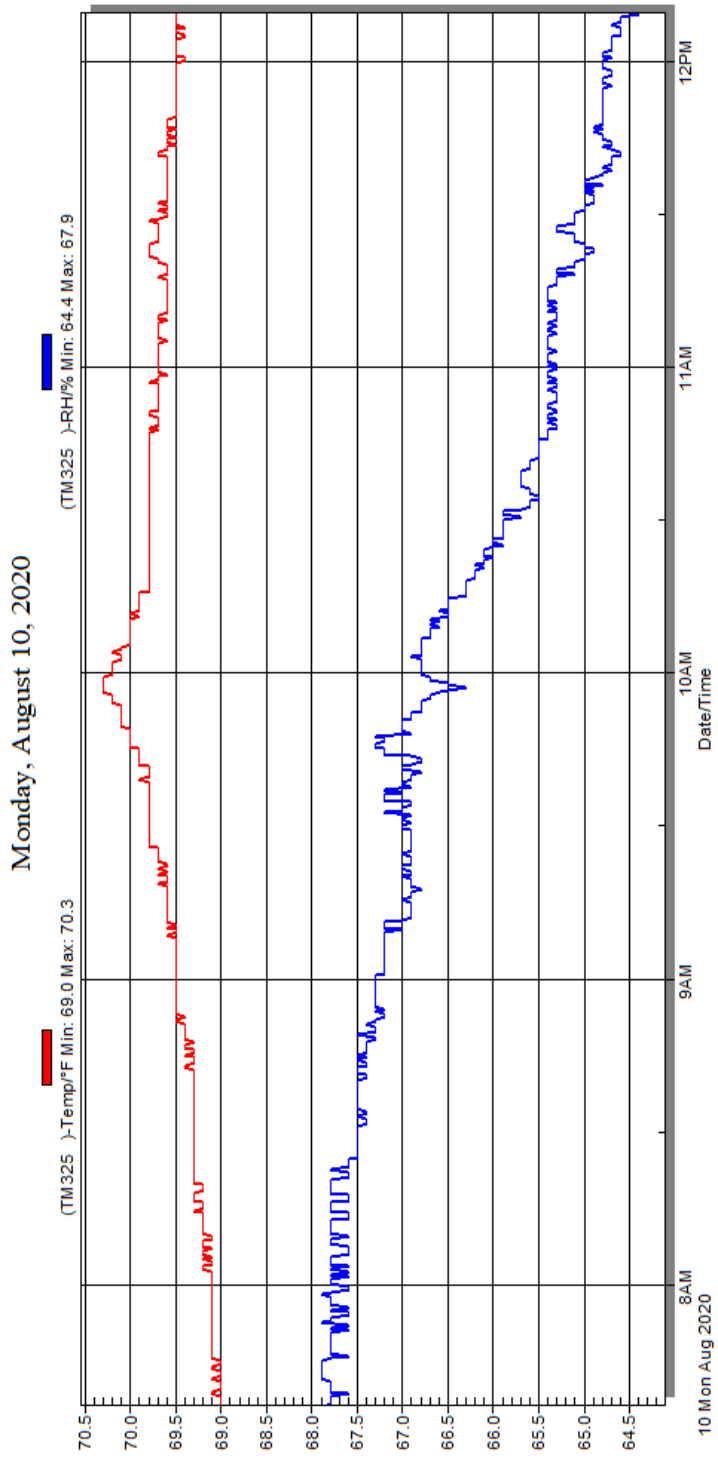
Test Phase	First 5 Minutes	Sixth Minute	Seventh Minute	Eighth Minute
0° to 90°	0	0	0	
90° to 180°	0	0	0	
180° to 270°	0	0	0	
270° to 360°	0	0	0	

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 Toyota Highlander SUV	NHTSA No.:	M20205100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	8/10/2020



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.*

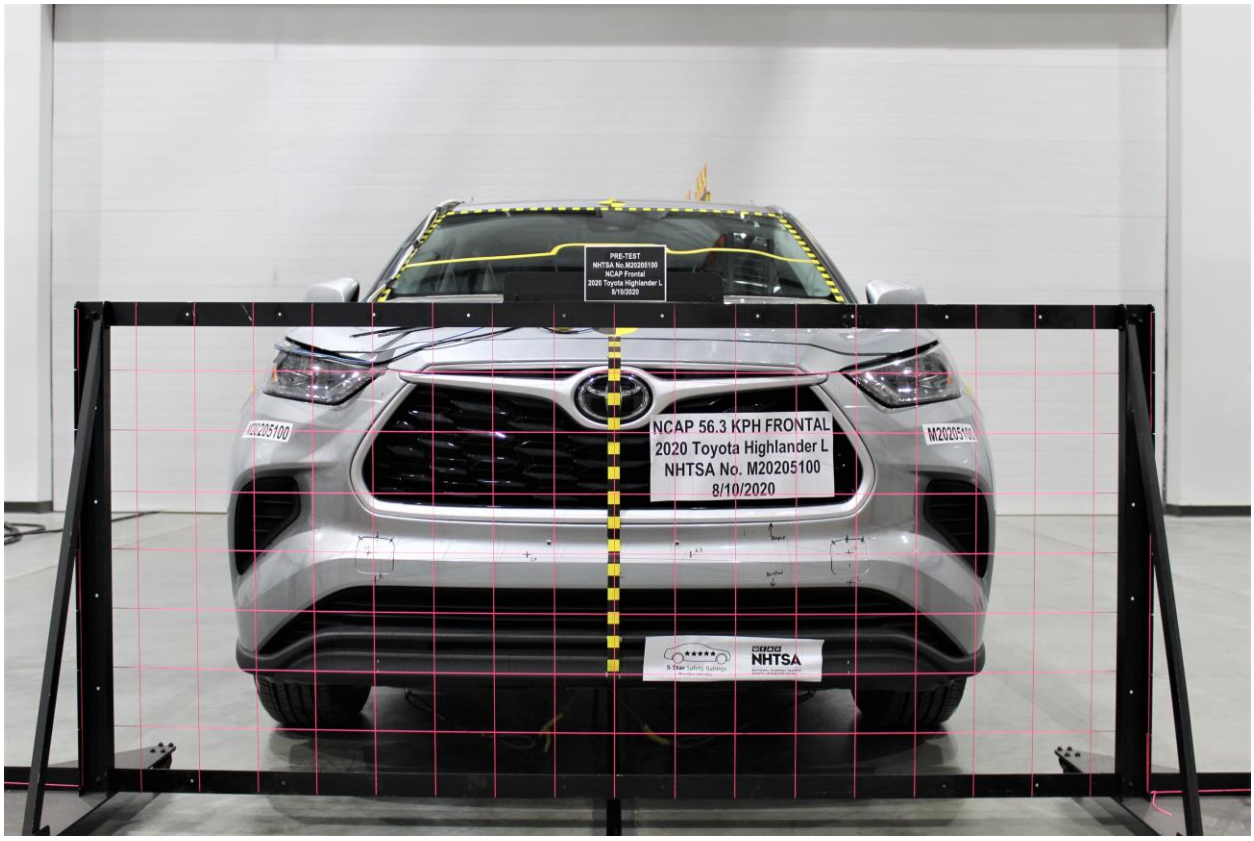


Figure A-1: Load Cell Location

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 Toyota Highlander Frontal As Delivered

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

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

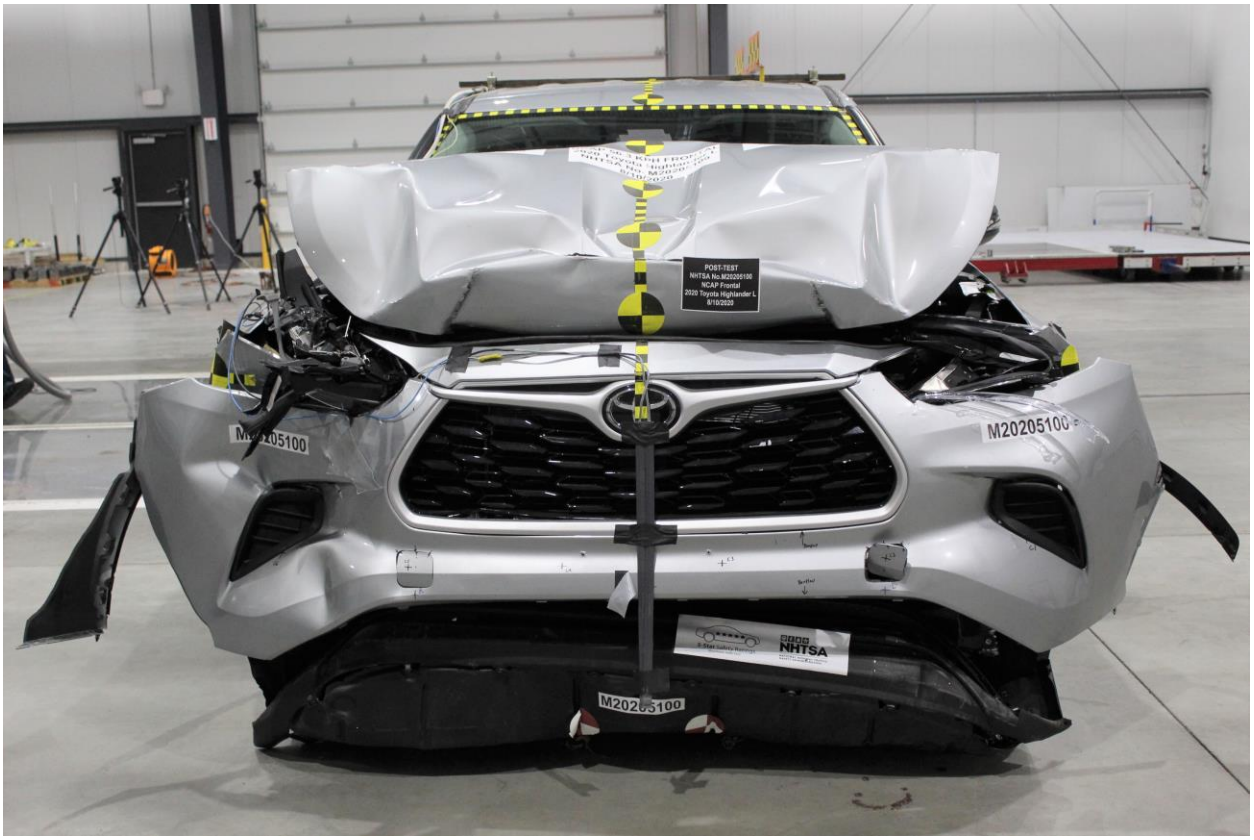


Figure A-9: Post-Test Front View of Test Vehicle

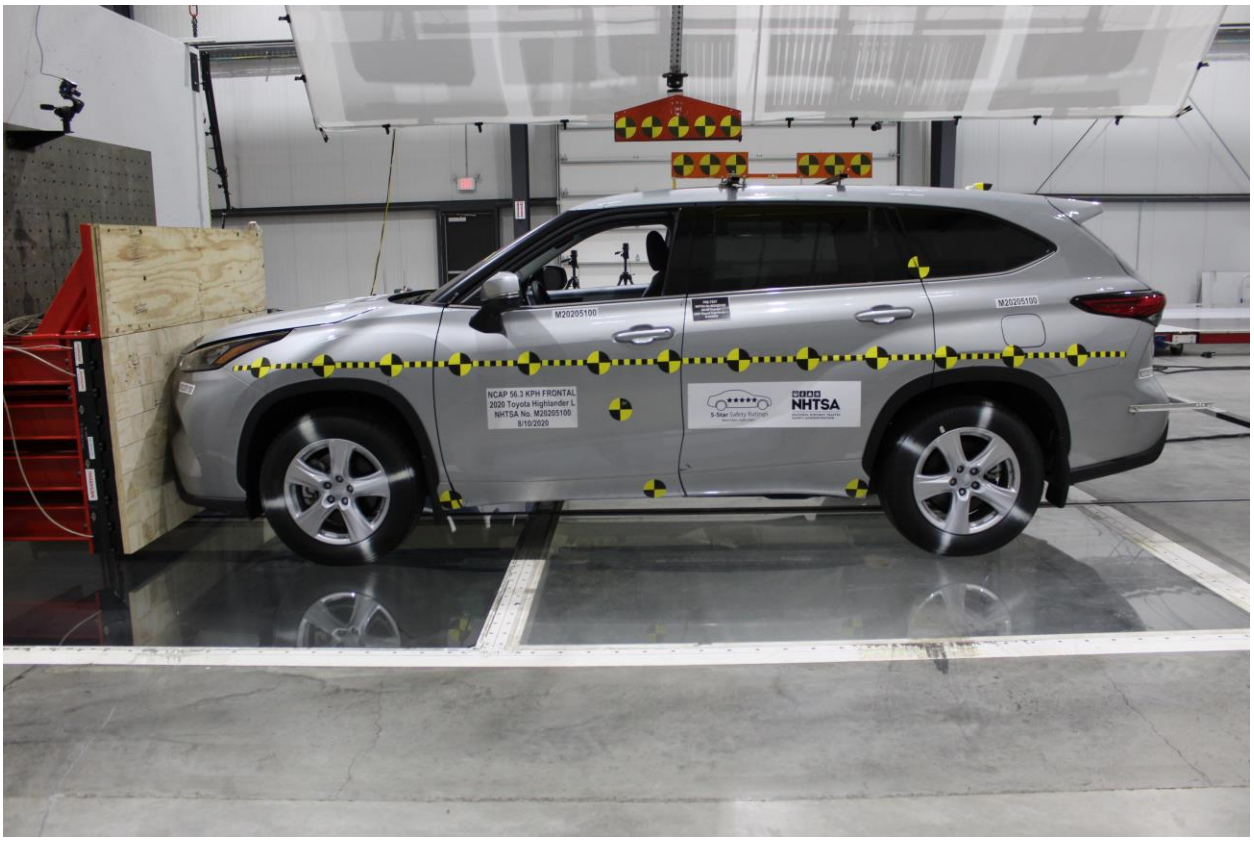


Figure A-10: Pre-Test Left View of Test Vehicle

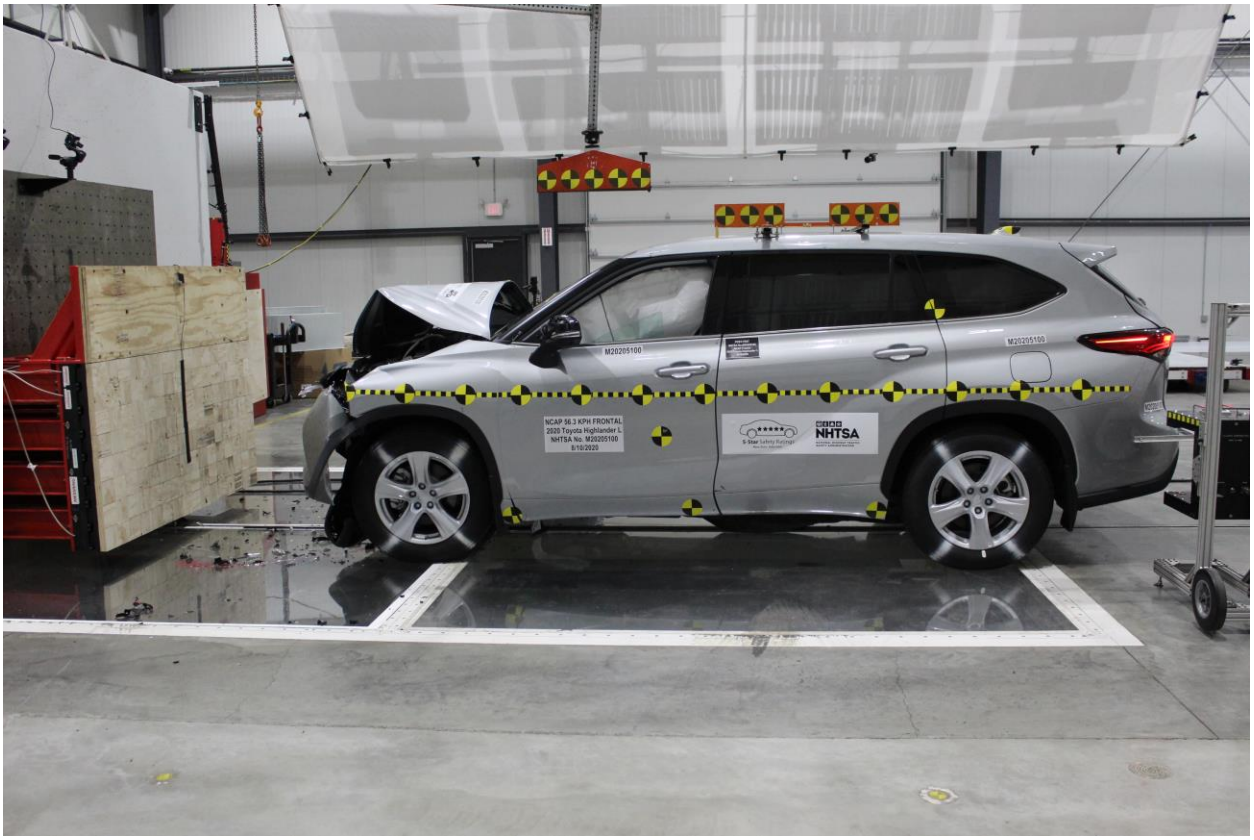


Figure A-11: Post-Test Left View of Test Vehicle

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

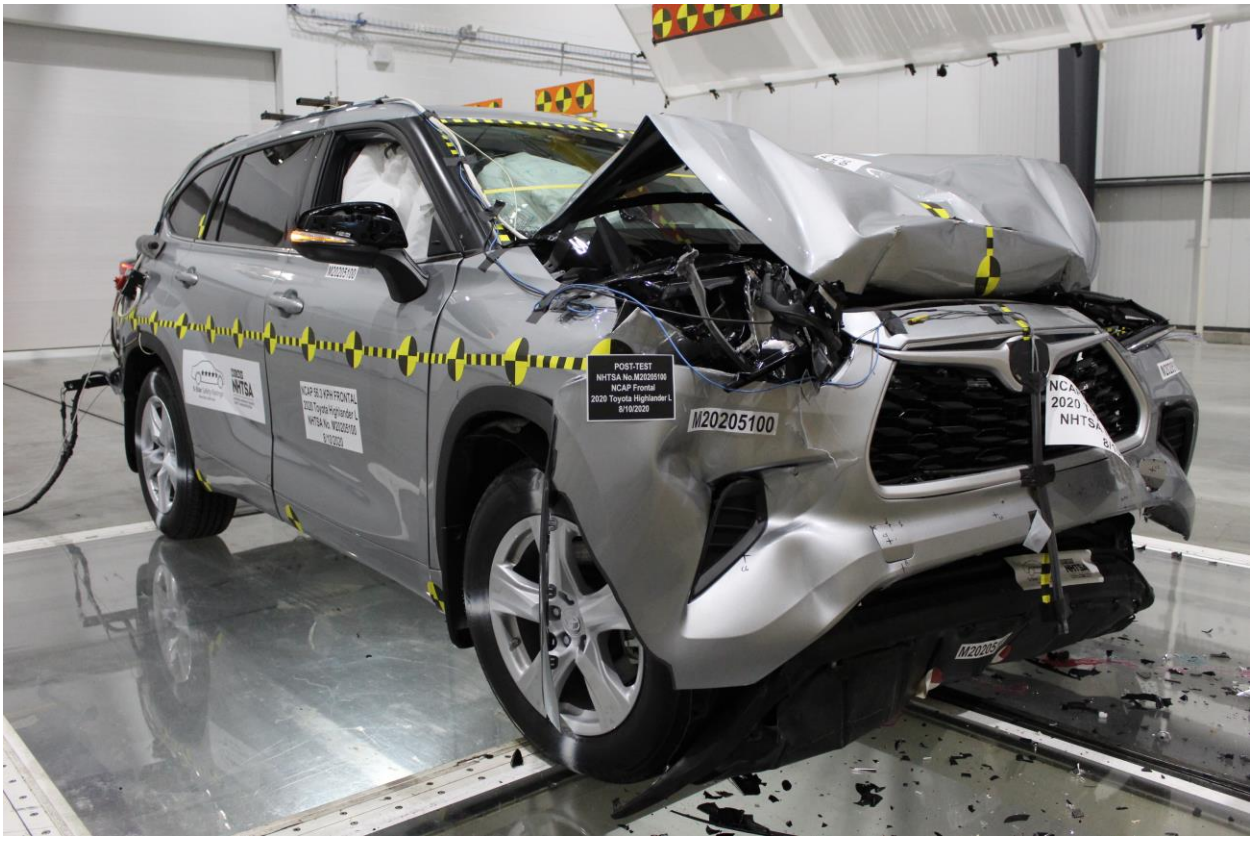


Figure A-15: Post-Test Right Front 3-4 View

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

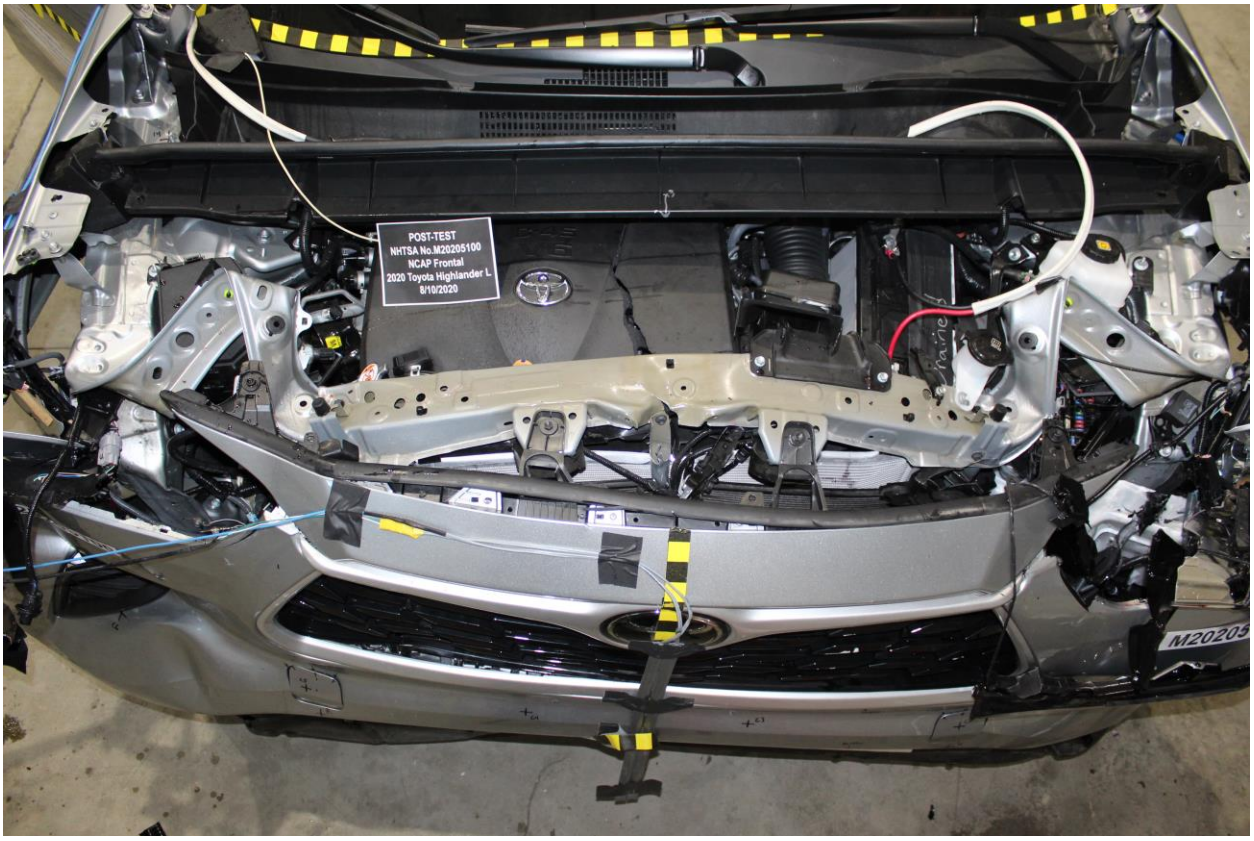


Figure A-21: Post-Test Engine Compartment View

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

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

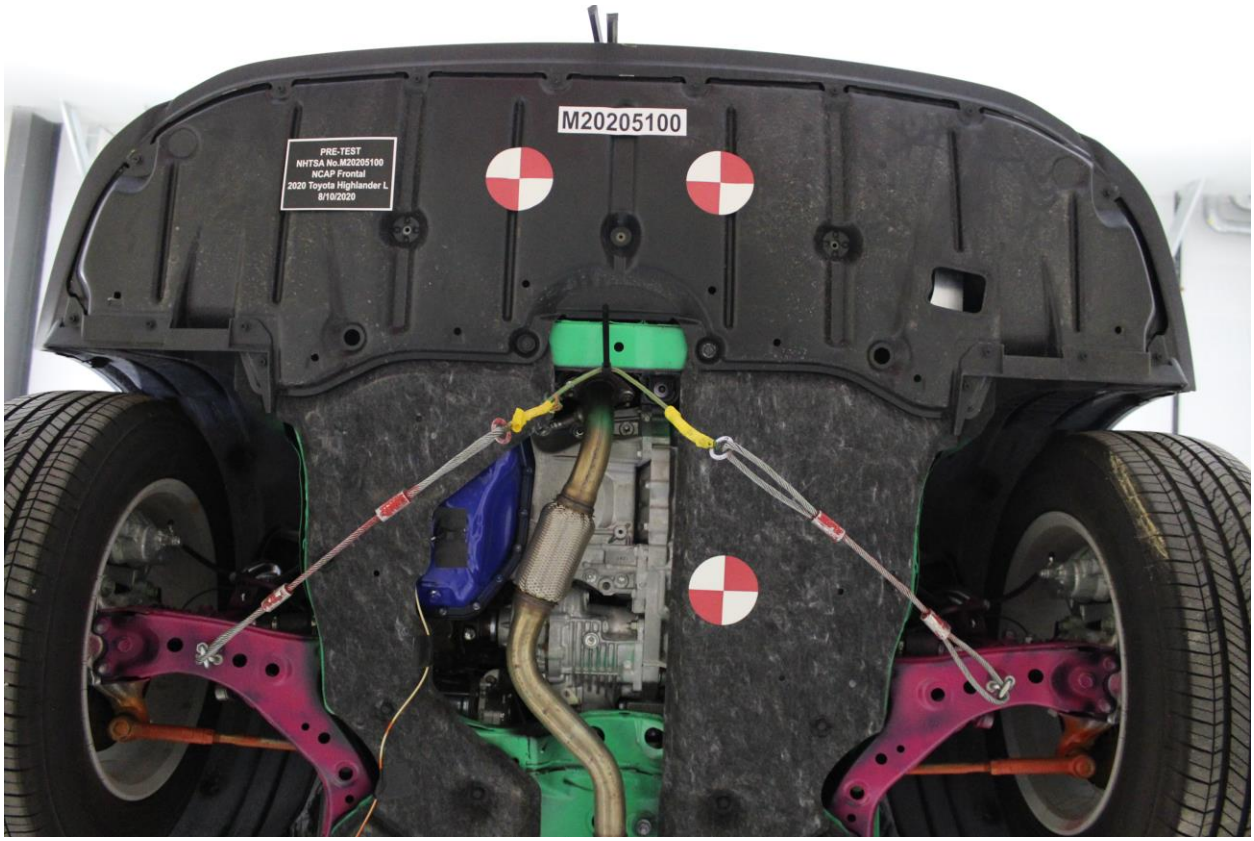


Figure A-24: Pre-Test Front Underbody View

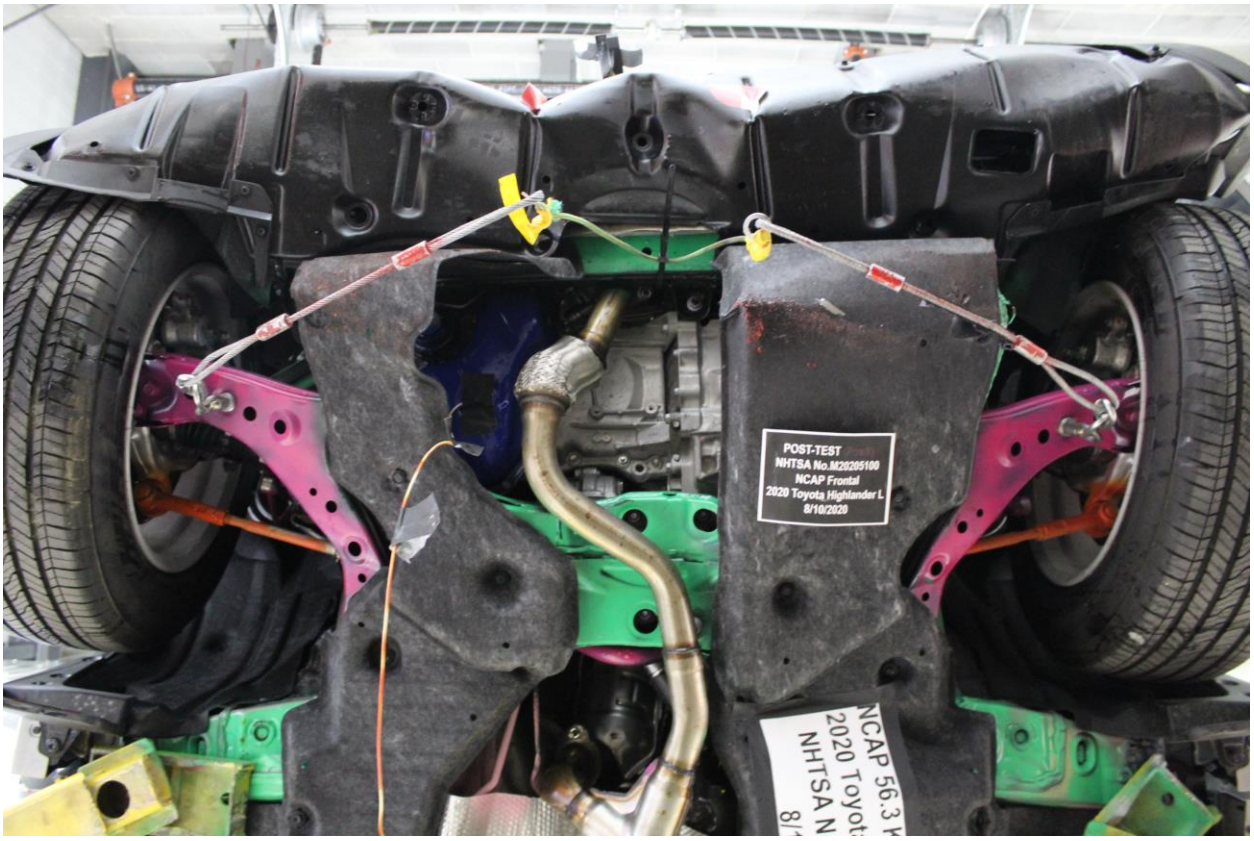


Figure A-25: Post-Test Front Underbody View

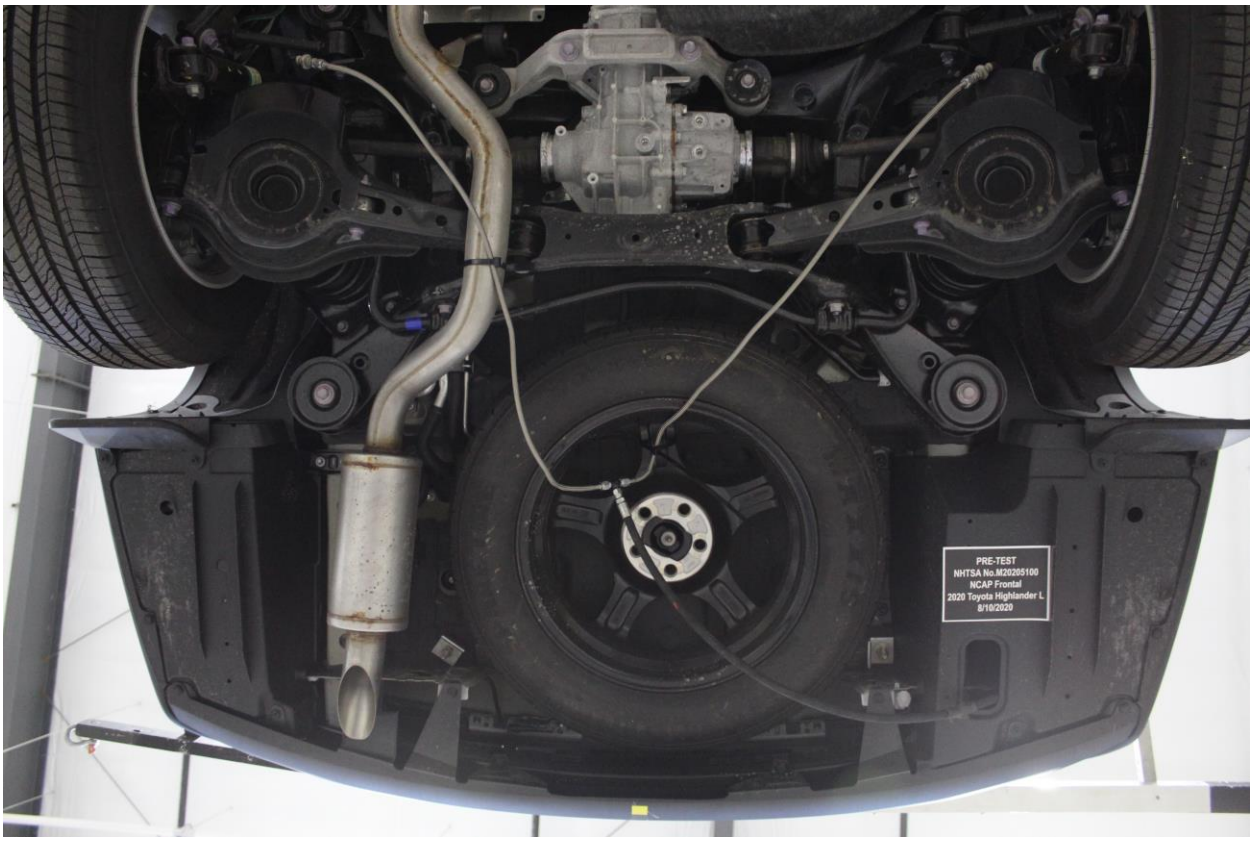


Figure A-26: Pre-Test Rear Underbody View

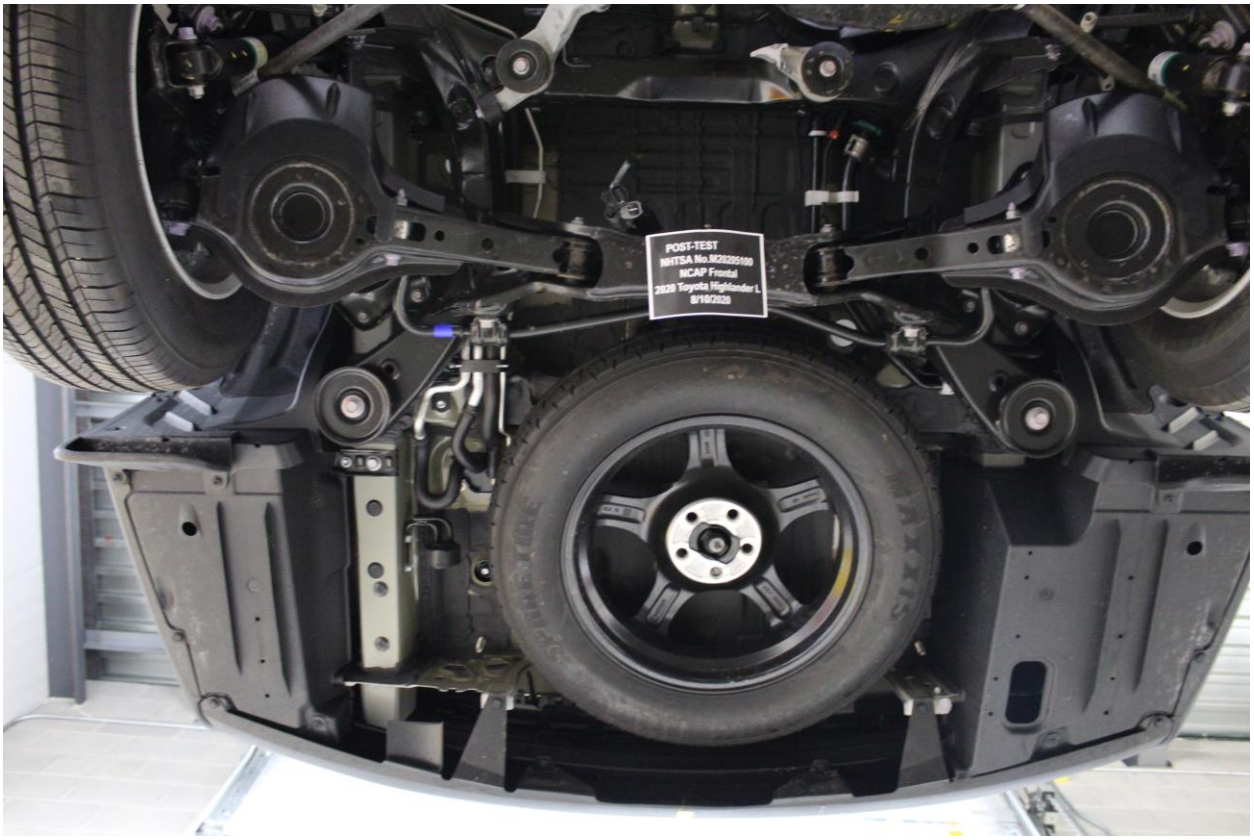


Figure A-27: Post-Test Rear Underbody View

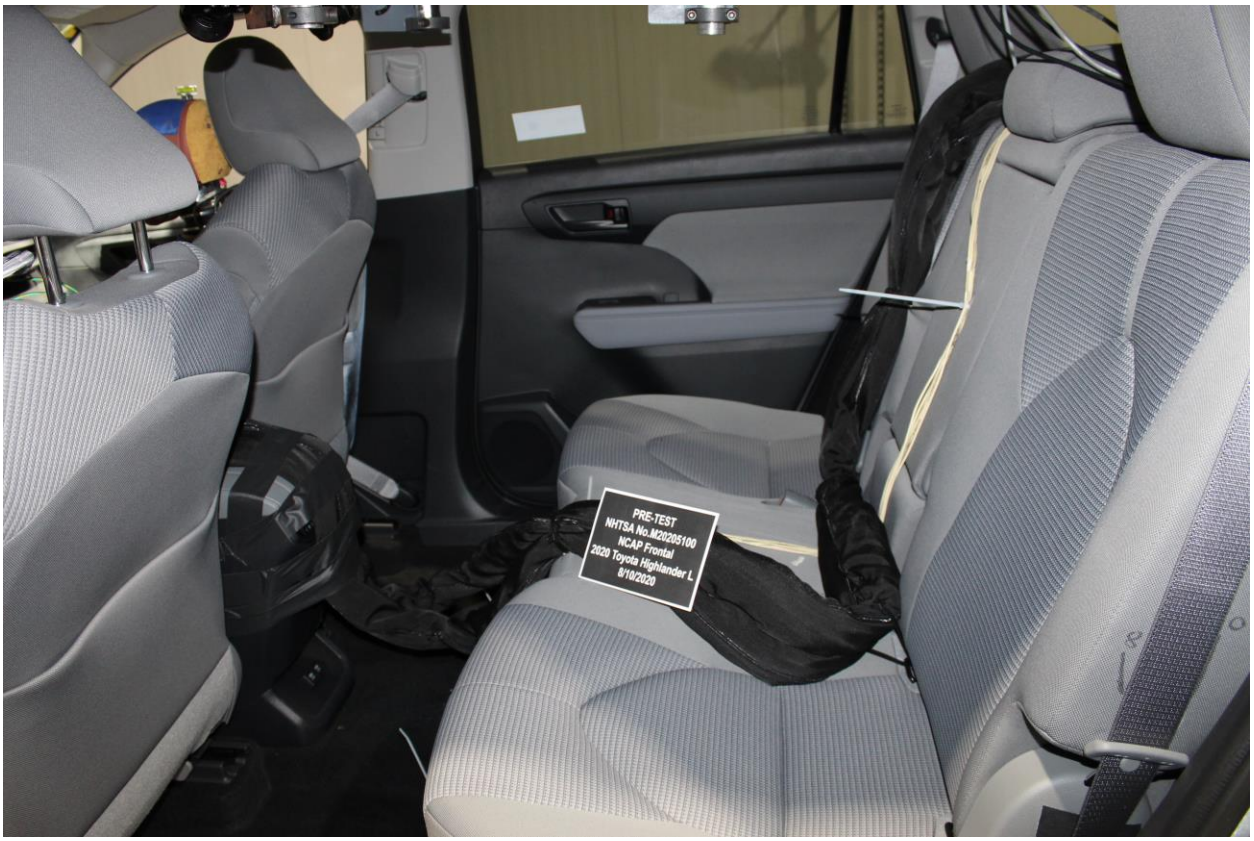


Figure A-28: Pre-Test Dummy Cable Routing

Figure A-29: Post-Test Dummy Cable Routing

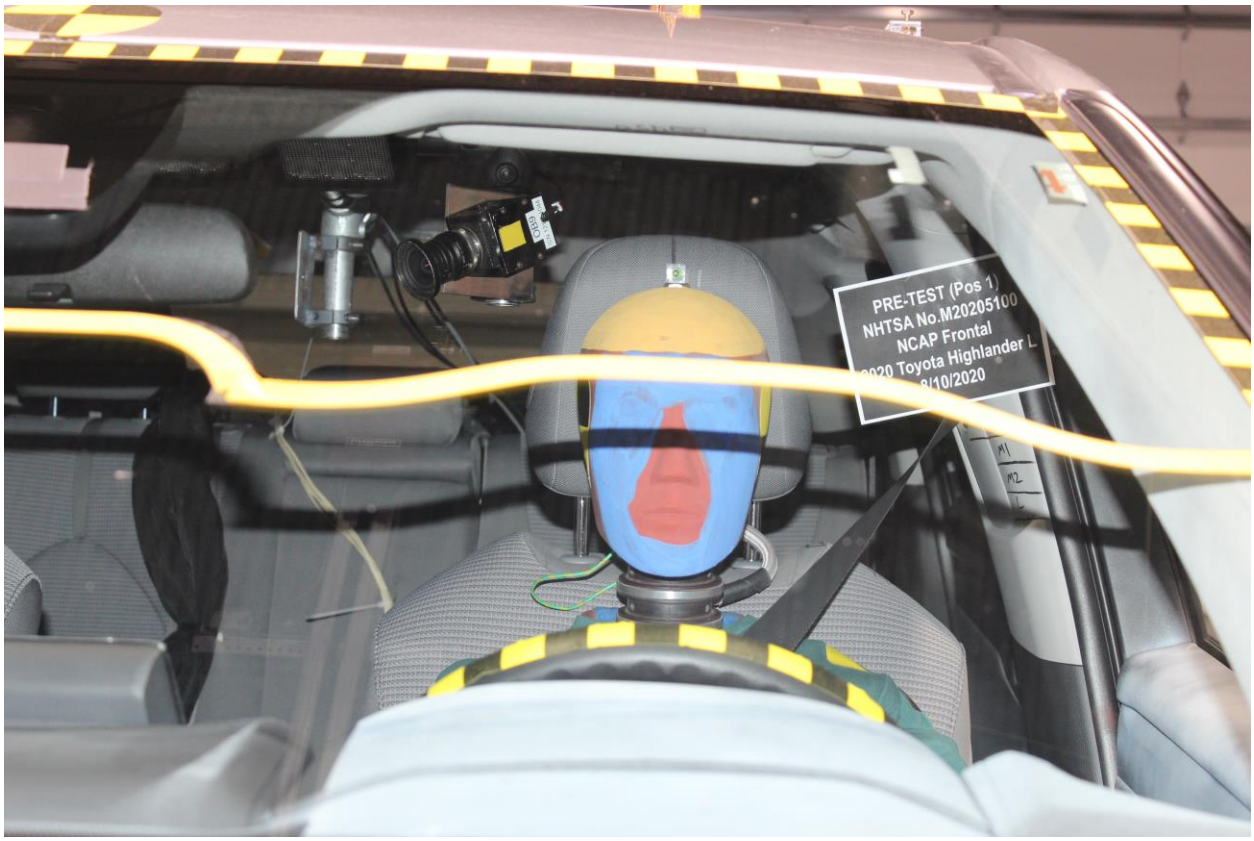


Figure A-30: Pre-Test Driver Dummy Front View

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

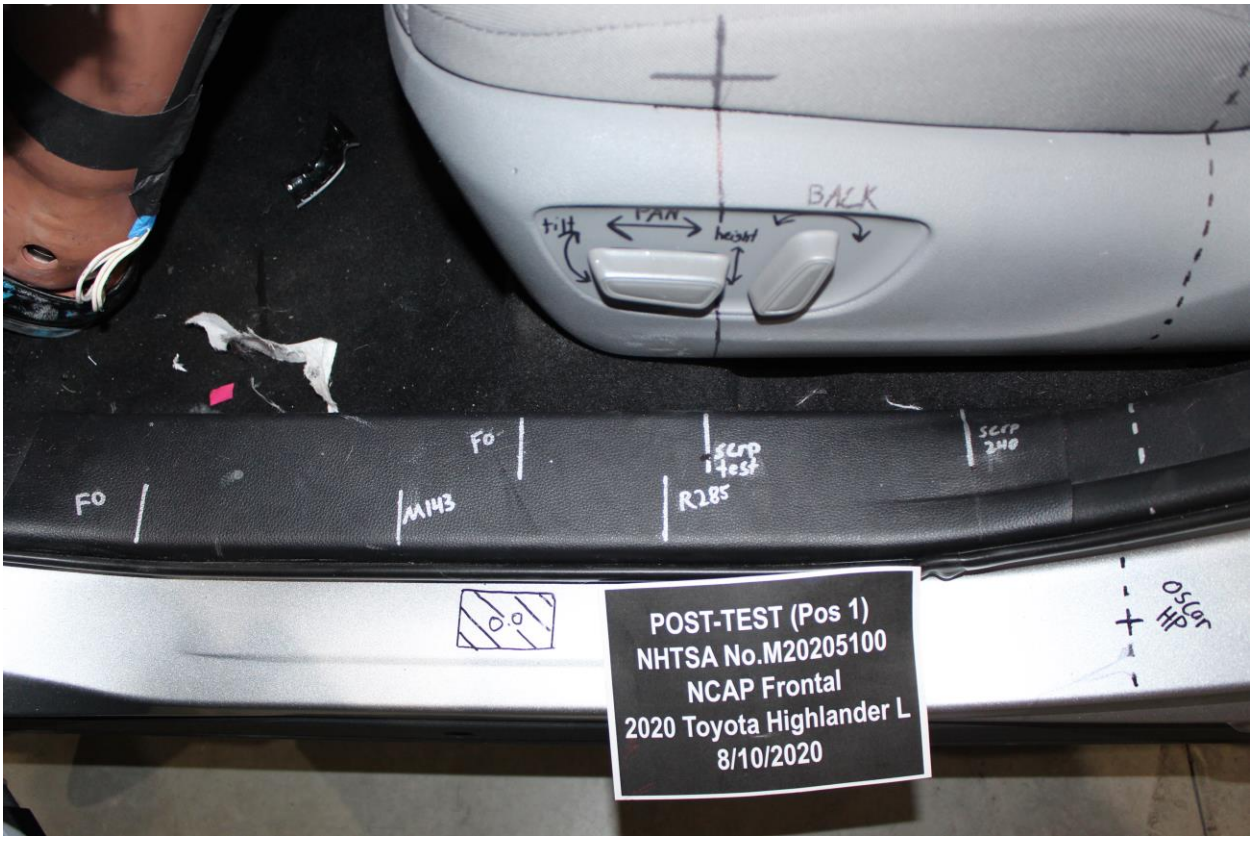


Figure A-37: Post-Test Driver's Seat Fore-Aft Markings

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

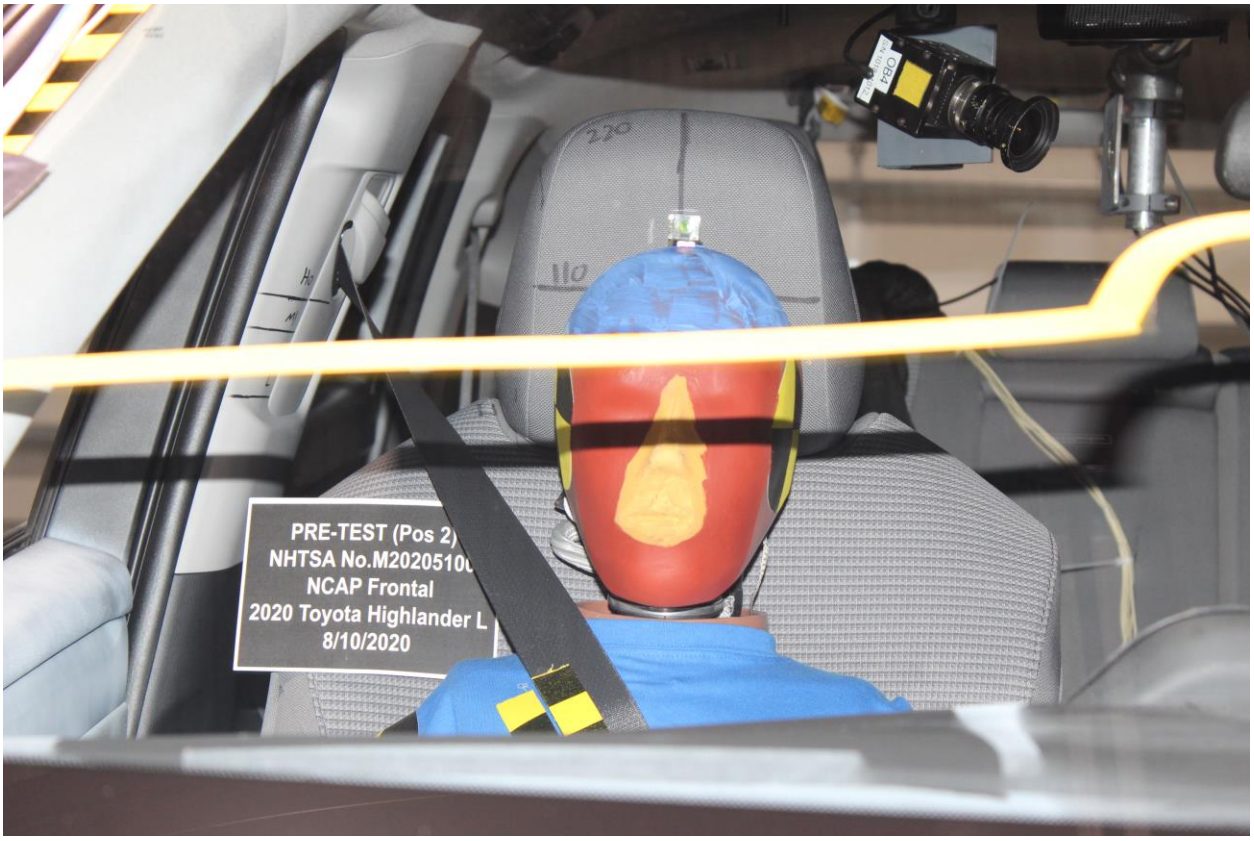


Figure A-53: Pre-Test Passenger Dummy Front View

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

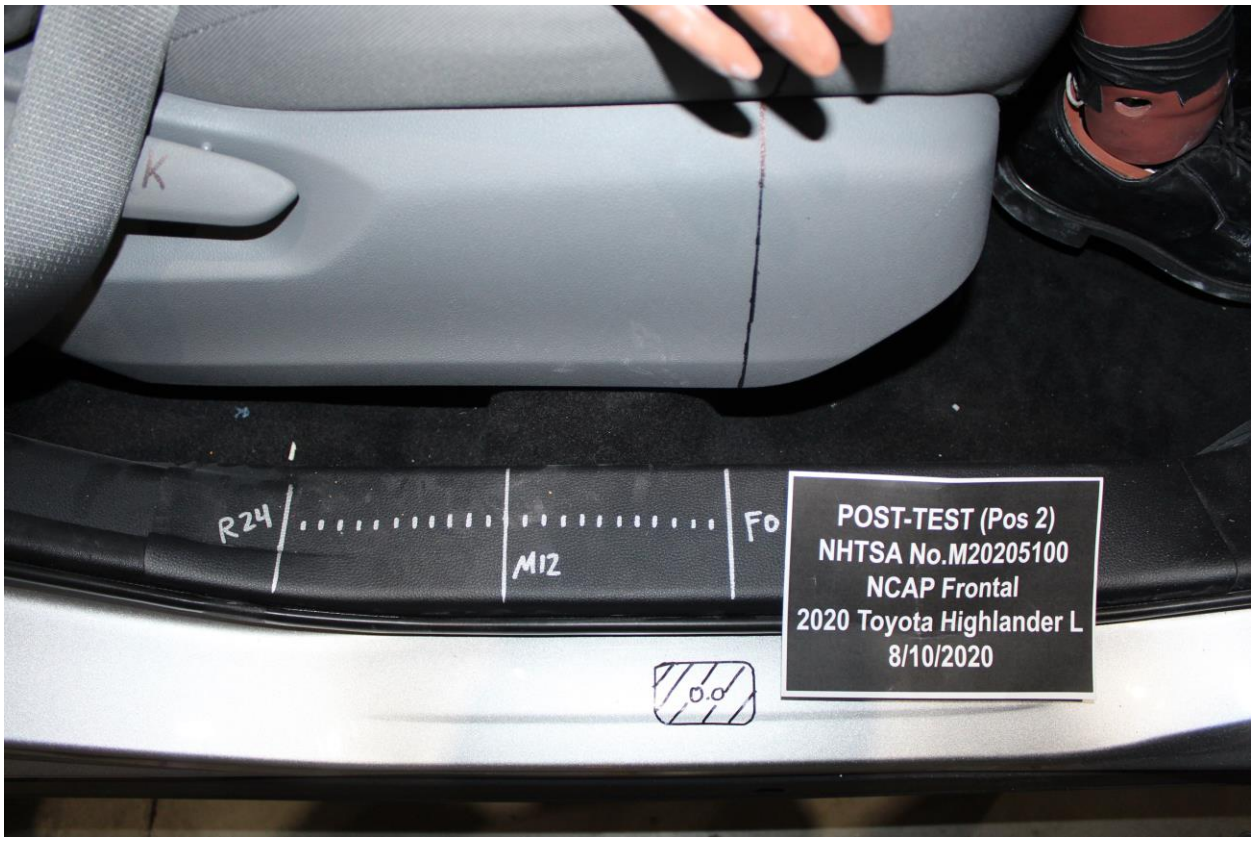


Figure A-60: Post-Test Passenger's Seat Fore-Aft Markings

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

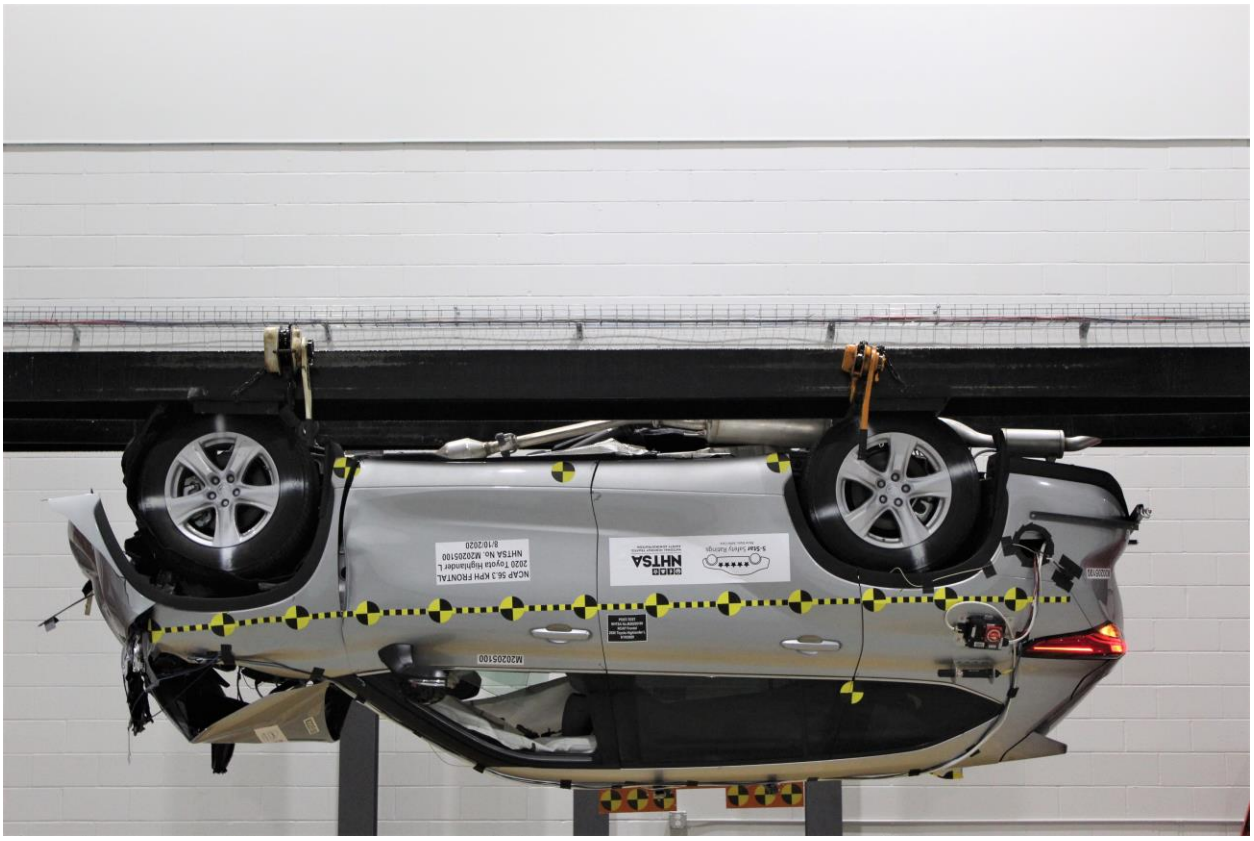


Figure A-79: Vehicle at 180º on Static Rollover Device

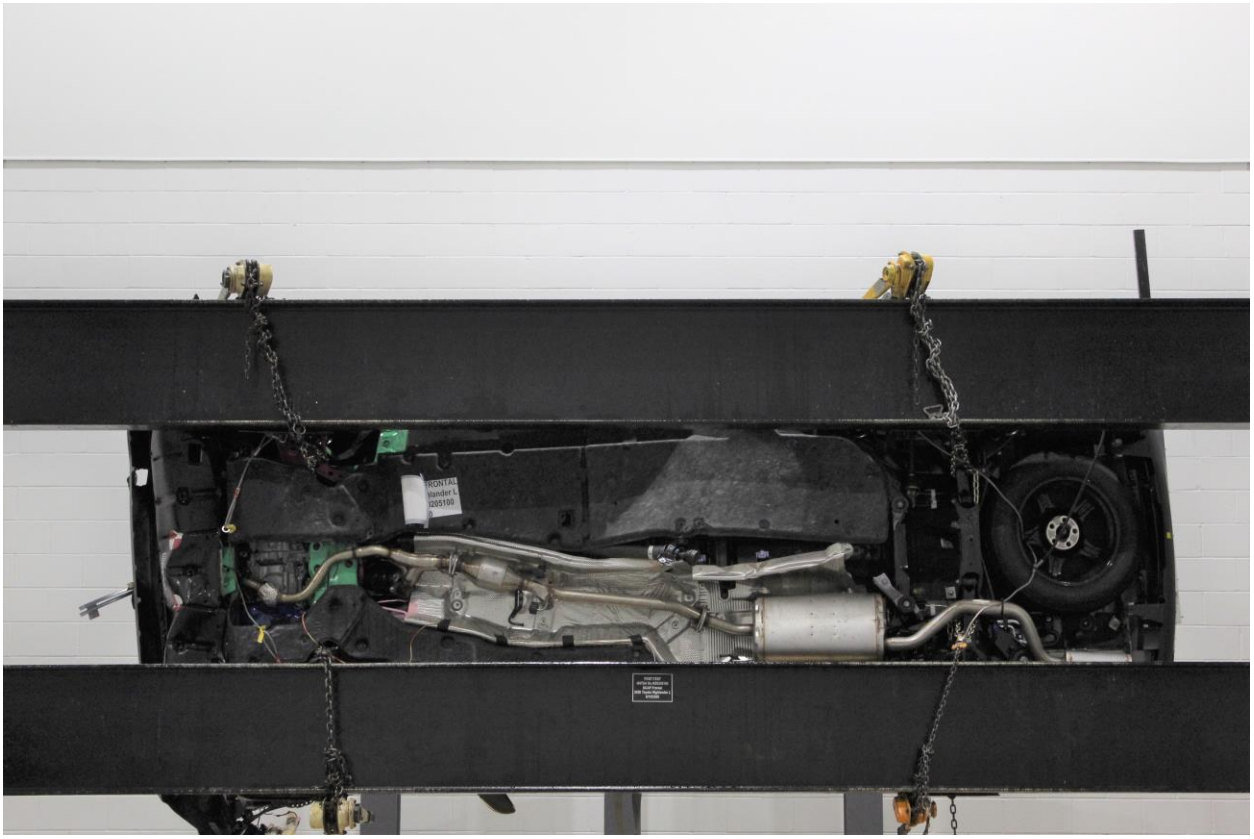


Figure A-80: Vehicle at 270º on Static Rollover Device

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

Figure A-82: 2020 Toyota Highlander Frontal Impact Event

Figure A-83: Monroney Label Photograph

APPENDIX B
VEHICLE & DUMMY RESPONSE DATA TRACES

Table of Data Plots

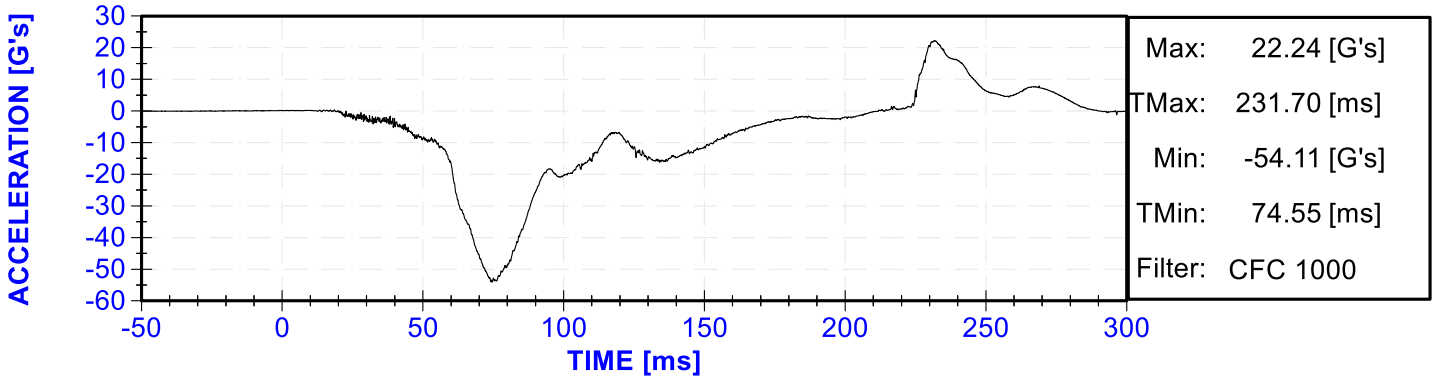
The following additional dummy and vehicle response data can be found in the R&D section of the NHTSA website at www.NHTSA.gov

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

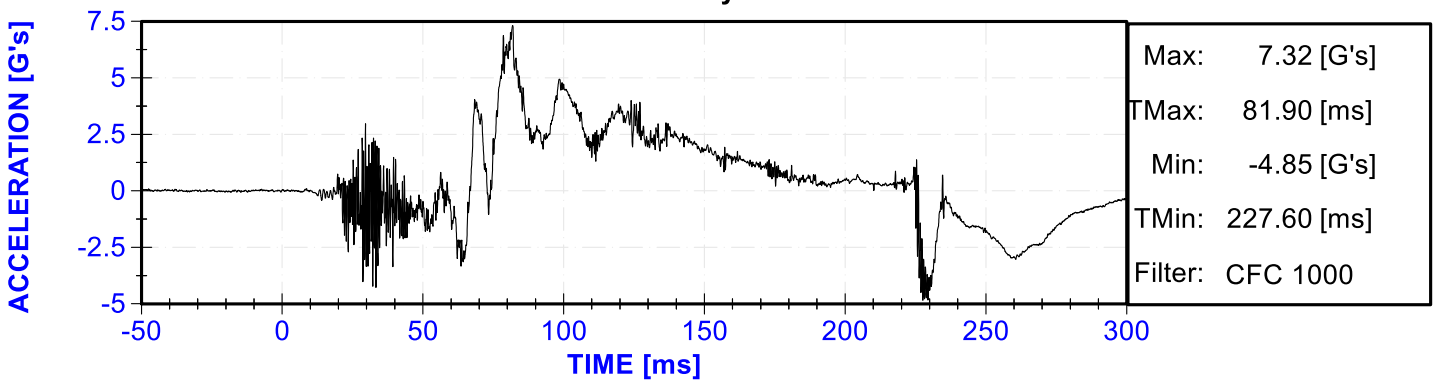
Driver Left Upper Tibia Force Z
Driver Left Lower Tibia Moment X
Driver Left Lower Tibia Moment Y
Driver Left Lower Tibia Force Z
Driver Right Upper Tibia Moment X
Driver Right Upper Tibia Moment Y
Driver Right Upper Tibia Force Z
Driver Right Lower Tibia Moment X
Driver Right Lower Tibia Moment Y
Driver 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

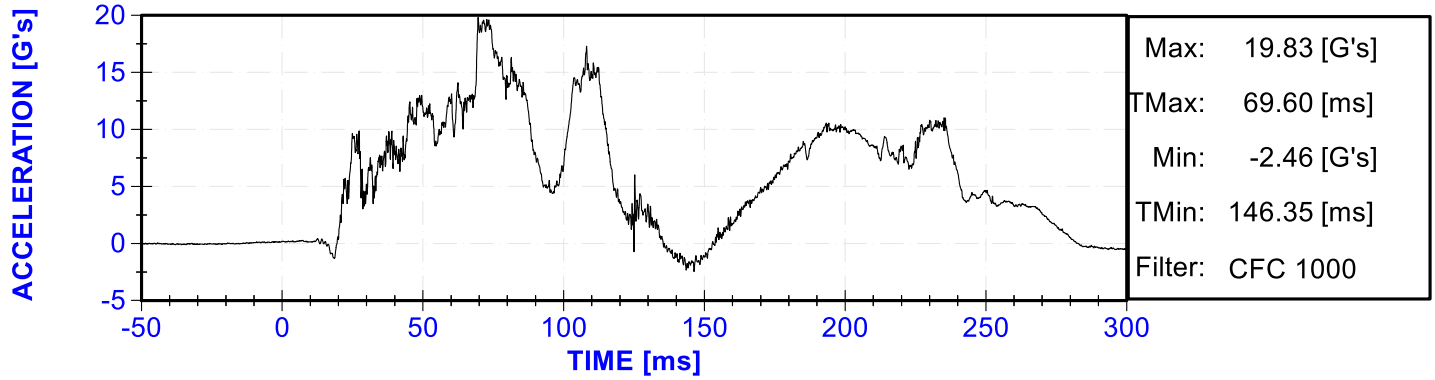
Driver Head X Acceleration vs. Time Primary



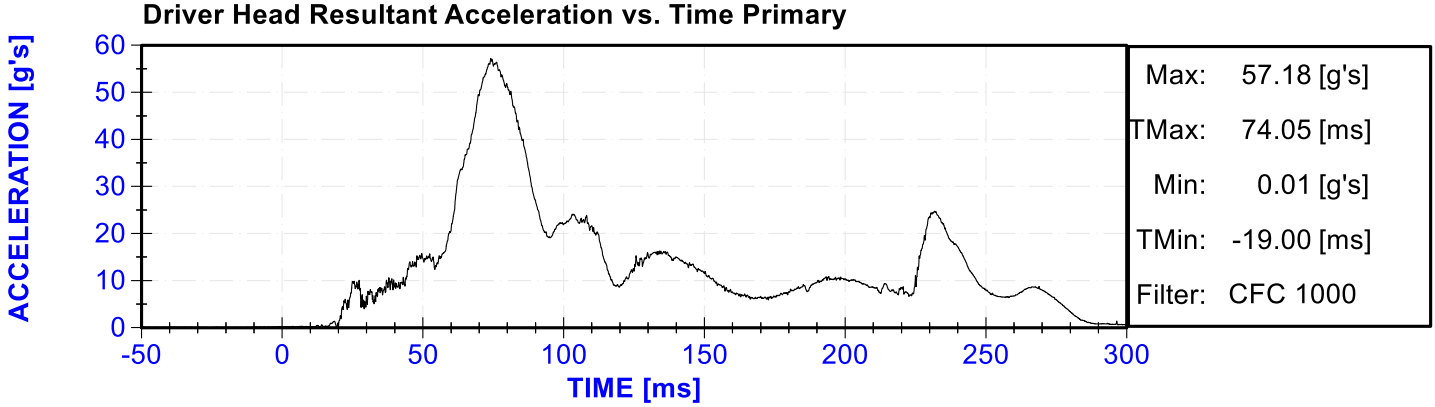
Driver Head Y Acceleration vs. Time Primary



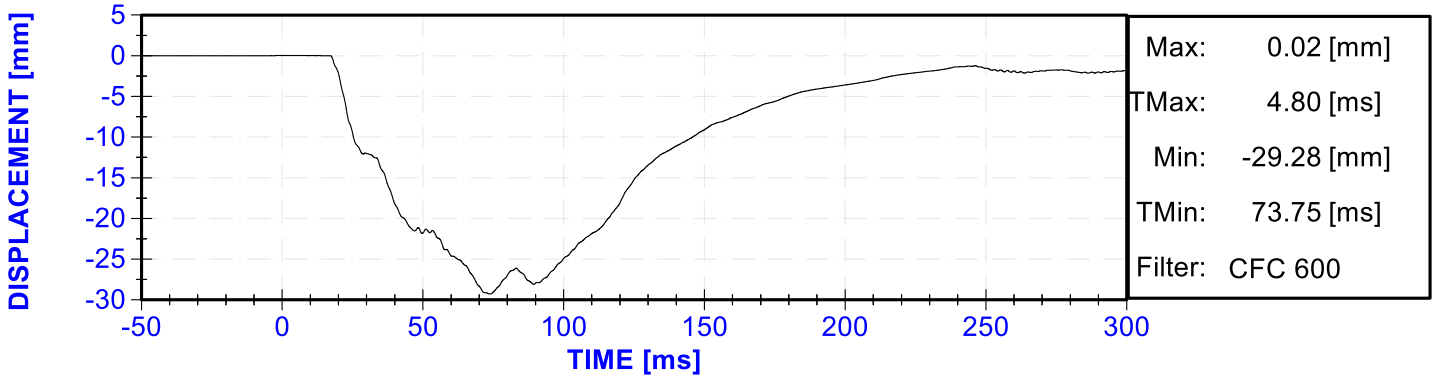
Driver Head Z Acceleration vs. Time Primary



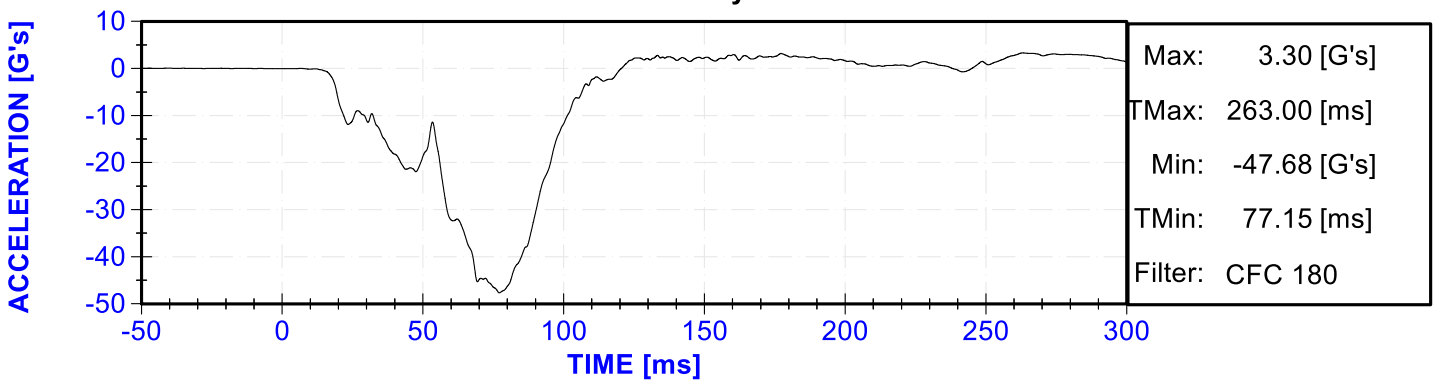
Driver Head Resultant Acceleration vs. Time Primary



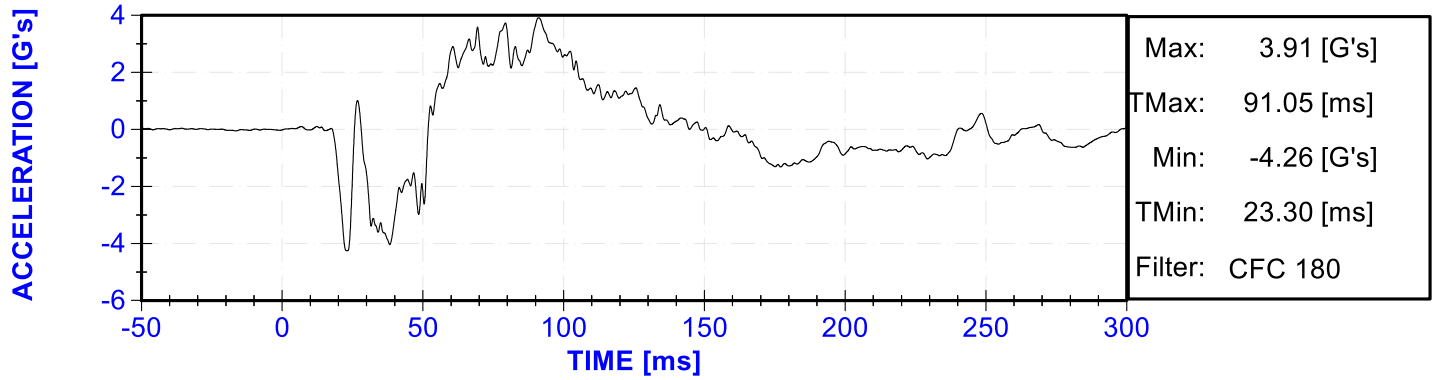
Driver Chest X Deflection vs. Time



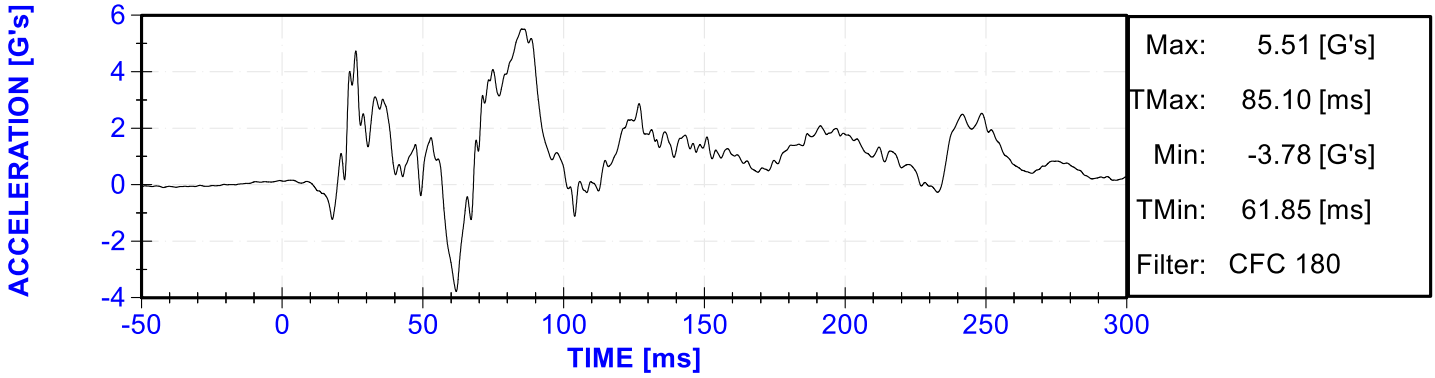
Driver Chest X Acceleration vs. Time Primary



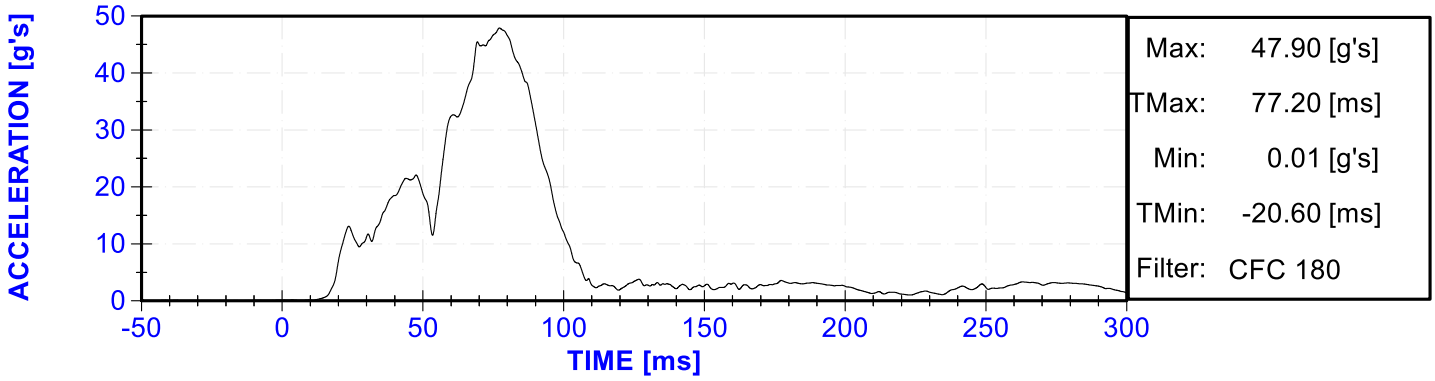
Driver Chest Y Acceleration vs. Time Primary



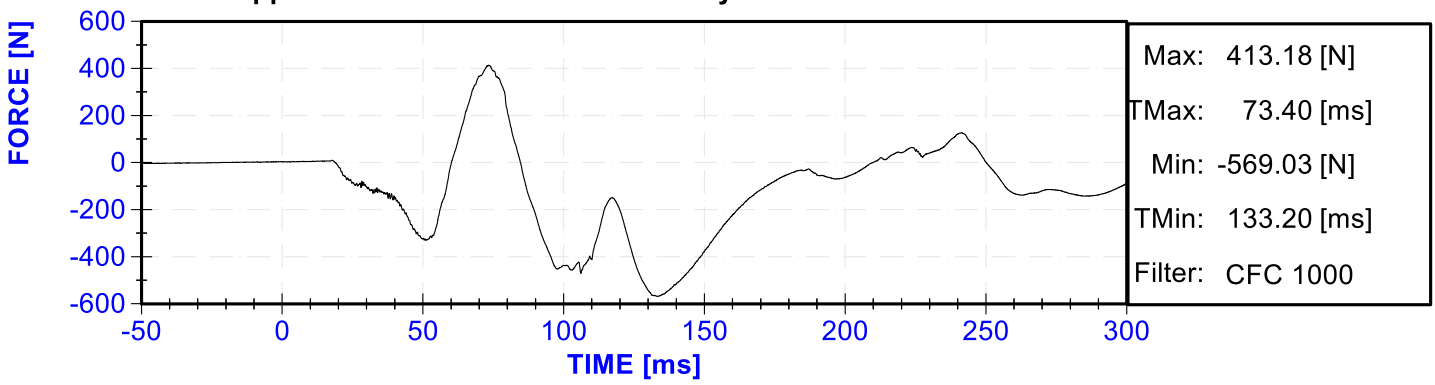
Driver Chest Z Acceleration vs. Time Primary



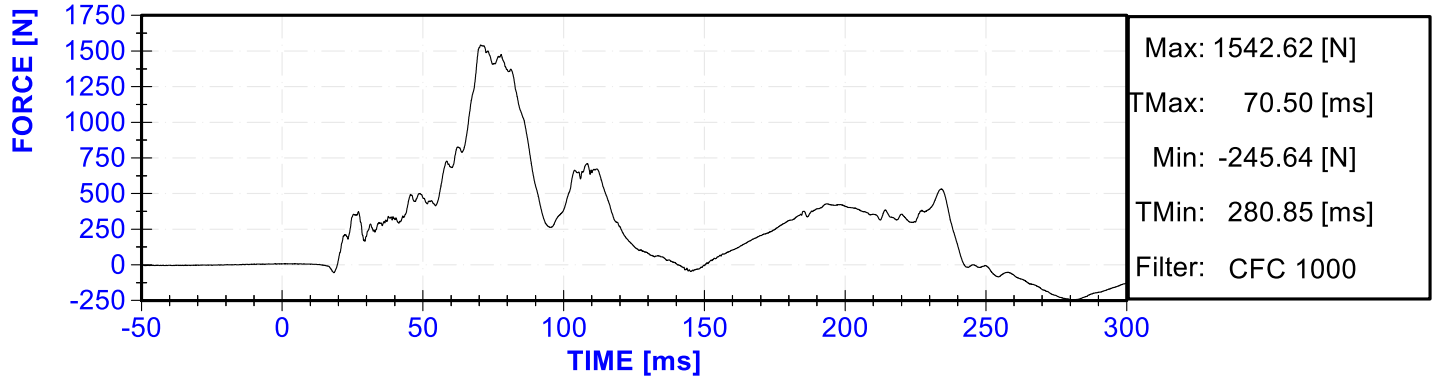
Driver Chest Resultant Acceleration vs. Time Primary



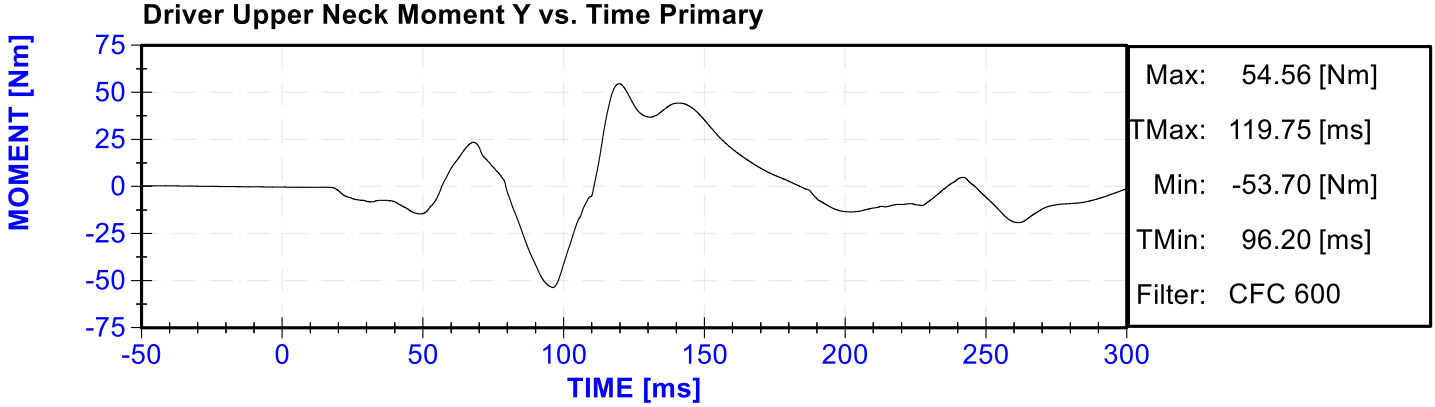
Driver Upper Neck Force X vs. Time Primary



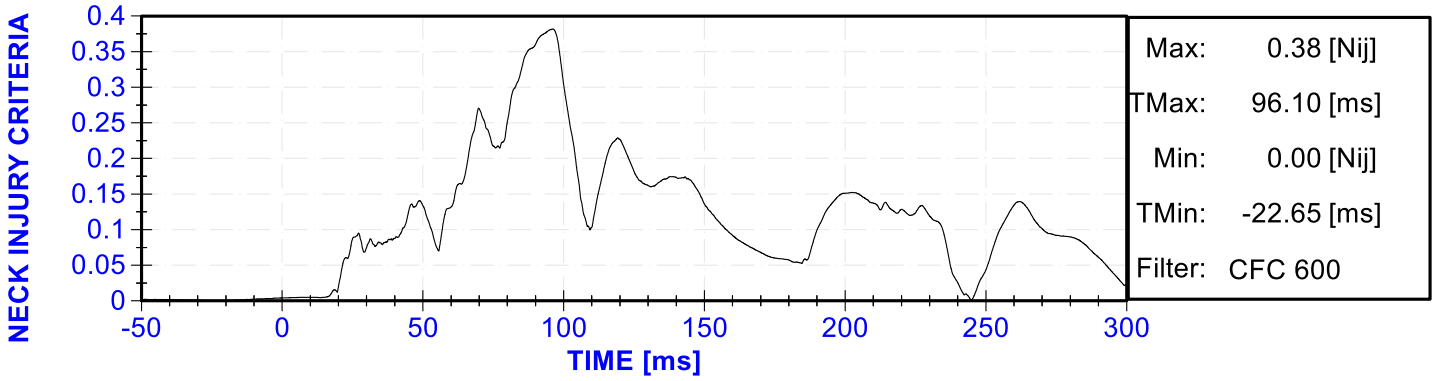
Driver Upper Neck Force Z vs. Time Primary



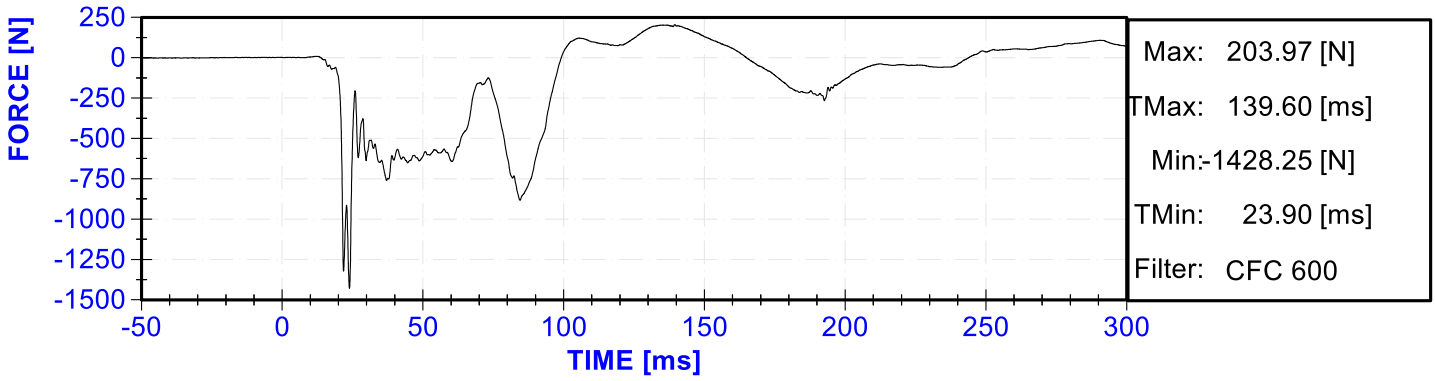
Driver Upper Neck Moment Y vs. Time Primary



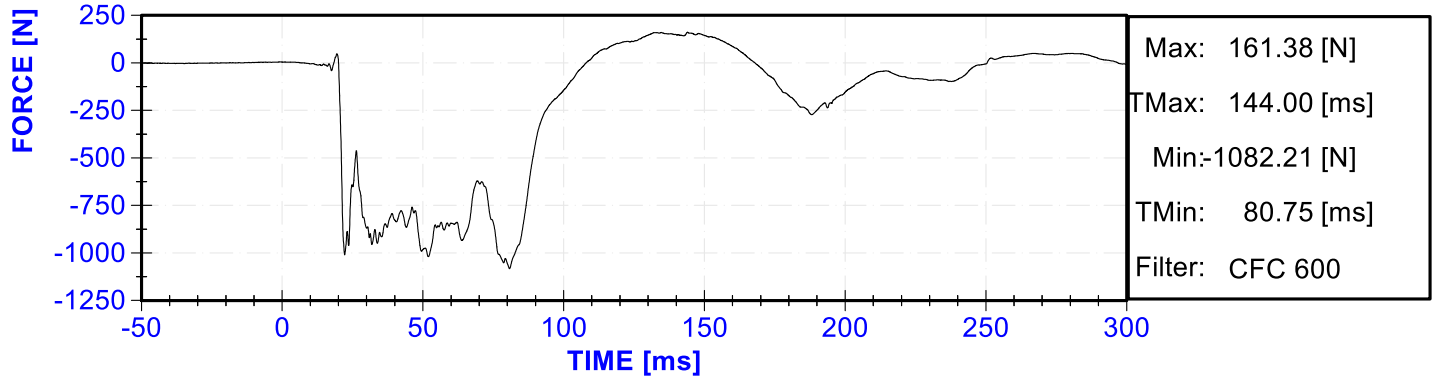
Driver Nij vs. Time Primary



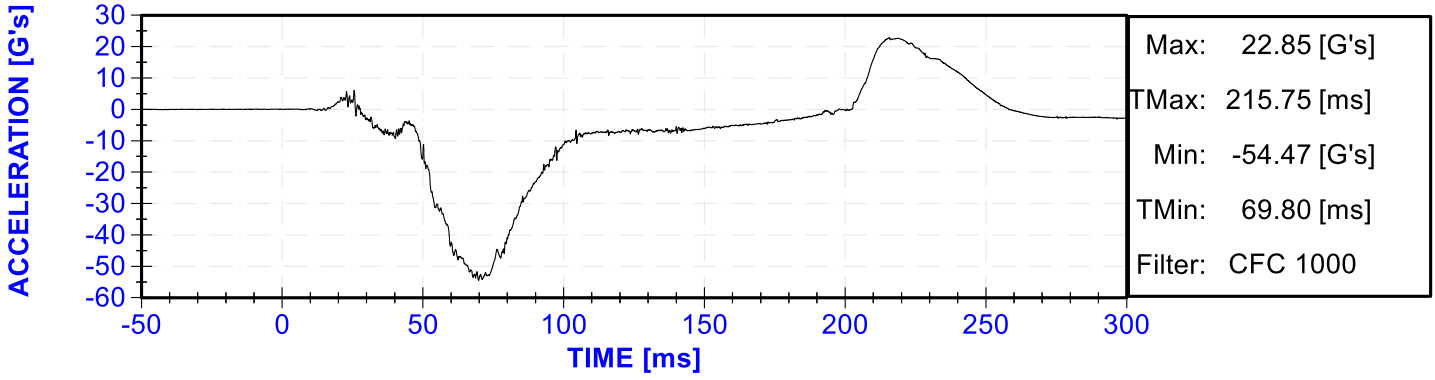
Driver Left Femur Force vs. Time



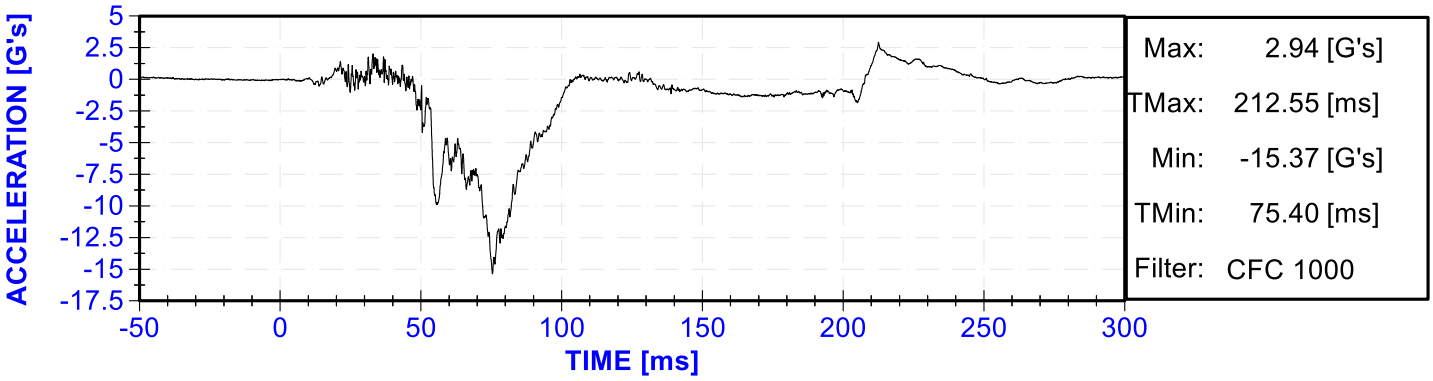
Driver Right Femur Force vs. Time



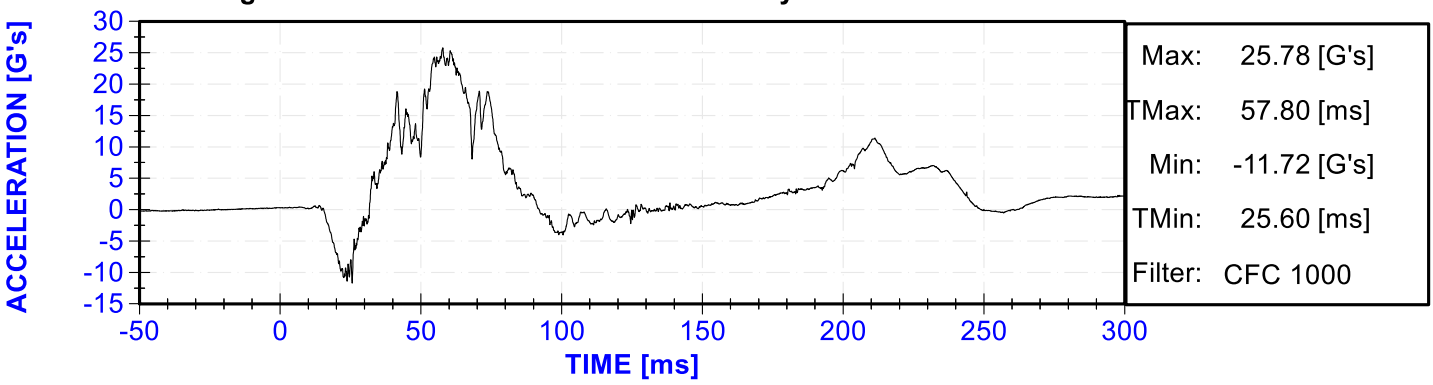
Passenger Head X Acceleration vs. Time Primary



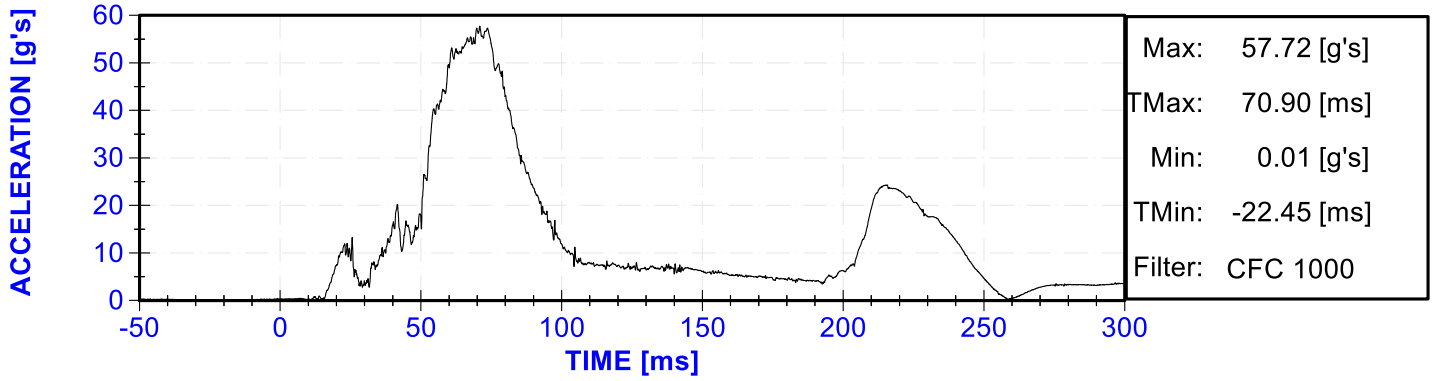
Passenger Head Y Acceleration vs. Time Primary



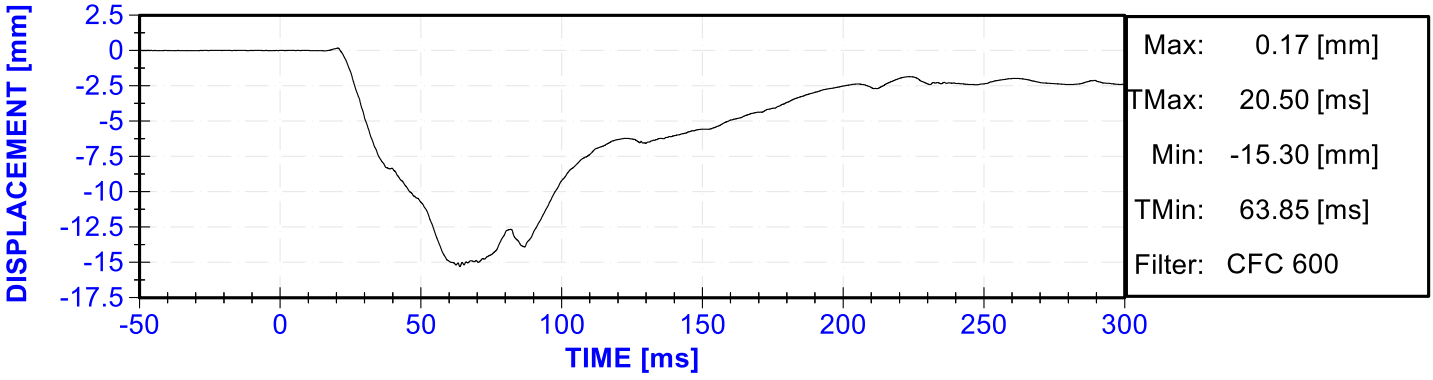
Passenger Head Z Acceleration vs. Time Primary



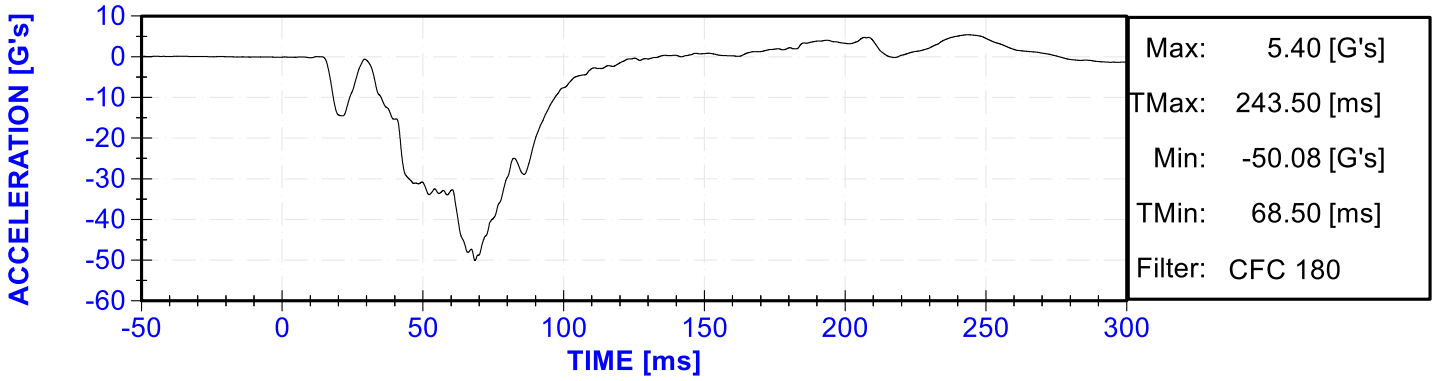
Passenger Head Resultant Acceleration vs. Time Primary



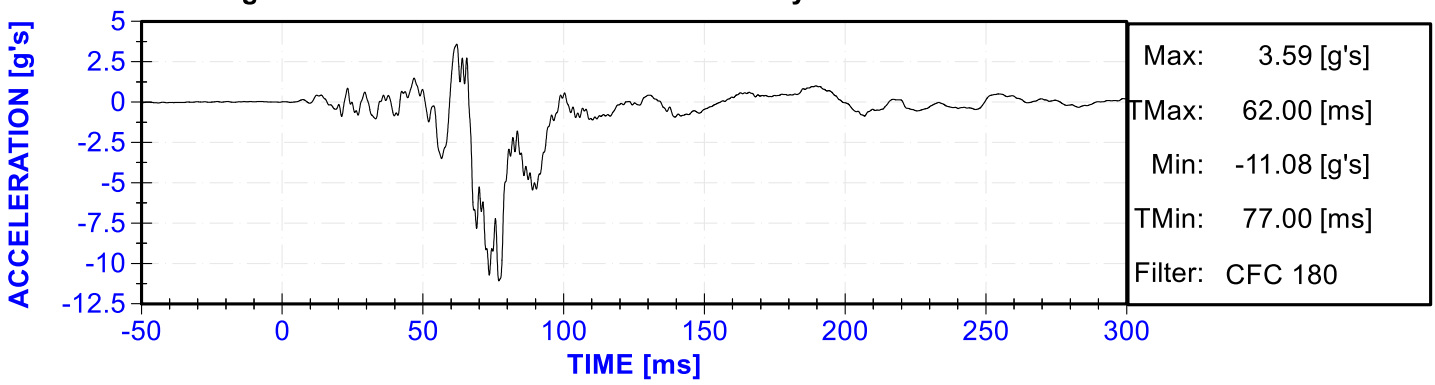
Passenger Chest X Deflection vs. Time



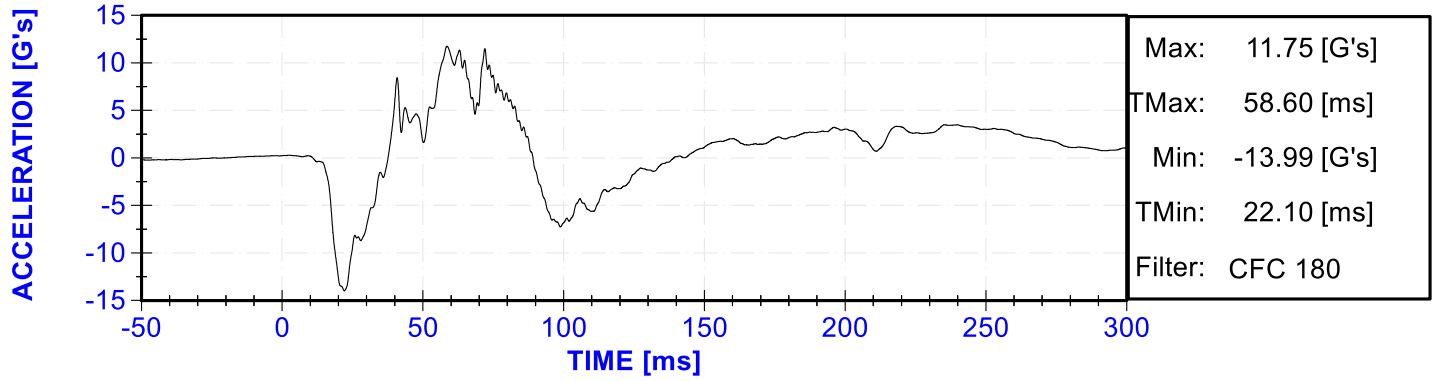
Passenger Chest X Acceleration vs. Time Primary



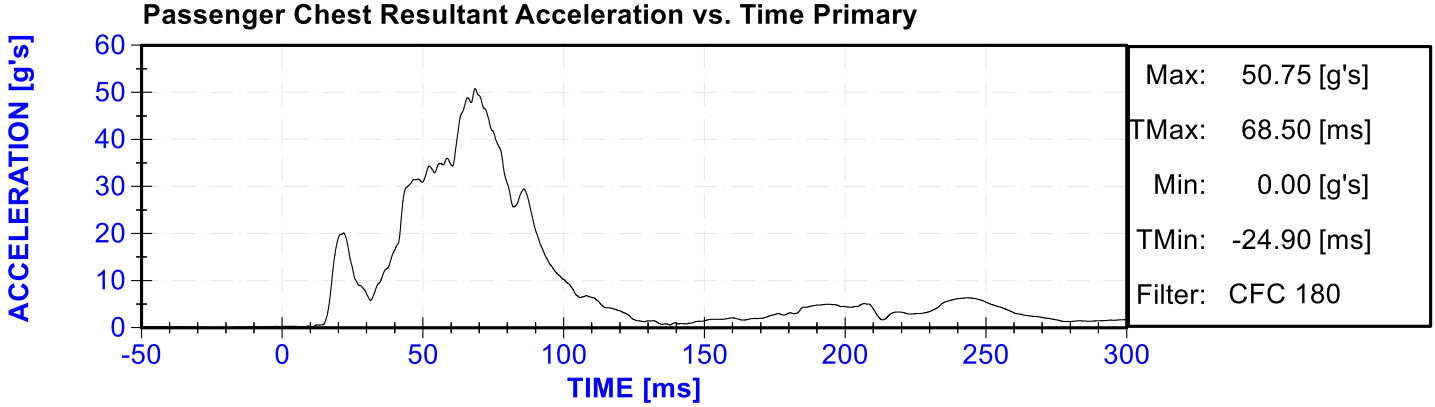
Passenger Chest Y Acceleration vs. Time Primary



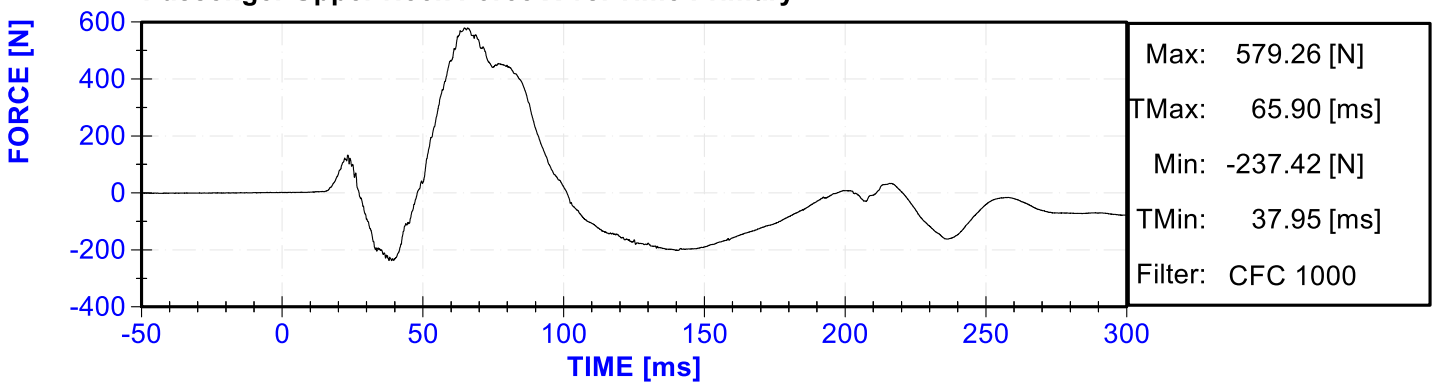
Passenger Chest Z Acceleration vs. Time Primary



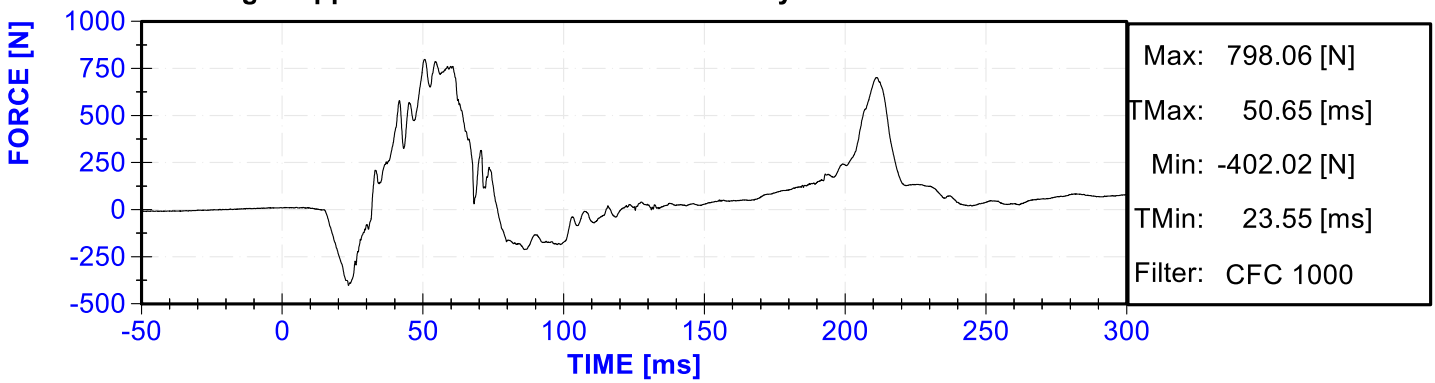
Passenger Chest Resultant Acceleration vs. Time Primary



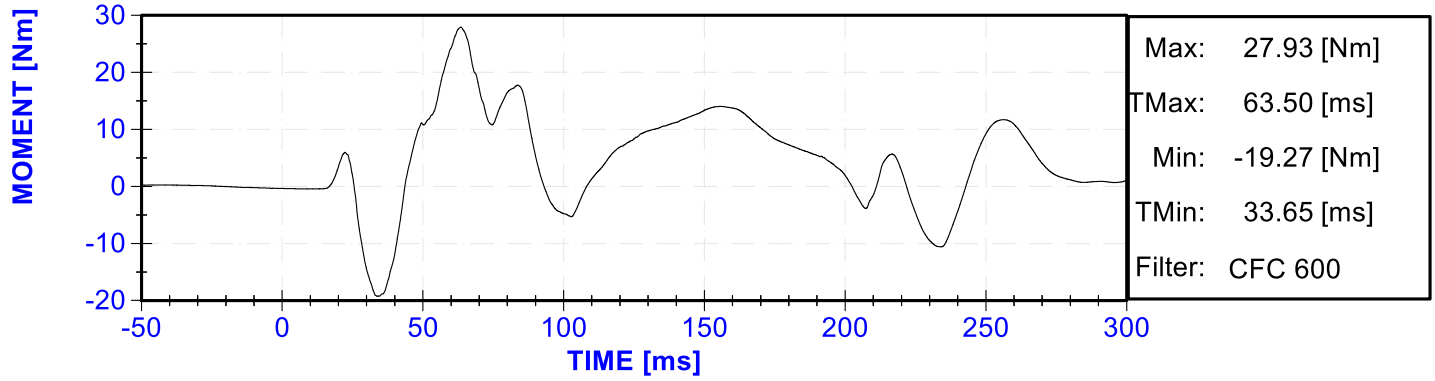
Passenger Upper Neck Force X vs. Time Primary



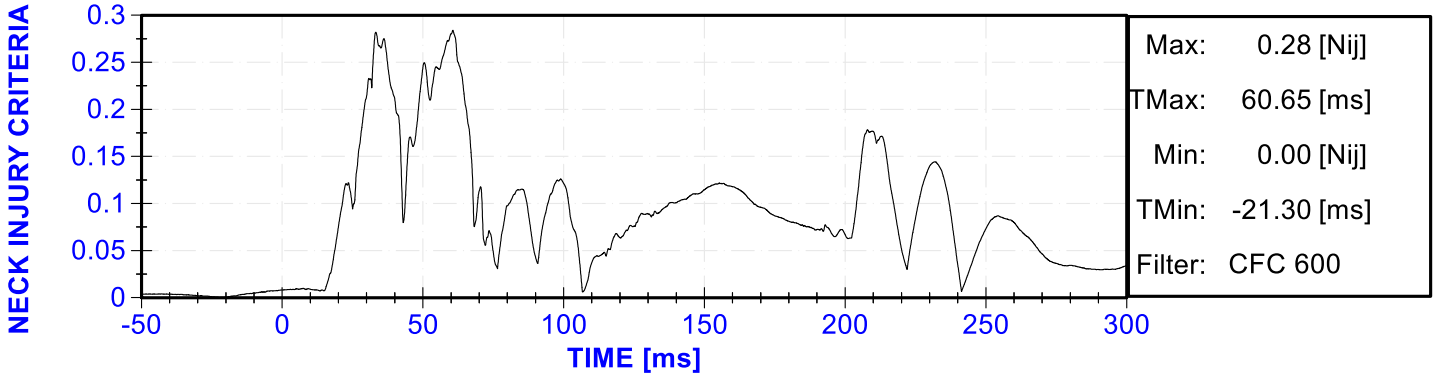
Passenger Upper Neck Force Z vs. Time Primary

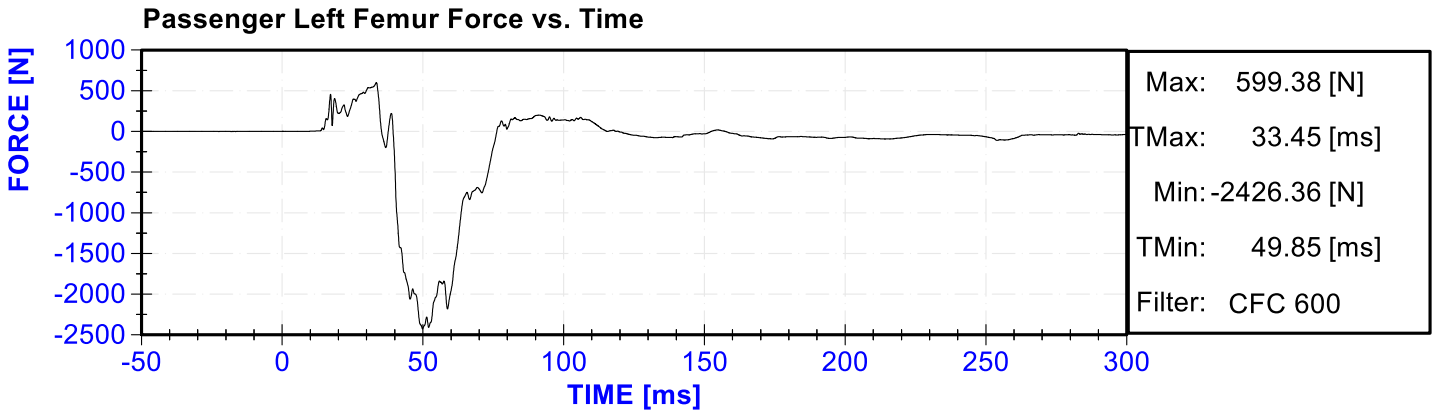


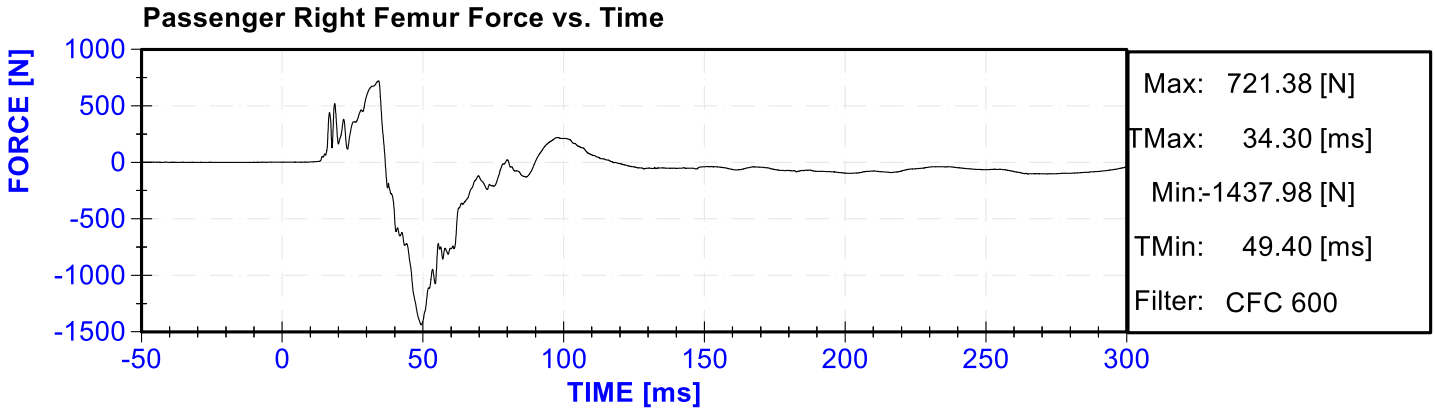
Passenger Upper Neck Moment Y vs. Time Primary



Passenger Nij vs. Time Primary




Passenger Left Femur Force vs. Time
FORCE [N]
1000
500
0
-500
-1000
-1500
-2000
-2500
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 599.38 [N]
TMax: 33.45 [ms]
Min: -2426.36 [N]
TMin: 49.85 [ms]
Filter: CFC 600


Passenger Right Femur Force vs. Time
FORCE [N]
1000
500
0
-500
-1000
-1500
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 721.38 [N]
TMax: 34.30 [ms]
Min: -1437.98 [N]
TMin: 49.40 [ms]
Filter: CFC 600

APPENDIX C

DUMMY CALIBRATION AND PERFORMANCE VERIFICATION DATA

CALIBRATION TEST RESULTS

PRE-TEST

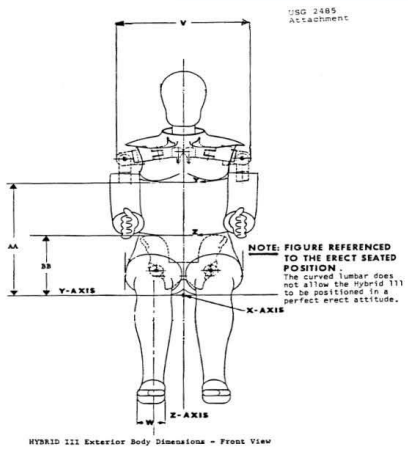
HYBRID III 50TH PERCENTILE MALE - DRIVER ATD

SERIAL NO: 142

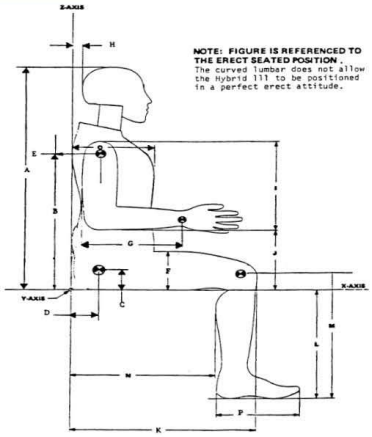
External Measurements - Hybrid 3 - 50th Male

Technician: K. Dutton Date: 08/04/2020

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	5.9	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	13.3	Pass
J	Elbow Rest Height	7.5	8.3	8.1	Pass
K	Buttock to Knee Length	22.8	23.8	23.1	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	18.5	Pass
O	Chest Depth without Jacket	8.4	9.0	8.6	Pass
P	Foot Length (right)	9.9	10.5	10.2	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

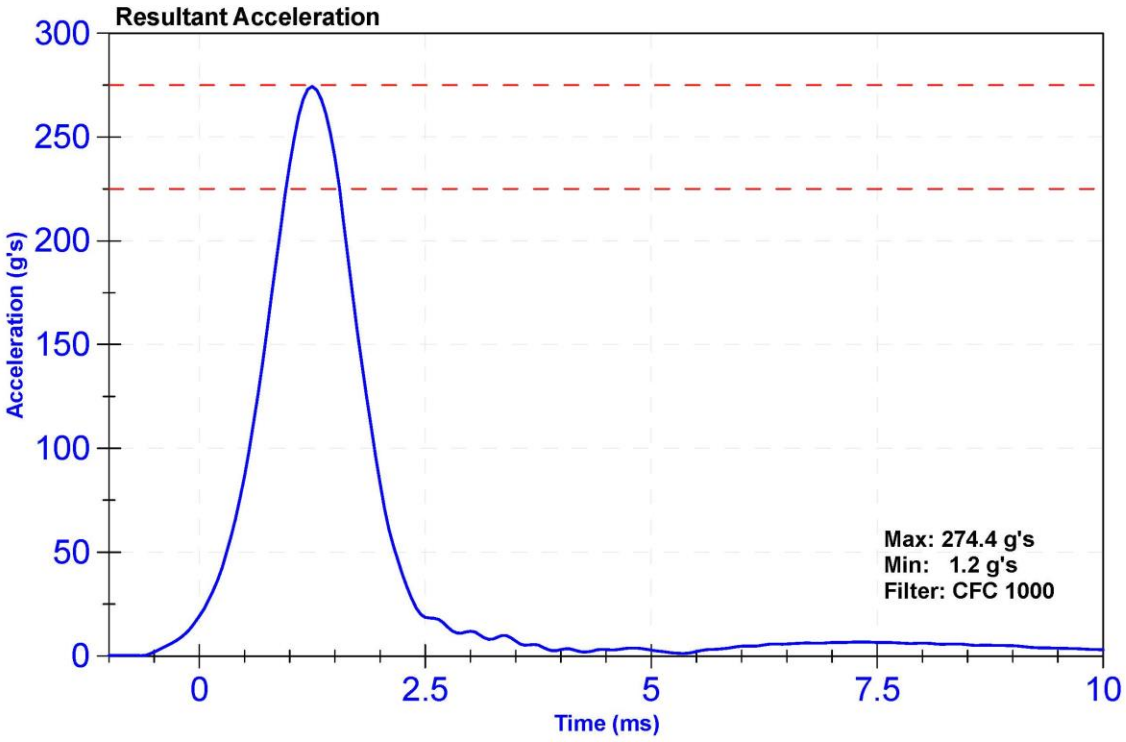
ATD Manufacturer	Humanetics	Test Technician	C. Mantell
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

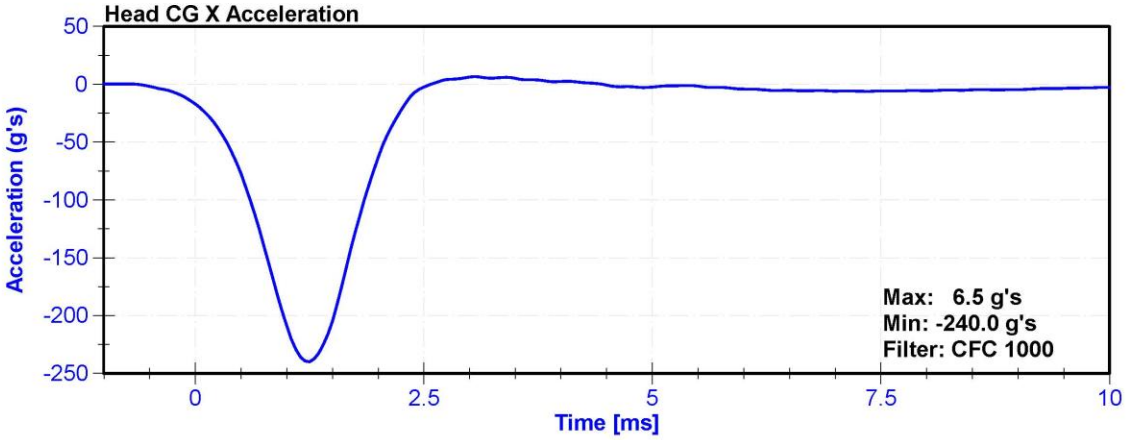
Results

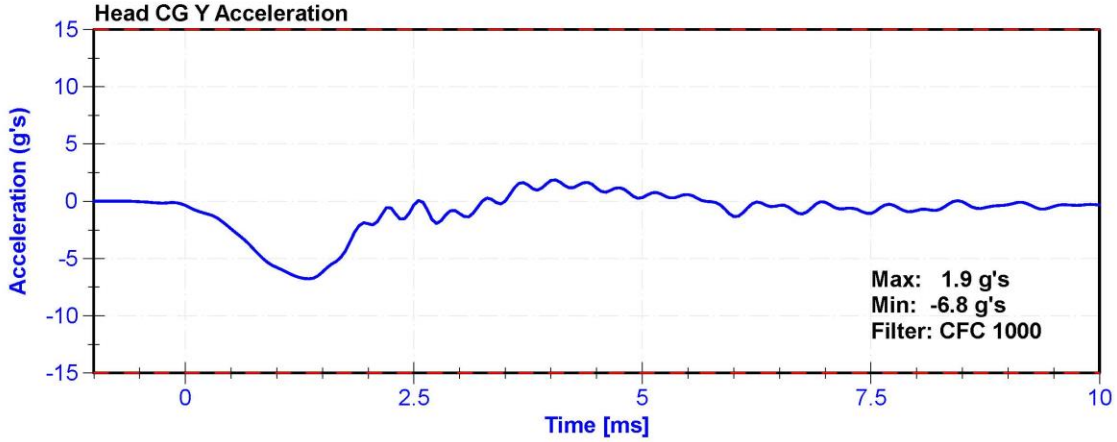
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.4	Pass
Humidity	10	70	%	65.7	Pass
Resultant Acceleration	225	275	g's	274.4	Pass
Oscillation	0	10	%	4.3	Pass
Lateral Acceleration	-15	15	g's	-6.8	Pass

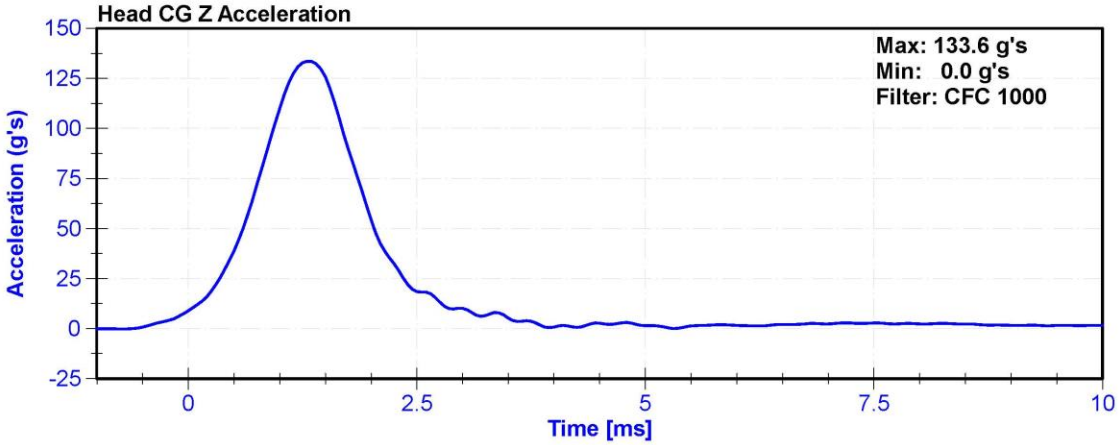
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264	P51681	4/17/2020	10/16/2020
Y Accelerometer	ENDEVCO 7264	P64151	4/17/2020	10/16/2020
Z Accelerometer	ENDEVCO 7264	P52114	4/17/2020	10/16/2020




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: -240.0 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: 1.9 g's
Min: -6.8 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: 133.6 g's
Min: 0.0 g's
Filter: CFC 1000

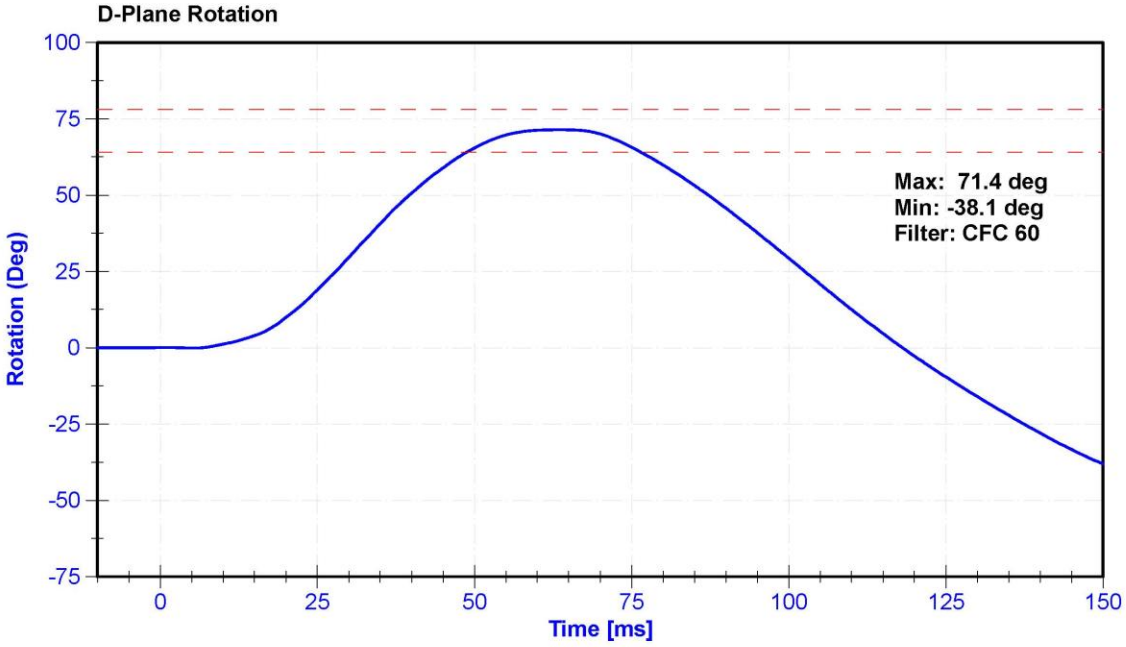
ATD Manufacturer	Humanetics	Test Technician	C. Mantell
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

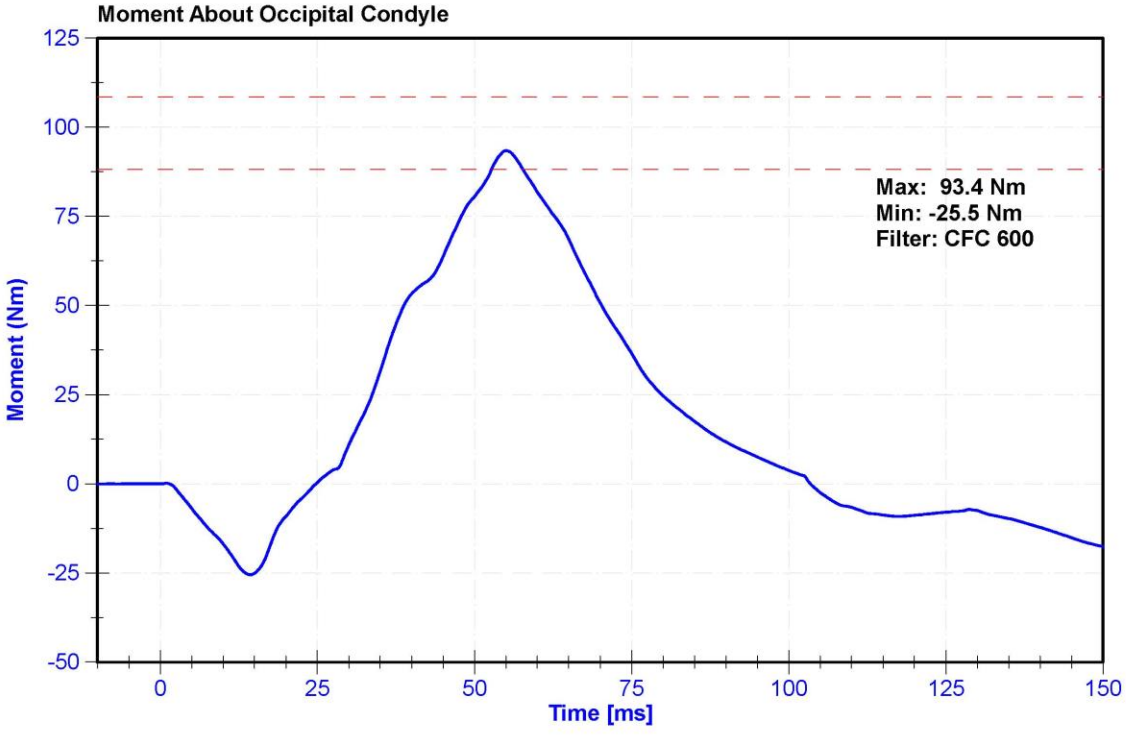
Results

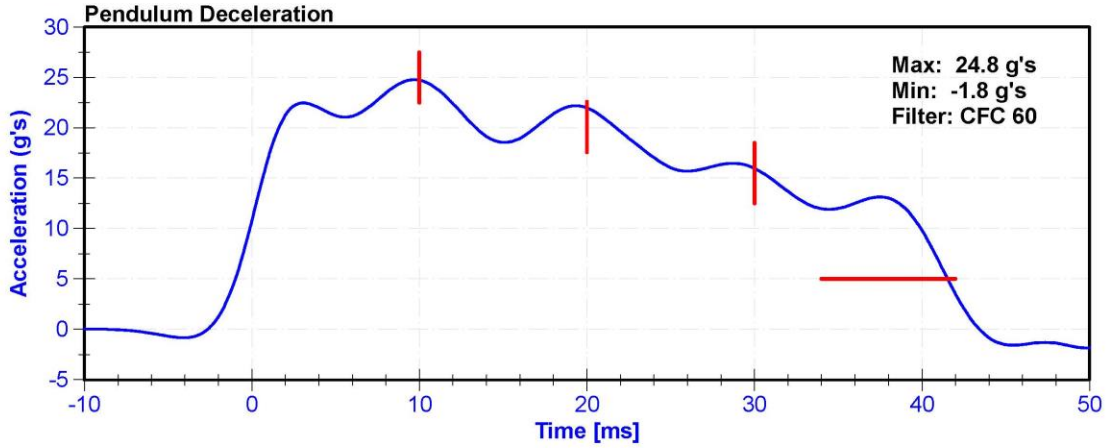
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	65.7	Pass
Velocity	6.89	7.13	m/s	6.903	Pass
Pendulum Deceleration at 10ms	22.5	27.5	g's	24.73	Pass
Pendulum Deceleration at 20ms	17.6	22.6	g's	21.97	Pass
Pendulum Deceleration at 30ms	12.5	18.5	g's	15.98	Pass
Max. Pendulum Deceleration After 30ms	0	29	g's	24.8	Pass
Pendulum Deceleration Time to 5 g's	34	42	ms	41.5	Pass
Maximum D Plane Rotation	64	78	deg	71.4	Pass
Time to Maximum Rotation	57	64	ms	63.6	Pass
Rotation Decay to Zero	113	127	ms	118.1	Pass
Moment About Occipital Condyle	88.1	108.4	Nm	93.38	Pass
Time to Maximum Moment	47	58	ms	55.0	Pass
Moment Decay to Zero	97	107	ms	103.4	Pass

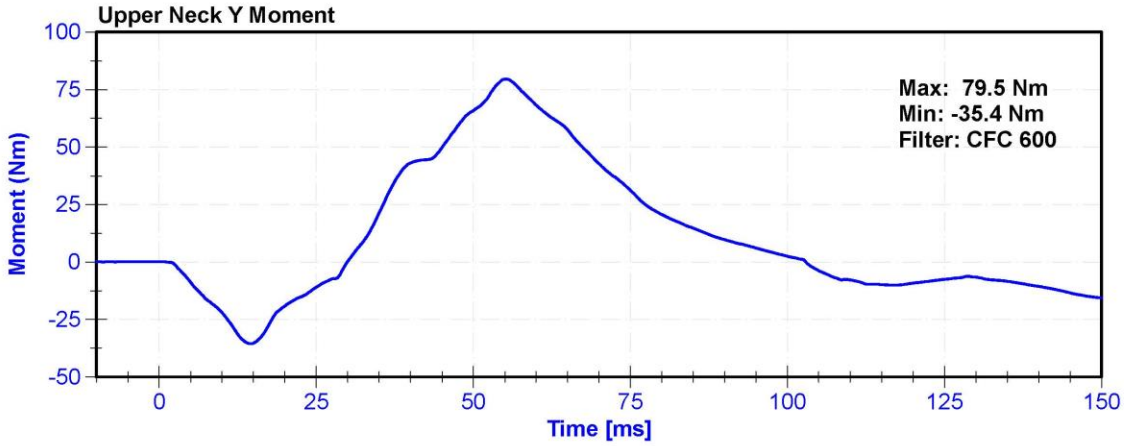
Transducer Calibrations

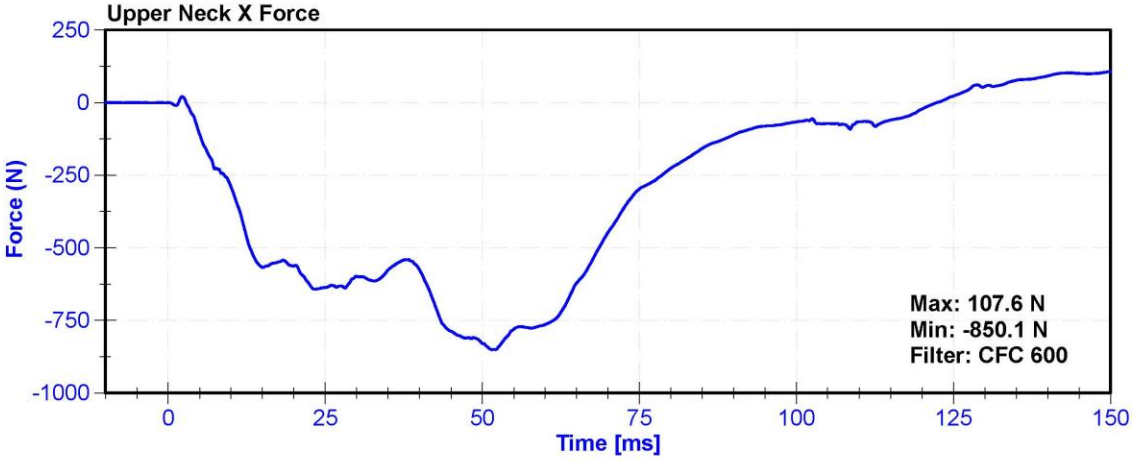
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton IF-205	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: 71.4 deg
Min: -38.1 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 93.4 Nm
Min: -25.5 Nm
Filter: CFC 600


Pendulum Deceleration
Acceleration (g's)
Time [ms]
Max: 24.8 g's
Min: -1.8 g's
Filter: CFC 60


Upper Neck Y Moment
Moment (Nm)
Time [ms]
Max: 79.5 Nm
Min: -35.4 Nm
Filter: CFC 600


Upper Neck X Force
Force (N)
Time [ms]
Max: 107.6 N
Min: -850.1 N
Filter: CFC 600

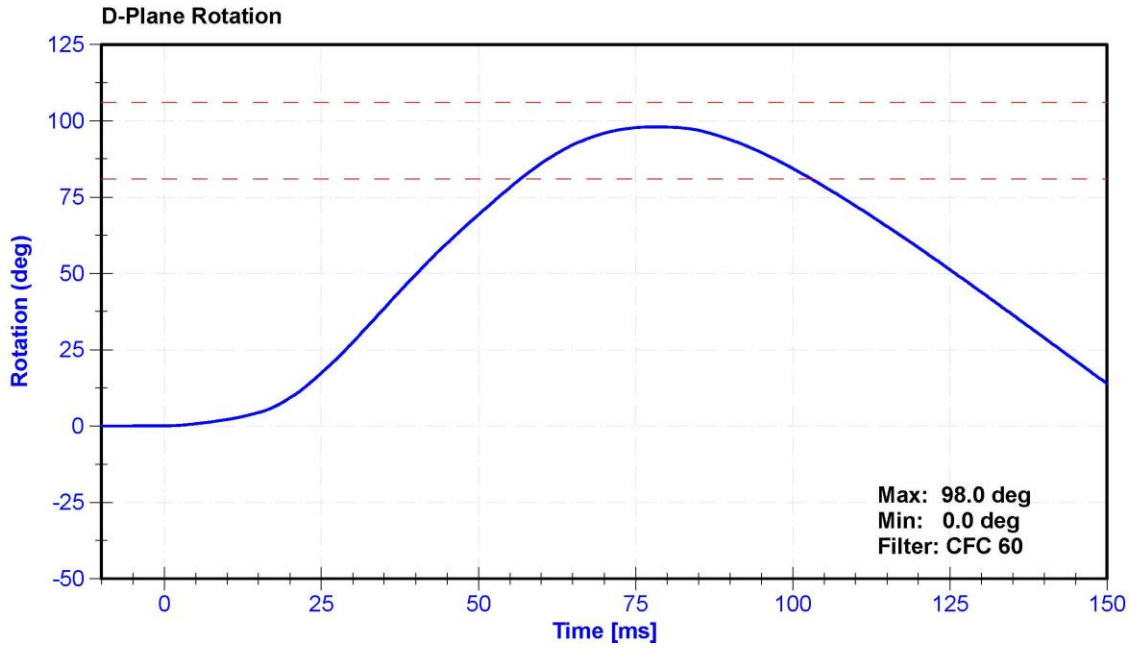
ATD Manufacturer	Humanetics	Test Technician	C. Mantell
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

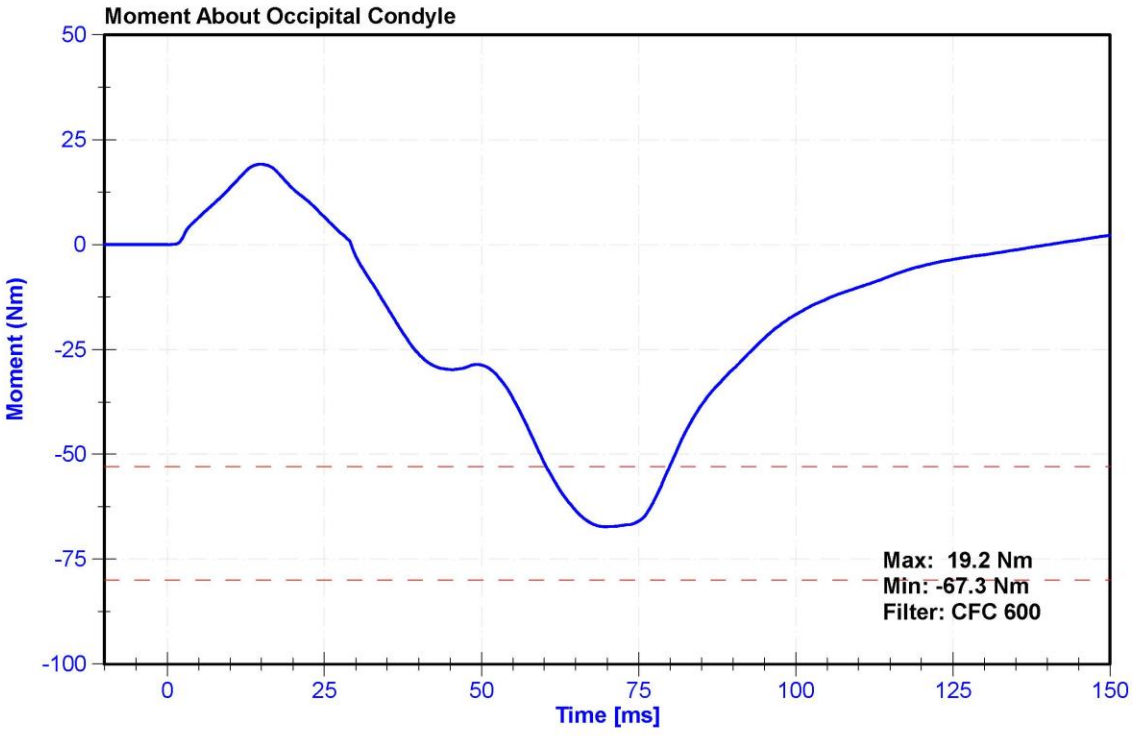
Results

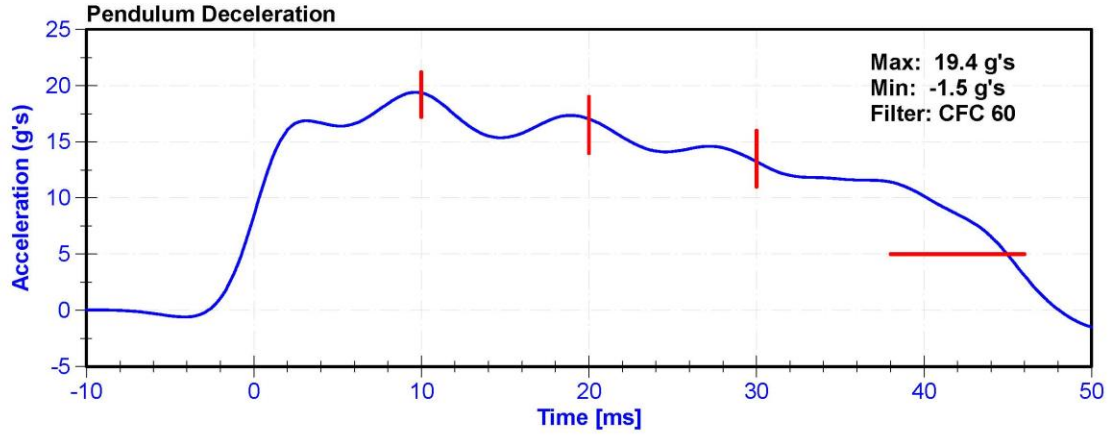
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.4	Pass
Humidity	10	70	%	67.8	Pass
Velocity	5.94	6.19	m/s	6.005	Pass
Pendulum Deceleration at 10ms	17.2	21.2	g's	19.35	Pass
Pendulum Deceleration at 20ms	14	19	g's	17.0	Pass
Pendulum Deceleration at 30ms	11	16	g's	13.2	Pass
Max. Pendulum Deceleration After 30ms	0	22	g's	19.4	Pass
Pendulum Deceleration Time to 5 g's	38	46	ms	45.0	Pass
Maximum D Plane Rotation	81	106	deg	98.0	Pass
Time to Maximum Rotation	72	82	ms	78.1	Pass
Rotation Decay to Zero	147	174	ms	159.4	Pass
Minimum Moment About OC	-80	-52.9	Nm	-67.28	Pass
Time to Minimum Moment	65	79	ms	69.6	Pass
Moment Decay to Zero	120	148	ms	140.5	Pass

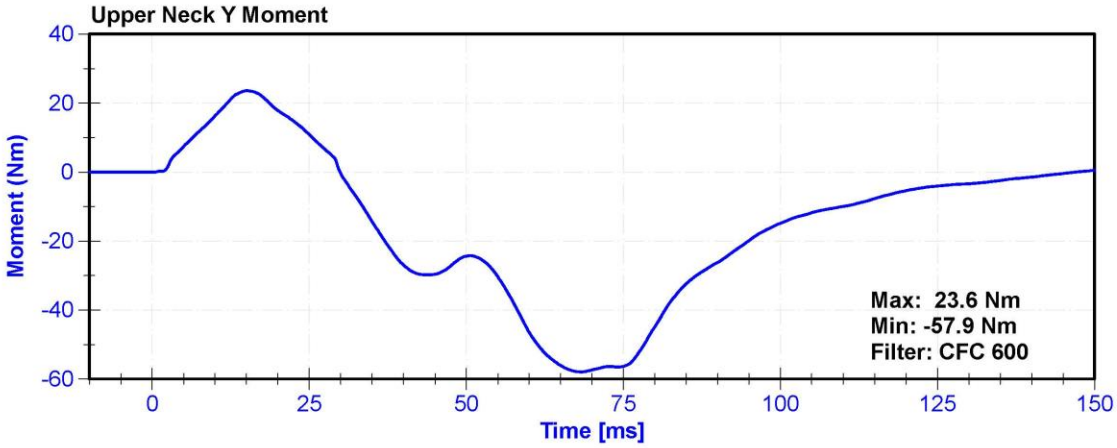
Transducer Calibrations

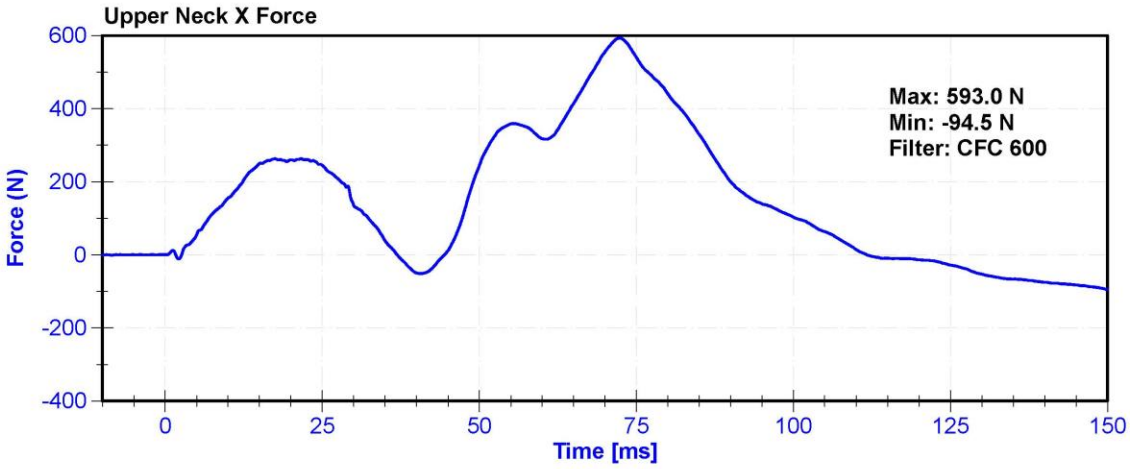
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton IF-205	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: 98.0 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: 19.2 Nm
Min: -67.3 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 19.4 g's
Min: -1.5 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: 23.6 Nm
Min: -57.9 Nm
Filter: CFC 600
Moment (Nm)
40
20
0
-20
-40
-60
0
25
50
75
100
125
150
Time [ms]


Upper Neck X Force
Max: 593.0 N
Min: -94.5 N
Filter: CFC 600
Force (N)
600
400
200
0
-200
-400
0
25
50
75
100
125
150
Time [ms]

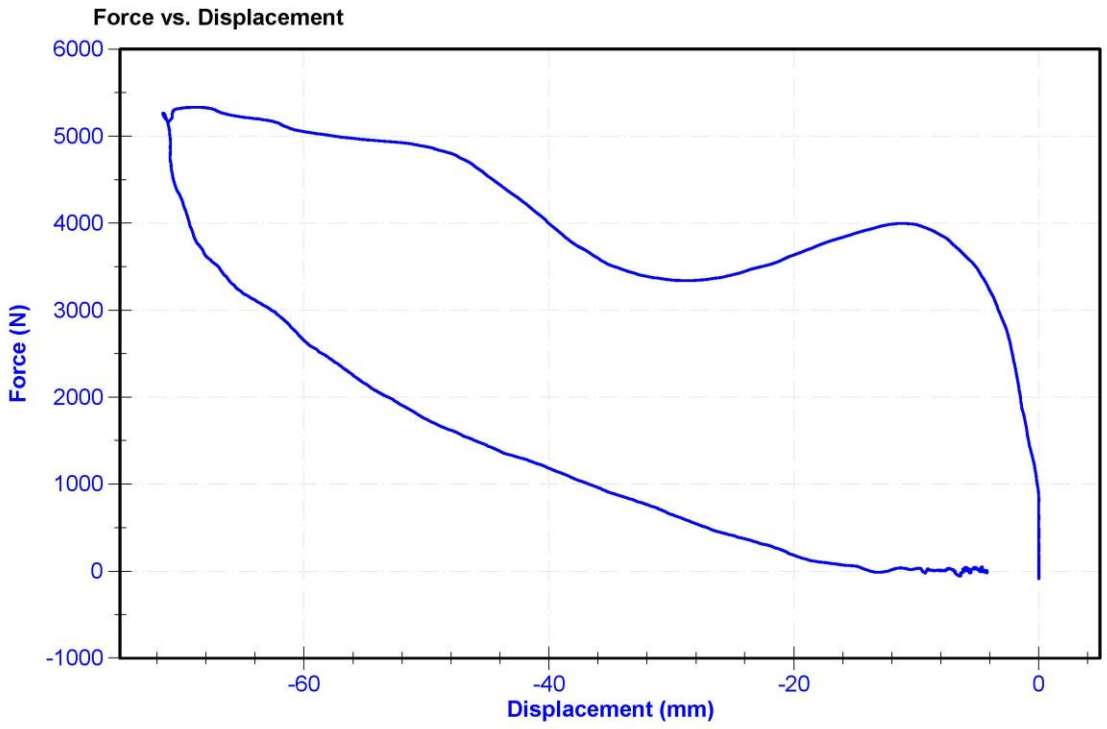
ATD Manufacturer	Humanetics	Test Technician	C. Mantell
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

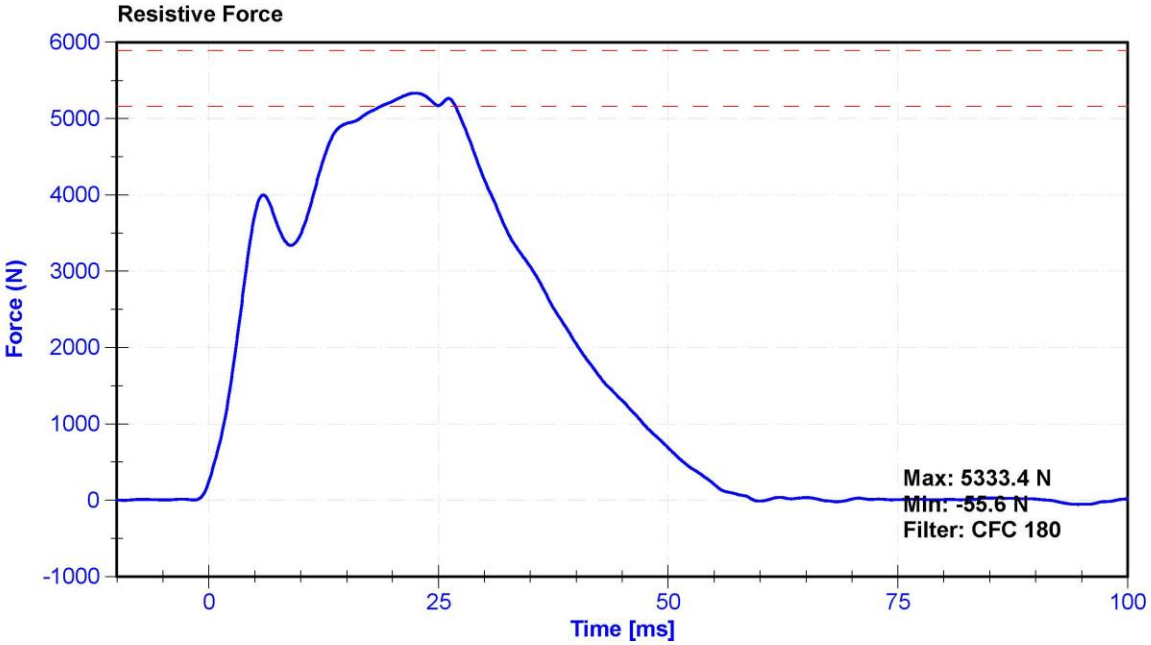
Results

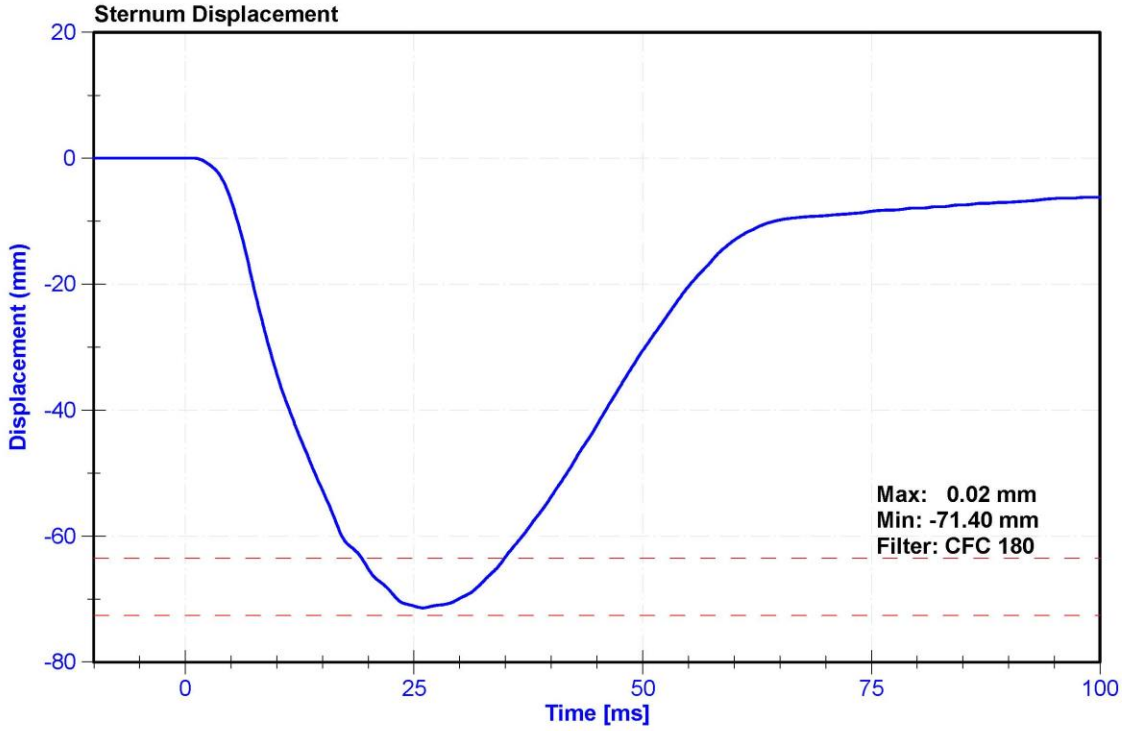
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.4	Pass
Humidity	10	70	%	65.8	Pass
Velocity	6.59	6.83	m/s	6.626	Pass
Chest Displacement	-72.6	-63.5	mm	-71.40	Pass
Resistive Force	5160	5894	N	5333.4	Pass
Hysteresis	65	85	%	69.6	Pass

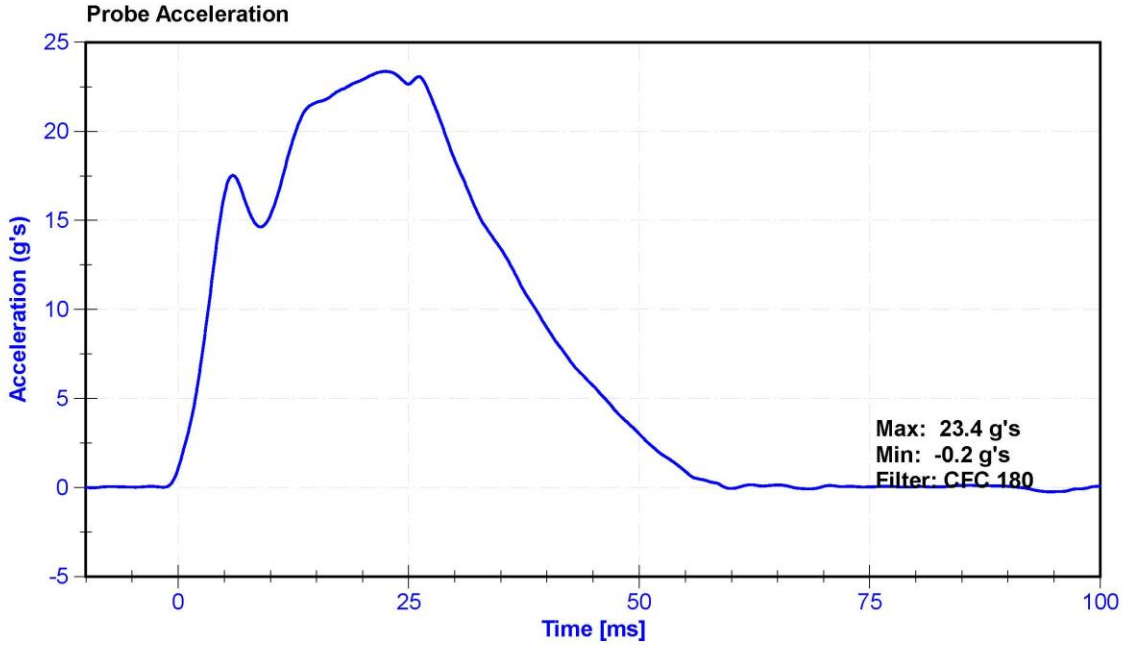
Transducer Calibrations

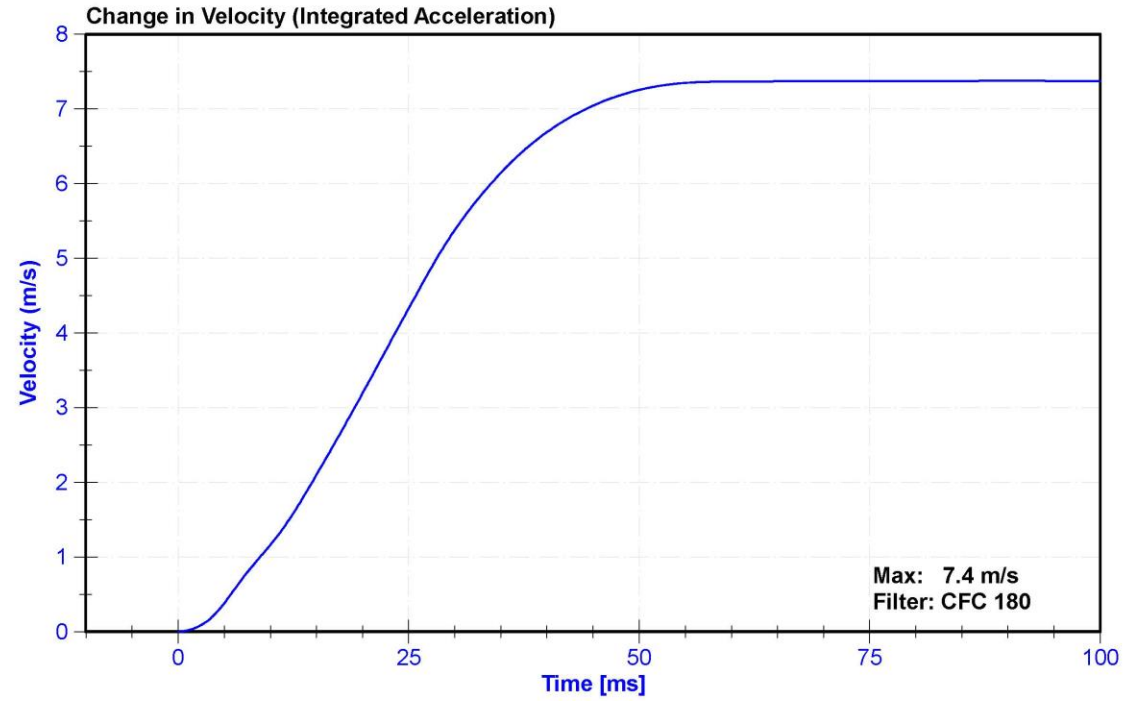
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021
Chest Potentiometer	Servo 6209-2038	DS-142	6/23/2020	12/22/2020




Resistive Force
Force (N)
6000
5000
4000
3000
2000
1000
0
-1000
0
25
50
75
100
Time [ms]
Max: 5333.4 N
Min: -55.6 N
Filter: CFC 180


Sternum Displacement
Displacement (mm)
20
0
-20
-40
-60
-80
0
25
50
75
100
Time [ms]
Max: 0.02 mm
Min: -71.40 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
25
20
15
10
5
0
-5
0
25
50
75
100
Time [ms]
Max: 23.4 g's
Min: -0.2 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

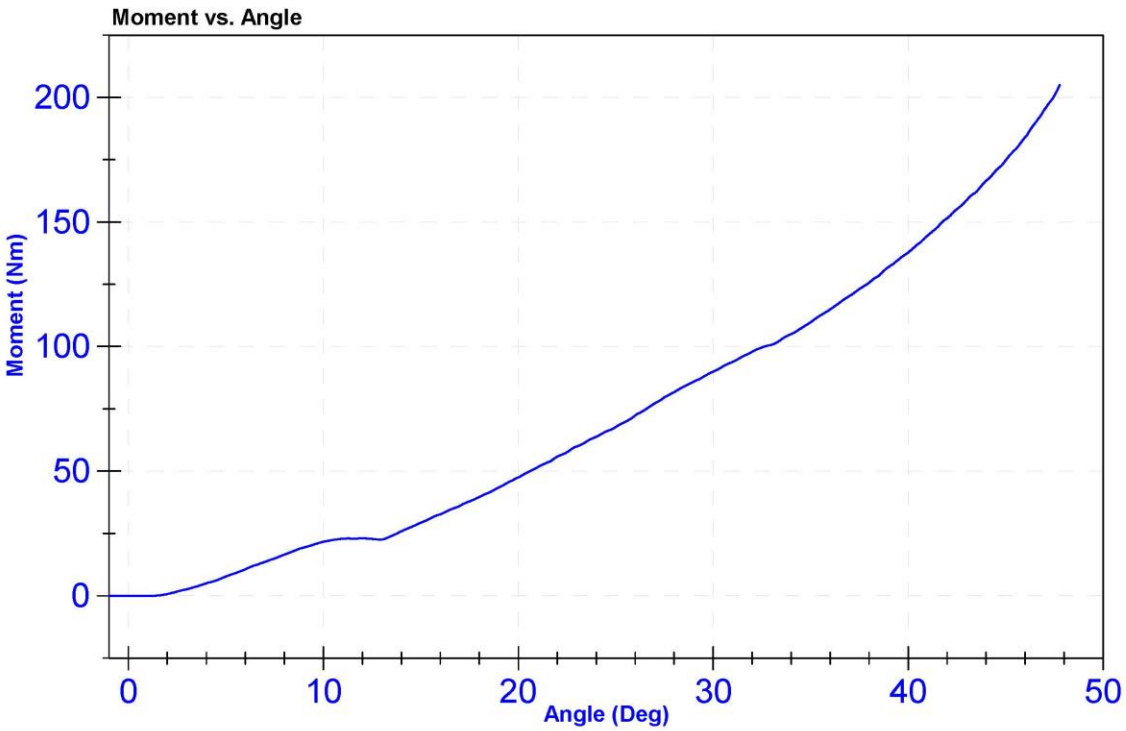
ATD Manufacturer	Humanetics	Test Technician	C. Mantell
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	65.9	Pass
Average Velocity	5	10	deg/s	7.3	Pass
Angle at 203Nm	40	50	deg	47.7	Pass
Moment at 30 degrees	0	94.9	Nm	90.0	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



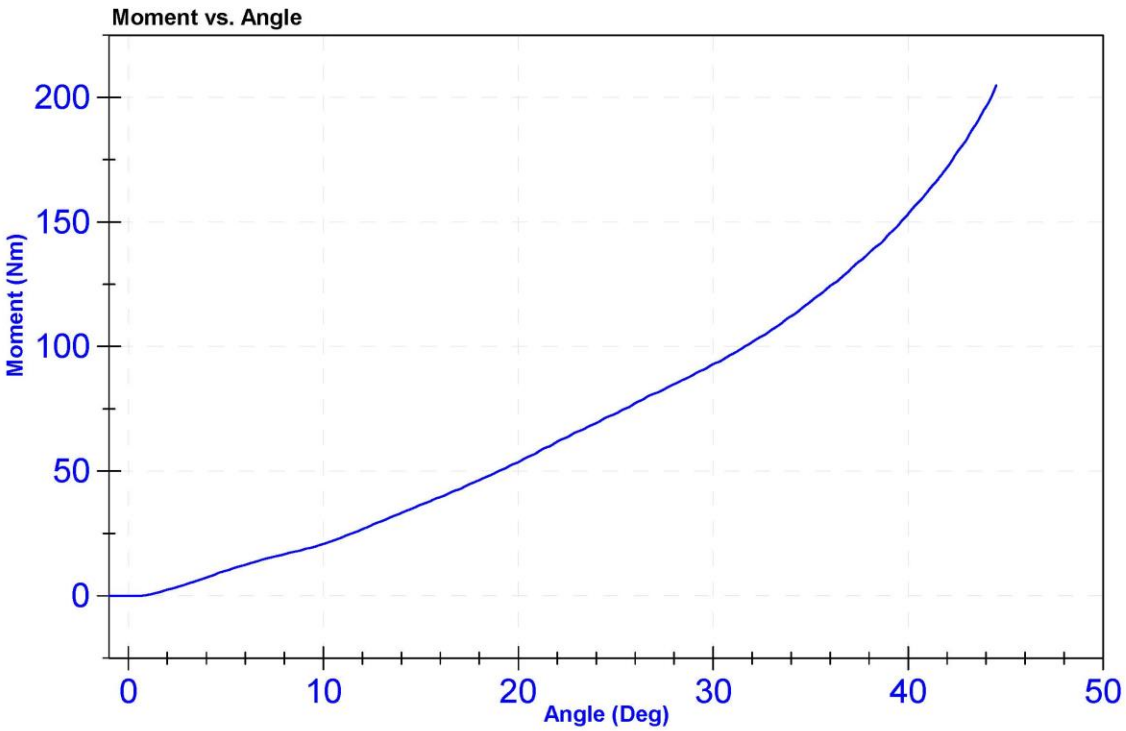
ATD Manufacturer	Humanetics	Test Technician	C. Mantell
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.6	Pass
Humidity	10	70	%	67.8	Pass
Average Velocity	5	10	deg/s	7.3	Pass
Angle at 203Nm	40	50	deg	44.4	Pass
Moment at 30 degrees	0	94.9	Nm	93.0	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



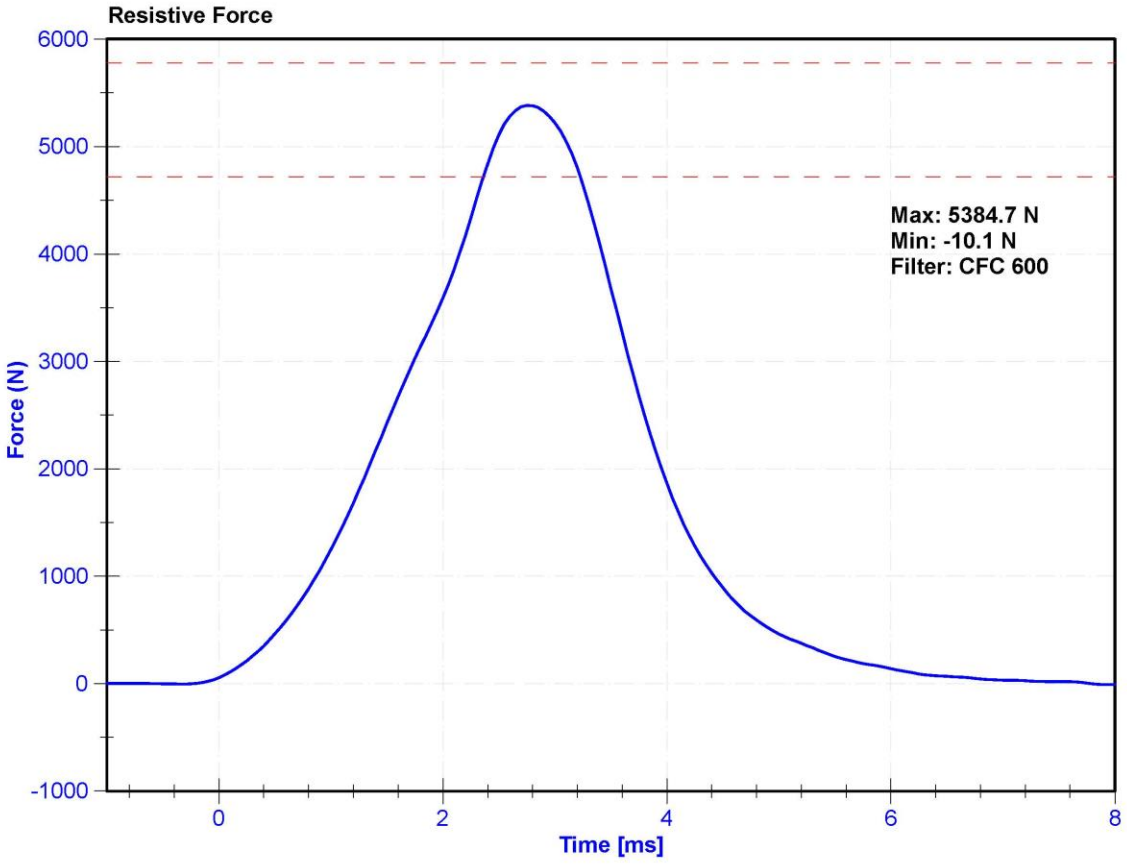
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

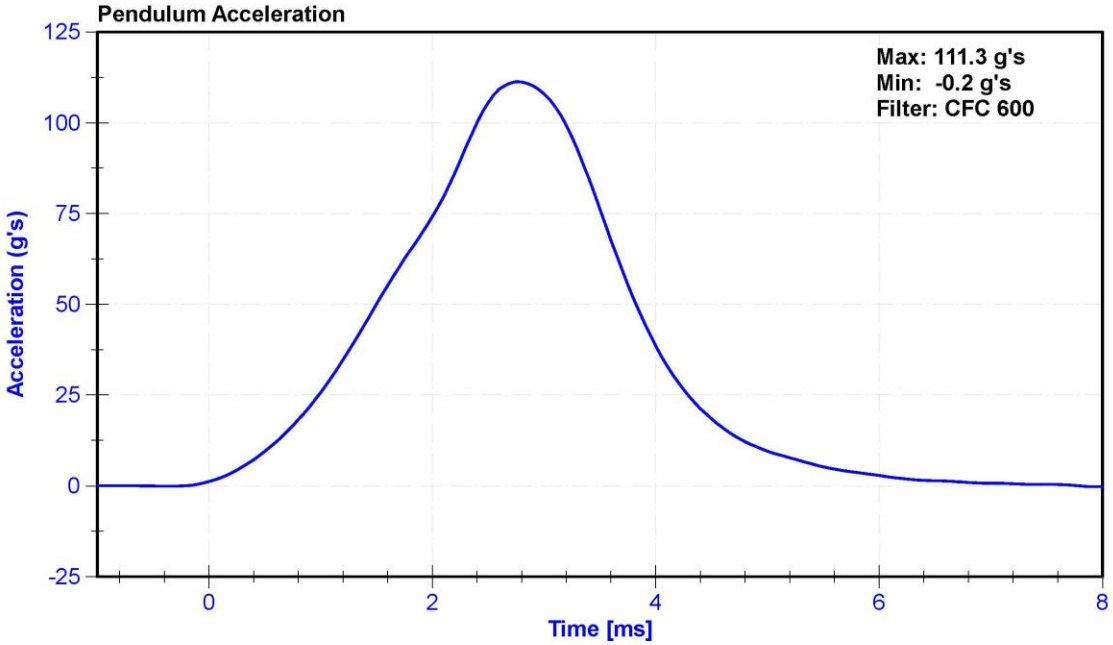
Results

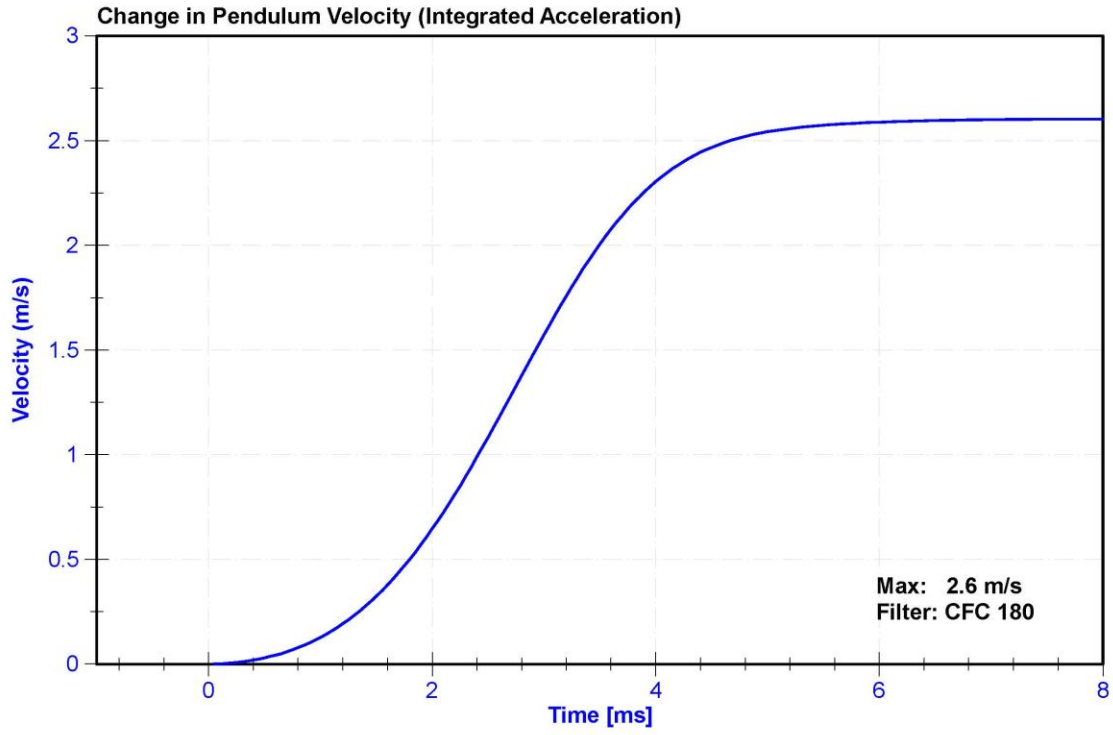
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.8	Pass
Humidity	10	70	%	67	Pass
Velocity	2.07	2.13	m/s	2.112	Pass
Maximum Resistive Force	4720	5780	N	5384.7	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021




Pendulum Acceleration
Max: 111.3 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)
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]

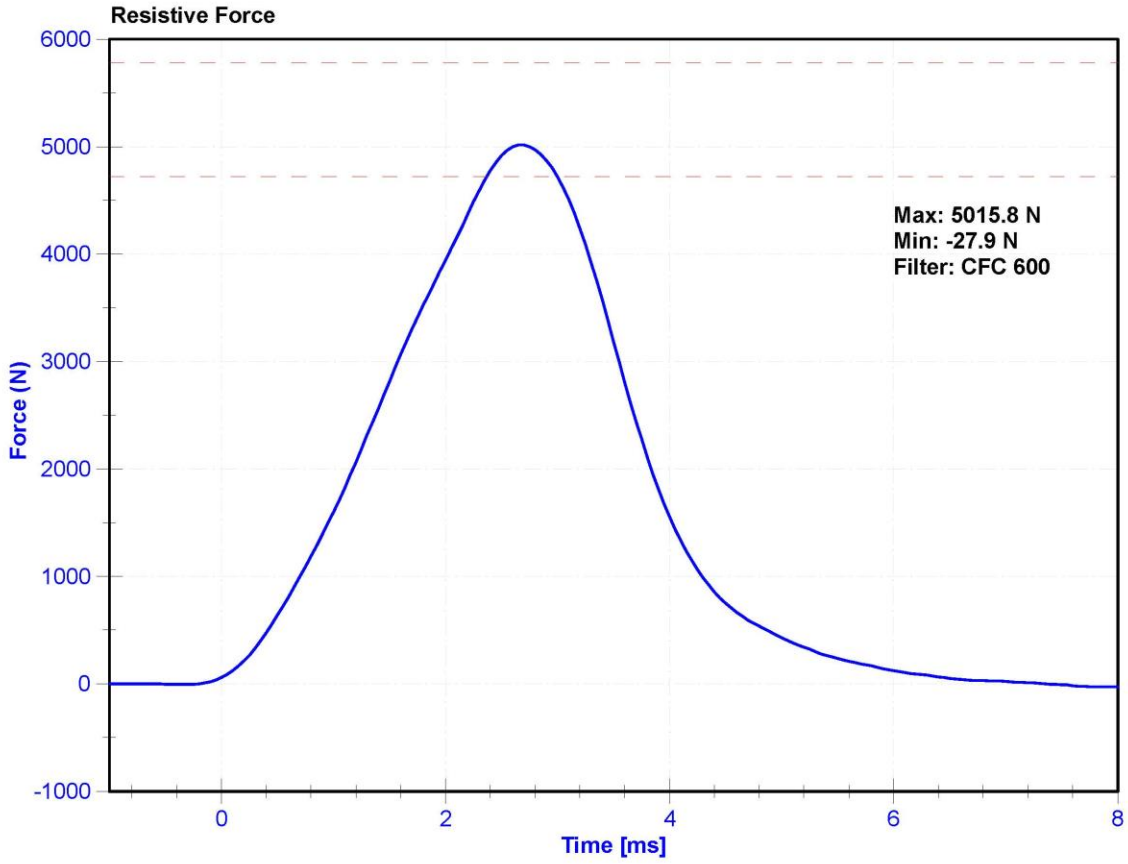
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

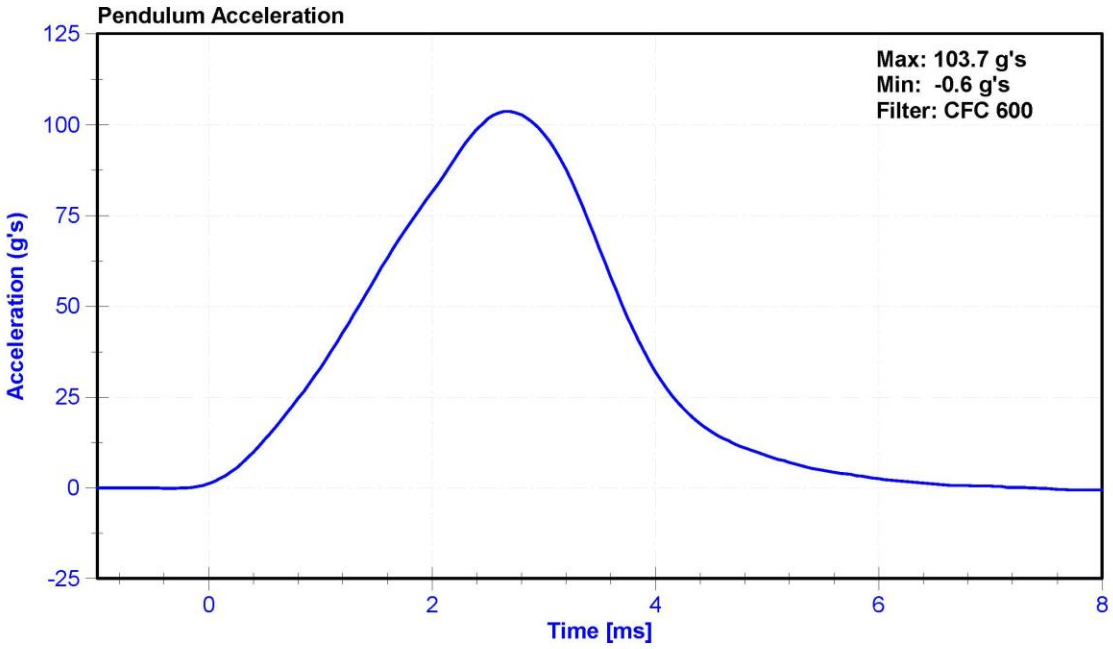
Results

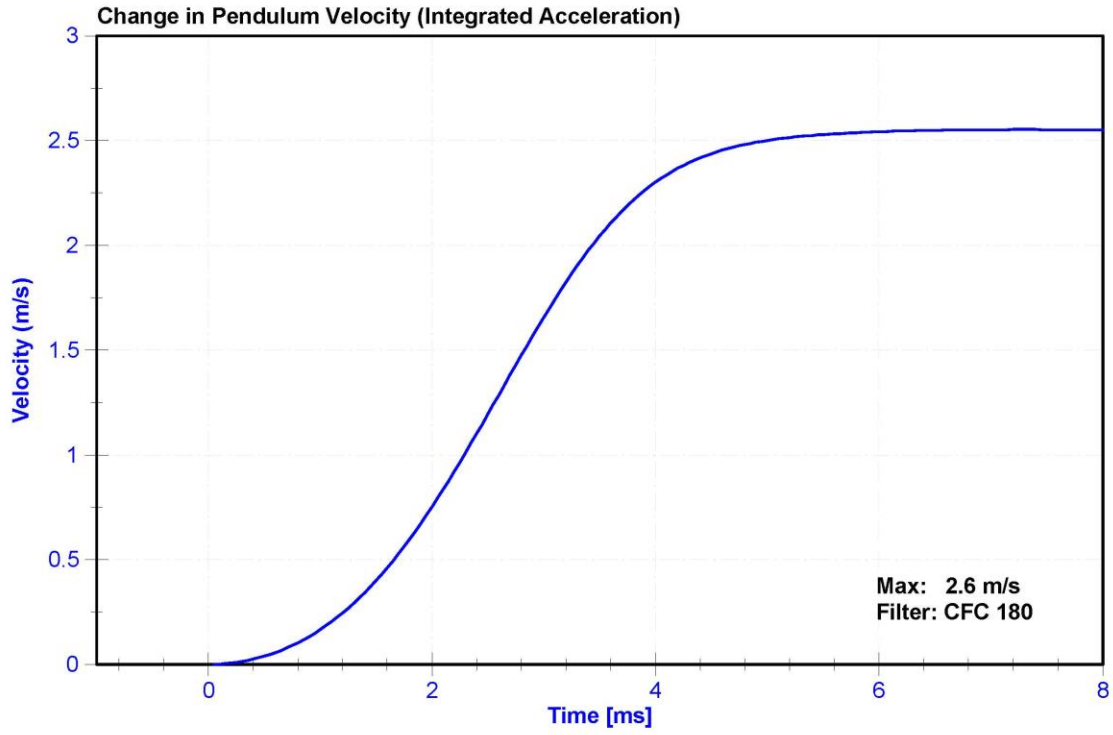
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	65	Pass
Velocity	2.07	2.13	m/s	2.115	Pass
Maximum Resistive Force	4720	5780	N	5015.8	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021




Pendulum Acceleration
Max: 103.7 g's
Min: -0.6 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

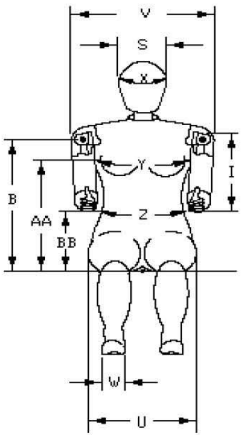
HYBRID III 5TH PERCENTILE - PASSENGER ATD

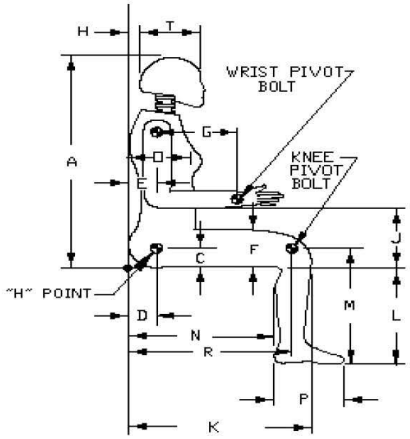
SERIAL NO: 139

External Measurements - Hybrid 3 - 5th Female

Technician: K. Brogan Date: 08/03/2020

Dummy Serial Number: 139





Symbol	Description	Specification (mm)		Result (mm)	Pass/Fail
A	Sitting Height	775	800	791	Pass
B	Shoulder Pivot Height	432	457	446	Pass
C	H-Point Height	81	86	84	Pass
D	H-Point from Backline	145	150	146	Pass
E	Shoulder Pivot from Backline	69	84	78	Pass
F	Thigh Clearance	119	135	128	Pass
G	Back of Elbow to Wrist Pivot	244	259	254	Pass
H	Head Back to Backline	43	48	45	Pass
I	Shoulder to Elbow Length	277	297	289	Pass
J	Elbow Rest Height	183	203	195	Pass
K	Buttock to Knee Length	521	546	542	Pass
L	Popliteal Height	356	376	363	Pass
M	Knee Pivot Height	394	419	402	Pass
N	Buttock Popliteal Length	414	439	425	Pass
O	Chest Depth without Jacket	175	191	185	Pass
P	Foot Length (right)	219	234	225	Pass
R	Buttock To Knee Pivot Length	457	483	473	Pass
S	Head Breadth	137	147	143	Pass
T	Head Depth	178	188	182	Pass
U	Hip Breadth	300	315	310	Pass
V	Shoulder Breadth	351	366	362	Pass
W	Foot Breadth	79	94	87	Pass
X	Head Circumference	528	549	535	Pass
Y	Chest Circumference with Jacket	851	881	861	Pass
Z	Waist Circumference	460	790	773	Pass
AA	Reference Location (Chest Circumference)	333	358	345	Pass
BB	Reference Location (Waist Circumference)	160	170	165	Pass

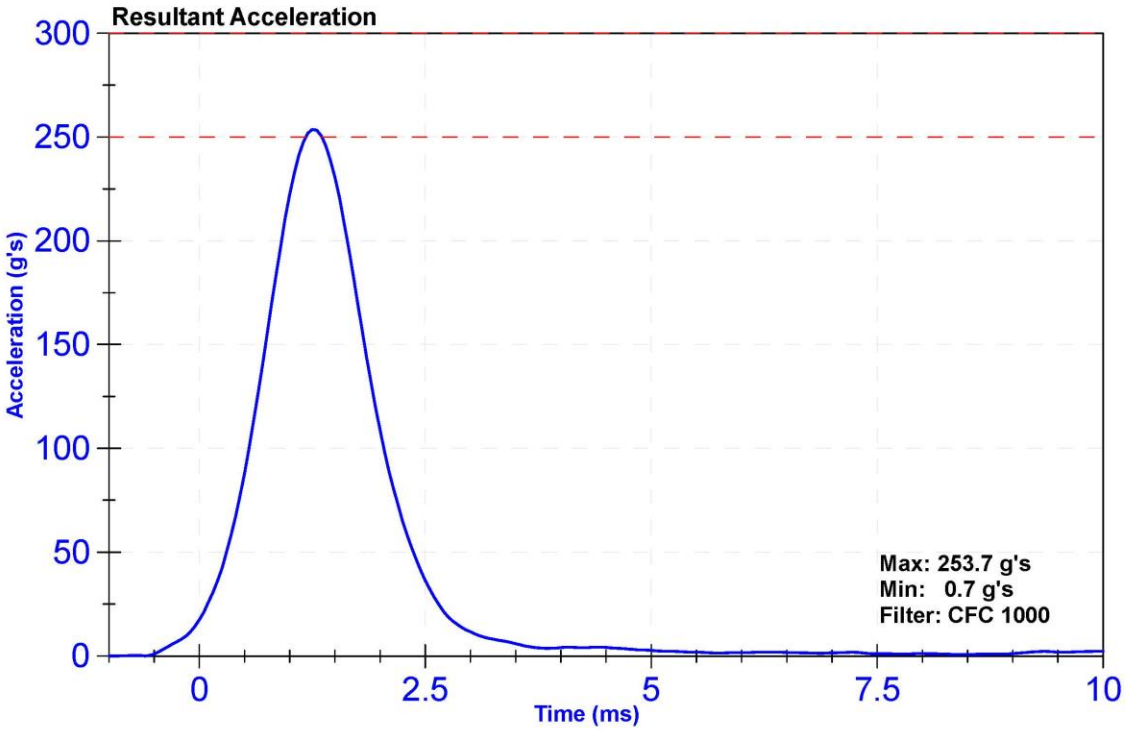
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

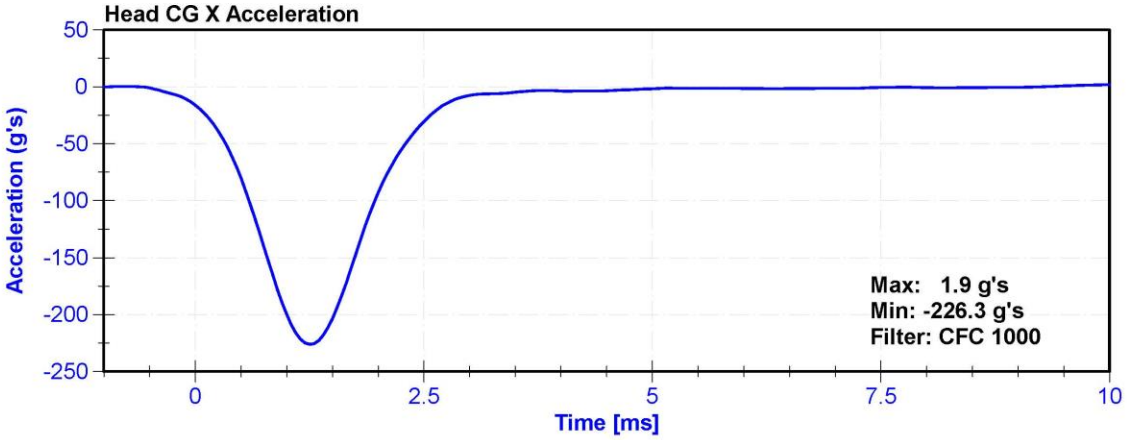
Results

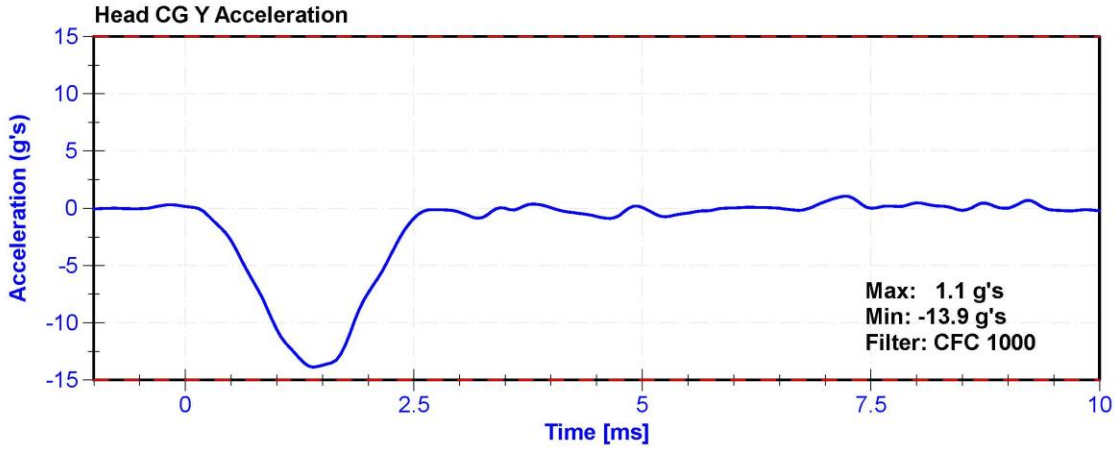
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	67	Pass
Resultant Acceleration	250	300	g's	253.7	Pass
Oscillation	0	10	%	1.7	Pass
Lateral Acceleration	-15	15	g's	-13.9	Pass

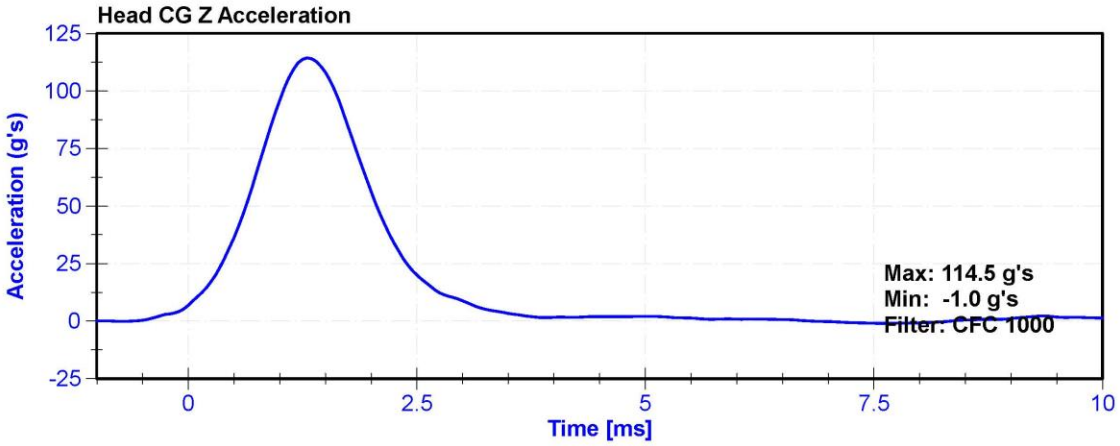
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264CT	AC-P19343	2/21/2020	8/21/2020
Y Accelerometer	MSI 64C-2000	A278994	5/8/2020	11/6/2020
Z Accelerometer	ENDEVCO 7264CT	AC-P23993	2/21/2020	8/21/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 1.9 g's
Min: -226.3 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: 1.1 g's
Min: -13.9 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: 114.5 g's
Min: -1.0 g's
Filter: CFC 1000

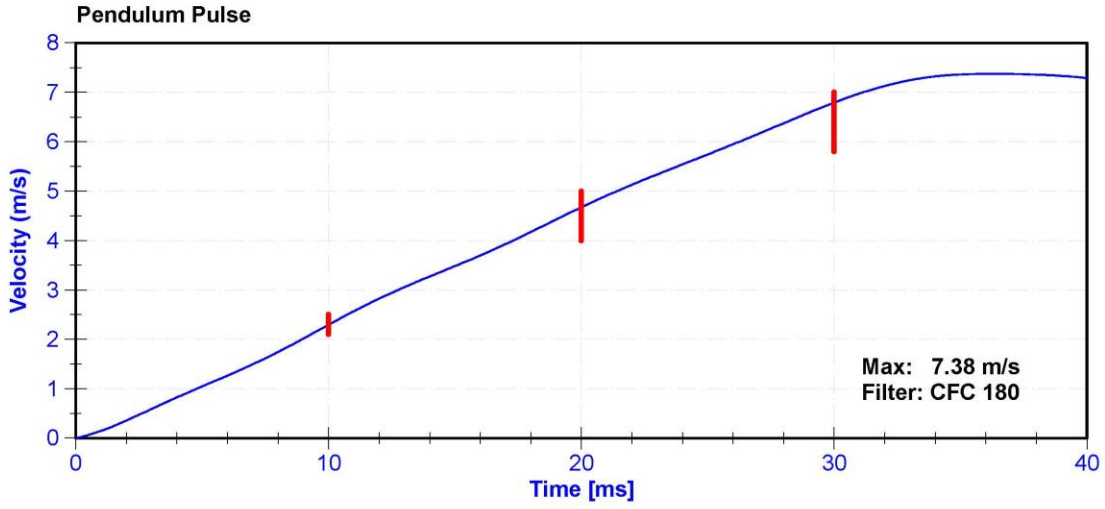
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

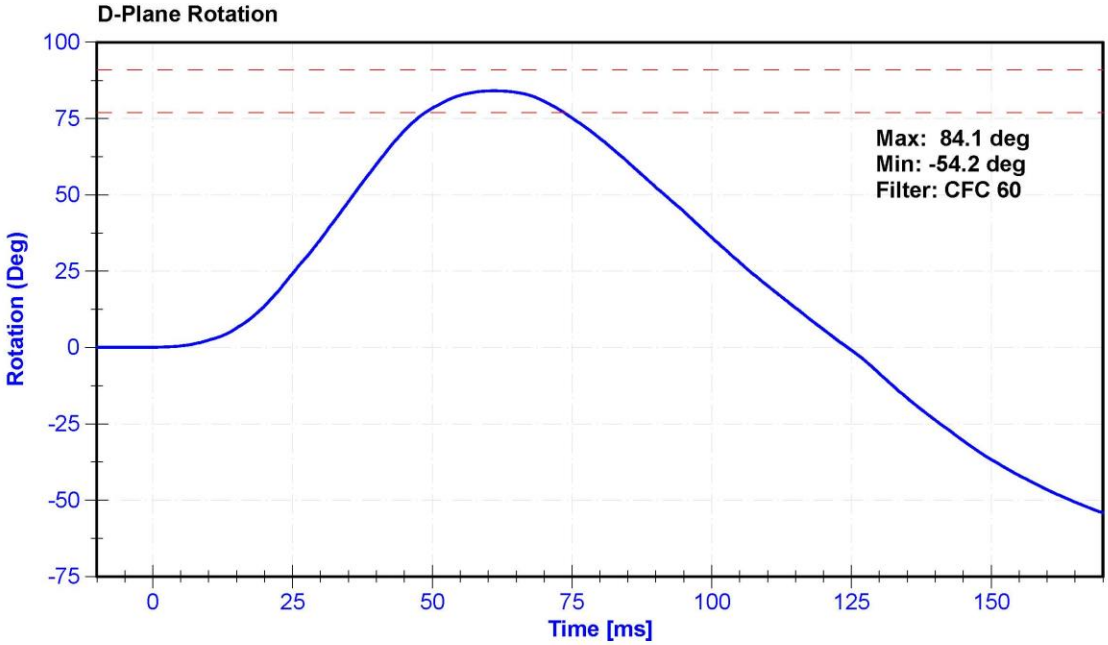
Results

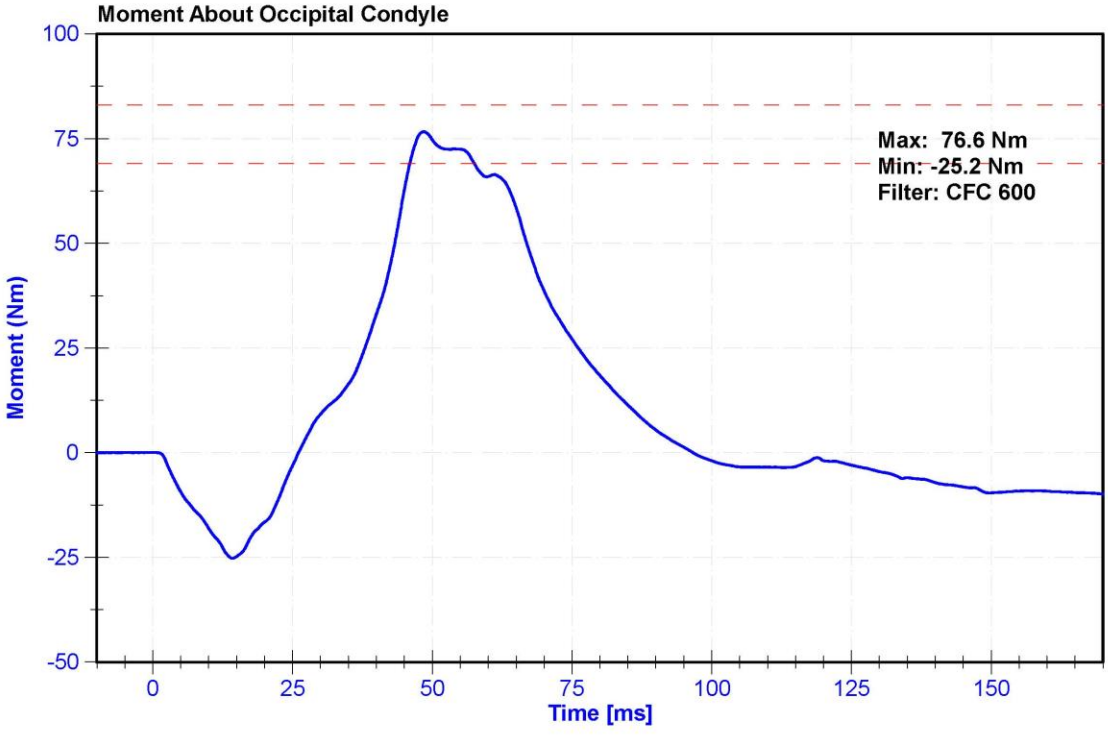
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.0	Pass
Humidity	10	70	%	69.0	Pass
Velocity	6.89	7.13	m/s	6.958	Pass
Pendulum Impulse at 10ms	2.1	2.5	m/s	2.29	Pass
Pendulum Impulse at 20ms	4.0	5.0	m/s	4.67	Pass
Pendulum Impulse at 30ms	5.8	7.0	m/s	6.79	Pass
Max D Plane Rotation	77	91	deg	84.1	Pass
Max Moment During Rotation Interval	69	83	Nm	76.6	Pass
Moment Decay to 10.0 Nm	80	100	ms	86.1	Pass

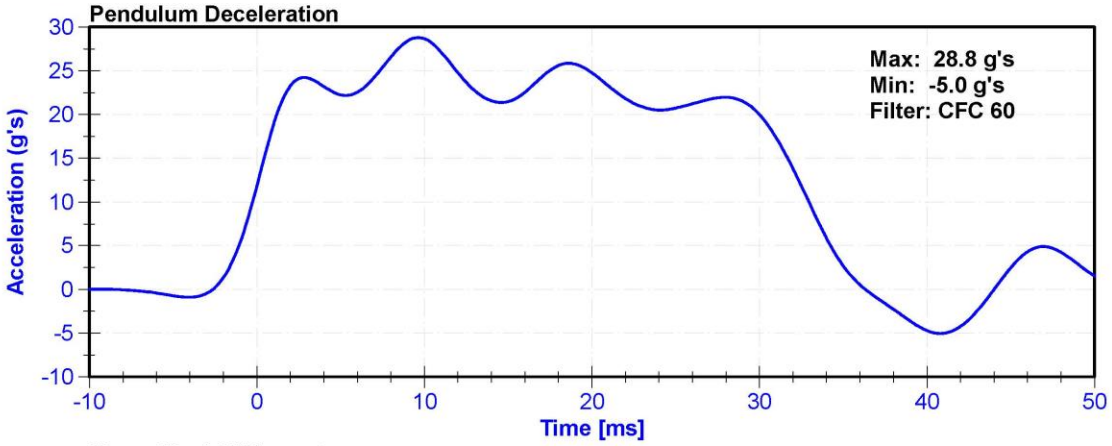
Transducer Calibrations

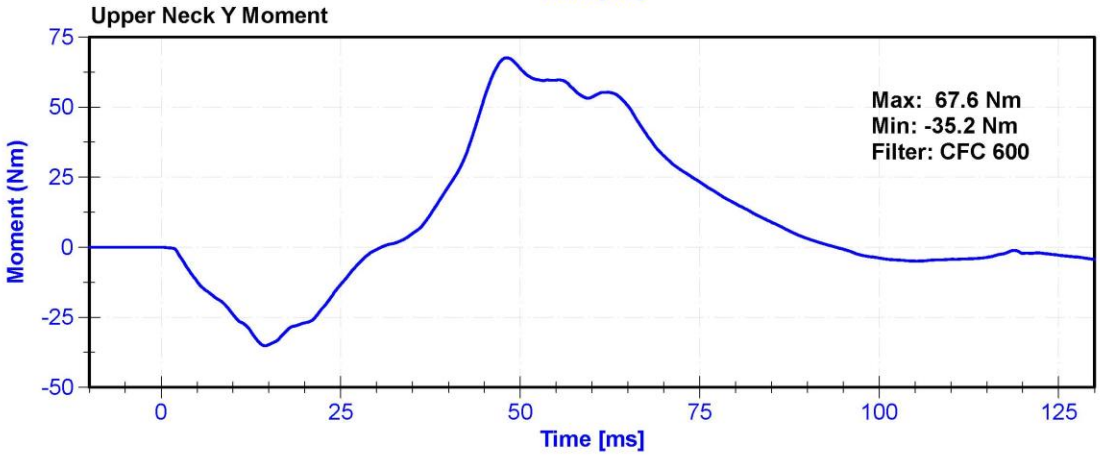
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton 1716A	LC-1916Fx	10/3/2019	10/2/2020

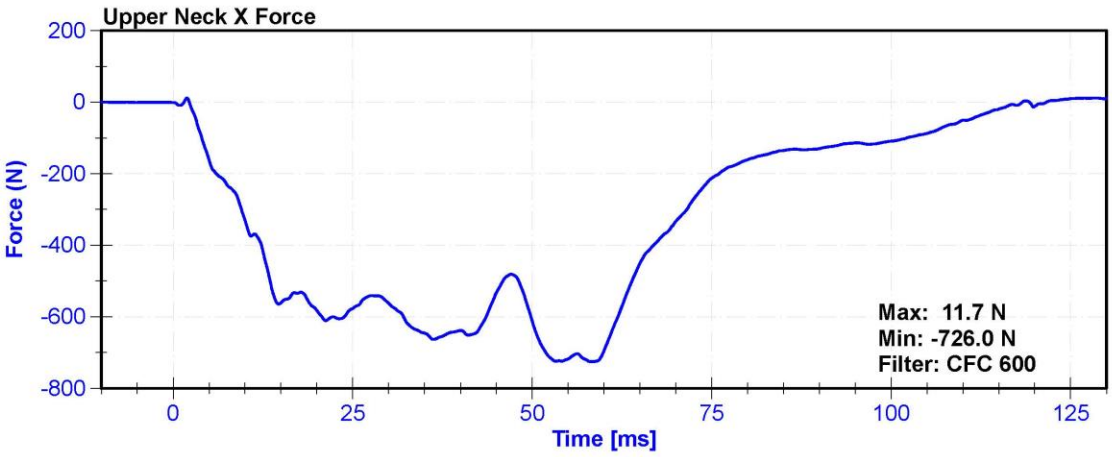



D-Plane Rotation
Max: 84.1 deg
Min: -54.2 deg
Filter: CFC 60
Rotation (Deg)
Time [ms]
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150


Moment About Occipital Condyle
Max: 76.6 Nm
Min: -25.2 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150


Pendulum Deceleration
Max: 28.8 g's
Min: -5.0 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 67.6 Nm
Min: -35.2 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 11.7 N
Min: -726.0 N
Filter: CFC 600
Force (N)
Time [ms]

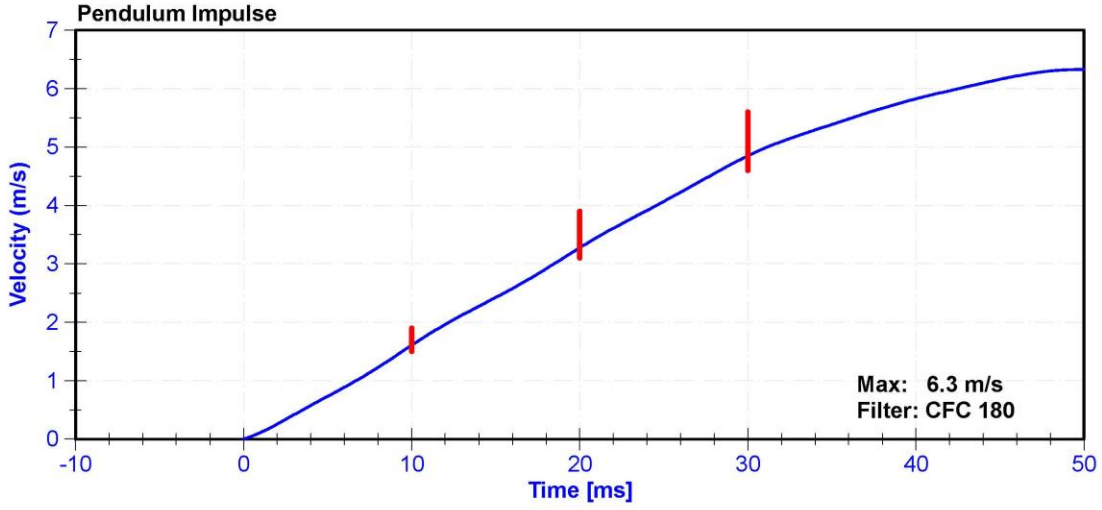
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

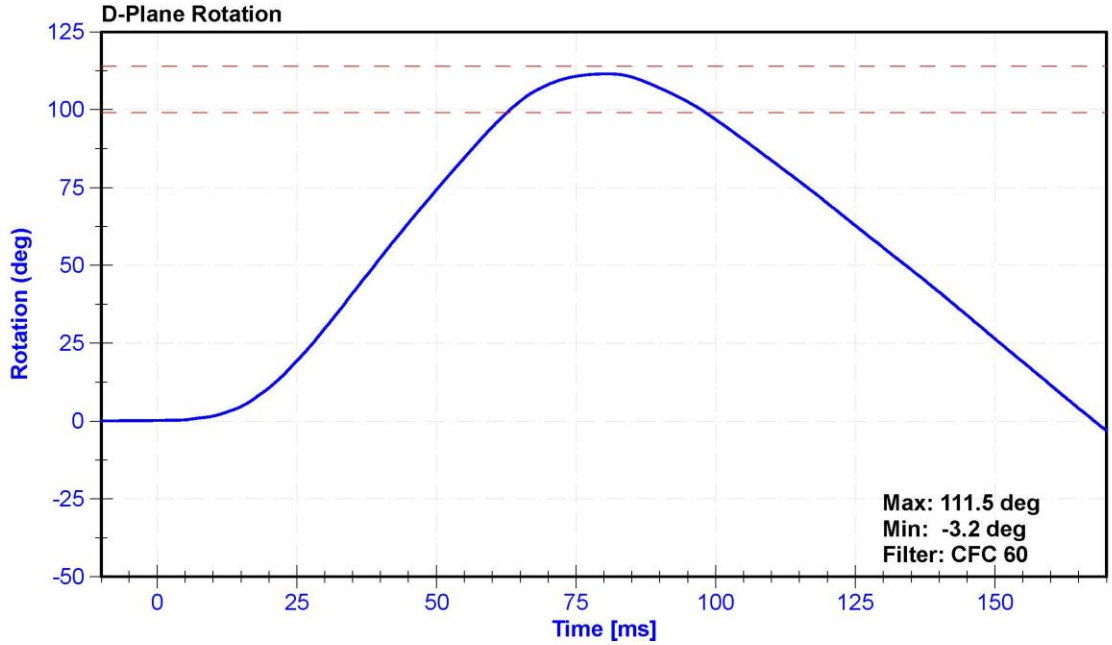
Results

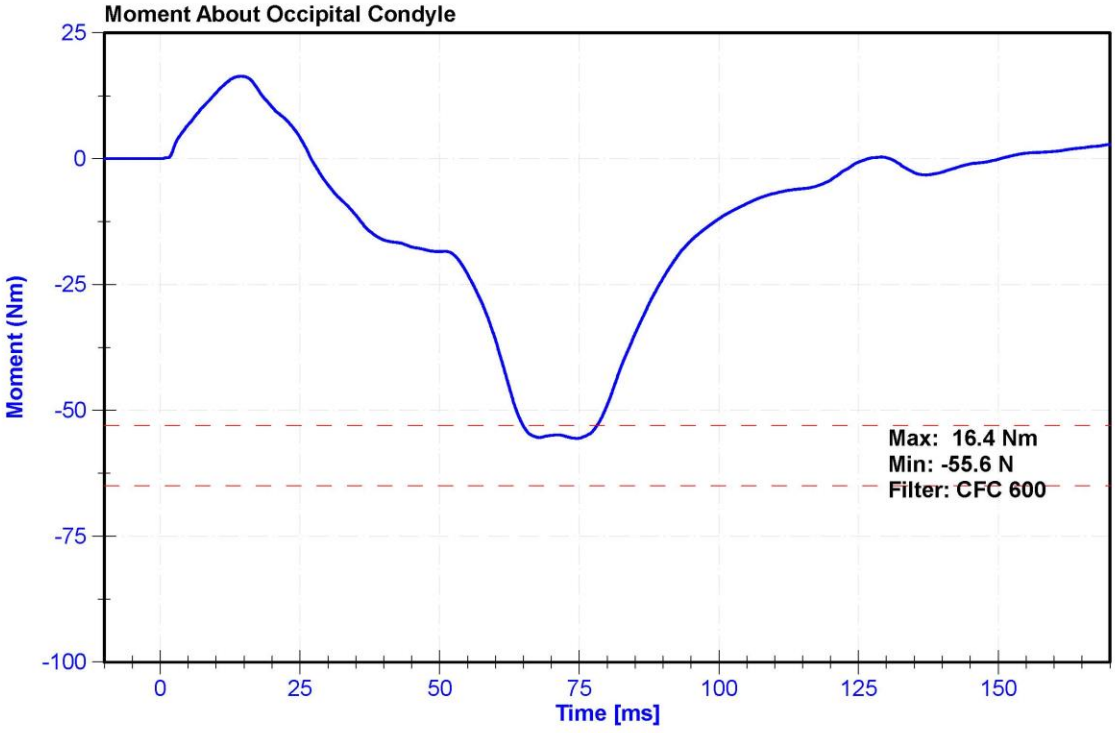
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	67.0	Pass
Velocity	5.95	6.19	m/s	6.046	Pass
Pendulum Impulse at 10ms	1.5	1.9	m/s	1.61	Pass
Pendulum Impulse at 20ms	3.1	3.9	m/s	3.28	Pass
Pendulum Impulse at 30ms	4.6	5.6	m/s	4.85	Pass
D Plane Rotation	99	114	deg	111.5	Pass
Moment During Rotation Interval	-65	-53	Nm	-55.6	Pass
Moment Decay to -10Nm	94	114	ms	103.1	Pass

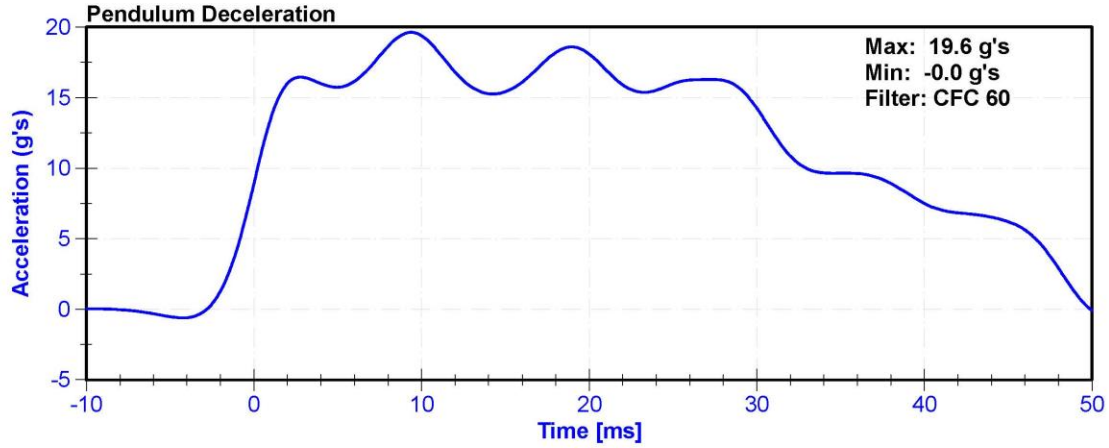
Transducer Calibrations

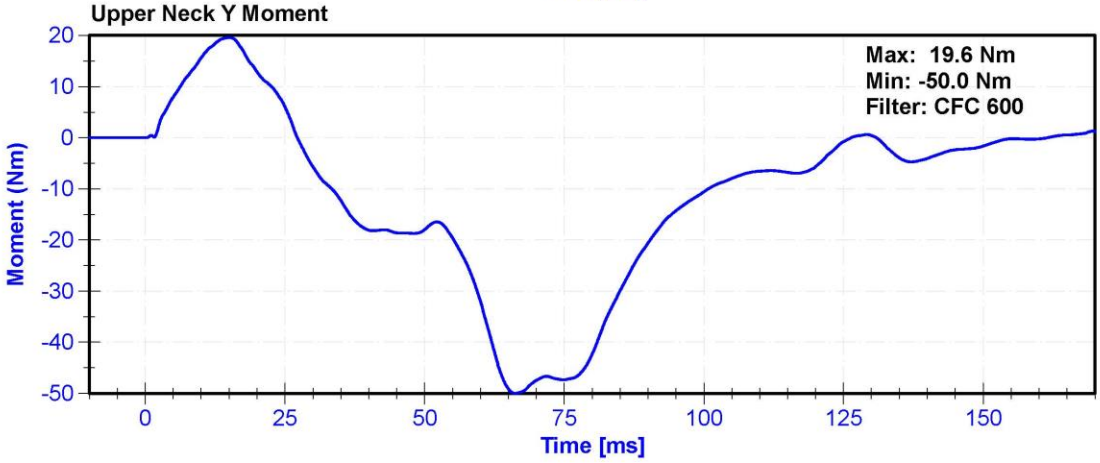
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton 1716A	LC-1916Fx	10/3/2019	10/2/2020

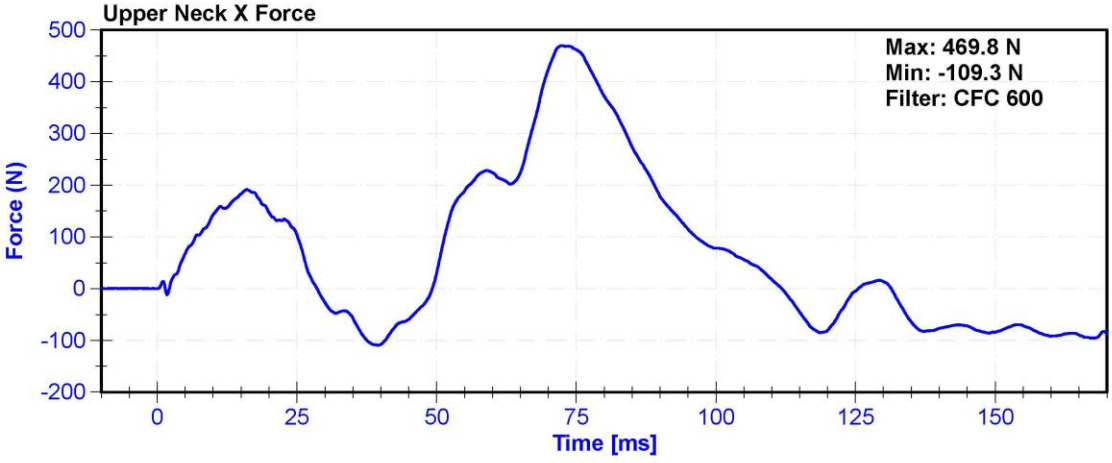



D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 111.5 deg
Min: -3.2 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
25
0
-25
-50
-75
-100
0
25
50
75
100
125
150
Time [ms]
Max: 16.4 Nm
Min: -55.6 N
Filter: CFC 600


Pendulum Deceleration
Max: 19.6 g's
Min: -0.0 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 19.6 Nm
Min: -50.0 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 469.8 N
Min: -109.3 N
Filter: CFC 600
Force (N)
Time [ms]

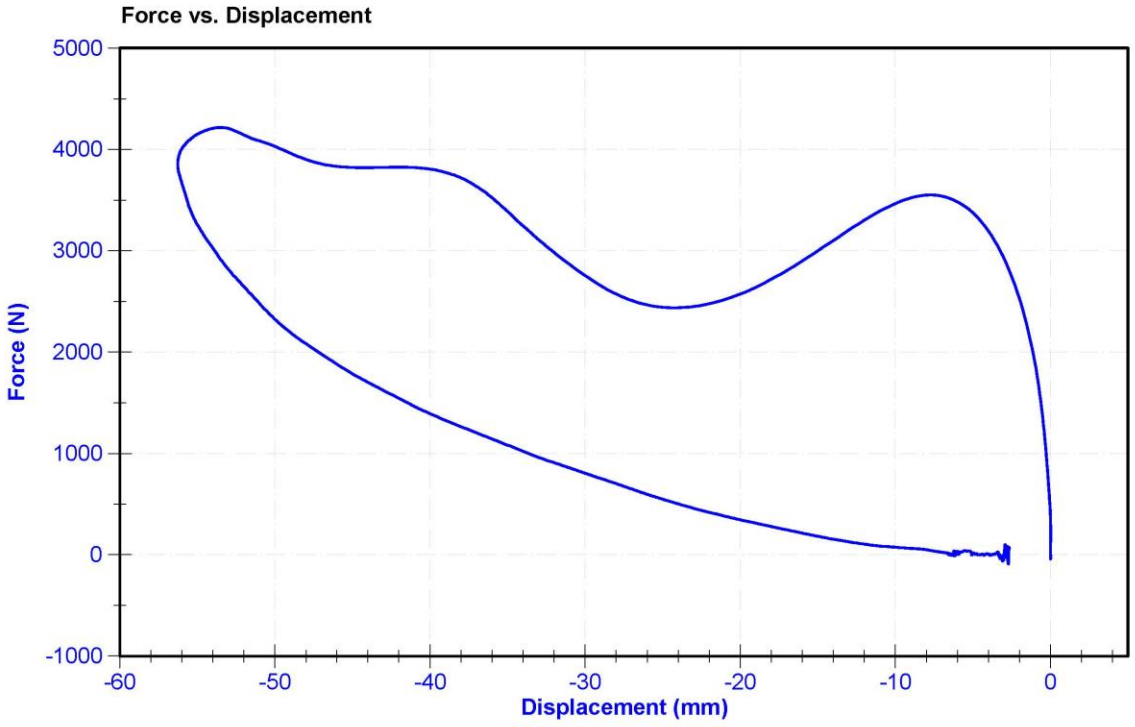
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

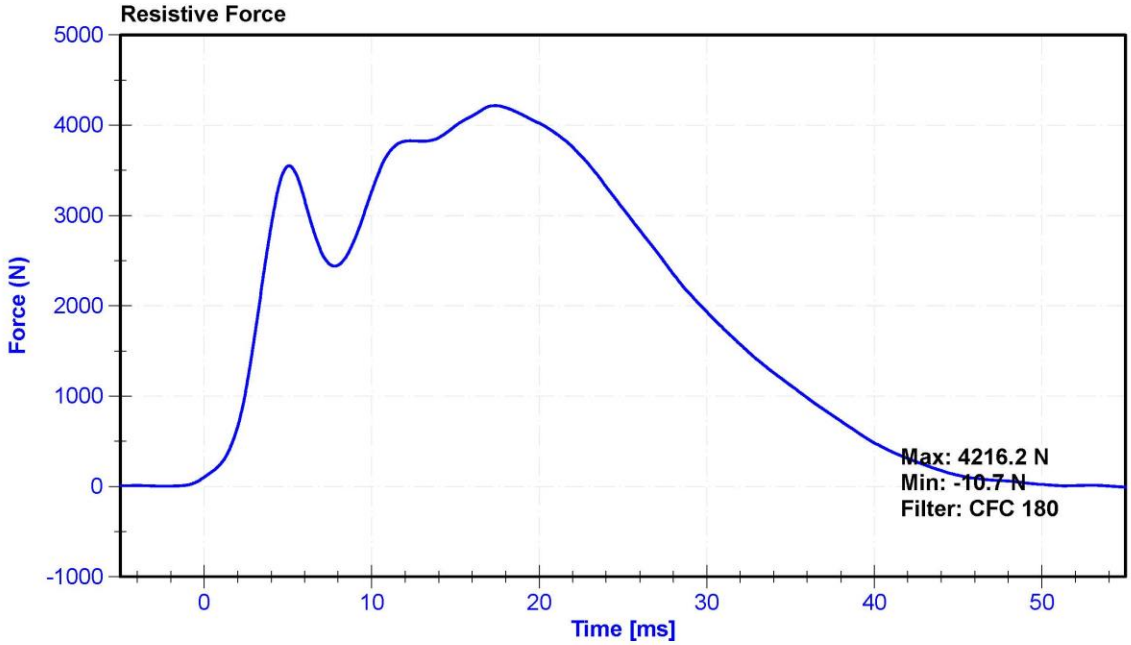
Results

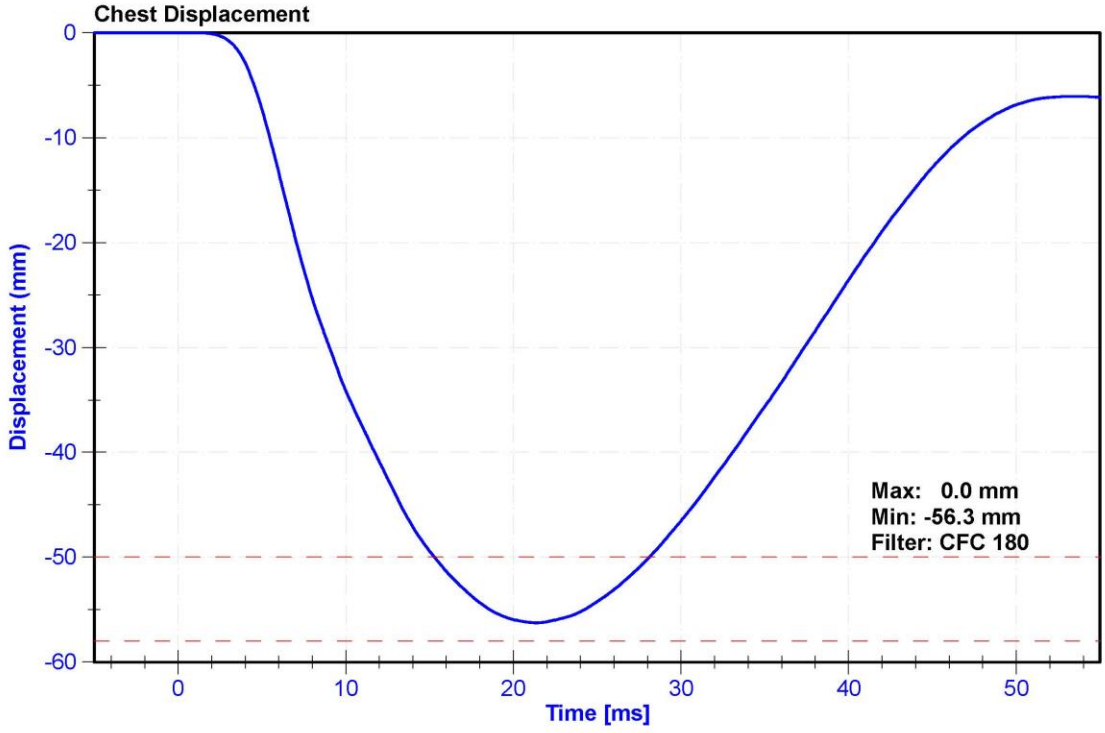
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.7	Pass
Humidity	10	70	%	65	Pass
Velocity	6.59	6.83	m/s	6.699	Pass
Chest Deflection	-58	-50	mm	-56.3	Pass
Maximum Resistive Force (50 to 58mm)	3900	4400	N	4216.2	Pass
Maximum Resistive Force (18 to 50mm)	0	4600	N	4025.2	Pass
Hysteresis	69	85	%	70.1	Pass

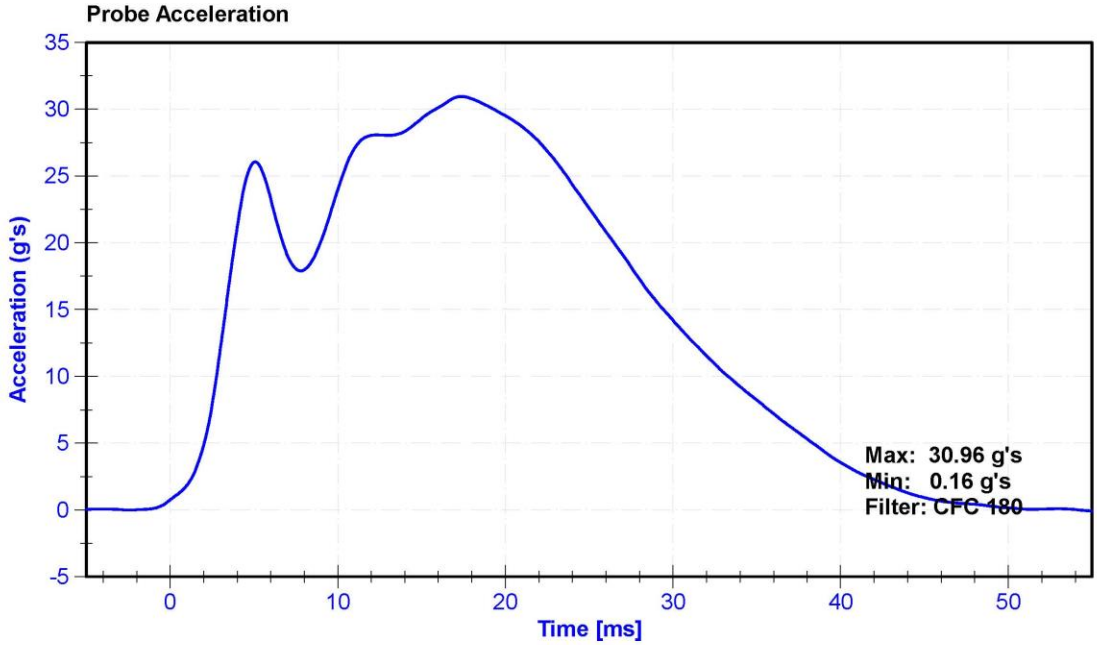
Transducer Calibrations

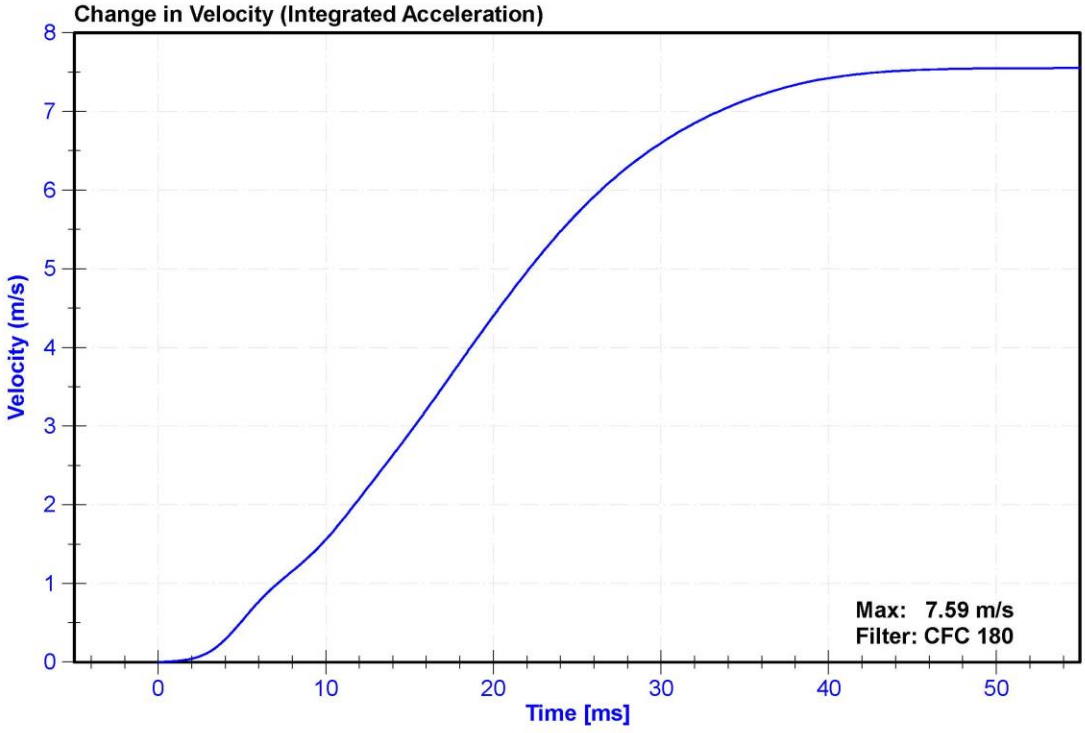
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021
Chest Potentiometer	SERVO H3CD	DS-503	4/2/2020	10/1/2020




Resistive Force
Force (N)
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50
Time [ms]
Max: 4216.2 N
Min: -10.7 N
Filter: CFC 180


Chest Displacement
Displacement (mm)
0
-10
-20
-30
-40
-50
-60
0
10
20
30
40
50
Time [ms]
Max: 0.0 mm
Min: -56.3 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: 30.96 g's
Min: 0.16 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: 7.59 m/s
Filter: CFC 180

ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K.Brogan

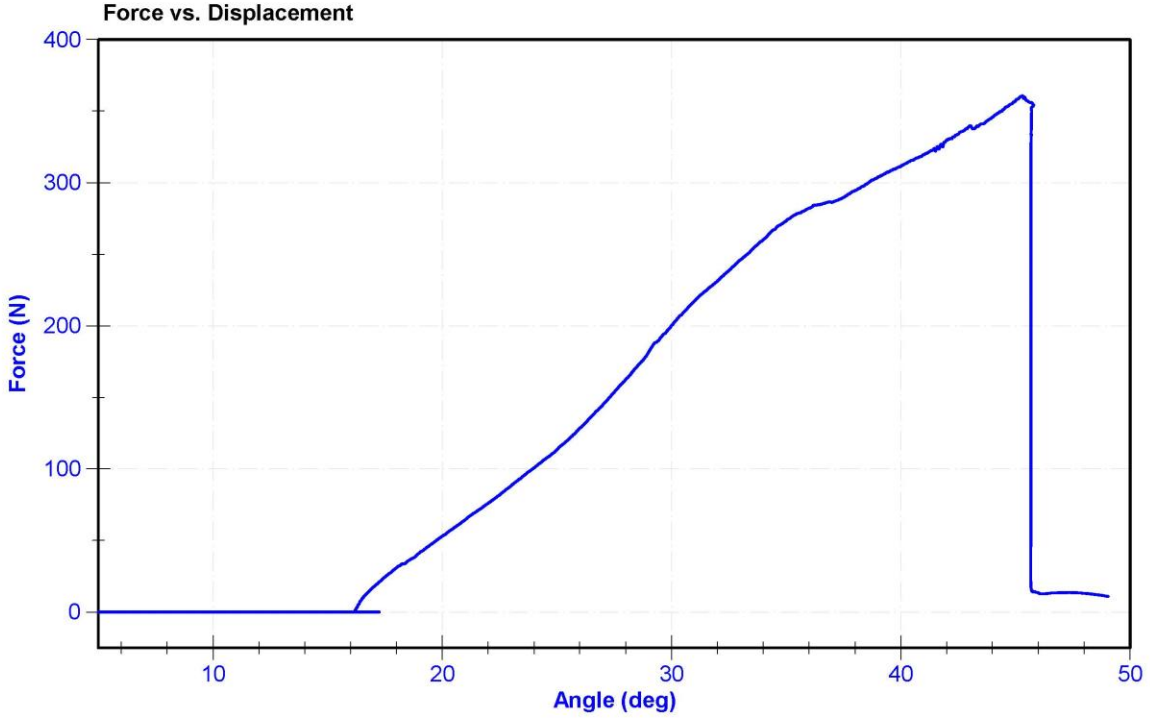
Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.6	25.6	ºC	21	Pass
Humidity	10	70	%	62	Pass
Initial Angle	0	20	deg	15.9	Pass
Force at 45 Degrees	320	390	N	360.7	Pass
Return Angle Relative to Initial	0	8	deg	2.0	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

Force vs. Displacement



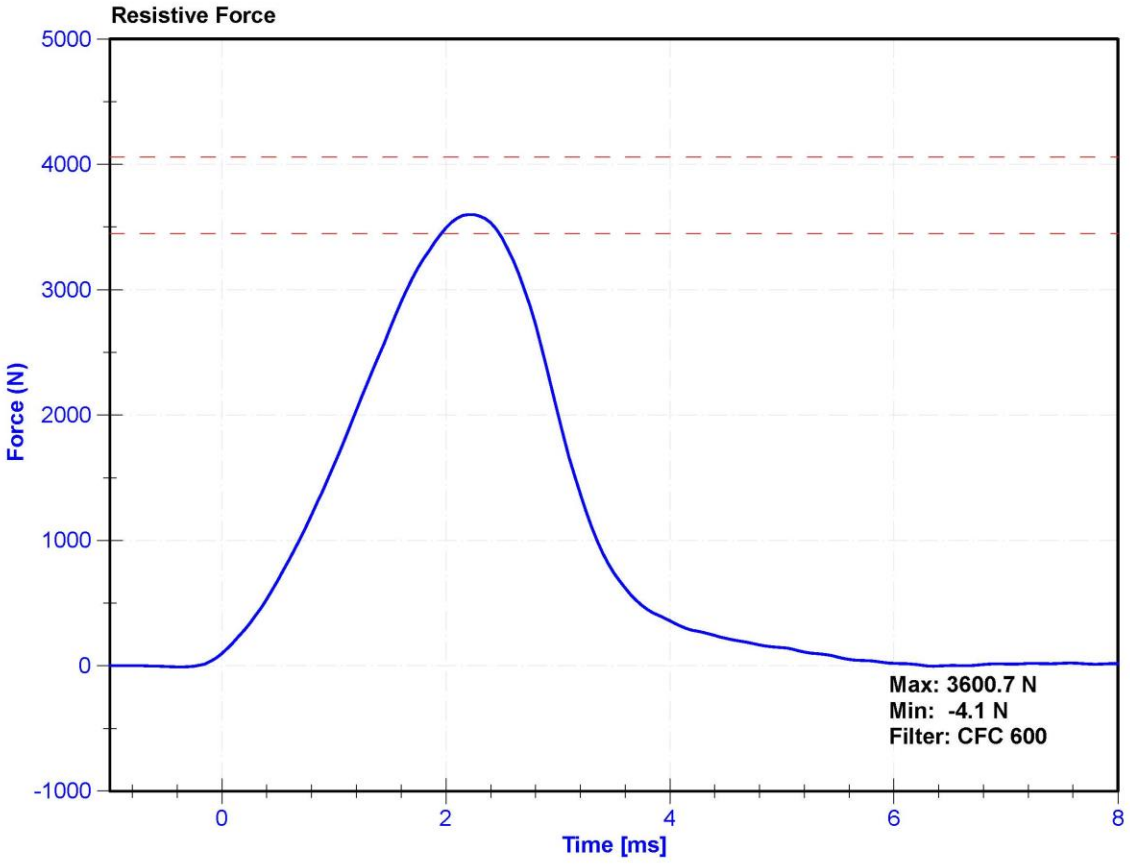
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K.Brogan

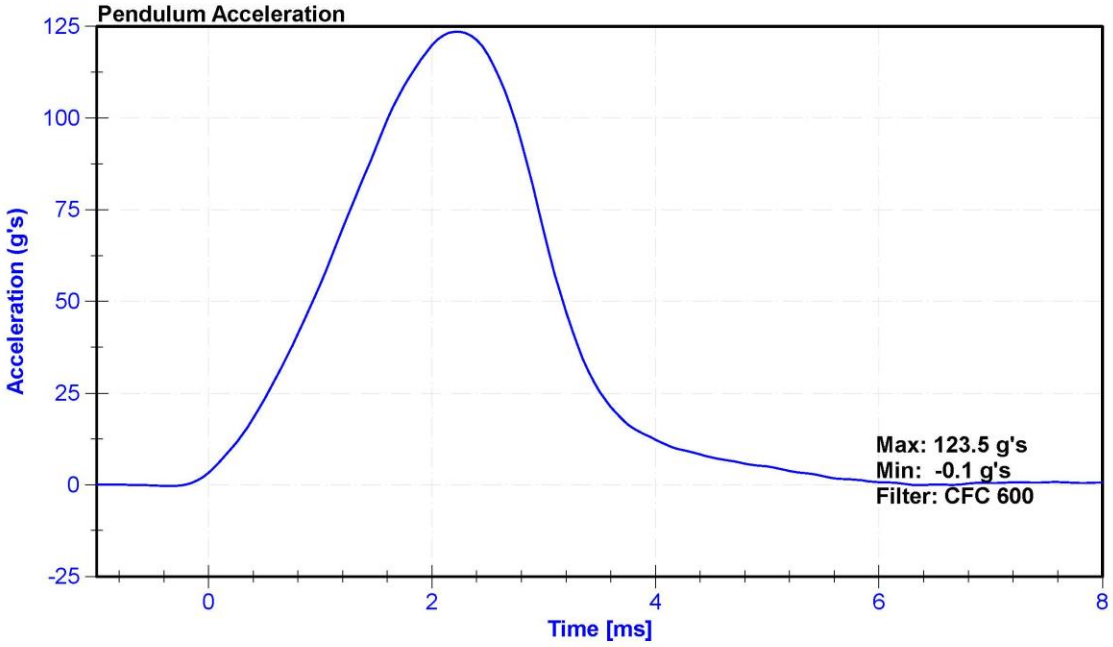
Results

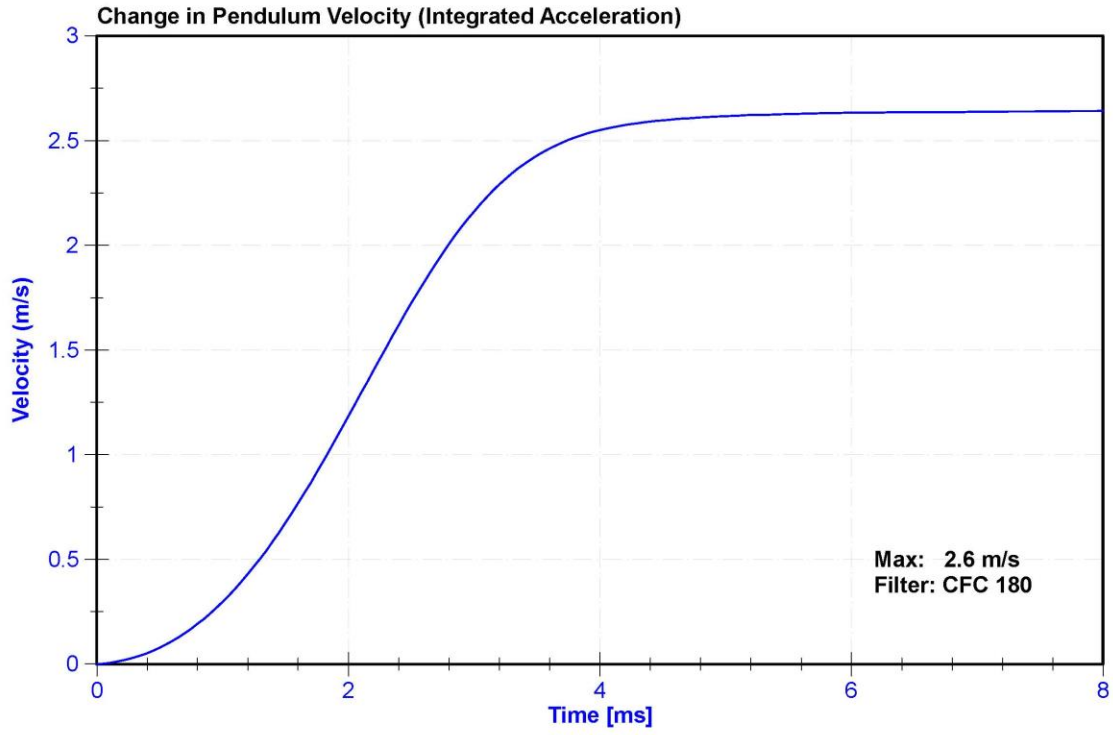
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.8	Pass
Humidity	10	70	%	67.0	Pass
Velocity	2.07	2.13	m/s	2.111	Pass
Resistive Force	3450	4060	N	3600.7	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021




Pendulum Acceleration
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 123.5 g's
Min: -0.1 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: 2.6 m/s
Filter: CFC 180

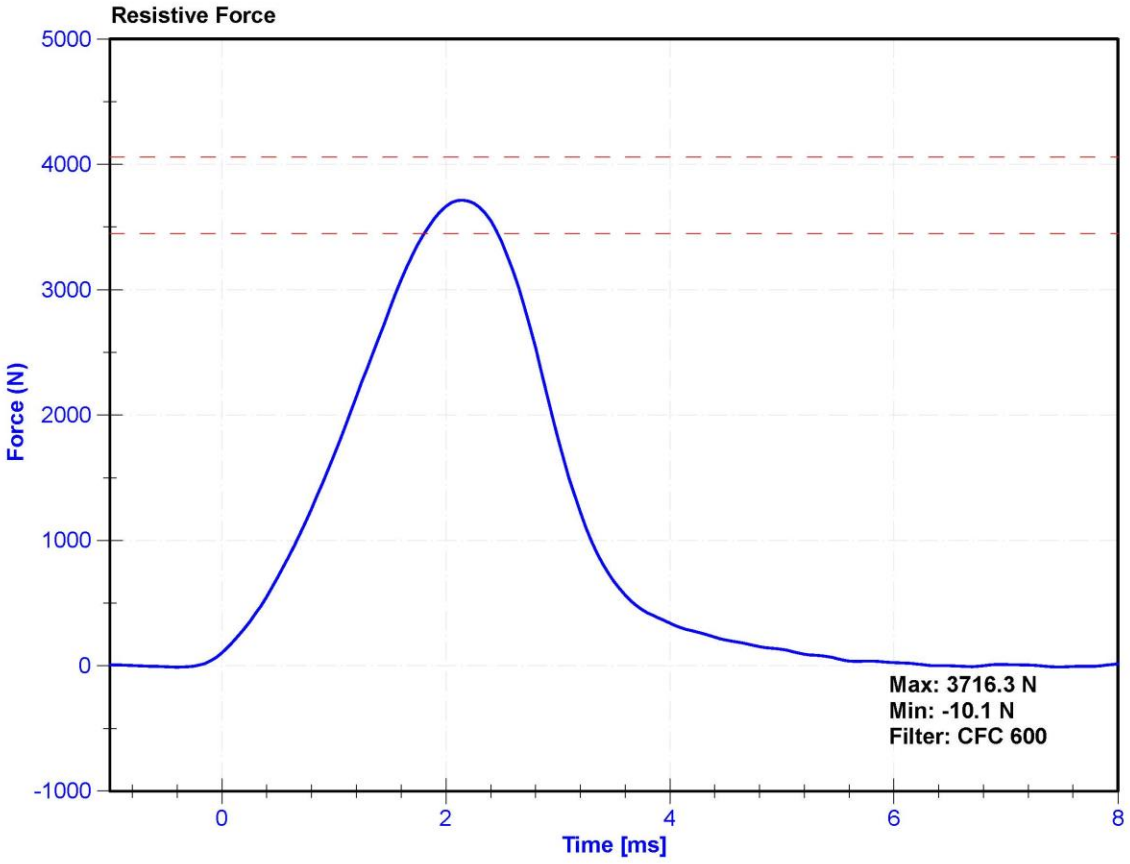
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

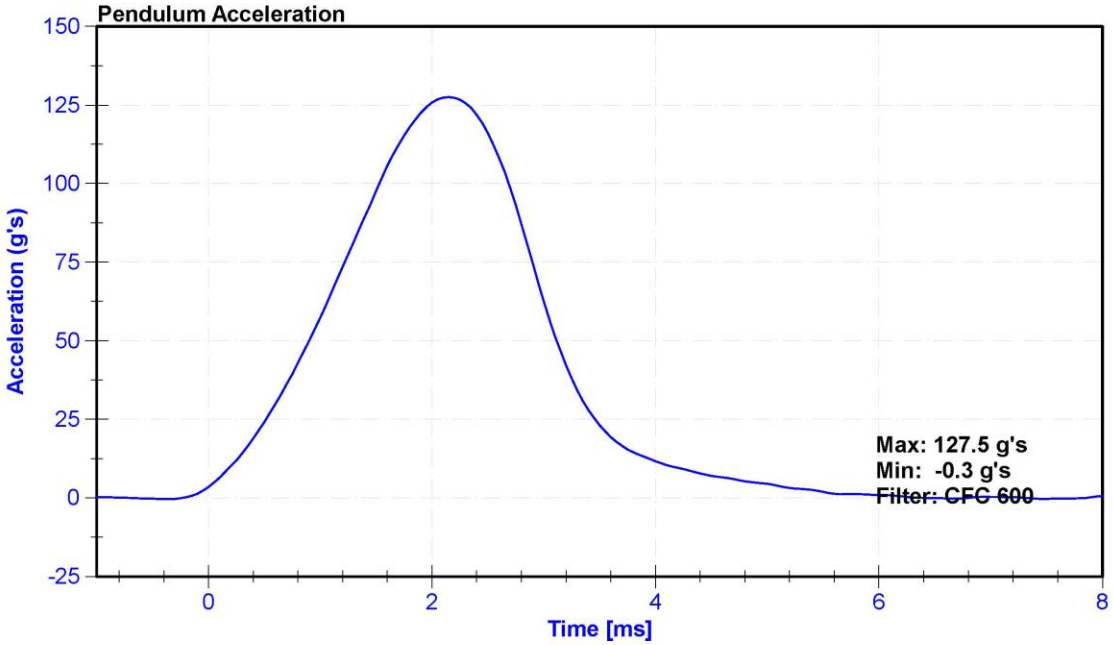
Results

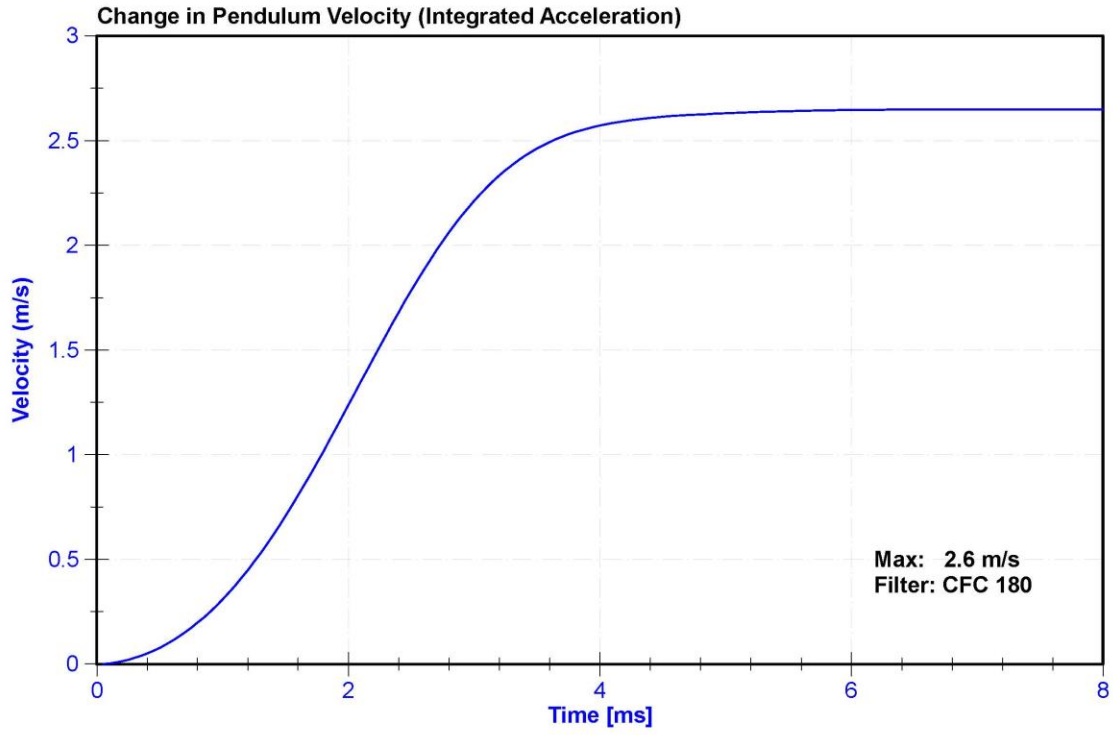
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	67.0	Pass
Velocity	2.07	2.13	m/s	2.105	Pass
Resistive Force	3450	4060	N	3716.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 127.5 g's
Min: -0.3 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: 2.6 m/s
Filter: CFC 180

CALIBRATION TEST RESULTS

POST-TEST

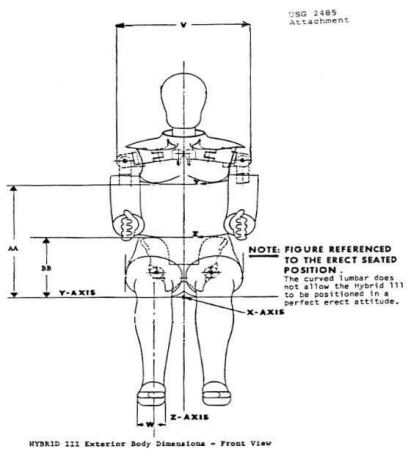
HYBRID III 50TH PERCENTILE MALE - DRIVER ATD

SERIAL NO: 142

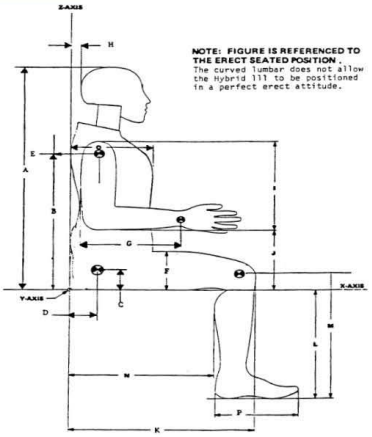
External Measurements - Hybrid 3 - 50th Male

Technician: K. Dutton Date: 08/11/2020

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	5.9	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	8.1	Pass
K	Buttock to Knee Length	22.8	23.8	23.1	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	8.6	Pass
P	Foot Length (right)	9.9	10.5	10.2	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

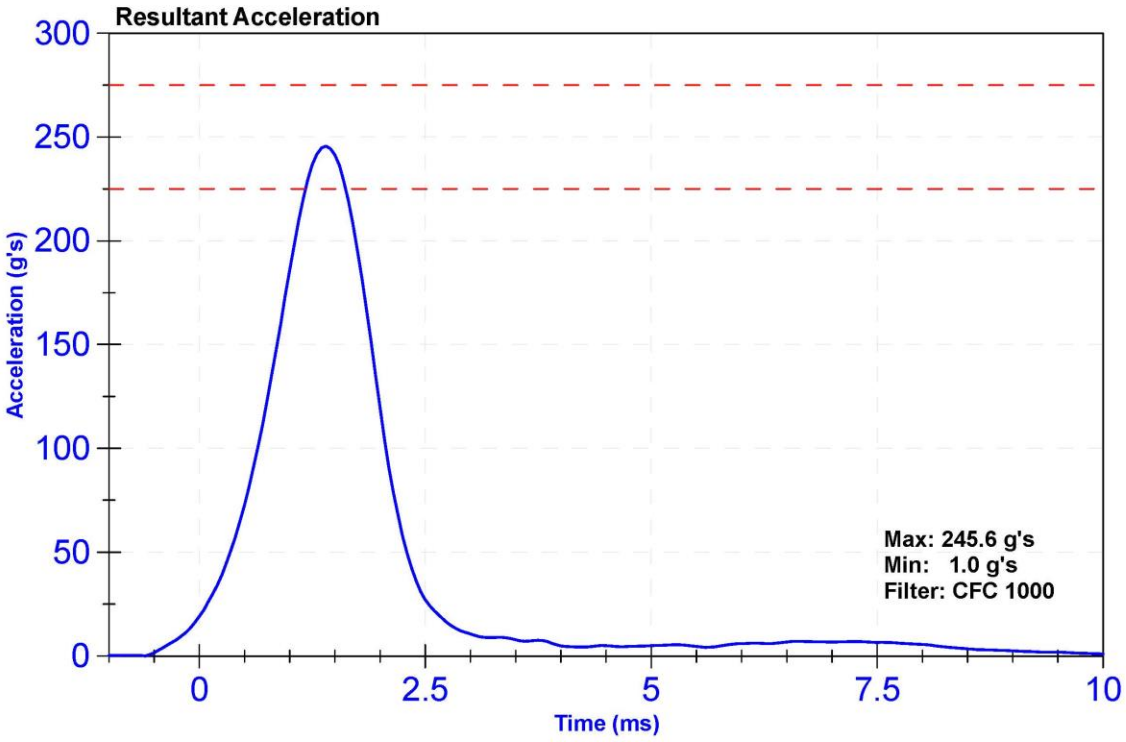
ATD Manufacturer	Humanetics	Test Technician	C. Mantell
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

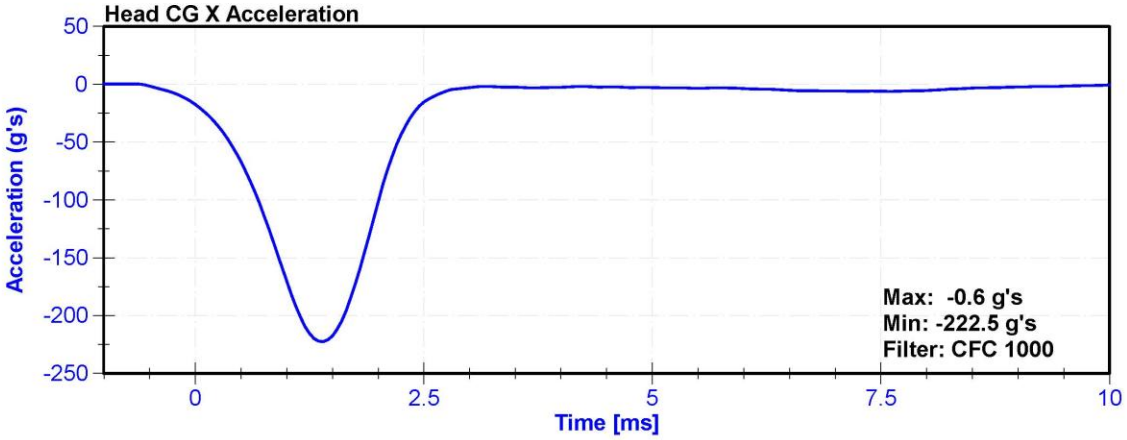
Results

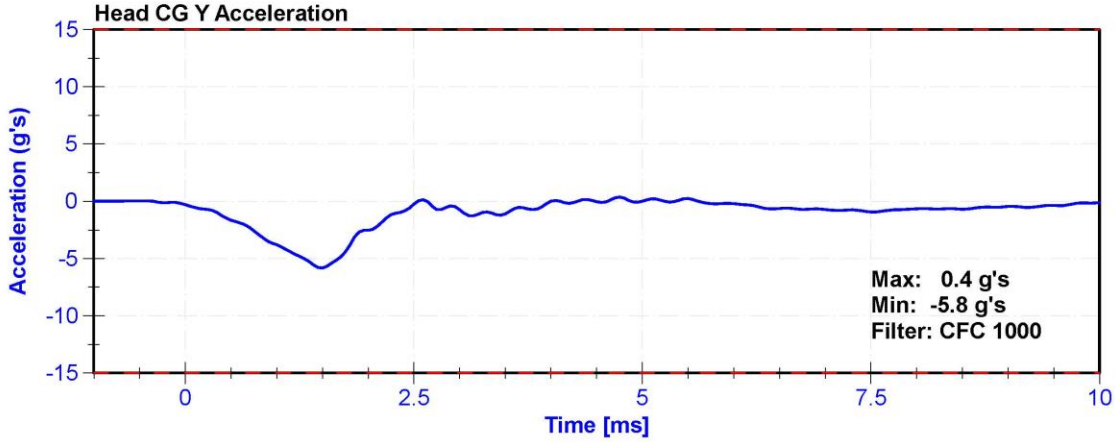
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.3	Pass
Humidity	10	70	%	55.6	Pass
Resultant Acceleration	225	275	g's	245.6	Pass
Oscillation	0	10	%	3.6	Pass
Lateral Acceleration	-15	15	g's	-5.8	Pass

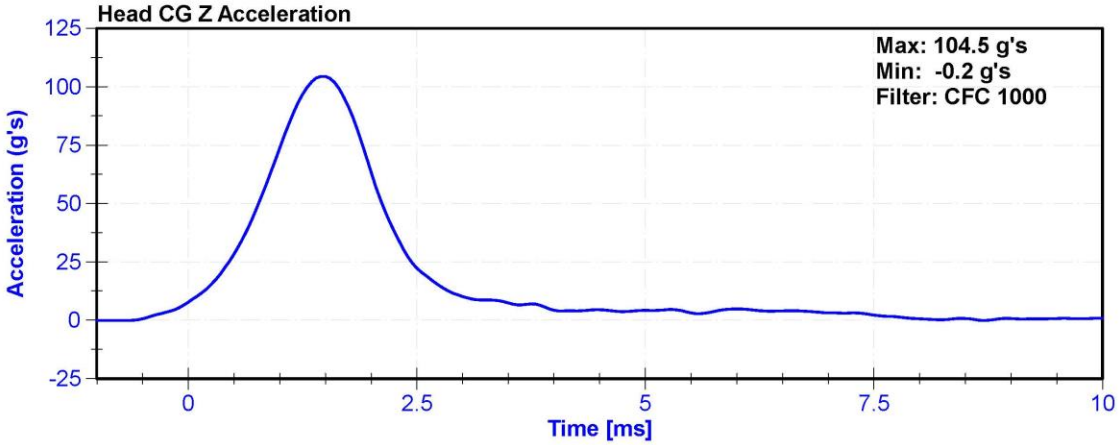
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264	P51681	4/17/2020	10/16/2020
Y Accelerometer	ENDEVCO 7264	P64151	4/17/2020	10/16/2020
Z Accelerometer	ENDEVCO 7264	P52114	4/17/2020	10/16/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: -0.6 g's
Min: -222.5 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: 0.4 g's
Min: -5.8 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: 104.5 g's
Min: -0.2 g's
Filter: CFC 1000

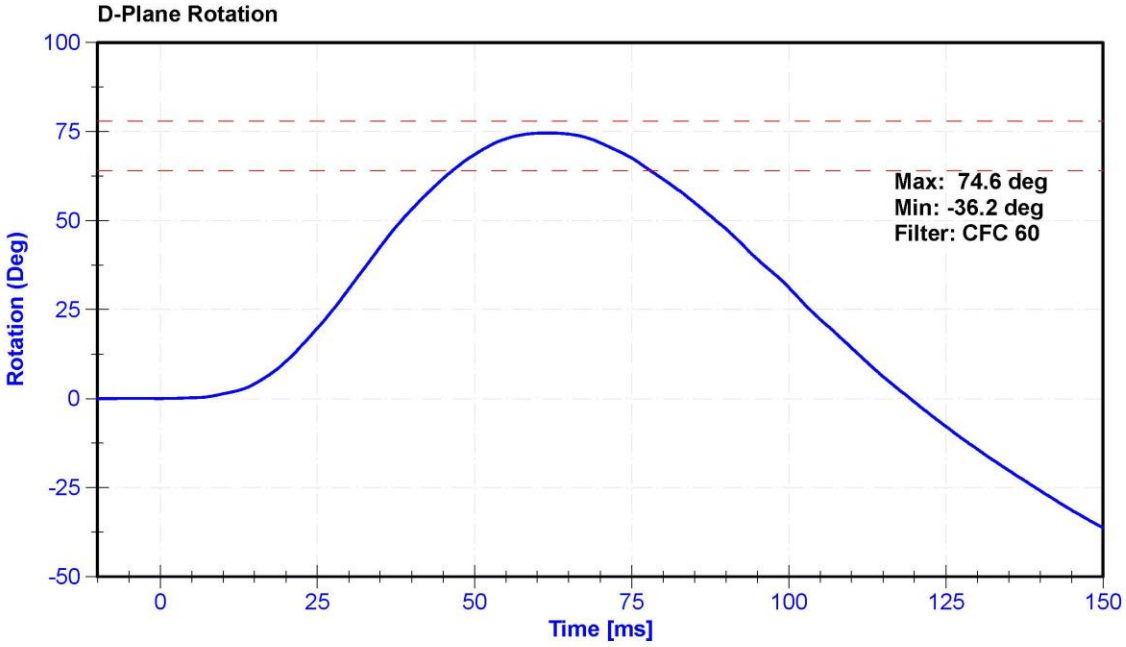
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

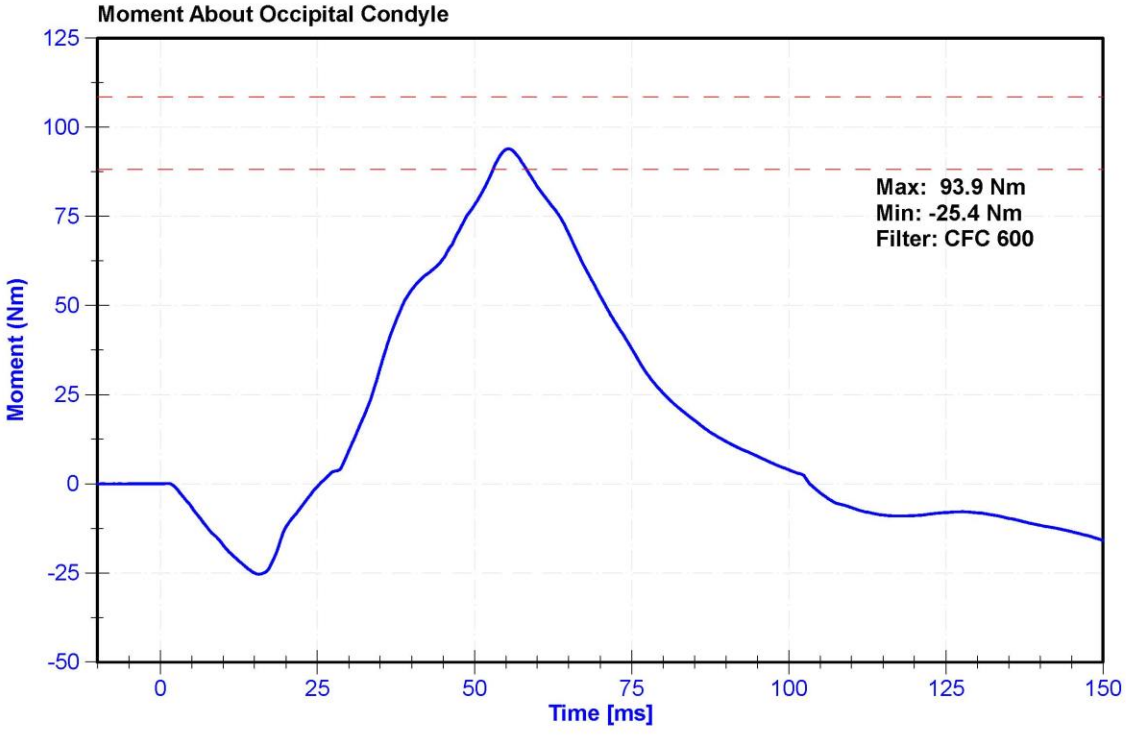
Results

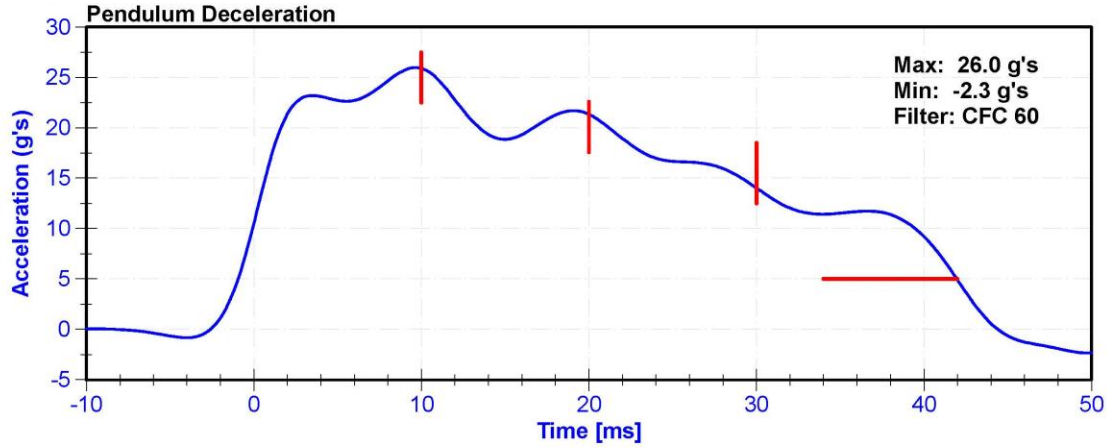
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	65.7	Pass
Velocity	6.89	7.13	m/s	6.958	Pass
Pendulum Deceleration at 10ms	22.5	27.5	g's	25.91	Pass
Pendulum Deceleration at 20ms	17.6	22.6	g's	21.34	Pass
Pendulum Deceleration at 30ms	12.5	18.5	g's	14.03	Pass
Max. Pendulum Deceleration After 30ms	0	29	g's	26.0	Pass
Pendulum Deceleration Time to 5 g's	34	42	ms	42.0	Pass
Maximum D Plane Rotation	64	78	deg	74.6	Pass
Time to Maximum Rotation	57	64	ms	61.5	Pass
Rotation Decay to Zero	113	127	ms	119.3	Pass
Moment About Occipital Condyle	88.1	108.4	Nm	93.86	Pass
Time to Maximum Moment	47	58	ms	55.4	Pass
Moment Decay to Zero	97	107	ms	103.4	Pass

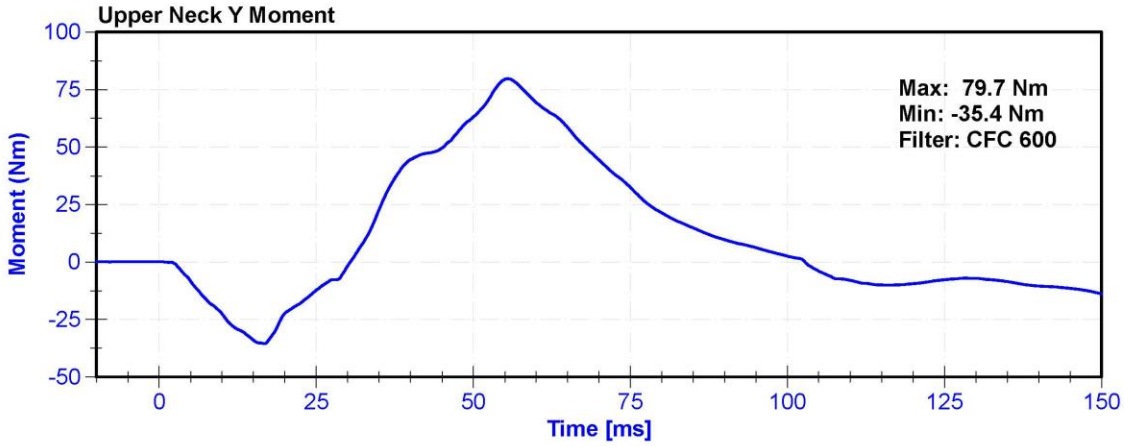
Transducer Calibrations

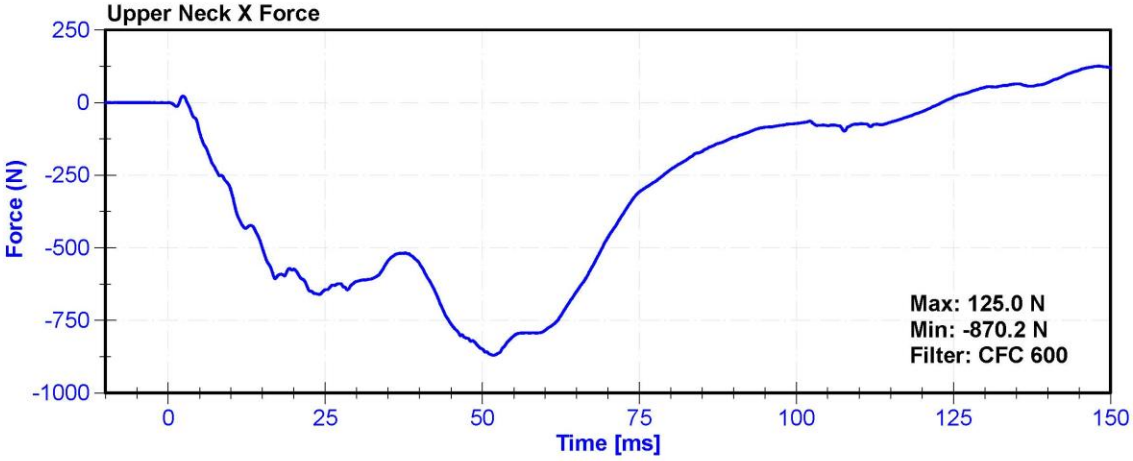
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton IF-205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


D-Plane Rotation
Rotation (Deg)
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 74.6 deg
Min: -36.2 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 93.9 Nm
Min: -25.4 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 26.0 g's
Min: -2.3 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 79.7 Nm
Min: -35.4 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 125.0 N
Min: -870.2 N
Filter: CFC 600
Force (N)
Time [ms]

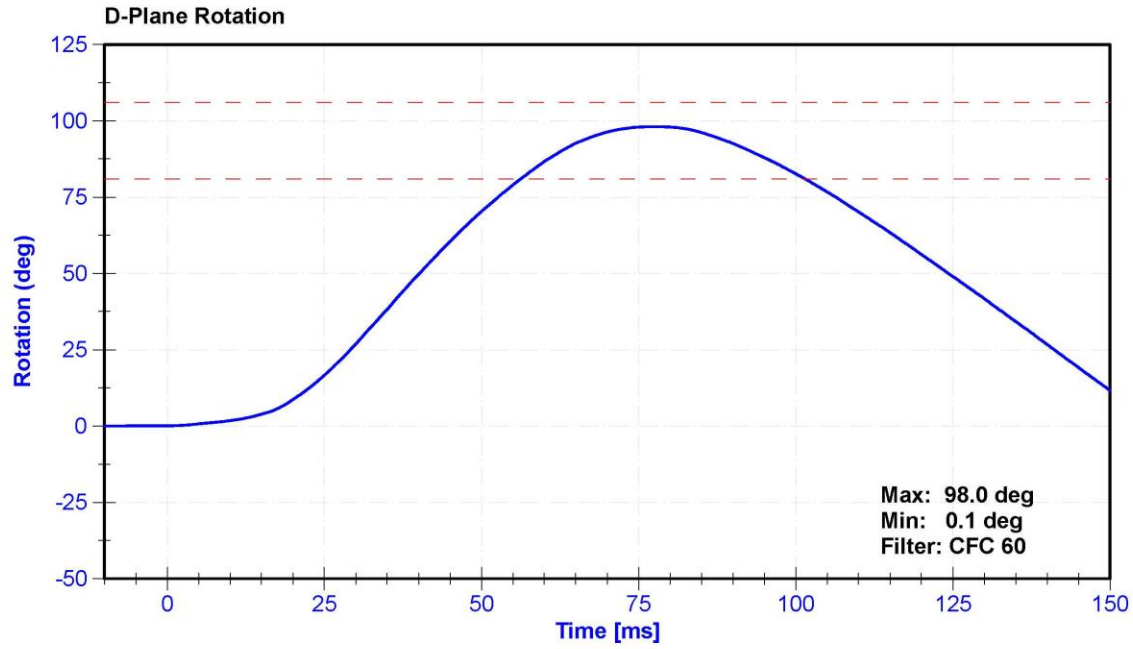
ATD Manufacturer	Humanetics	Test Technician	C. Mantell
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

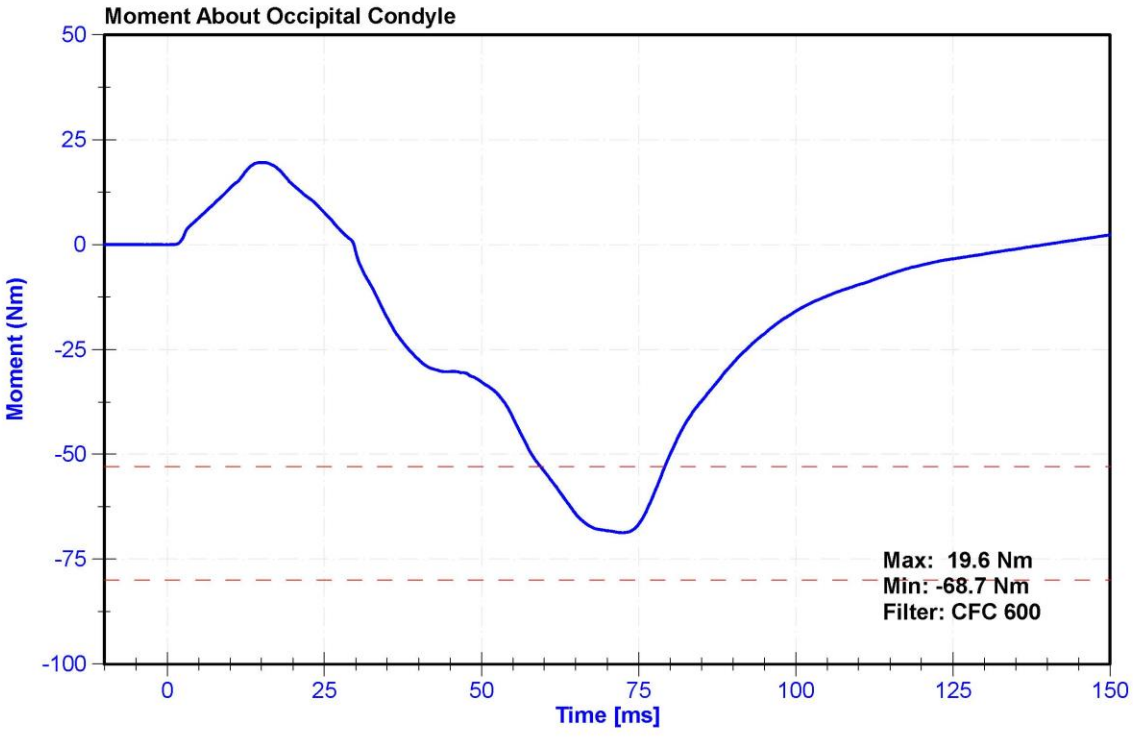
Results

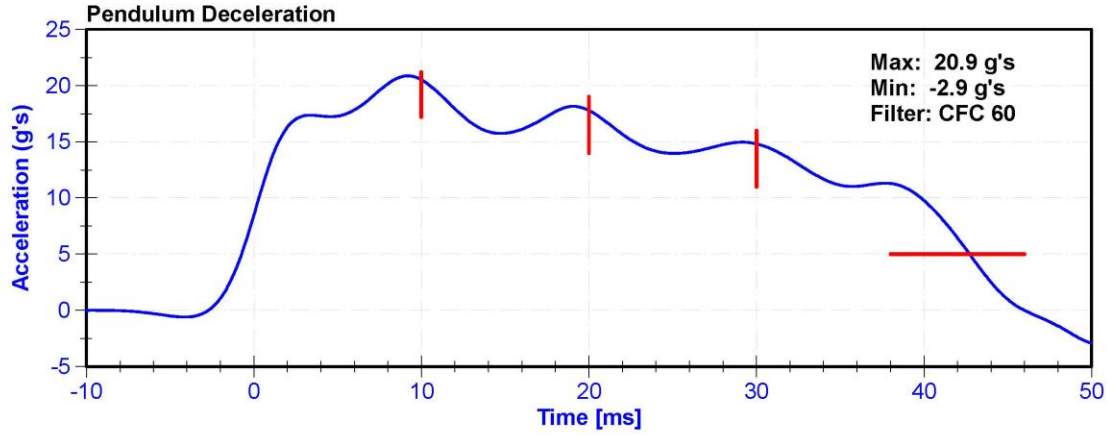
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	67	Pass
Velocity	5.94	6.19	m/s	6.005	Pass
Pendulum Deceleration at 10ms	17.2	21.2	g's	20.52	Pass
Pendulum Deceleration at 20ms	14	19	g's	17.8	Pass
Pendulum Deceleration at 30ms	11	16	g's	14.8	Pass
Max. Pendulum Deceleration After 30ms	0	22	g's	20.9	Pass
Pendulum Deceleration Time to 5 g's	38	46	ms	42.8	Pass
Maximum D Plane Rotation	81	106	deg	98.0	Pass
Time to Maximum Rotation	72	82	ms	77.5	Pass
Rotation Decay to Zero	147	174	ms	158.1	Pass
Minimum Moment About OC	-80	-52.9	Nm	-68.71	Pass
Time to Minimum Moment	65	79	ms	72.5	Pass
Moment Decay to Zero	120	148	ms	139.8	Pass

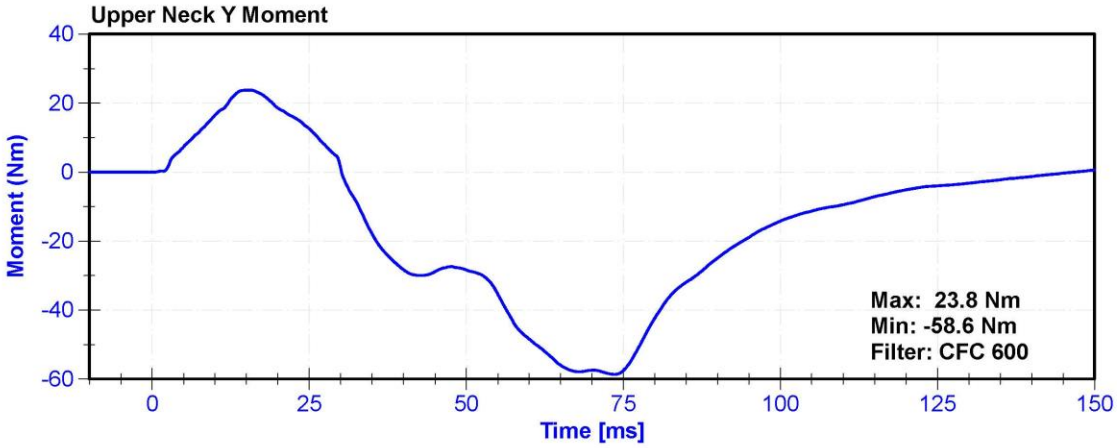
Transducer Calibrations

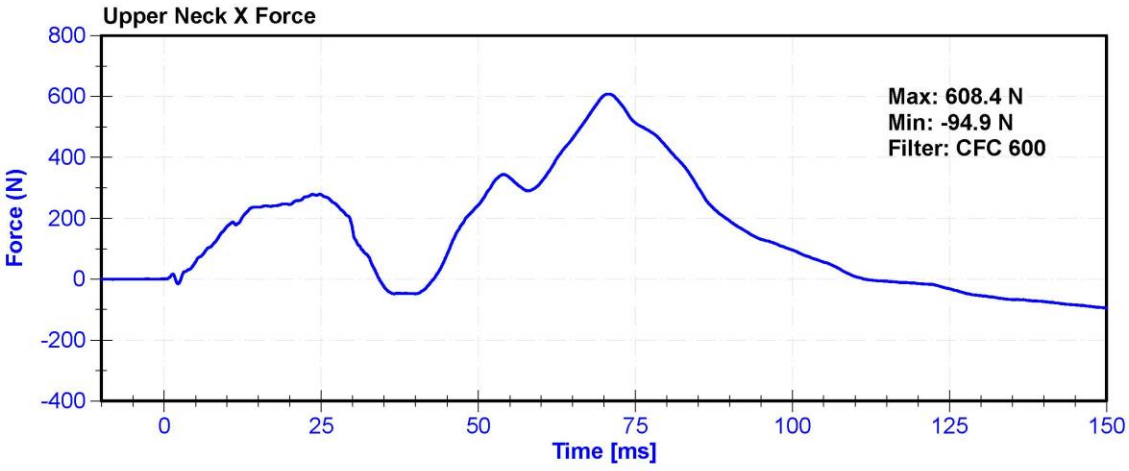
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton IF-205	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: 98.0 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: 19.6 Nm
Min: -68.7 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 20.9 g's
Min: -2.9 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 23.8 Nm
Min: -58.6 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 608.4 N
Min: -94.9 N
Filter: CFC 600
Force (N)
Time [ms]

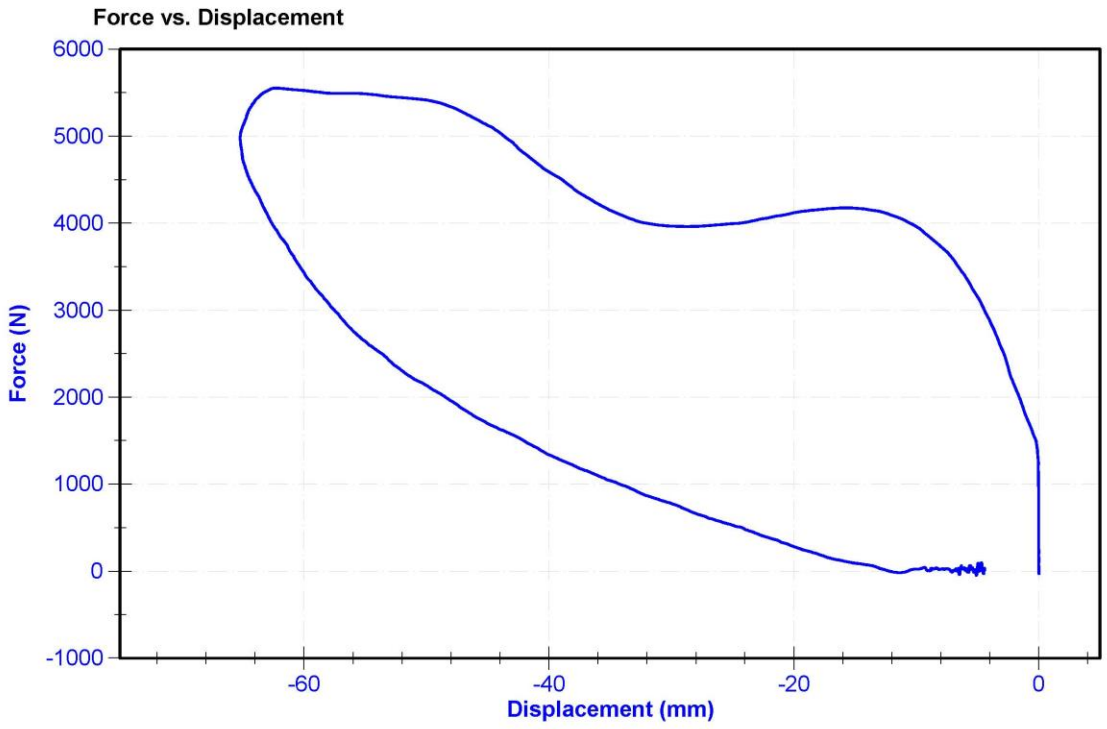
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

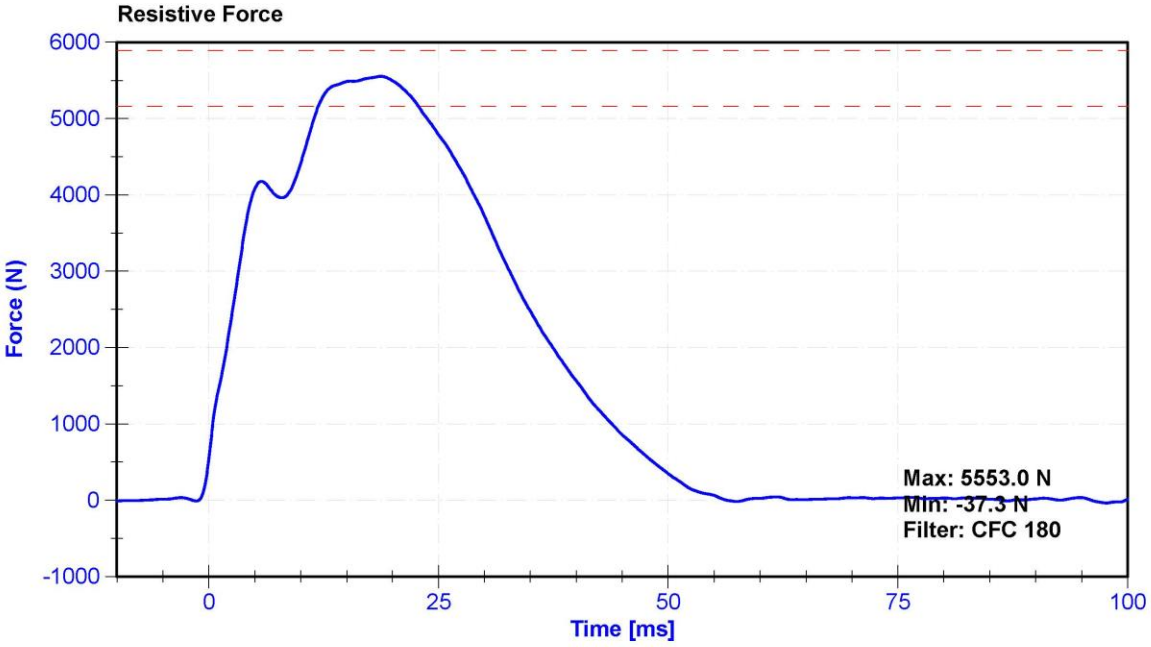
Results

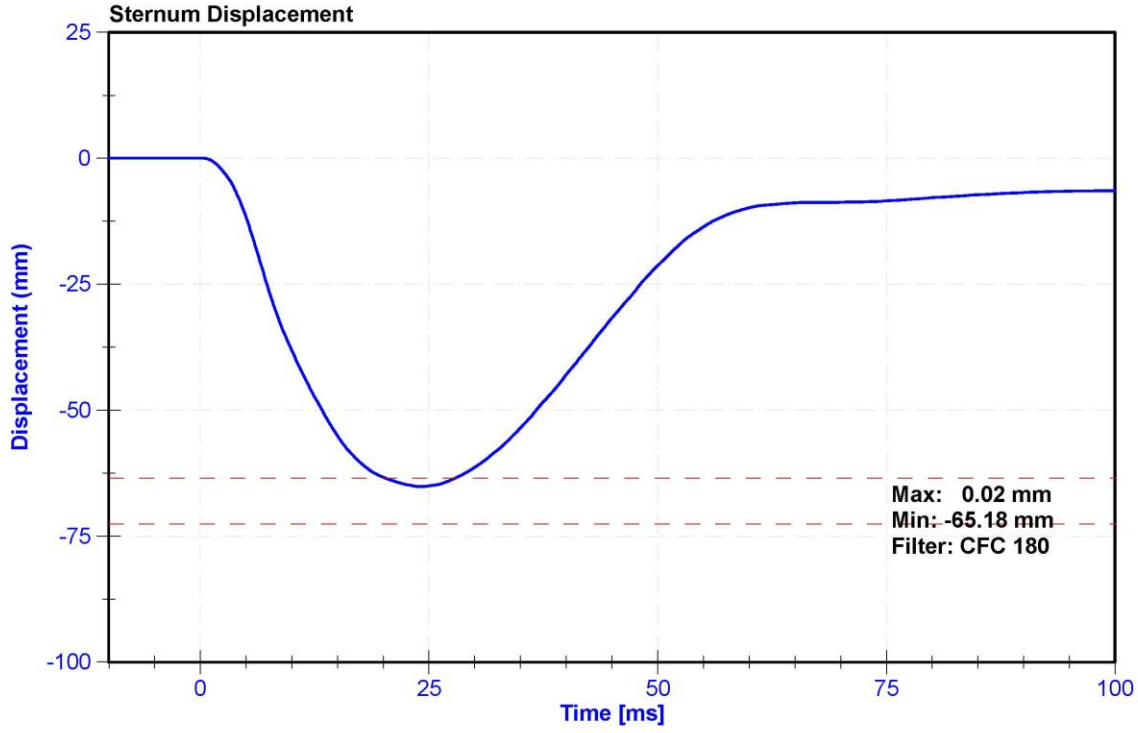
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.7	Pass
Humidity	10	70	%	56	Pass
Velocity	6.59	6.83	m/s	6.597	Pass
Chest Displacement	-72.6	-63.5	mm	-65.18	Pass
Resistive Force	5160	5894	N	5553.0	Pass
Hysteresis	65	85	%	71.5	Pass

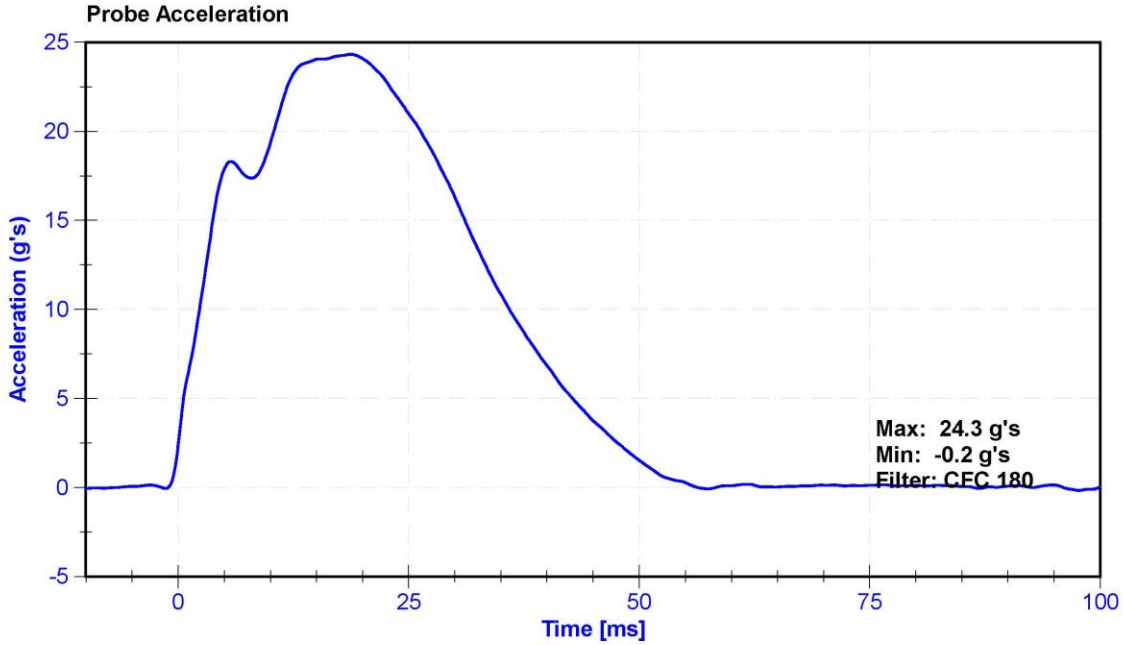
Transducer Calibrations

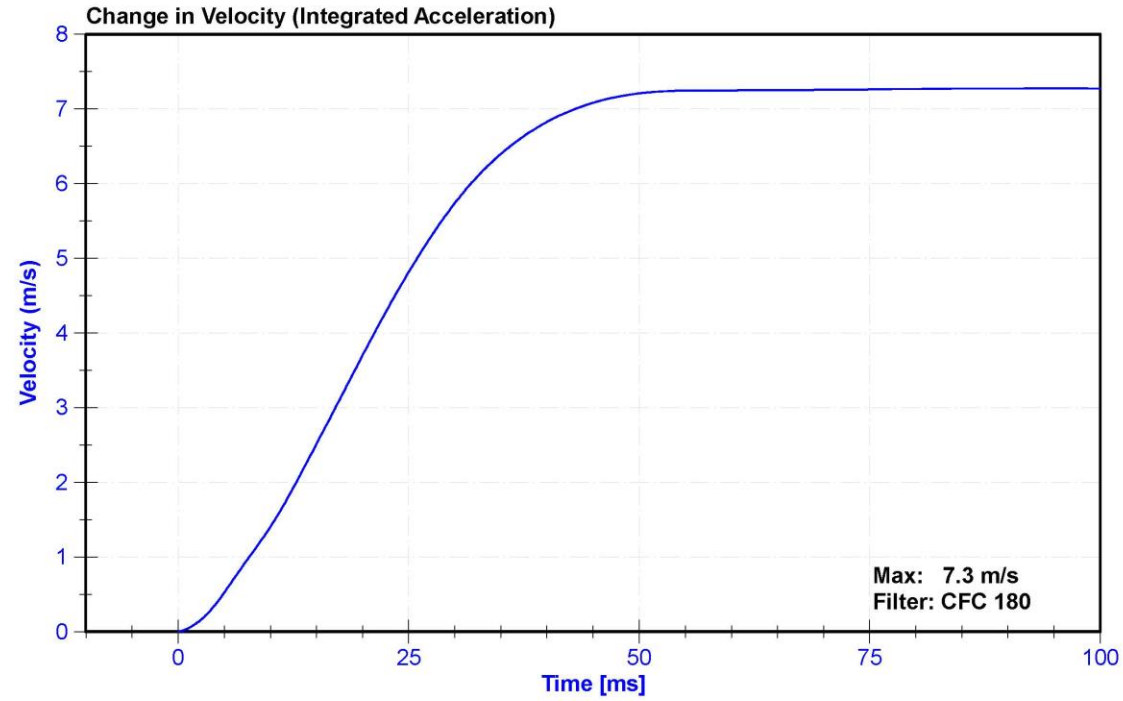
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A286228	1/29/2020	1/28/2021
Chest Potentiometer	Servo 6209-2038	DS-142	6/23/2020	12/22/2020




Resistive Force
6000
5000
4000
3000
2000
1000
0
-1000
Force (N)
0
25
50
75
100
Time [ms]
Max: 5553.0 N
Min: -37.3 N
Filter: CFC 180


Sternum Displacement
25
0
-25
-50
-75
-100
Displacement (mm)
0
25
50
75
100
Time [ms]
Max: 0.02 mm
Min: -65.18 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
25
20
15
10
5
0
-5
0
25
50
75
100
Time [ms]
Max: 24.3 g's
Min: -0.2 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: 7.3 m/s
Filter: CFC 180

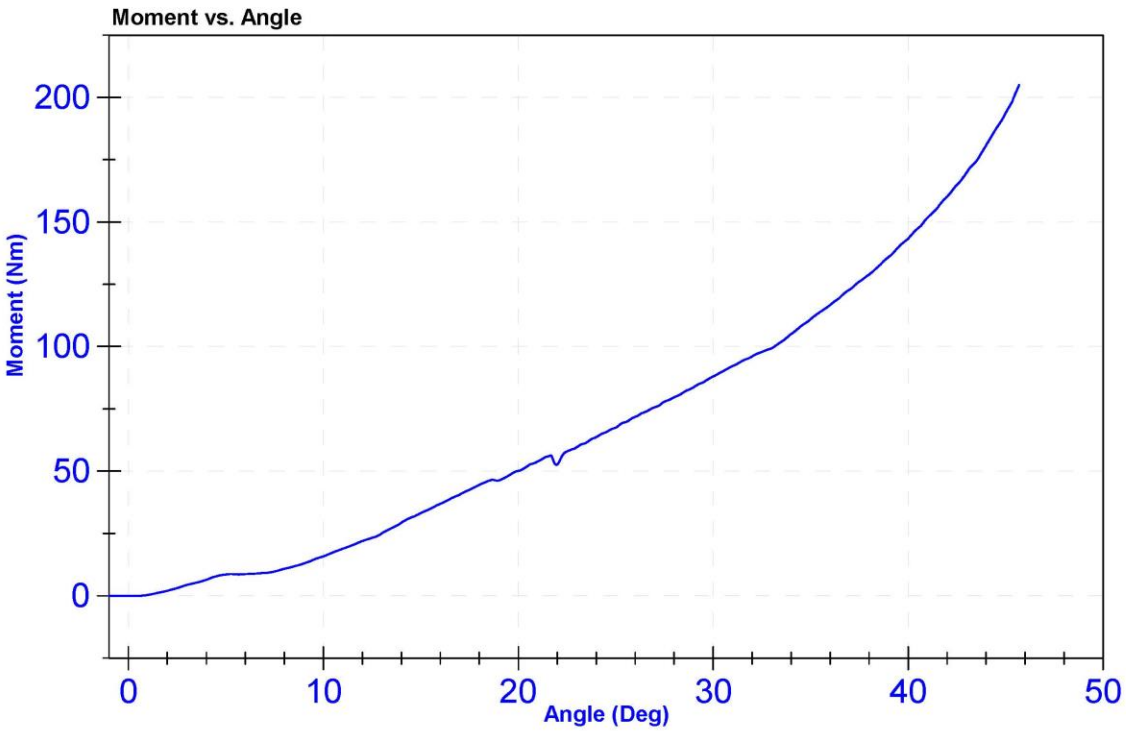
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	65.9	Pass
Average Velocity	5	10	deg/s	7.2	Pass
Angle at 203Nm	40	50	deg	45.6	Pass
Moment at 30 degrees	0	94.9	Nm	88.1	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



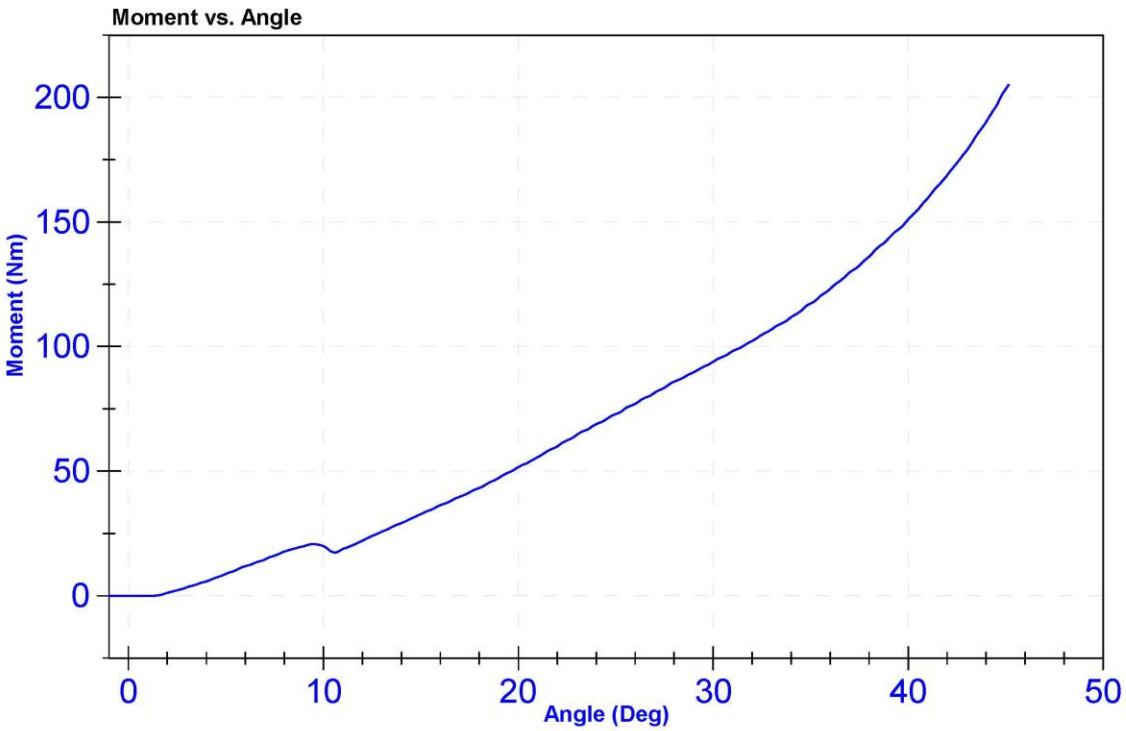
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.7	Pass
Humidity	10	70	%	57.0	Pass
Average Velocity	5	10	deg/s	7.3	Pass
Angle at 203Nm	40	50	deg	45.0	Pass
Moment at 30 degrees	0	94.9	Nm	94.0	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



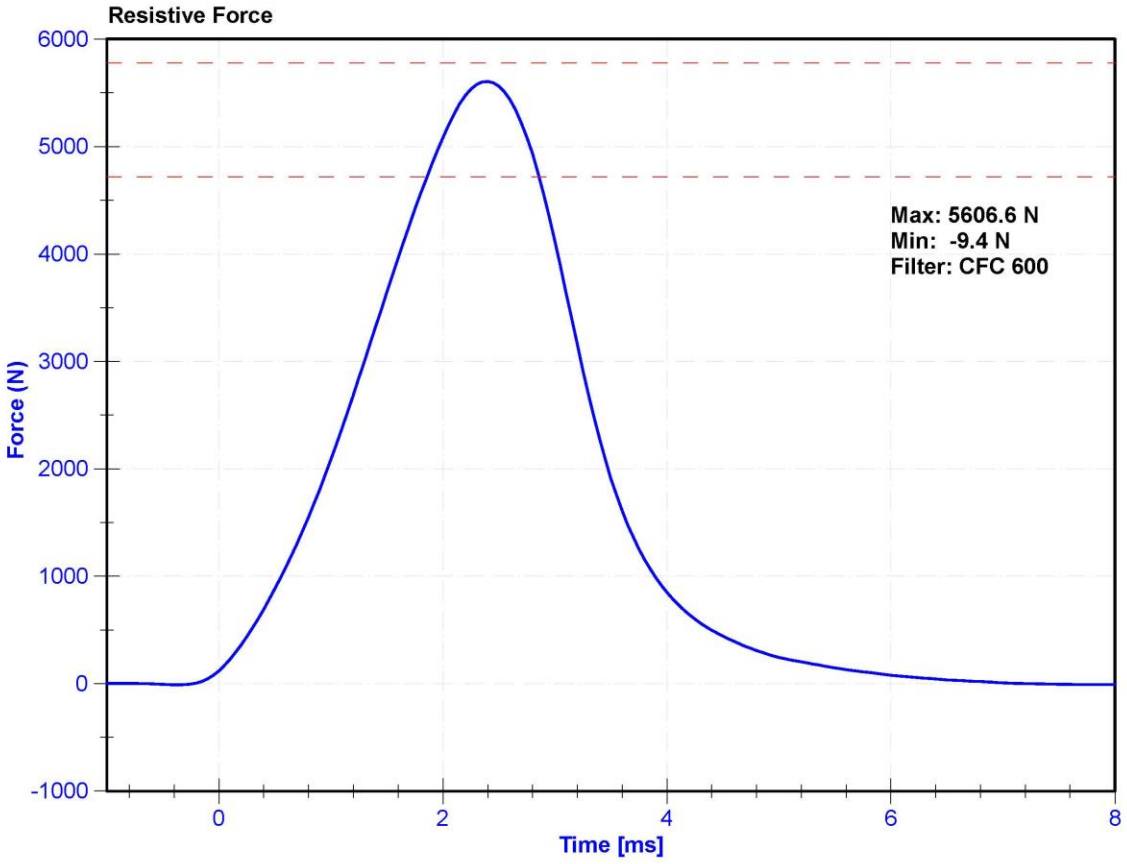
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

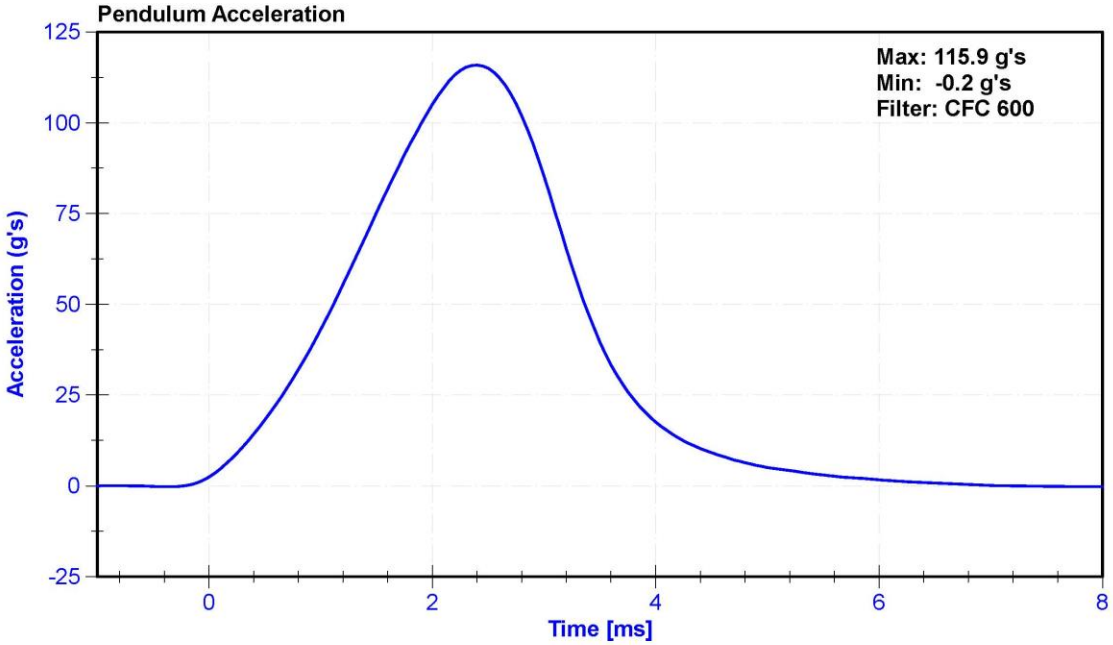
Results

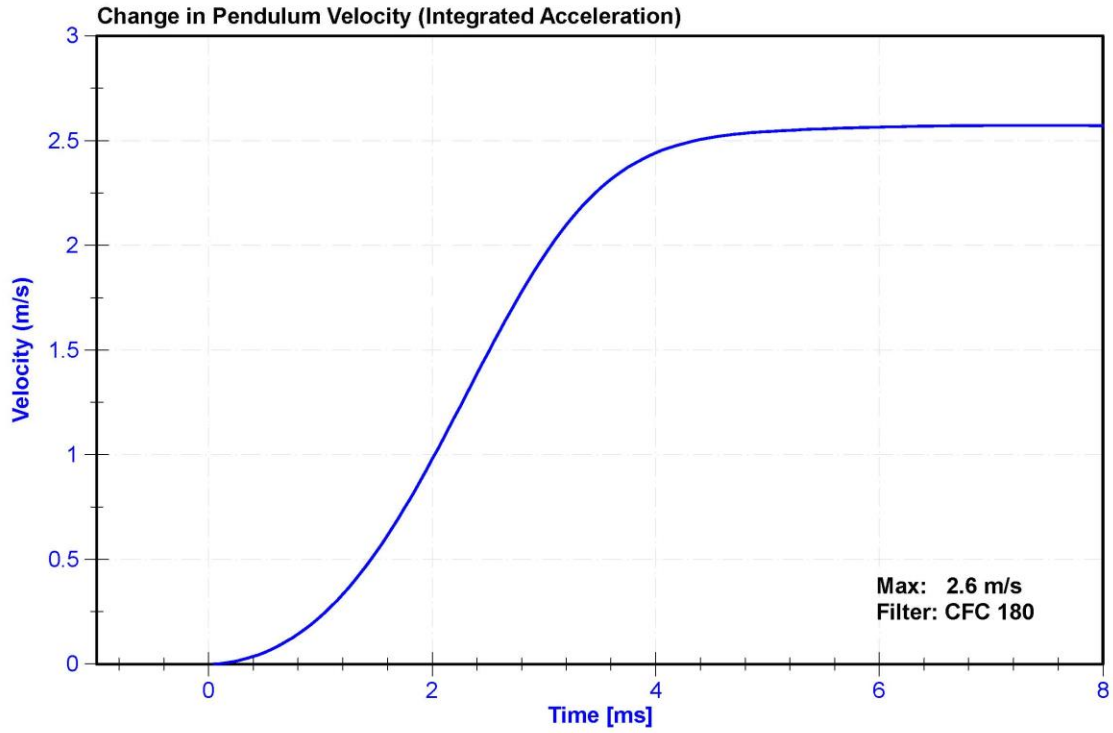
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.7	Pass
Humidity	10	70	%	57	Pass
Velocity	2.07	2.13	m/s	2.104	Pass
Maximum Resistive Force	4720	5780	N	5606.6	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A279031	5/8/2020	5/8/2021




Pendulum Acceleration
Max: 115.9 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)
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]

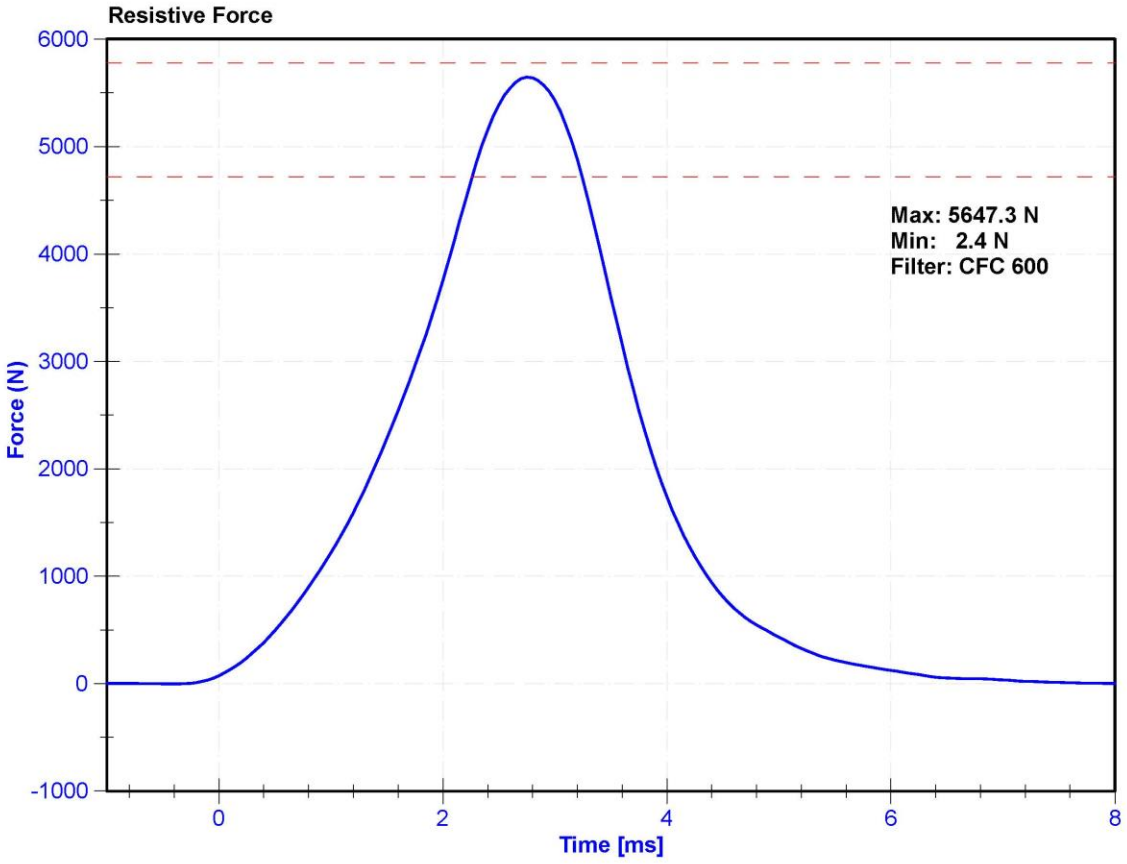
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

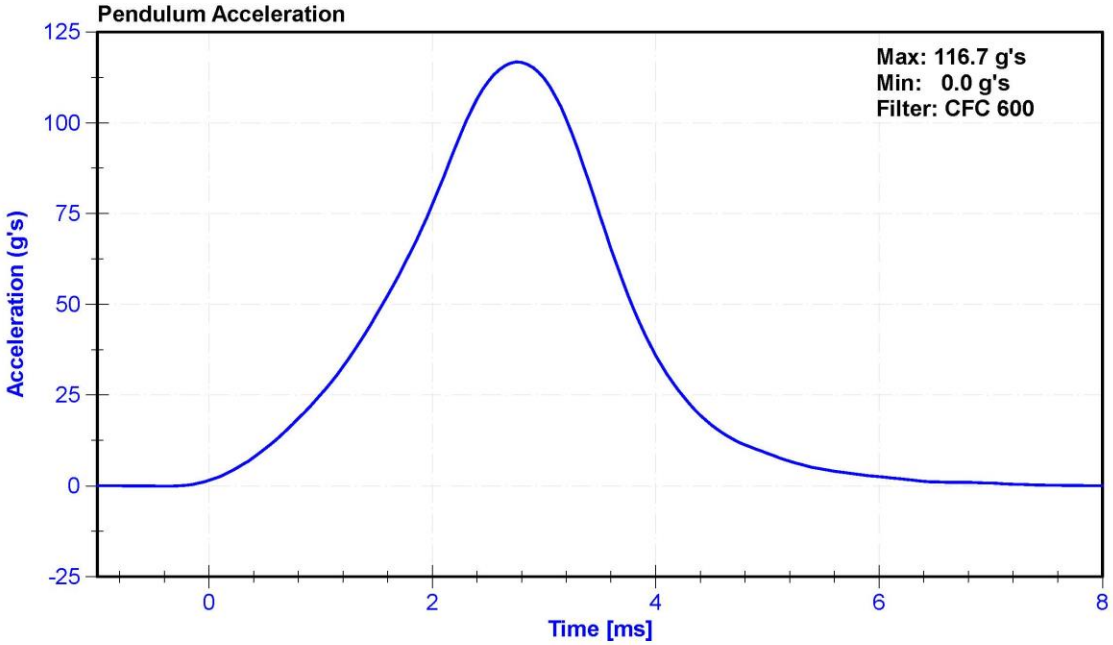
Results

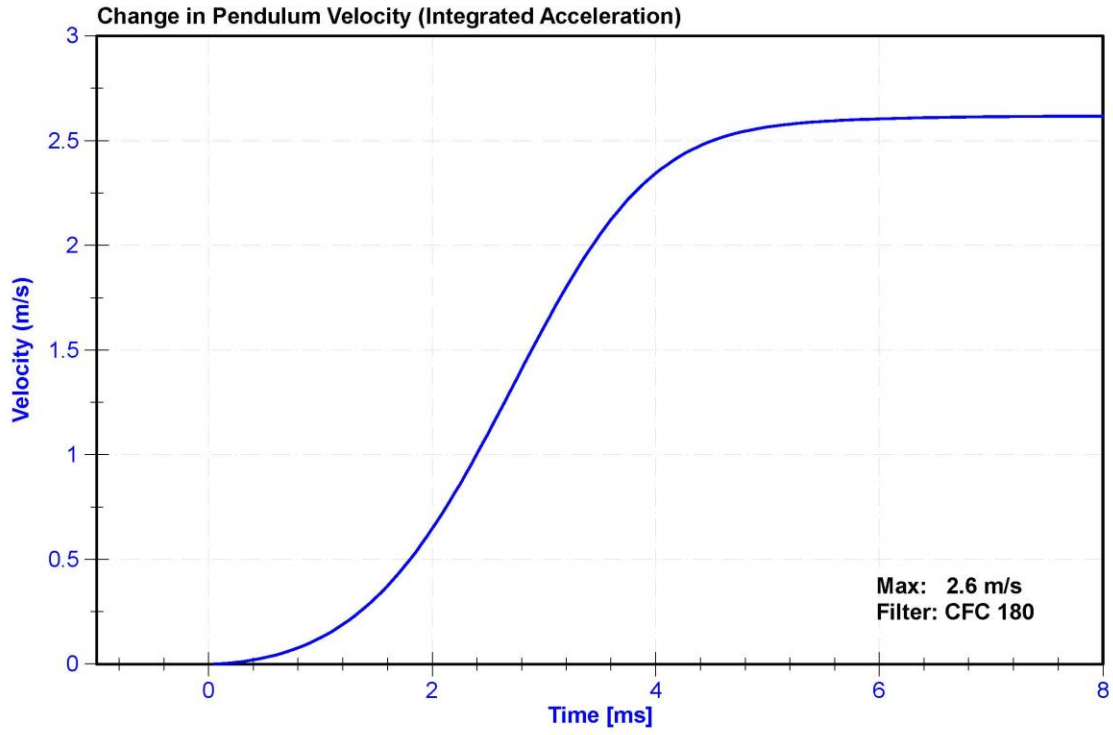
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	53	Pass
Velocity	2.07	2.13	m/s	2.105	Pass
Maximum Resistive Force	4720	5780	N	5647.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A279031	5/8/2020	5/8/2021




Pendulum Acceleration
Max: 116.7 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)
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

POST-TEST

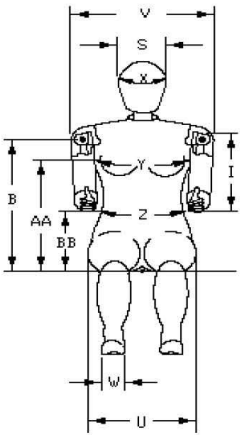
HYBRID III 5TH PERCENTILE FEMALE - PASSENGER ATD

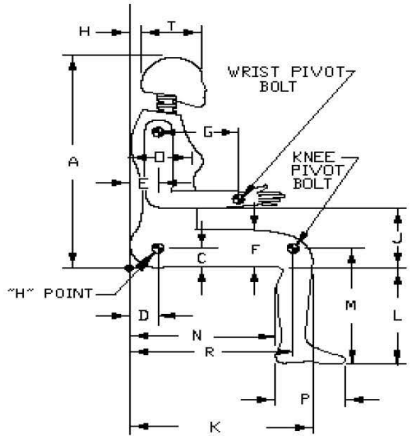
SERIAL NO: 139

External Measurements - Hybrid 3 - 5th Female

Technician: K. Brogan Date: 08/11/2020

Dummy Serial Number: 139





Symbol	Description	Specification (mm)		Result (mm)	Pass/Fail
A	Sitting Height	775	800	791	Pass
B	Shoulder Pivot Height	432	457	446	Pass
C	H-Point Height	81	86	84	Pass
D	H-Point from Backline	145	150	146	Pass
E	Shoulder Pivot from Backline	69	84	78	Pass
F	Thigh Clearance	119	135	128	Pass
G	Back of Elbow to Wrist Pivot	244	259	254	Pass
H	Head Back to Backline	43	48	45	Pass
I	Shoulder to Elbow Length	277	297	289	Pass
J	Elbow Rest Height	183	203	195	Pass
K	Buttock to Knee Length	521	546	542	Pass
L	Popliteal Height	356	376	363	Pass
M	Knee Pivot Height	394	419	402	Pass
N	Buttock Popliteal Length	414	439	425	Pass
O	Chest Depth without Jacket	175	191	185	Pass
P	Foot Length (right)	219	234	225	Pass
R	Buttock To Knee Pivot Length	457	483	475	Pass
S	Head Breadth	137	147	143	Pass
T	Head Depth	178	188	182	Pass
U	Hip Breadth	300	315	309	Pass
V	Shoulder Breadth	351	366	362	Pass
W	Foot Breadth	79	94	87	Pass
X	Head Circumference	528	549	535	Pass
Y	Chest Circumference with Jacket	851	881	861	Pass
Z	Waist Circumference	460	790	773	Pass
AA	Reference Location (Chest Circumference)	333	358	345	Pass
BB	Reference Location (Waist Circumference)	160	170	165	Pass

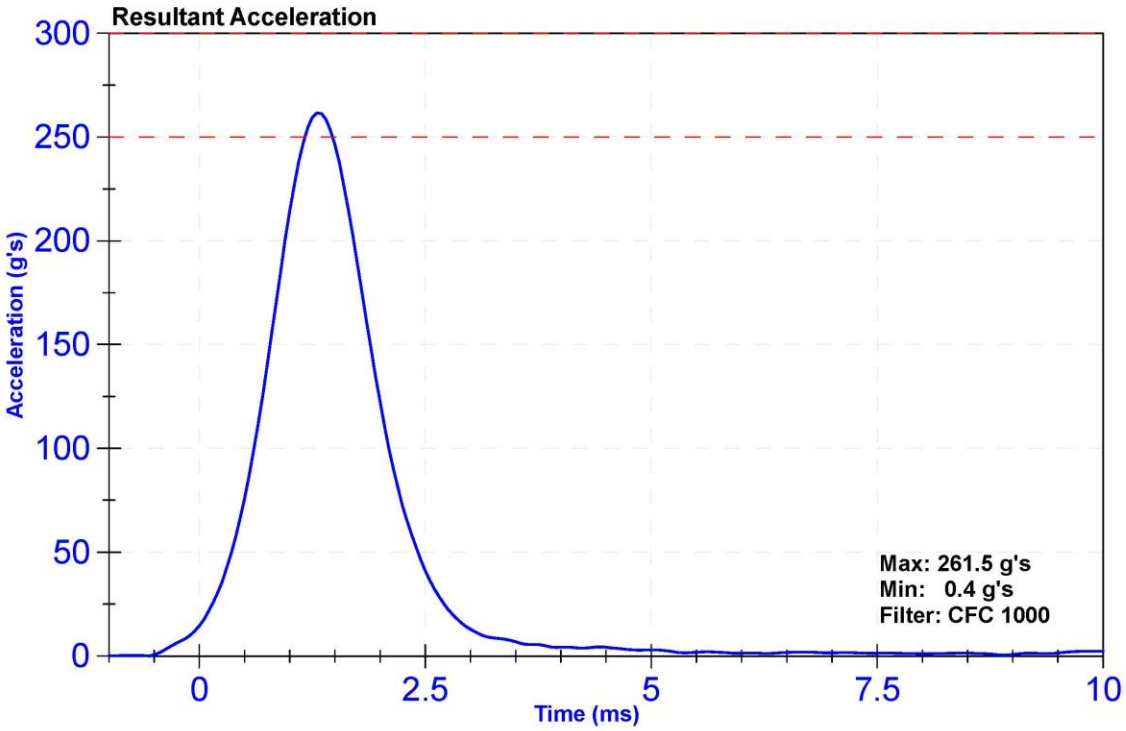
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

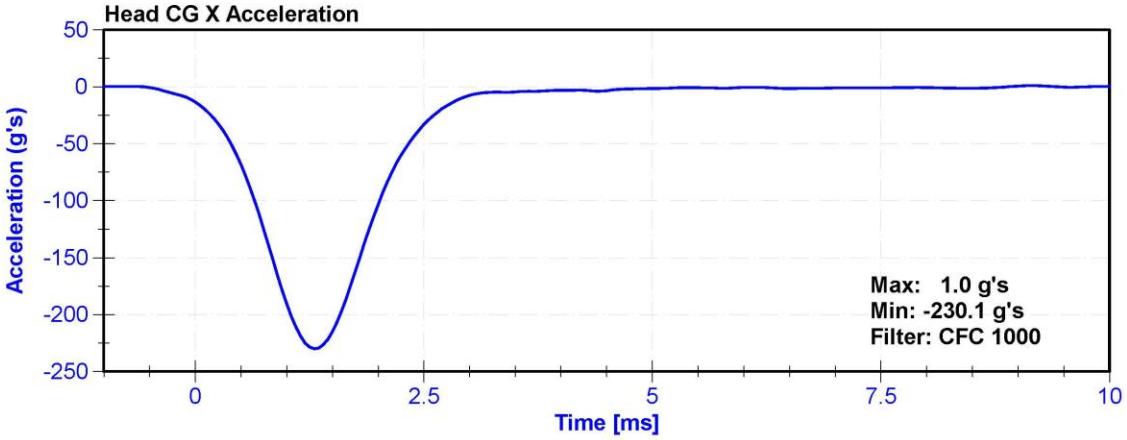
Results

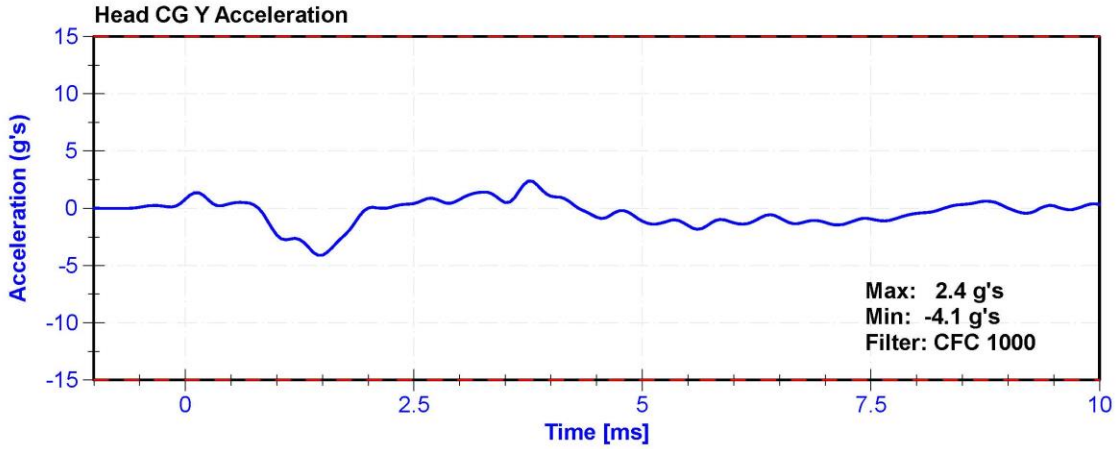
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	67	Pass
Resultant Acceleration	250	300	g's	261.5	Pass
Oscillation	0	10	%	2.1	Pass
Lateral Acceleration	-15	15	g's	-4.1	Pass

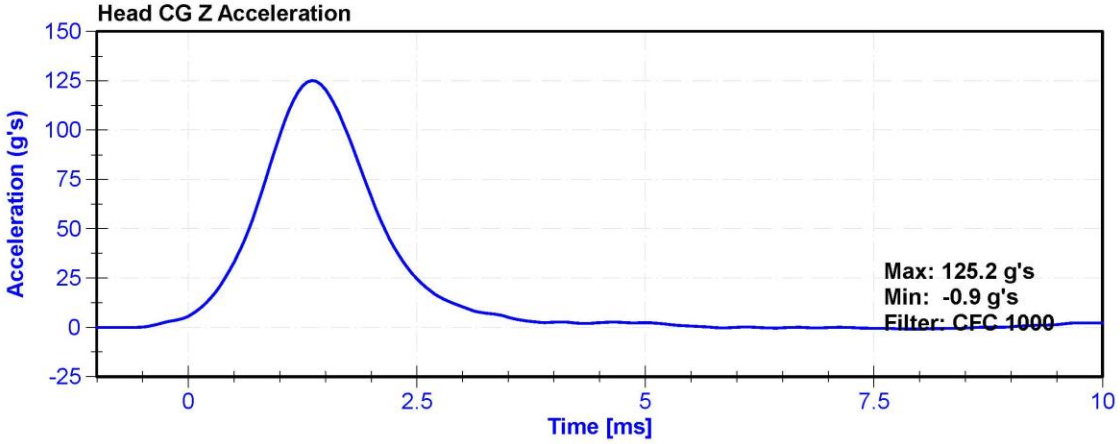
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264CT	AC-P58780	4/17/2020	10/16/2020
Y Accelerometer	ENDEVCO 7264	AC-P83320	4/17/2020	10/16/2020
Z Accelerometer	ENDEVCO 7264CT	AC-P58997	4/17/2020	10/16/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 1.0 g's
Min: -230.1 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: 2.4 g's
Min: -4.1 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: 125.2 g's
Min: -0.9 g's
Filter: CFC 1000

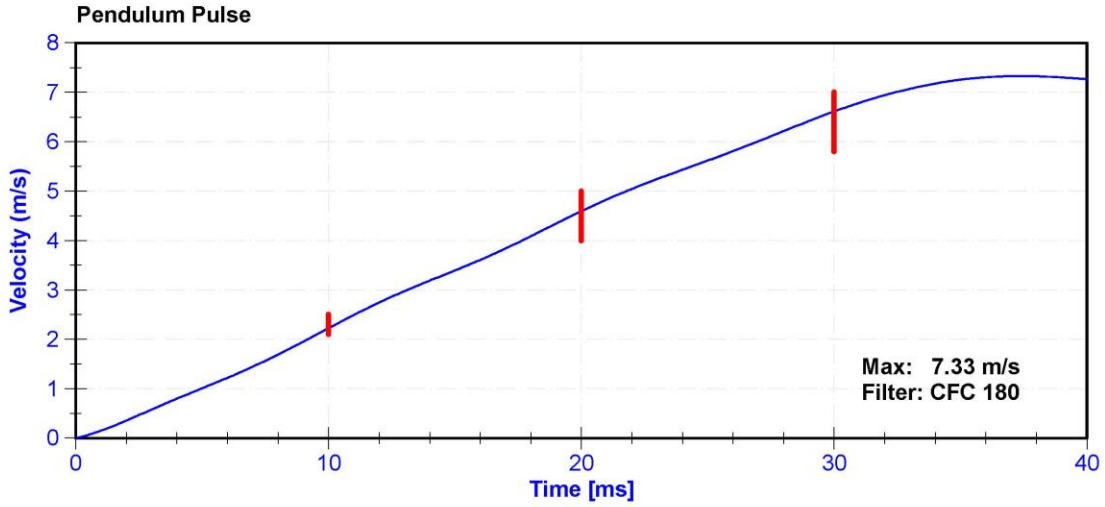
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

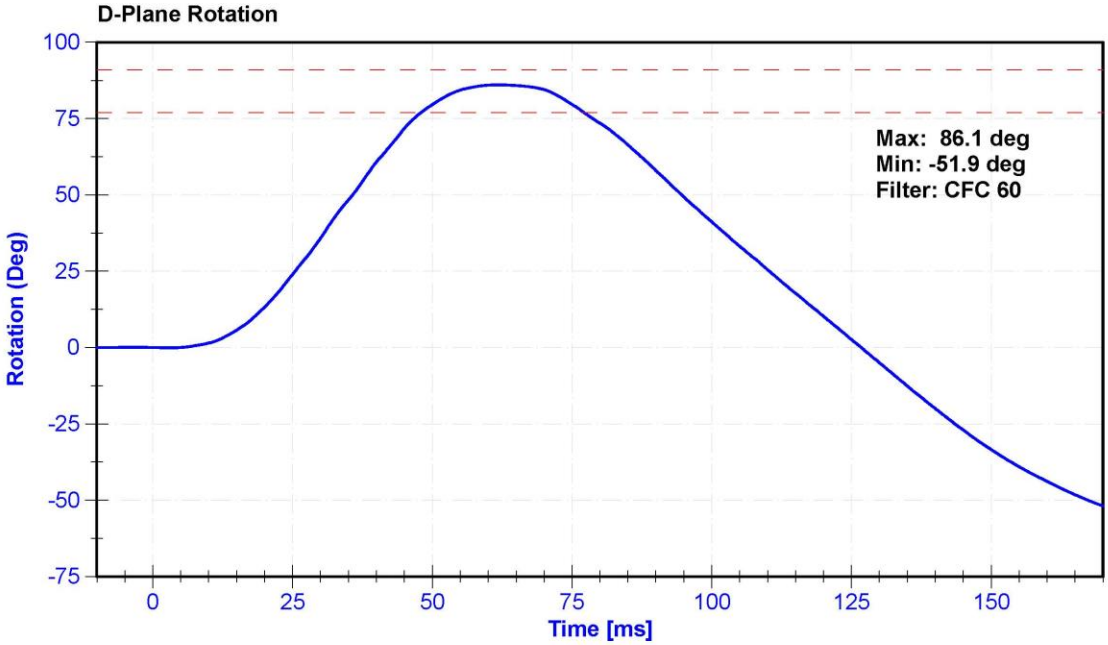
Results

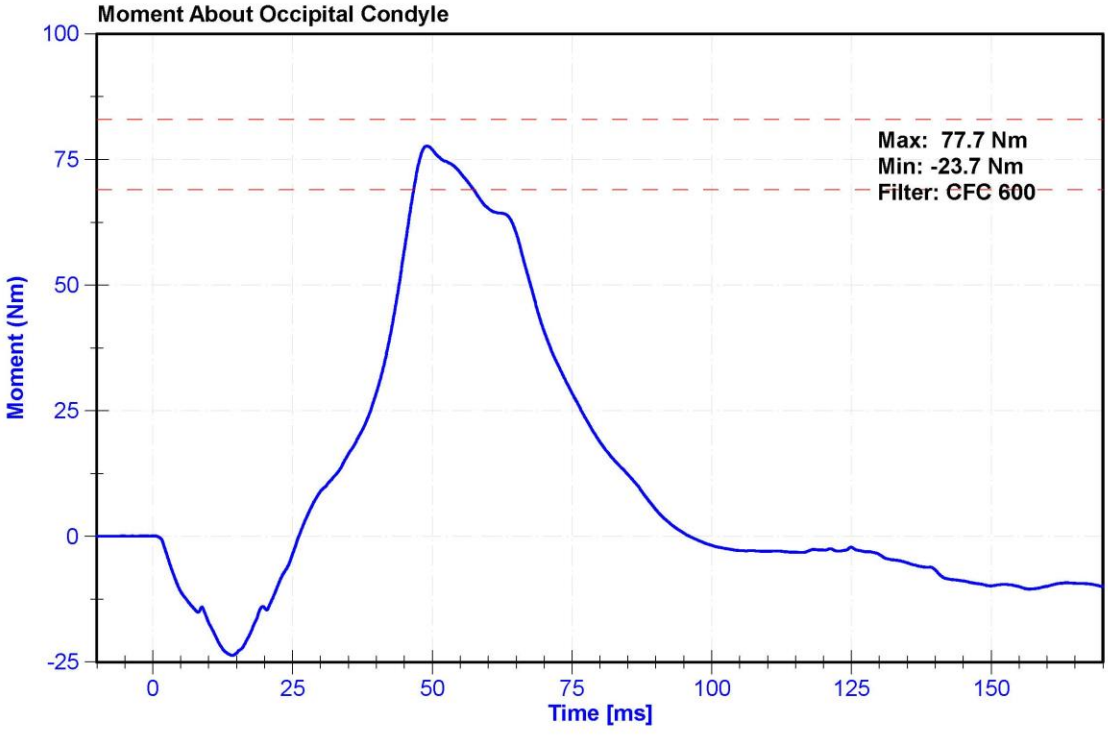
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	56.0	Pass
Velocity	6.89	7.13	m/s	6.958	Pass
Pendulum Impulse at 10ms	2.1	2.5	m/s	2.22	Pass
Pendulum Impulse at 20ms	4.0	5.0	m/s	4.59	Pass
Pendulum Impulse at 30ms	5.8	7.0	m/s	6.61	Pass
Max D Plane Rotation	77	91	deg	86.1	Pass
Max Moment During Rotation Interval	69	83	Nm	77.7	Pass
Moment Decay to 10.0 Nm	80	100	ms	86.8	Pass

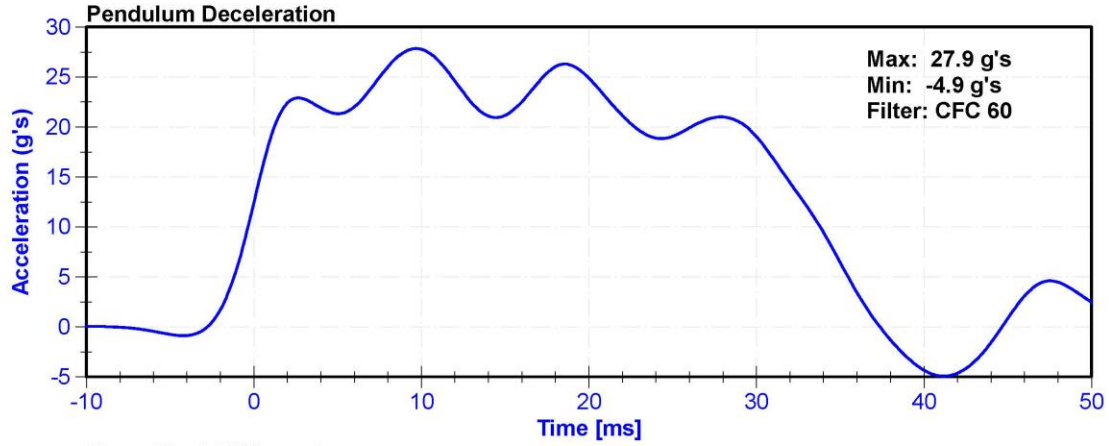
Transducer Calibrations

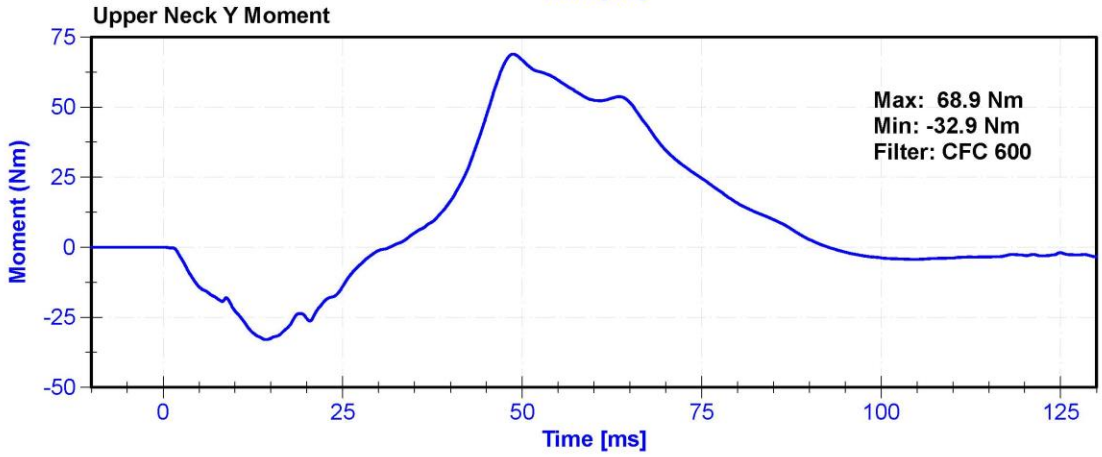
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton 1716A	LC-1916Fx	10/3/2019	10/2/2020

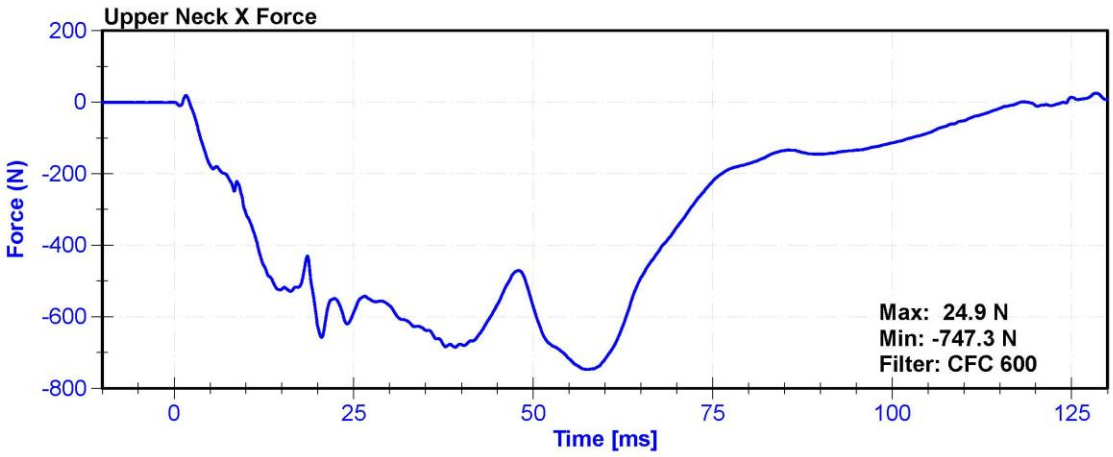



D-Plane Rotation
Rotation (Deg)
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150
Time [ms]
Max: 86.1 deg
Min: -51.9 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
100
75
50
25
0
-25
0
25
50
75
100
125
150
Time [ms]
Max: 77.7 Nm
Min: -23.7 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 27.9 g's
Min: -4.9 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 68.9 Nm
Min: -32.9 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 24.9 N
Min: -747.3 N
Filter: CFC 600
Force (N)
Time [ms]

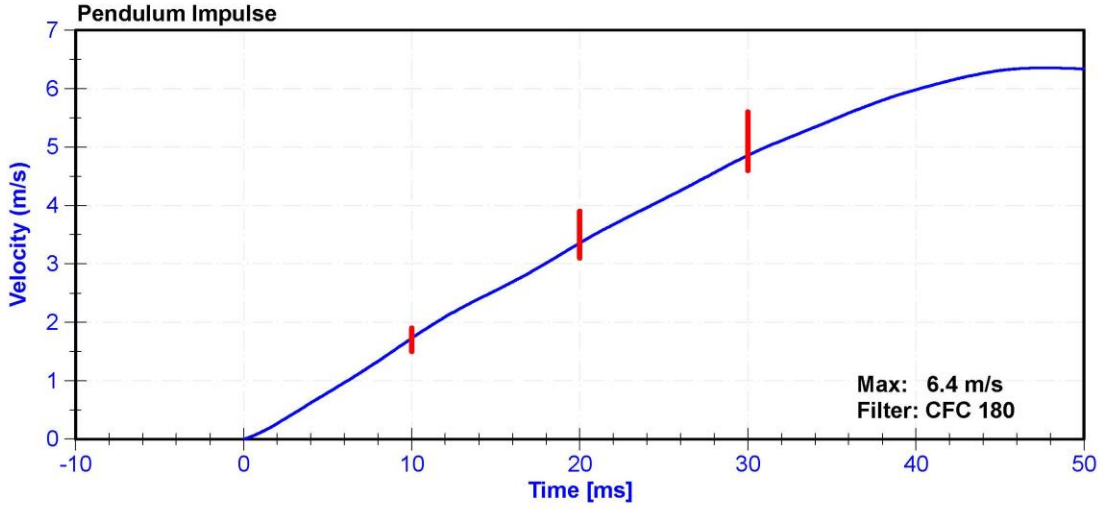
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

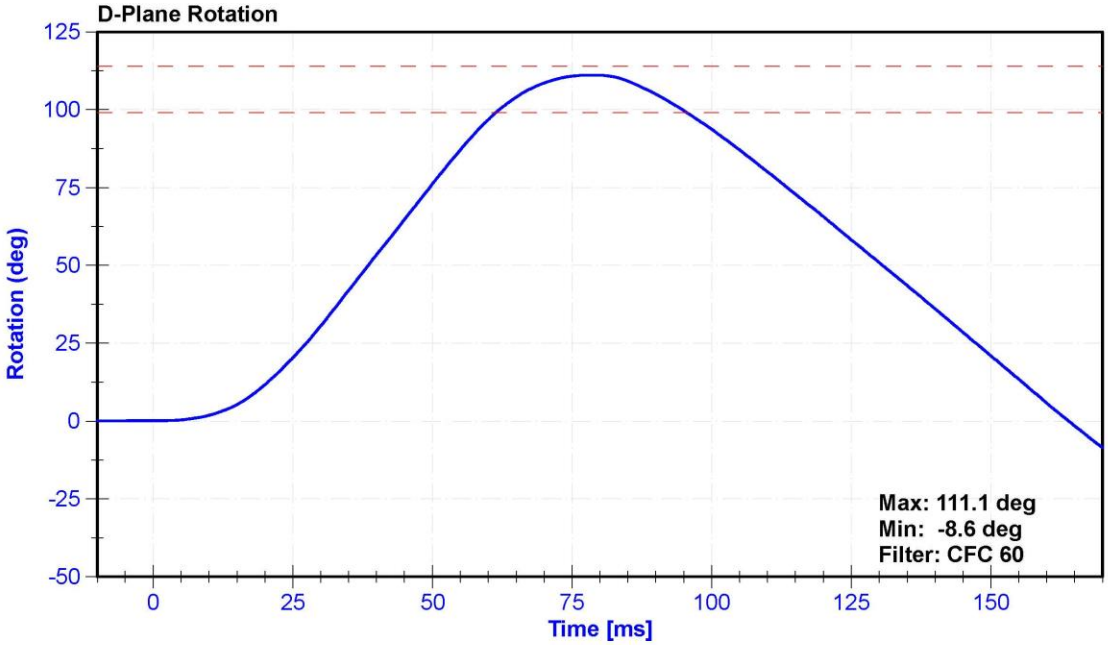
Results

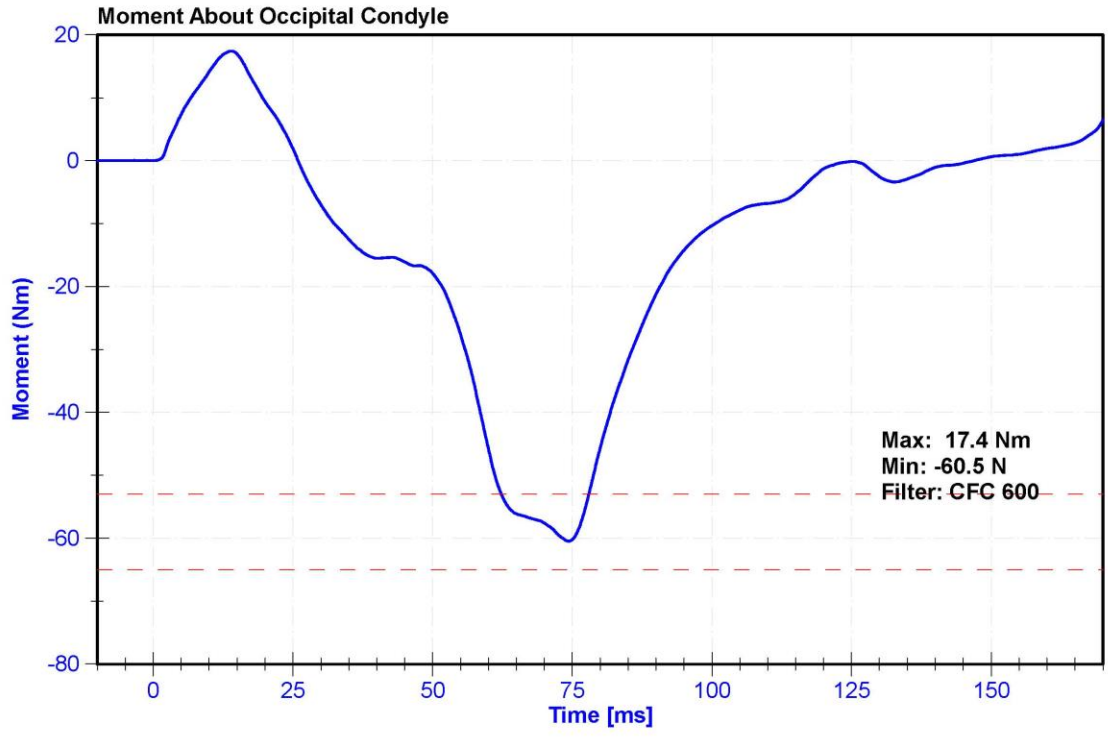
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	57.0	Pass
Velocity	5.95	6.19	m/s	6.046	Pass
Pendulum Impulse at 10ms	1.5	1.9	m/s	1.73	Pass
Pendulum Impulse at 20ms	3.1	3.9	m/s	3.36	Pass
Pendulum Impulse at 30ms	4.6	5.6	m/s	4.86	Pass
D Plane Rotation	99	114	deg	111.1	Pass
Moment During Rotation Interval	-65	-53	Nm	-60.5	Pass
Moment Decay to -10Nm	94	114	ms	100.6	Pass

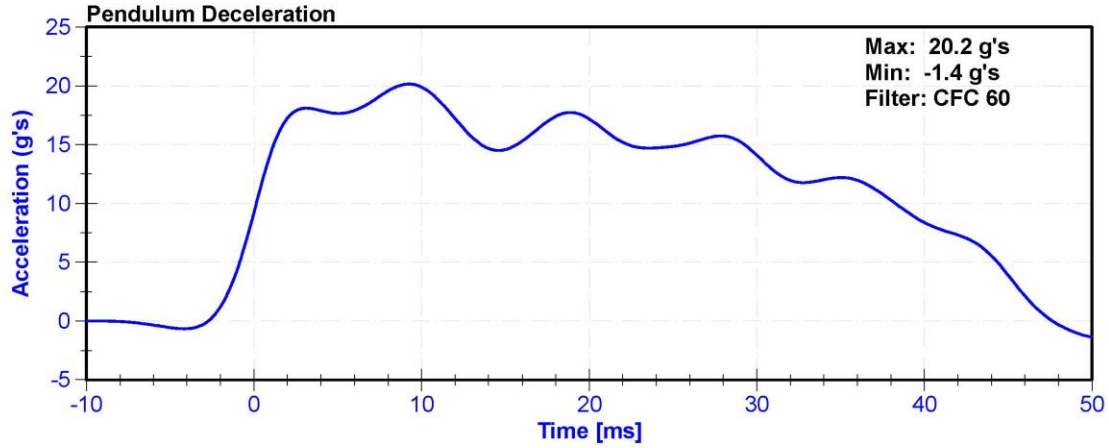
Transducer Calibrations

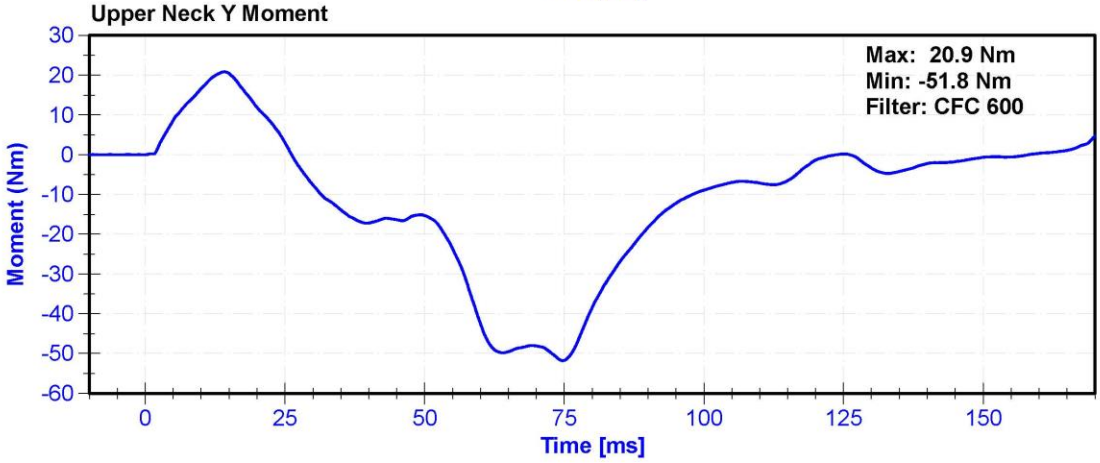
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/30/2020	1/29/2021
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	Denton 1716A	LC-1916Fx	10/3/2019	10/2/2020

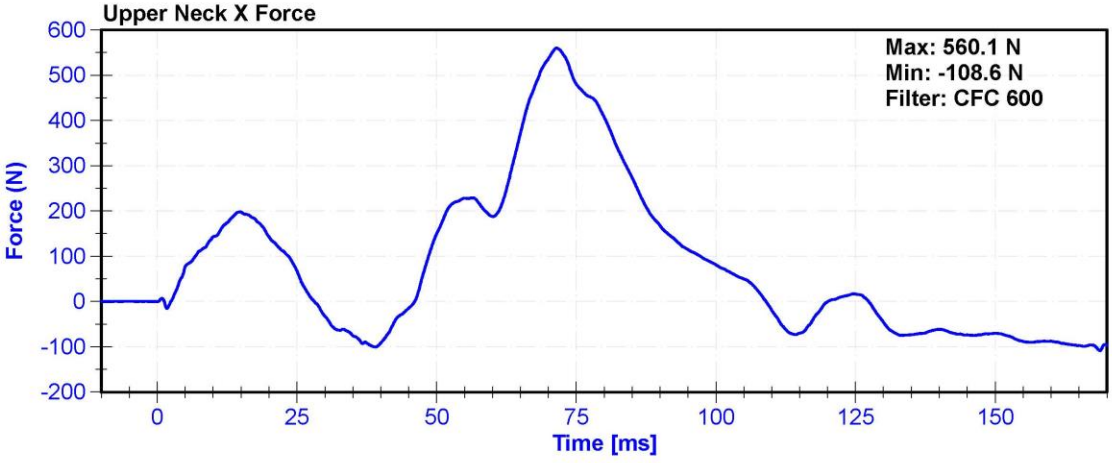



D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 111.1 deg
Min: -8.6 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
20
0
-20
-40
-60
-80
0
25
50
75
100
125
150
Time [ms]
Max: 17.4 Nm
Min: -60.5 N
Filter: CFC 600


Pendulum Deceleration
Max: 20.2 g's
Min: -1.4 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 20.9 Nm
Min: -51.8 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 560.1 N
Min: -108.6 N
Filter: CFC 600
Force (N)
Time [ms]

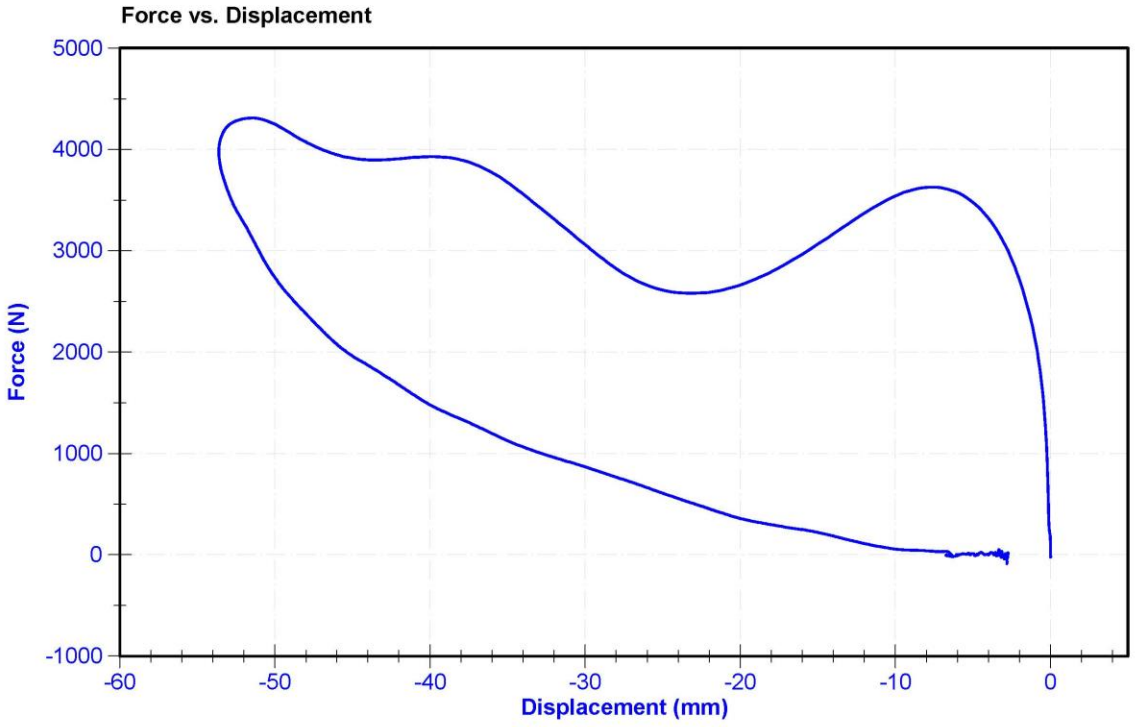
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

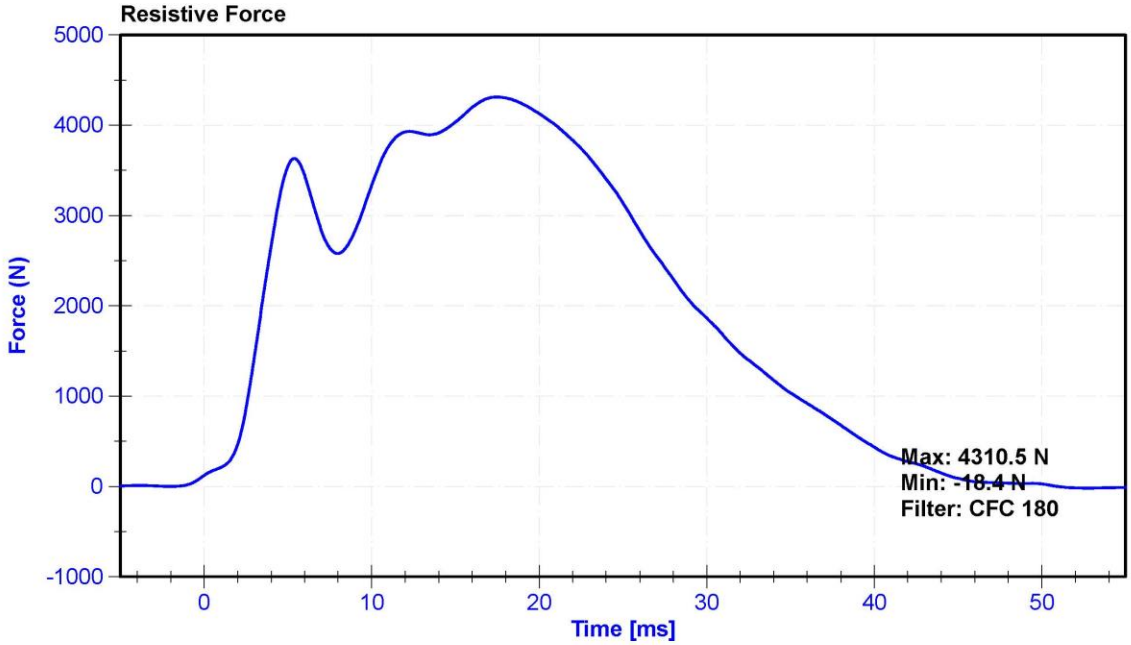
Results

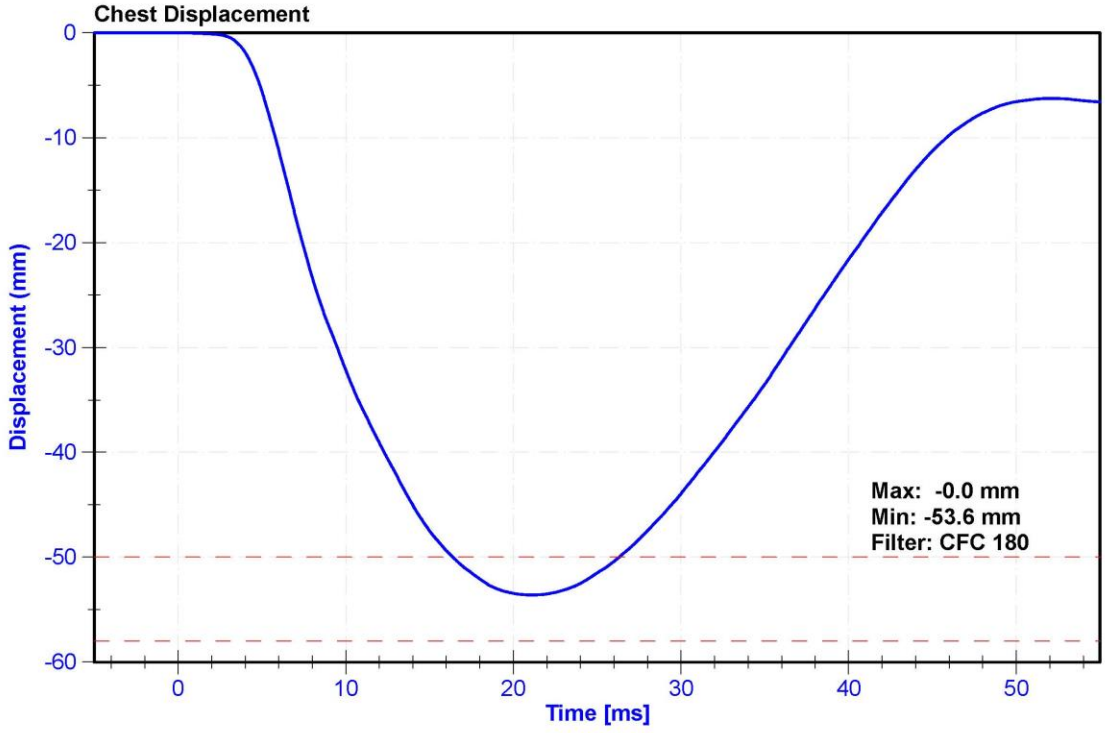
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	64	Pass
Velocity	6.59	6.83	m/s	6.641	Pass
Chest Deflection	-58	-50	mm	-53.6	Pass
Maximum Resistive Force (50 to 58mm)	3900	4400	N	4310.5	Pass
Maximum Resistive Force (18 to 50mm)	0	4600	N	4243.6	Pass
Hysteresis	69	85	%	71.4	Pass

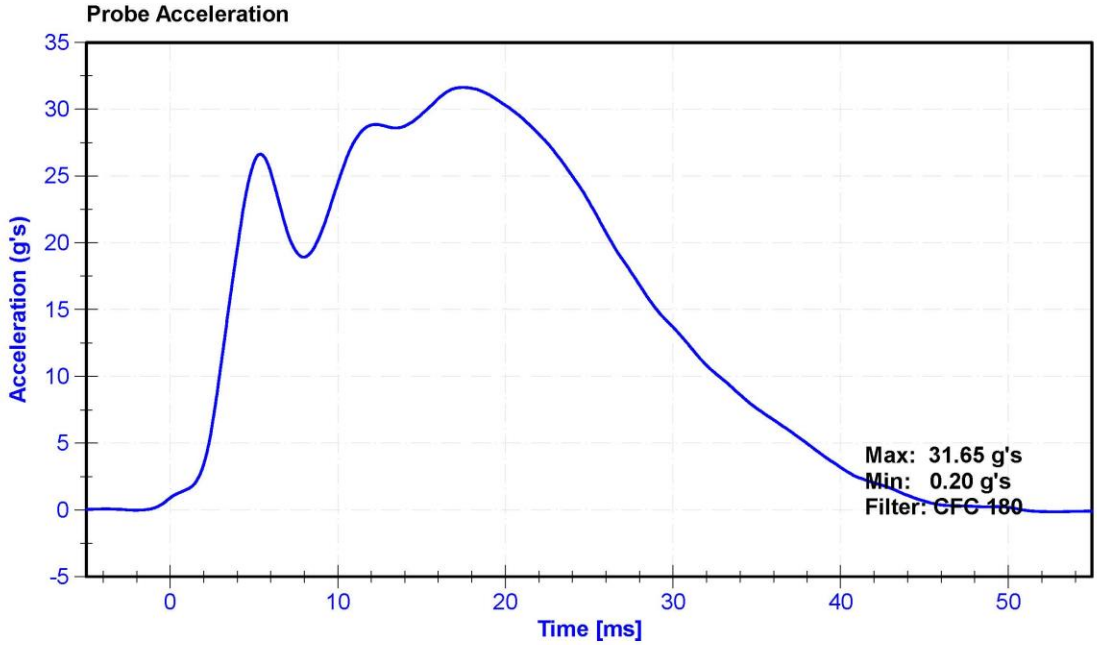
Transducer Calibrations

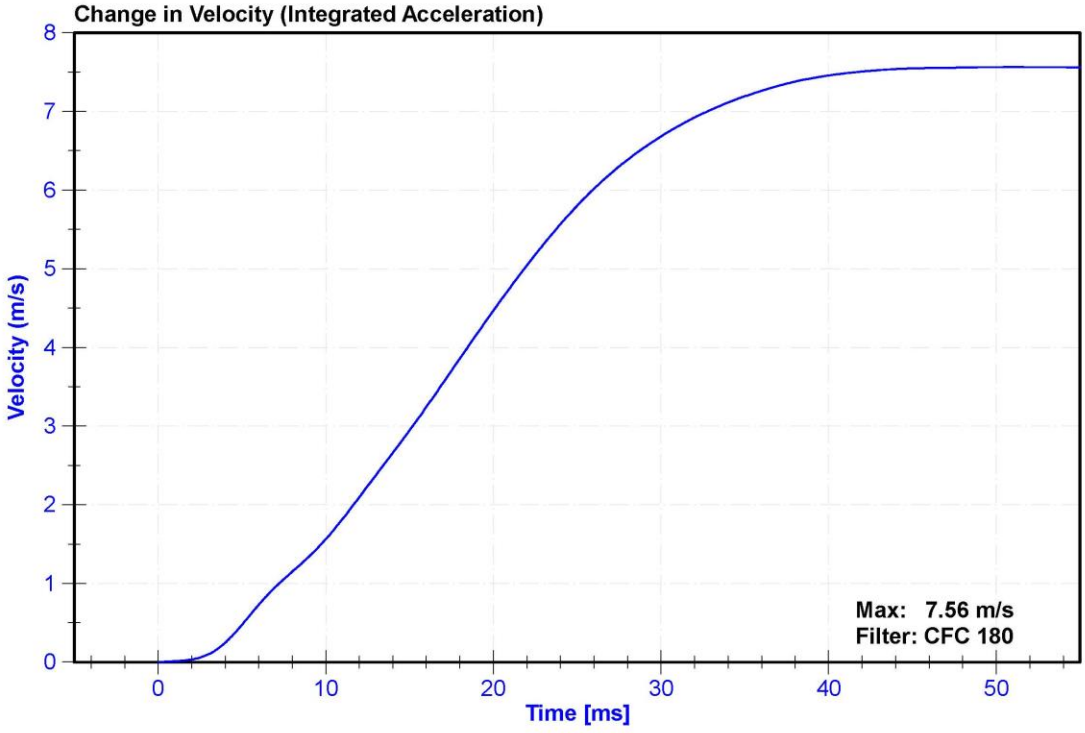
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A279031	5/8/2020	5/8/2021
Chest Potentiometer	SERVO H3CD	DS-503	8/3/2020	2/1/2021




Resistive Force
Force (N)
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50
Time [ms]
Max: 4310.5 N
Min: -18.4 N
Filter: CFC 180


Chest Displacement
Displacement (mm)
0
-10
-20
-30
-40
-50
-60
0
10
20
30
40
50
Time [ms]
Max: -0.0 mm
Min: -53.6 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: 31.65 g's
Min: 0.20 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: 7.56 m/s
Filter: CFC 180

ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K.Brogan

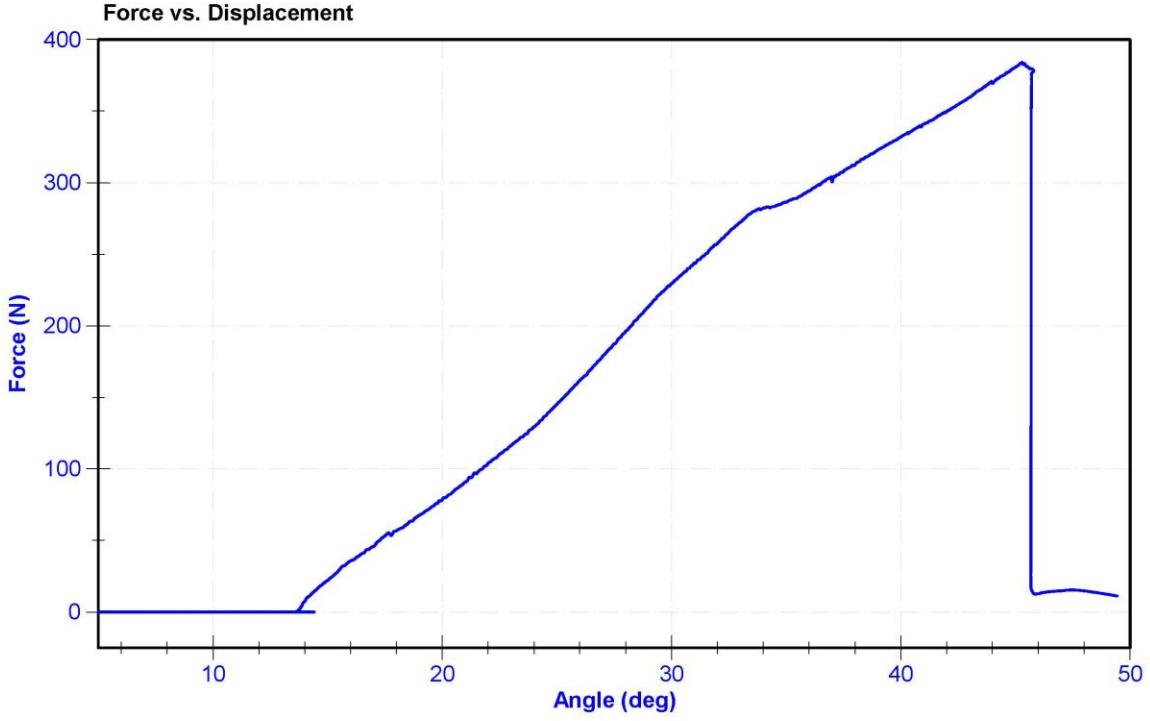
Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.6	25.6	ºC	20.8	Pass
Humidity	10	70	%	58	Pass
Initial Angle	0	20	deg	13.4	Pass
Force at 45 Degrees	320	390	N	384.1	Pass
Return Angle Relative to Initial	0	8	deg	2.6	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

Force vs. Displacement



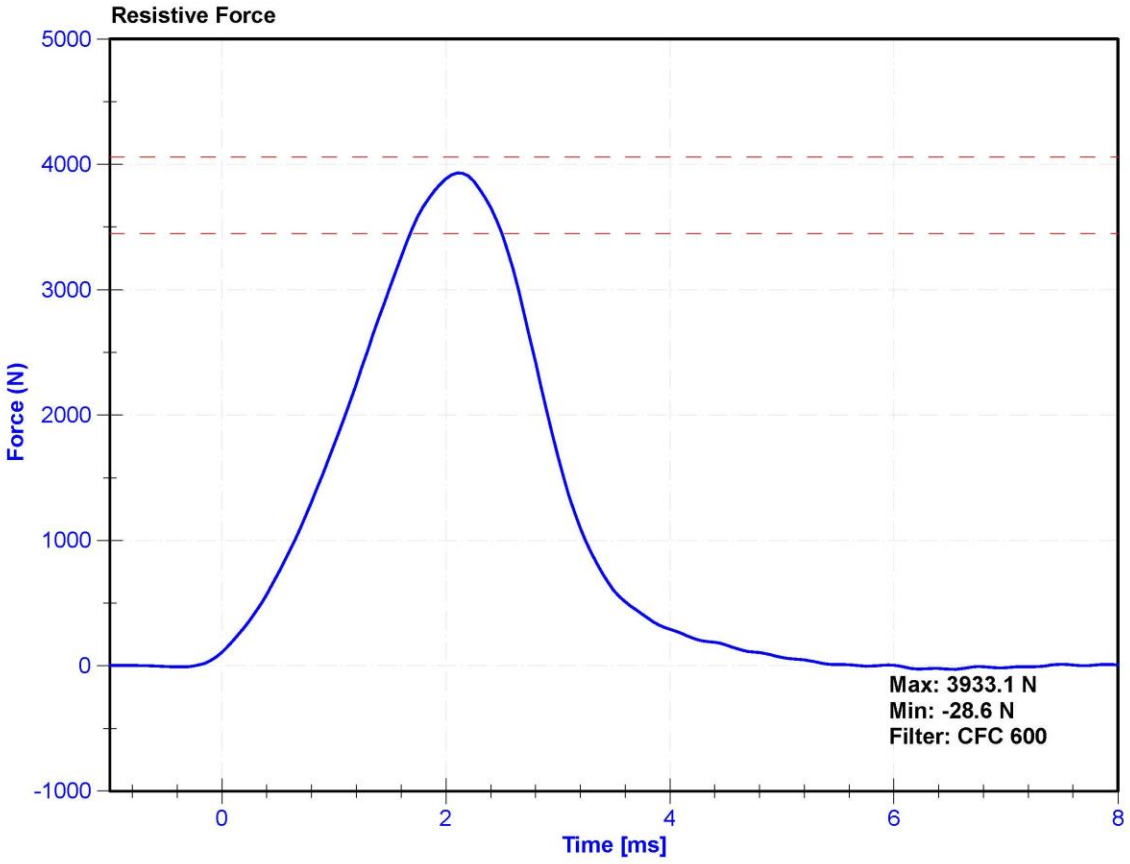
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K.Brogan

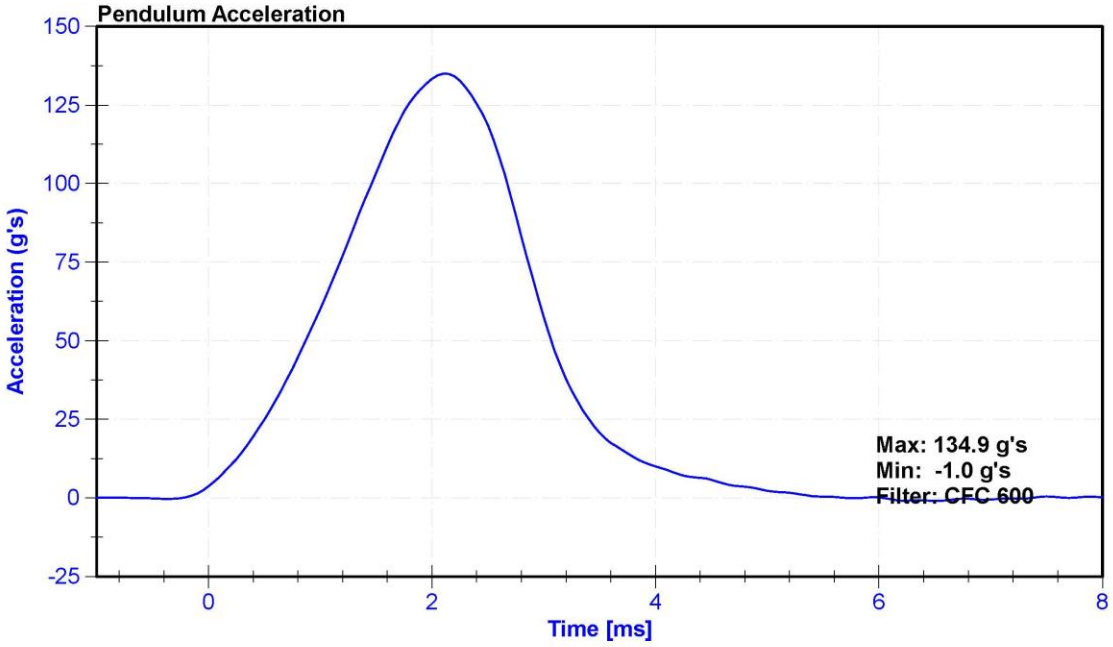
Results

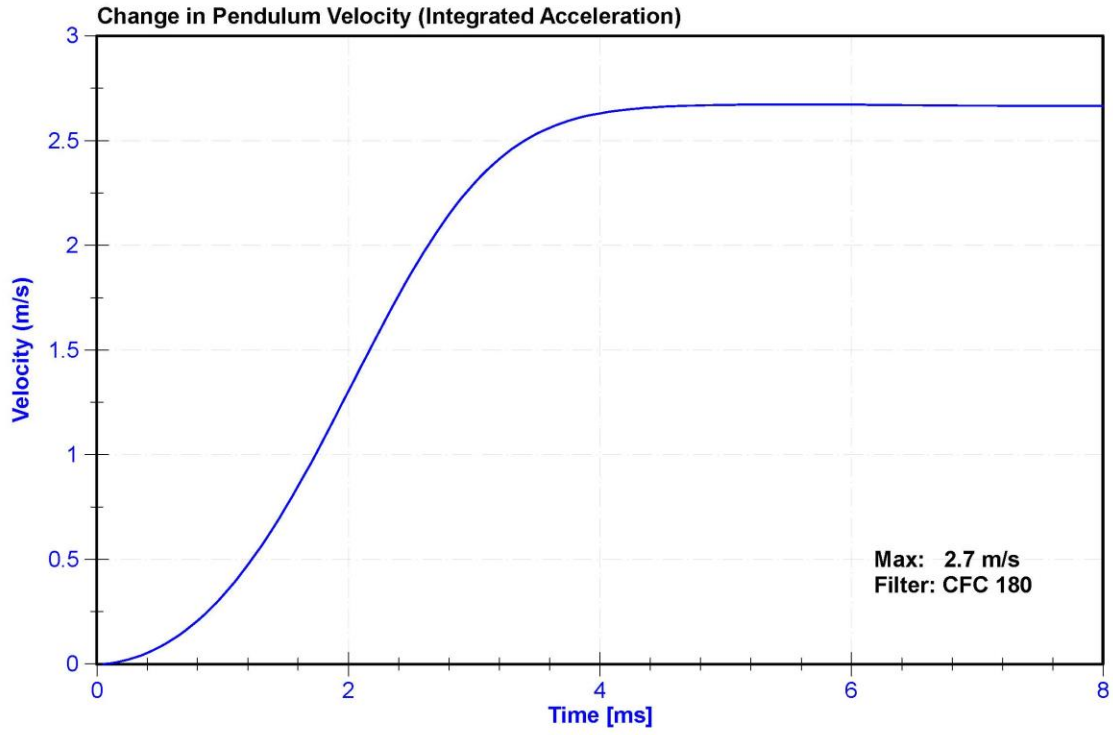
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.7	Pass
Humidity	10	70	%	57.0	Pass
Velocity	2.07	2.13	m/s	2.126	Pass
Resistive Force	3450	4060	N	3933.1	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A279031	5/8/2020	5/8/2021




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 134.9 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: 2.7 m/s
Filter: CFC 180

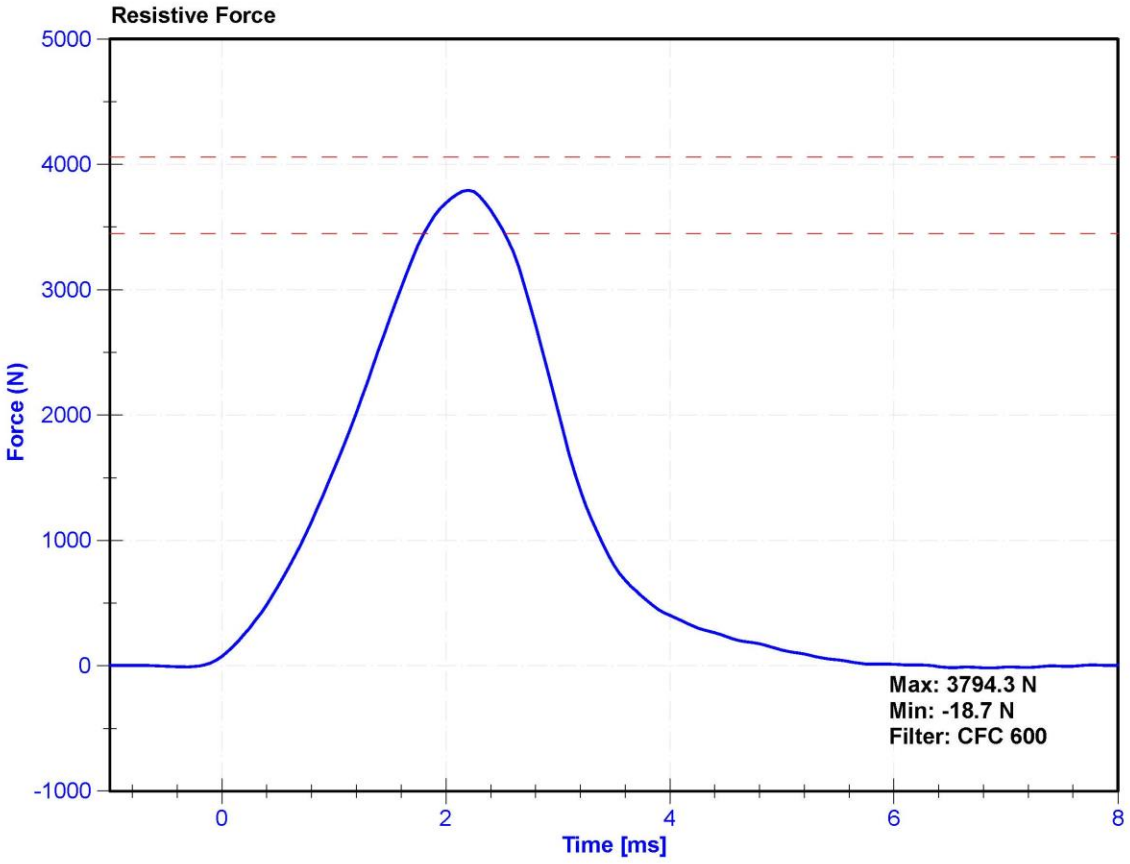
ATD Manufacturer	Denton	Test Technician	D.Reinhard
ATD Serial Number	139	Laboratory Supervisor	K. Brogan

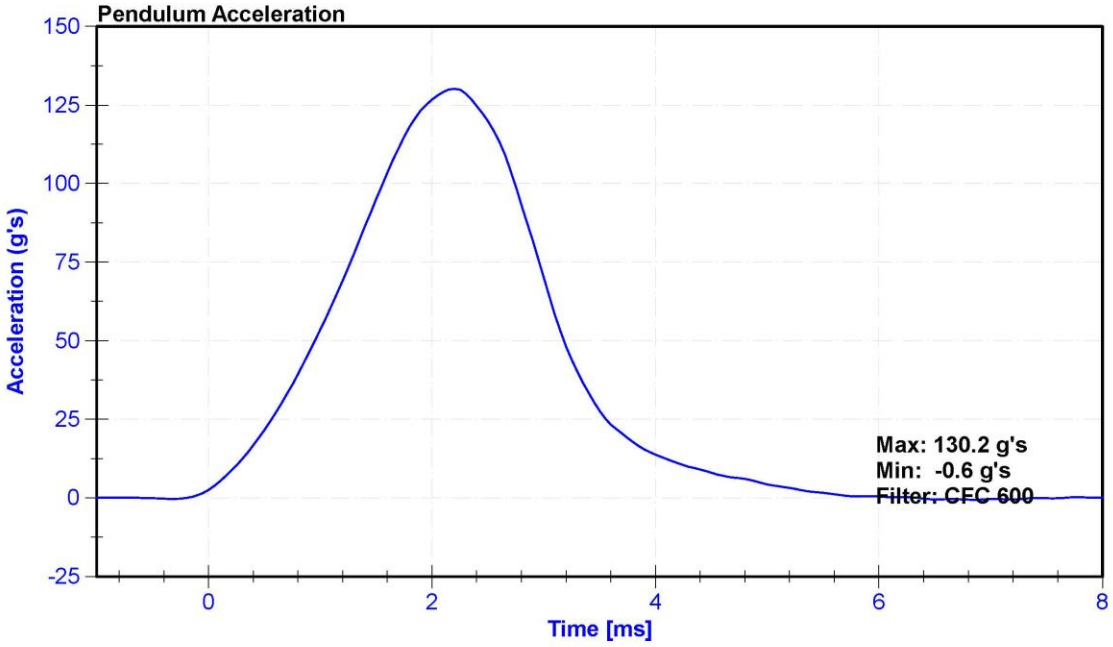
Results

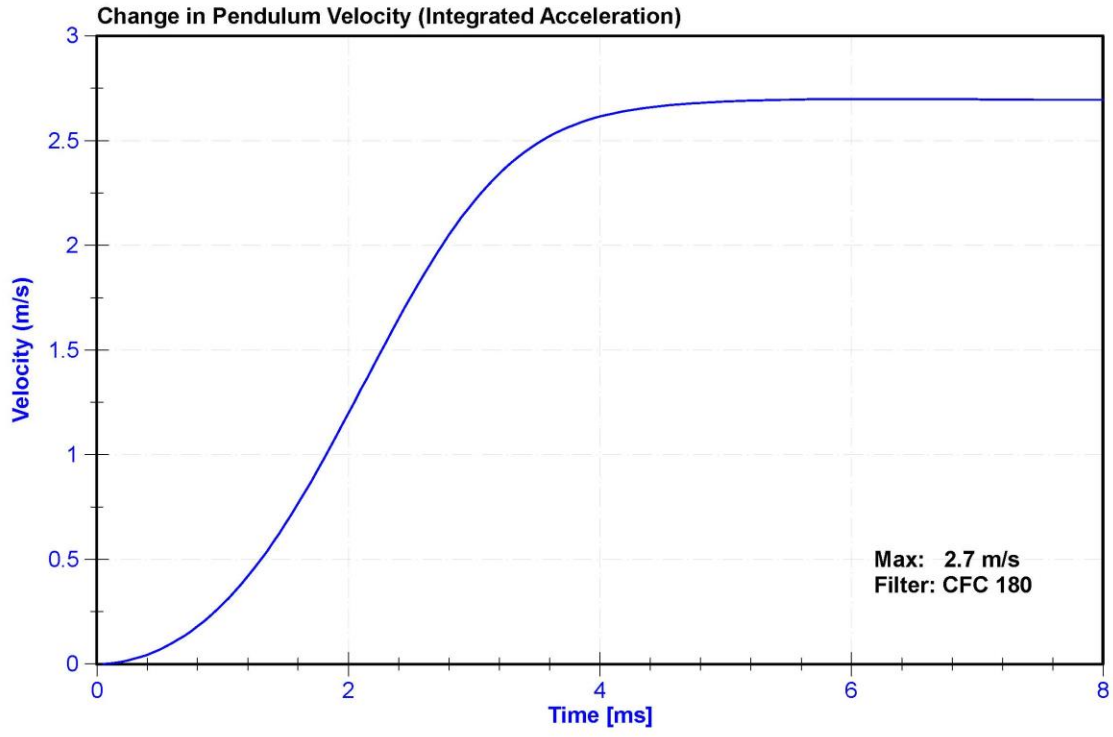
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.7	Pass
Humidity	10	70	%	57.0	Pass
Velocity	2.07	2.13	m/s	2.124	Pass
Resistive Force	3450	4060	N	3794.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A279031	5/8/2020	5/8/2021




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 130.2 g's
Min: -0.6 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: 2.7 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:		
			Serial Number	Manufacturer	Calibration Date
Head Accelerometers	Primary	X	P51681	ENDEVCO	4/17/2020
		Y	P64151	ENDEVCO	4/17/2020
		Z	P52114	ENDEVCO	4/17/2020
	Redundant	X	P58833	ENDEVCO	4/17/2020
		Y	P58905	ENDEVCO	4/17/2020
		Z	P63996	ENDEVCO	4/17/2020
Head Angular Rate Sensors		X	ARS15217	DTS PRO-8K 2KHz	2/21/2020
		Y	ARS15697	DTS PRO-18K 2KHz	2/21/2020
		Z	ARS15696	DTS PRO-18K 2KHz	2/21/2020
Upper Neck Load Cell		FX, Fy, Fz MX,MY, MZ	LC-280FxGFE	Denton	10/3/2019
Chest Accelerometers	Primary	X	AC-P51994	ENDEVCO	5/15/2020
		Y	AC-P51991	ENDEVCO	5/15/2020
		Z	AC-P49185	ENDEVCO	5/15/2020
	Redundant	X	AC-P51713	ENDEVCO	5/15/2020
		Y	AC-P68059	ENDEVCO	5/15/2020
		Z	AC-P78824	ENDEVCO	5/15/2020
Chest Potentiometer		X	DS-142	Servo	6/23/2020
Pelvis Accelerometer		X	AC-P58800	ENDEVCO	4/17/2020
		Y	AC-P52157	ENDEVCO	4/17/2020
		Z	AC-P52156	ENDEVCO	4/17/2020
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	9/25/2019
	Lower	MX, MY, FZ	LC-396Fz	Denton	9/25/2019
Tibia Load Cells – Right	Upper	MX, MY, FZ	LC-364Fz	Denton	10/3/2019
	Lower	MX, MY, FZ	36440364 FZ	Denton	9/25/2019
Foot Accelerometers - Left	Rear	X	AC-P50084	ENDEVCO	4/20/2020
	Front	Z	AC-P58779	ENDEVCO	4/20/2020
Foot Accelerometers - Right	Rear	X	AC-P51872	ENDEVCO	4/20/2020
	Front	Z	AC-P58893	ENDEVCO	4/20/2020
Seat belt Load Cells	Lap		NA	NA	NA
	Shoulder		NA	NA	NA

Table 2 – Front Passenger Dummy Instrumentation

Instrumentation		Axis/Location	Hybrid III 5th S/N:		
			Serial Number	Manufacturer	Calibration Date
Head Accelerometers	Primary	X	AC-P58780	ENDEVCO	4/17/2020
		Y	AC-P83320	ENDEVCO	4/17/2020
		Z	AC-P58997	ENDEVCO	4/17/2020
	Redundant	X	AC-P58998	ENDEVCO	4/17/2020
		Y	AC-P58749	ENDEVCO	4/17/2020
		Z	AC-P71292	ENDEVCO	4/17/2020
Head Angular Rate Sensors		X	ARS15684	DTS PRO-18K 2KHz	2/21/2020
		Y	ARS15691	DTS PRO-18K 2KHz	2/21/2020
		Z	ARS15220	DTS PRO-8K 2KHz	2/21/2020
Upper Neck Load Cell		FX, Fy, Fz MX,MY, MZ	LC-1916Fx	Denton	10/3/2019
Chest Accelerometers	Primary	X	AC-P51965	ENDEVCO	4/15/2020
		Y	AC-P23904	ENDEVCO	4/15/2020
		Z	AC-P50062	ENDEVCO	4/15/2020
	Redundant	X	AC-P52007	ENDEVCO	4/15/2020
		Y	AC-P51259	ENDEVCO	4/15/2020
		Z	AC-P58981	ENDEVCO	4/14/2020
Chest Potentiometer		X	DS-503	SERVO	8/3/2020
Pelvis Accelerometer		X	AC-P58912	ENDEVCO	4/14/2020
		Y	AC-P51220	ENDEVCO	4/14/2020
		Z	AC-P82759	ENDEVCO	4/14/2020
Femur Load Cells - Left	Primary	Z	LC-118Fz1	Denton	10/3/2019
	Redundant	Z	LC-118Fz2	Denton	10/3/2019
Femur Load Cells - Right	Primary	Z	LC-117Fz1	Denton	10/3/2019
	Redundant	Z	LC-117Fz2	Denton	10/3/2019
Tibia Load Cells - Left	Upper	MX, MY, FZ	36430362-FZ	Denton	10/3/2019
	Lower	MX, MY, FZ	36440674-FZ	Denton	10/3/2019
Tibia Load Cells – Right	Upper	MX, MY, FZ	36430486-FX	Denton	10/3/2019
	Lower	MX, MY, FZ	36440495-FZ	Denton	10/3/2019
Foot Accelerometers - Left	Rear	X	AC-P82750	ENDEVCO	5/19/2020
	Front	Z	AC-P64006	ENDEVCO	4/15/2020
Foot Accelerometers - Right	Rear	X	AC-P78669	ENDEVCO	4/15/2020
	Front	Z	AC-P52054	ENDEVCO	4/15/2020
Seat belt Load Cells	Lap		NA	NA	NA
	Shoulder		NA	NA	NA

Table 3 – Vehicle Instrumentation

Instrumentation			Axis	Serial Number	Manufacturer	Calibration Date
Crossmember/Rear Seat Accelerometers	Left	Primary	X	A280965	MSI 1201-1000	5/5/2020
			Z	A315882	MSI 1201-1000	5/1/2020
		Redundant	X	A281003	MSI 1201-1000	5/6/2020
	Right	Primary	X	A315101	MSI 1201-1000	3/30/2020
			Z	A315998	MSI 1201-1000	3/31/2020
		Redundant	X	A315125	MSI 1201-1000	4/1/2020
Engine Accelerometers	Top		X	A315798	MSI 1201-1000	3/31/2020
	Bottom		X	A315738	MSI 1201-1000	3/30/2020