REPORT NUMBER: NCAP-CAL-20-004

NEW CAR ASSESSMENT PROGRAM (NCAP)
FRONTAL BARRIER IMPACT TEST

General Motors LLC
2020 Chevrolet Malibu
Four Door Sedan

NHTSA No: M20200110

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

January 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: Vanessa Hansen Date: January 6, 2020
Vanessa Hansen, Operations Manager

Approved by: Edward Dutton Date: January 6, 2020
Edward Dutton, Director

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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9. Performing Organization Name and Address Calspan Corporation Transportation Test Operations P.O. Box 400 Buffalo, New York 104625		***10. Work Unit No.*** ***11. Contract or Grant No.*** 693JJ919D000005
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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 Chevrolet Malibu four door sedan in accordance with the specifications of the Office of Crashworthiness Standards Laboratory Procedure for NCAP Full Frontal Rigid Barrier Impact Testing. This test was conducted to obtain data related to FMVSS Nos. 208, 212, 219 (partial), 301, and 305 performance. The test was conducted at Calspan Corporation's Transportation Test Operations facility in Buffalo, New York on November 18, 2019.

The impact velocity of the vehicle was 56.24 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 457 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. 140)	
		Threshold	Result	Threshold	Result
Head Injury Criteria (HIC_{15})		700	172.315	700	272.275
Maximum Chest Compression	mm	63	-24.293	52	-16.568
Nij		1	0.184	1	0.357
Neck Tension	N	4,170	962.666	2,620	751.235
Neck Compression	N	4,000	-131.176	2,520	-113.578
Left Femur Force	N	10,008	-1122.665	6,805	-720.042
Right Femur Force	N	10,008	-1362.295	6,805	-1032.632

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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 Chevrolet Malibu four door sedan at a velocity of 56.24 km/h. The test was performed at Calspan Corporation's Transportation Test Operations facility in Buffalo, New York on November 18, 2019. Pre- and post-test photographs of the vehicle and dummies to document the test can be found in Appendix A. One real-time camera and 16 high-speed cameras were used to document the frontal barrier impact event. Camera locations and other pertinent camera information can be found in Data Sheet 6 of this report.

One Part 572E, 50th percentile male anthropomorphic test device (ATD), was placed in the driver seating position and one Part 572O 5th percentile female ATD was placed in the right-front passenger seating position according to dummy placement instructions specified in the Laboratory Procedure for NCAP Full Frontal Rigid Barrier Impact Testing. Both ATDs were fully instrumented with head, chest and pelvis tri-axial accelerometers, chest displacement potentiometers, upper neck transducers, femur load cells, and lower leg instrumentation. Seat belt load cells were installed on the driver's and passenger's lap and shoulder belts to measure dummy torso and pelvic section loading. The driver (position 1) ATD (Serial No. 142) and the right-front passenger (position 2) ATD (Serial No. 140) 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 457 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, side header 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 knee airbag.

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})	172.315	0.184	962.666	-131.176	40.184	-24.293	-1122.665	-1362.295
Passenger (5^{th})	272.275	0.357	751.235	-113.578	37.012	-16.568	-720.042	-1032.632

GENERAL COMMENTS:

1. P1 (Driver) serial number - 142
2. P2 (Passenger) serial number - 140

Data Anomalies:

- Barrier F-14 FX has QUESTIONABLE SPIKES THROUGHOUT
- Barrier F-14 MY has QUESTIONABLE SPIKES THROUGHOUT
- Barrier F-14 MZ has QUESTIONABLE SPIKES THROUGHOUT
- Barrier H-11 FX has QUESTIONABLE SPIKES THROUGHOUT
- Barrier H-11 MY has QUESTIONABLE SPIKES THROUGHOUT
- Barrier H-11 MZ has QUESTIONABLE SPIKES THROUGHOUT
- Passenger Left Upper Tibia Y Moment has QUESTIONABLE SPIKES PRESENT IN DATA
- Passenger Left Upper Tibia Z Force has QUESTIONABLE SPIKES PRESENT IN DATA
- The correct NHTSA Number is M20200110. All Pre and Post Test placards have the wrong NHTSA number (M20190110).

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 Chevrolet Malibu four door sedan
NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test
Test Date: 11/18/2019

TEST VEHICLE INFORMATION AND OPTIONS

NHTSA No.	M20200110
Model Year	2020
Make	Chevrolet
Model	Malibu
Body Style	Four Door Sedan
VIN	1G1ZB5STXLF009126
Body Color	Gray
Odometer Reading (km /mi)	9 mi
Engine Displacement (L)	1.5
Type / No. Cylinders	I4
Engine Placement	Transverse
Transmission Type	Automatic
Transmission Speeds	CVT
Overdrive	Yes
Final Drive	Front Wheel Drive
Roof Rack	No
Sunroof / T-Top	No
Running Boards	No
Tilt Steering Wheel	Yes
Power Seats	No
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	Yes
Driver Pretensioner	Yes
Driver Load Limiter	Yes
Front Pass. Pretensioner	Yes
Front Pass. Load Limiter	Yes
Other –	-

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

DATA FROM CERTIFICATION LABEL

Manufactured By	General Motors LLC
Date of Manufacture	07/19

GVWR (kg)	1839
GAWR Front (kg)	947
GAWR Rear (kg)	893

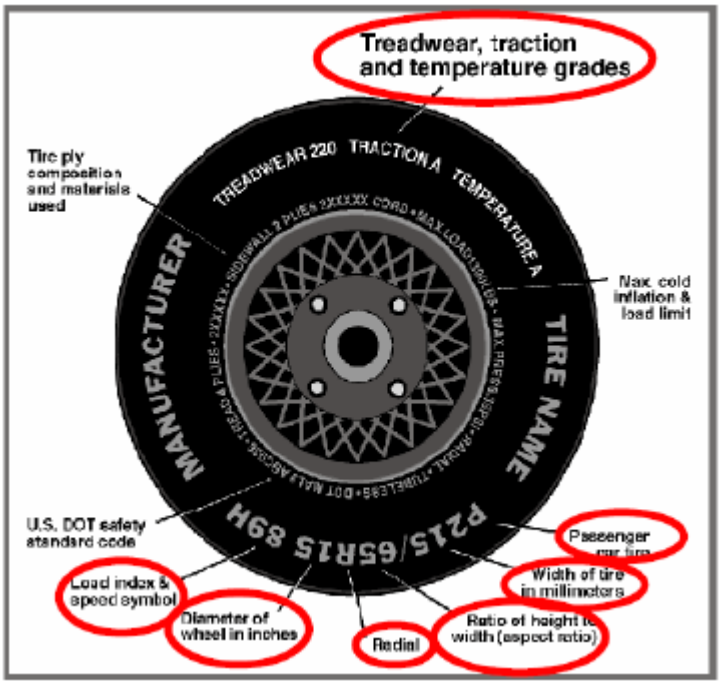
VEHICLE SEATING AND WEIGHT CAPACITY DATA

Measured Parameter	Front	Rear	Third	Total
Type of Seats	Bucket	Bench	N/A	
Number of Occupants	2	3	N/A	5
Capacity Wt. (VCW) (kg)				408
Cargo Wt. (RCLW) (kg)				67.8

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

Test Vehicle:	2020 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019

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



VEHICLE TIRE INFORMATION

Measured Parameter	Front	Rear
Maximum Tire Pressure (kPa)	300	300
Cold Pressure (kPa)	240	240
Recommended Tire Size	P205/65R16	P205/65R16
Tire Size on Vehicle	P205/65R16	P205/65R16
Tire Manufacturer	Firestone	Firestone
Tire Model	FT140	FT140
Treadwear	560	560
Traction	A	A
Temperature Grades	A	A
Tire Plies Sidewall	1 Polyester	1 Polyester
Tire Plies Body	1 Polyester, 2 Steel, 1 Nylon	1 Polyester, 2 Steel, 1 Nylon
Load Index / Speed Symbol	94H	94H
Tire Material	Polyester, Steel, Nylon	Polyester, Steel, Nylon
DOT Safety Code Left	8X84 FTO 2519	8X84 FTO 2519
DOT Safety Code Right	8X84 FTO 2519	8X84 FTO 2519

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

Test Vehicle: 2020 Chevrolet Malibu four door sedan NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test Test Date: 11/18/2019

TEST VEHICLE WEIGHTS

	Units	As Delivered Weights (UVW)			As Tested Weights (ATW)		
		Front Axle	Rear Axle	Total	Front Axle	Rear Axle	Total
Left	kg	426	306		466	369	
Right	kg	438	253		464	326	
Ratio	%	60.7	39.3		57.2	42.8	
Totals	kg	864	559	1423	930	695	1625

TARGET TEST WEIGHT CALCULATION

Measured Parameter	Units	Value	
Total Delivered Weight (UVW)	kg	1423	(A)
Weight of 1 P572E ATD & 1 P572O ATD	kg	142	(B)
Rated Cargo / Luggage Weight (RCLW)	kg	67.8	(C)
Calculated Vehicle Target Weight (TVTW)	kg	1632.8	(A+B+C)

TEST VEHICLE ATTITUDES AND CG

Condition	Units	LF	RF	LR	RR	CG (aft of front axle)
As Delivered	mm	714	720	741	748	1110.9
As Tested	mm	703	708	708	712	1209
Post-Test	mm	742	751	705	709	

GENERAL TEST VEHICLE DATA

Measurement Description	Units	Value
Total Vehicle Wheel Base	mm	2828
Total Vehicle Length at Left Side	mm	4758
Total Vehicle Length at Centerline	mm	4932
Total Vehicle Length at Right Side	mm	4758
Weight of Ballast in Cargo Area	kg	20
Weight of Vehicle Components Removed	kg	21
Amount of Stoddard Solvent in Fuel Tank	L	55.6

LIST OF COMPONENTS REMOVED TO MEET TEST WEIGHT:

Trunk carpeting, spare tire, jack, tail light

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

Test Vehicle: 2020 Chevrolet Malibu four door sedan NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test Test Date: 11/18/2019

TARGET VEHICLE STRUCTURAL MEASUREMENT

No.	Description	Pre-Test
1	Total Length	4932
2	Total Width	1831
3*	Bumper Top Height	503
4*	Bumper Bottom Height	397
5*	Longitudinal Member Top Height	534
6	Distance Between Longitudinal Members	1021
7	Longitudinal Member Width	64
8*	Engine Top Height	798
9*	Engine Bottom Height	266
10	Engine and Gearbox Width	524
11	Front Bumper-Engine Distance	622
12*	Front Shock Absorber Fixing Height	853
13*	Bonnet Leading Edge Height	808
14	Front Shock Absorber Fixing Width	1201
15	Front Bumper – Front Axle Distance	972
16	Front Axle – A Pillar Distance	560
17	A-Pillar – B-Pillar Distance	1124
18	B-Pillar – Rear Axle Distance	1141
19	B-Pillar – C-Pillar Distance	1013
20*	Roof Sill Bottom Height	1288
21*	Roof Sill Top Height	1342
22*	Floor Sill Bottom Height	310
23*	Floor Sill Top Height	349

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

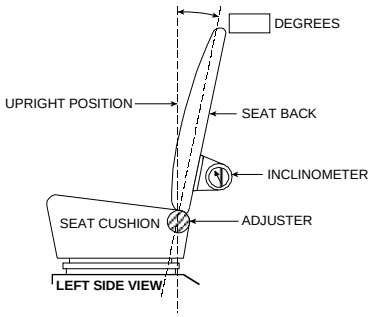
DATA SHEET NO. 2
SEAT ADJUSTMENT, FUEL SYSTEM, AND STEERING WHEEL DATA

Test Vehicle:	2020 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019

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	14.1
Passenger Seat Back Angle	17.9



FRONT SEAT ASSEMBLY

SEAT FORE / AFT POSITIONS

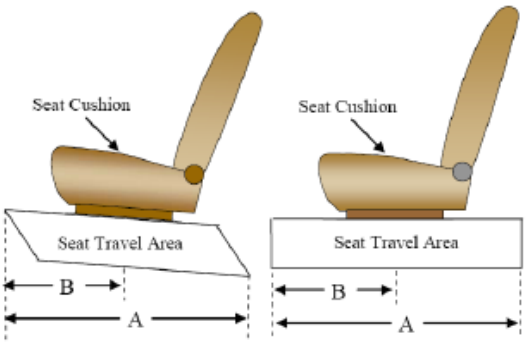
The driver's seat was positioned at the mid-point of fore/aft travel at its lowest position. The passenger's seat was positioned at the most forward position of fore/aft travel. Zero is defined as the forward most position.

Seating Position	Total Fore / Aft Travel	Placed in Position #
Driver Seat	27 (0 – 26)	10
Passenger Seat	25 (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	Fixed	Fixed
Passenger Seat	Fixed	Fixed



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

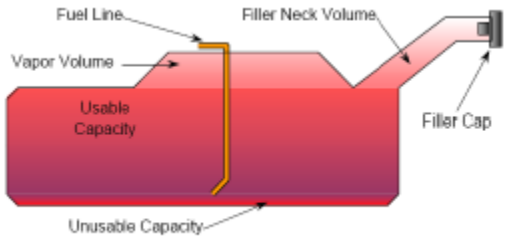
Test Vehicle: 2020 Chevrolet Malibu four door sedan
NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test
Test Date: 11/18/2019

FUEL TANK CAPACITY

Description	Liters
Usable Capacity of "Standard Tank"	59.8
Usable Capacity of "Optional Tank"	N/A
92%-94% of Usable Capacity	55 – 56.2
Actual Amount of Solvent Used	55.6
1/3 of Usable Capacity	19.7

FUEL PUMP

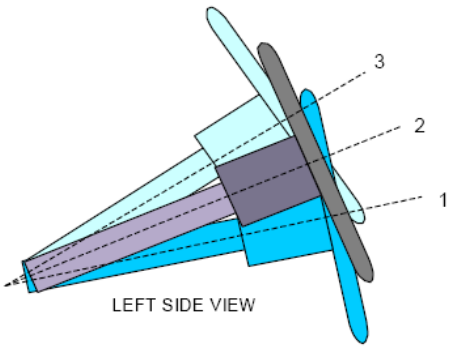
The vehicle is equipped with an electric fuel pump. The fuel filler neck is on the right side of the vehicle. The pump creates positive pressure in the fuel lines, pushing the gasoline to the engine. See form 1 for more information.



VEHICLE FUEL TANK ASSEMBLY

STEERING COLUMN ADJUSTMENT

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



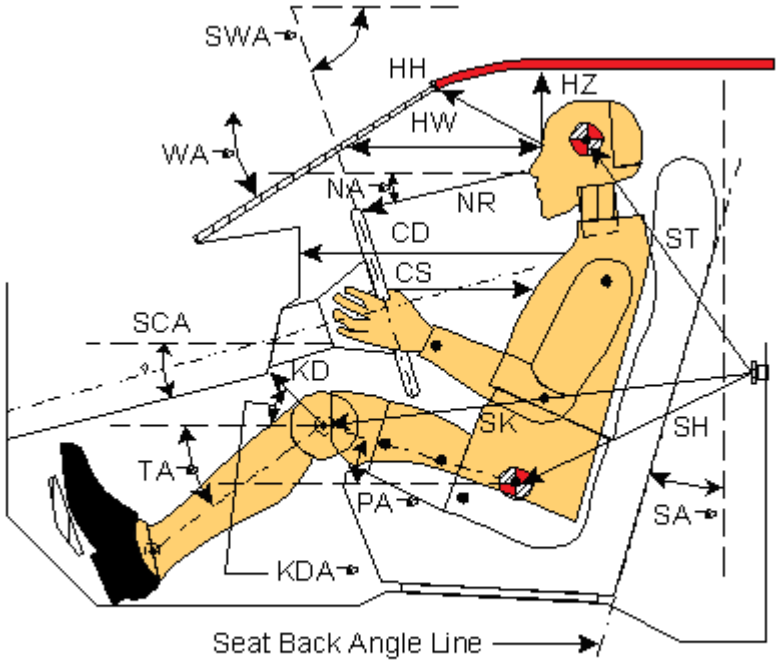
STEERING COLUMN ASSEMBLY

STEERING COLUMN POSITIONS

Description	Degrees	Fore / Aft Position (mm)
Lowermost position No. 1	19.7	
Geometric center position No. 2	21.8	
Uppermost position No. 3	23.9	
Telescoping Steering Wheel Travel		60
Test Position	21.8	30

DATA SHEET NO. 3
DUMMY LONGITUDINAL CLEARANCE DIMENSIONS

Test Vehicle: 2020 Chevrolet Malibu four door sedan
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20200110
Test Date: 11/18/2019



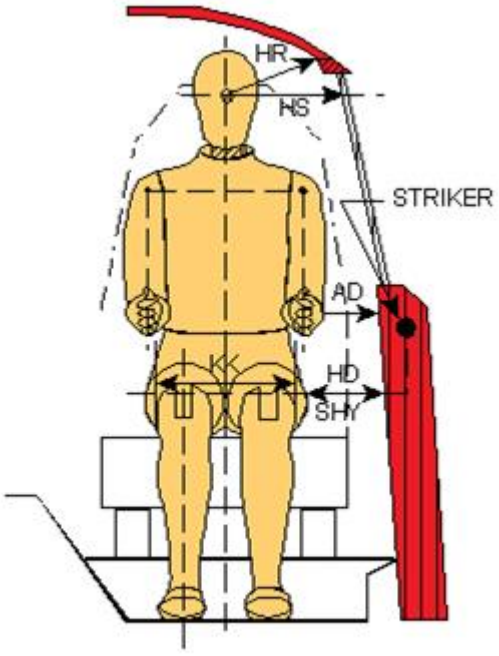
Left Side View

Code	Measurement Description	Driver (SN: 142)		Passenger (SN: 140)	
		Length (mm)	Angle (°)	Length (mm)	Angle (°)
WA°	Windshield Angle		26.0		
SWA°	Steering Wheel Angle		21.6		
SCA°	Steering Column Angle		68.4		
SA°	Seat Back Angle (on headrest post)		13.5		17.9
HZ	Head to Roof (Z)	239	90	253	90
HH	Head to Header	426	25.2	360	44.1
HW	Head to Windshield	779	0	781	0
NR	Nose to Rim / Dash	458	4.8	516	18.7
CD	Chest to Dash	579		456	
CS	Chest to Steering Hub	377	1.6		
RA	Rim to Abdomen	262	0		
KDL	Left Knee to Dash	245	26.2	157	17.8
KDR	Right Knee to Dash	224	21.8	154	24.1
PA°	Pelvic Angle		24.2		21.6
TA°	Tibia Angle		23		40.1
SK	Striker to Knee	547	11.8	644	8.8
ST	Striker to Head	482	88.3	426	62.4
SH	Striker to H-Point	253	50.2	392	28

DATA SHEET NO. 4
DUMMY LATERAL CLEARANCE DIMENSIONS

Test Vehicle: 2020 Chevrolet Malibu four door sedan
Test Program: NCAP Frontal Barrier Impact Test

NHTSA No.: M20200110
Test Date: 11/18/2019

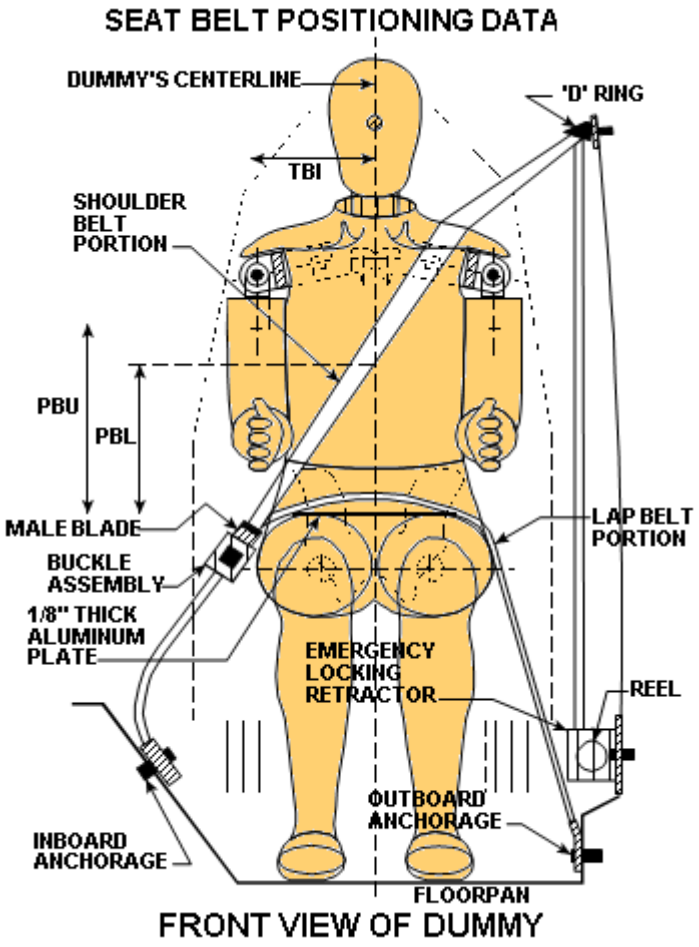


Front View

Code	Description	Driver (mm)	Passenger (mm)
AD	Arm to Door	141	80
HD	H-Point to Door	152	168
HR	Head to Side Header	226	274
HS	Head to Side Window	364	404
KK	Knee to Knee	330	220
SHY	Striker to H-Point (Y Direction)	245	260
AA	Ankle to Ankle	338	165

DATA SHEET NO. 5
SEAT BELT POSITIONING DATA

Test Vehicle:	2020 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019



SEAT BELT POSITIONING MEASUREMENTS

Measurement Description	Units	Driver	Passenger
PBU — Top surface of reference to belt upper edge	mm	355	275
PBL — Top surface of reference to belt lower edge	mm	280	200

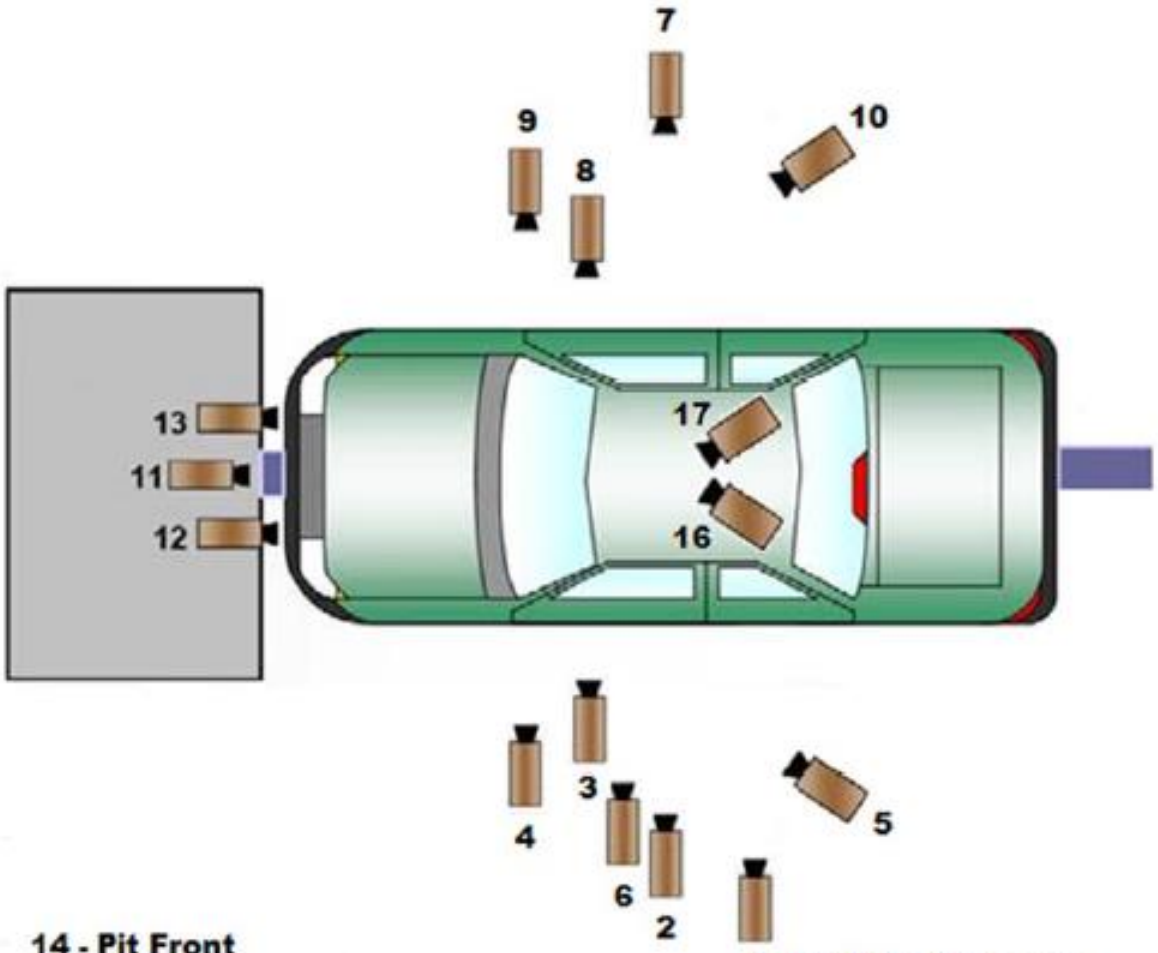
BELT LENGTH DATA

Measurement Description	Units	Driver	Passenger
Shoulder belt length as measured on ATD	mm	804	873
Lap Belt Length as measured on ATD	mm	540	620
Remainder of belt on reel	mm	1056	907
Total belt length for continuous webbing systems	mm	2400	2400

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

Test Vehicle:	2020 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019

CAMERA POSITIONS FOR FRONTAL IMPACTS



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

Test Vehicle: 2020 Chevrolet Malibu four door sedan NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test Test Date: 11/18/2019

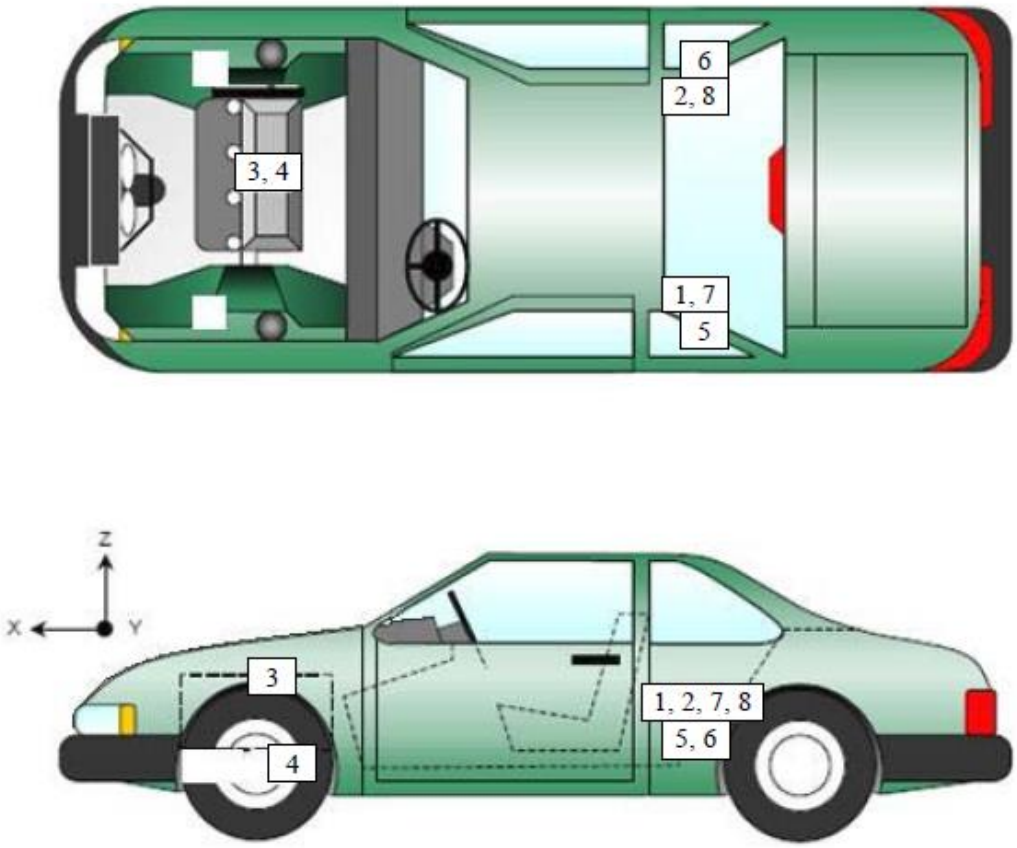
CAMERA LOCATIONS

No.	Camera View	Location (mm)			Lens (mm)	Speed (fps)
		X	Y	Z		
1	Real-Time Left Overall	-	-	-		60
2	Left Overall	-2926	-7740	-1352	24	1000
3	Driver Close-Up	-3391	-7162	-1436	50	1000
4	Left Front Half	-3293	-7140	-1300	28	1000
5	Left Angle	-5880	-4044	-1659	50	1000
6	Steering Column	-3371	-6896	-1827	50	1000
7	Right Overall	-3093	7329	-1285	24	1000
8	Passenger Close-Up	-2728	6824	-1453	50	1000
9	Right Front Half	-2258	6245	-1302	28	1000
10	Right Angle	-6063	4067	-1702	50	1000
11	Windshield	1179	0	-3471	12.5	1000
12	Driver Windshield	990	-356	-2280	25	1000
13	Passenger Windshield	990	356	-2280	25	1000
14	Pit Front	-521	0	2227	12.5	1000
15	Pit Rear	-2485	0	2258	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 Chevrolet Malibu four door sedan
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20200110
Test Date: 11/18/2019



VEHICLE ACCELEROMETER PRE-TEST LOCATIONS

No.	Accelerometer Location	Measurements (mm)		
		X	Y	Z
1	Left Rear Accelerometer – X Direction	2009	-354	45
2	Right Rear Accelerometer – X Direction	2009	332	46
3	Engine Top X	4273	110	-327
4	Engine Bottom X	4090	111	283
5	Left Rear Accelerometer – Z Direction	2009	-354	45
6	Right Rear Accelerometer – Z Direction	2009	332	46
7	Left Rear Accelerometer – X Direction Redundant	2008	-374	46
8	Right Rear Accelerometer – X Direction Redundant	2009	342	51

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

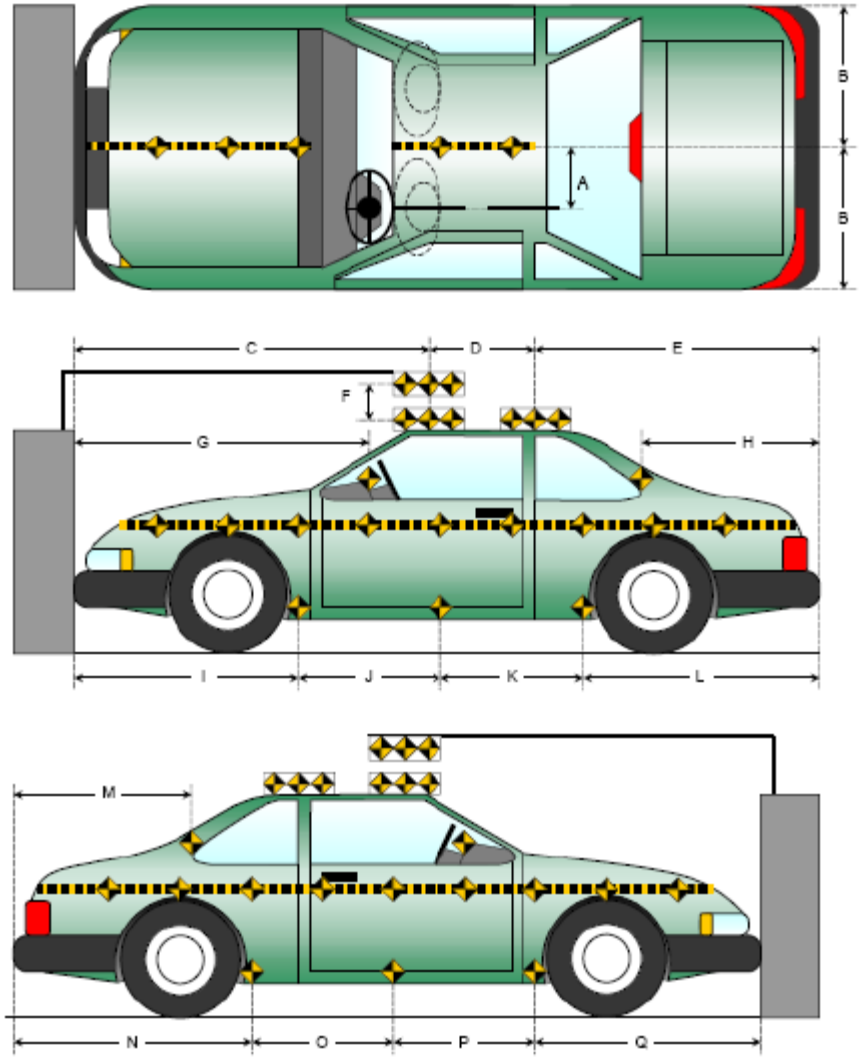
DATA SHEET NO. 8
PHOTOGRAPHIC REFERENCE TARGET LOCATIONS

Test Vehicle: 2020 Chevrolet Malibu four door sedan
Test Program: NCAP Frontal Barrier Impact Test

NHTSA No.: M20200110
Test Date: 11/18/2019

Item	Value
A	384
B	915
C	2722
D	610
E	1599
F	195
G	1848
H	1180
I	1414
J	1068
K	870
L	1579
M	1174
N	1579
O	871
P	1067
Q	1416

All units in millimeters



DATA SHEET NO. 9
LOAD CELL LOCATIONS ON FIXED BARRIER

Test Vehicle:	2020 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019

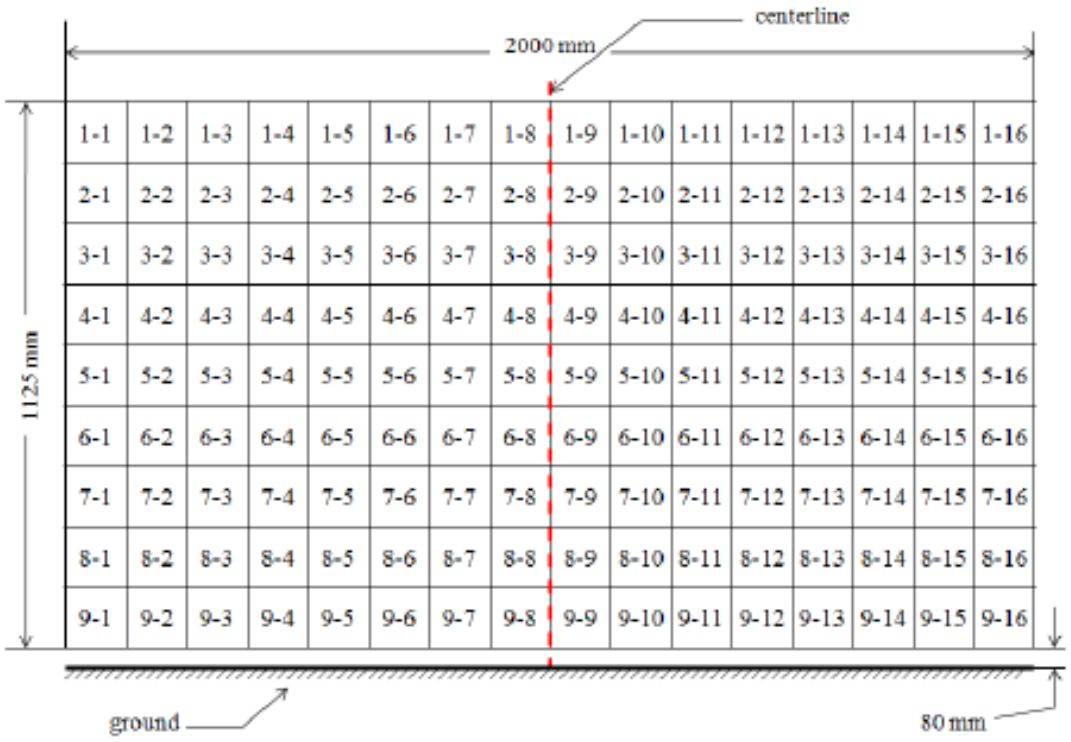


Figure 1 - Load Cell Locations on a 128-Load Cell Barrier with Plywood Height Extension*
Please note above diagram is not actual representation of load cell barrier used.

DATA SHEET NO. 10
TEST VEHICLE SUMMARY OF RESULTS

Test Vehicle: 2020 Chevrolet Malibu four door sedan NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test Test Date: 11/18/2019

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 Chevrolet Malibu four door sedan NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test Test Date: 11/18/2019

TEST DUMMY INFORMATION AND CONTACT LOCATIONS

Description	Driver	Passenger
Dummy Type / Serial No.	P572E 50th Male / 142	P5720 5th Female / 140
Head Contact	Front Airbag, Side Header & Headrest	Front Airbag & Headrest
Upper Torso Contact	Front Airbag	Front Airbag
Lower Torso Contact	None	None
Left Knee Contact	Knee Airbag	Knee Airbag
Right Knee Contact	Knee Airbag	Knee Airbag

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	None
Window Damage	None
Other	Left Rear seat unlatched during impact and will not latch post impact

VEHICLE REBOUND FROM BARRIER

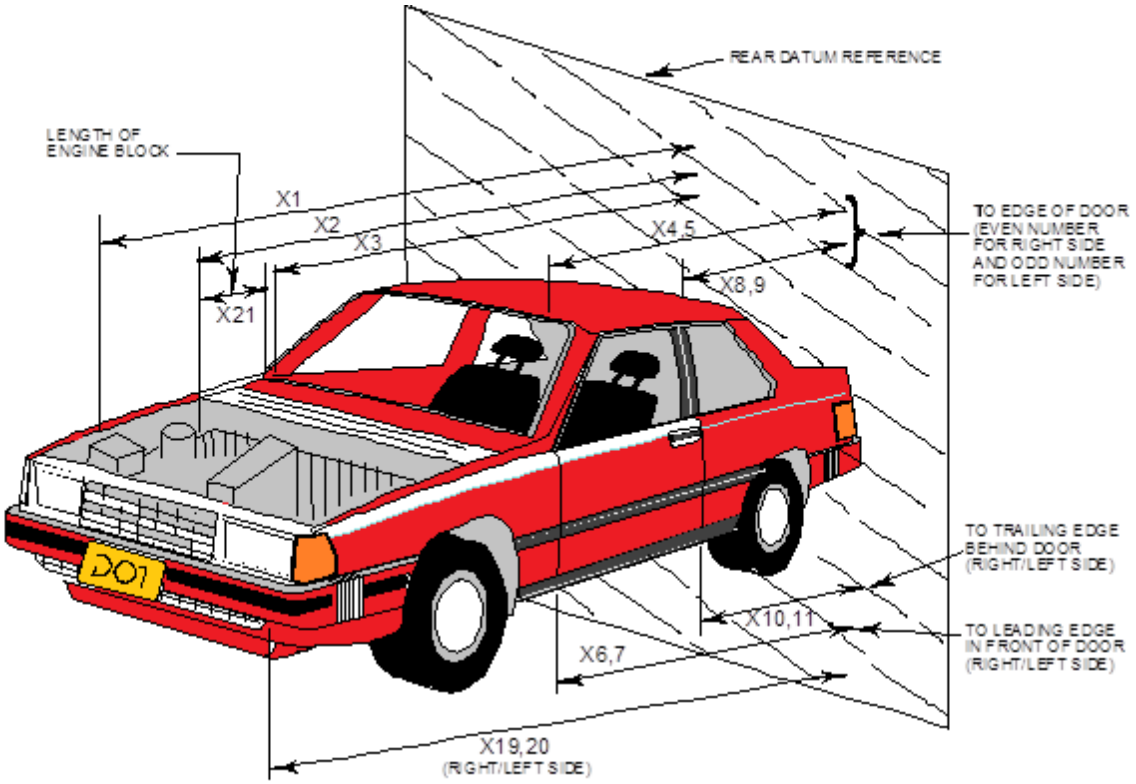
Measured Parameter	Units	Value
Left Side	mm	826
Center	mm	951
Right Side	mm	832
Average	mm	870

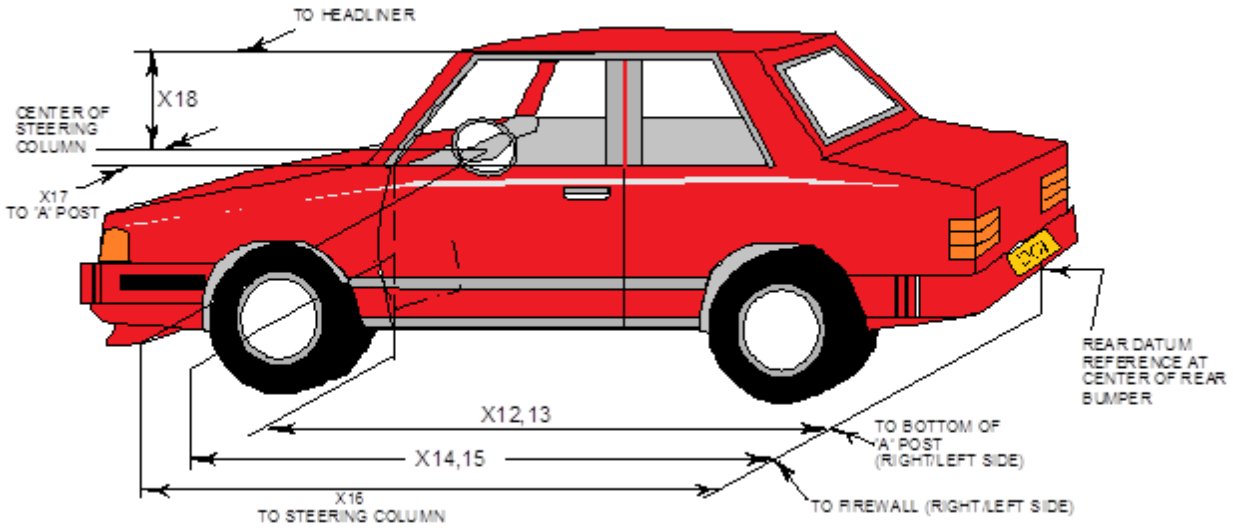
SUPPLEMENTAL RESTRAINT SYSTEM INFORMATION

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	Yes	Yes
Seat Belt Pretensioner	Yes	Yes	Yes	Yes
Seat Belt Load Limiter	Yes	Yes	Yes	Yes
Other				

DATA SHEET NO. 12
VEHICLE PROFILE MEASUREMENTS

Test Vehicle:	2020 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019





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

Test Vehicle: 2020 Chevrolet Malibu four door sedan NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test Test Date: 11/18/2019

No.	Measurement Description	Pre-Test	Post-Test	Difference
1	Total Length of Vehicle at Centerline	4932	4498	-434
2	Rear Surface of Vehicle (RSOV) to Front of Engine	4310	4061	-249
3	RSOV to Firewall	3834	3830	-4
4	RSOV to Upper Leading Edge of Right Door	3461	3459	-2
5	RSOV to Upper Leading Edge of Left Door	3463	3464	1
6	RSOV to Lower Leading Edge of Right Door	3422	3425	3
7	RSOV to Lower Leading Edge of Left Door	3423	3425	2
8	RSOV to Upper Trailing Edge of Right Door	2284	2284	0
9	RSOV to Upper Trailing Edge of Left Door	2284	2284	0
10	RSOV to Lower Trailing Edge of Right Door	2300	2303	3
11	RSOV to Lower Trailing Edge of Left Door	2299	2304	5
12	RSOV to Bottom of “A” Post of Right Side	3437	3435	-2
13	RSOV to Bottom of “A” Post of Left Side	3439	3438	-1
14	RSOV to Firewall, Right Side	3878	3870	-8
15	RSOV to Firewall, Left Side	3875	3855	-20
16	RSOV to Steering Column	2922	2990	68
17	Center of Steering Column to “A” Post	295	295	0
18	Center of Steering Column to Headliner	419	440	21
19	RSOV to Right Side of Front Bumper	4811	4386	-425
20	RSOV to Left Side of Front Bumper	4813	4512	-301
21	Length of Engine Block	256	256	0
RD	RSOV to Right Side of Dash Panel	3120	3120	0
CD	RSOV to Center of Dash Panel	3003	3004	1
LD	RSOV to Left Side of Dash Panel	3122	3121	-1

All Dimensions in mm

DATA SHEET NO. 13
ACCIDENT INVESTIGATION DIVISION DATA

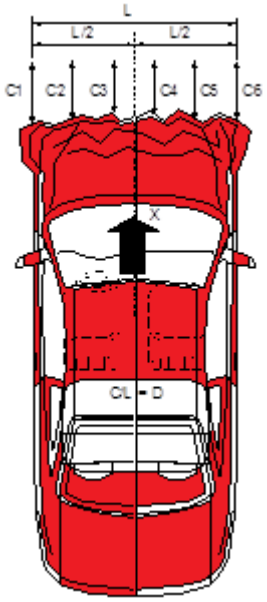
Test Vehicle:	2020 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019

VEHICLE INFORMATION

VIN:	1G1ZB5STXLF009126	Wheelbase (mm):	2828
Vehicle Size Category:	Passenger Car	Test Weight (kg):	1625

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):	56.24
Velocity Change (km/h):	65.23
Time of Separation (ms):	130



CRUSH PROFILE

Collision Deformation Classification:	12FDEW2
Midpoint of Damage:	C4
Damage Region Length (mm):	1419
Impact Mode:	Frontal

No.	Measurement Description	Units	Pre-Test	Post-Test	Difference
C1	Crush Zone 1 at Left Side	mm	4695	4478	217
C2	Crush Zone 2 at Left Side	mm	4834	4425	409
C3	Crush Zone 3 at Left Side	mm	4889	4444	445
C4	Crush Zone 4 at Right Side	mm	4888	4431	457
C5	Crush Zone 5 at Right Side	mm	4848	4399	449
C6	Crush Zone 6 at Right Side	mm	4685	4378	307
L	C1 to C6	mm	1419	1544	-125

DATA SHEET NO. 14
VEHICLE INTRUSION MEASUREMENTS

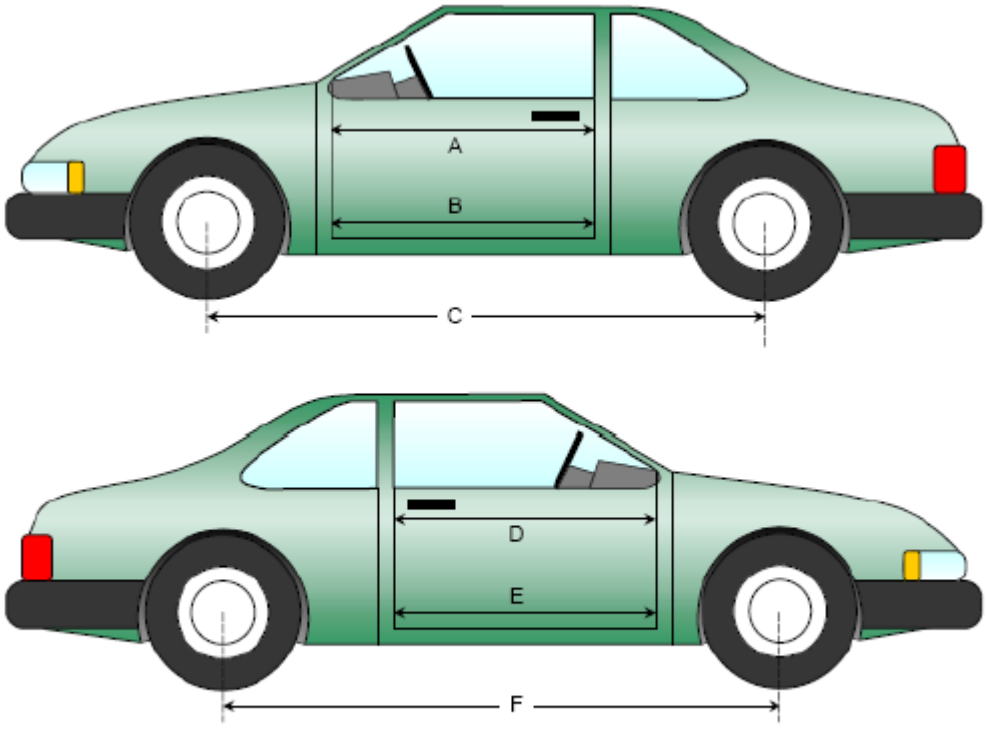
Test Vehicle: 2020 Chevrolet Malibu four door sedan
NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test
Test Date: 11/18/2019

DOOR OPENING WIDTH

Item	Description	Units	Pre-Test	Post-Test	Difference
A	Left Side Upper	mm	1048	1047	-1
B	Left Side Lower	mm	927	927	0
D	Right Side Upper	mm	1049	1049	0
E	Right Side Lower	mm	895	895	0

WHEELBASE MEASUREMENTS

Item	Description	Units	Pre-Test	Post-Test	Difference
C	Left Side Wheelbase	mm	2828	2758	-70
F	Right Side Wheelbase	mm	2828	2778	-50



Left & Right Side Views

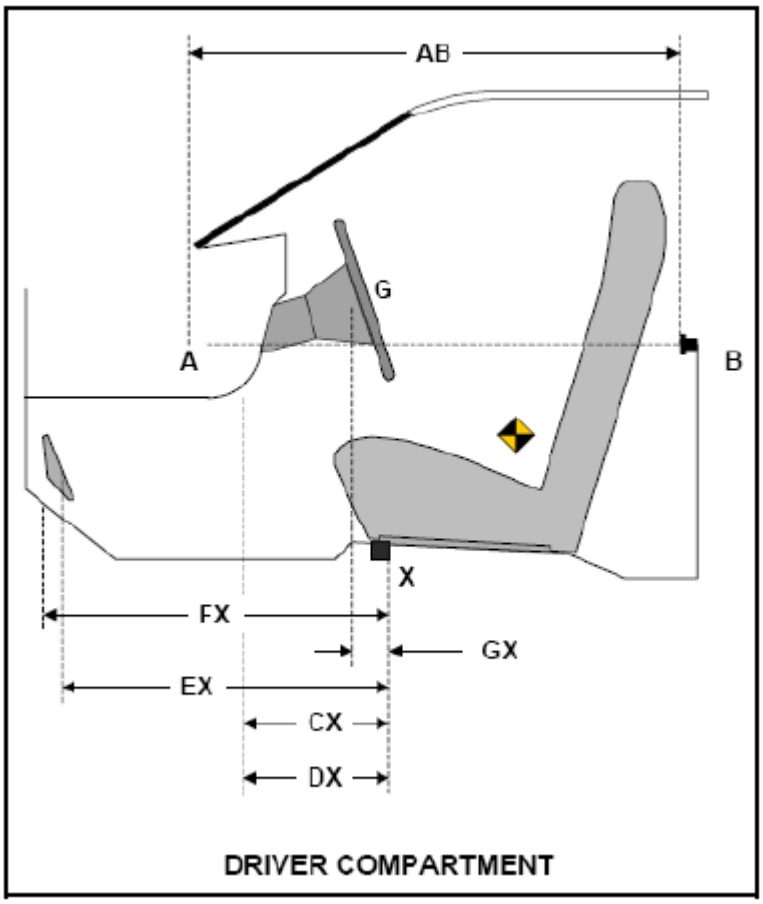
DATA SHEET NO.14 … (CONTINUED)
VEHICLE INTRUSION MEASUREMENTS

Test Vehicle: 2020 Chevrolet Malibu four door sedan NHTSA No.: M20200110
Test Program: NCAP Frontal Barrier Impact Test Test Date: 11/18/2019

DRIVER COMPARTMENT INTRUSION

Item	Description	Units	Pre-Test	Post-Test	Difference
AB	Door Opening (Inside Window Jam)	mm	768	767	-1
CX	Left Knee Bolster to X	mm	326	326	0
DX	Right Knee Bolster to X	mm	317	319	2
EX	Brake Pedal to X	mm	591	555	-36
FX	Foot Rest to X	mm	607	600	-7
GX	Center of Steering Column Wheel Hub to X	mm	90	158	68

X = Front of Seat Track (Stationary)



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

Test Vehicle:	2020 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019

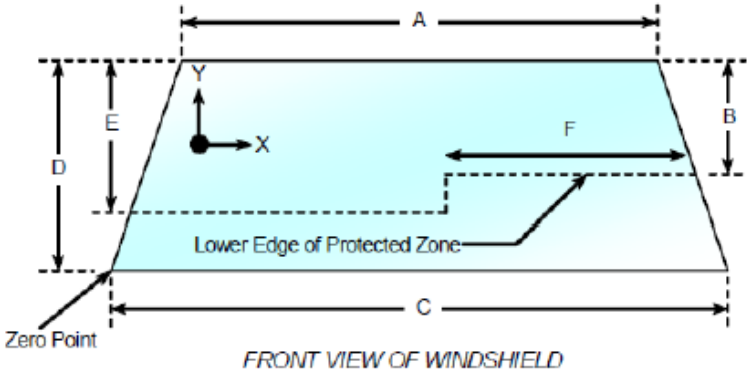
Windshield Mounting Details: A 0.8 mm trim surrounds the top and side of windshield while a plastic shroud is on the bottom.

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	2235	2235	100
Right Side	2235	2235	100
Total	4470	4470	100



FRONT VIEW OF WINDSHIELD

Item	Units	Value
A	mm	1277
B	mm	581
C	mm	1563
D	mm	815
E	mm	587
F	mm	574

AREAS OF PROTECTED ZONE FAILURES

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

X	Y

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

X	Y

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

Test Vehicle:	2020 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019

FMVSS 301 FUEL SYSTEM INTEGRITY POST IMPACT DATA

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

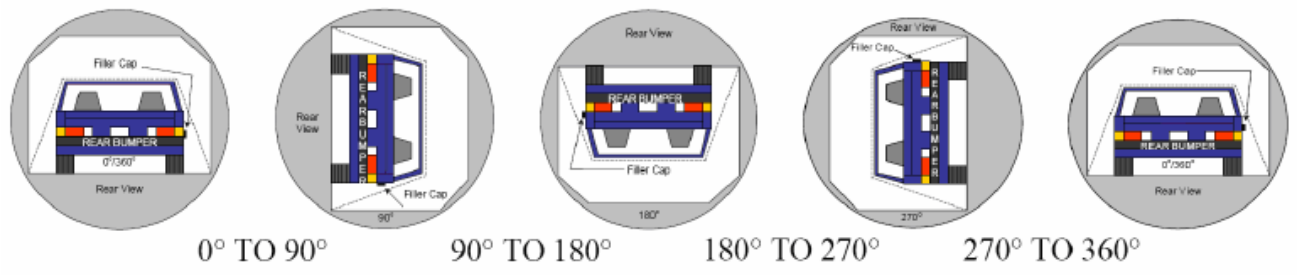
STODDARD SOLVENT SPILLAGE MEASUREMENTS

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

D. Spillage: No Spillage Occurred

DATA SHEET NO. 16
FMVSS 301 STATIC ROLLOVER RESULTS

Test Vehicle: 2020 Chevrolet Malibu four door sedan
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20200110
Test Date: 11/18/2019



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°	64	300	364
180° to 270°	62	300	362
270° to 360°	68	300	368

FMVSS 301 SPILLAGE TABLE

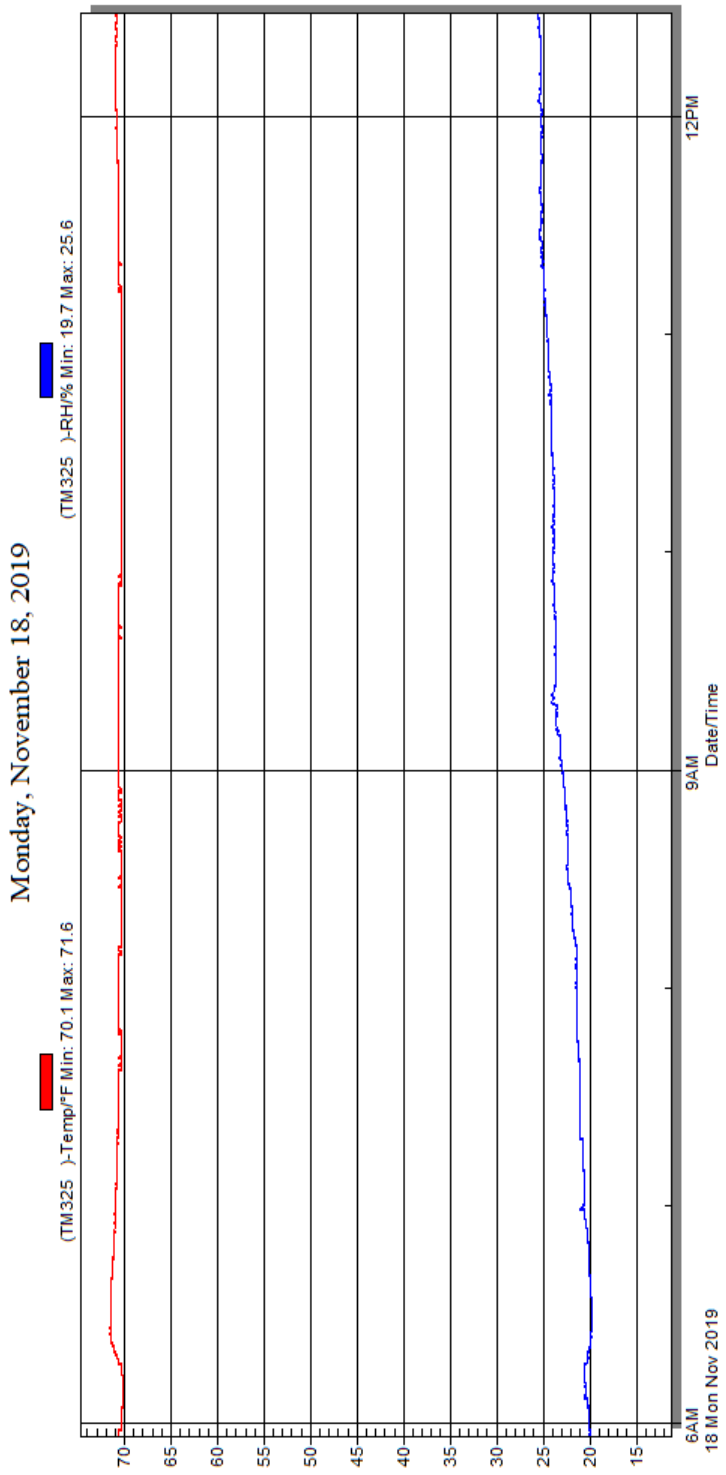
Test Phase	First 5 Minutes	Sixth Minute	Seventh Minute	Eighth Minute
0° to 90°	0	0	0	
90° to 180°	0	0	0	
180° to 270°	0	0	0	
270° to 360°	0	0	0	

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 Chevrolet Malibu four door sedan	NHTSA No.:	M20200110
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	11/18/2019



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

APPENDIX A

PHOTOGRAPHS

The correct NHTSA Number is M20200110. All Pre and Post Test placards have the wrong NHTSA number (M20190110).

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.*

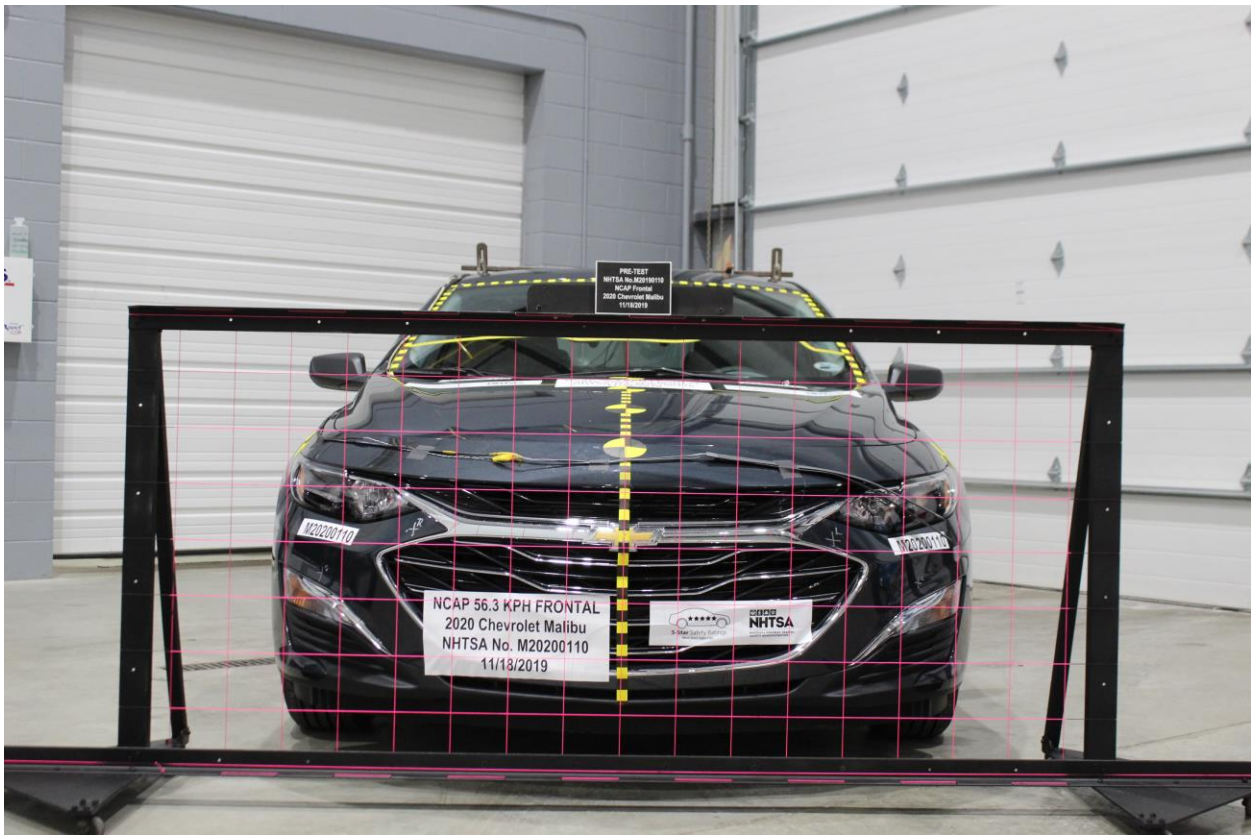


Figure A-1: Load Cell Location

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 Chevrolet Malibu Frontal As Delivered

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

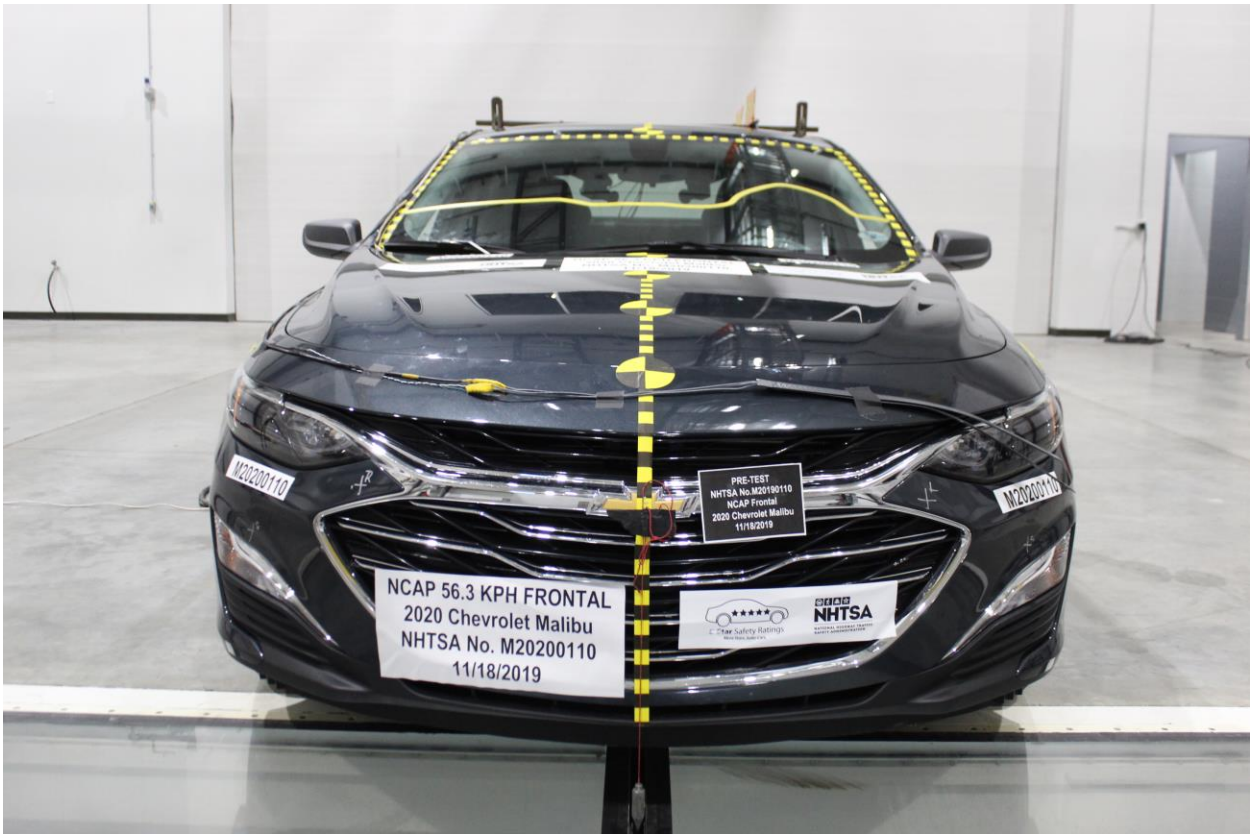


Figure A-8: Pre-Test Front View of Test Vehicle

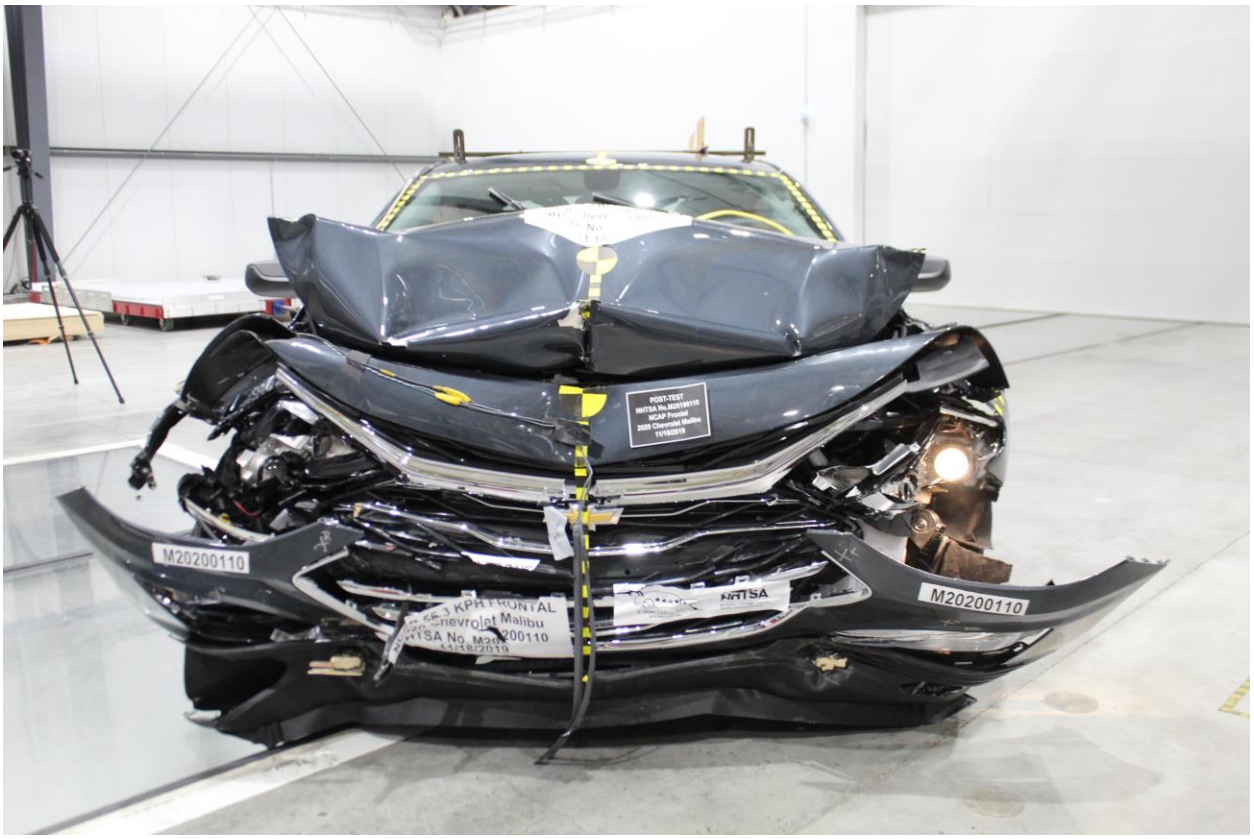


Figure A-9: Post-Test Front View of Test Vehicle

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

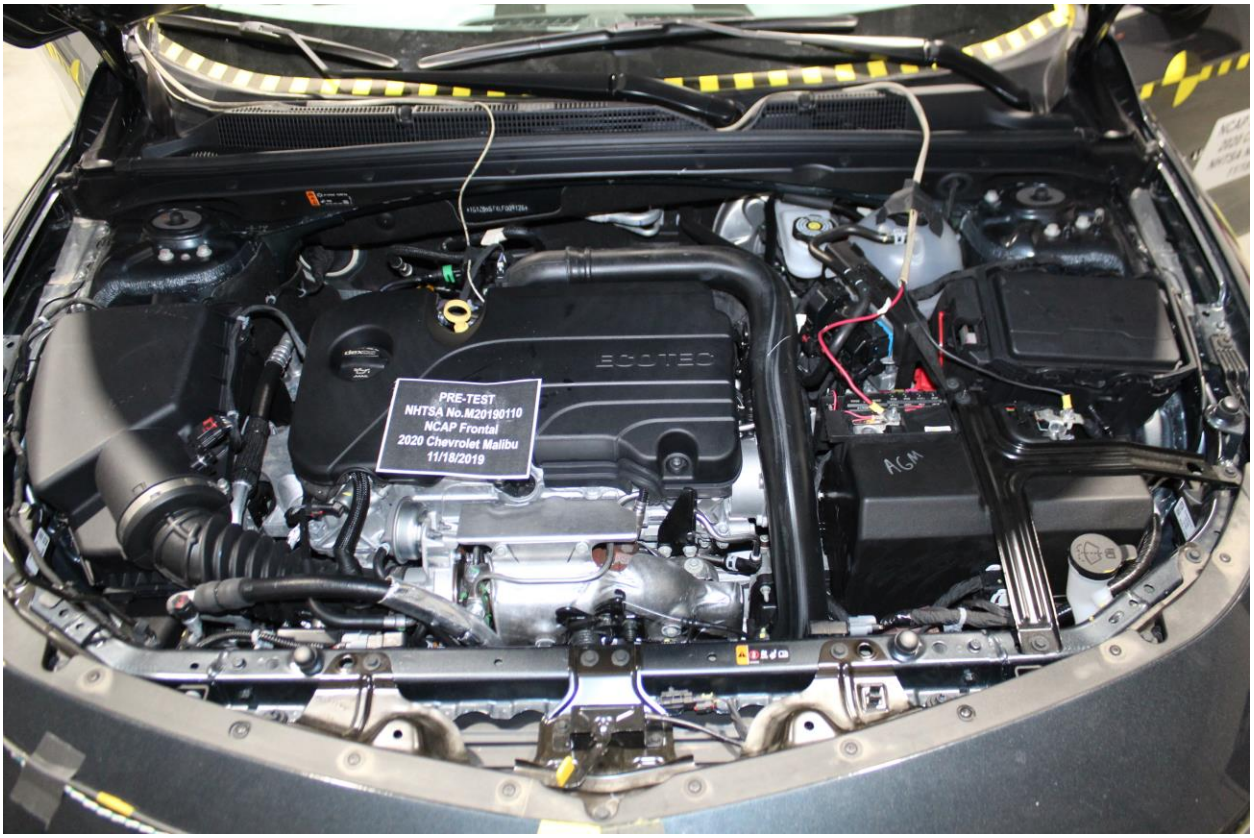


Figure A-20: Pre-Test Engine Compartment View

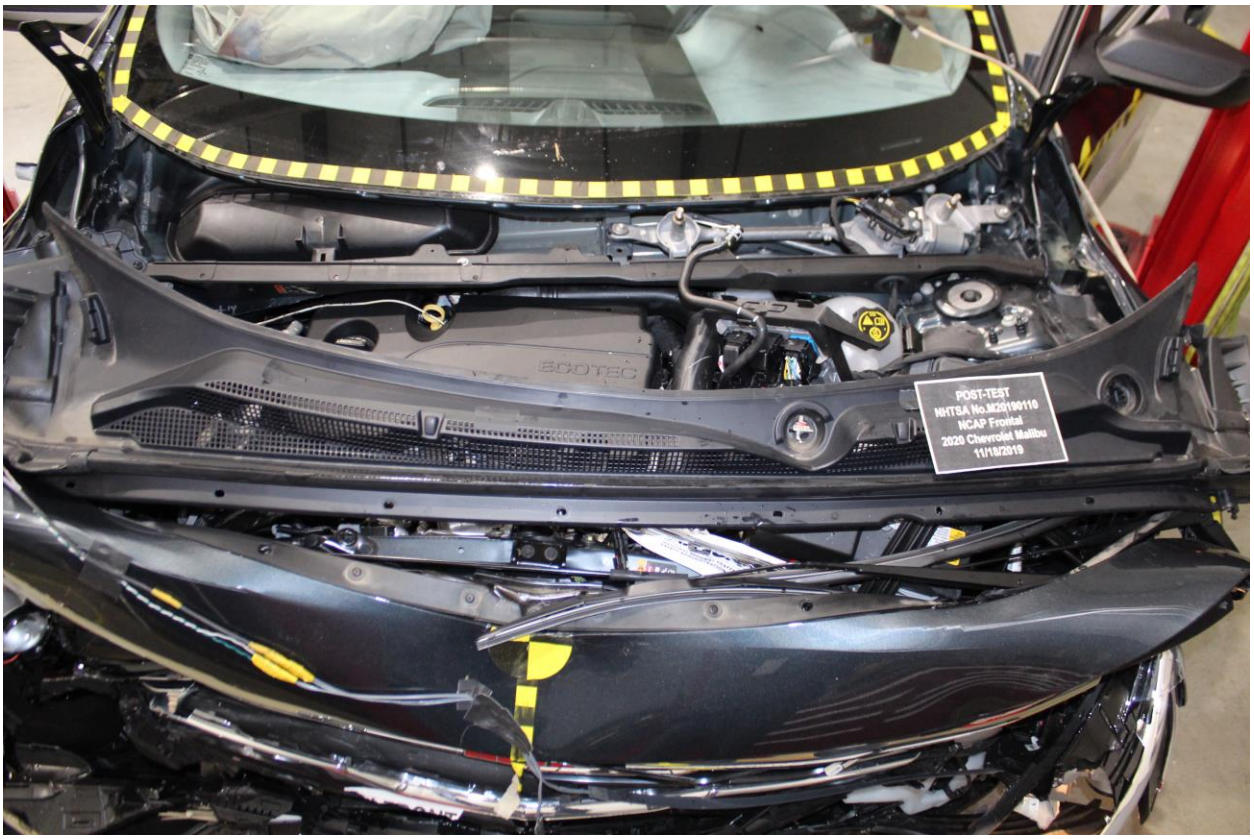


Figure A-21: Post-Test Engine Compartment View

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

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

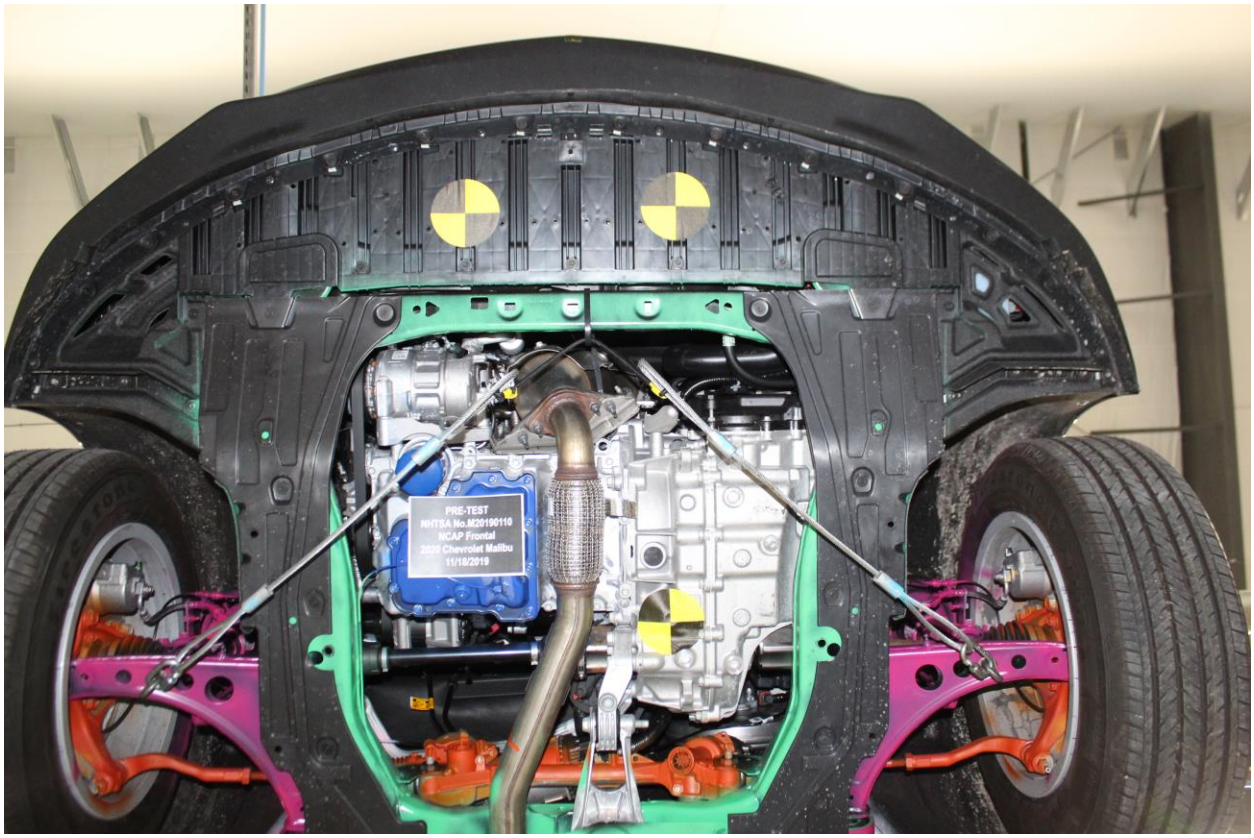


Figure A-24: Pre-Test Front Underbody View

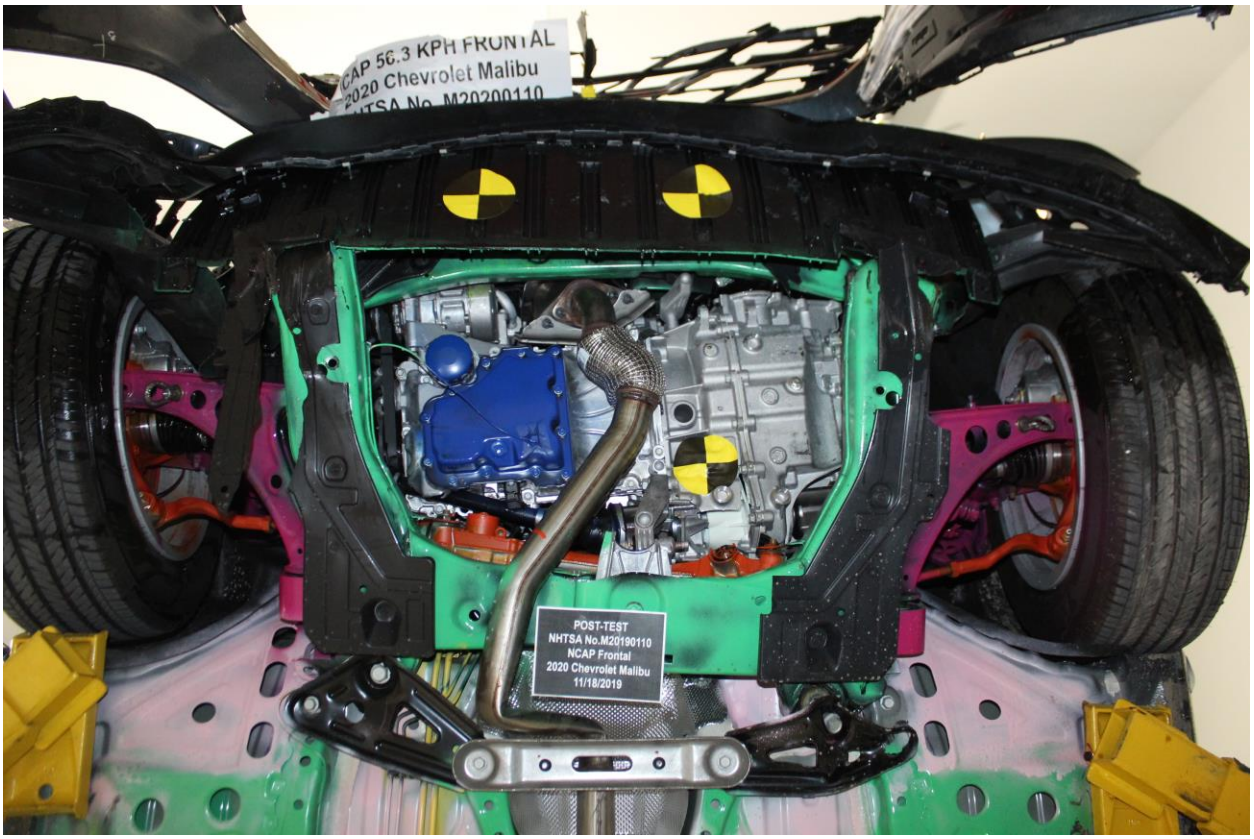


Figure A-25: Post-Test Front Underbody View

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

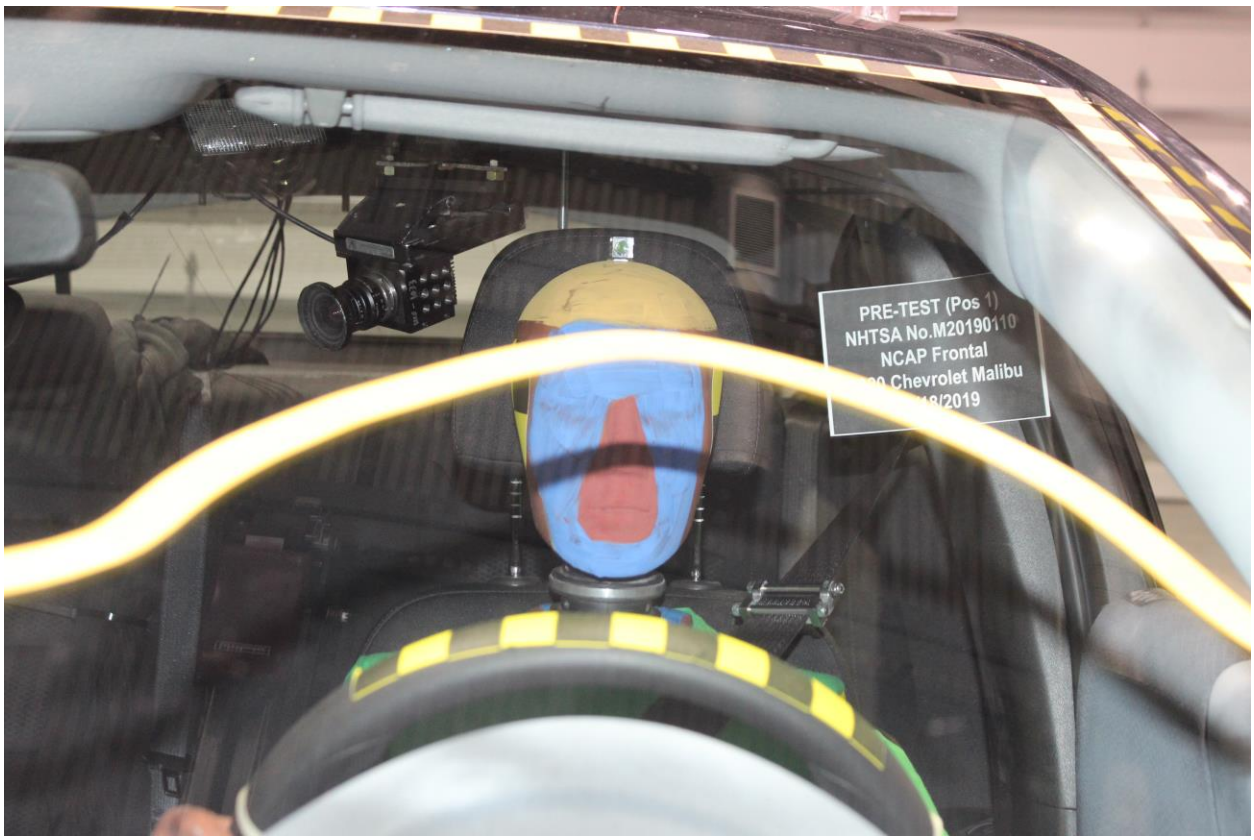


Figure A-30: Pre-Test Driver Dummy Front View

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

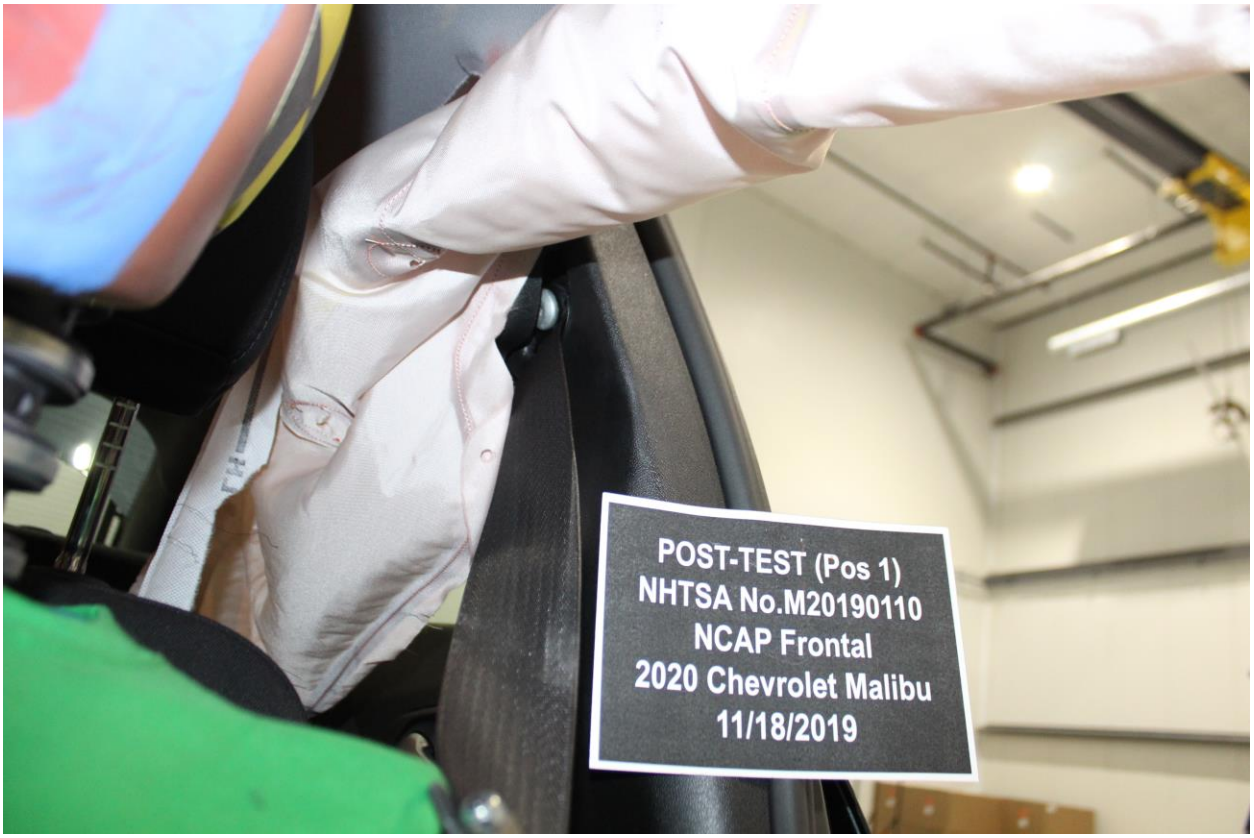


Figure A-39: Post-Test View of Belt Anchorage for Driver Dummy

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

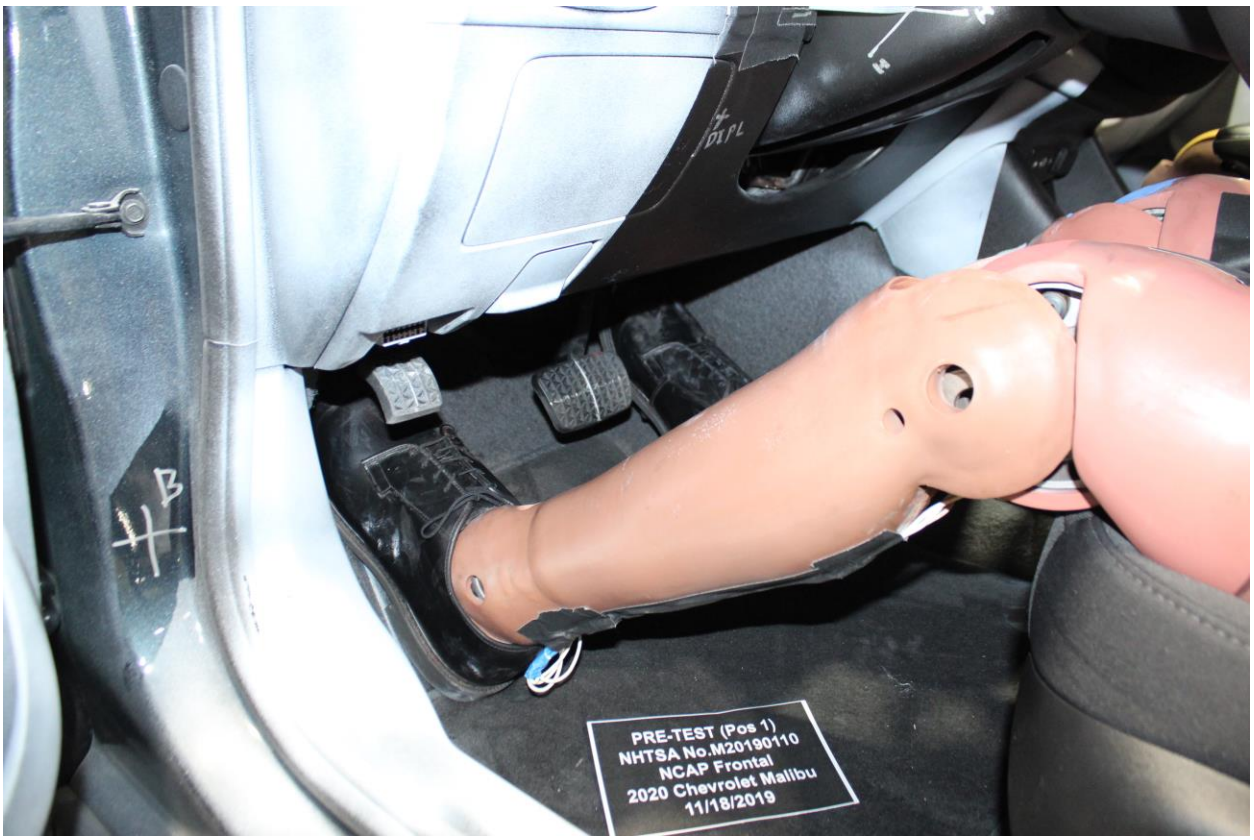


Figure A-42: Pre-Test Driver Dummy Feet

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

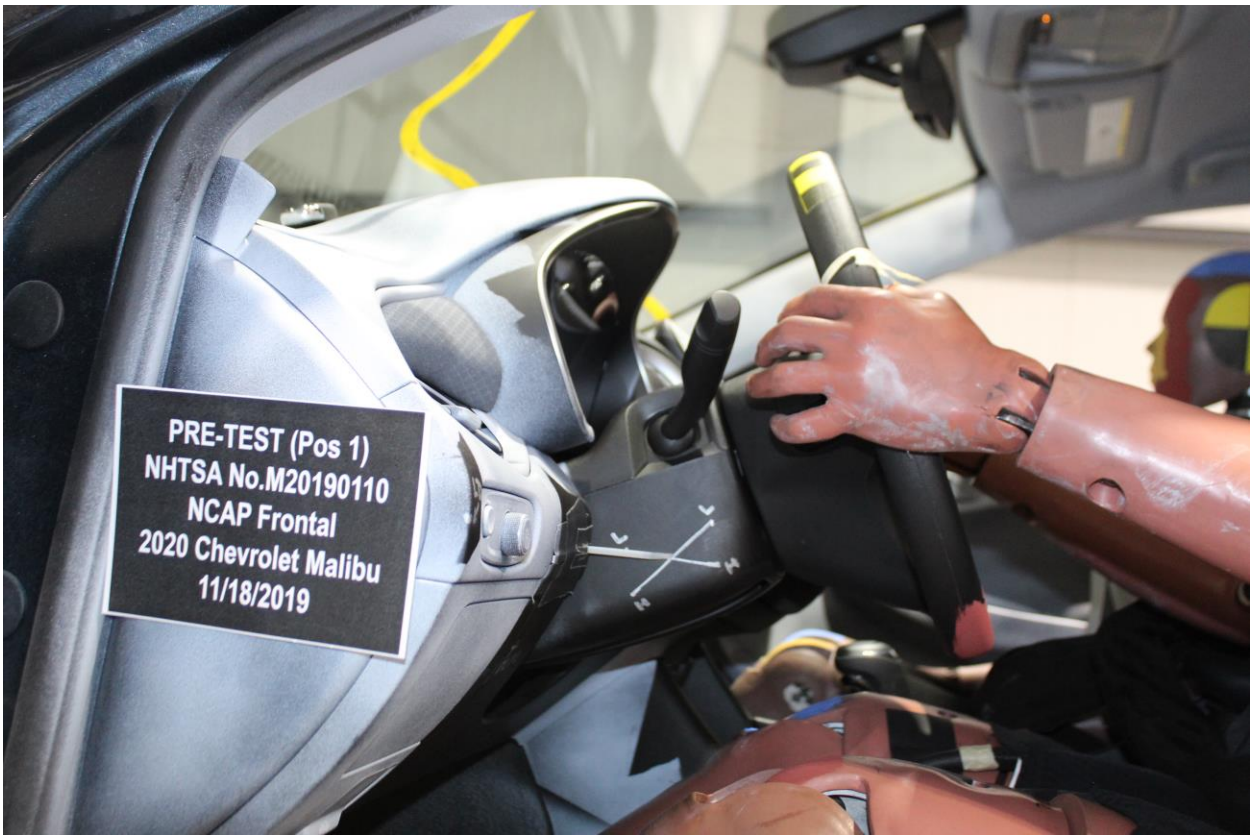


Figure A-51: Pre-Test View of the Steering Wheel

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

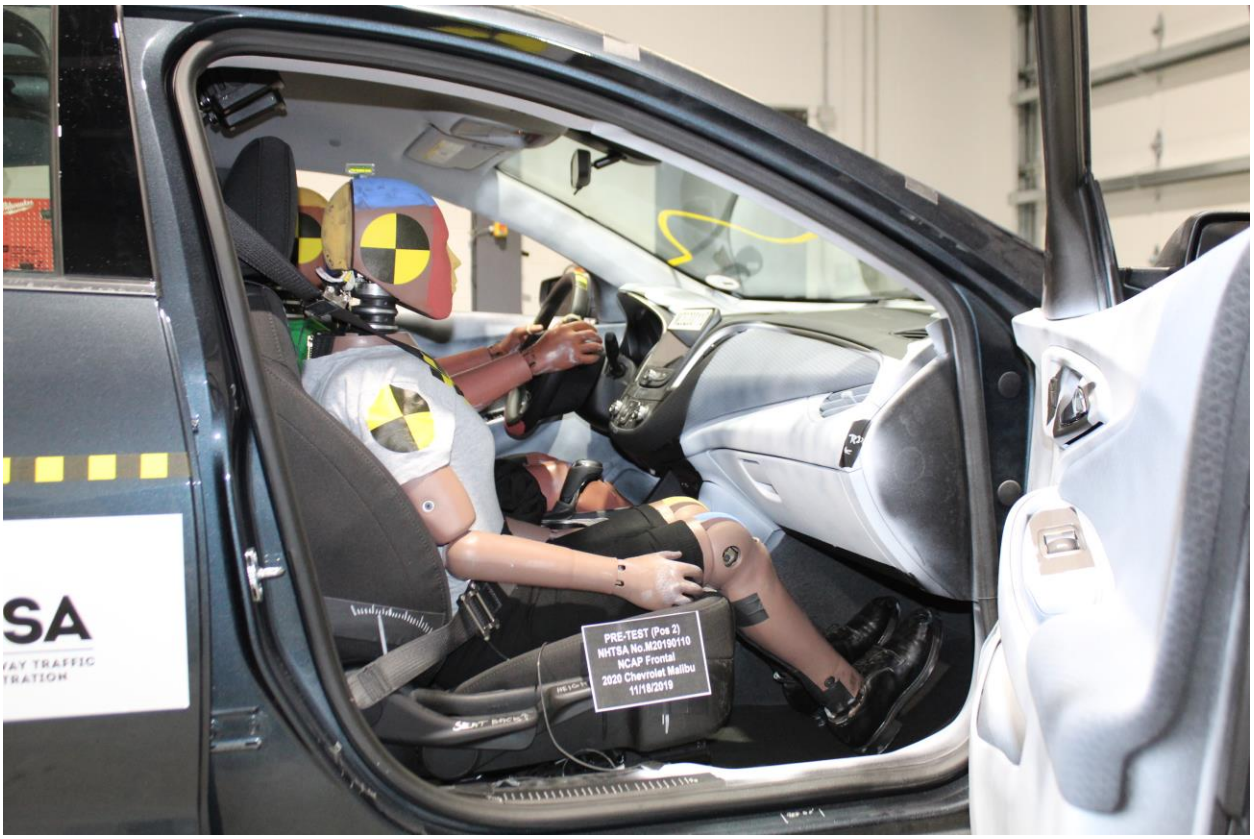


Figure A-57: Pre-Test Passenger Dummy and Vehicle Interior View

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

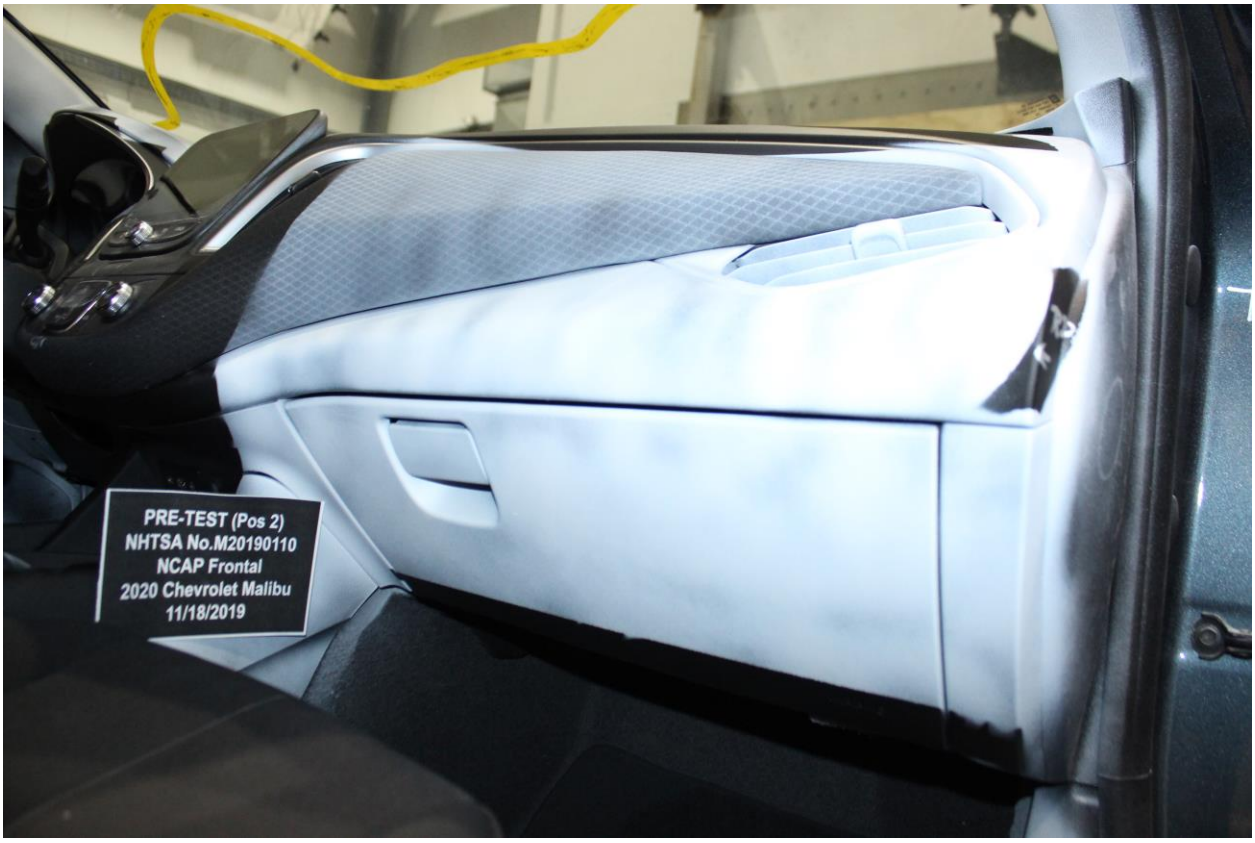


Figure A-67: Pre-Test Passenger's Side Knee Bolster

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

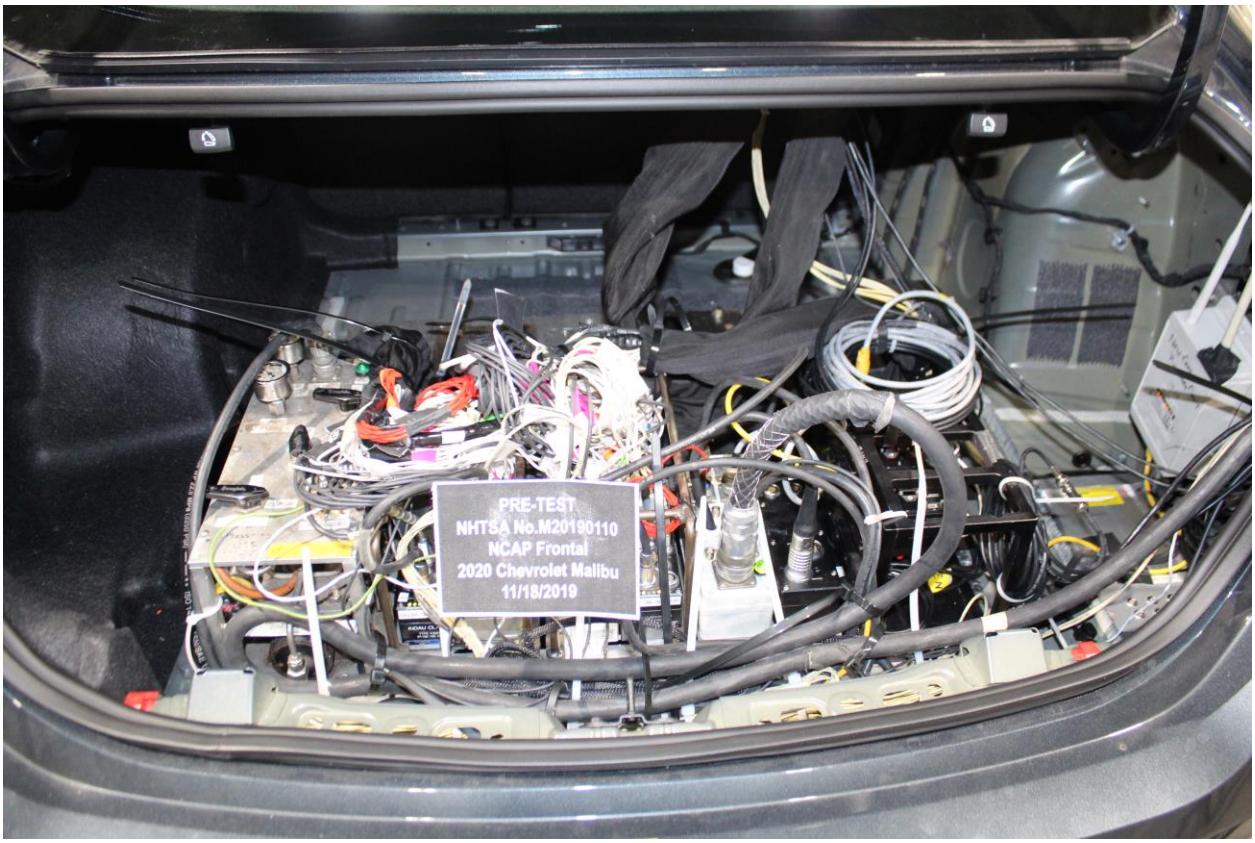


Figure A-74: Photograph of Ballast Installed in Vehicle

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

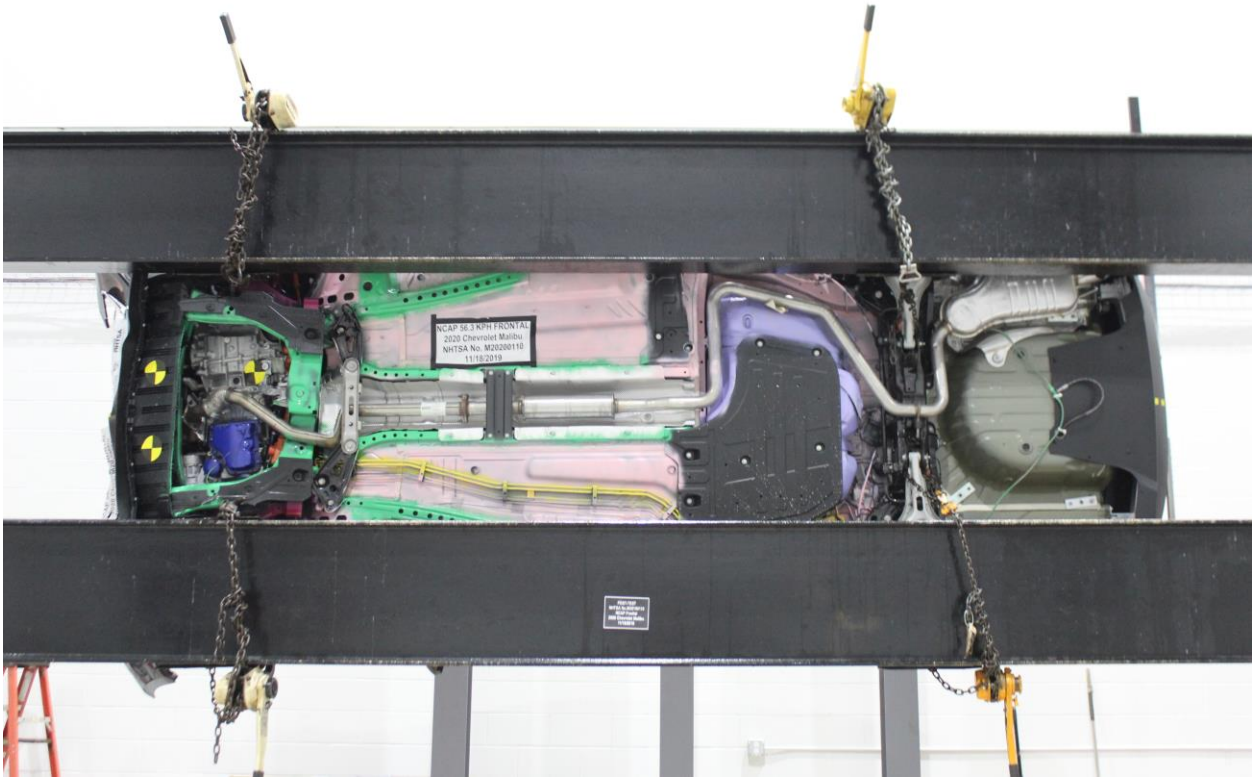


Figure A-78: Vehicle at 90º on Static Rollover Device

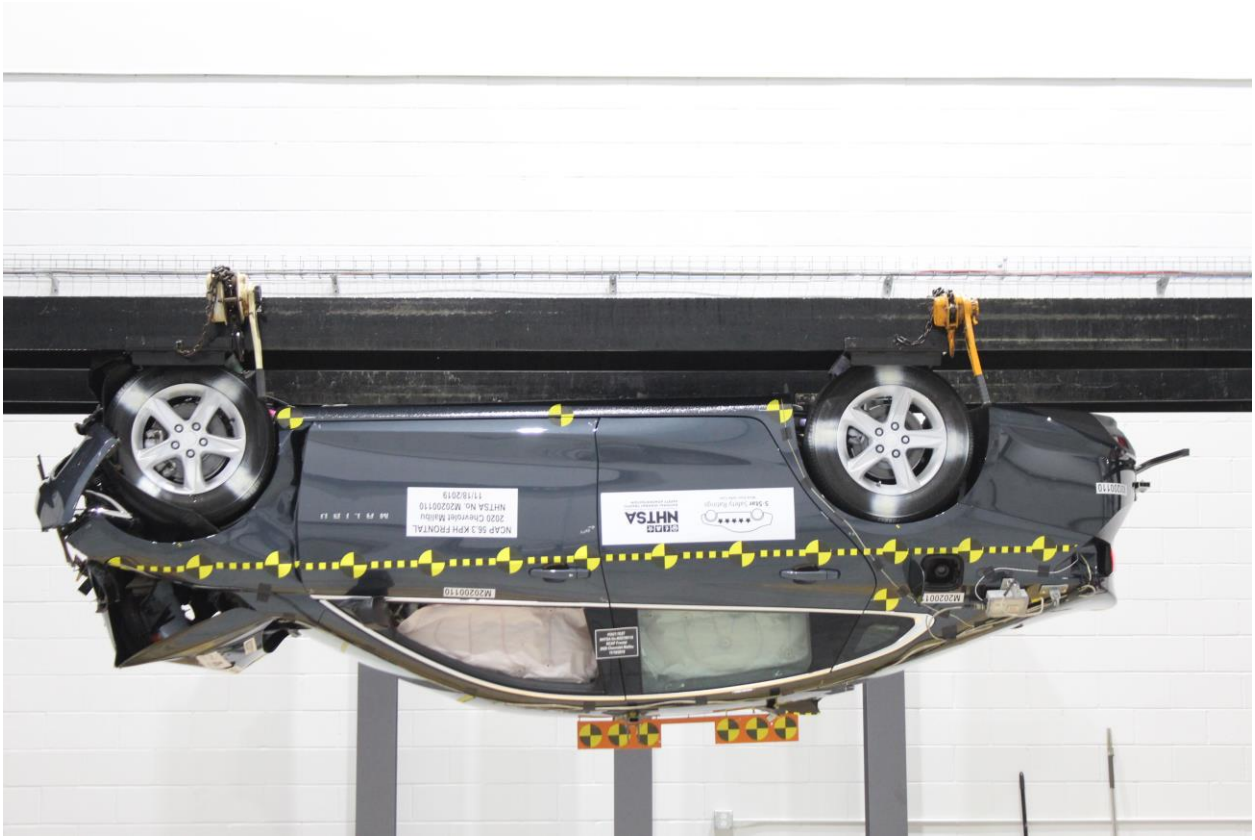


Figure A-79: Vehicle at 180º on Static Rollover Device

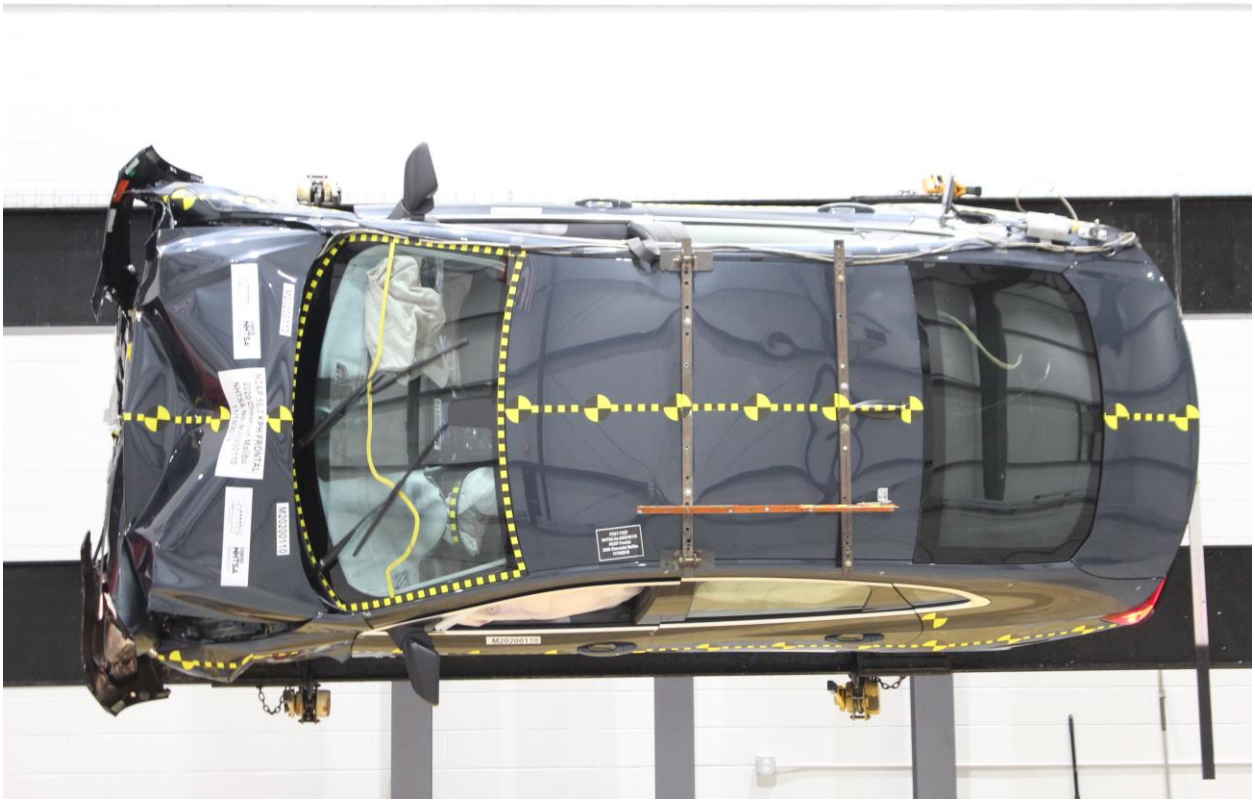


Figure A-80: Vehicle at 270º on Static Rollover Device

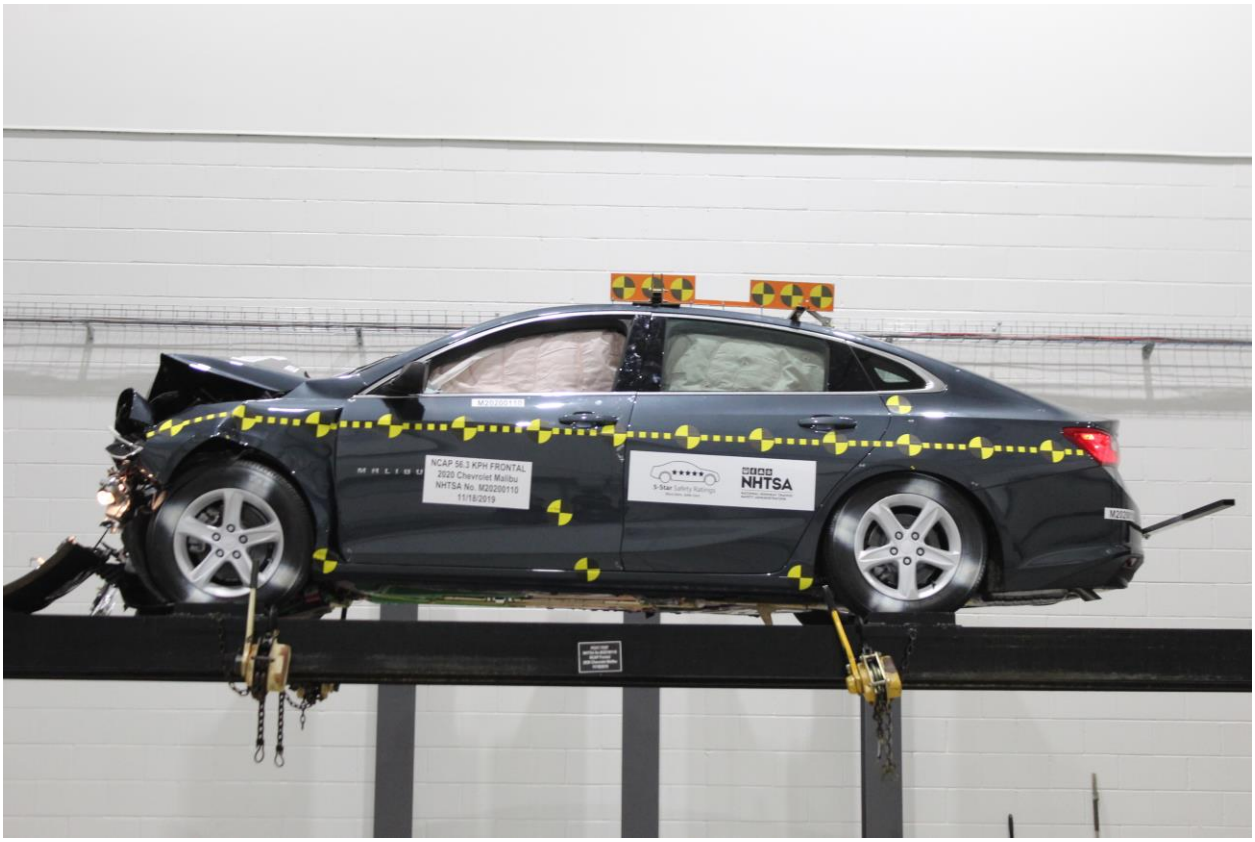


Figure A-81: Vehicle at 360º on Static Rollover Device

Figure A-82: 2020 Chevrolet Malibu Frontal Impact Event

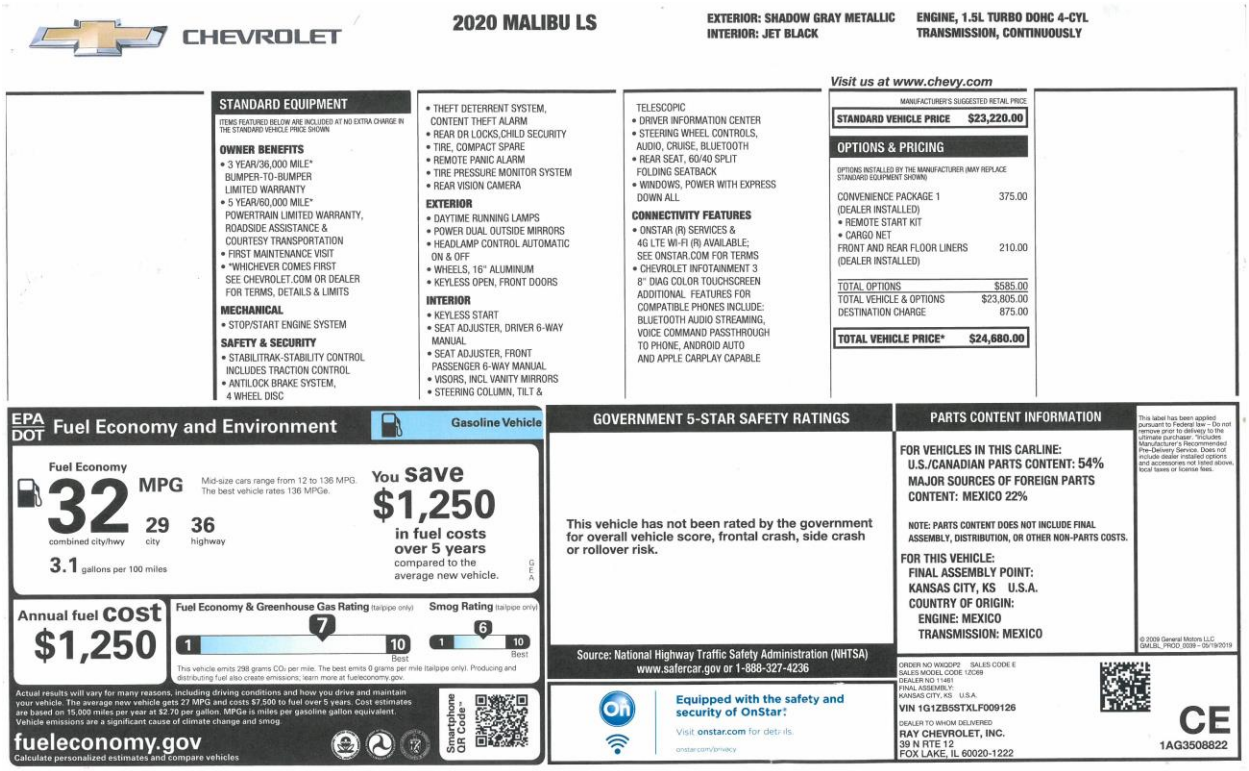


Figure A-83: Monroney Label Photograph

APPENDIX B
VEHICLE & DUMMY RESPONSE DATA TRACES

Table of Data Plots

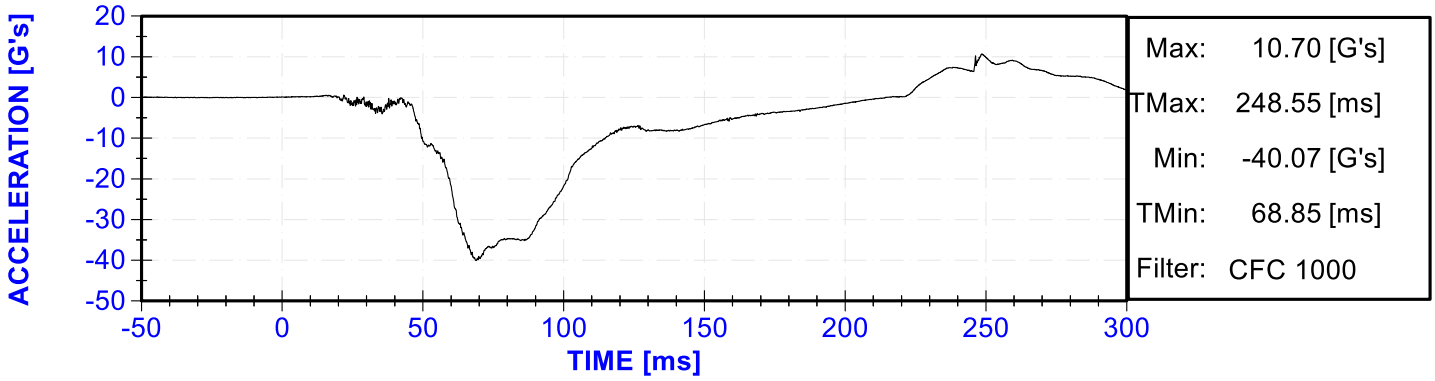
The following additional dummy and vehicle response data can be found in the R&D section of the NHTSA website at www.nhtsa.gov

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

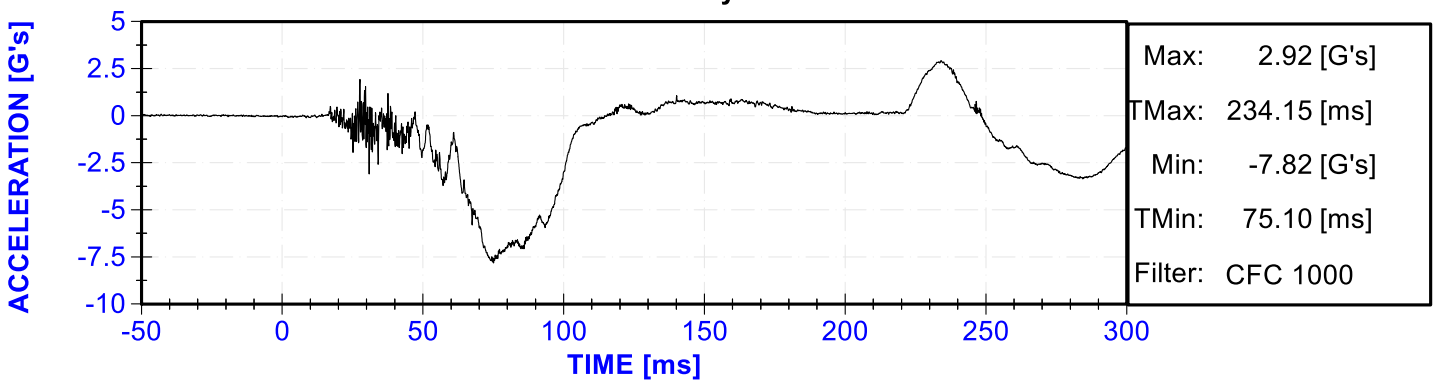
Driver Left Upper Tibia Force Z
Driver Left Lower Tibia Moment X
Driver Left Lower Tibia Moment Y
Driver Left Lower Tibia Force Z
Driver Right Upper Tibia Moment X
Driver Right Upper Tibia Moment Y
Driver Right Upper Tibia Force Z
Driver Right Lower Tibia Moment X
Driver Right Lower Tibia Moment Y
Driver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

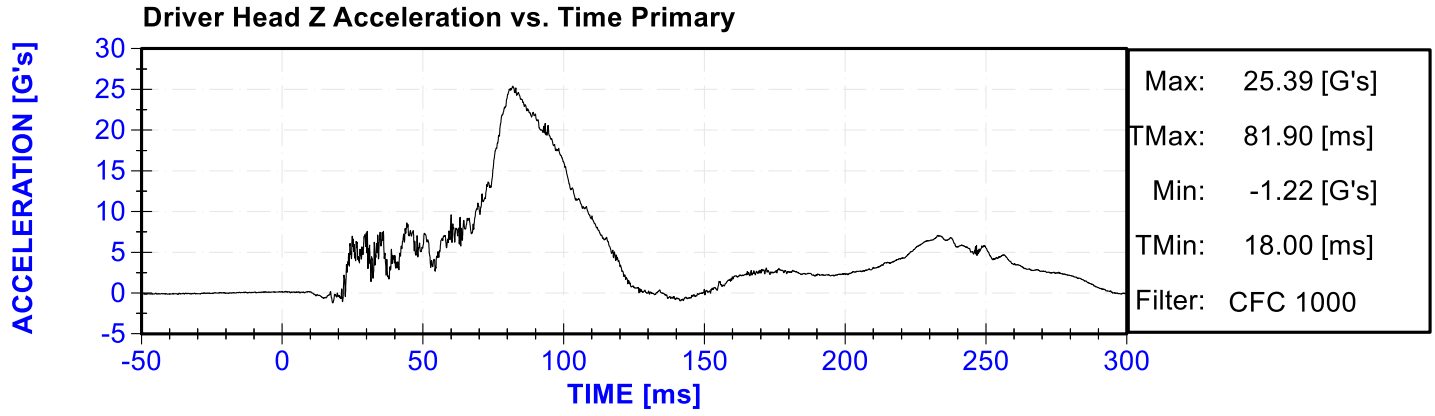
Driver Head X Acceleration vs. Time Primary



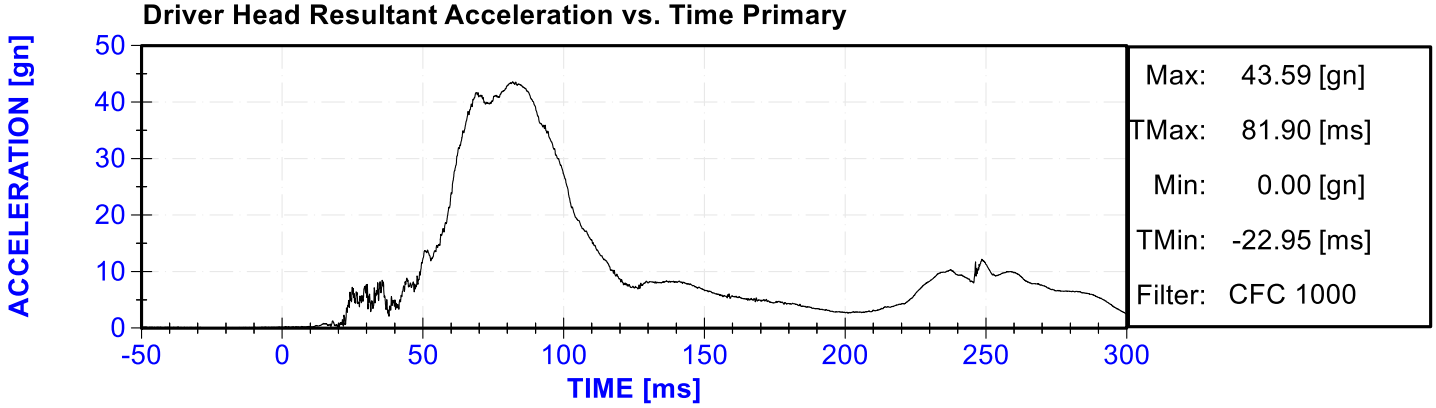
Driver Head Y Acceleration vs. Time Primary



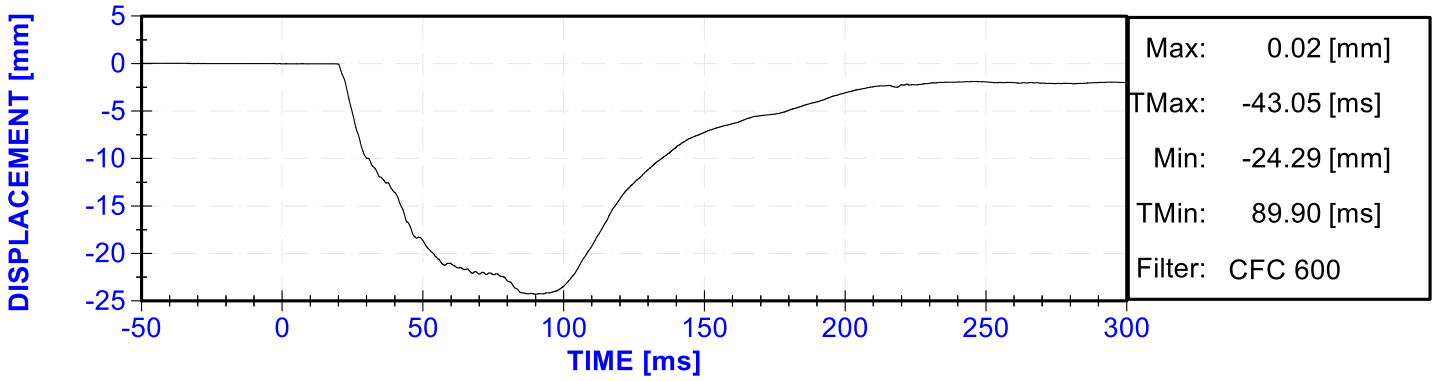
Driver Head Z Acceleration vs. Time Primary



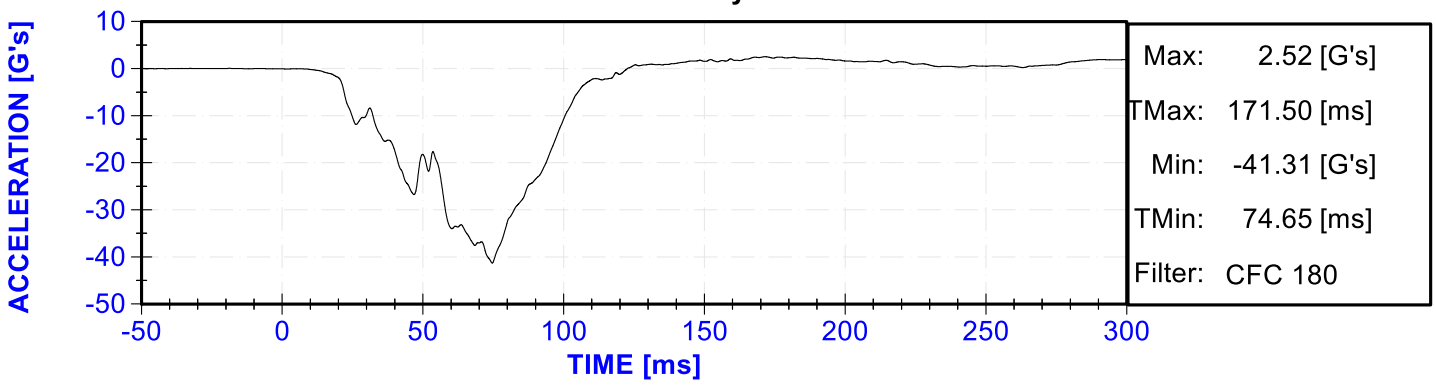
Driver Head Resultant Acceleration vs. Time Primary



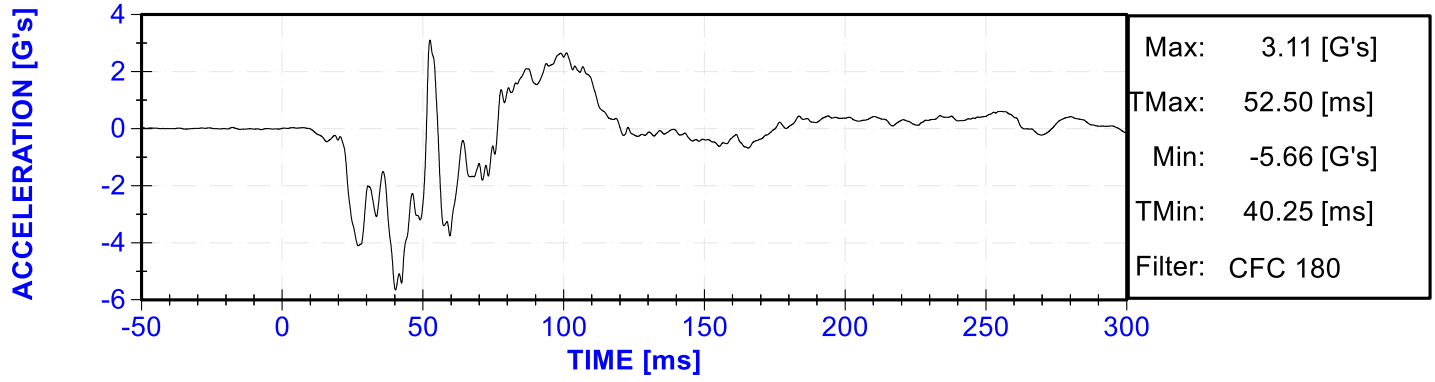
Driver Chest X Deflection vs. Time



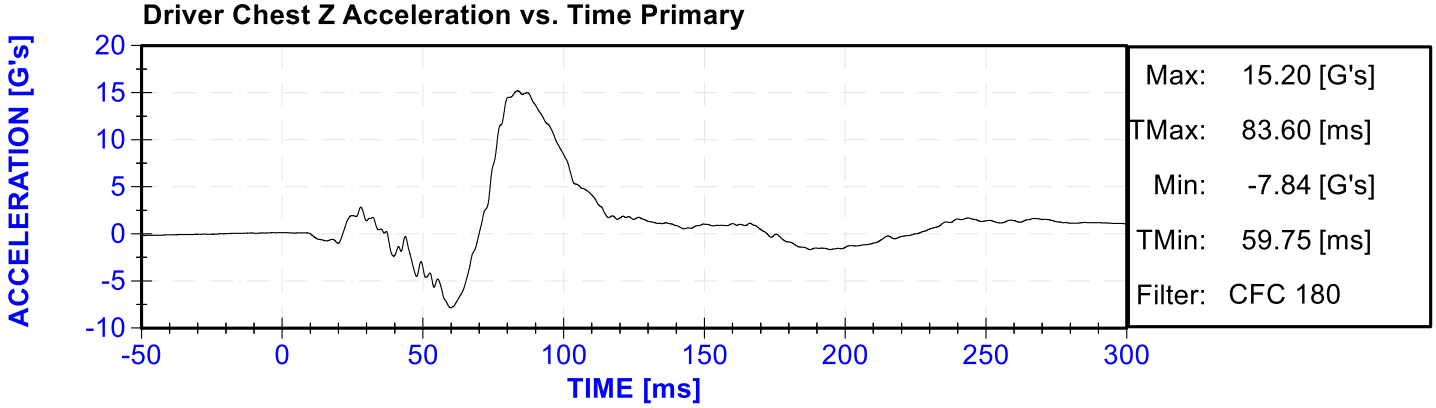
Driver Chest X Acceleration vs. Time Primary



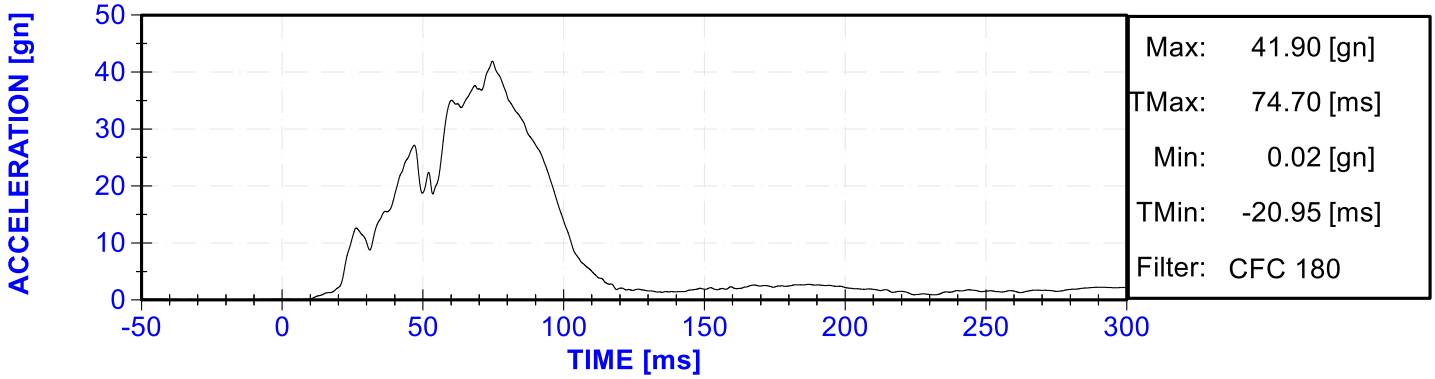
Driver Chest Y Acceleration vs. Time Primary



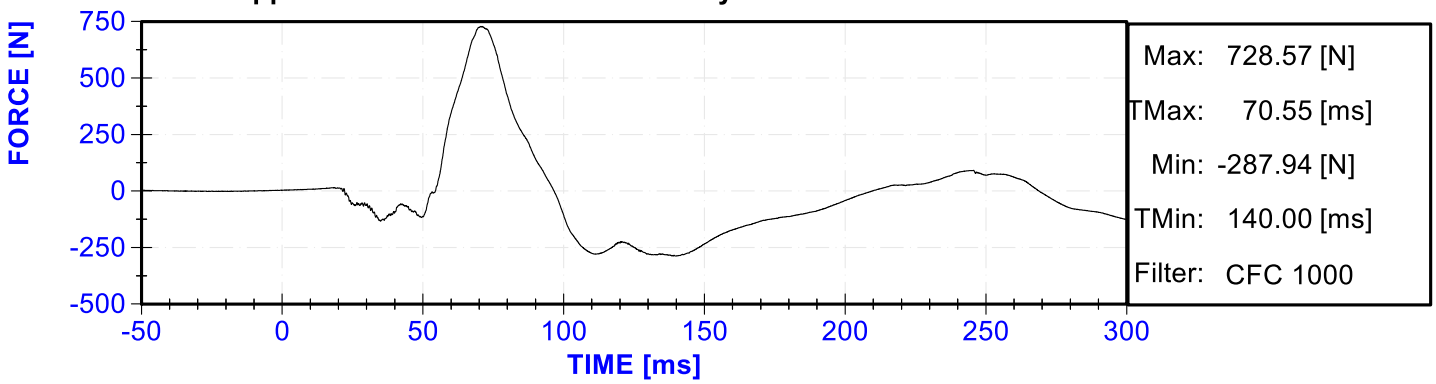
Driver Chest Z Acceleration vs. Time Primary



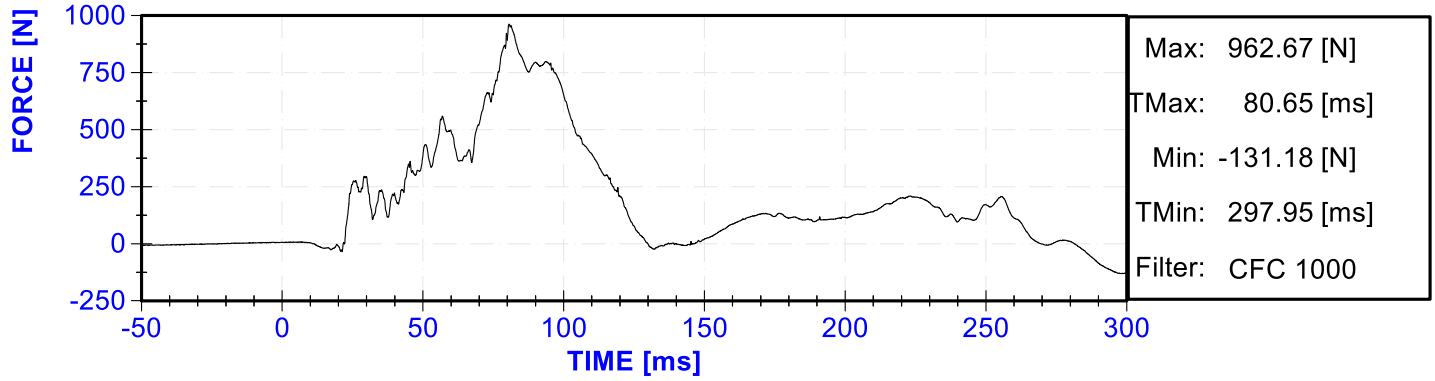
Driver Chest Resultant Acceleration vs. Time Primary



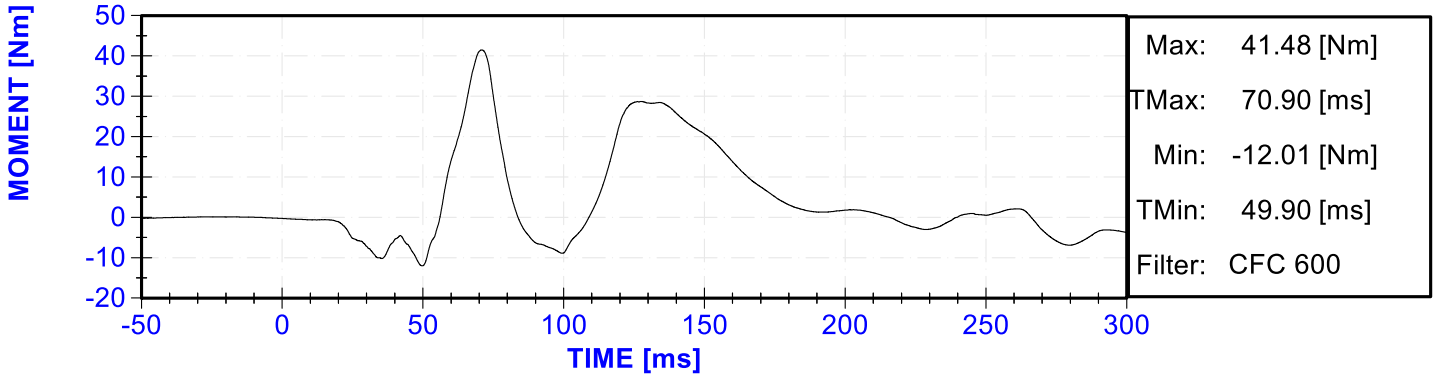
Driver Upper Neck Force X vs. Time Primary



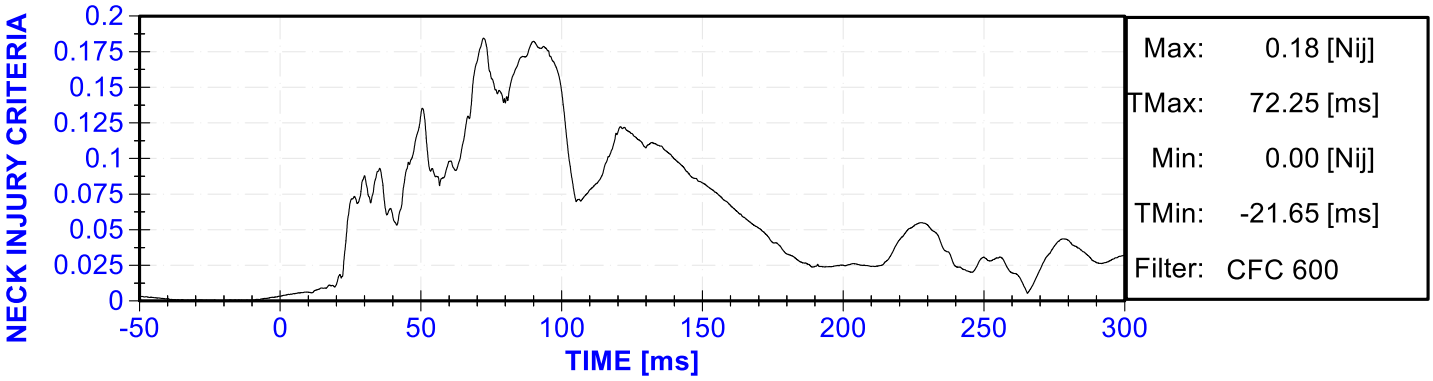
Driver Upper Neck Force Z vs. Time Primary



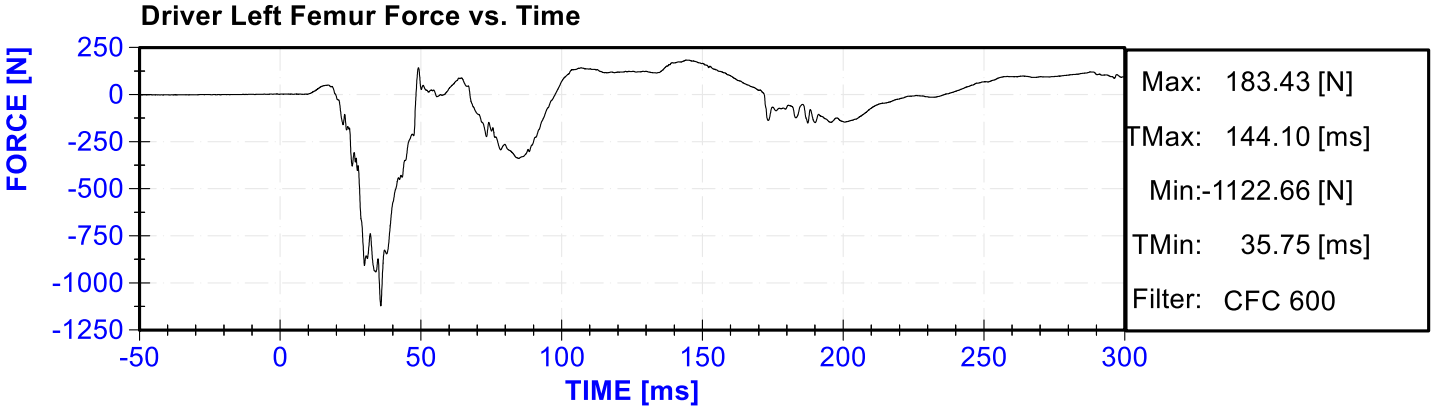
Driver Upper Neck Moment Y vs. Time Primary



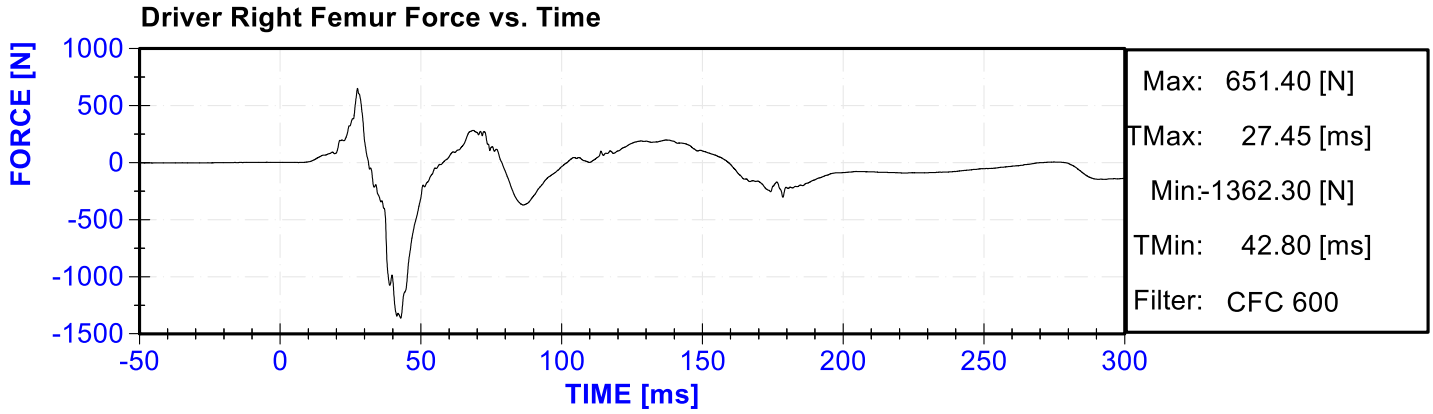
Driver Nij vs. Time Primary



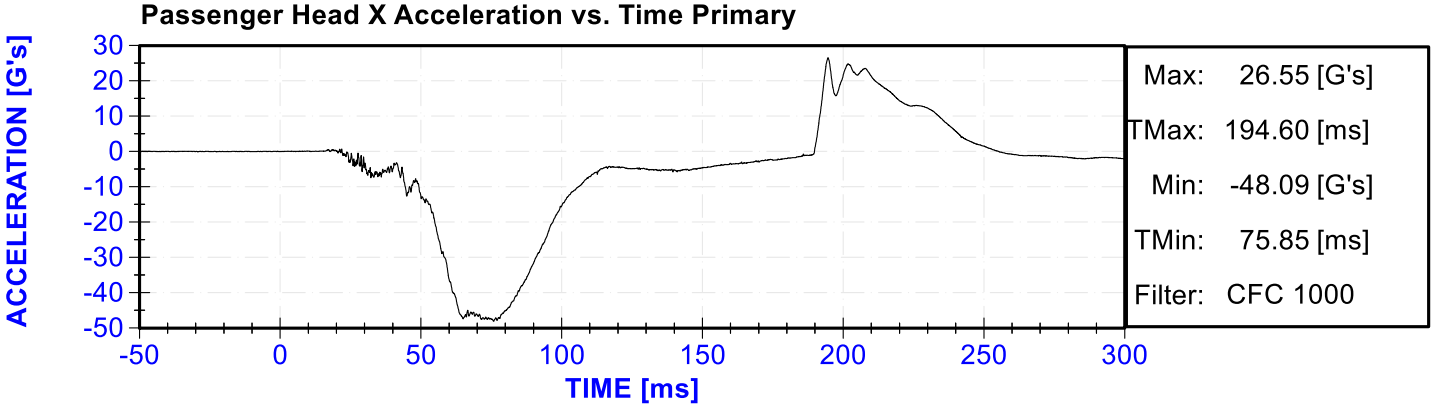
Driver Left Femur Force vs. Time



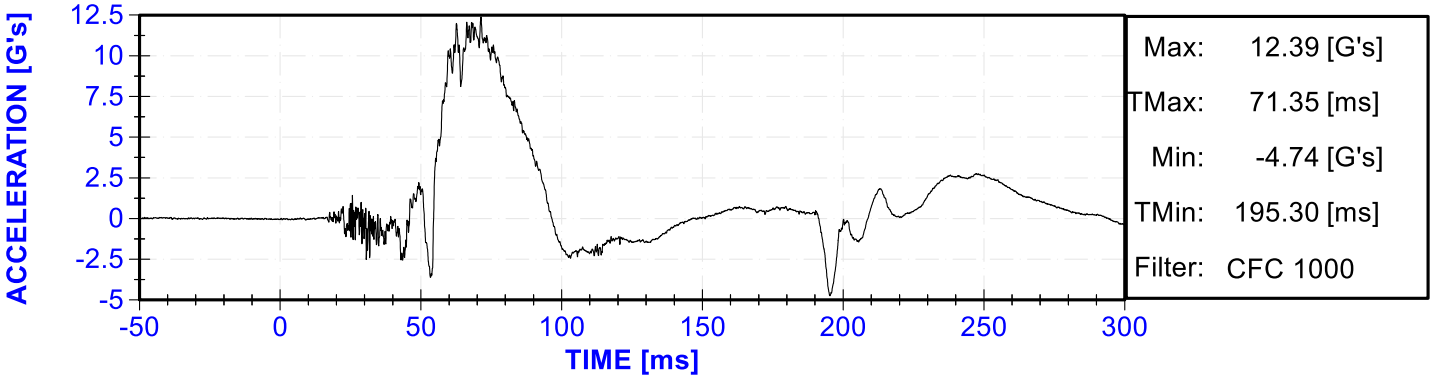
Driver Right Femur Force vs. Time



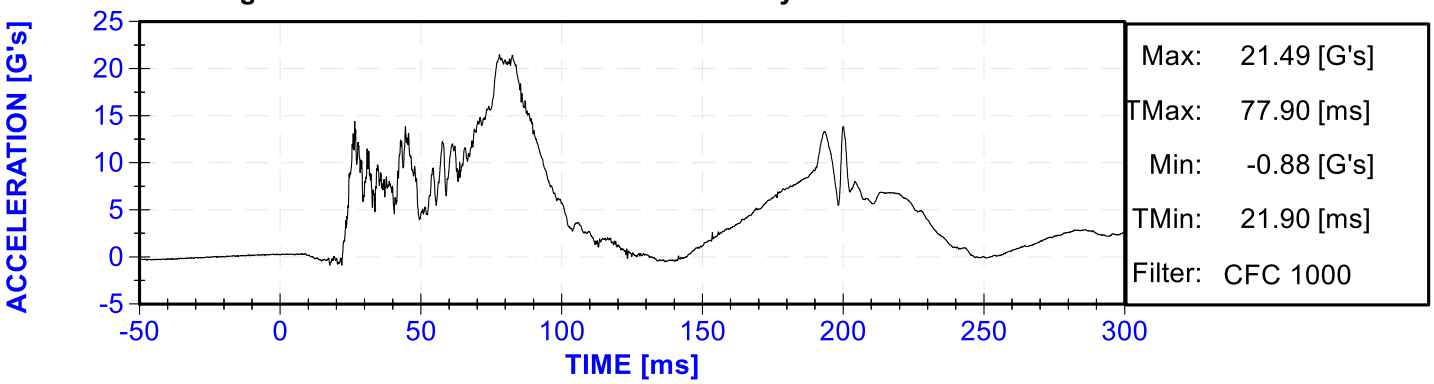
Passenger Head X Acceleration vs. Time Primary



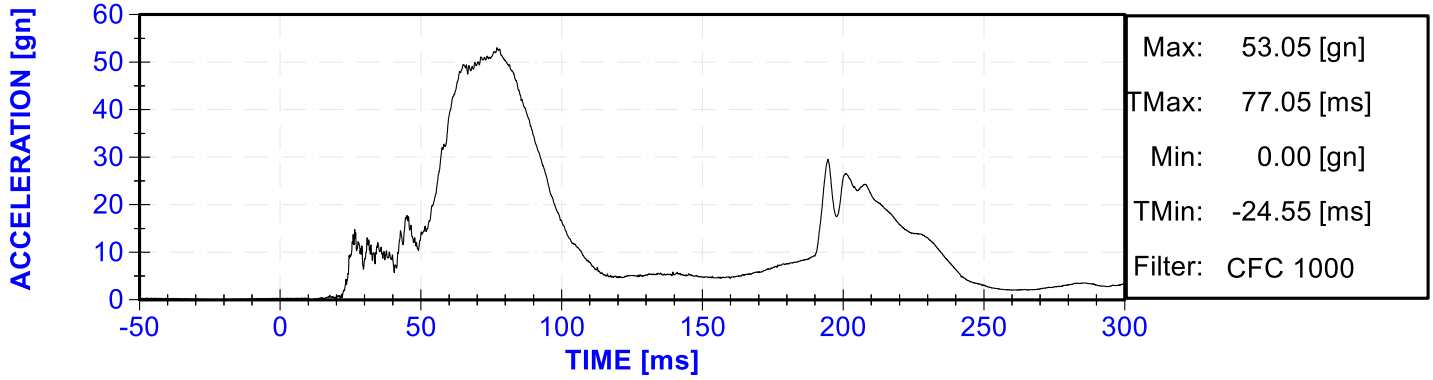
Passenger Head Y Acceleration vs. Time Primary



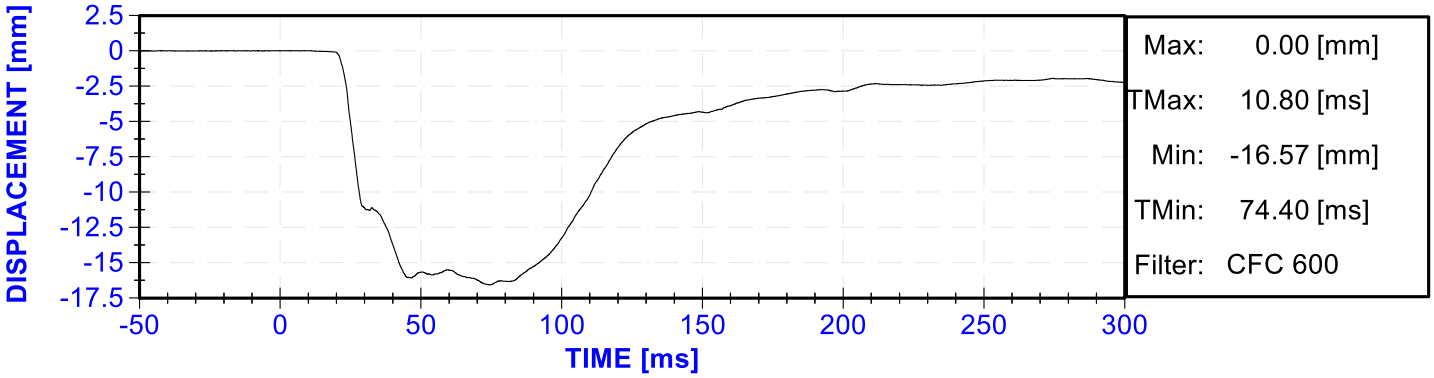
Passenger Head Z Acceleration vs. Time Primary



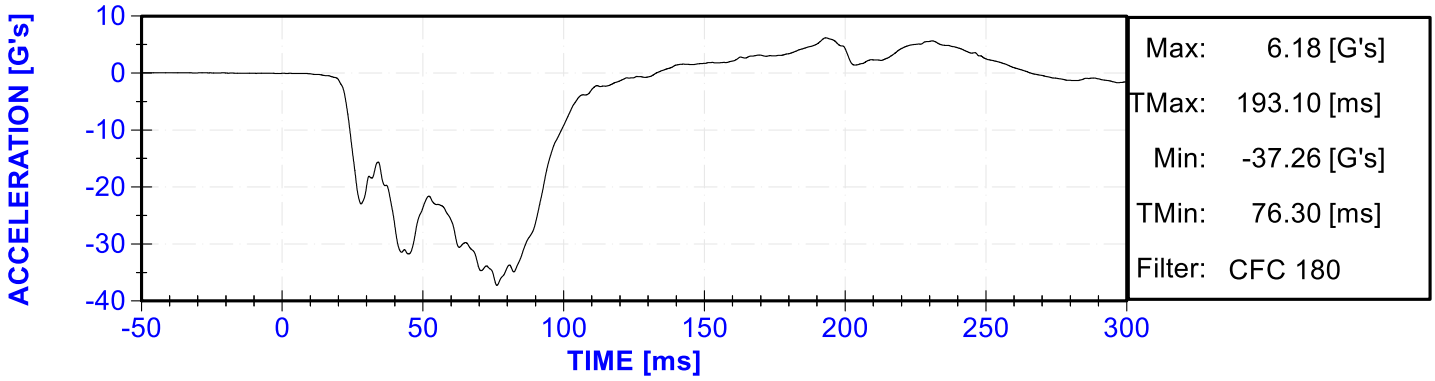
Passenger Head Resultant Acceleration vs. Time Primary



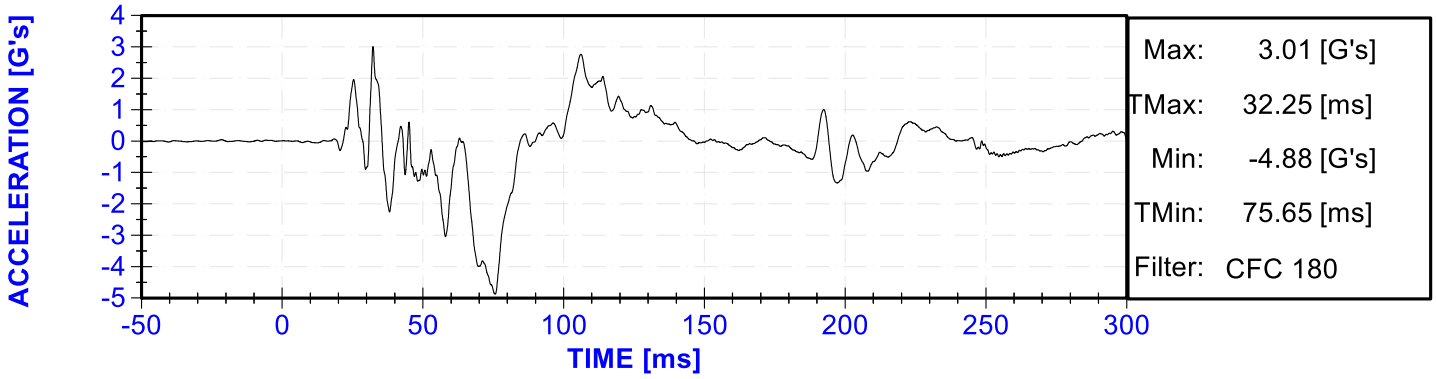
Passenger Chest X Deflection vs. Time



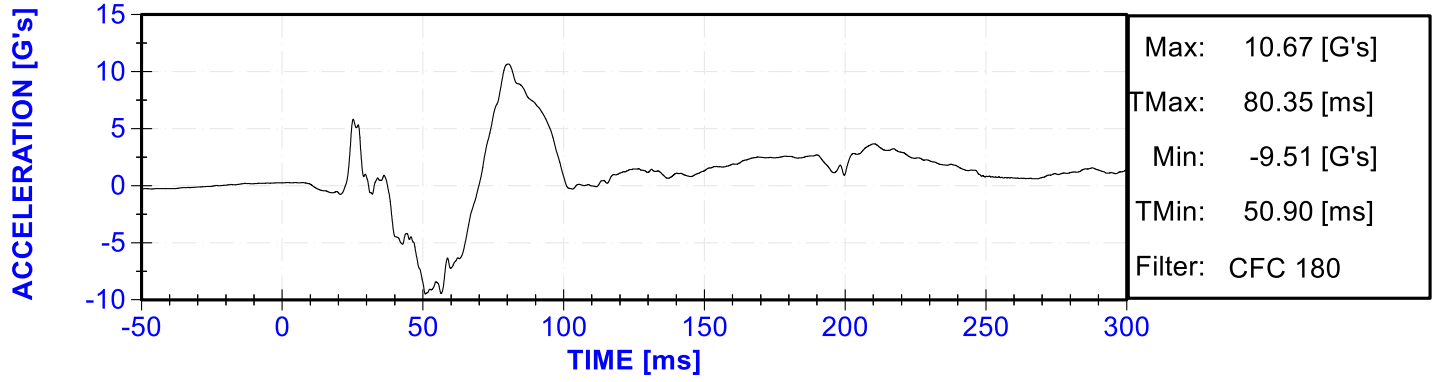
Passenger Chest X Acceleration vs. Time Primary



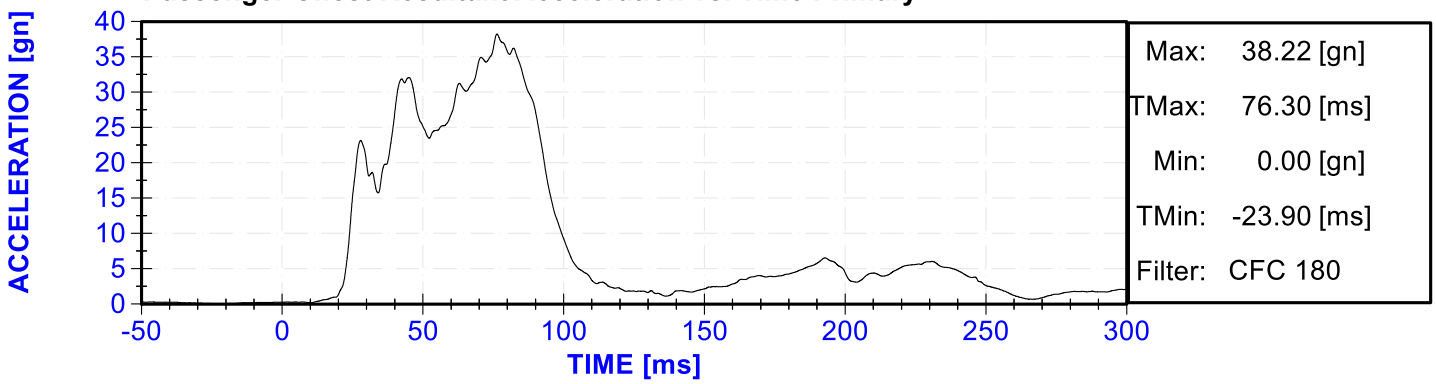
Passenger Chest Y Acceleration vs. Time Primary



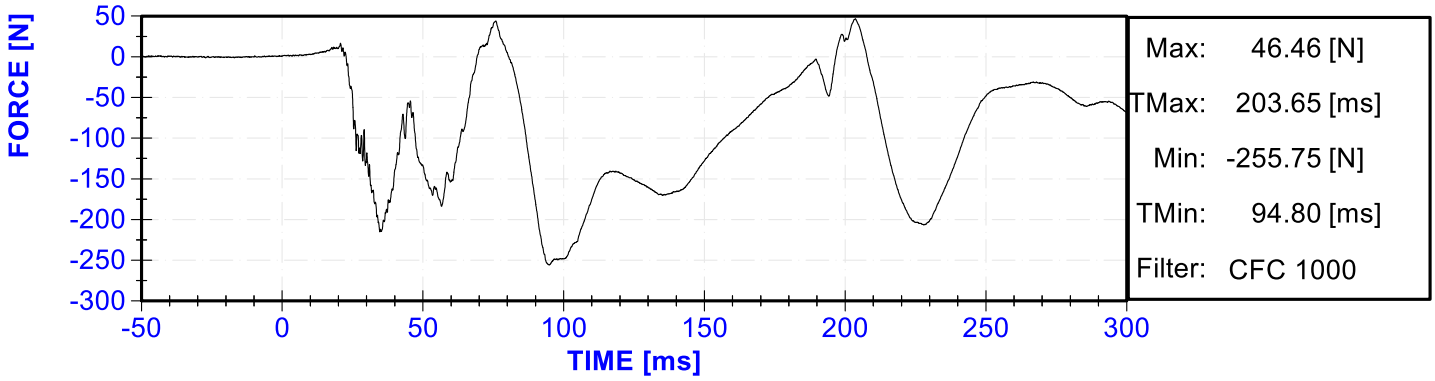
Passenger Chest Z Acceleration vs. Time Primary



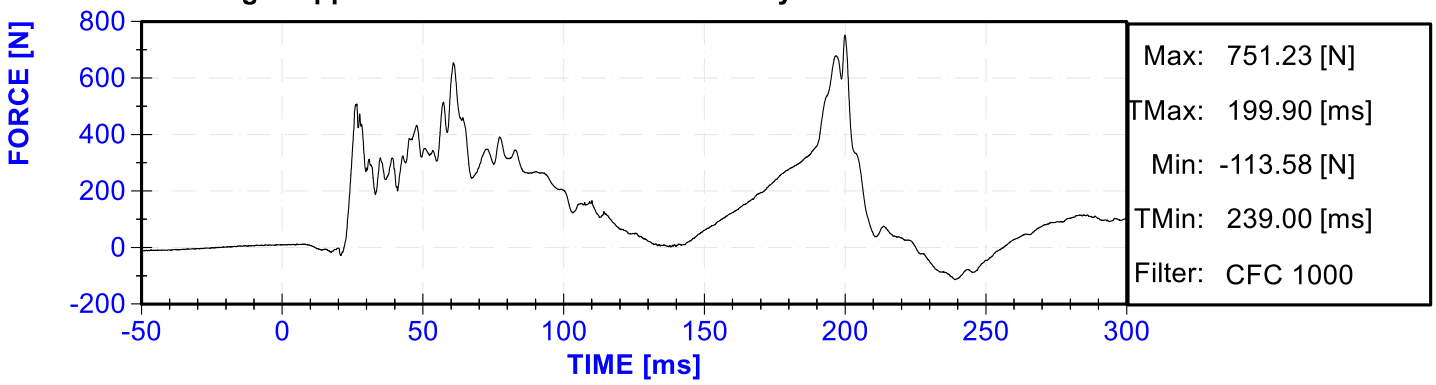
Passenger Chest Resultant Acceleration vs. Time Primary



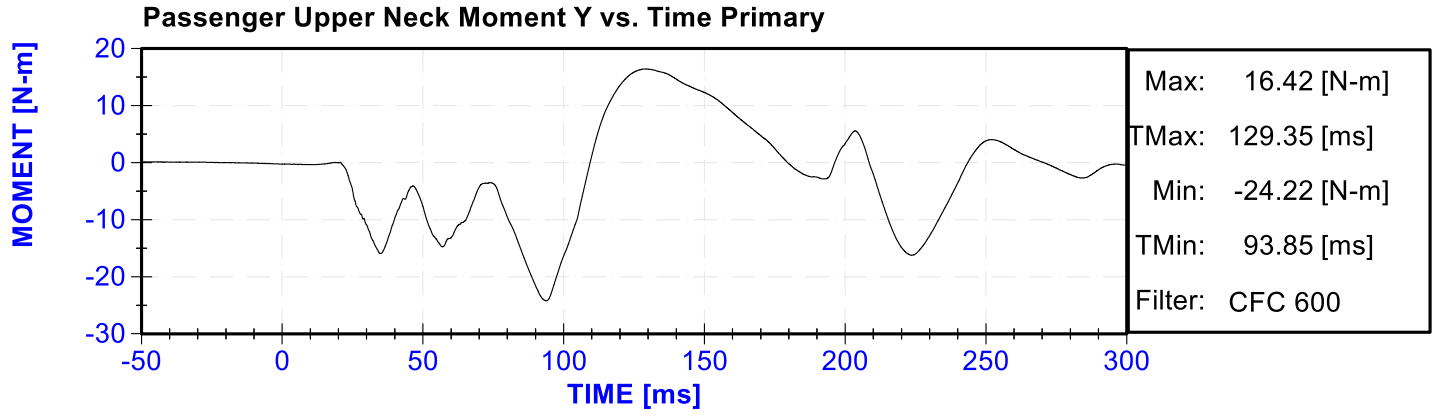
Passenger Upper Neck Force X vs. Time Primary



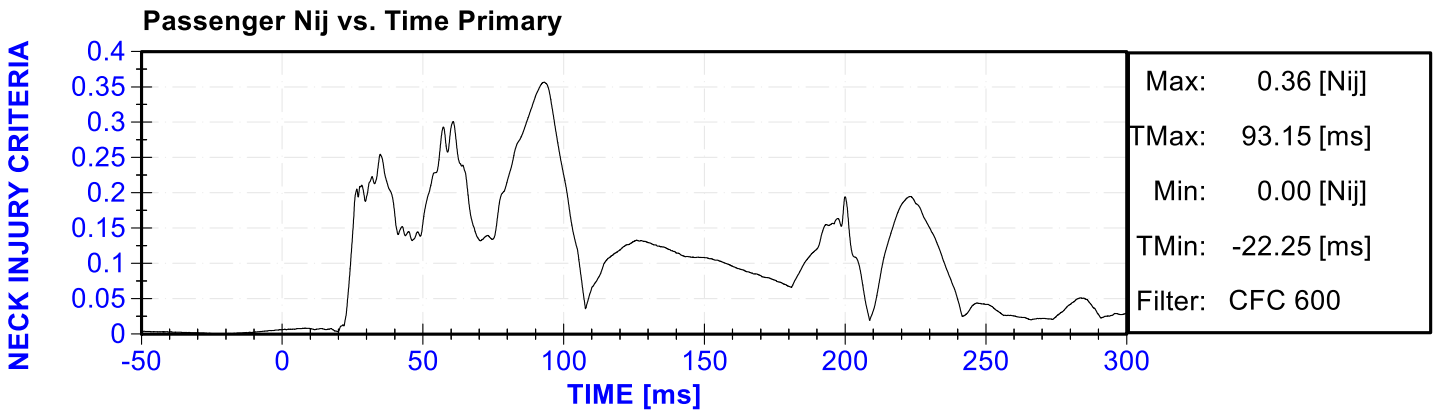
Passenger Upper Neck Force Z vs. Time Primary



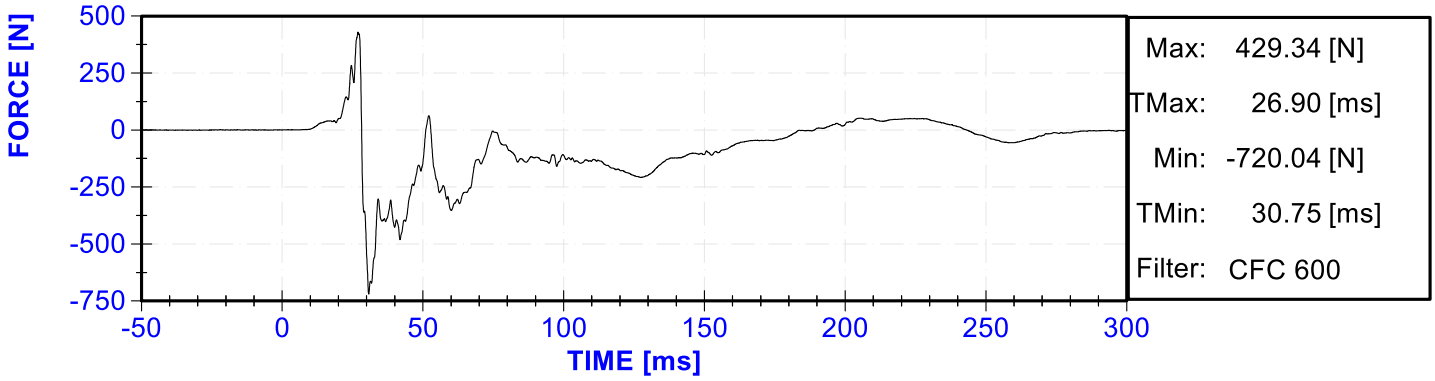
Passenger Upper Neck Moment Y vs. Time Primary



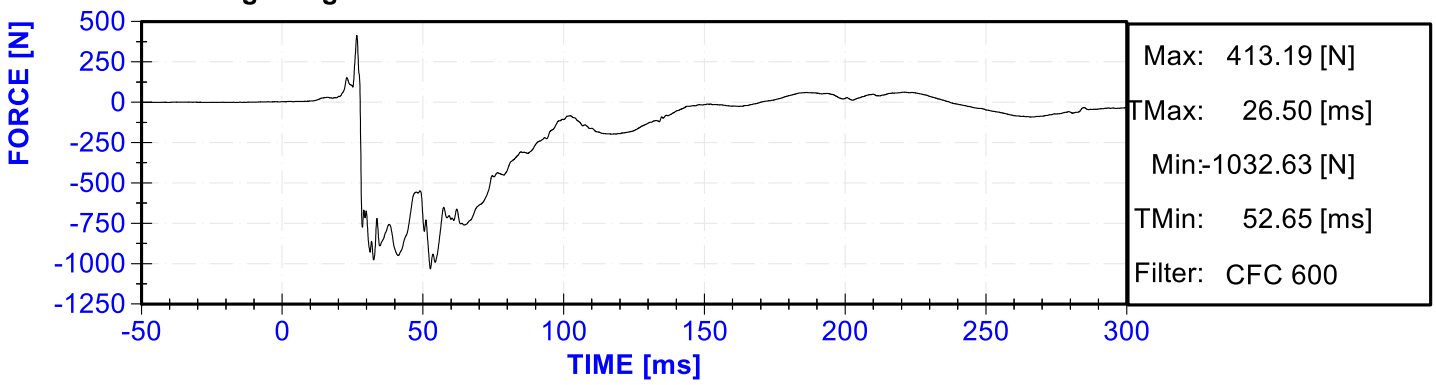
Passenger Nij vs. Time Primary



Passenger Left Femur Force vs. Time



Passenger Right Femur Force vs. Time



APPENDIX C

DUMMY CALIBRATION AND PERFORMANCE VERIFICATION DATA

CALIBRATION TEST RESULTS

PRE-TEST

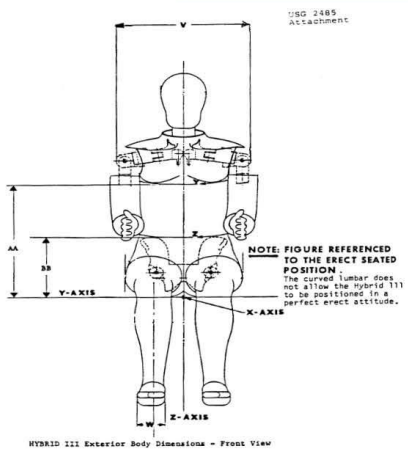
HYBRID III 50TH PERCENTILE MALE - DRIVER ATD

SERIAL NO: 142

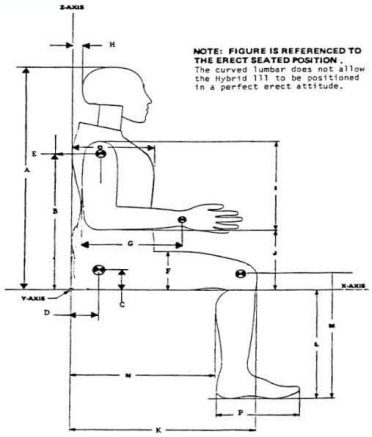
External Measurements - Hybrid 3 - 50th Male

Technician: K. Dutton Date: 11/12/2019

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	3.5	Pass
F	Thigh Clearance	5.5	6.1	5.7	Pass
G	Back of Elbow to Wrist Pivot	11.4	12.0	11.8	Pass
H	Head Back to Backline	1.6	1.8	1.7	Pass
I	Shoulder to Elbow Length	13.0	13.6	13.5	Pass
J	Elbow Rest Height	7.5	8.3	8.2	Pass
K	Buttock to Knee Length	22.8	23.8	23.3	Pass
L	Popliteal Height	16.9	17.9	17.3	Pass
M	Knee Pivot Height	19.1	19.7	19.4	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	10.3	Pass
V	Shoulder Breadth	16.3	17.2	16.8	Pass
W	Foot Breadth	3.6	4.2	3.8	Pass
Y	Chest Circumference with Jacket	38.2	39.4	38.9	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

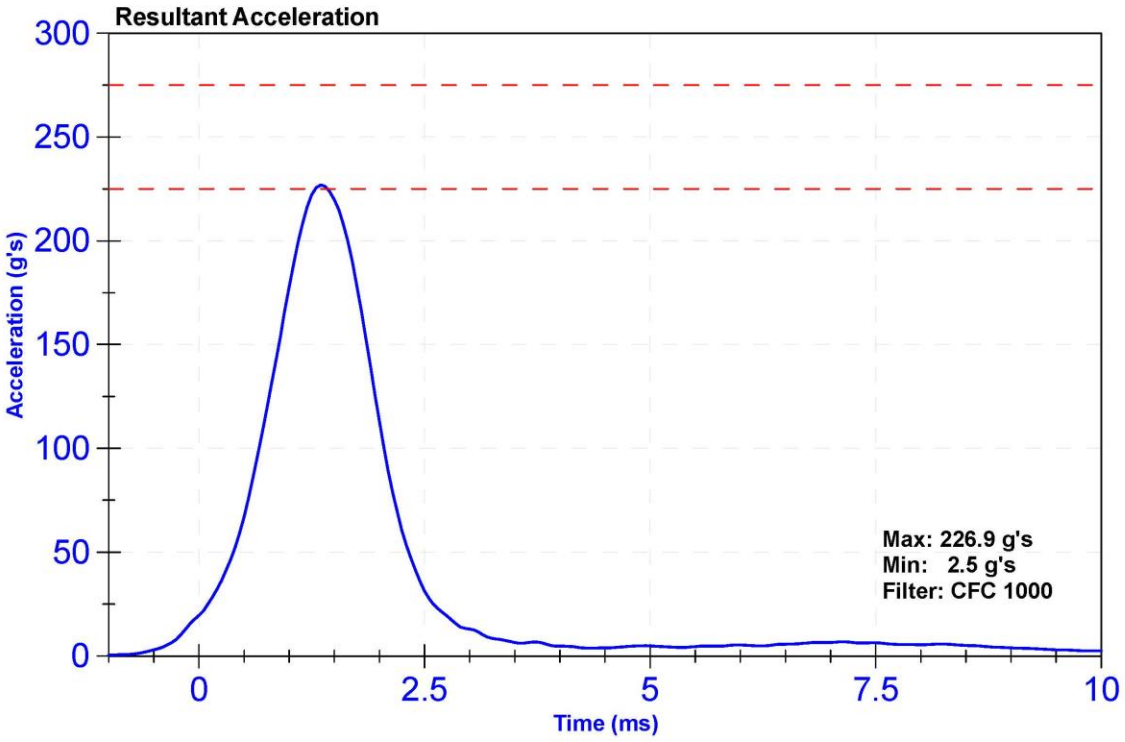
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

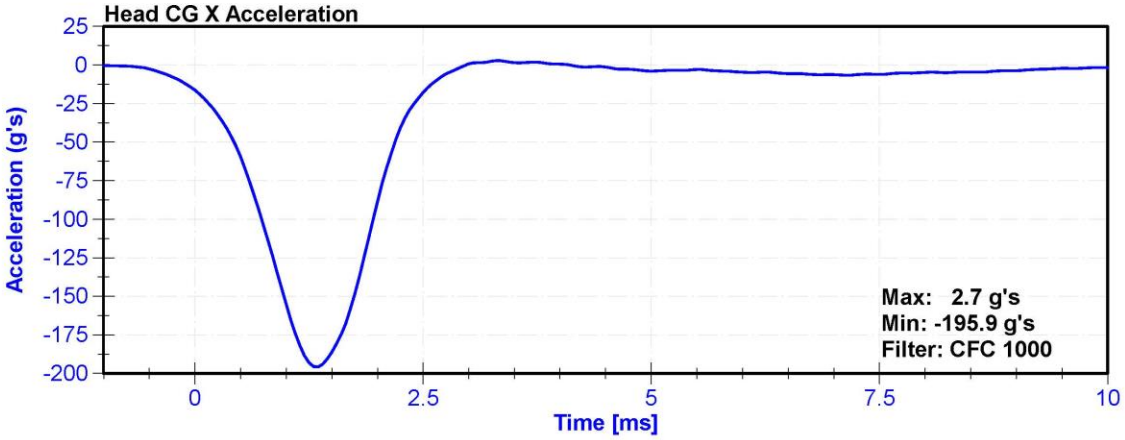
Results

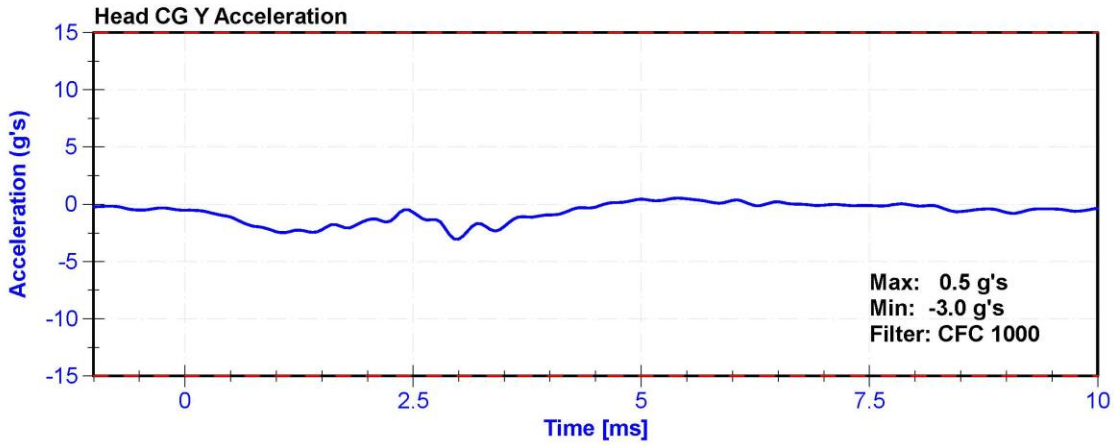
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.7	Pass
Humidity	10	70	%	27.1	Pass
Resultant Acceleration	225	275	g's	226.9	Pass
Oscillation	0	10	%	3.0	Pass
Lateral Acceleration	-15	15	g's	-3.2	Pass

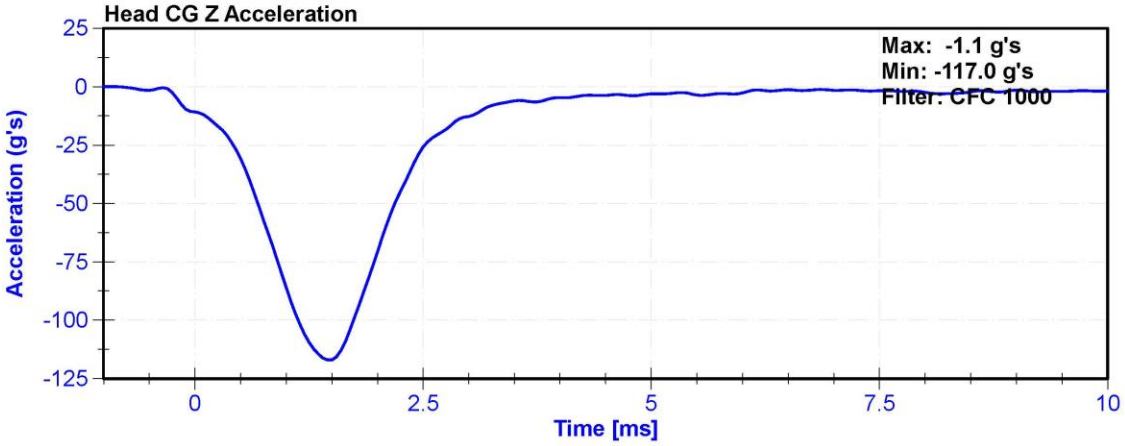
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	Endevco	P51681	8/13/2019	2/13/2020
Y Accelerometer	Endevco	P64151	8/13/2019	2/13/2020
Z Accelerometer	Endevco	P52114	8/13/2019	2/13/2020




Head CG X Acceleration
Acceleration (g's)
25
0
-25
-50
-75
-100
-125
-150
-175
-200
0
2.5
5
7.5
10
Time [ms]
Max: 2.7 g's
Min: -195.9 g's
Filter: CFC 1000


Head CG Y Acceleration
Acceleration (g's)
15
10
5
0
-5
-10
-15
0
2.5
5
7.5
10
Time [ms]
Max: 0.5 g's
Min: -3.0 g's
Filter: CFC 1000


Head CG Z Acceleration
Acceleration (g's)
25
0
-25
-50
-75
-100
-125
0
2.5
5
7.5
10
Time [ms]
Max: -1.1 g's
Min: -117.0 g's
Filter: CFC 1000

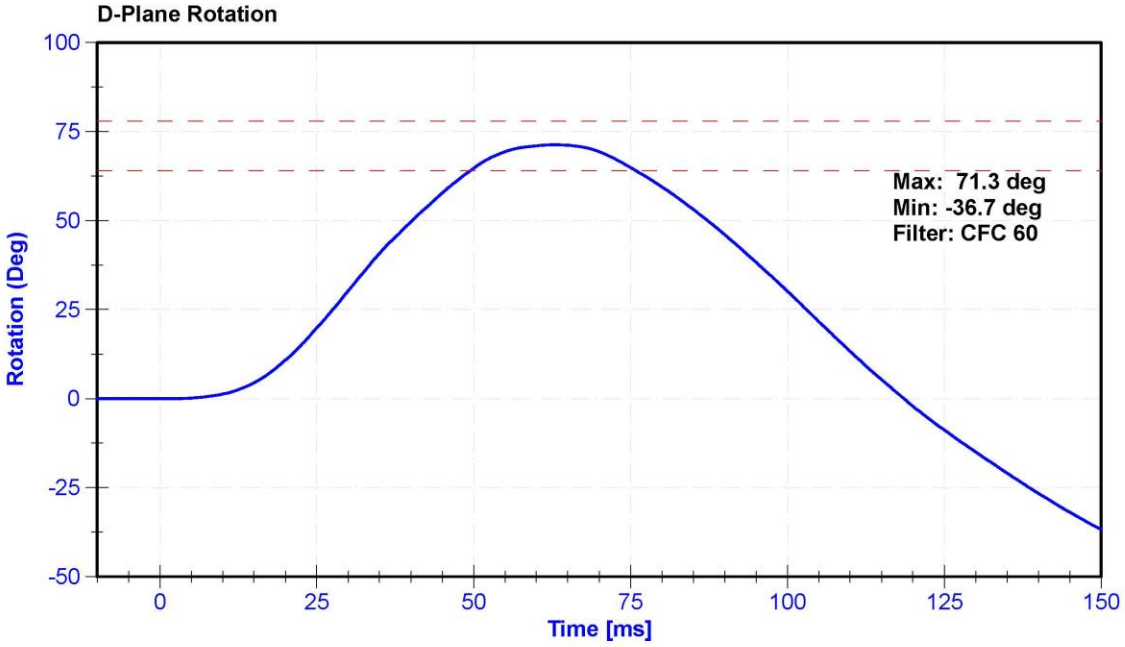
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

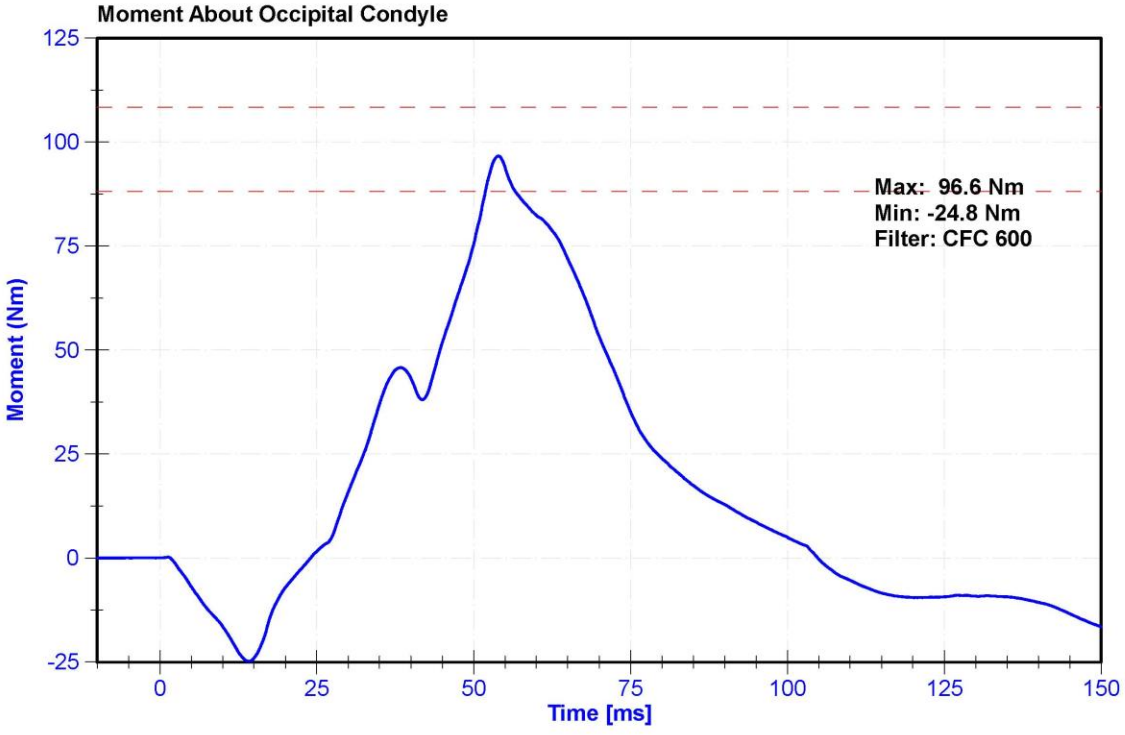
Results

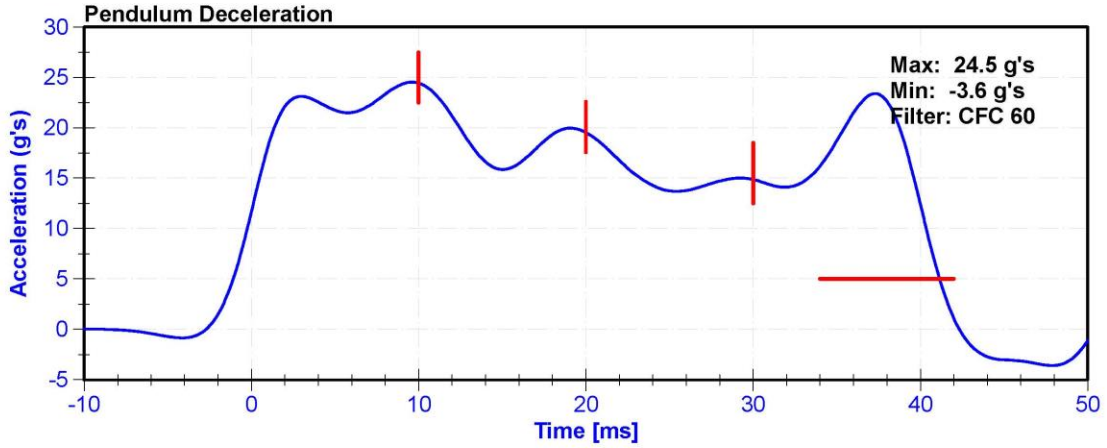
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	25.0	Pass
Velocity	6.89	7.13	m/s	6.903	Pass
Pendulum Deceleration at 10ms	22.5	27.5	g's	24.45	Pass
Pendulum Deceleration at 20ms	17.6	22.6	g's	19.54	Pass
Pendulum Deceleration at 30ms	12.5	18.5	g's	14.87	Pass
Max. Pendulum Deceleration After 30ms	0	29	g's	24.5	Pass
Pendulum Deceleration Time to 5 g's	34	42	ms	41.2	Pass
Maximum D Plane Rotation	64	78	deg	71.3	Pass
Time to Maximum Rotation	57	64	ms	63.0	Pass
Rotation Decay to Zero	113	127	ms	118.6	Pass
Moment About Occipital Condyle	88.1	108.4	Nm	96.62	Pass
Time to Maximum Moment	47	58	ms	54.0	Pass
Moment Decay to Zero	97	107	ms	104.9	Pass

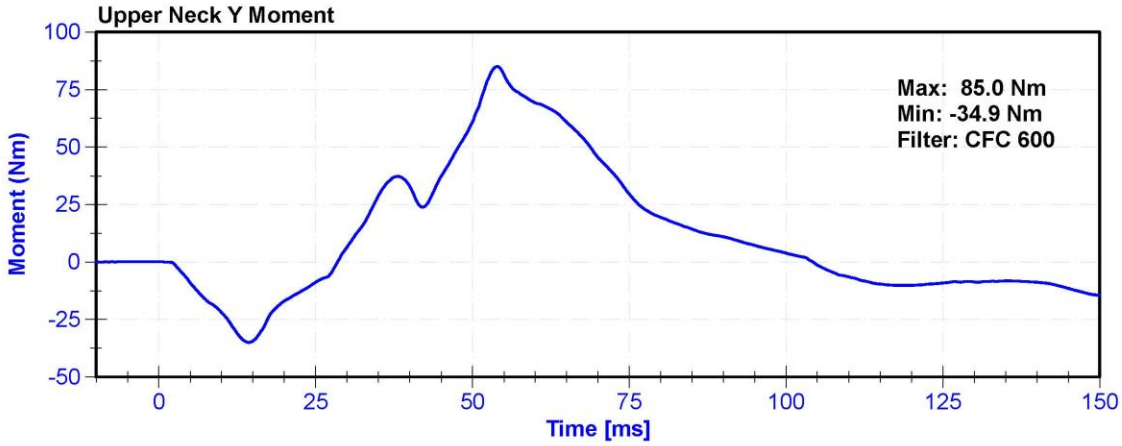
Transducer Calibrations

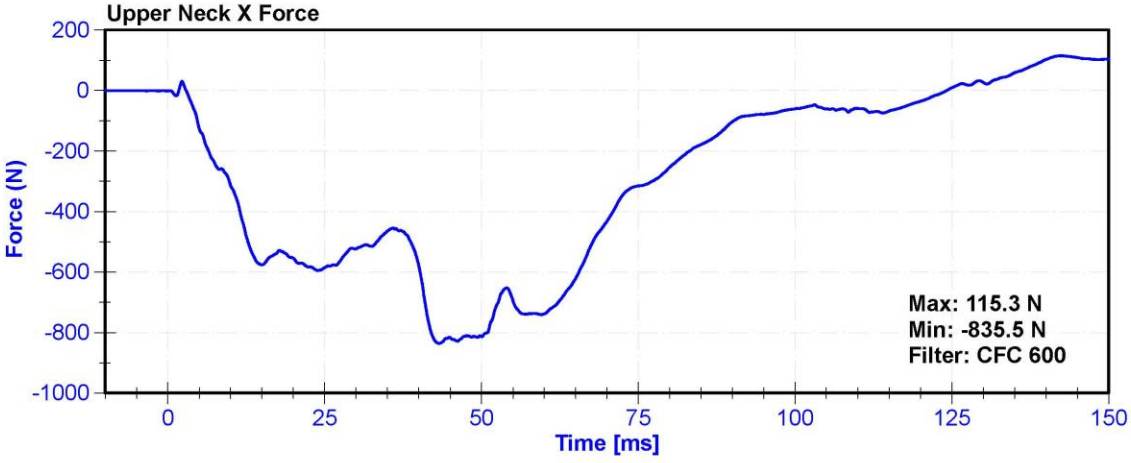
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/29/2019	1/29/2020
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	11/15/2018	11/15/2019
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	11/15/2018	11/15/2019
Upper Neck Load Cell	Denton 1716	17162019 FX	2/18/2019	2/18/2020


D-Plane Rotation
Rotation (Deg)
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 71.3 deg
Min: -36.7 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
125
100
75
50
25
0
-25
0
25
50
75
100
125
150
Time [ms]
Max: 96.6 Nm
Min: -24.8 Nm
Filter: CFC 600


Pendulum Deceleration
Acceleration (g's)
Time [ms]
Max: 24.5 g's
Min: -3.6 g's
Filter: CFC 60


Upper Neck Y Moment
Moment (Nm)
Time [ms]
Max: 85.0 Nm
Min: -34.9 Nm
Filter: CFC 600


Upper Neck X Force
Force (N)
Time [ms]
Max: 115.3 N
Min: -835.5 N
Filter: CFC 600

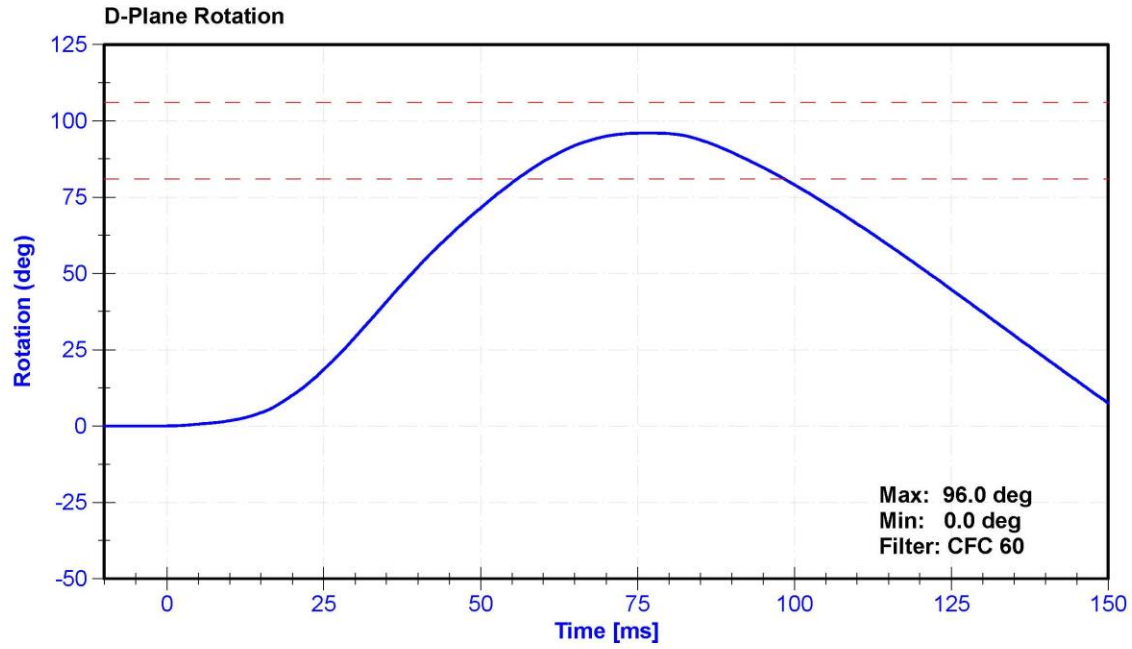
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

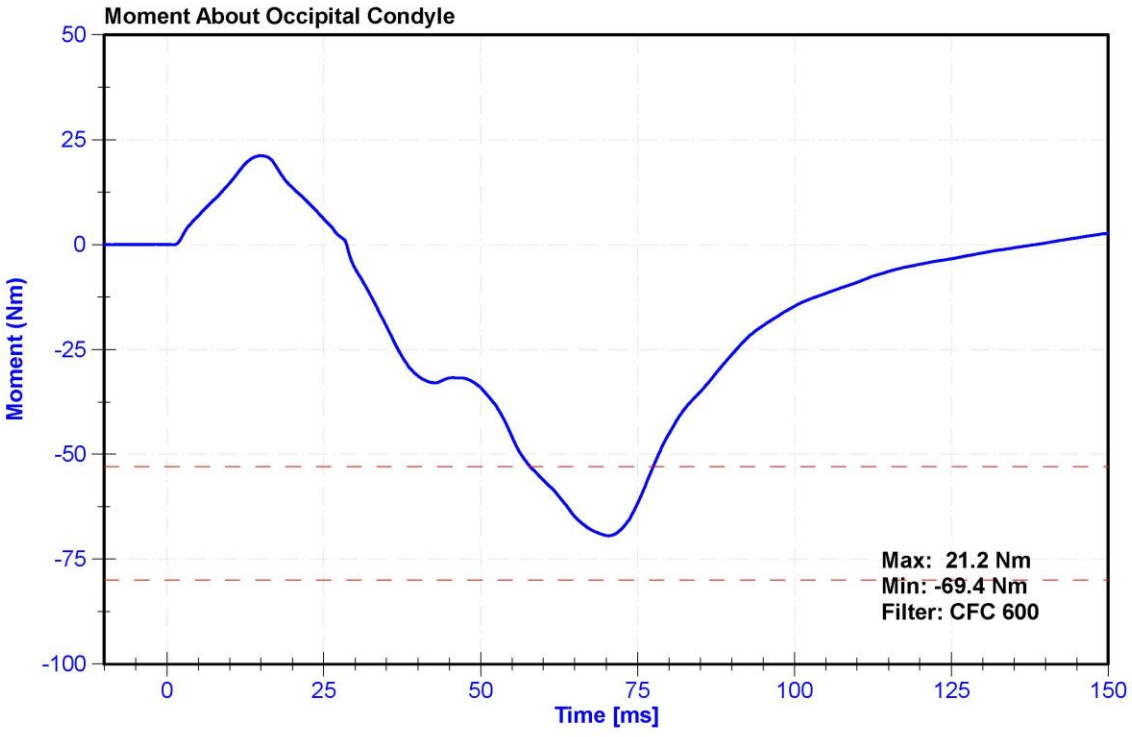
Results

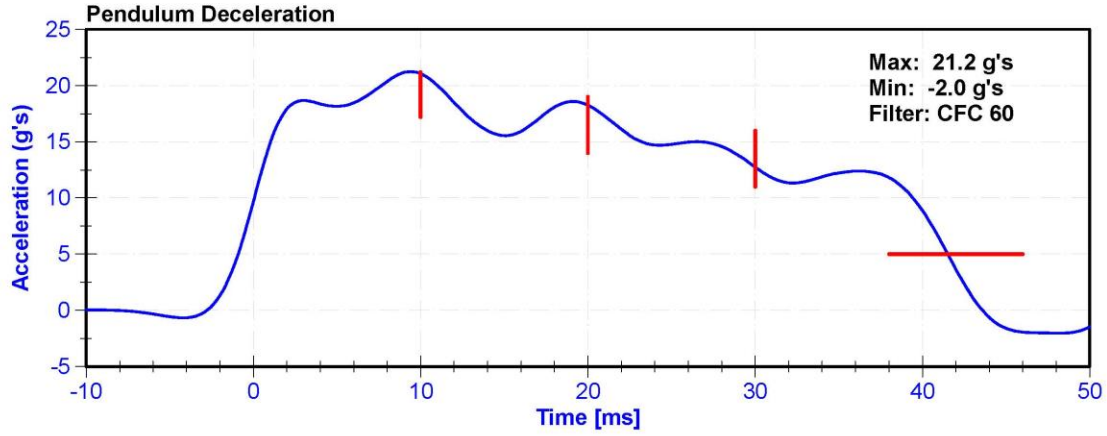
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.6	Pass
Humidity	10	70	%	26	Pass
Velocity	5.94	6.19	m/s	5.964	Pass
Pendulum Deceleration at 10ms	17.2	21.2	g's	21.06	Pass
Pendulum Deceleration at 20ms	14	19	g's	18.3	Pass
Pendulum Deceleration at 30ms	11	16	g's	12.8	Pass
Max. Pendulum Deceleration After 30ms	0	22	g's	21.2	Pass
Pendulum Deceleration Time to 5 g's	38	46	ms	41.5	Pass
Maximum D Plane Rotation	81	106	deg	96.0	Pass
Time to Maximum Rotation	72	82	ms	76.5	Pass
Rotation Decay to Zero	147	174	ms	155.1	Pass
Minimum Moment About OC	-80	-52.9	Nm	-69.39	Pass
Time to Minimum Moment	65	79	ms	70.3	Pass
Moment Decay to Zero	120	148	ms	138.6	Pass

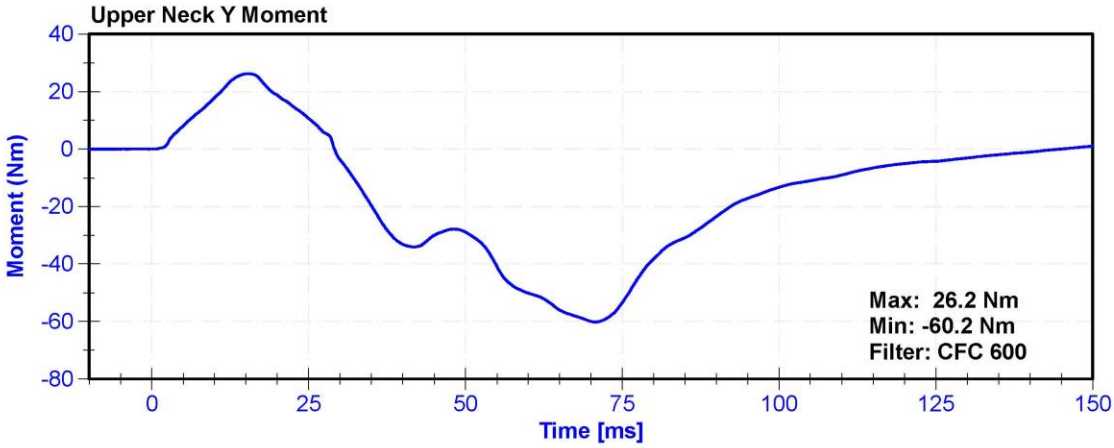
Transducer Calibrations

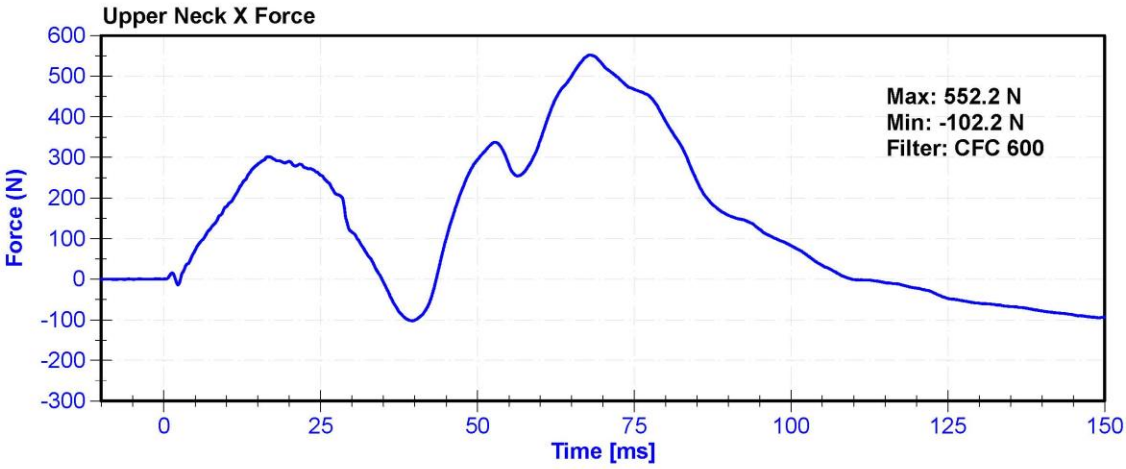
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/29/2019	1/29/2020
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	11/15/2018	11/15/2019
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	11/15/2018	11/15/2019
Upper Neck Load Cell	Denton 1716	17162019 FX	2/18/2019	2/18/2020


D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 96.0 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: 21.2 Nm
Min: -69.4 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 21.2 g's
Min: -2.0 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 26.2 Nm
Min: -60.2 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 552.2 N
Min: -102.2 N
Filter: CFC 600
Force (N)
Time [ms]

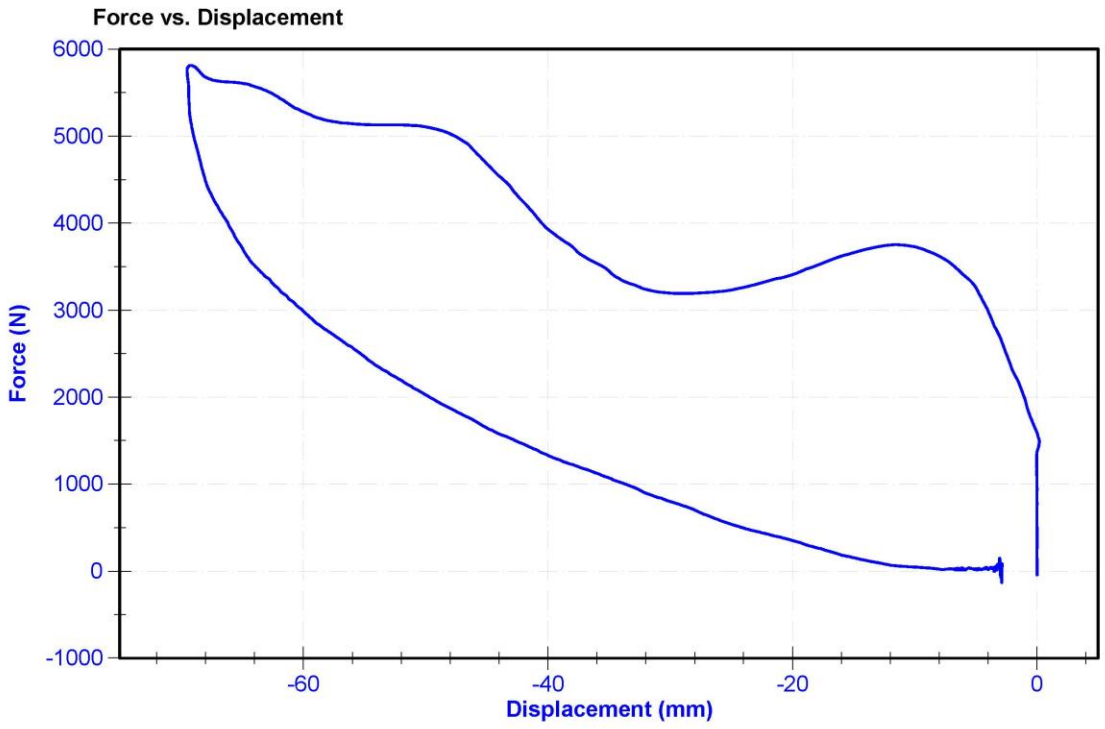
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K.Brogan

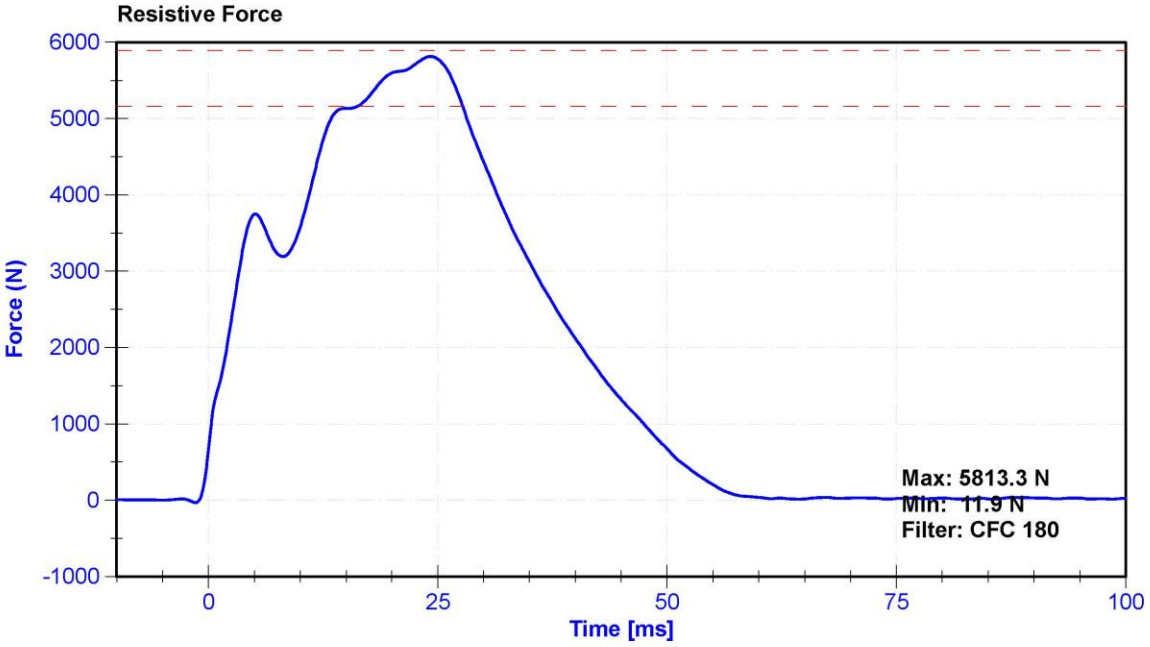
Results

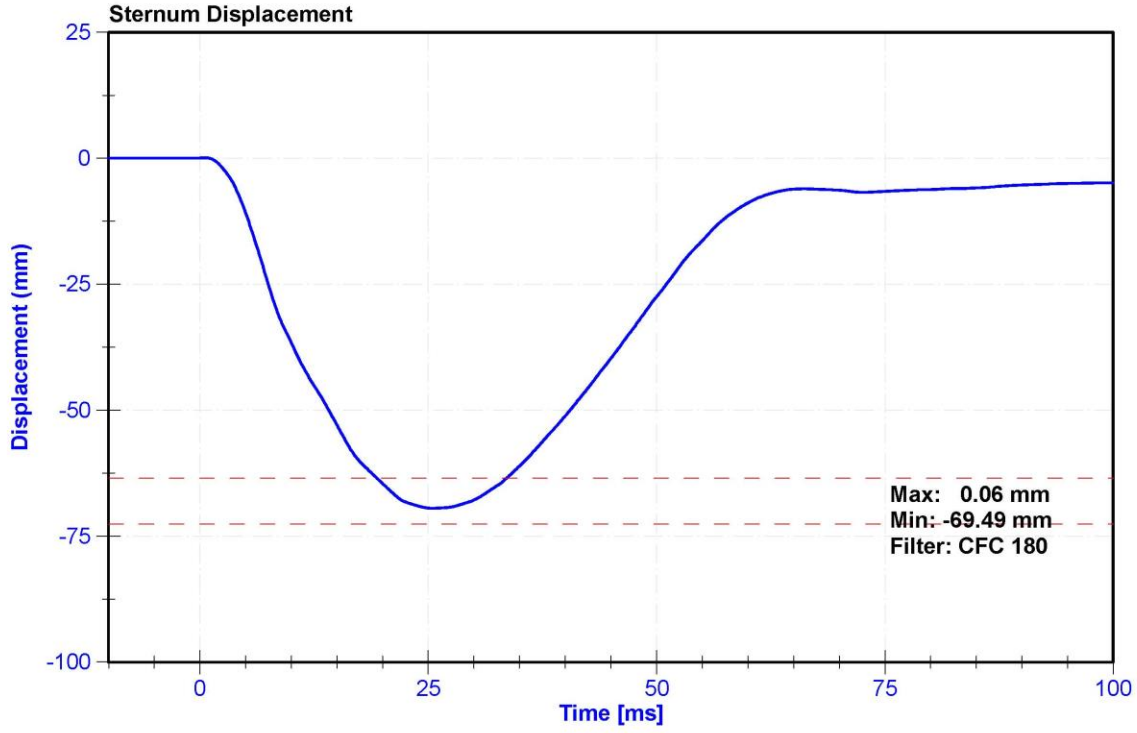
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	36.1	Pass
Velocity	6.59	6.83	m/s	6.758	Pass
Chest Displacement	-72.6	-63.5	mm	-69.49	Pass
Resistive Force	5160	5894	N	5813.3	Pass
Hysteresis	65	85	%	66.4	Pass

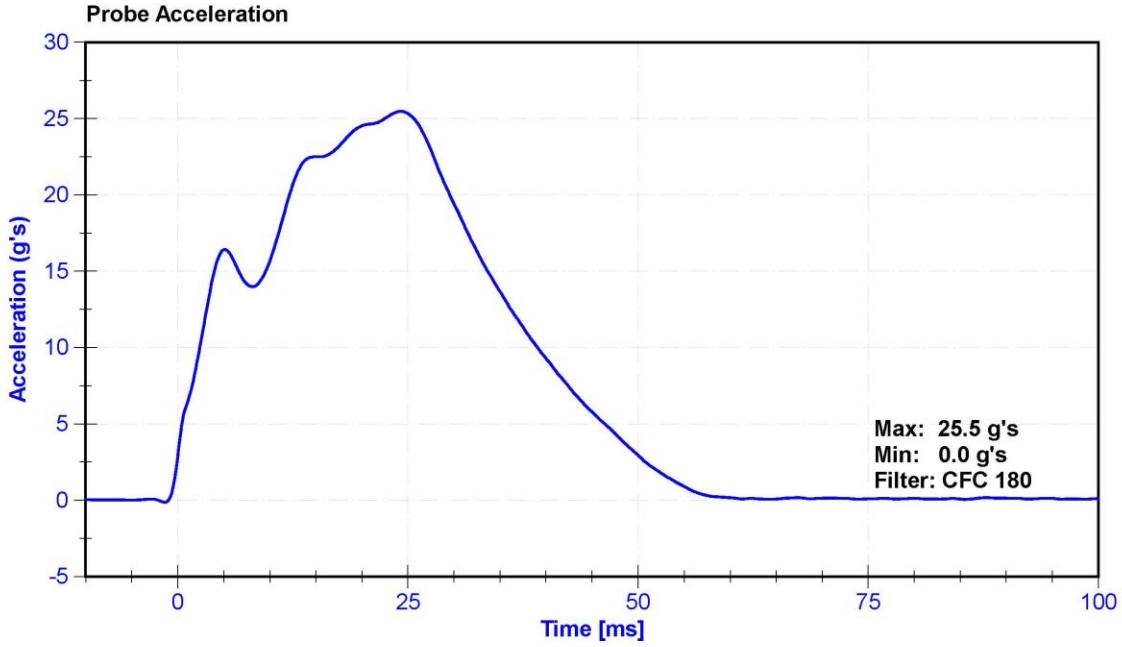
Transducer Calibrations

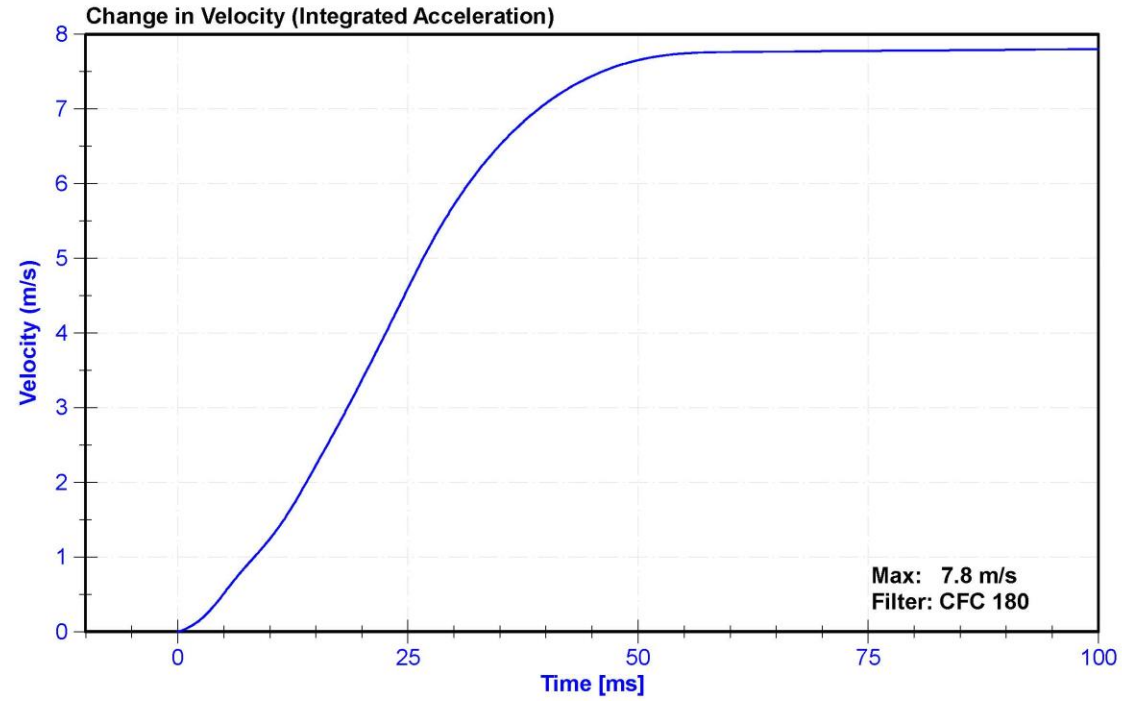
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260487	8/22/2019	2/20/2020
Chest Potentiometer	JDK 6209-2038	DS-142	9/12/2019	9/11/2020




Resistive Force
Force (N)
6000
5000
4000
3000
2000
1000
0
-1000
0
25
50
75
100
Time [ms]
Max: 5813.3 N
Min: 11.9 N
Filter: CFC 180


Sternum Displacement
Displacement (mm)
25
0
-25
-50
-75
-100
0
25
50
75
100
Time [ms]
Max: 0.06 mm
Min: -69.49 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
30
25
20
15
10
5
0
-5
0
25
50
75
100
Time [ms]
Max: 25.5 g's
Min: 0.0 g's
Filter: CFC 180


Change in Velocity (Integrated Acceleration)
Velocity (m/s)
8
7
6
5
4
3
2
1
0
0
25
50
75
100
Time [ms]
Max: 7.8 m/s
Filter: CFC 180

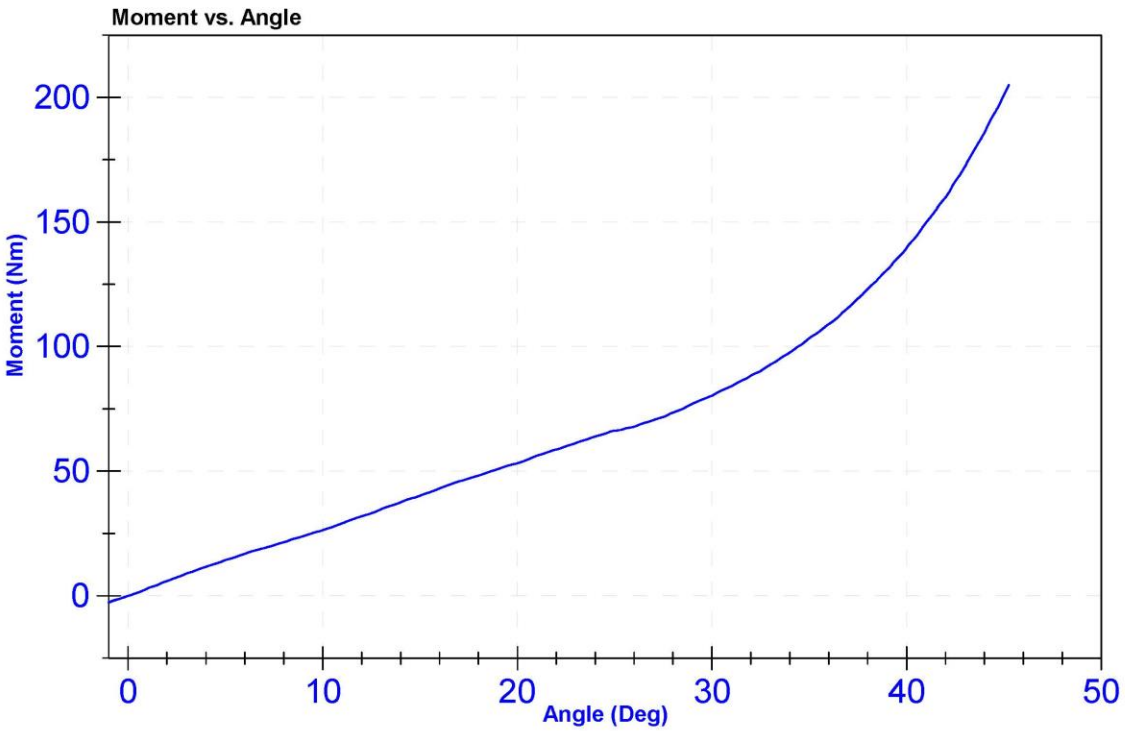
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.7	Pass
Humidity	10	70	%	21.4	Pass
Average Velocity	5	10	deg/s	7.2	Pass
Angle at 203Nm	40	50	deg	45.1	Pass
Moment at 30 degrees	0	94.9	Nm	80.4	Pass

Transducer Calibrations

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



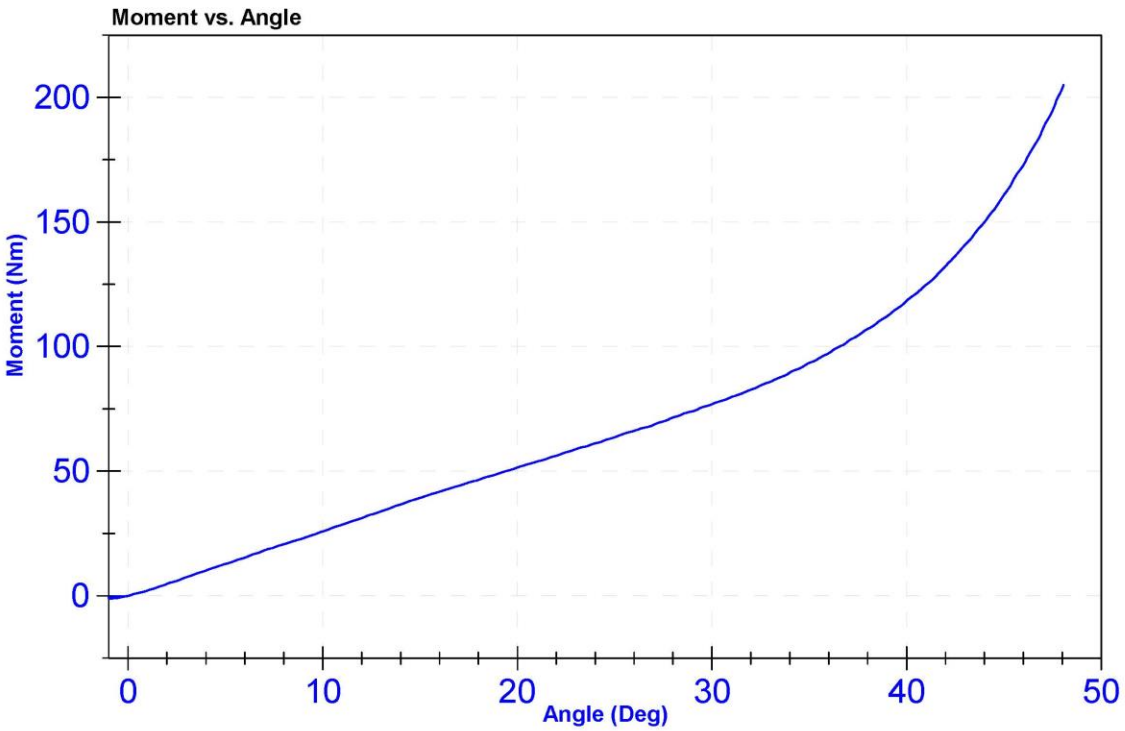
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.4	Pass
Humidity	10	70	%	21.4	Pass
Average Velocity	5	10	deg/s	7.3	Pass
Angle at 203Nm	40	50	deg	48.0	Pass
Moment at 30 degrees	0	94.9	Nm	76.9	Pass

Transducer Calibrations

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



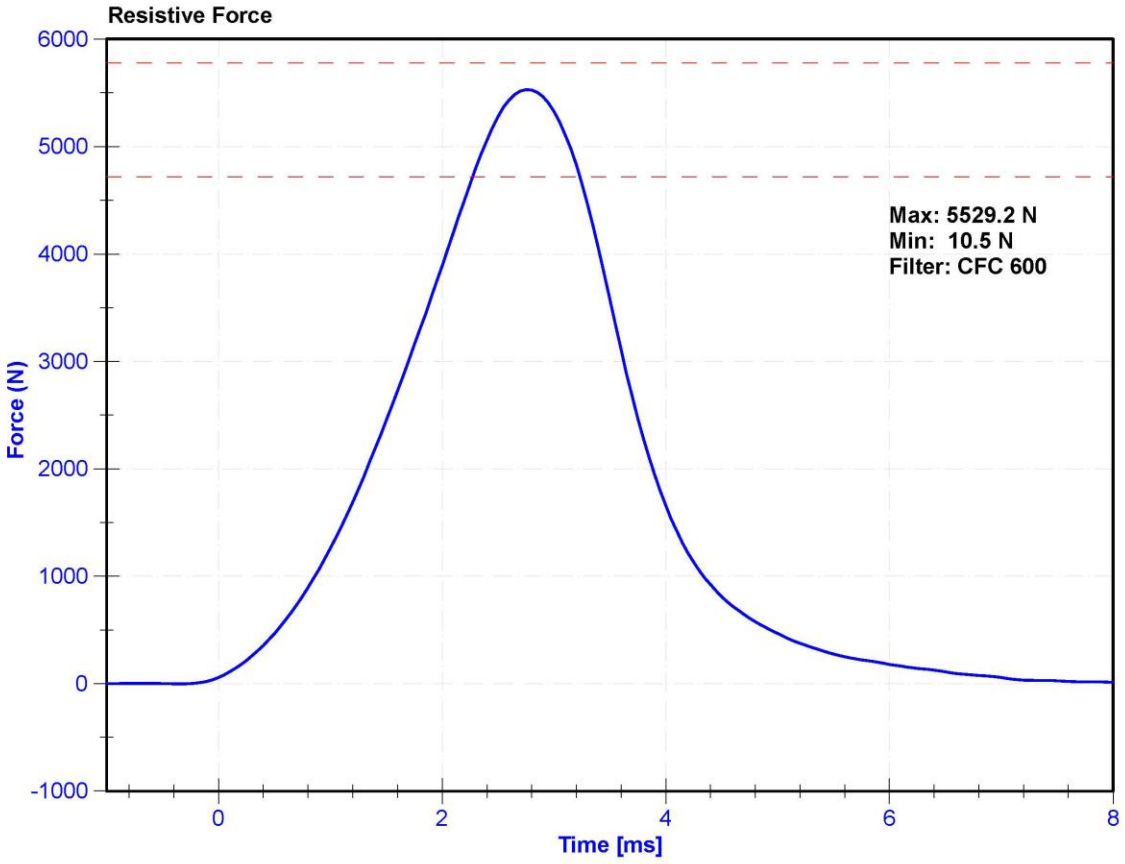
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K.Brogan

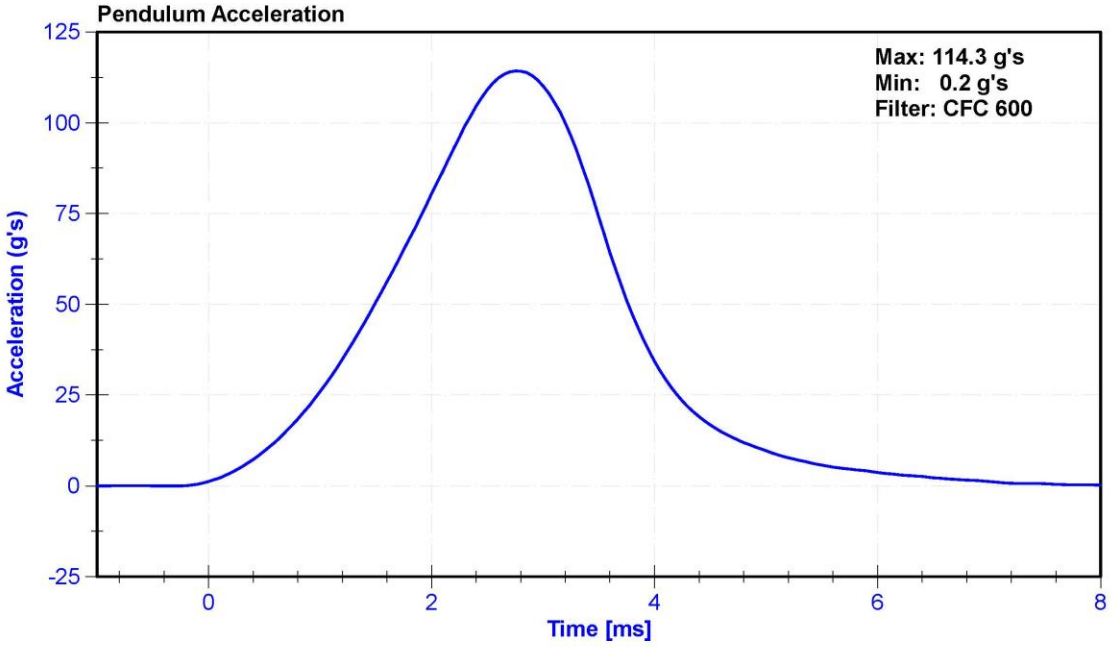
Results

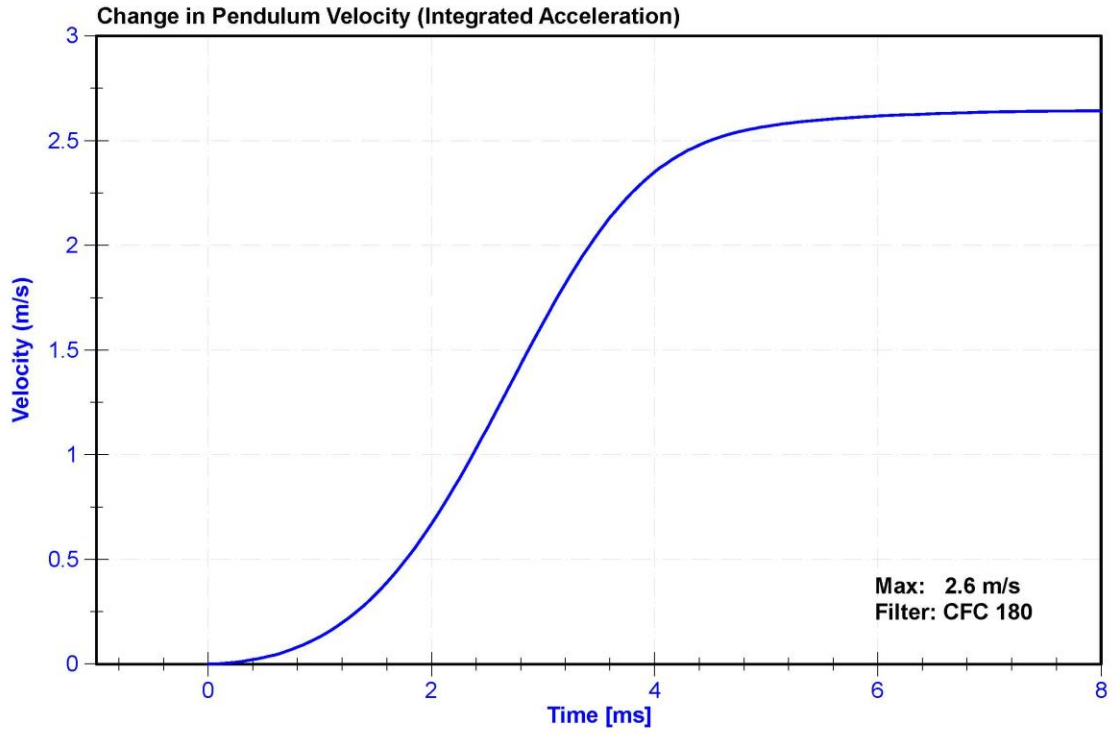
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21	Pass
Humidity	10	70	%	26	Pass
Velocity	2.07	2.13	m/s	2.112	Pass
Maximum Resistive Force	4720	5780	N	5529.2	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	7/29/2019	1/27/2020




Pendulum Acceleration
Max: 114.3 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)
Max: 2.6 m/s
Filter: CFC 180
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]

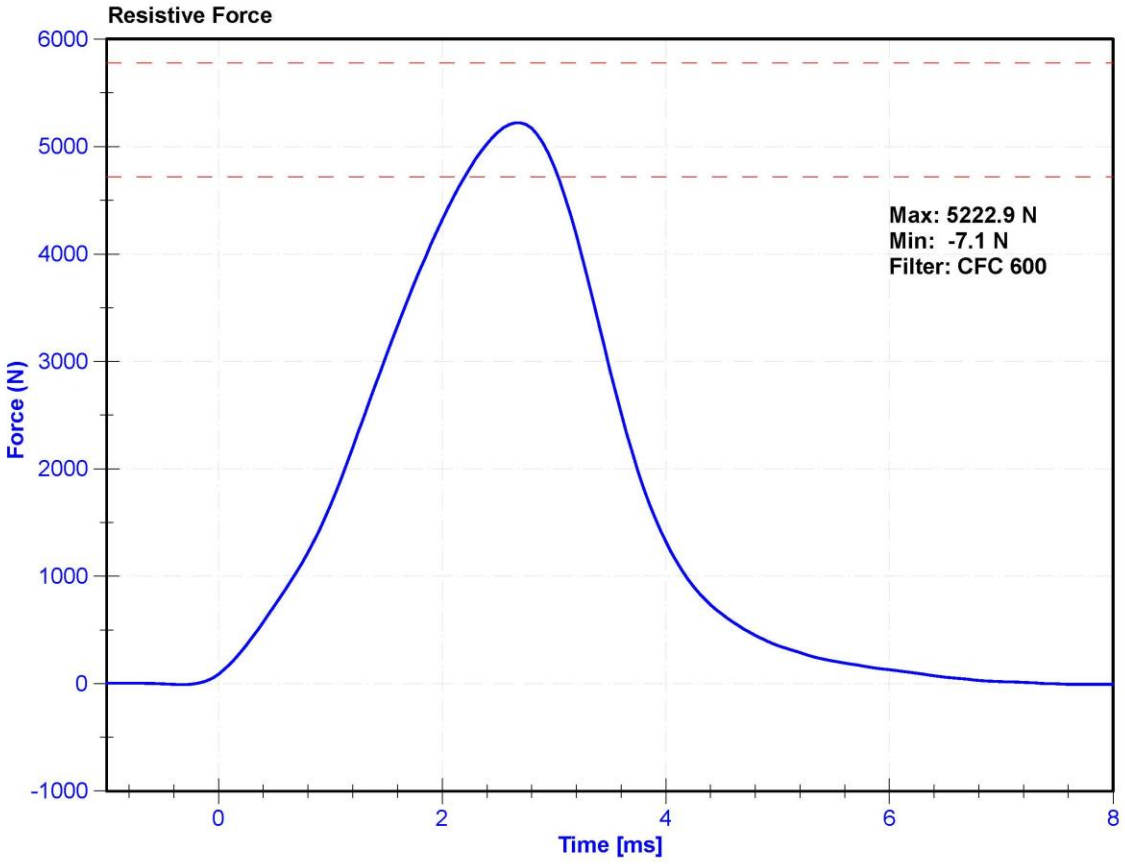
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K.Brogan

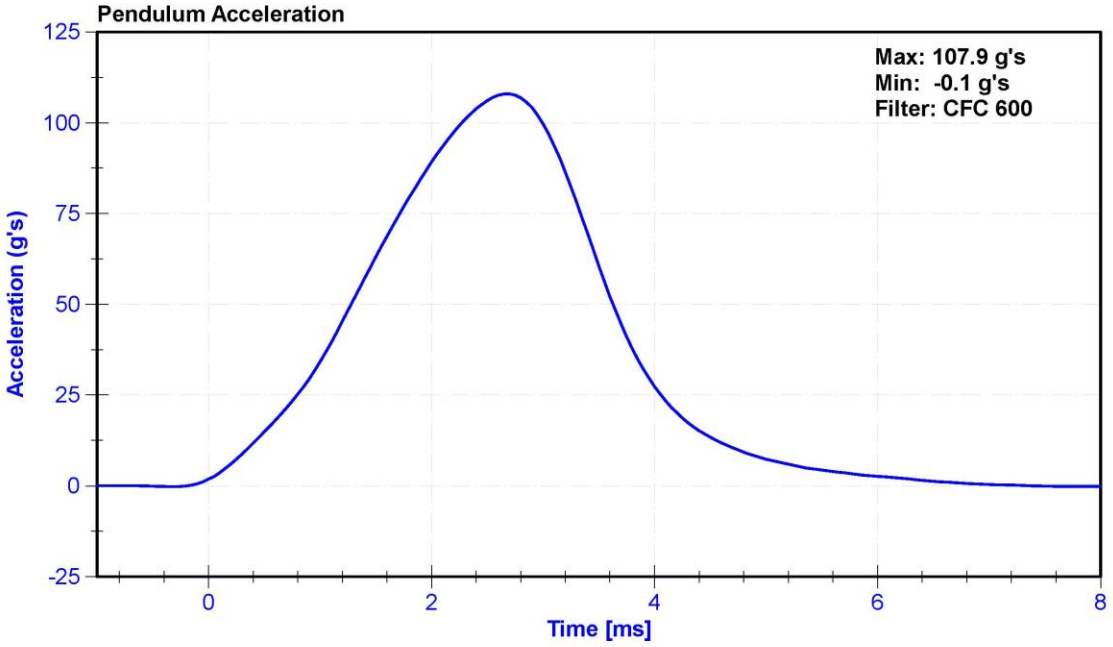
Results

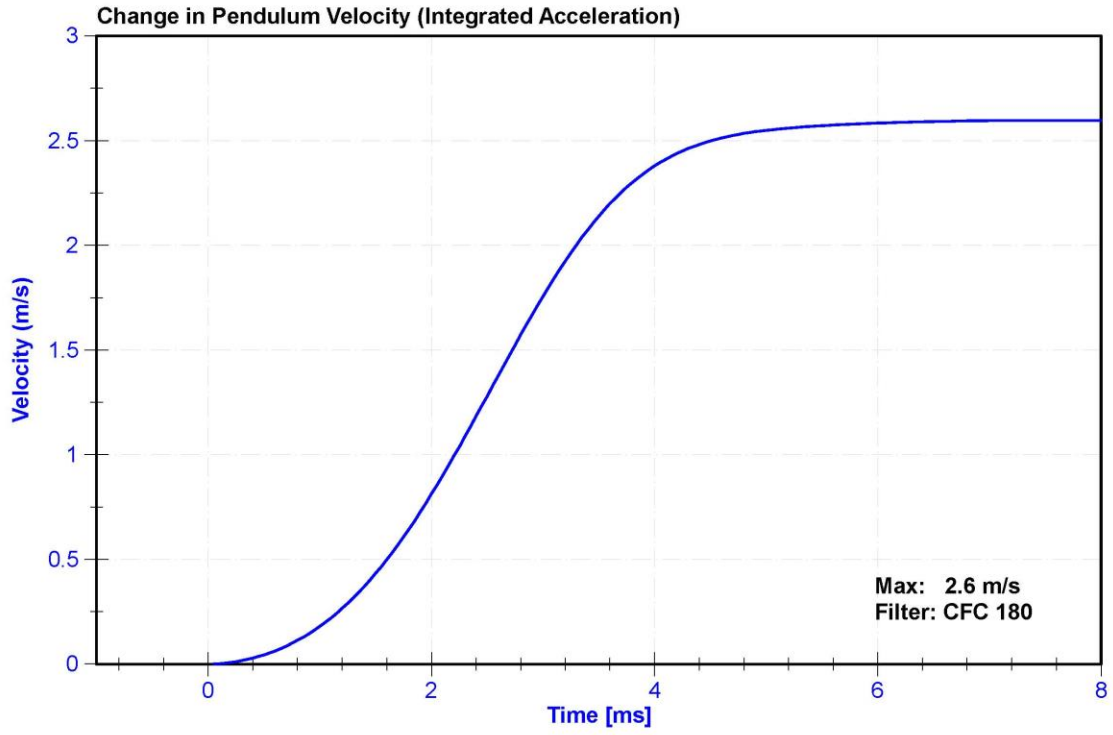
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21	Pass
Humidity	10	70	%	26	Pass
Velocity	2.07	2.13	m/s	2.111	Pass
Maximum Resistive Force	4720	5780	N	5222.9	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	7/29/2019	1/27/2020




Pendulum Acceleration
Max: 107.9 g's
Min: -0.1 g's
Filter: CFC 600
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]


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

CALIBRATION TEST RESULTS

PRE-TEST

HYBRID III 5TH PERCENTILE - PASSENGER ATD

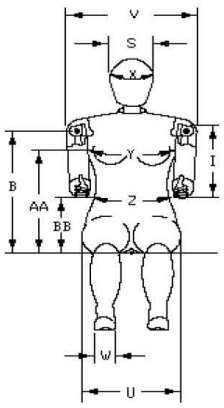
SERIAL NO: 140

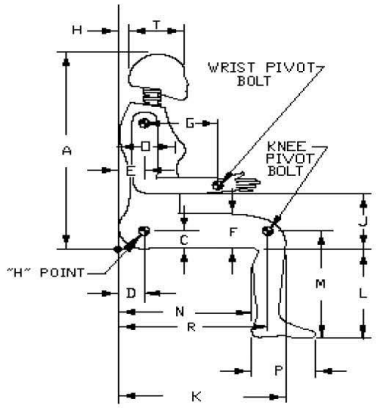
Calspan

External Measurements - Hybrid 3 - 5th Female

Technician: K. Brogan Date: 11/12/2019

Dummy Serial Number: 140





Symbol	Description	Specification (mm)		Result (mm)	Pass/Fail
A	Sitting Height	775	800	791	Pass
B	Shoulder Pivot Height	432	457	442	Pass
C	H-Point Height	81	86	84	Pass
D	H-Point from Backline	145	150	147	Pass
E	Shoulder Pivot from Backline	69	84	74	Pass
F	Thigh Clearance	119	135	126	Pass
G	Back of Elbow to Wrist Pivot	244	259	250	Pass
H	Head Back to Backline	43	48	45	Pass
I	Shoulder to Elbow Length	277	297	290	Pass
J	Elbow Rest Height	183	203	194	Pass
K	Buttock to Knee Length	521	546	535	Pass
L	Popliteal Height	356	376	366	Pass
M	Knee Pivot Height	394	419	409	Pass
N	Buttock Popliteal Length	414	439	428	Pass
O	Chest Depth without Jacket	175	191	182	Pass
P	Foot Length (right)	219	234	228	Pass
R	Buttock To Knee Pivot Length	457	483	467	Pass
S	Head Breadth	137	147	142	Pass
T	Head Depth	178	188	180	Pass
U	Hip Breadth	300	315	313	Pass
V	Shoulder Breadth	351	366	361	Pass
W	Foot Breadth	79	94	83	Pass
X	Head Circumference	528	549	540	Pass
Y	Chest Circumference with Jacket	851	881	874	Pass
Z	Waist Circumference	460	790	624	Pass
AA	Reference Location (Chest Circumference)	333	358	345	Pass
BB	Reference Location (Waist Circumference)	160	170	165	Pass

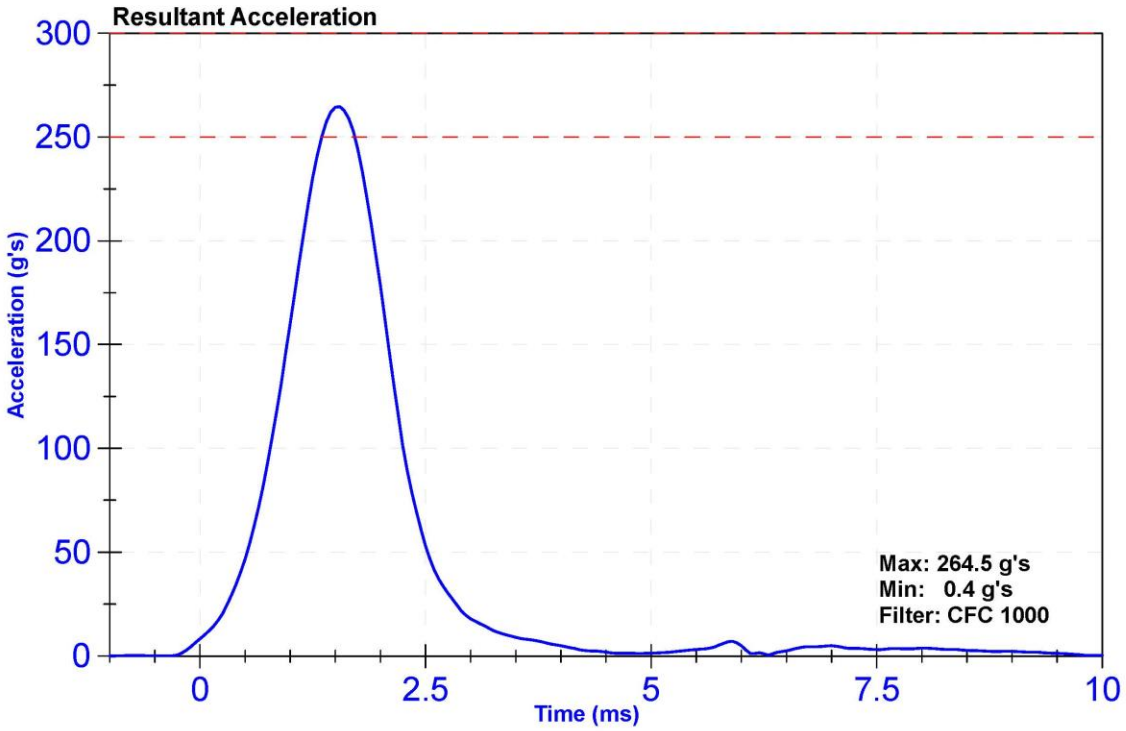
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

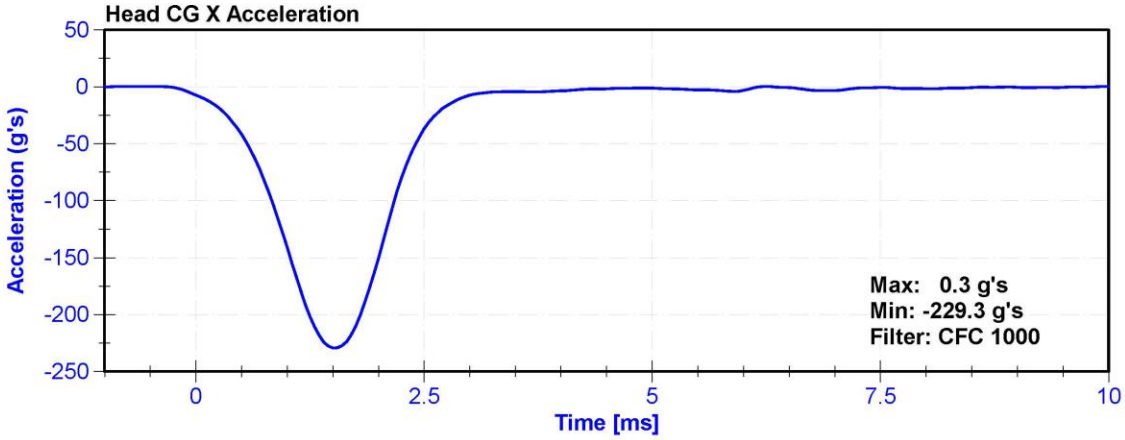
Results

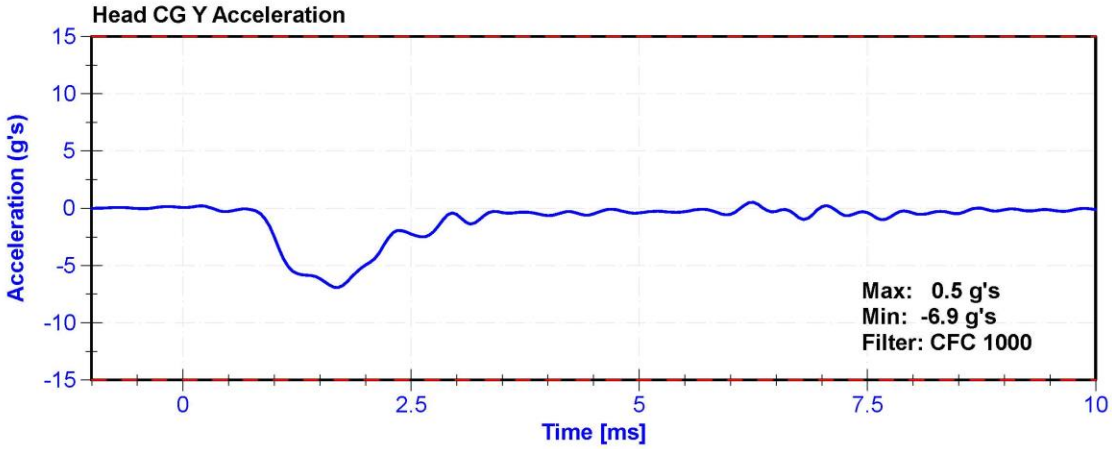
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.7	Pass
Humidity	10	70	%	27.1	Pass
Resultant Acceleration	250	300	g's	264.5	Pass
Oscillation	0	10	%	2.6	Pass
Lateral Acceleration	-15	15	g's	-6.9	Pass

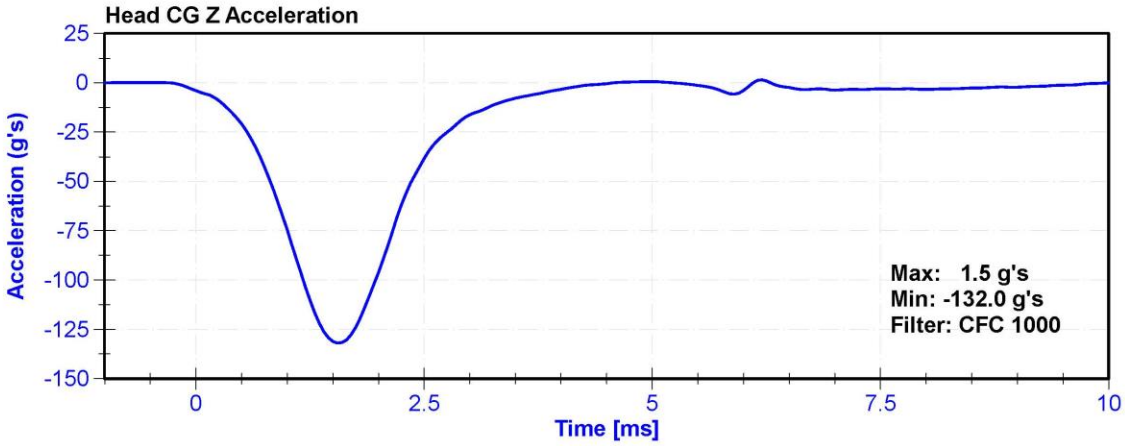
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	Endevco	P58998	9/30/2019	3/30/2020
Y Accelerometer	Endevco	P51722	9/30/2019	3/30/2020
Z Accelerometer	Endevco	P58997	9/30/2019	3/30/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 0.3 g's
Min: -229.3 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: 0.5 g's
Min: -6.9 g's
Filter: CFC 1000


Head CG Z Acceleration
Acceleration (g's)
25
0
-25
-50
-75
-100
-125
-150
0
2.5
5
7.5
10
Time [ms]
Max: 1.5 g's
Min: -132.0 g's
Filter: CFC 1000

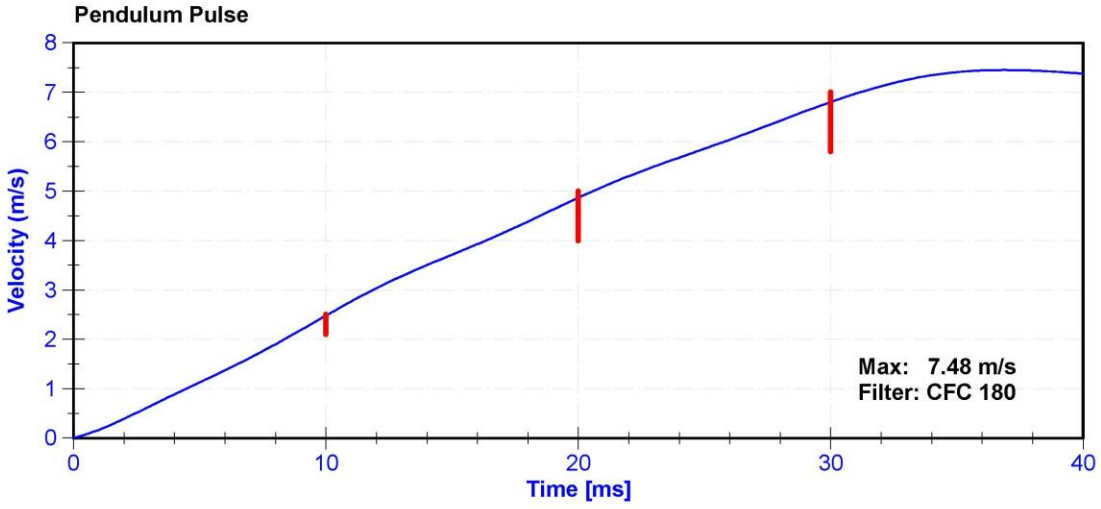
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

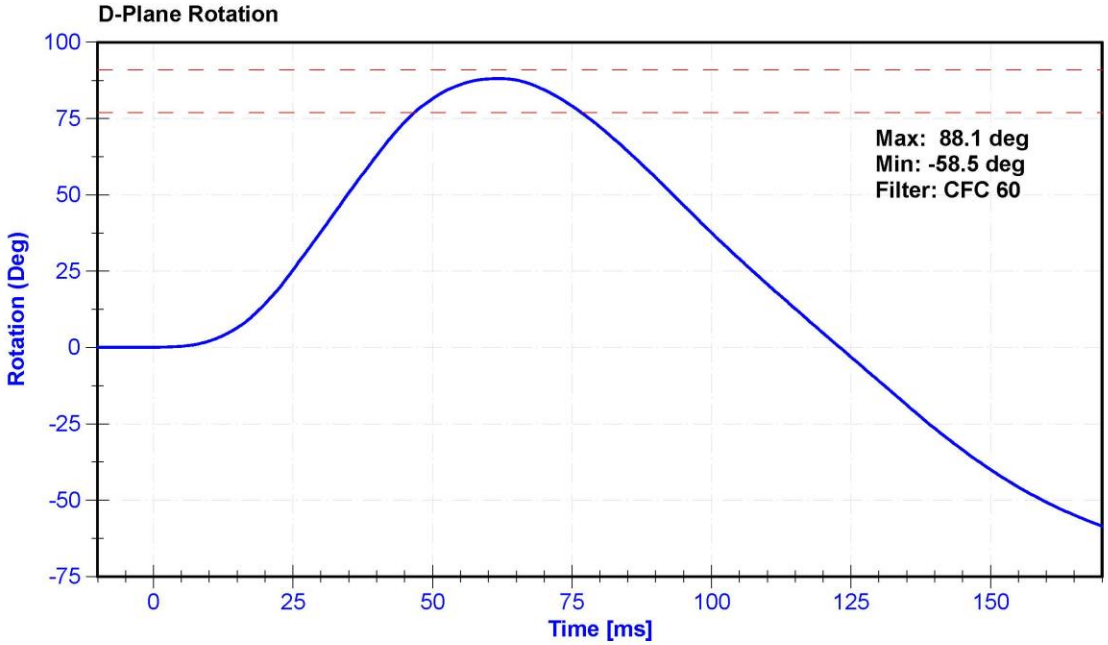
Results

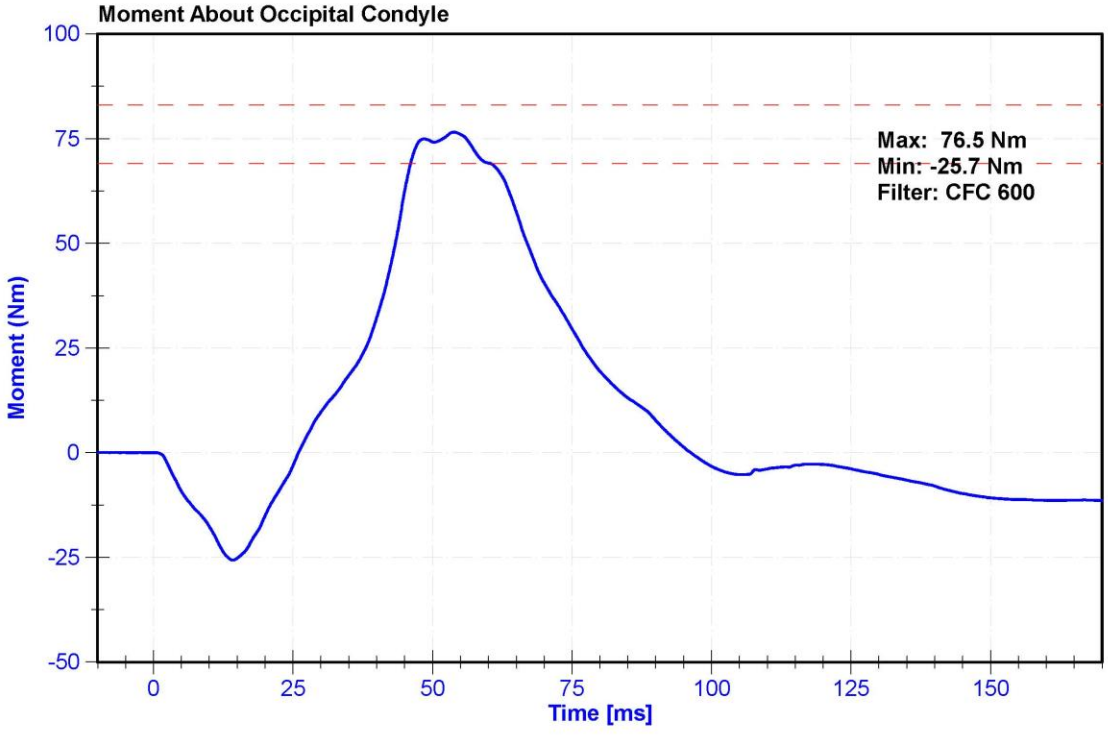
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	21.0	Pass
Velocity	6.89	7.13	m/s	7.013	Pass
Pendulum Impulse at 10ms	2.1	2.5	m/s	2.48	Pass
Pendulum Impulse at 20ms	4.0	5.0	m/s	4.87	Pass
Pendulum Impulse at 30ms	5.8	7.0	m/s	6.80	Pass
Max D Plane Rotation	77	91	deg	88.1	Pass
Max Moment During Rotation Interval	69	83	Nm	76.5	Pass
Moment Decay to 10.0 Nm	80	100	ms	88.4	Pass

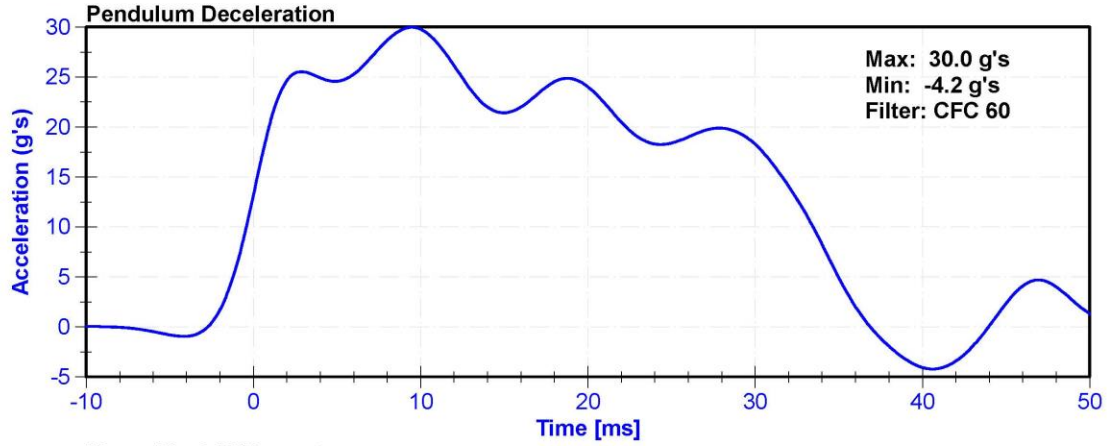
Transducer Calibrations

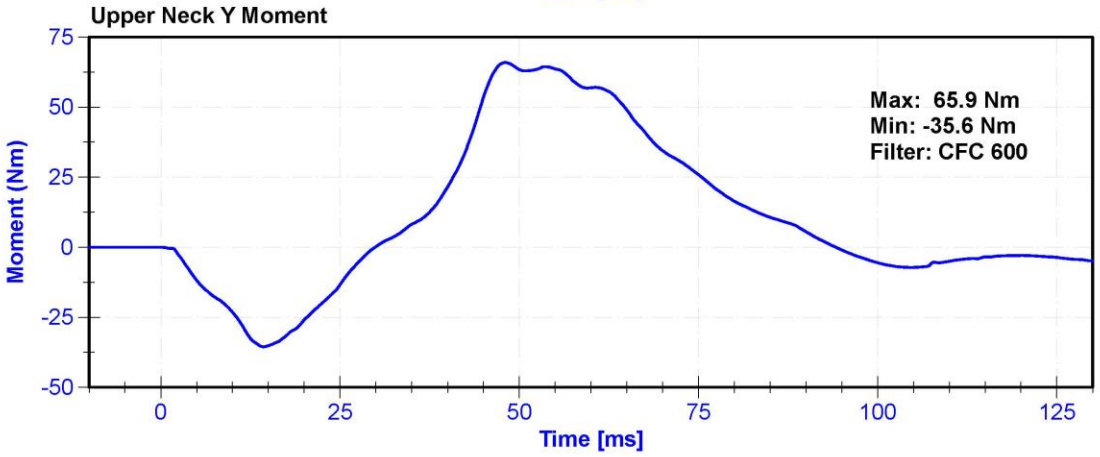
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/29/2019	1/29/2020
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	11/15/2018	11/15/2019
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	11/15/2018	11/15/2019
Upper Neck Load Cell	DENTON 1716A	LC-2206Fx	2/18/2019	2/18/2020

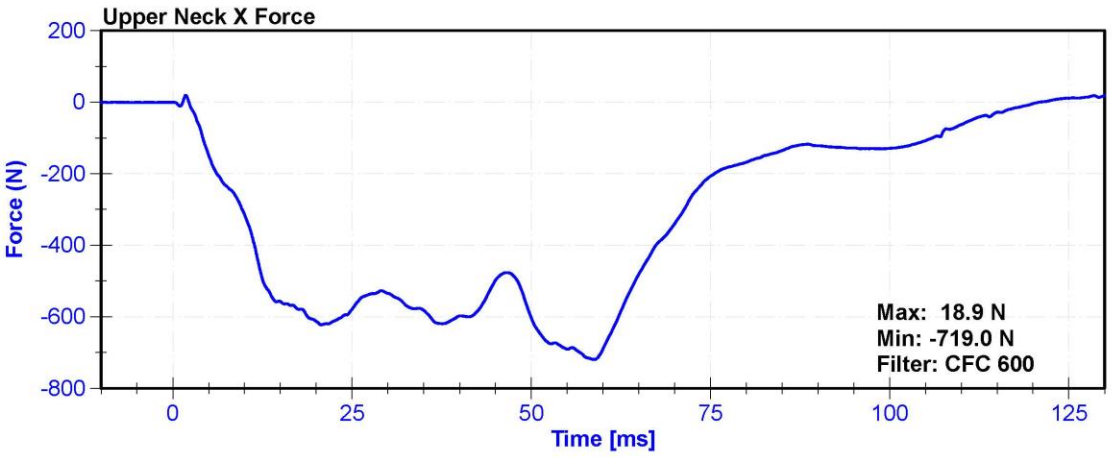



D-Plane Rotation
Max: 88.1 deg
Min: -58.5 deg
Filter: CFC 60
Rotation (Deg)
Time [ms]
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150


Moment About Occipital Condyle
Max: 76.5 Nm
Min: -25.7 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: 30.0 g's
Min: -4.2 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 65.9 Nm
Min: -35.6 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 18.9 N
Min: -719.0 N
Filter: CFC 600
Force (N)
Time [ms]

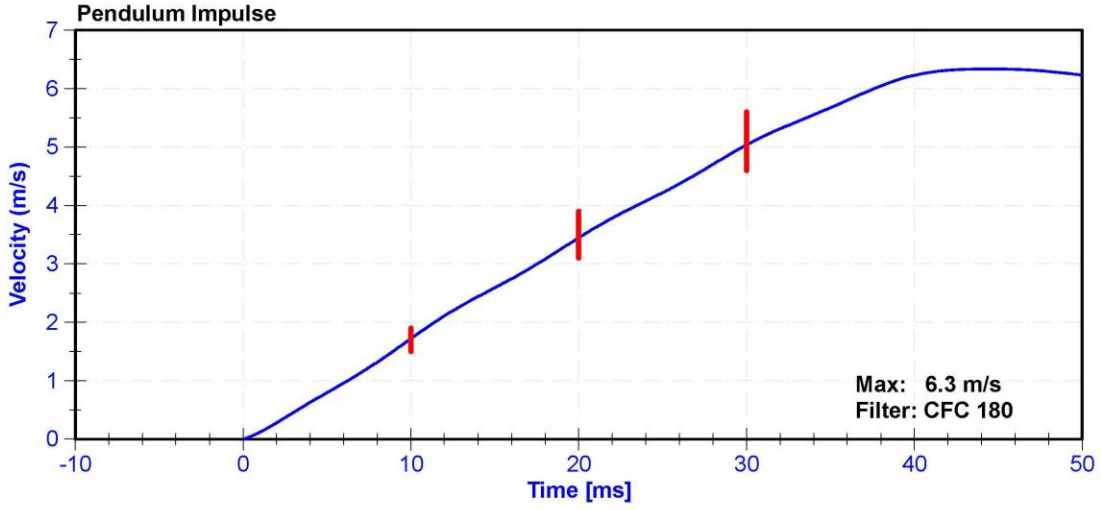
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

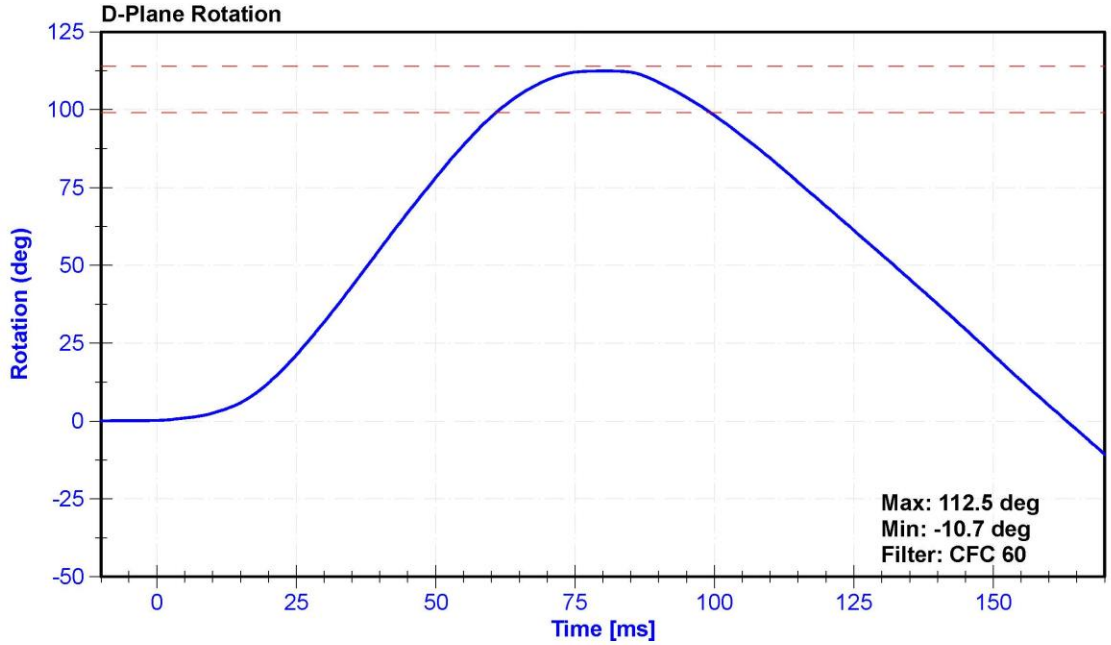
Results

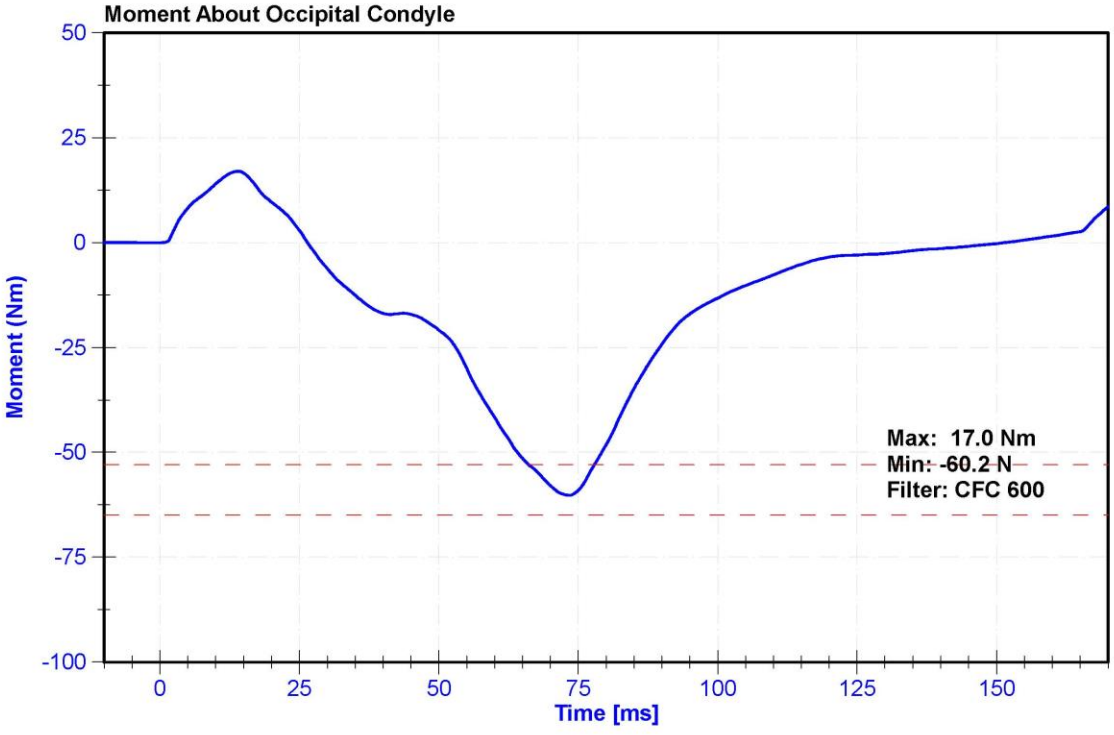
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.2	Pass
Humidity	10	70	%	22.0	Pass
Velocity	5.95	6.19	m/s	6.046	Pass
Pendulum Impulse at 10ms	1.5	1.9	m/s	1.72	Pass
Pendulum Impulse at 20ms	3.1	3.9	m/s	3.45	Pass
Pendulum Impulse at 30ms	4.6	5.6	m/s	5.04	Pass
D Plane Rotation	99	114	deg	112.5	Pass
Moment During Rotation Interval	-65	-53	Nm	-60.2	Pass
Moment Decay to -10Nm	94	114	ms	105.6	Pass

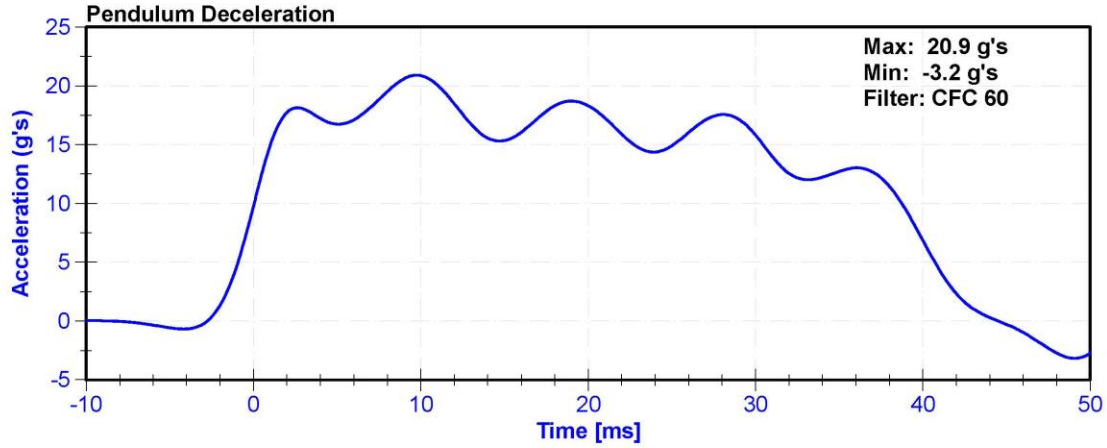
Transducer Calibrations

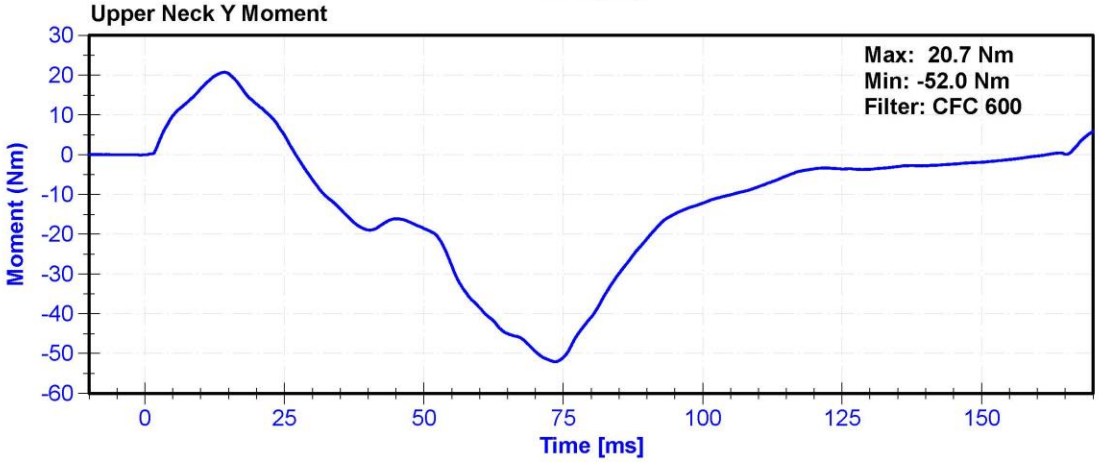
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/29/2019	1/29/2020
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	11/15/2018	11/15/2019
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	11/15/2018	11/15/2019
Upper Neck Load Cell	DENTON 1716A	LC-2206My	2/18/2019	2/18/2020

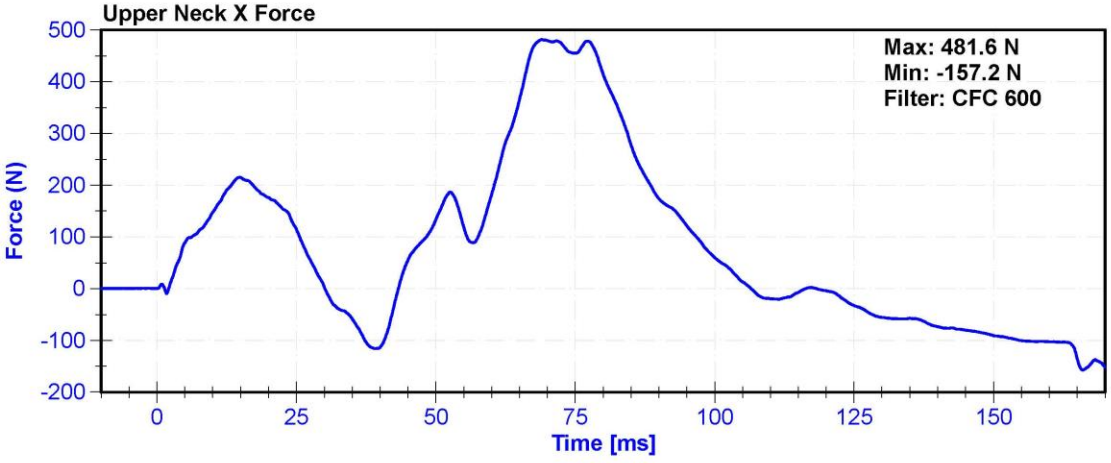



D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 112.5 deg
Min: -10.7 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
50
25
0
-25
-50
-75
-100
0
25
50
75
100
125
150
Time [ms]
Max: 17.0 Nm
Min: -60.2 N
Filter: CFC 600


Pendulum Deceleration
Max: 20.9 g's
Min: -3.2 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 20.7 Nm
Min: -52.0 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 481.6 N
Min: -157.2 N
Filter: CFC 600
Force (N)
Time [ms]

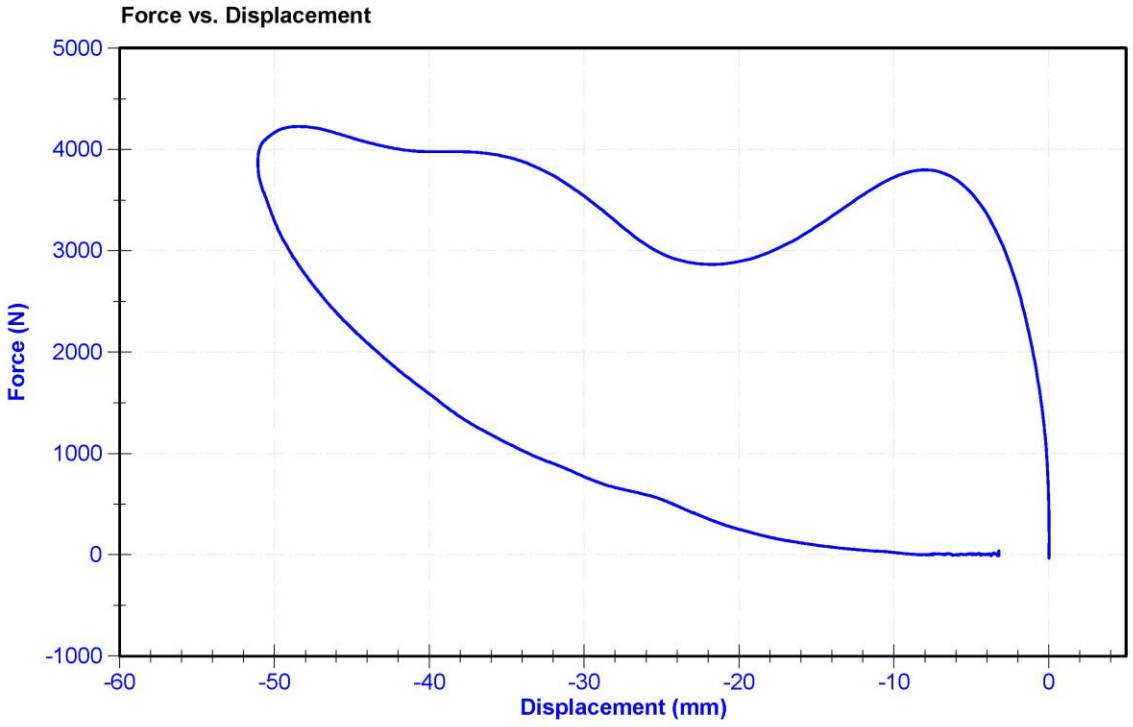
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

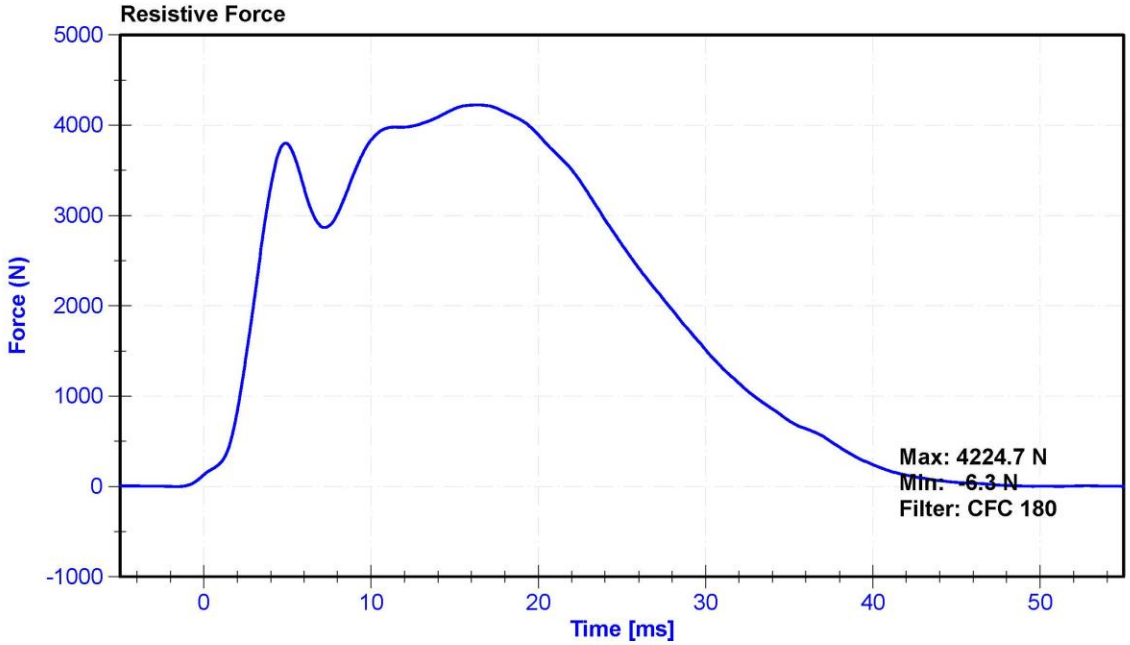
Results

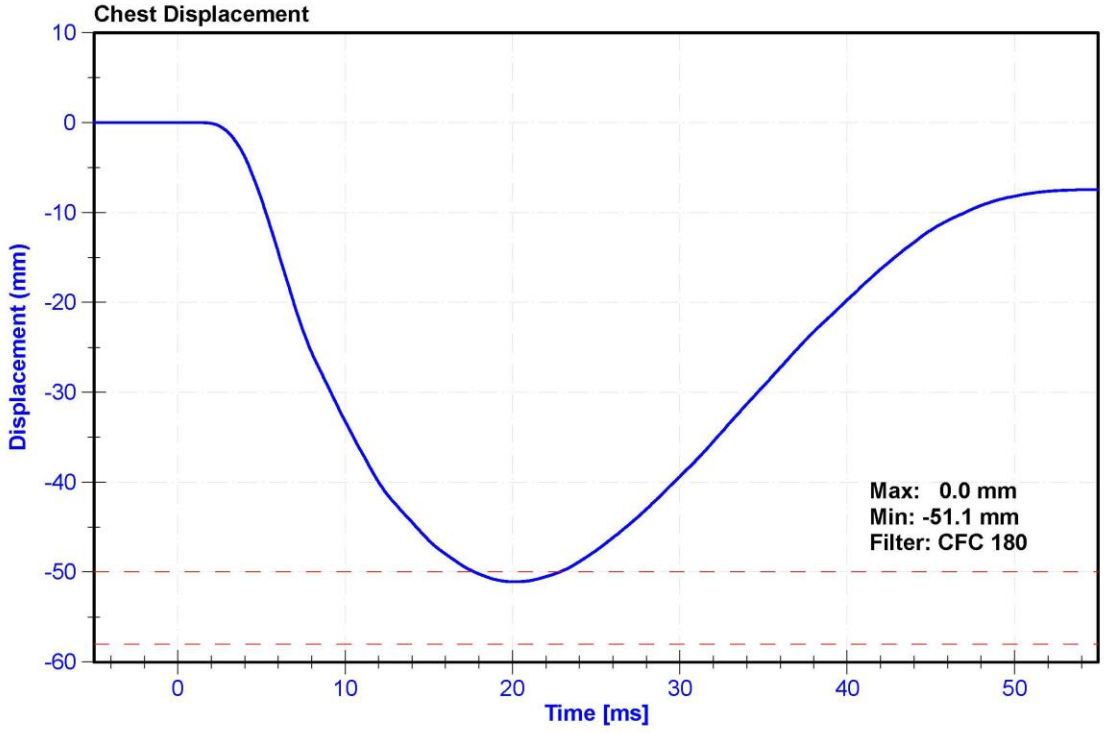
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	25.4	Pass
Velocity	6.59	6.83	m/s	6.641	Pass
Chest Deflection	-58	-50	mm	-51.1	Pass
Maximum Resistive Force (50 to 58mm)	3900	4400	N	4170.2	Pass
Maximum Resistive Force (18 to 50mm)	0	4600	N	4224.7	Pass
Hysteresis	69	85	%	75.3	Pass

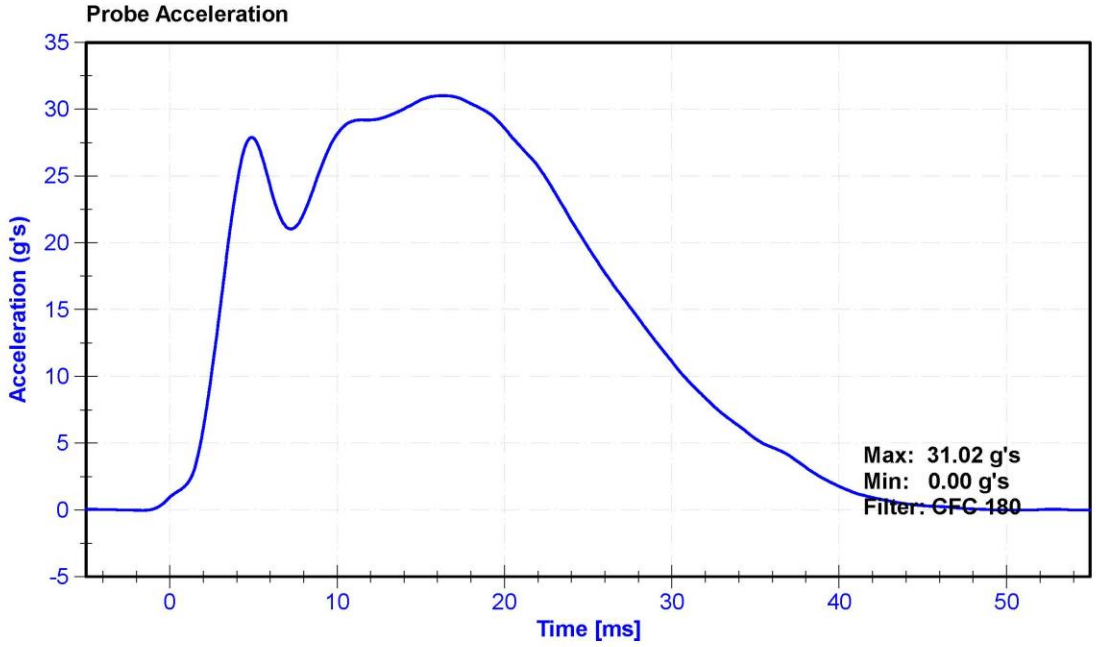
Transducer Calibrations

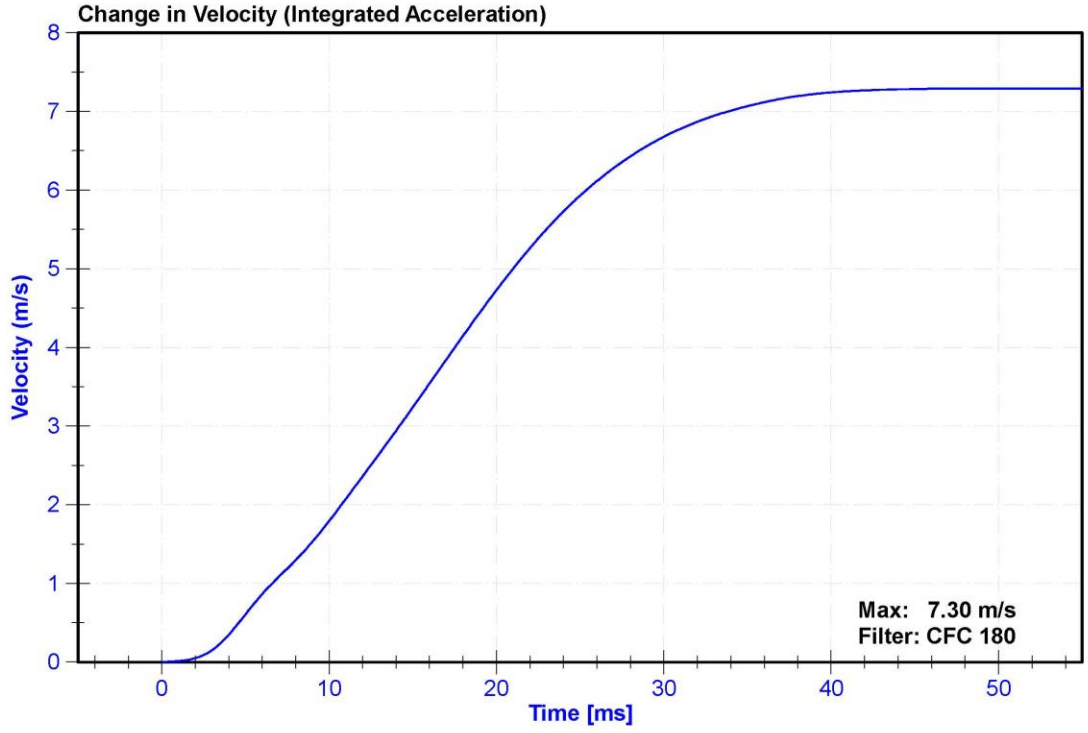
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260487	8/22/2019	2/20/2020
Chest Potentiometer	SERVO 14CBI-3615	DS-140GFE	6/21/2019	6/20/2020




Resistive Force
Force (N)
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50
Time [ms]
Max: 4224.7 N
Min: -6.3 N
Filter: CFC 180


Chest Displacement
Displacement (mm)
10
0
-10
-20
-30
-40
-50
-60
0
10
20
30
40
50
Time [ms]
Max: 0.0 mm
Min: -51.1 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: 31.02 g's
Min: 0.00 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: 7.30 m/s
Filter: CFC 180

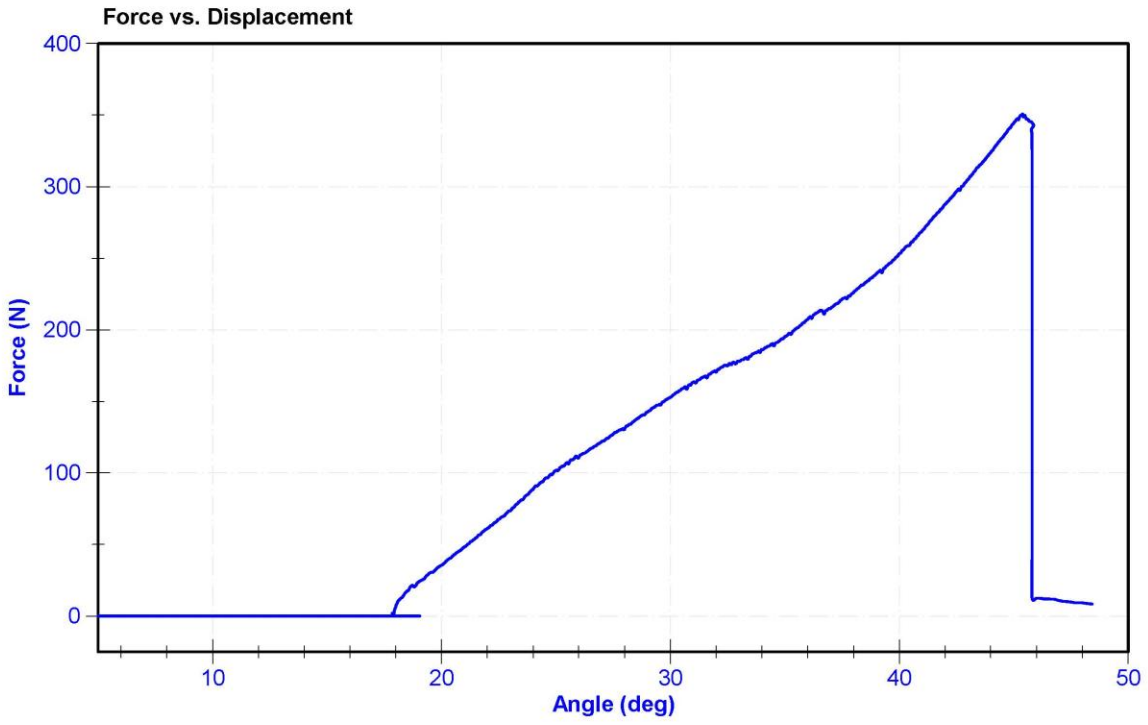
ATD Manufacturer	Humanetics	Test Technician	K. Dutton
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.6	25.6	ºC	21.2	Pass
Humidity	10	70	%	27.6	Pass
Initial Angle	0	20	deg	17.6	Pass
Force at 45 Degrees	320	390	N	350.8	Pass
Return Angle Relative to Initial	0	8	deg	2.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	Rieker N4C-1	DS-13051548	11/25/2018	11/25/2019
Load Cell	Interface SML-200	LC-493319	11/25/2018	11/25/2019



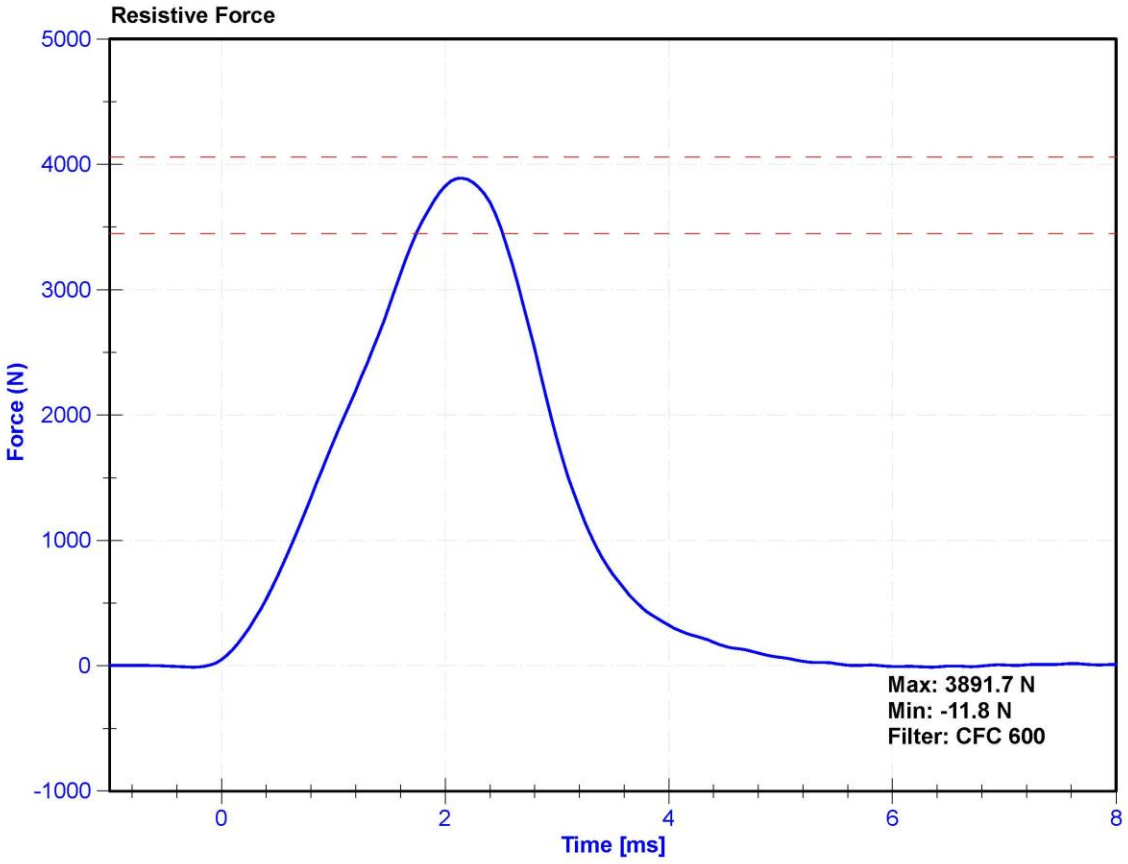
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	140	Laboratory Supervisor	K.Brogan

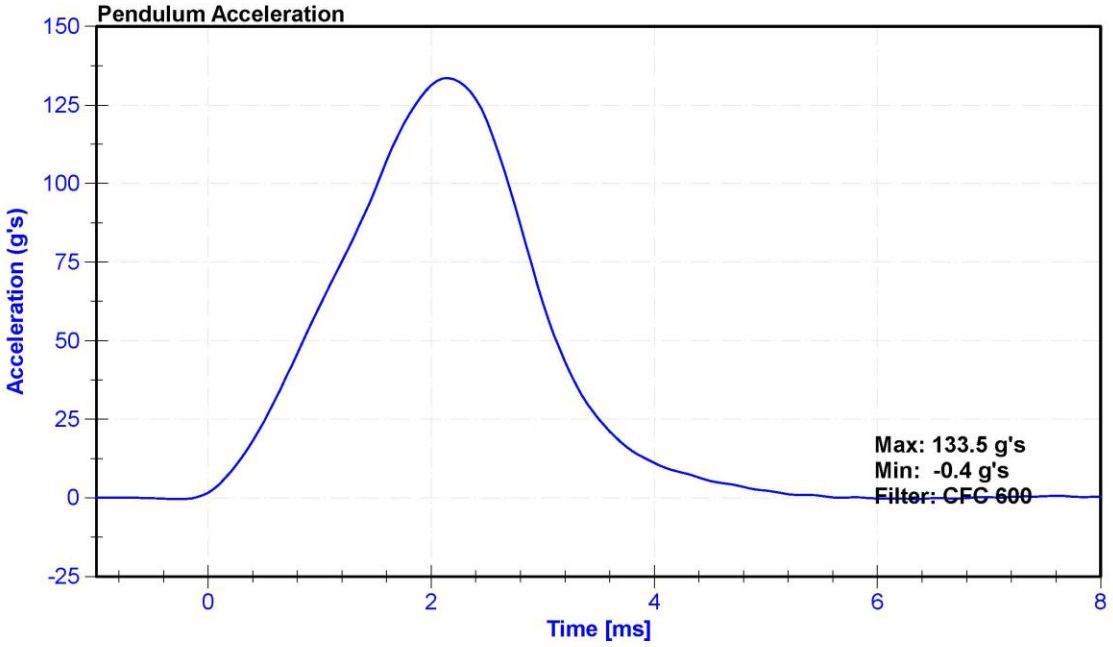
Results

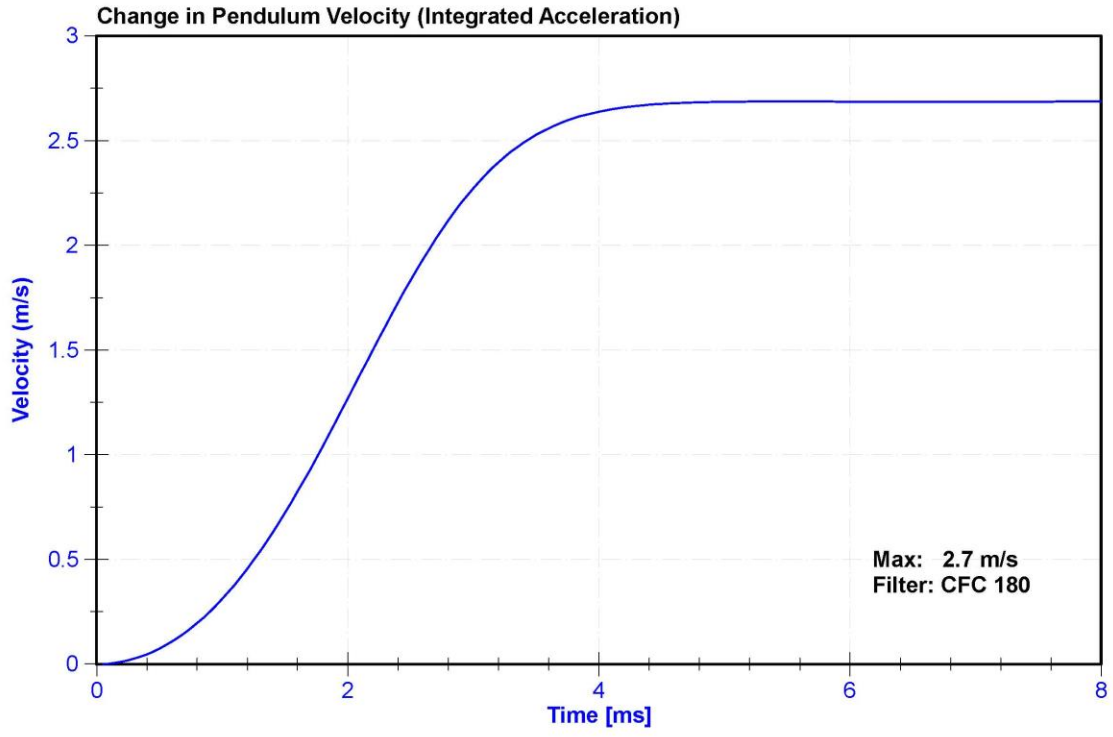
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.6	Pass
Humidity	10	70	%	27.0	Pass
Velocity	2.07	2.13	m/s	2.081	Pass
Resistive Force	3450	4060	N	3891.7	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	7/29/2019	1/27/2020




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 133.5 g's
Min: -0.4 g's
Filter: CFC 600


Change in Pendulum Velocity (Integrated Acceleration)
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]
Max: 2.7 m/s
Filter: CFC 180

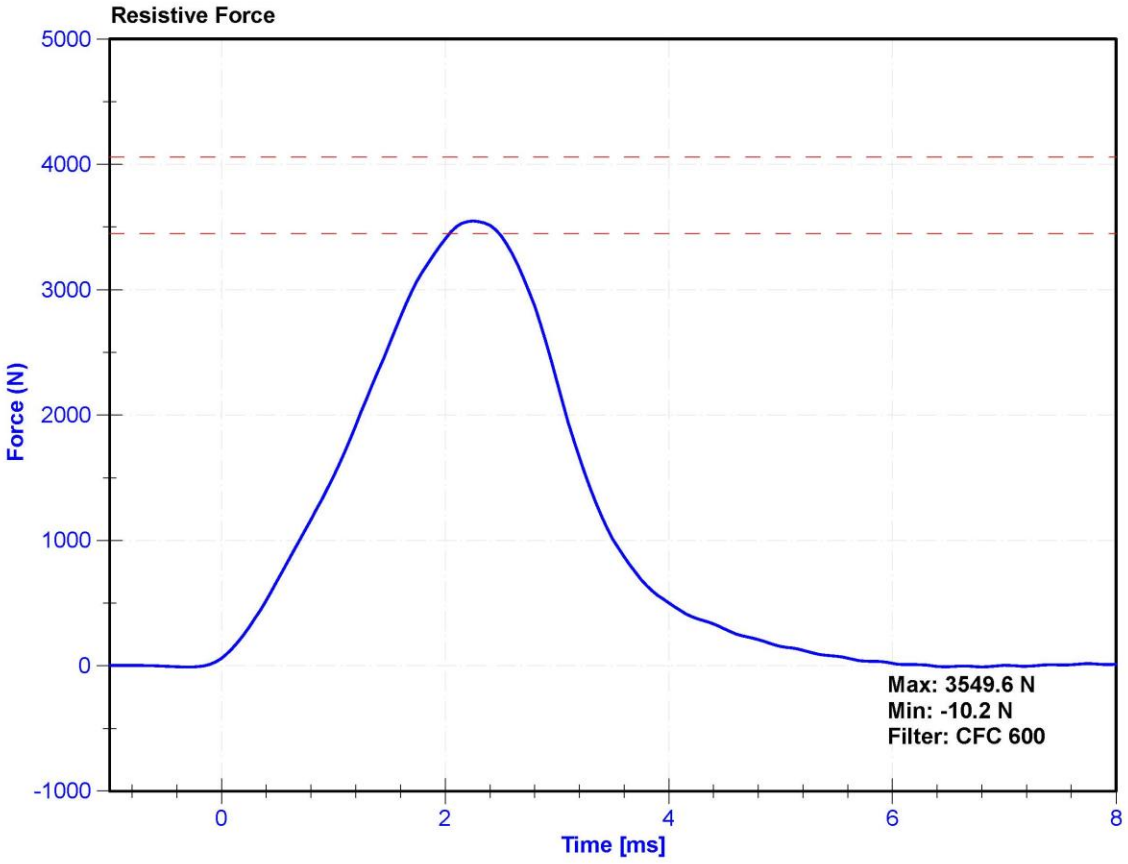
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	140	Laboratory Supervisor	K.Brogan

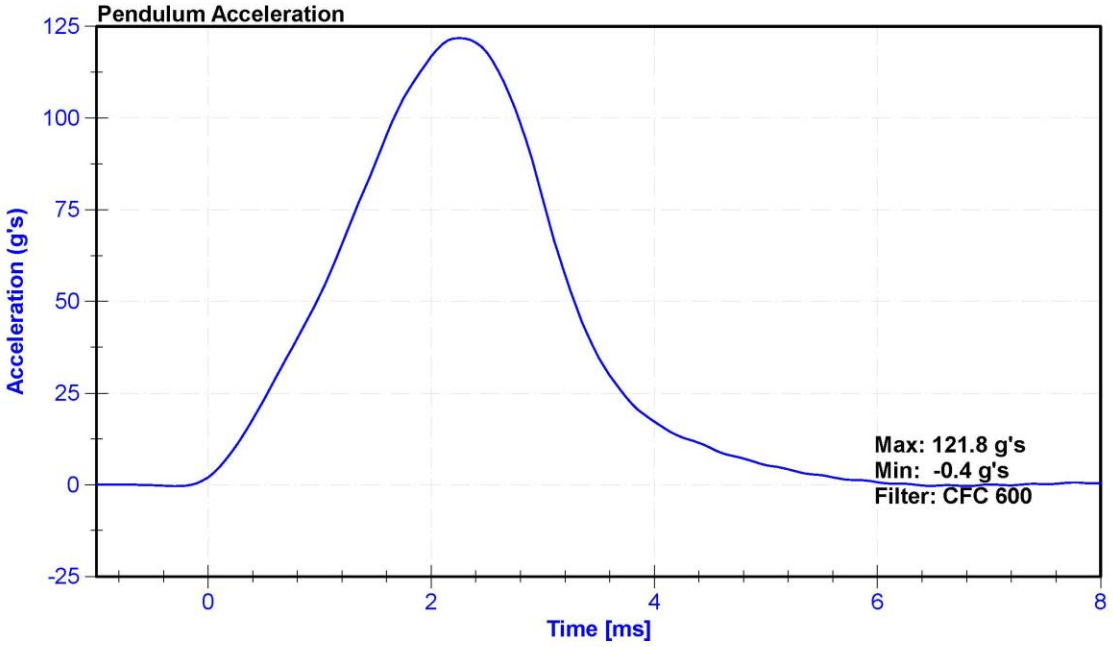
Results

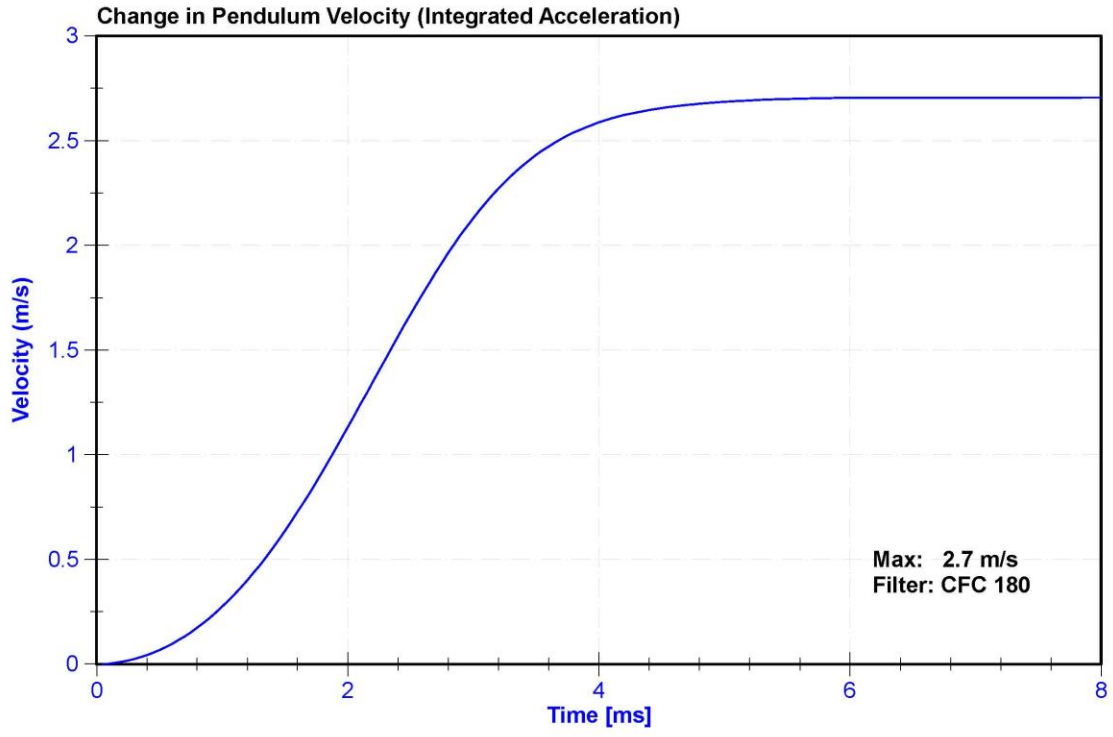
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.9	Pass
Humidity	10	70	%	27.0	Pass
Velocity	2.07	2.13	m/s	2.083	Pass
Resistive Force	3450	4060	N	3549.6	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	7/29/2019	1/27/2020




Pendulum Acceleration
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 121.8 g's
Min: -0.4 g's
Filter: CFC 600


Change in Pendulum Velocity (Integrated Acceleration)
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]
Max: 2.7 m/s
Filter: CFC 180

CALIBRATION TEST RESULTS

POST-TEST

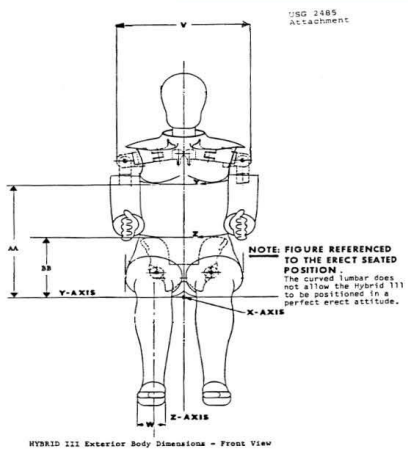
HYBRID III 50TH PERCENTILE MALE - DRIVER ATD

SERIAL NO: 142

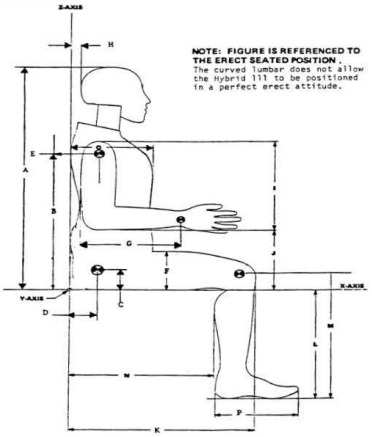
External Measurements - Hybrid 3 - 50th Male

Technician: K. Dutton Date: 11/19/2019

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	3.5	Pass
F	Thigh Clearance	5.5	6.1	5.7	Pass
G	Back of Elbow to Wrist Pivot	11.4	12.0	11.8	Pass
H	Head Back to Backline	1.6	1.8	1.7	Pass
I	Shoulder to Elbow Length	13.0	13.6	13.5	Pass
J	Elbow Rest Height	7.5	8.3	8.2	Pass
K	Buttock to Knee Length	22.8	23.8	23.3	Pass
L	Popliteal Height	16.9	17.9	17.3	Pass
M	Knee Pivot Height	19.1	19.7	19.4	Pass
N	Buttock Popliteal Length	17.8	18.8	18.4	Pass
O	Chest Depth without Jacket	8.4	9.0	8.7	Pass
P	Foot Length (right)	9.9	10.5	10.3	Pass
V	Shoulder Breadth	16.3	17.2	16.8	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

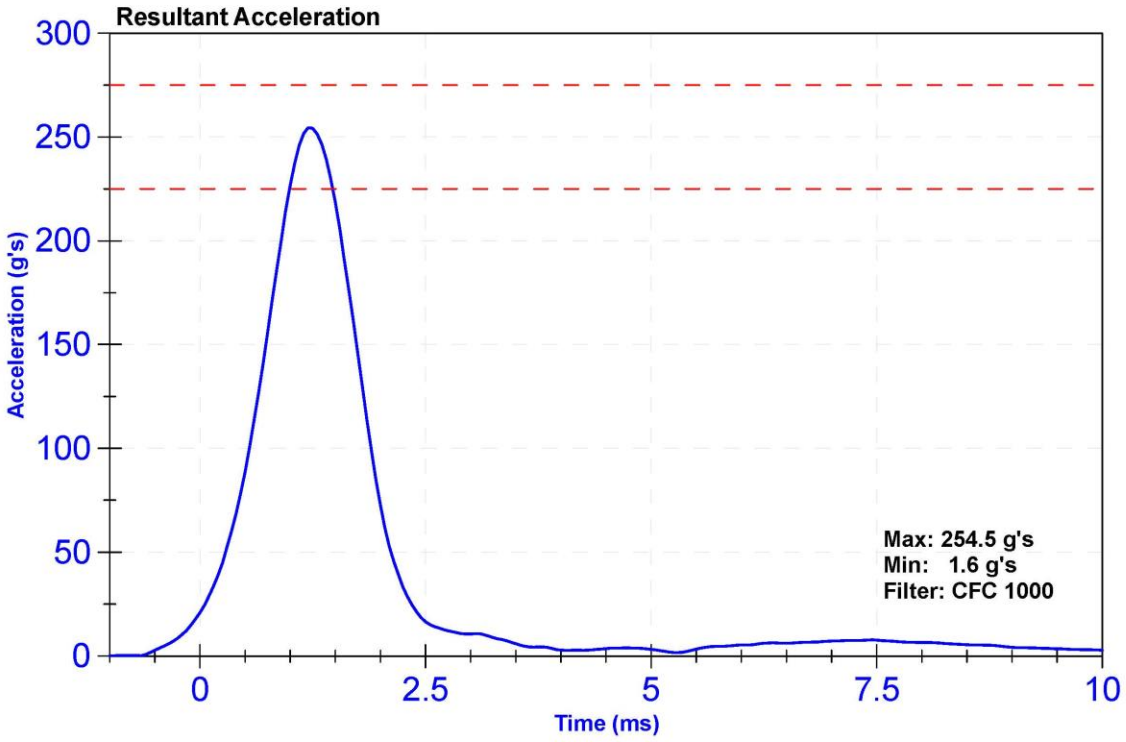
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

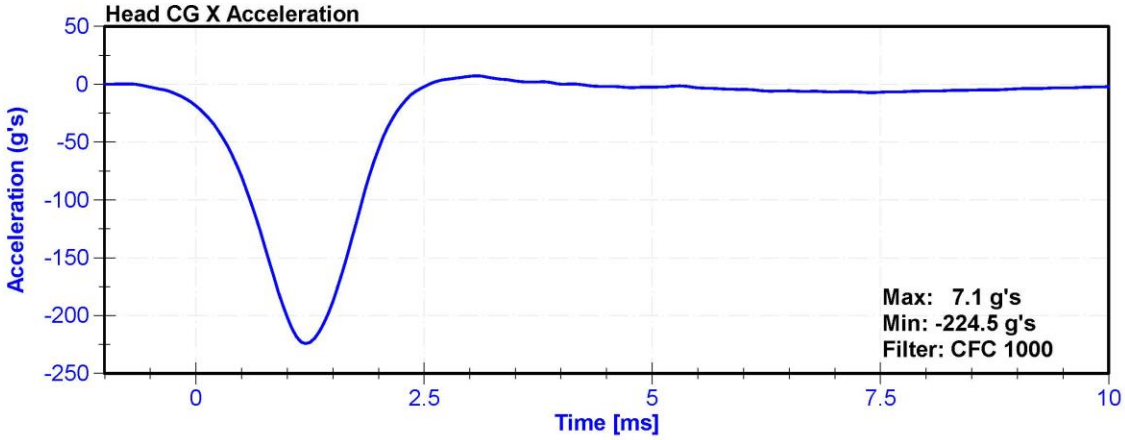
Results

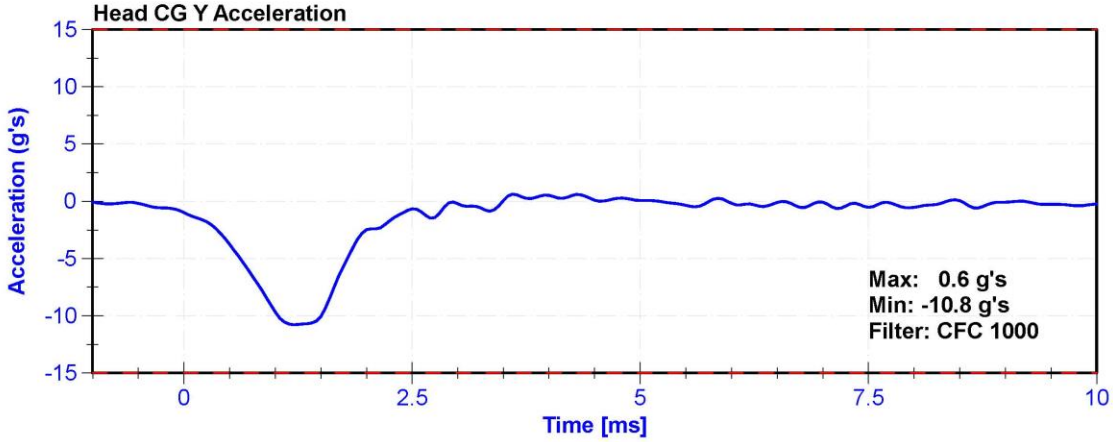
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	31.0	Pass
Resultant Acceleration	225	275	g's	254.5	Pass
Oscillation	0	10	%	4.2	Pass
Lateral Acceleration	-15	15	g's	-10.8	Pass

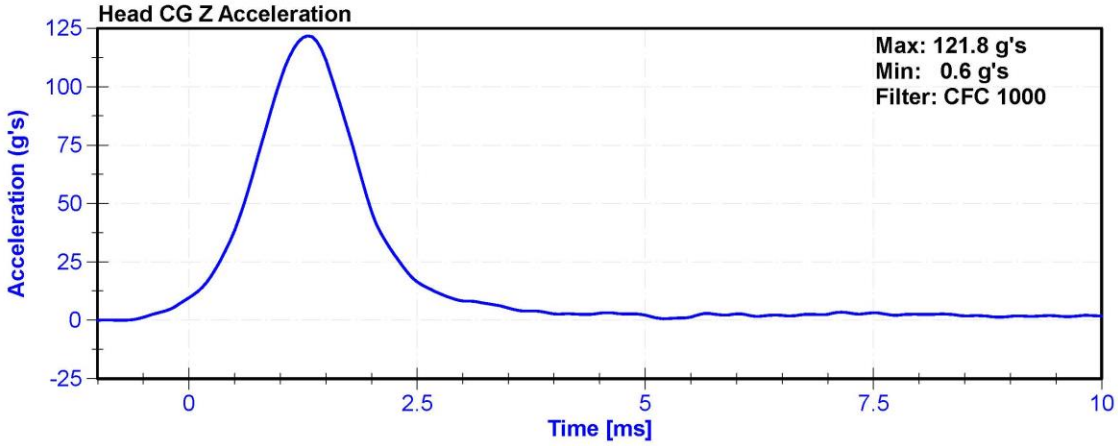
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	Endevco	P51681	8/13/2019	2/13/2020
Y Accelerometer	Endevco	P64151	8/13/2019	2/13/2020
Z Accelerometer	Endevco	P52114	8/13/2019	2/13/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 7.1 g's
Min: -224.5 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: 0.6 g's
Min: -10.8 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: 121.8 g's
Min: 0.6 g's
Filter: CFC 1000

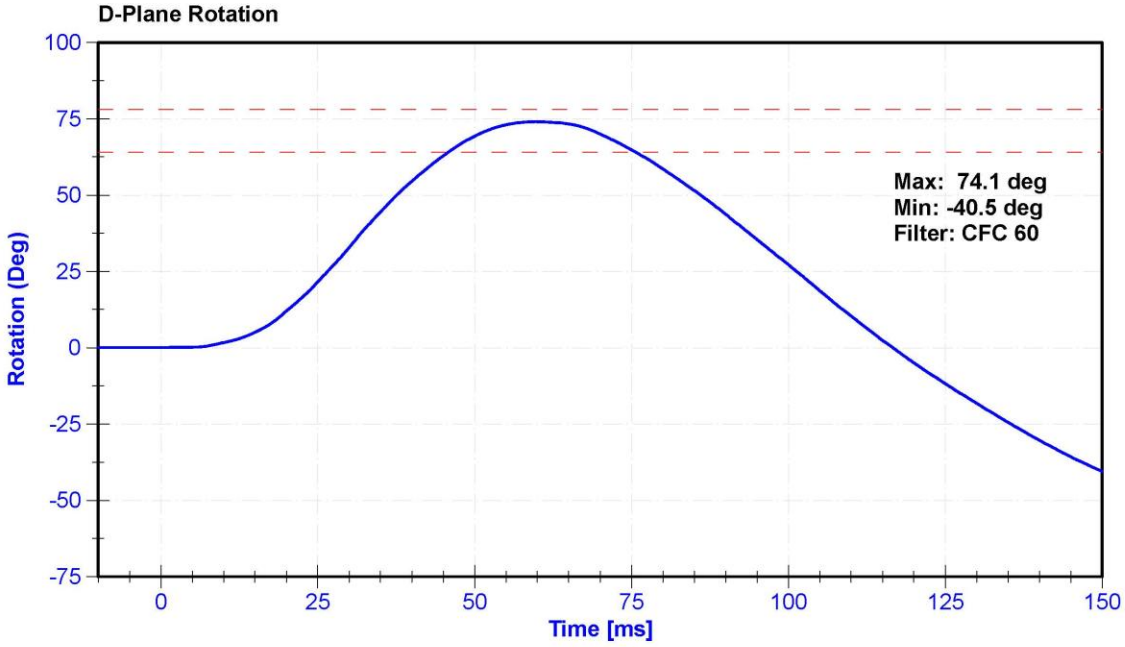
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

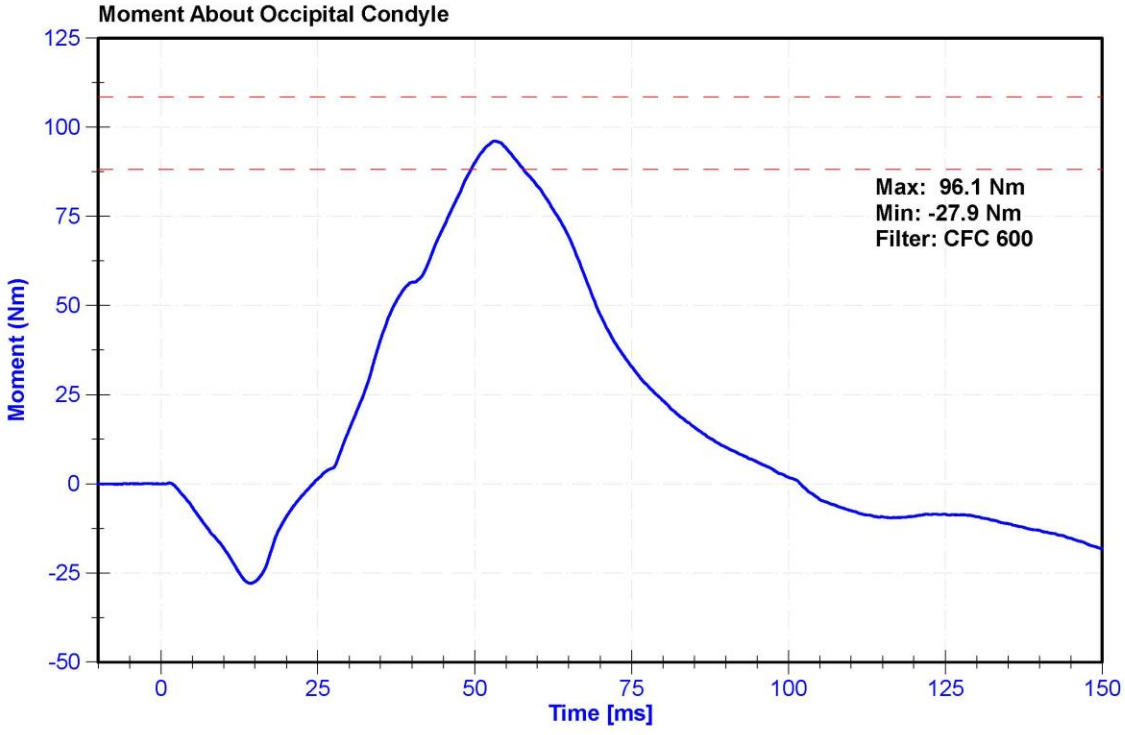
Results

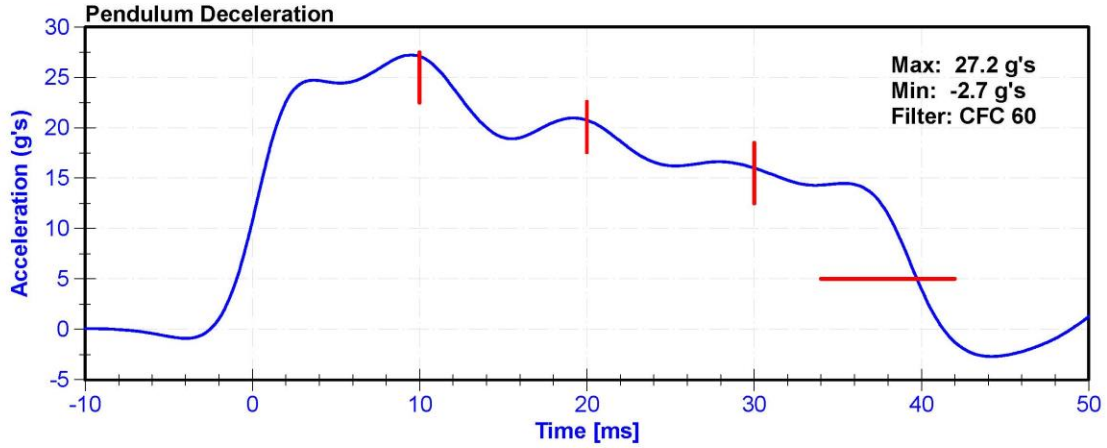
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	31.0	Pass
Velocity	6.89	7.13	m/s	7.070	Pass
Pendulum Deceleration at 10ms	22.5	27.5	g's	27.09	Pass
Pendulum Deceleration at 20ms	17.6	22.6	g's	20.76	Pass
Pendulum Deceleration at 30ms	12.5	18.5	g's	16.02	Pass
Max. Pendulum Deceleration After 30ms	0	29	g's	27.2	Pass
Pendulum Deceleration Time to 5 g's	34	42	ms	39.7	Pass
Maximum D Plane Rotation	64	78	deg	74.1	Pass
Time to Maximum Rotation	57	64	ms	59.7	Pass
Rotation Decay to Zero	113	127	ms	116.6	Pass
Moment About Occipital Condyle	88.1	108.4	Nm	96.13	Pass
Time to Maximum Moment	47	58	ms	53.2	Pass
Moment Decay to Zero	97	107	ms	101.9	Pass

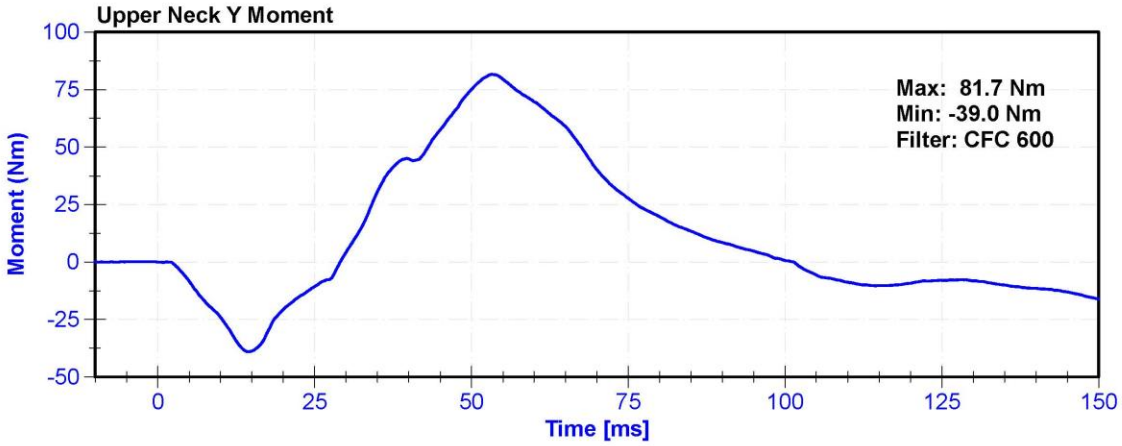
Transducer Calibrations

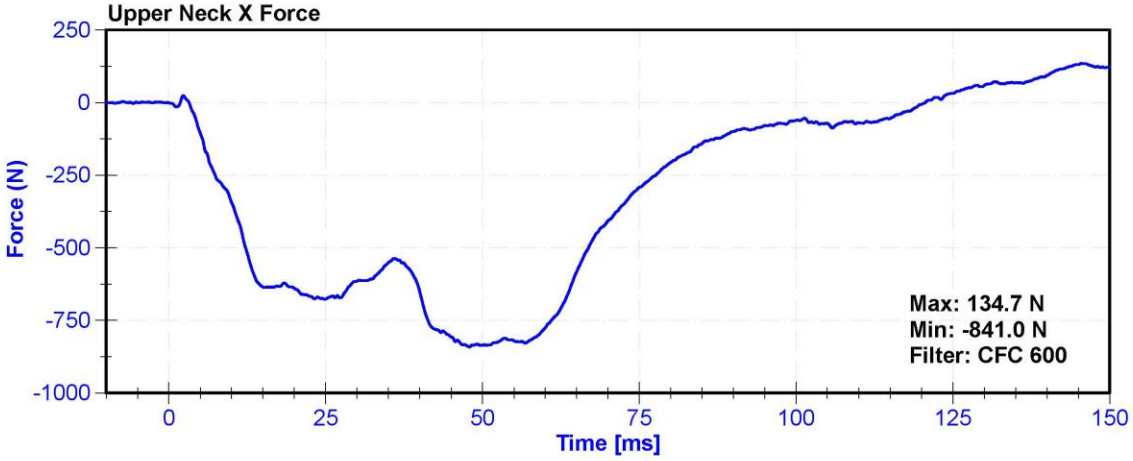
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	Endevco	AH5M9	10/25/2019	4/25/2020
Pendulum Potentiometer	ETI SP22G	LABPOT1	9/13/2019	9/13/2020
Condyle Potentiometer	ETI SP22G	LABPOT2	9/13/2019	9/13/2020
Upper Neck Load Cell	Denton	2019-1716A-Fx	2/18/2019	2/18/2020


D-Plane Rotation
Rotation (Deg)
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150
Time [ms]
Max: 74.1 deg
Min: -40.5 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: 96.1 Nm
Min: -27.9 Nm
Filter: CFC 600


Pendulum Deceleration
Acceleration (g's)
Time [ms]
Max: 27.2 g's
Min: -2.7 g's
Filter: CFC 60


Upper Neck Y Moment
Moment (Nm)
Time [ms]
Max: 81.7 Nm
Min: -39.0 Nm
Filter: CFC 600


Upper Neck X Force
Force (N)
Time [ms]
Max: 134.7 N
Min: -841.0 N
Filter: CFC 600

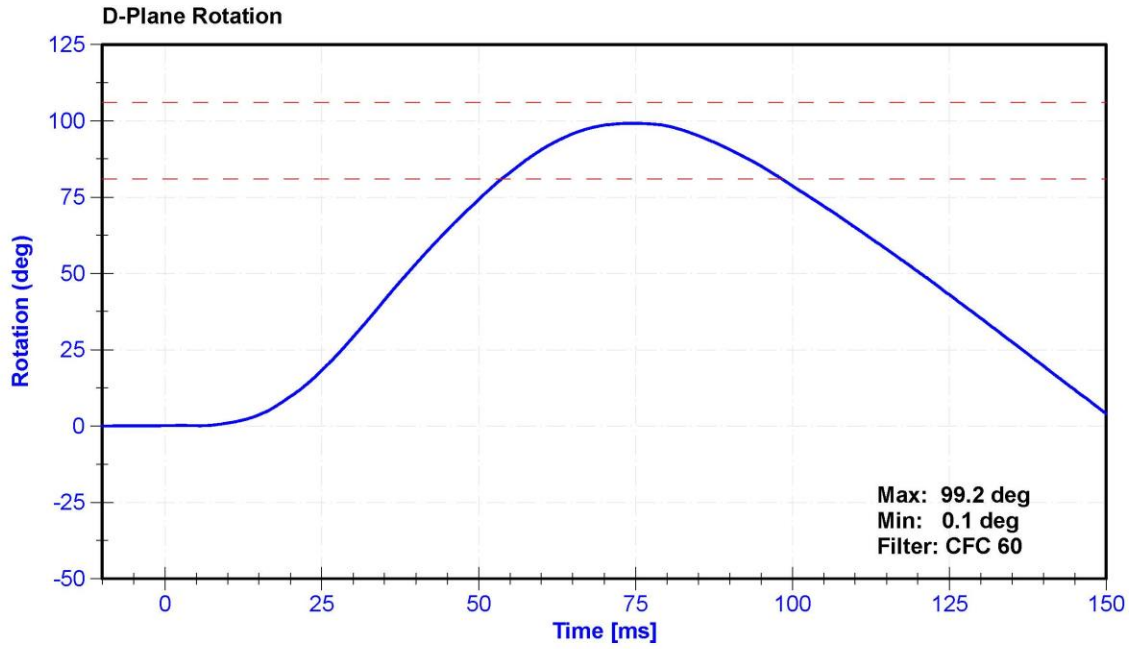
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

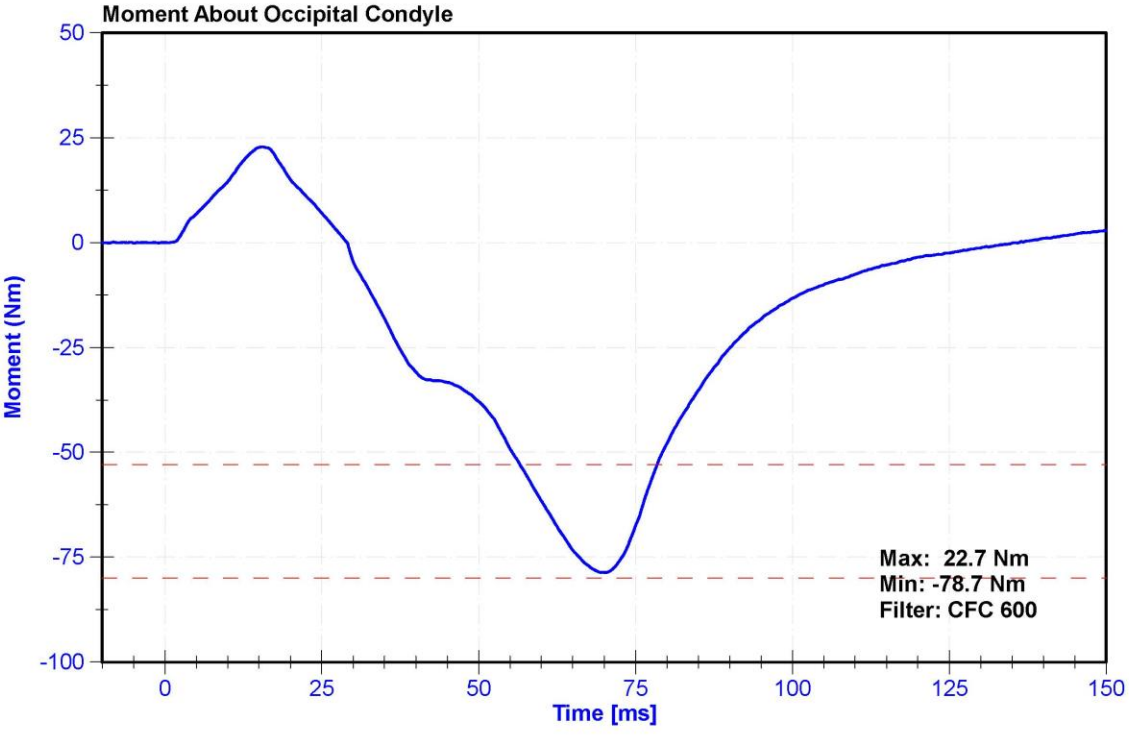
Results

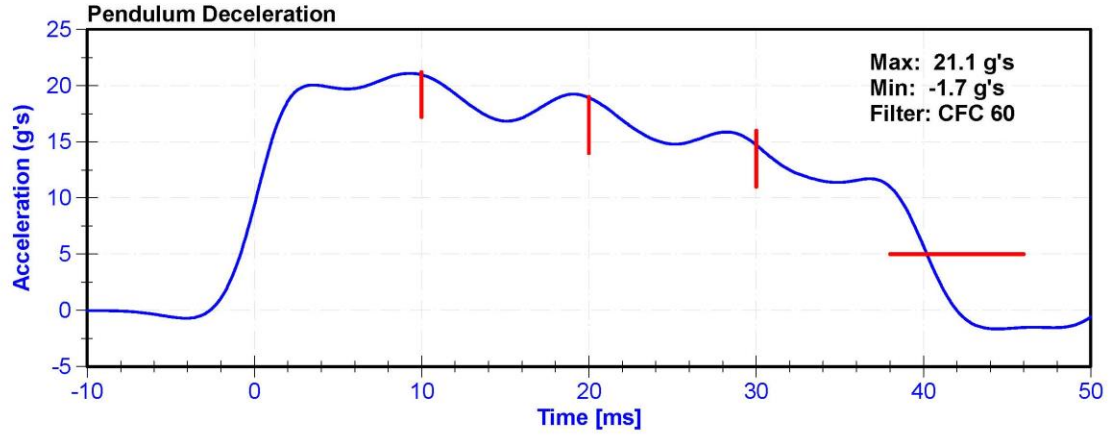
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	30	Pass
Velocity	5.94	6.19	m/s	6.131	Pass
Pendulum Deceleration at 10ms	17.2	21.2	g's	20.96	Pass
Pendulum Deceleration at 20ms	14	19	g's	18.9	Pass
Pendulum Deceleration at 30ms	11	16	g's	14.7	Pass
Max. Pendulum Deceleration After 30ms	0	22	g's	21.1	Pass
Pendulum Deceleration Time to 5 g's	38	46	ms	40.2	Pass
Maximum D Plane Rotation	81	106	deg	99.2	Pass
Time to Maximum Rotation	72	82	ms	74.4	Pass
Rotation Decay to Zero	147	174	ms	152.6	Pass
Minimum Moment About OC	-80	-52.9	Nm	-78.66	Pass
Time to Minimum Moment	65	79	ms	70.0	Pass
Moment Decay to Zero	120	148	ms	136.1	Pass

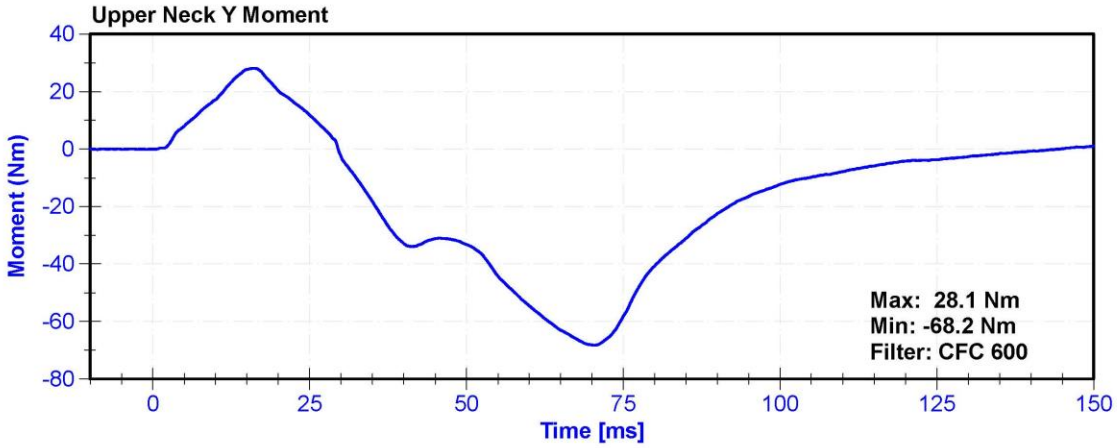
Transducer Calibrations

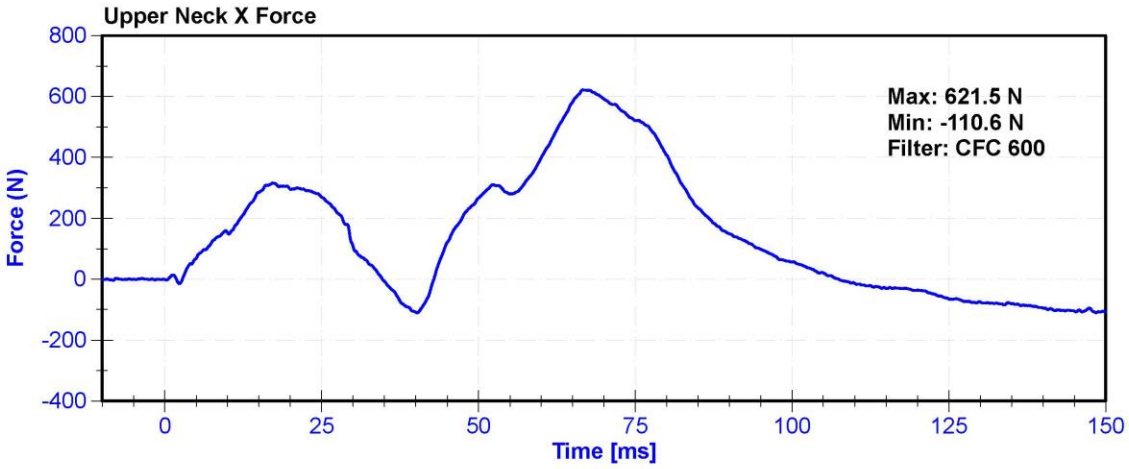
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	Endevco	AH5M9	10/25/2019	4/25/2020
Pendulum Potentiometer	ETI SP22G	LABPOT1	9/13/2019	9/13/2020
Condyle Potentiometer	ETI SP22G	LABPOT2	9/13/2019	9/13/2020
Upper Neck Load Cell	Denton	2019-1716A-Fx	2/18/2019	2/18/2020


D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 99.2 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: 22.7 Nm
Min: -78.7 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 21.1 g's
Min: -1.7 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 28.1 Nm
Min: -68.2 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 621.5 N
Min: -110.6 N
Filter: CFC 600
Force (N)
Time [ms]

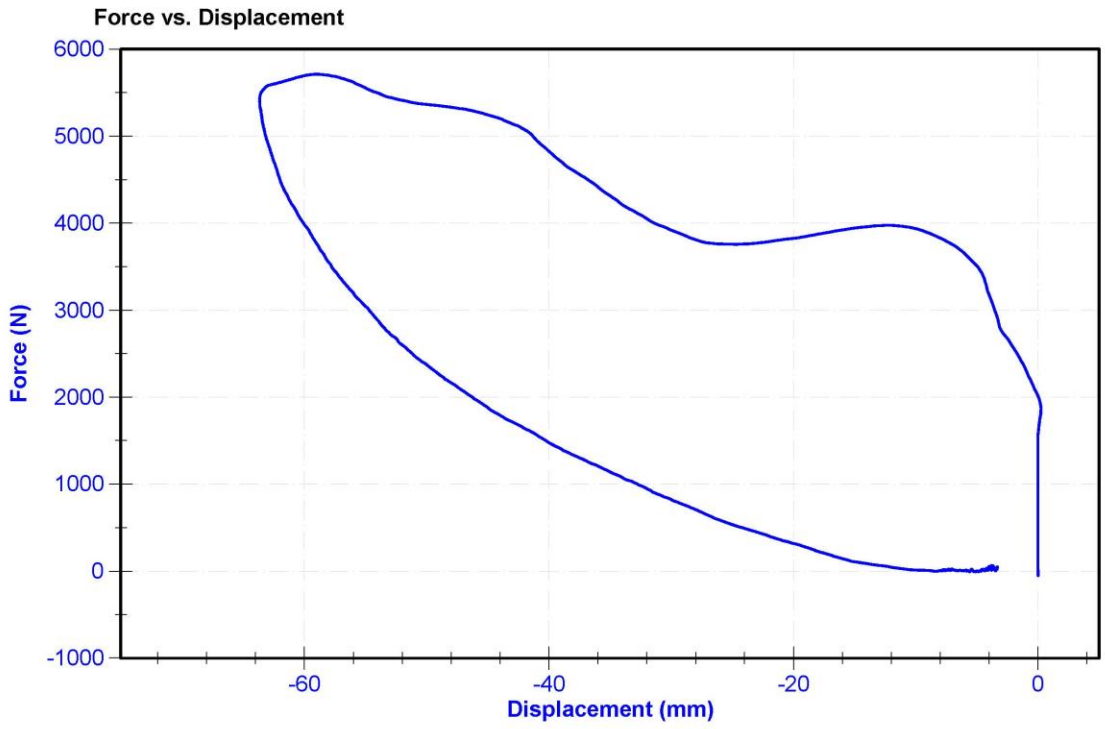
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K.Brogan

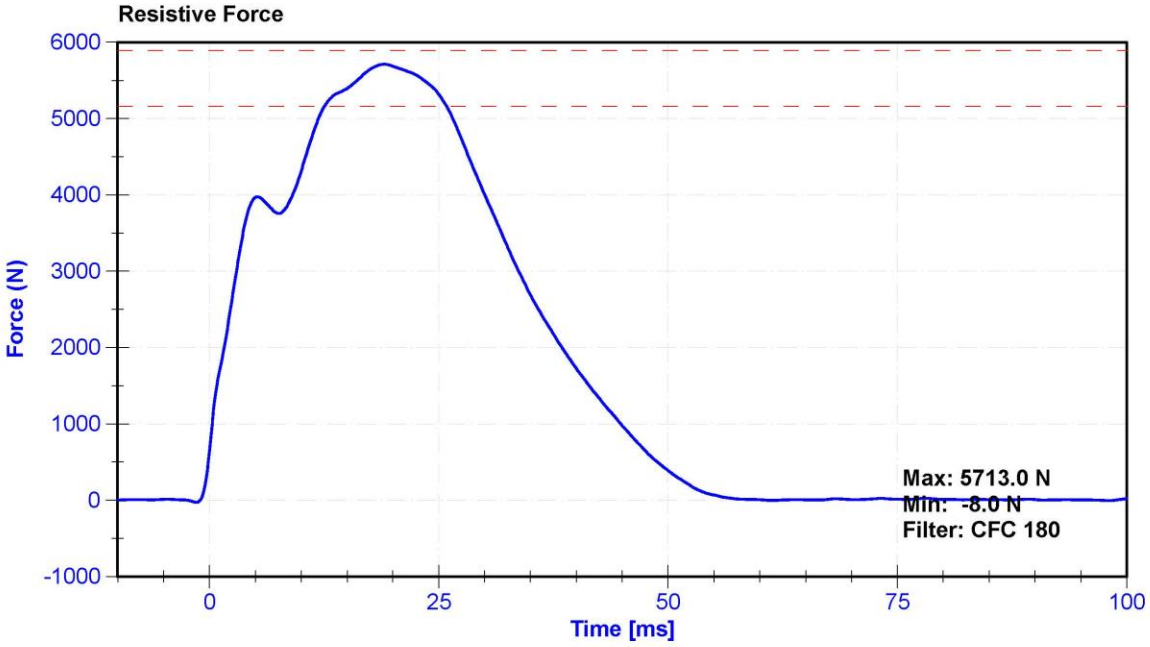
Results

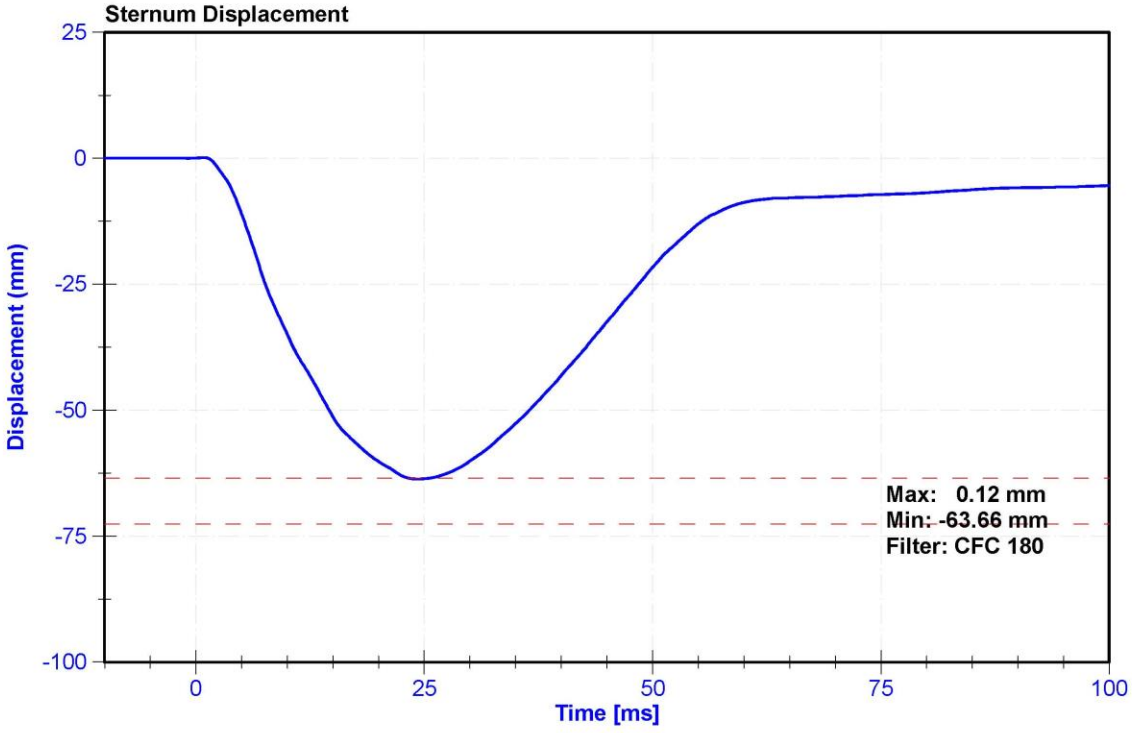
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.9	Pass
Humidity	10	70	%	37	Pass
Velocity	6.59	6.83	m/s	6.788	Pass
Chest Displacement	-72.6	-63.5	mm	-63.66	Pass
Resistive Force	5160	5894	N	5713.0	Pass
Hysteresis	65	85	%	69.9	Pass

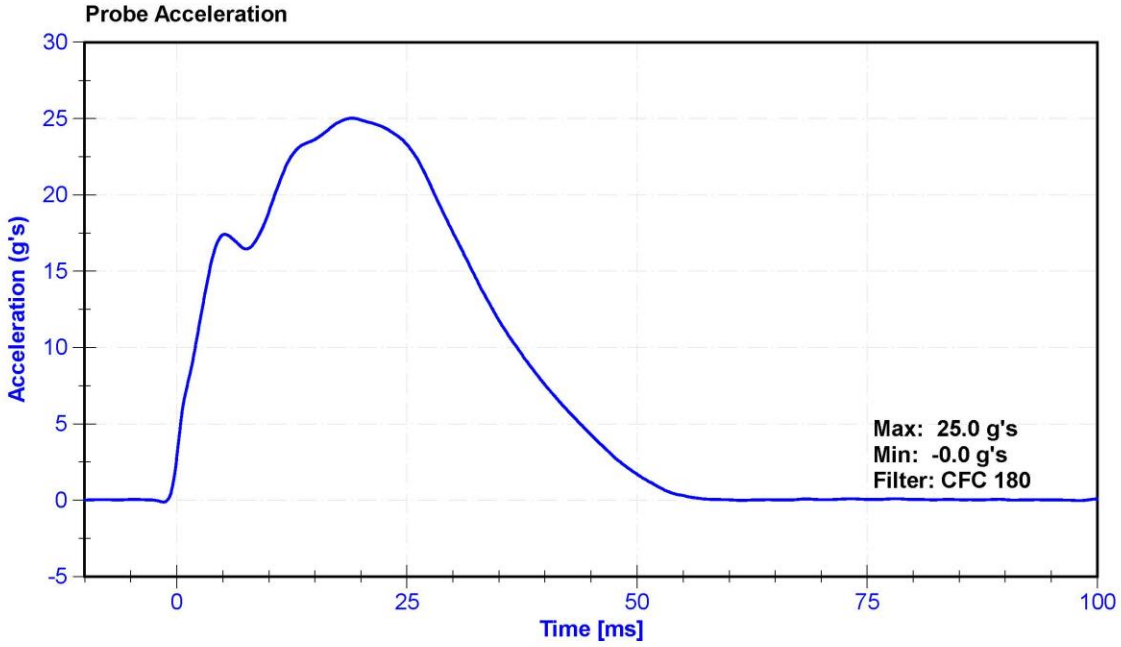
Transducer Calibrations

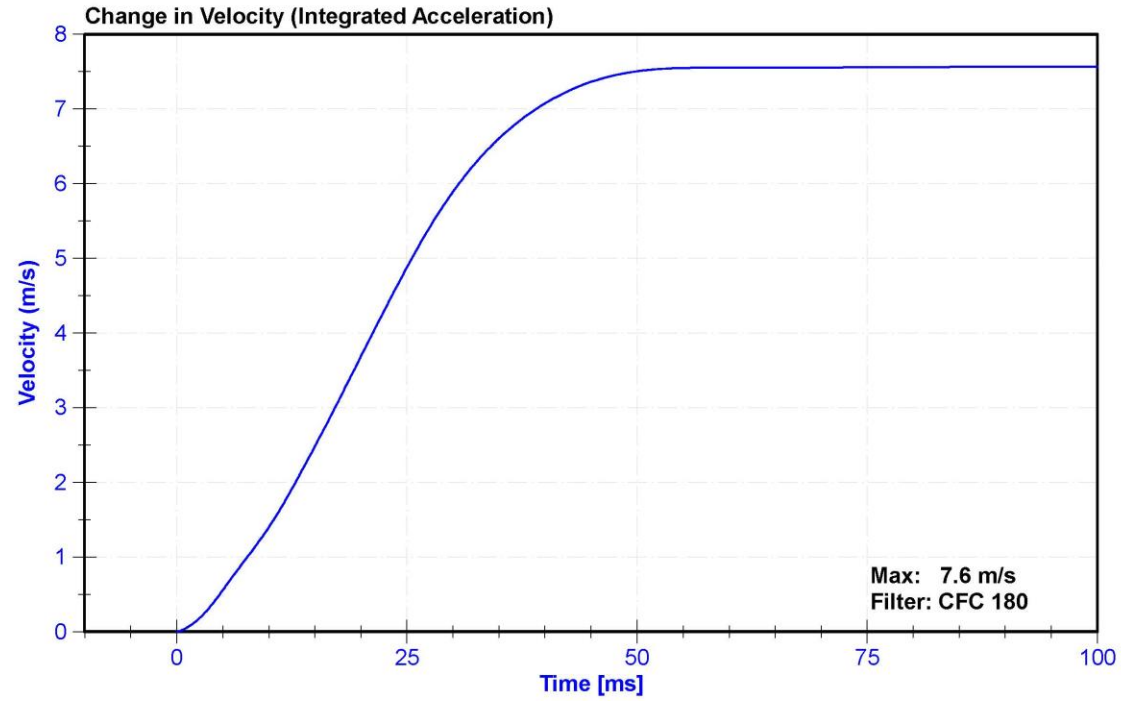
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260568	7/29/2019	1/27/2020
Chest Potentiometer	JDK 6209-2038	DS-142	9/12/2019	9/11/2020




Resistive Force
Force (N)
6000
5000
4000
3000
2000
1000
0
-1000
0
25
50
75
100
Time [ms]
Max: 5713.0 N
Min: -8.0 N
Filter: CFC 180


Sternum Displacement
Displacement (mm)
25
0
-25
-50
-75
-100
0
25
50
75
100
Time [ms]
Max: 0.12 mm
Min: -63.66 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
30
25
20
15
10
5
0
-5
0
25
50
75
100
Time [ms]
Max: 25.0 g's
Min: -0.0 g's
Filter: CFC 180


Change in Velocity (Integrated Acceleration)
Velocity (m/s)
8
7
6
5
4
3
2
1
0
0
25
50
75
100
Time [ms]
Max: 7.6 m/s
Filter: CFC 180

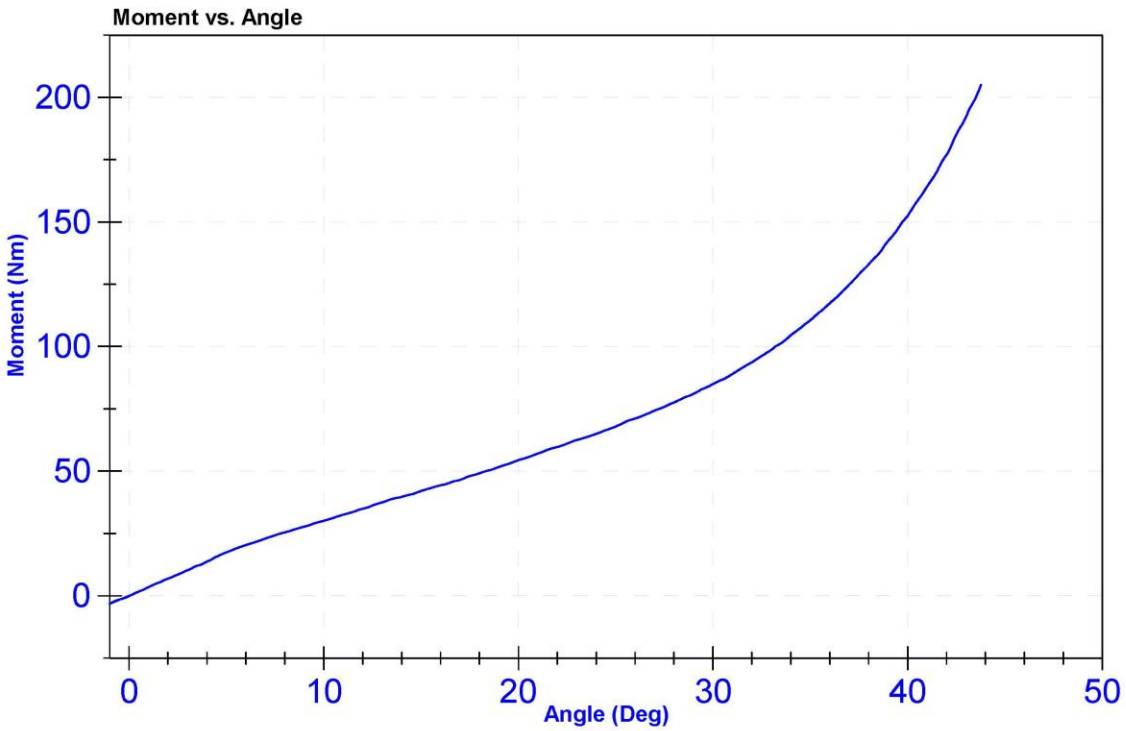
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	34.0	Pass
Average Velocity	5	10	deg/s	6.9	Pass
Angle at 203Nm	40	50	deg	43.7	Pass
Moment at 30 degrees	0	94.9	Nm	85.0	Pass

Transducer Calibrations

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



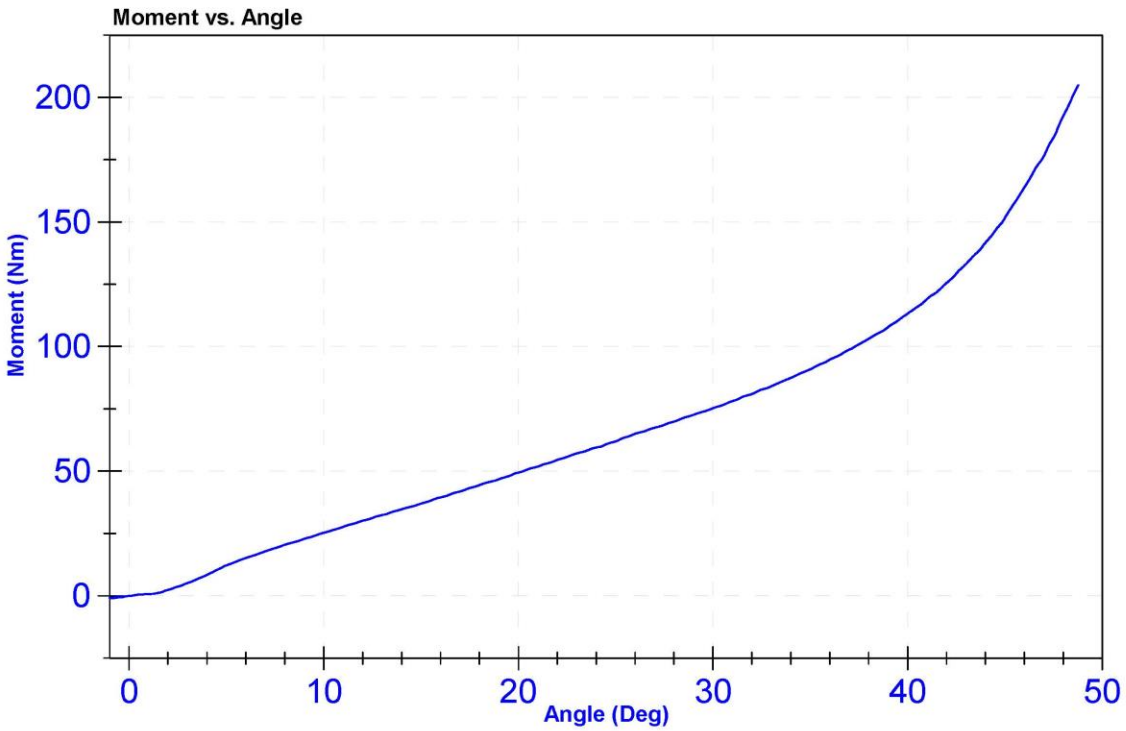
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.0	Pass
Humidity	10	70	%	34.0	Pass
Average Velocity	5	10	deg/s	7.0	Pass
Angle at 203Nm	40	50	deg	48.6	Pass
Moment at 30 degrees	0	94.9	Nm	75.3	Pass

Transducer Calibrations

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



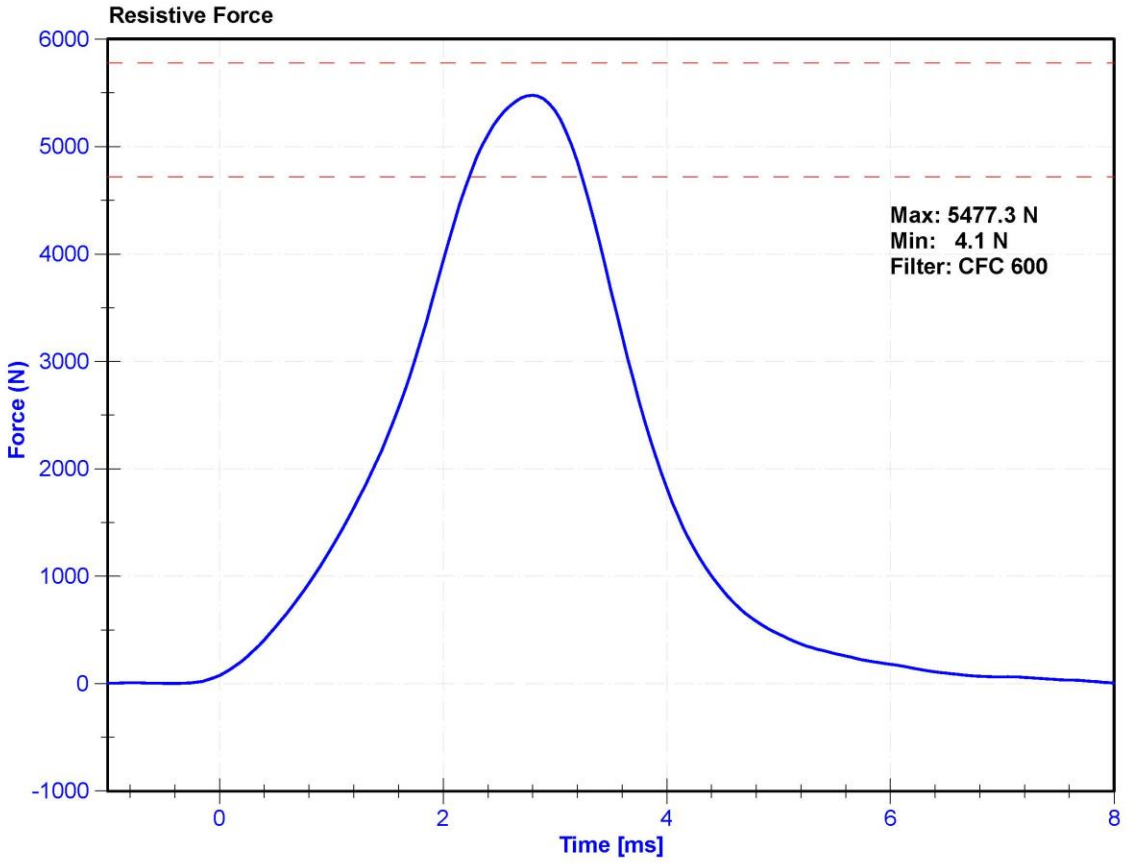
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

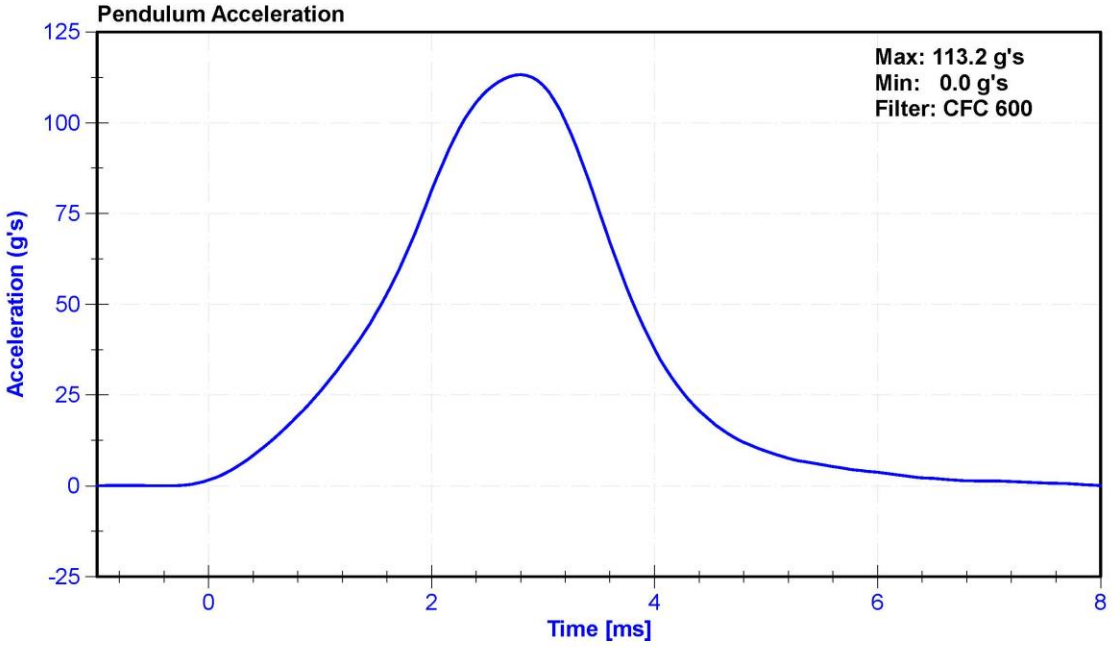
Results

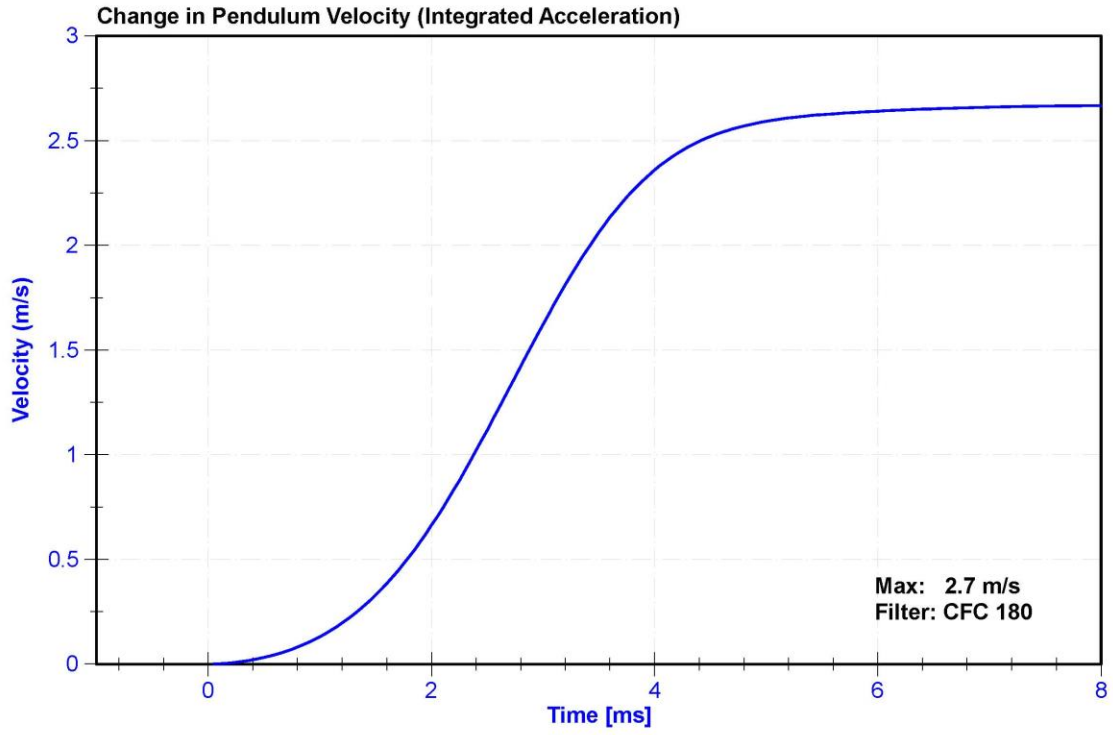
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.2	Pass
Humidity	10	70	%	33.6	Pass
Velocity	2.07	2.13	m/s	2.114	Pass
Maximum Resistive Force	4720	5780	N	5477.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	Measurement Specialties	A260568	07/29/2019	01/29/2020




Pendulum Acceleration
Max: 113.2 g's
Min: 0.0 g's
Filter: CFC 600
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]


Change in Pendulum Velocity (Integrated Acceleration)
Max: 2.7 m/s
Filter: CFC 180
Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
Time [ms]

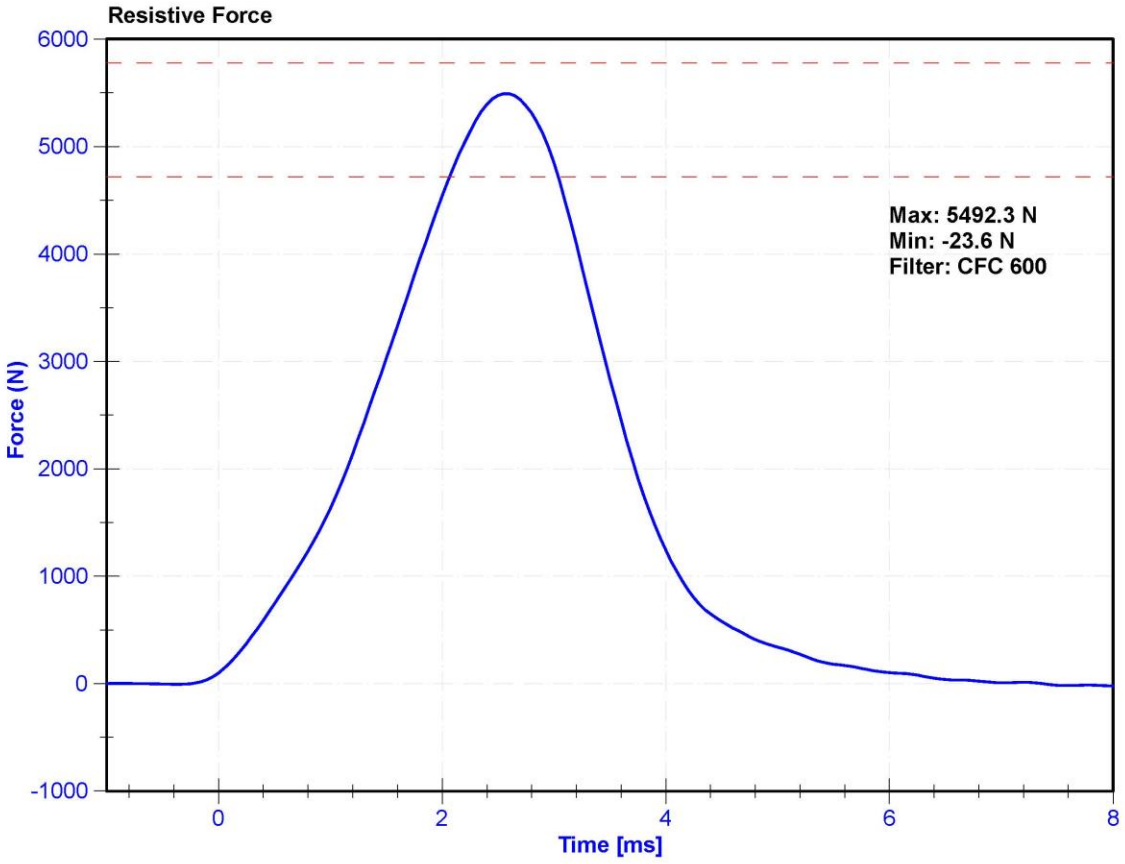
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

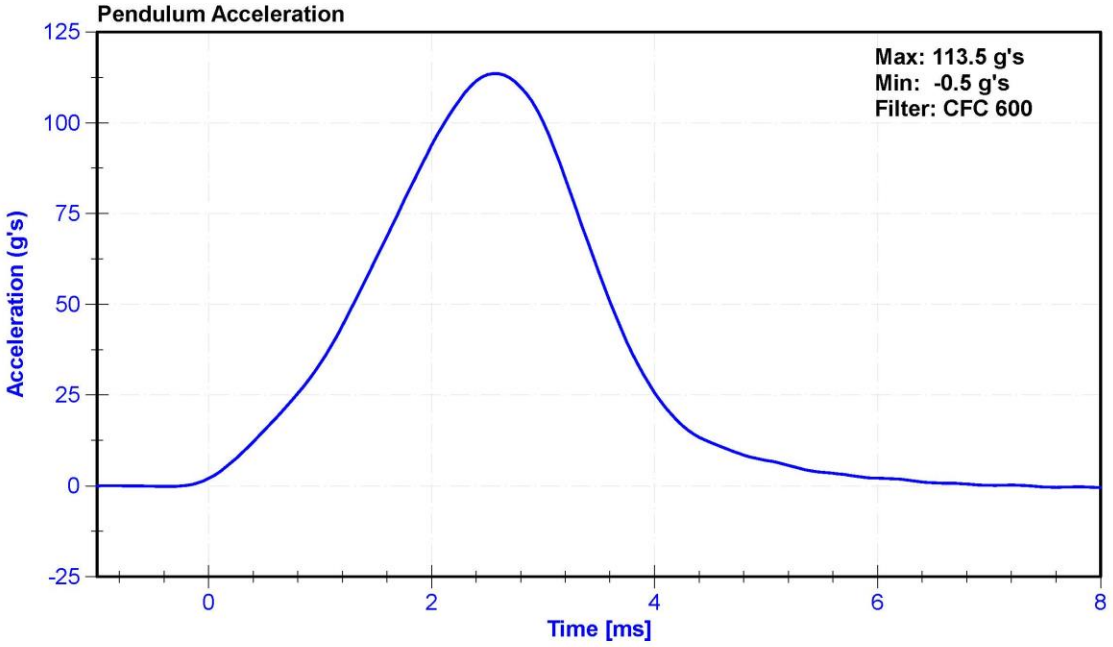
Results

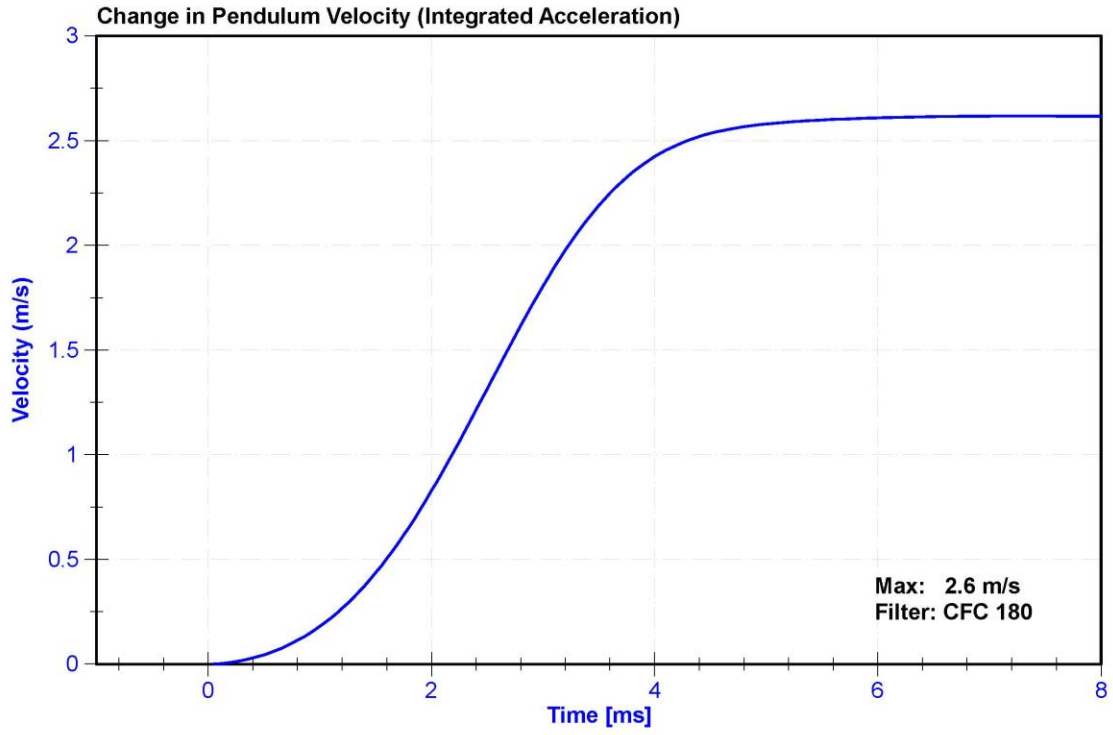
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.4	Pass
Humidity	10	70	%	33.9	Pass
Velocity	2.07	2.13	m/s	2.115	Pass
Maximum Resistive Force	4720	5780	N	5492.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	Measurement Specialties	A260568	07/29/2019	01/29/2020




Pendulum Acceleration
Max: 113.5 g's
Min: -0.5 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

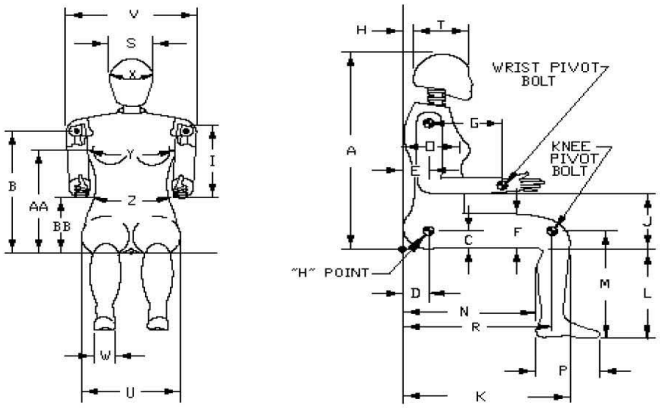
HYBRID III 5TH PERCENTILE FEMALE - PASSENGER ATD

SERIAL NO: 140

External Measurements - Hybrid 3 - 5th Female

Technician: K. Brogan Date: 11/18/2019

Dummy Serial Number: 140



Symbol	Description	Specification (mm)		Result (mm)	Pass/Fail
A	Sitting Height	775	800	791	Pass
B	Shoulder Pivot Height	432	457	442	Pass
C	H-Point Height	81	86	83	Pass
D	H-Point from Backline	145	150	147	Pass
E	Shoulder Pivot from Backline	69	84	75	Pass
F	Thigh Clearance	119	135	126	Pass
G	Back of Elbow to Wrist Pivot	244	259	250	Pass
H	Head Back to Backline	43	48	45	Pass
I	Shoulder to Elbow Length	277	297	290	Pass
J	Elbow Rest Height	183	203	194	Pass
K	Buttock to Knee Length	521	546	535	Pass
L	Popliteal Height	356	376	366	Pass
M	Knee Pivot Height	394	419	409	Pass
N	Buttock Popliteal Length	414	439	428	Pass
O	Chest Depth without Jacket	175	191	182	Pass
P	Foot Length (right)	219	234	228	Pass
R	Buttock To Knee Pivot Length	457	483	467	Pass
S	Head Breadth	137	147	142	Pass
T	Head Depth	178	188	180	Pass
U	Hip Breadth	300	315	313	Pass
V	Shoulder Breadth	351	366	361	Pass
W	Foot Breadth	79	94	83	Pass
X	Head Circumference	528	549	540	Pass
Y	Chest Circumference with Jacket	851	881	874	Pass
Z	Waist Circumference	460	790	624	Pass
AA	Reference Location (Chest Circumference)	333	358	345	Pass
BB	Reference Location (Waist Circumference)	160	170	165	Pass

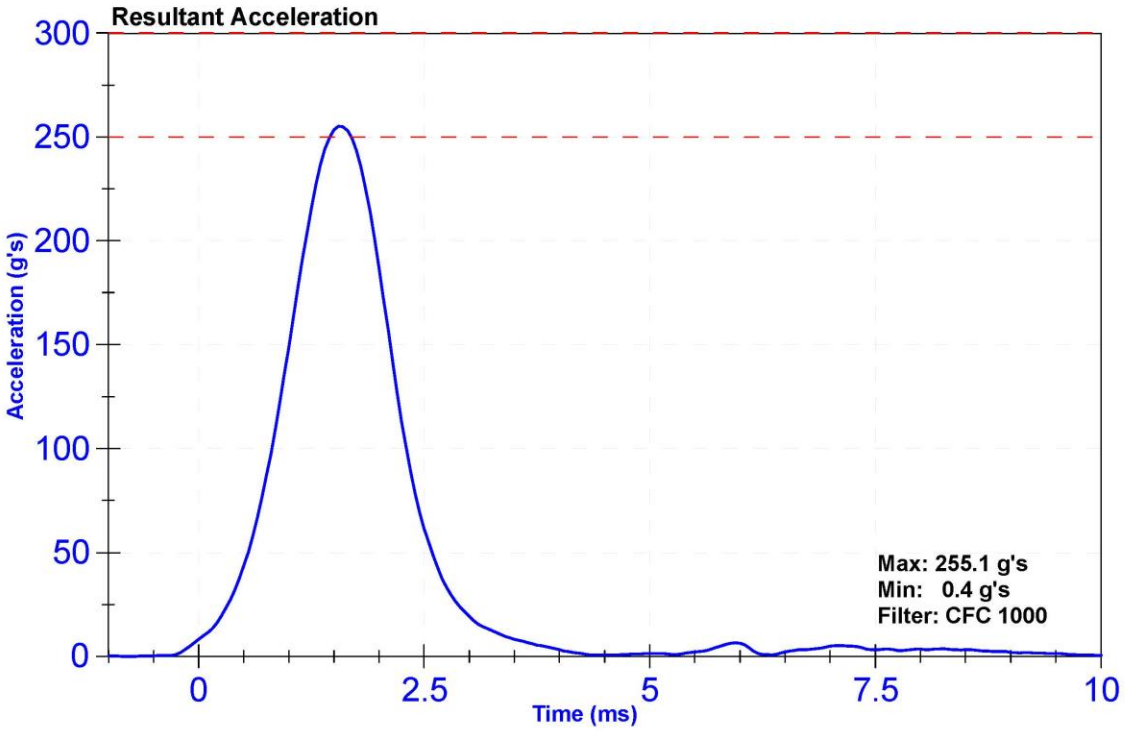
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

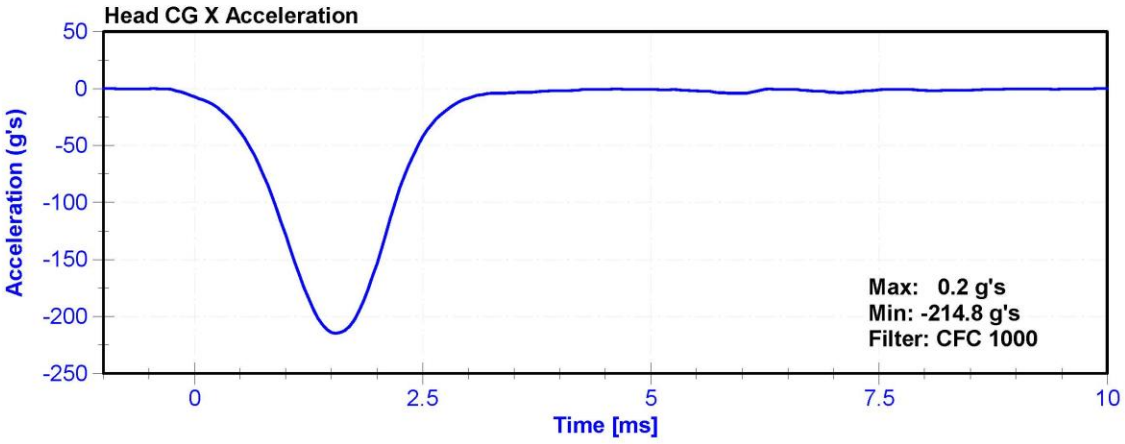
Results

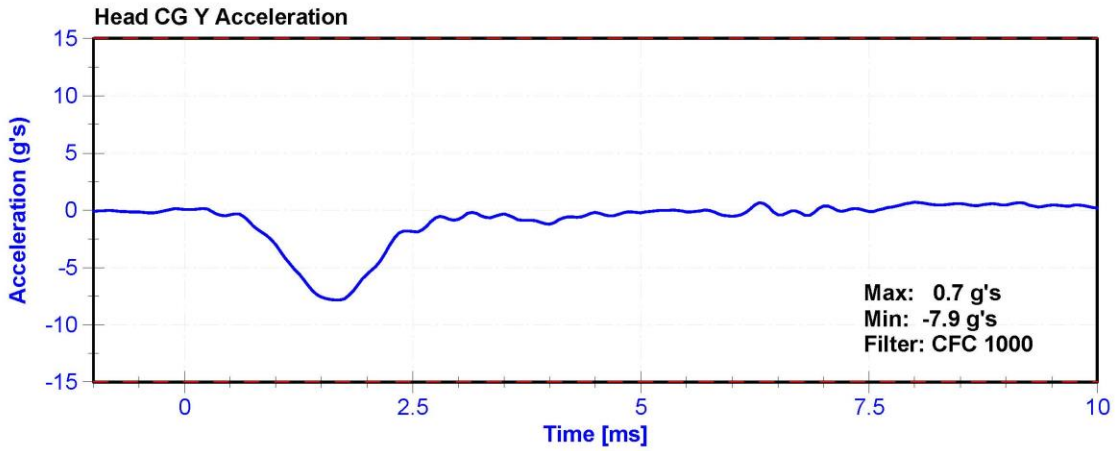
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	30	Pass
Resultant Acceleration	250	300	g's	255.1	Pass
Oscillation	0	10	%	2.6	Pass
Lateral Acceleration	-15	15	g's	-7.9	Pass

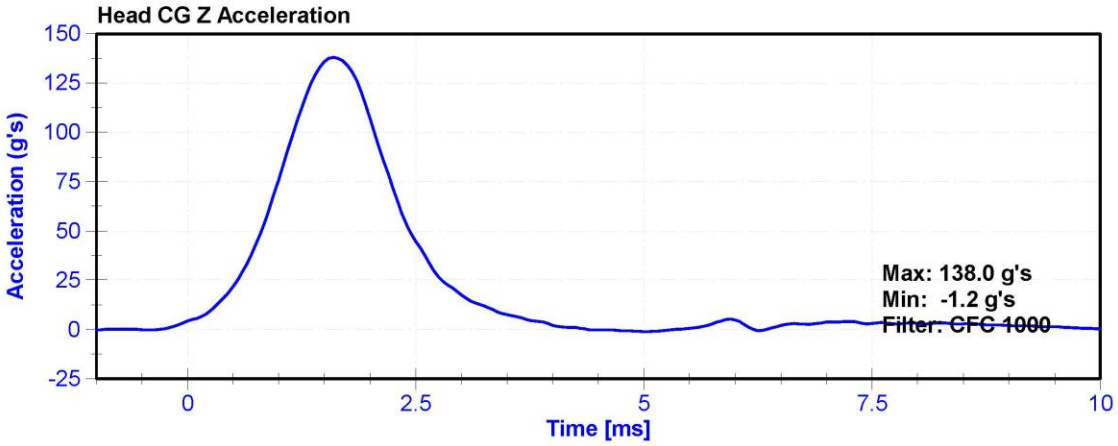
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	Endevco	P58998	9/30/2019	3/30/2020
Y Accelerometer	Endevco	P51722	9/30/2019	3/30/2020
Z Accelerometer	Endevco	P58997	9/30/2019	3/30/2020




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 0.2 g's
Min: -214.8 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: 0.7 g's
Min: -7.9 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: 138.0 g's
Min: -1.2 g's
Filter: CFC 1000

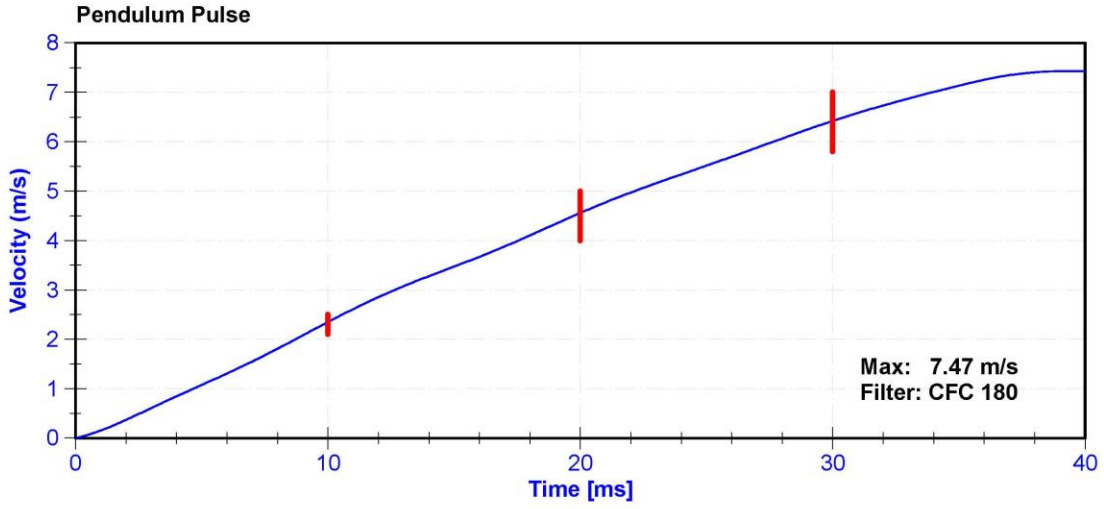
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

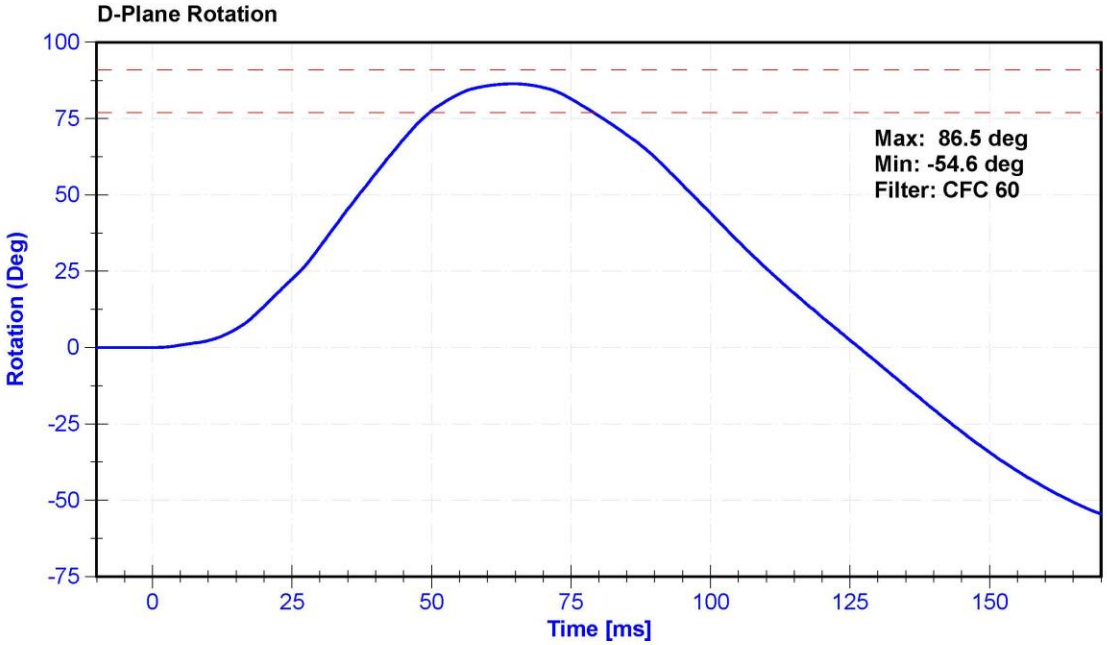
Results

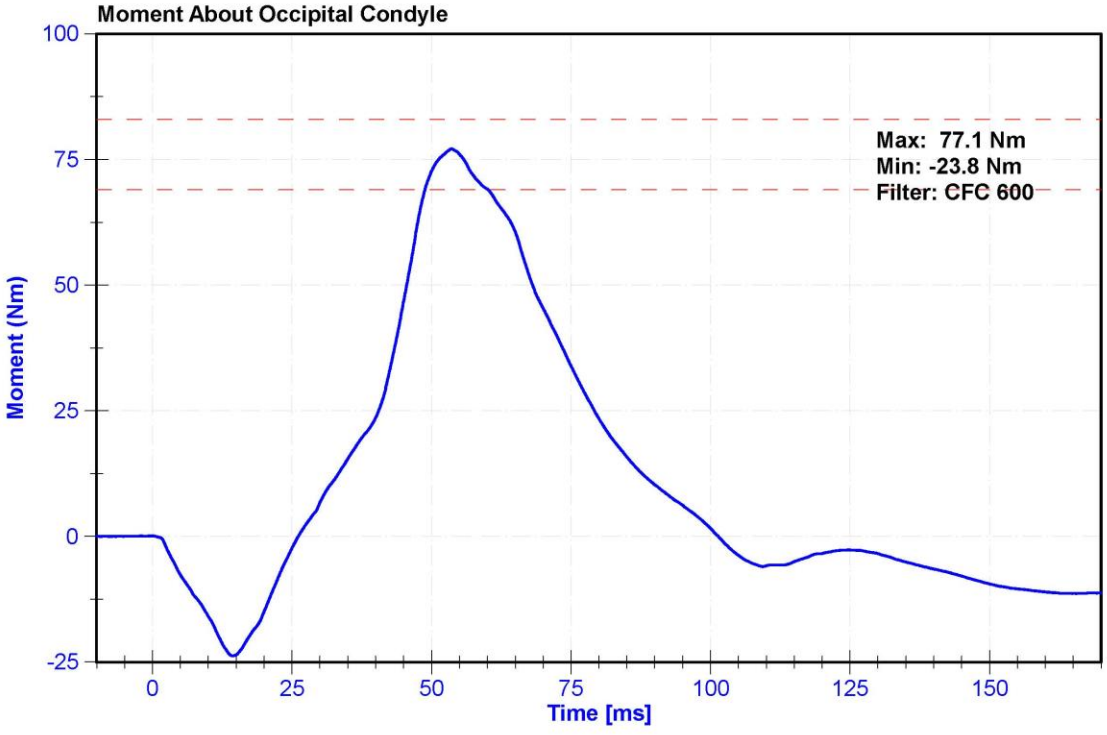
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.0	Pass
Humidity	10	70	%	31.0	Pass
Velocity	6.89	7.13	m/s	7.013	Pass
Pendulum Impulse at 10ms	2.1	2.5	m/s	2.35	Pass
Pendulum Impulse at 20ms	4.0	5.0	m/s	4.56	Pass
Pendulum Impulse at 30ms	5.8	7.0	m/s	6.42	Pass
Max D Plane Rotation	77	91	deg	86.5	Pass
Max Moment During Rotation Interval	69	83	Nm	77.1	Pass
Moment Decay to 10.0 Nm	80	100	ms	90.4	Pass

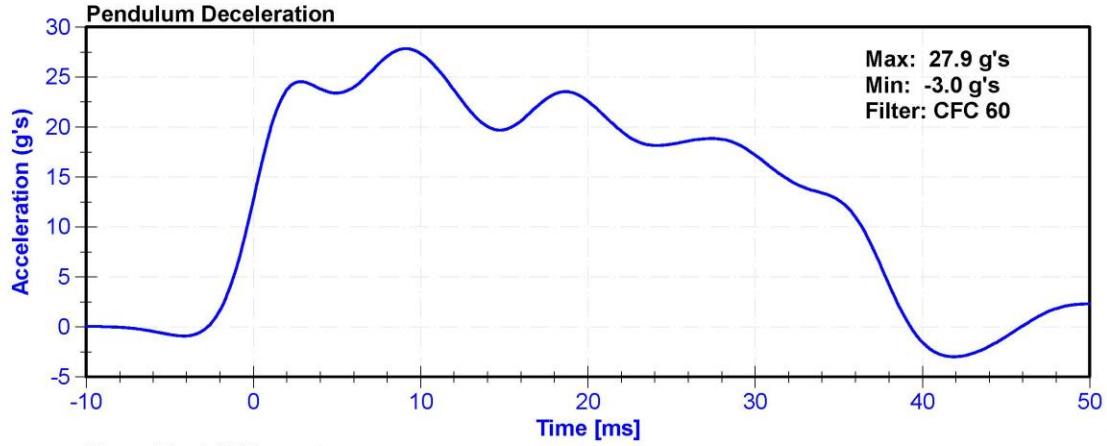
Transducer Calibrations

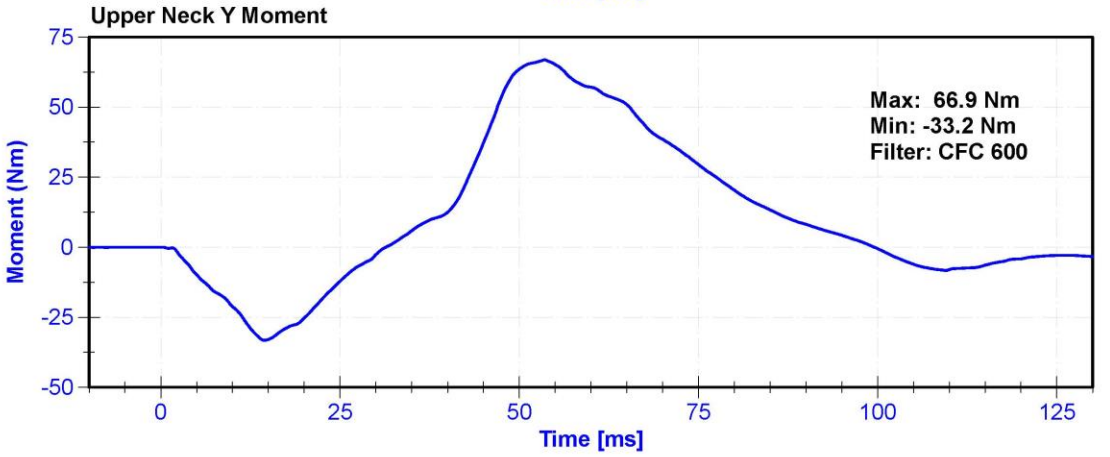
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/29/2019	1/29/2020
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	DENTON 1716A	LC-2206Fx	2/18/2019	2/18/2020

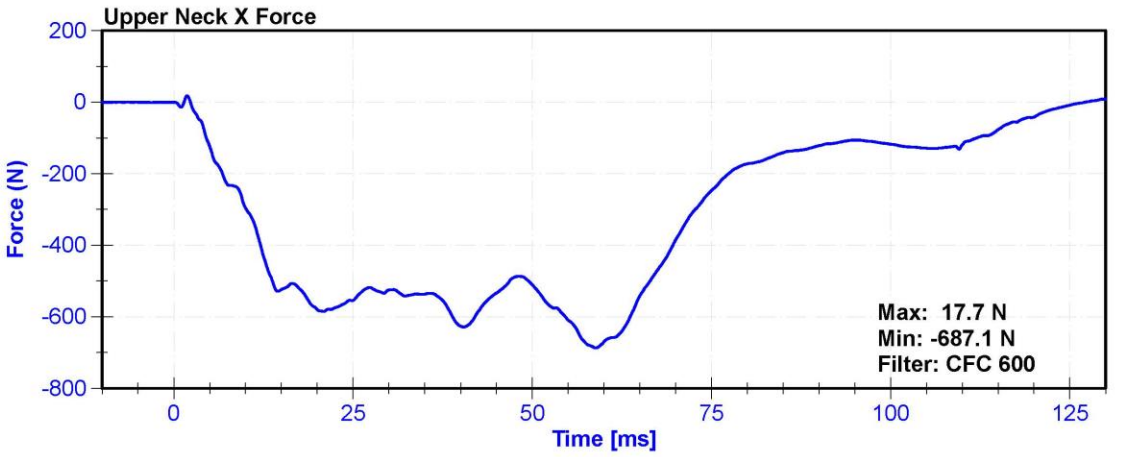



D-Plane Rotation
Max: 86.5 deg
Min: -54.6 deg
Filter: CFC 60
Rotation (Deg)
Time [ms]
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150


Moment About Occipital Condyle
Max: 77.1 Nm
Min: -23.8 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]
100
75
50
25
0
-25
0
25
50
75
100
125
150


Pendulum Deceleration
Max: 27.9 g's
Min: -3.0 g's
Filter: CFC 60
Acceleration (g's)
30
25
20
15
10
5
0
-5
-10
0
10
20
30
40
50
Time [ms]


Upper Neck Y Moment
Max: 66.9 Nm
Min: -33.2 Nm
Filter: CFC 600
Moment (Nm)
75
50
25
0
-25
-50
0
25
50
75
100
125
Time [ms]


Upper Neck X Force
Max: 17.7 N
Min: -687.1 N
Filter: CFC 600
Force (N)
200
0
-200
-400
-600
-800
0
25
50
75
100
125
Time [ms]

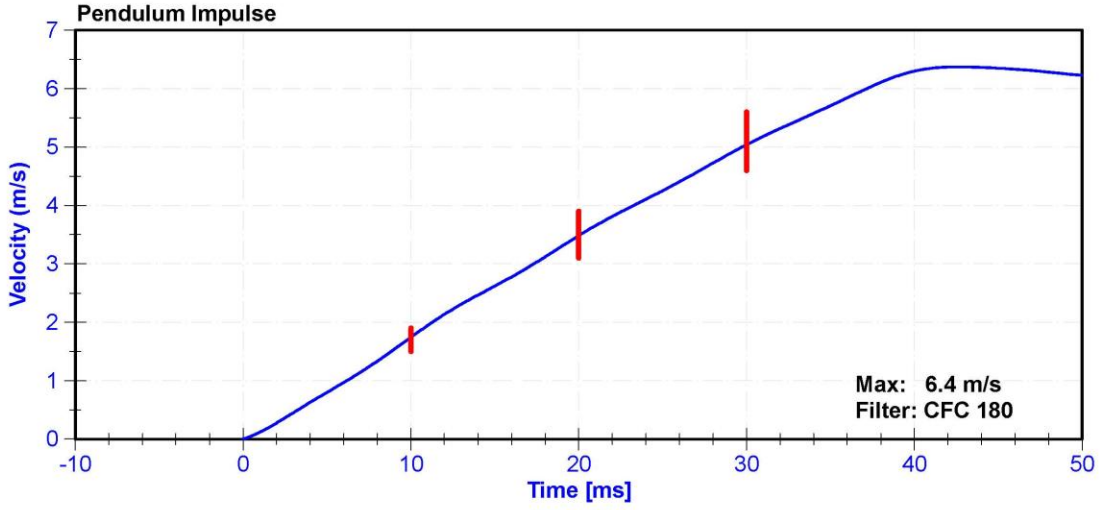
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

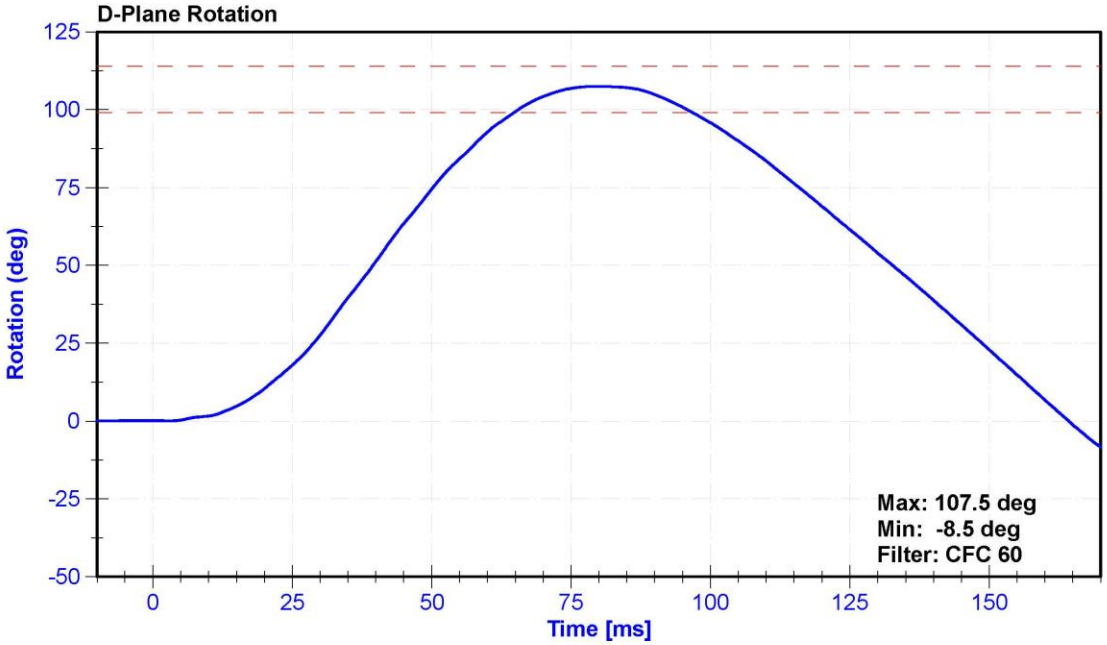
Results

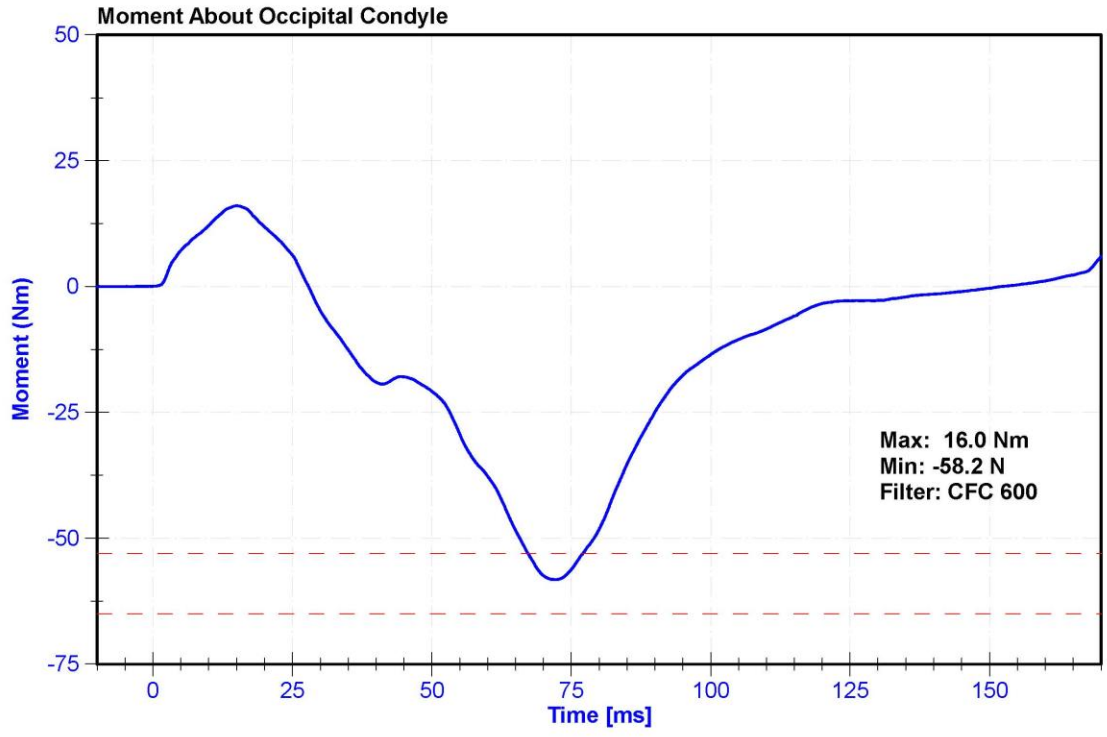
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.6	Pass
Humidity	10	70	%	30.0	Pass
Velocity	5.95	6.19	m/s	6.005	Pass
Pendulum Impulse at 10ms	1.5	1.9	m/s	1.74	Pass
Pendulum Impulse at 20ms	3.1	3.9	m/s	3.48	Pass
Pendulum Impulse at 30ms	4.6	5.6	m/s	5.04	Pass
D Plane Rotation	99	114	deg	107.5	Pass
Moment During Rotation Interval	-65	-53	Nm	-58.2	Pass
Moment Decay to -10Nm	94	114	ms	106.2	Pass

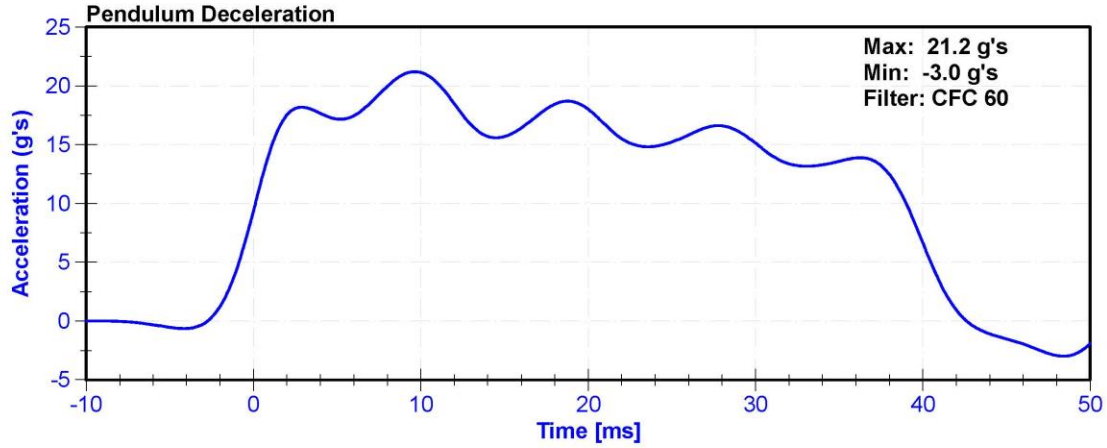
Transducer Calibrations

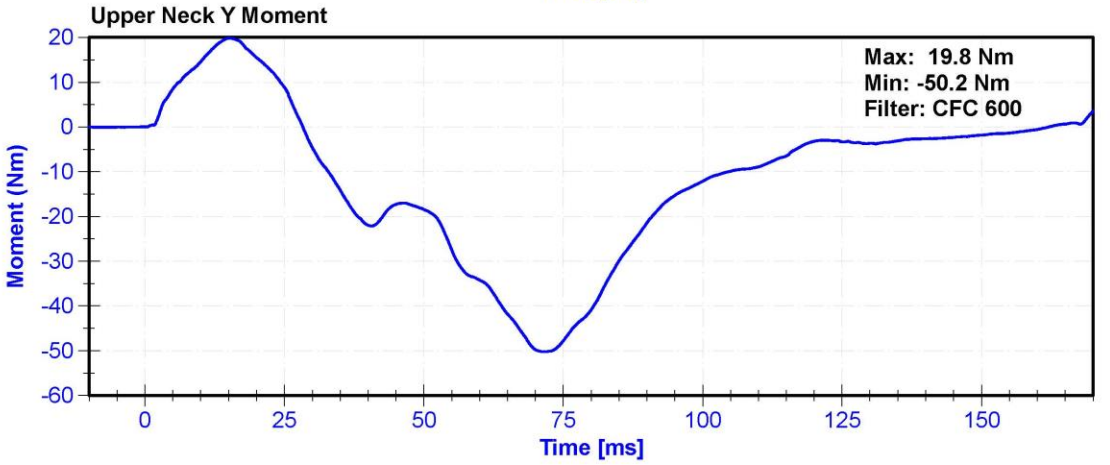
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-AH5M9 Pend	1/29/2019	1/29/2020
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/13/2019	9/12/2020
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/13/2019	9/12/2020
Upper Neck Load Cell	DENTON 1716A	LC-2206Fx	2/18/2019	2/18/2020

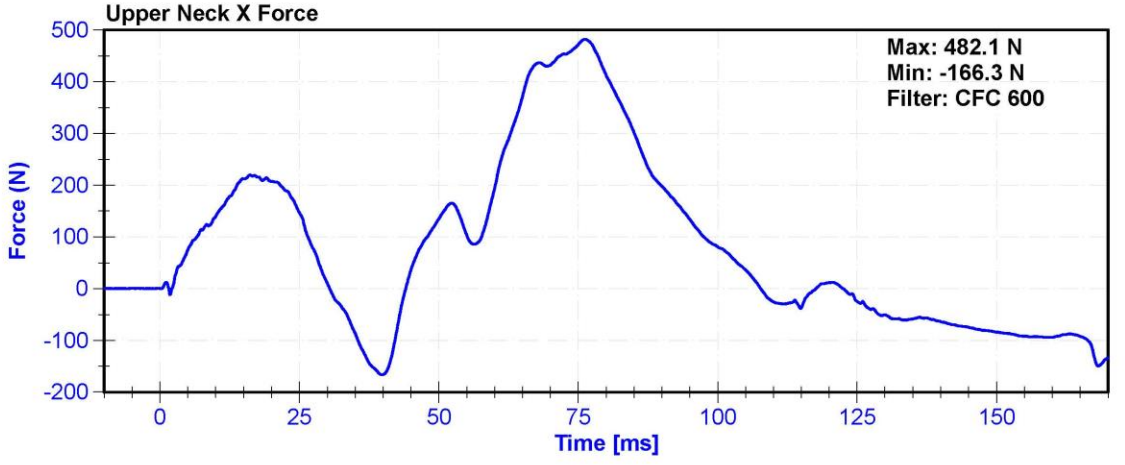



D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 107.5 deg
Min: -8.5 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
50
25
0
-25
-50
-75
0
25
50
75
100
125
150
Time [ms]
Max: 16.0 Nm
Min: -58.2 N
Filter: CFC 600


Pendulum Deceleration
Max: 21.2 g's
Min: -3.0 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: 19.8 Nm
Min: -50.2 Nm
Filter: CFC 600
Moment (Nm)
20
10
0
-10
-20
-30
-40
-50
-60
0
25
50
75
100
125
150
Time [ms]


Upper Neck X Force
Max: 482.1 N
Min: -166.3 N
Filter: CFC 600
Force (N)
500
400
300
200
100
0
-100
-200
0
25
50
75
100
125
150
Time [ms]

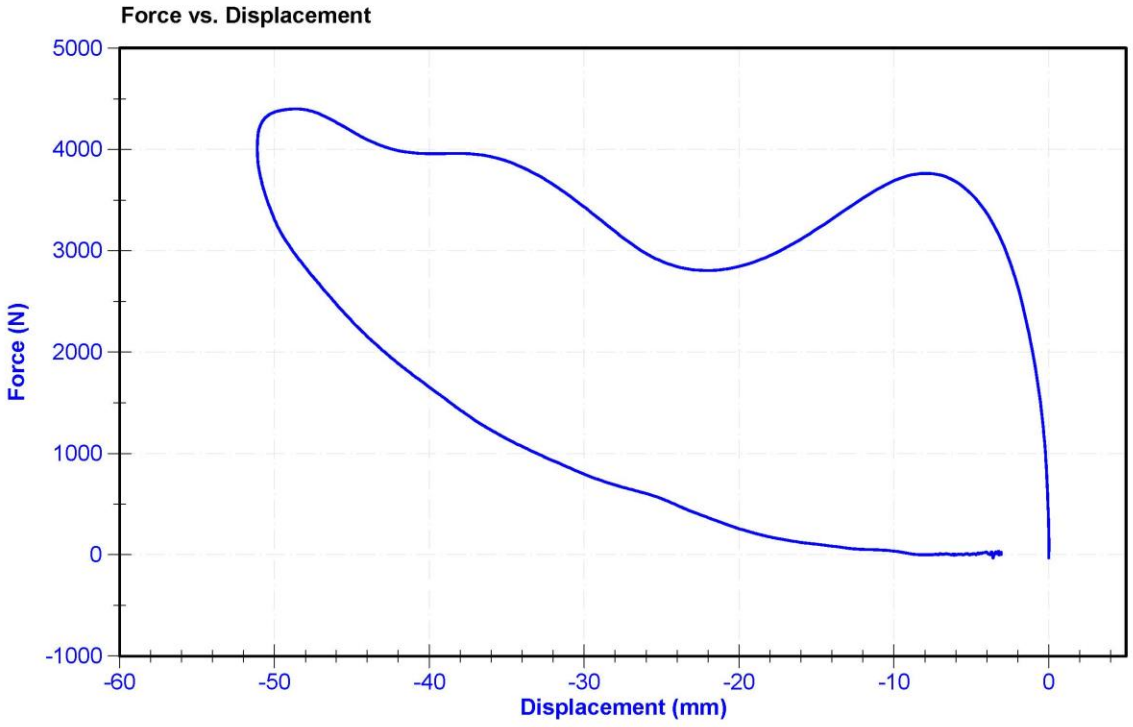
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

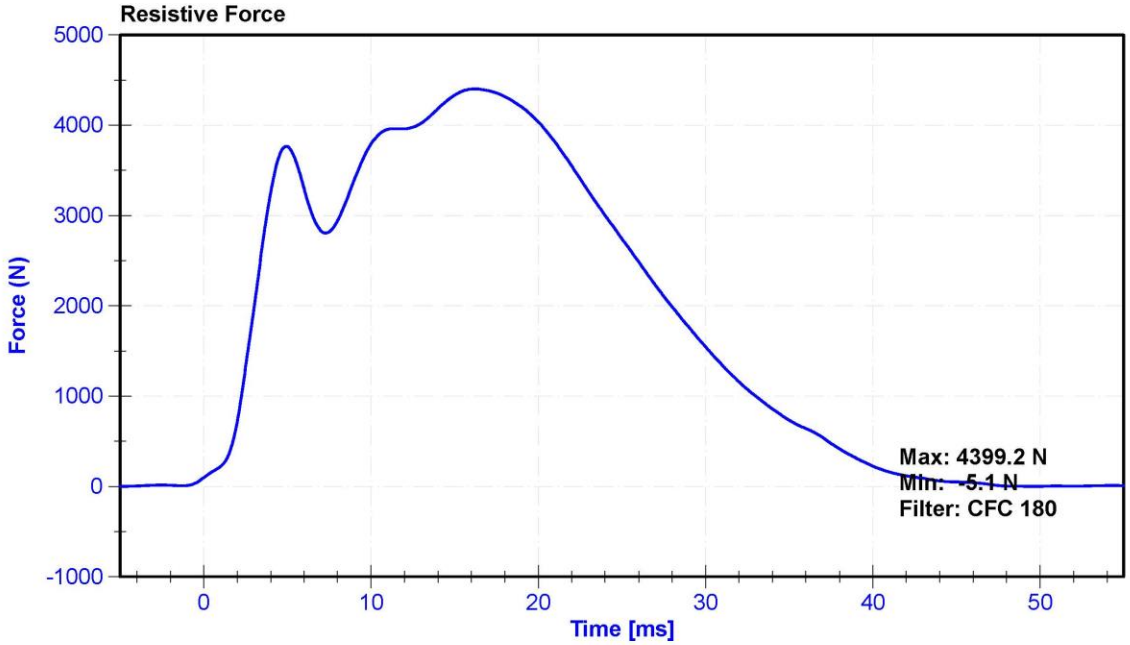
Results

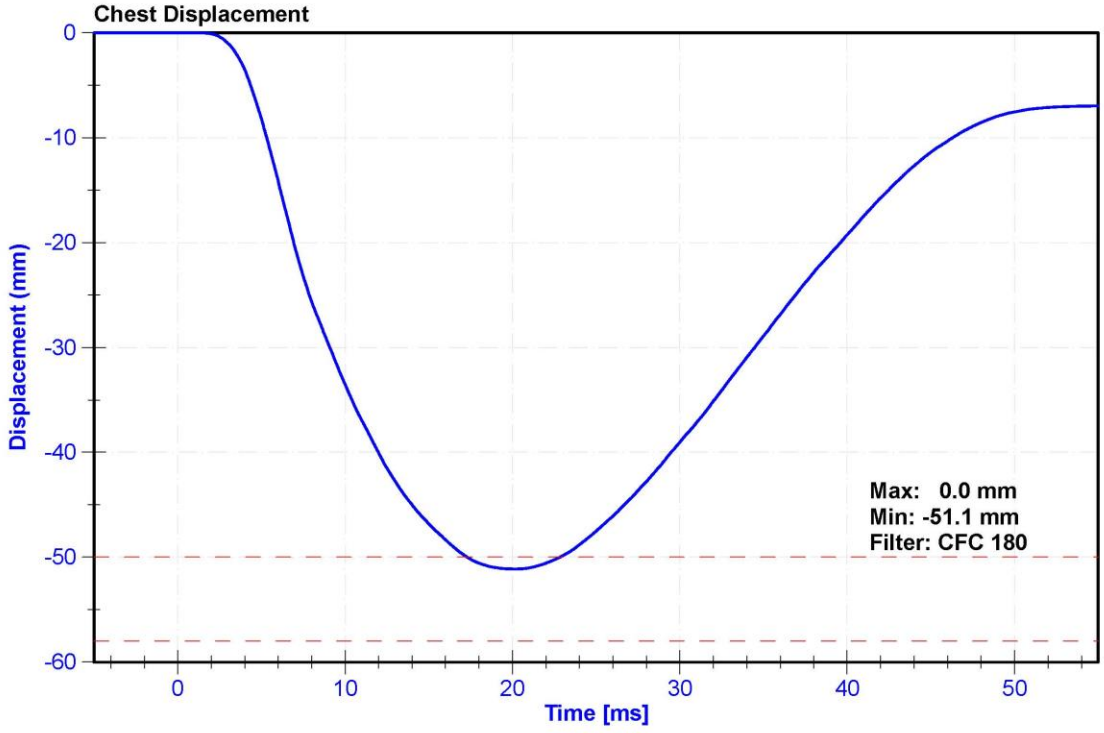
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	38	Pass
Velocity	6.59	6.83	m/s	6.655	Pass
Chest Deflection	-58	-50	mm	-51.1	Pass
Maximum Resistive Force (50 to 58mm)	3900	4400	N	4369.7	Pass
Maximum Resistive Force (18 to 50mm)	0	4600	N	4399.2	Pass
Hysteresis	69	85	%	74.4	Pass

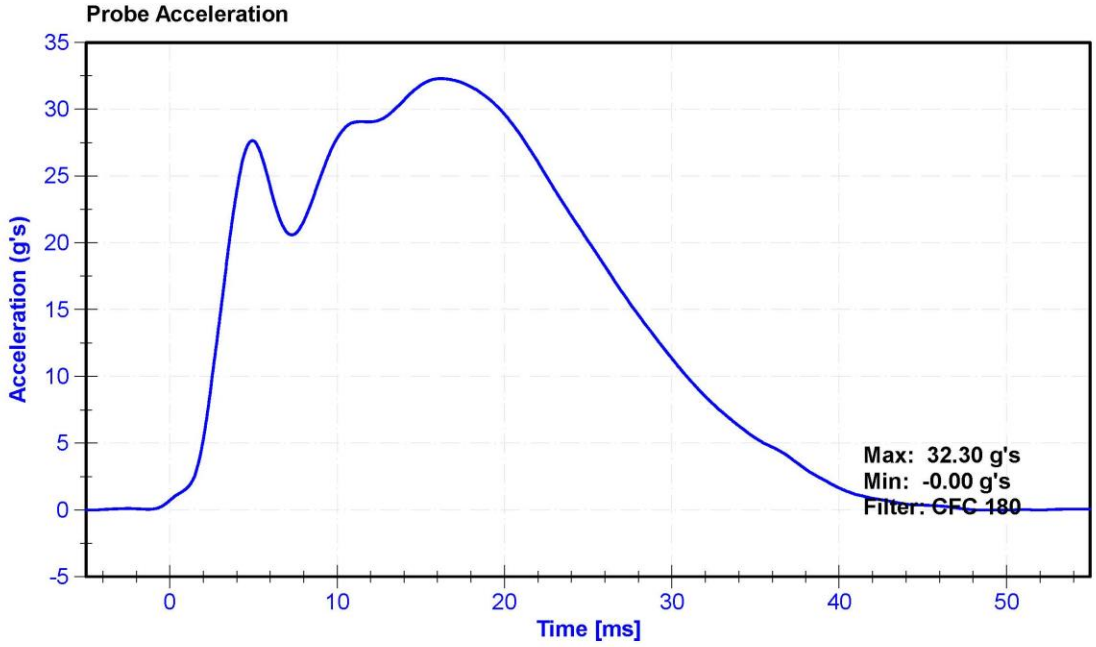
Transducer Calibrations

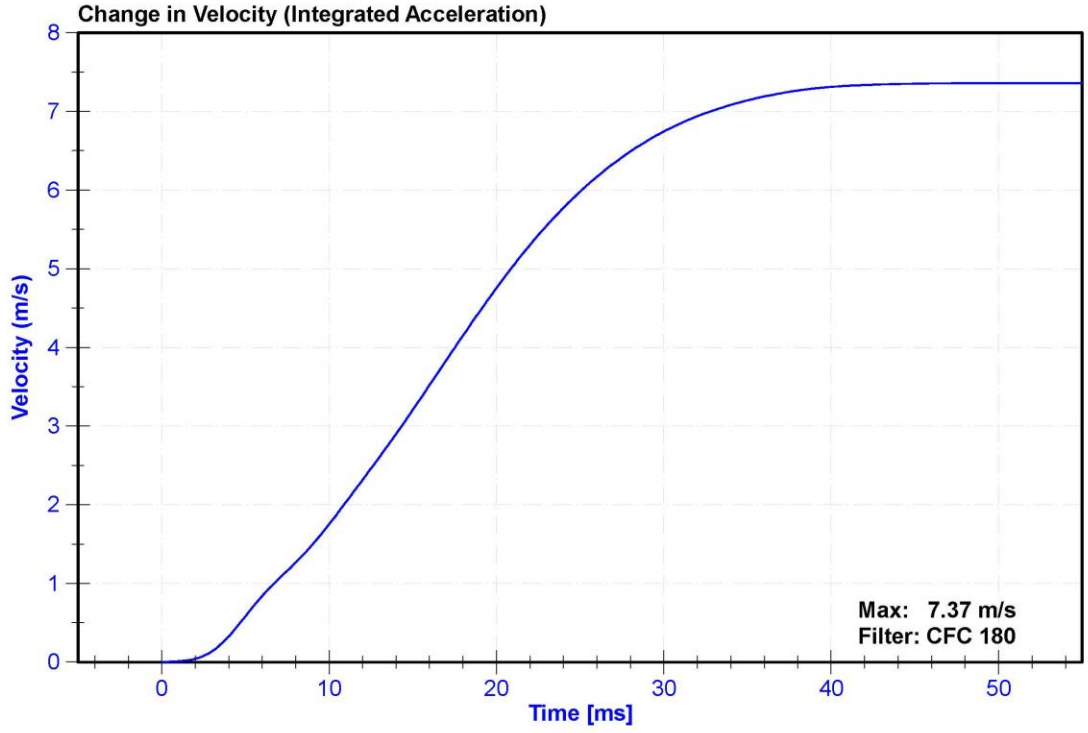
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A260487	8/22/2019	2/20/2020
Chest Potentiometer	SERVO 14CBI-3615	DS-140GFE	6/21/2019	6/20/2020




Resistive Force
Force (N)
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50
Time [ms]
Max: 4399.2 N
Min: -5.1 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: -51.1 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
35
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
Time [ms]
Max: 32.30 g's
Min: -0.00 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: 7.37 m/s
Filter: CFC 180

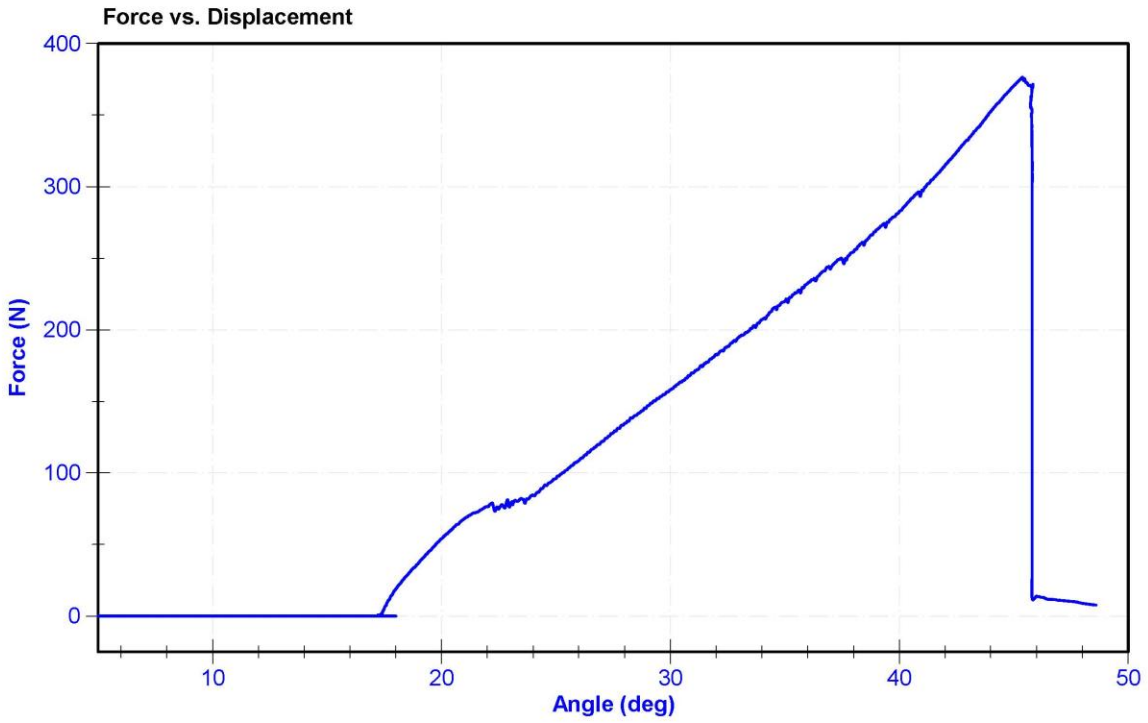
ATD Manufacturer	Humanetics	Test Technician	K. Dutton
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.6	25.6	ºC	21.4	Pass
Humidity	10	70	%	34	Pass
Initial Angle	0	20	deg	16.7	Pass
Force at 45 Degrees	320	390	N	376.4	Pass
Return Angle Relative to Initial	0	8	deg	2.2	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	Rieker N4C-1	DS-13051548	2018-11-25	2019-11-25
Load Cell	Interface SML-200	LC-493319	2018-11-25	2019-11-25



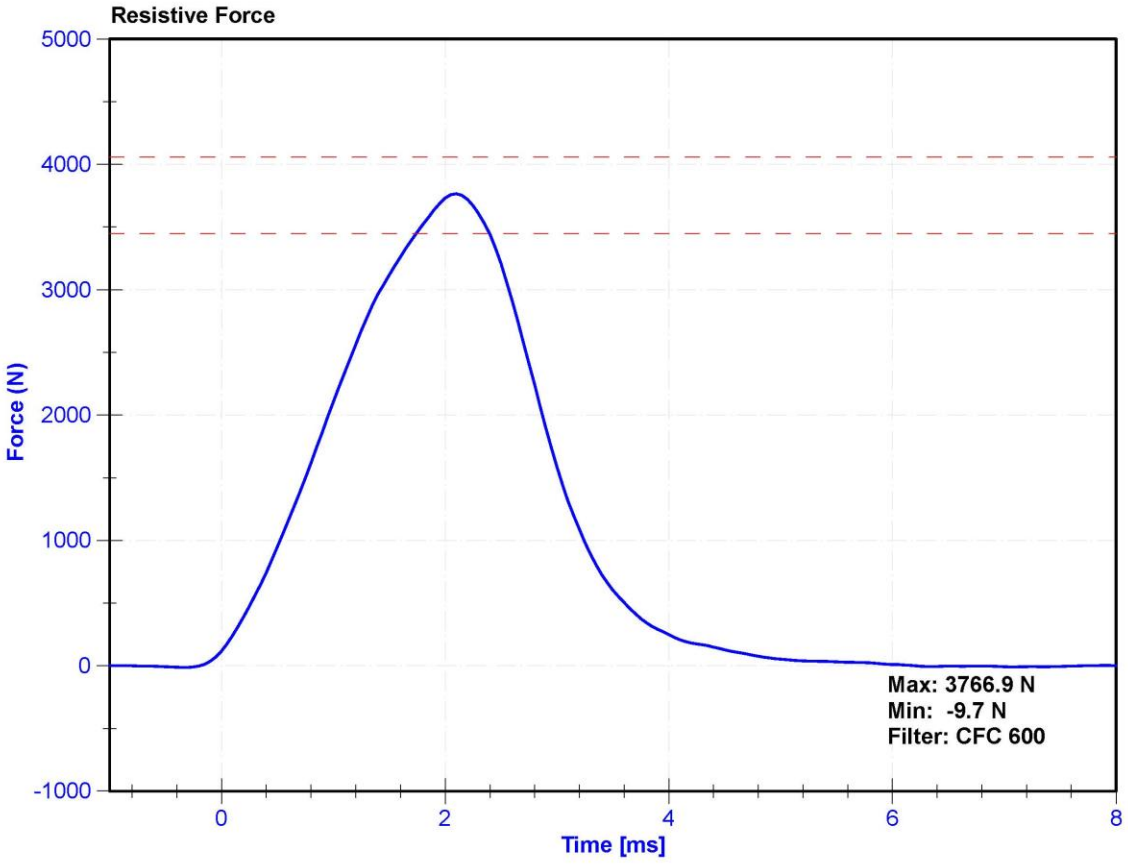
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

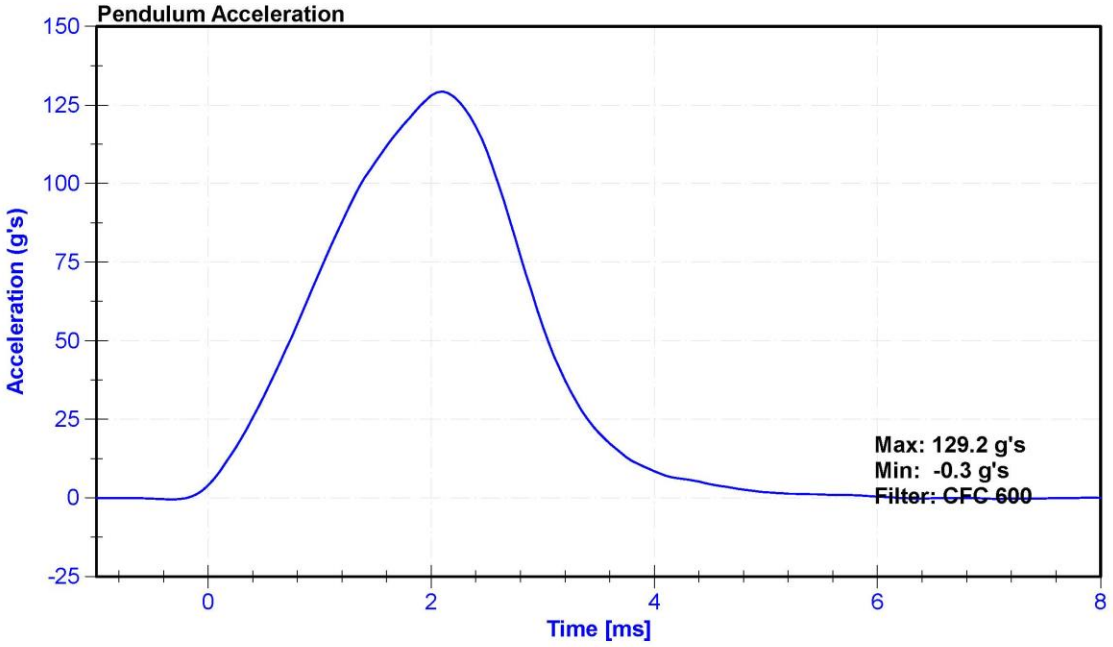
Results

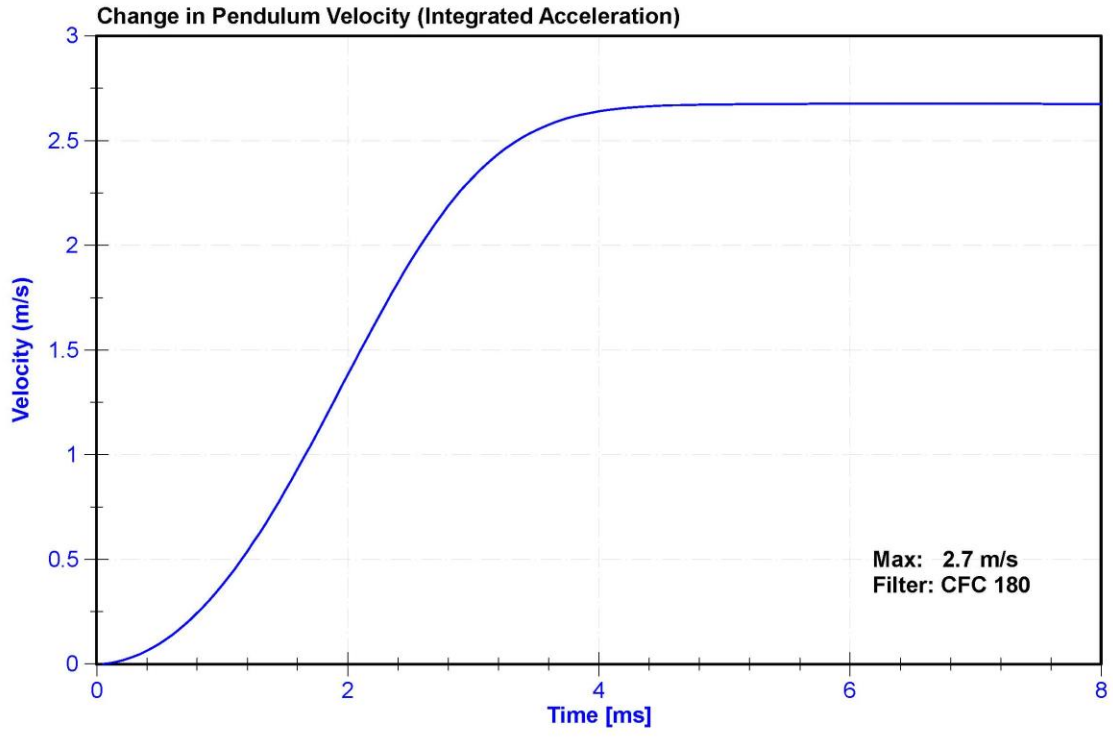
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.2	Pass
Humidity	10	70	%	34.0	Pass
Velocity	2.07	2.13	m/s	2.093	Pass
Resistive Force	3450	4060	N	3766.9	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI	A260568	07/29/2019	01/29/2020




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 129.2 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: 2.7 m/s
Filter: CFC 180

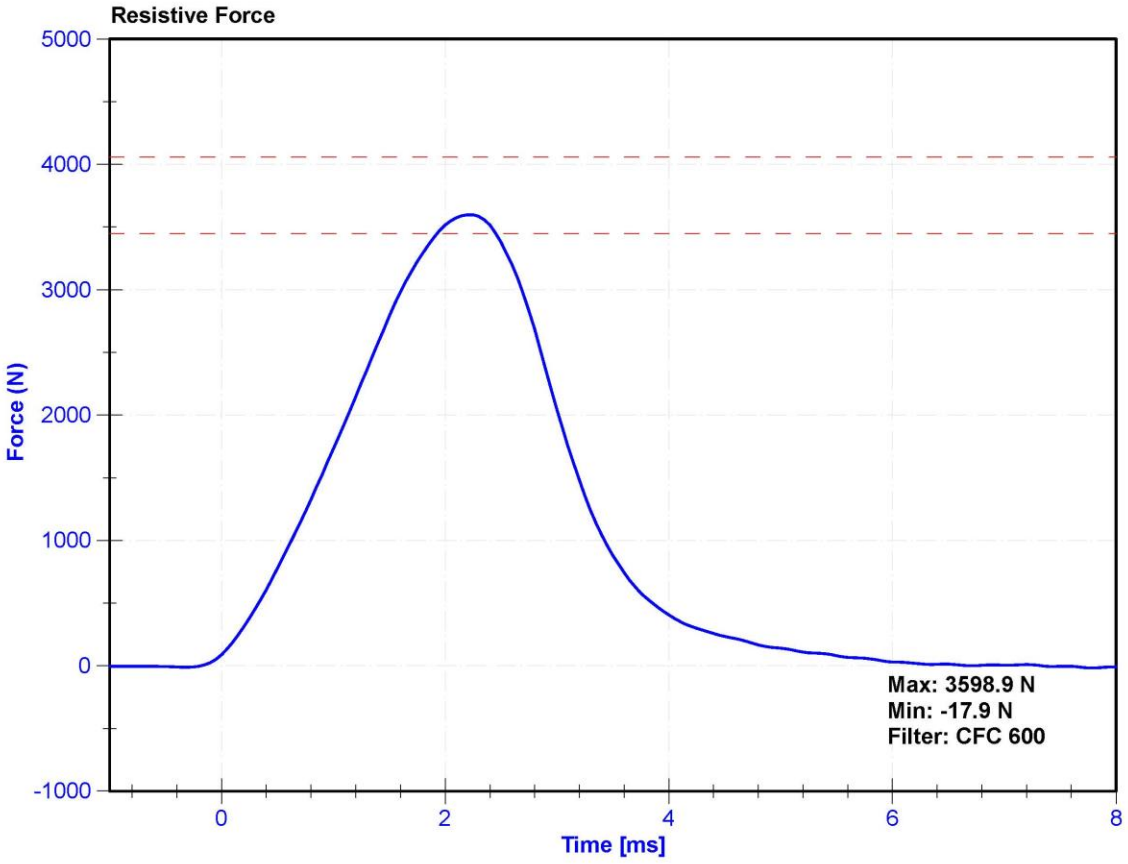
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

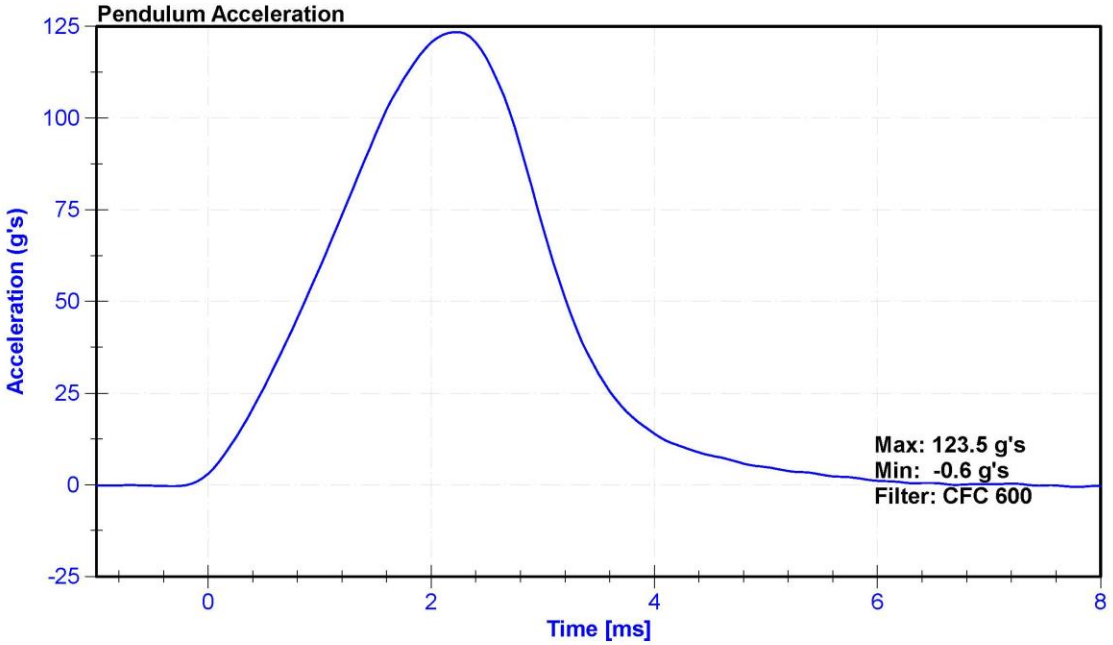
Results

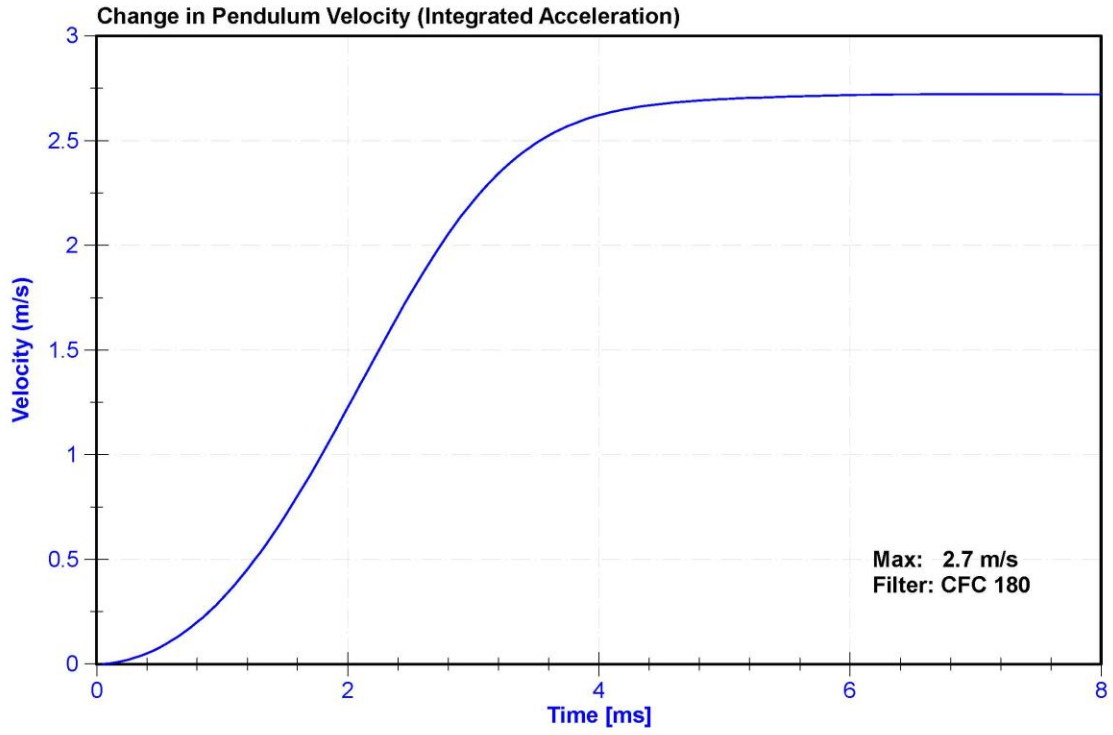
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.0	Pass
Humidity	10	70	%	34.2	Pass
Velocity	2.07	2.13	m/s	2.093	Pass
Resistive Force	3450	4060	N	3598.9	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI	A260568	07/29/2019	01/29/2020




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: -0.6 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: 142		
			Serial Number	Manufacturer	Calibration Date
Head Accelerometers	Primary	X	P51681	ENDEVCO	8/13/2019
		Y	P64151	ENDEVCO	8/13/2019
		Z	P52114	ENDEVCO	8/13/2019
	Redundant	X	P58833	ENDEVCO	8/13/2019
		Y	P58905	ENDEVCO	8/13/2019
		Z	P63996	ENDEVCO	8/13/2019
Head Angular Rate Sensors		X	ARS-5941 GFE	DTS ARS	7/8/2019
		Y	ARS-6014 GFE	DTS ARS	7/8/2019
		Z	ARS-5990	DTS ARS	7/8/2019
Upper Neck Load Cell		FX, Fy, Fz MX,MY, MZ	17162019 FX	Denton	2/18/2019
Chest Accelerometers	Primary	X	AC-P51994	ENDEVCO	10/21/2019
		Y	AC-P51991	ENDEVCO	10/21/2019
		Z	AC-P49185	ENDEVCO	10/21/2019
	Redundant	X	AC-P51713	ENDEVCO	10/21/2019
		Y	AC-P68059	ENDEVCO	10/21/2019
		Z	AC-P78824	ENDEVCO	10/21/2019
Chest Potentiometer		X	DS-142	JDK 6209-2038	9/12/2019
Pelvis Accelerometer		X	AC-P58800	ENDEVCO	9/30/2019
		Y	AC-P52157	ENDEVCO	9/30/2019
		Z	AC-P52156	ENDEVCO	9/30/2019
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-651 Fz	Denton	2/18/2019
	Lower	MX, MY, FZ	LC-364Fz	Denton	9/25/2019
Foot Accelerometers - Left	Rear	X	AC-P50084	ENDEVCO	9/30/2019
	Front	Z	AC-P58779	ENDEVCO	9/30/2019
Foot Accelerometers - Right	Rear	X	AC-P51872	ENDEVCO	10/1/2019
	Front	Z	AC-P58893	ENDEVCO	9/30/2019
Seat belt Load Cells	Lap		LC-278	FTSS IF-964	11/2/2019
	Shoulder		LC-290	FTSS IF-964	11/2/2019

Table 2 – Front Passenger Dummy Instrumentation

Instrumentation		Axis/Location	Hybrid III 5th S/N: 140		
			Serial Number	Manufacturer	Calibration Date
Head Accelerometers	Primary	X	AC-P58998	ENDEVCO	9/30/2019
		Y	AC-P51722	ENDEVCO	10/1/2019
		Z	AC-P58997	ENDEVCO	9/30/2019
	Redundant	X	AC-P58780	ENDEVCO	9/30/2019
		Y	AC-P58749	ENDEVCO	9/30/2019
		Z	AC-P58909	ENDEVCO	9/30/2019
Head Angular Rate Sensors		X	ARS-6986	DTS ARS	1/4/2019
		Y	ARS-9141	DTS ARS	12/14/2018
		Z	ARS-9080	DTS ARS	1/4/2019
Upper Neck Load Cell		FX, Fy, Fz MX,MY, MZ	LC-2206Fx	Denton	2/18/2019
Chest Accelerometers	Primary	X	AC-P59019	ENDEVCO	9/30/2019
		Y	AC-P51965	ENDEVCO	9/30/2019
		Z	AC-P58981	ENDEVCO	9/30/2019
	Redundant	X	AC-P64000	ENDEVCO	9/30/2019
		Y	AC-P51970	ENDEVCO	9/30/2019
		Z	AC-P51689	ENDEVCO	9/30/2019
Chest Potentiometer		X	DS-140GFE	SERVO	6/21/2019
Pelvis Accelerometer		X	AC-P58912	ENDEVCO	10/21/2019
		Y	AC-P51220	ENDEVCO	10/21/2019
		Z	AC-P51989	ENDEVCO	10/21/2019
Femur Load Cells - Left	Primary	Z	LC-DI4213-1	Denton	2/18/2019
	Redundant	Z	LC-DI4213-2	Denton	2/18/2019
Femur Load Cells - Right	Primary	Z	LC-DH3271Fz1	Denton	2/18/2019
	Redundant	Z	LC-DH3271Fz2	Denton	2/18/2019
Tibia Load Cells - Left	Upper	MX, MY, FZ	3643-93 Fz	Denton	10/3/2019
	Lower	MX, MY, FZ	LC-490Fz	Denton	10/3/2019
Tibia Load Cells – Right	Upper	MX, MY, FZ	LC-91Fz	Denton	10/3/2019
	Lower	MX, MY, FZ	LC-398Fz	Denton	10/3/2019
Foot Accelerometers - Left	Rear	X	AC-P64005	ENDEVCO	10/21/2019
	Front	Z	AC-P64006	ENDEVCO	10/21/2019
Foot Accelerometers - Right	Rear	X	AC-P52018	ENDEVCO	10/21/2019
	Front	Z	AC-P78669	ENDEVCO	10/21/2019
Seat belt Load Cells	Lap		LC-DK1753	FTSS IF-964	5/4/2019
	Shoulder		LC-174	FTSS IF-964	5/4/2019

Table 3 – Vehicle Instrumentation

Instrumentation			Axis	Serial Number	Manufacturer	Calibration Date
Crossmember/Rear Seat Accelerometers	Left	Primary	X	AC-A280328	MSI 1201-1000	10/9/2019
			Z	A283623	MSI 1201-1000	10/9/2019
		Redundant	X	AC-A280834	MSI 1201-1000	10/9/2019
	Right	Primary	X	AC-A255837	MSI 1201-1000	10/25/2019
			Z	A284340	MSI 1201-1000	10/25/2019
		Redundant	X	AC-A280355	MSI 1201-1000	10/25/2019
Engine Accelerometers	Top		X	AC-A280312	MSI 1201-1000	7/3/2019
	Bottom		X	AC-A250367	MSI 1201-1000	11/8/2019