REPORT NUMBER: NCAP-CAL-21-005

NEW CAR ASSESSMENT PROGRAM (NCAP)
FRONTAL BARRIER IMPACT TEST

General Motors Corporation
2021 Buick Envision Preferred
Five Door SUV

NHTSA No: M20210100

PREPARED BY:
CALSPAN CORPORATION
P.O. BOX 400
BUFFALO, NEW YORK 14225

June 8, 2021

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

This final test report was prepared for the U.S. Department of Transportation, National Highway Traffic Administration, in response to Contract Number 693JJ919D000005.

Prepared by: Matthew Pronko Date: June 8, 2021
Matthew Pronko, Test Engineer

Approved by: Vanessa Hansen Date: June 8, 2021
Vanessa Hansen, Operations Manager

FINAL REPORT ACCEPTANCE BY OCWS:

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

Date: _____

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

Date: _____

TECHNICAL REPORT DOCUMENTATION PAGE

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4. Title and Subtitle Final Report of New Car Assessment Program Frontal Impact Testing of a 2021 Buick Envision Preferred SUV NHTSA No.: M20210100		*5. Report Date* June 8, 2021 *6. Performing Organization Code* CAL
7. Author(s) Matthew Pronko, Test Engineer Vanessa Hansen, Operations Manager		*8. Performing Organization Report No.* CAL-DOT-2021-005
9. Performing Organization Name and Address Calspan Corporation Transportation Test Operations P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* *11. Contract or Grant No.* 693JJ919D000005
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15. Supplementary Notes		

16. Abstract

A 56.3 km/h (35 mph), NCAP frontal rigid barrier impact test was conducted on a 2021 Buick Envision Preferred SUV in accordance with the specifications of the Office of Crashworthiness Standards Laboratory Procedure for NCAP Full Frontal Rigid Barrier Impact Testing. The test was conducted at Calspan Corporation's Transportation Test Operations facility in Buffalo, New York on March 10, 2021.

The impact velocity of the vehicle was 56.34 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 vehicle centerline. 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	174.979	700	223.372
Maximum Chest Compression	mm	63	-27.781	52	-15.900
Nij		1	0.213	1	0.231
Neck Tension	N	4,170	865.402	2,620	494.170
Neck Compression	N	4,000	-110.828	2,520	-271.619
Left Femur Force	N	10,008	-678.573	6,805	-980.997
Right Femur Force	N	10,008	-1716.569	6,805	-94.952

17. Key Words	*18. Distribution Statement*
56.3 km/h (35 mph) Full Frontal Rigid Barrier Impact Test New Car Assessment Program (NCAP)	Copies of this report are available from: National Highway Traffic Safety Administration Technical Information Services Division 1200 New Jersey Ave, SE Washington, DC 20590

19. Security Class. (of this report)	*20. Security Class. (of this page)*	*21. No. of Pages*	*22. Price*
UNCLASSIFIED	UNCLASSIFIED	169	

Form DOT F1700.7 (8-69)

TABLE OF CONTENTS

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 2021 Buick Envision Preferred SUV at a velocity of 56.34 km/h. The test was performed at Calspan Corporation's Transportation Test Operations facility in Buffalo, New York on March 10, 2021. 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 and then the head restraint. The upper torso contacted the frontal airbag. Both knees contacted the knee air bag.

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

The occupant data is summarized below.

ATD Position	HIC_{15}	Nij	Neck Tension (N)	Neck Comp. (N)	3ms Chest Clip (Gs)	Chest Disp. (mm)	Left Femur (N)	Right Femur (N)
Driver (50^{th})	174.979	0.213	856.402	-110.828	36.611	-27.781	-678.573	-1716.569
Passenger (5^{th})	223.372	0.231	494.170	-271.619	44.338	-15.900	-980.997	-94.952

GENERAL COMMENTS:

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

Data Anomalies:

The following channel was questionable for

- Bottom of Engine X, Exceeded calibration range at 23.7 ms

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: 2021 Buick Envision Preferred SUV NHTSA No.: M20210100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/10/2021

TEST VEHICLE INFORMATION AND OPTIONS

NHTSA No.	M20210100
Model Year	2021
Make	Buick
Model	Envision Preferred
Body Style	SUV
VIN	LRBFZMR44MD074029
Body Color	Orange
Odometer Reading (km /mi)	59 miles
Engine Displacement (L)	2.0
Type / No. Cylinders	I4
Engine Placement	Transverse
Transmission Type	Automatic
Transmission Speeds	9-Speed
Overdrive	Yes
Final Drive	All Wheel Drive
Roof Rack	No
Sunroof / T-Top	No
Running Boards	No
Tilt Steering Wheel	Yes
Power Seats	Yes
Anti-Lock Brakes (ABS)	Yes
Automatic Door Locks (ADLs)	Yes

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

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

DATA FROM CERTIFICATION LABEL

Manufactured By	SAIC General Motors Corporation Limited for General Motors LLC
Date of Manufacture	12/20

GVWR (kg)	2300
GAWR Front (kg)	1270
GAWR Rear (kg)	1225

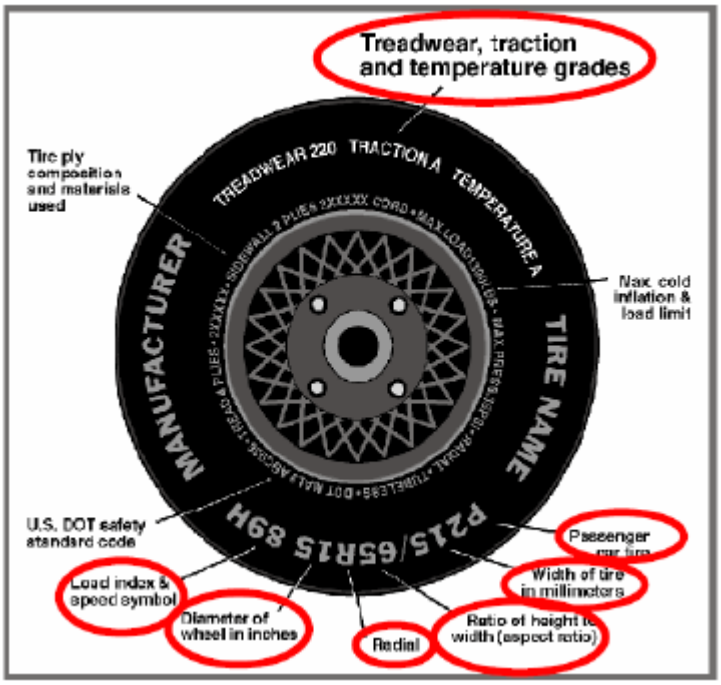
VEHICLE SEATING AND WEIGHT CAPACITY DATA

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)				529
Cargo Wt. (RCLW) (kg)				136

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

Test Vehicle:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021

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



VEHICLE TIRE INFORMATION

Measured Parameter	Front	Rear
Maximum Tire Pressure (kPa)	350	350
Cold Pressure (kPa)	240	240
Recommended Tire Size	235/60R18	235/60R18
Tire Size on Vehicle	235/60R18	235/60R18
Tire Manufacturer	Continental	Continental
Tire Model	ProContact	ProContact
Treadwear	500	500
Traction	A	A
Temperature Grades	A	A
Tire Plies Sidewall	2 Polyester	2 Polyester
Tire Plies Body	2 Polyester, 2 Steel, 1 Polyamide	2 Polyester, 2 Steel, 1 Polyamide
Load Index / Speed Symbol	103H	103H
Tire Material	Rubber	Rubber
DOT Safety Code Left	1LF0FBBYB4720	1LF0FBBYB4720
DOT Safety Code Right	1LF0FBBYB4720	1LF0FBBYB4720

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

Test Vehicle: 2021 Buick Envision Preferred SUV NHTSA No.: M20210100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/10/2021

TEST VEHICLE WEIGHTS

	Units	As Delivered Weights (UVW)			As Tested Weights (ATW)		
		Front Axle	Rear Axle	Total	Front Axle	Rear Axle	Total
Left	kg	522	365.5		561	475	
Right	kg	520	341		537	445	
Ratio	%	59.6	40.4		54.4	45.6	
Totals	kg	1042	706.5	1748.5	1098	920	2018

TARGET TEST WEIGHT CALCULATION

Measured Parameter	Units	Value	
Total Delivered Weight (UVW)	kg	1748.5	(A)
Weight of 1 P572E ATD & 1 P572O ATD	kg	142	(B)
Rated Cargo / Luggage Weight (RCLW)	kg	136	(C)
Calculated Vehicle Target Weight (TVTW)	kg	2026.5	(A+B+C)

TEST VEHICLE ATTITUDES AND CG

Condition	Units	LF	RF	LR	RR	CG (aft of front axle)
As Delivered	mm	878	882	909	912	1124
As Tested	mm	858	864	855	858	1268
Post-Test	mm	935	951	846	853	

GENERAL TEST VEHICLE DATA

Measurement Description	Units	Value
Total Vehicle Wheel Base	mm	2781
Total Vehicle Length at Left Side	mm	4515
Total Vehicle Length at Centerline	mm	4639
Total Vehicle Length at Right Side	mm	4515
Weight of Ballast in Cargo Area	kg	87
Weight of Vehicle Components Removed	kg	30
Amount of Stoddard Solvent in Fuel Tank	L	56

LIST OF COMPONENTS REMOVED TO MEET TEST WEIGHT:

Trunk carpeting, spare tire, jack

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

Test Vehicle: 2021 Buick Envision Preferred SUV NHTSA No.: M20210100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/10/2021

TARGET VEHICLE STRUCTURAL MEASUREMENT

No.	Description	Pre-Test
1	Total Length	4639
2	Total Width	1860
3*	Bumper Top Height	623
4*	Bumper Bottom Height	516
5*	Longitudinal Member Top Height	613
6	Distance Between Longitudinal Members	1014
7	Longitudinal Member Width	48
8*	Engine Top Height	863
9*	Engine Bottom Height	257
10	Engine and Gearbox Width	423
11	Front Bumper-Engine Distance	629
12*	Front Shock Absorber Fixing Height	945
13*	Bonnet Leading Edge Height	897
14	Front Shock Absorber Fixing Width	1200
15	Front Bumper – Front Axle Distance	975
16	Front Axle – A Pillar Distance	520
17	A-Pillar – B-Pillar Distance	1112
18	B-Pillar – Rear Axle Distance	1152
19	B-Pillar – C-Pillar Distance	1095
20*	Roof Sill Bottom Height	1530
21*	Roof Sill Top Height	1577
22*	Floor Sill Bottom Height	331
23*	Floor Sill Top Height	435

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

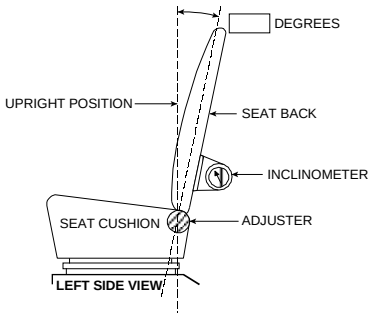
DATA SHEET NO. 2
SEAT ADJUSTMENT, FUEL SYSTEM, AND STEERING WHEEL DATA

Test Vehicle:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021

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	10.8
Passenger Seat Back Angle	18.2



FRONT SEAT ASSEMBLY

SEAT FORE / AFT POSITIONS

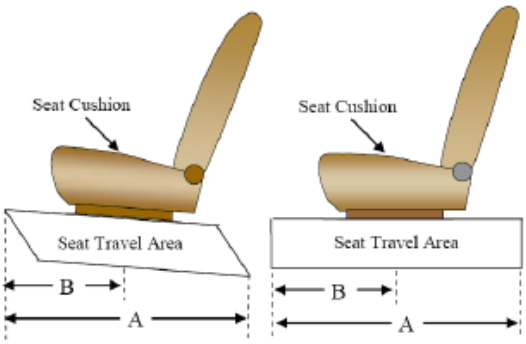
The driver's seat was positioned at the mid-point of fore/aft travel at its lowest position. The passenger's seat was positioned at the most forward position of fore/aft travel. Zero is defined as the forward most position.

Seating Position	Total Fore / Aft Travel	Placed in Position #
Driver Seat	310	155
Passenger Seat	26 (0-25)	0

SEAT BELT UPPER ANCHORAGE

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

Seating Position	Total # of Positions	Placed in Position #
Driver Seat	4	0
Passenger Seat	4	0



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

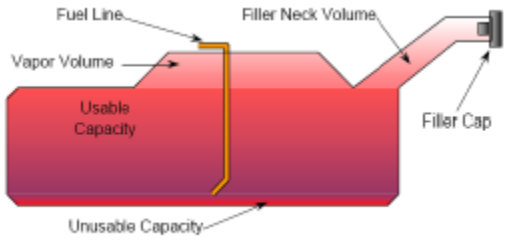
Test Vehicle:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021

FUEL TANK CAPACITY

Description	Liters
Usable Capacity of "Standard Tank"	60.2
Usable Capacity of "Optional Tank"	N/A
92%-94% of Usable Capacity	55.4 – 56.6
Actual Amount of Solvent Used	56.0
1/3 of Usable Capacity	20.0

FUEL PUMP

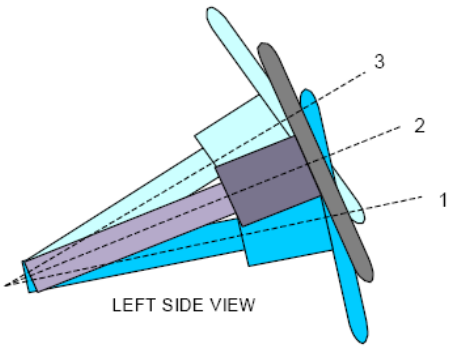
The vehicle is equipped with an electric fuel pump. The fuel filler neck is on the right side of the vehicle. The pump creates positive pressure in the fuel lines, pushing the gasoline to the engine. See form 1 for more information.



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.



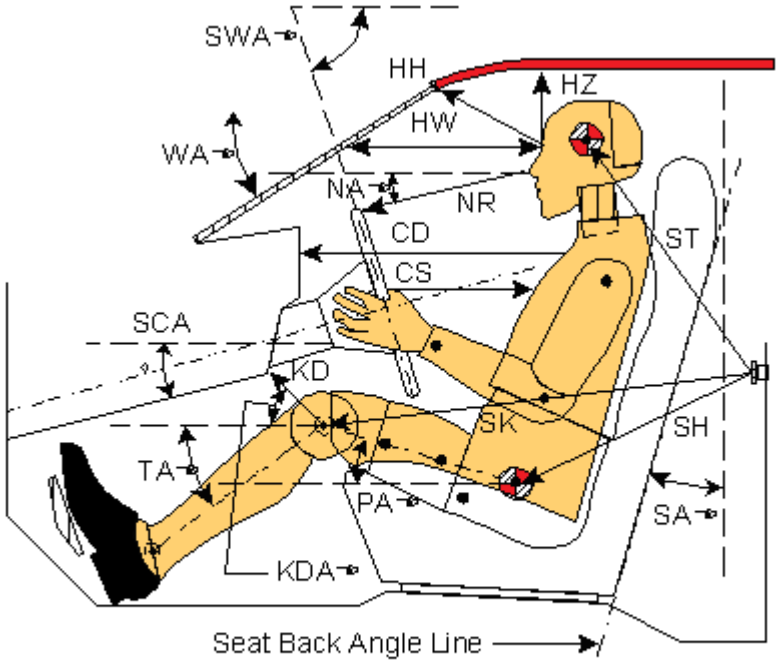
STEERING COLUMN ASSEMBLY

STEERING COLUMN POSITIONS

Description	Degrees	Fore / Aft Position (mm)
Lowermost position No. 1	22.5	
Geometric center position No. 2	24.9	
Uppermost position No. 3	27.2	
Telescoping Steering Wheel Travel		70
Test Position	24.9	30

DATA SHEET NO. 3
DUMMY LONGITUDINAL CLEARANCE DIMENSIONS

Test Vehicle: 2021 Buick Envision Preferred SUV
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20210100
Test Date: 3/10/2021

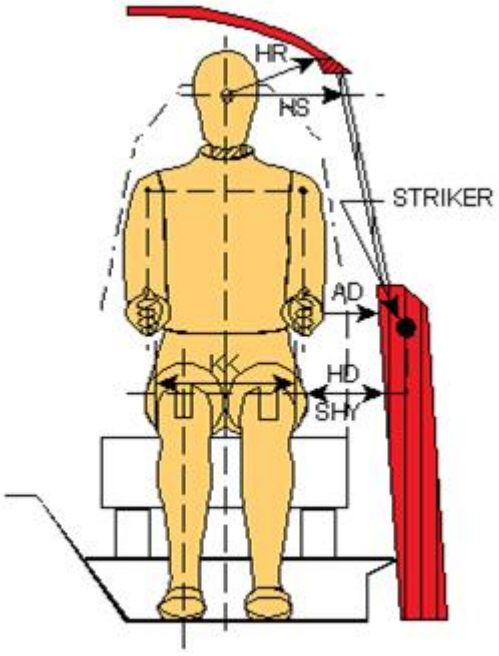


Left Side View

Code	Measurement Description	Driver (SN: 142)		Passenger (SN: 140)	
		Length (mm)	Angle (°)	Length (mm)	Angle (°)
WA°	Windshield Angle		29.9		
SWA°	Steering Wheel Angle		24.4		
SCA°	Steering Column Angle		65.6		
SA°	Seat Back Angle (on headrest post)		10.8		18.2
HZ	Head to Roof (Z)	258	90	271	90
HH	Head to Header	459	23.1	392	41.4
HW	Head to Windshield	773	0	749	0
NR	Nose to Rim / Dash	469	8.3	438	19.4
CD	Chest to Dash	578		404	
CS	Chest to Steering Hub	367	3.1		
RA	Rim to Abdomen	251	0		
KDL	Left Knee to Dash	245	21.6	140	27.7
KDR	Right Knee to Dash	238	12.4	150	25.2
PA°	Pelvic Angle		23.2		20.1
TA°	Tibia Angle		30.6		47.6
SK	Striker to Knee	515	13.9	614	10.9
ST	Striker to Head	487	86.7	431	68.4
SH	Striker to H-Point	210	61.2	314	38.6

DATA SHEET NO. 4
DUMMY LATERAL CLEARANCE DIMENSIONS

Test Vehicle: 2021 Buick Envision Preferred SUV
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20210100
Test Date: 3/10/2021

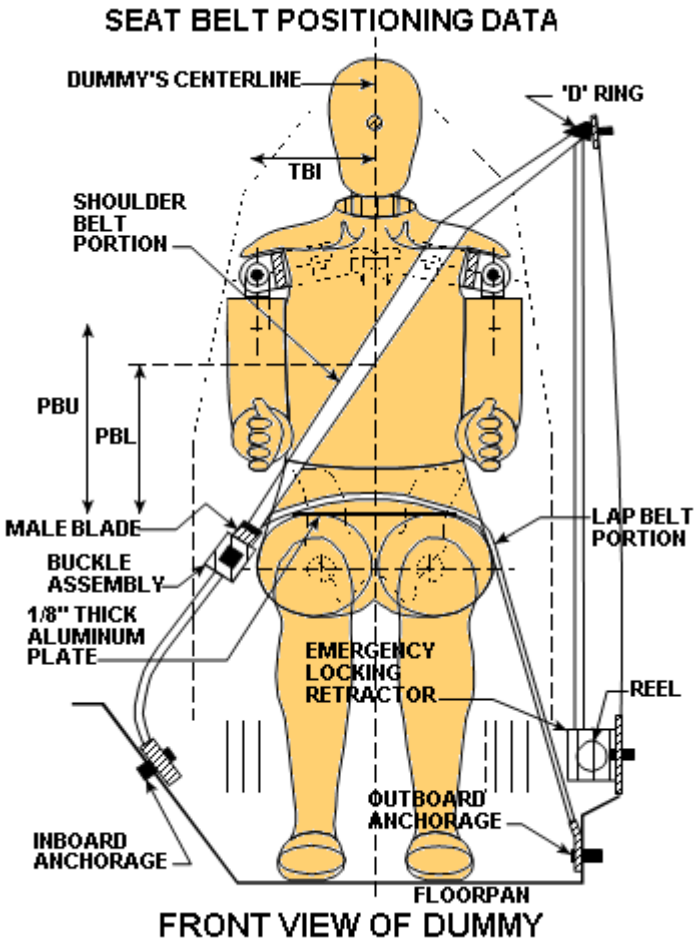


Front View

Code	Description	Driver (mm)	Passenger (mm)
AD	Arm to Door	137	96
HD	H-Point to Door	154	183
HR	Head to Side Header	248	290
HS	Head to Side Window	360	395
KK	Knee to Knee	335	210
SHY	Striker to H-Point (Y Direction)	270	270
AA	Ankle to Ankle	340	165

DATA SHEET NO. 5
SEAT BELT POSITIONING DATA

Test Vehicle:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021



SEAT BELT POSITIONING MEASUREMENTS

Measurement Description	Units	Driver	Passenger
PBU — Top surface of reference to belt upper edge	mm	295	280
PBL — Top surface of reference to belt lower edge	mm	220	195

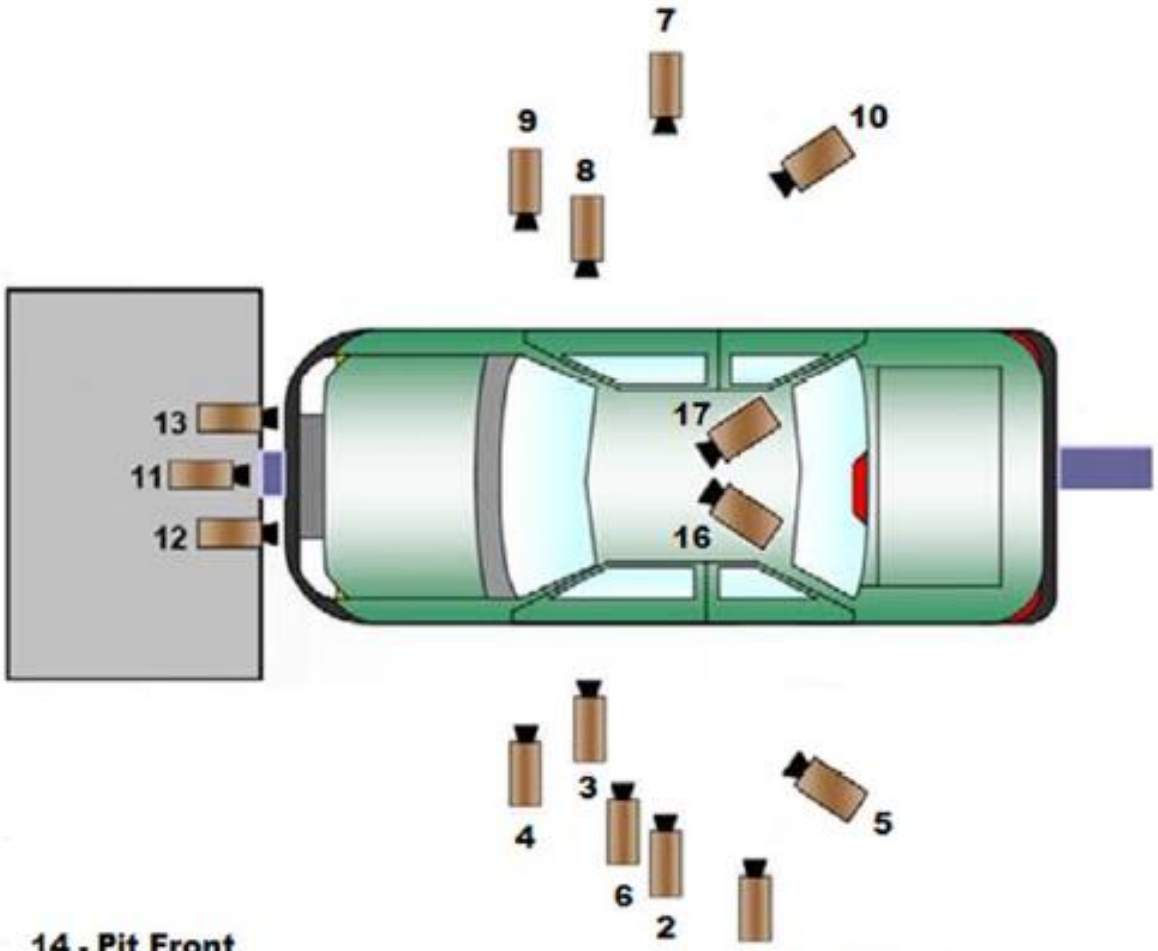
BELT LENGTH DATA

Measurement Description	Units	Driver	Passenger
Shoulder belt length as measured on ATD	mm	810	860
Lap Belt Length as measured on ATD	mm	575	630
Remainder of belt on reel	mm	965	860
Total belt length for continuous webbing systems	mm	2350	2350

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

Test Vehicle:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021

CAMERA POSITIONS FOR FRONTAL IMPACTS



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

Test Vehicle: 2021 Buick Envision Preferred SUV NHTSA No.: M20210100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/10/2021

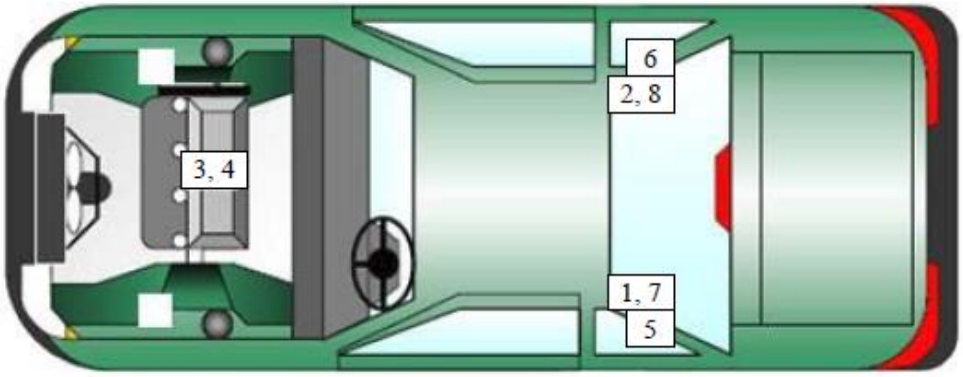
CAMERA LOCATIONS

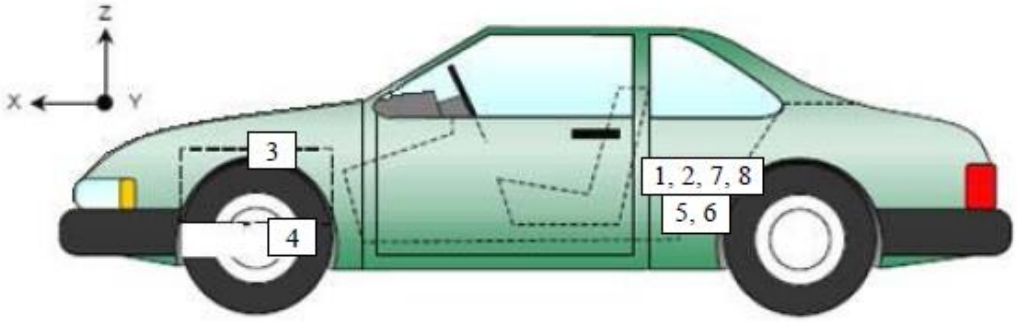
No.	Camera View	Location (mm)			Lens (mm)	Speed (fps)
		X	Y	Z		
1	Real-Time Left Overall				Zoom	60
2	Left Overall	-2298	-7136	-1408	24	1000
3	Driver Close-Up	-1345	-7192	-1553	50	1000
4	Left Front Half	-1024	-5794	-1251	28	1000
5	Left Angle	-4347	-5055	-2476	50	1000
6	Steering Column	-1462	-8236	-2407	75	1000
7	Right Overall	-2269	7527	-1445	24	1000
8	Passenger Close-Up	-1613	6390	-1459	50	1000
9	Right Front Half	-1312	5711	-1424	28	1000
10	Right Angle	-4326	4789	-2470	50	1000
11	Windshield	1162	0	-3471	12.5	1000
12	Driver Windshield	1137	-405	-2304	25	1000
13	Passenger Windshield	1137	405	-2304	25	1000
14	Pit Front	-1161	0	2335	12.5	1000
15	Pit Rear	-2510	0	2236	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: 2021 Buick Envision Preferred SUV NHTSA No.: M20210100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/10/2021





VEHICLE ACCELEROMETER PRE-TEST LOCATIONS

No.	Accelerometer Location	Measurements (mm)		
		X	Y	Z
1	Left Rear Accelerometer – X Direction	1711	-365	309
2	Right Rear Accelerometer – X Direction	1709	363	290
3	Engine Top X	3835	-61	-163
4	Engine Bottom X	3946	23	433
5	Left Rear Accelerometer – Z Direction	1711	-365	309
6	Right Rear Accelerometer – Z Direction	1709	363	290
7	Left Rear Accelerometer – X Direction Redundant	1711	-366	309
8	Right Rear Accelerometer – X Direction Redundant	1709	363	290

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

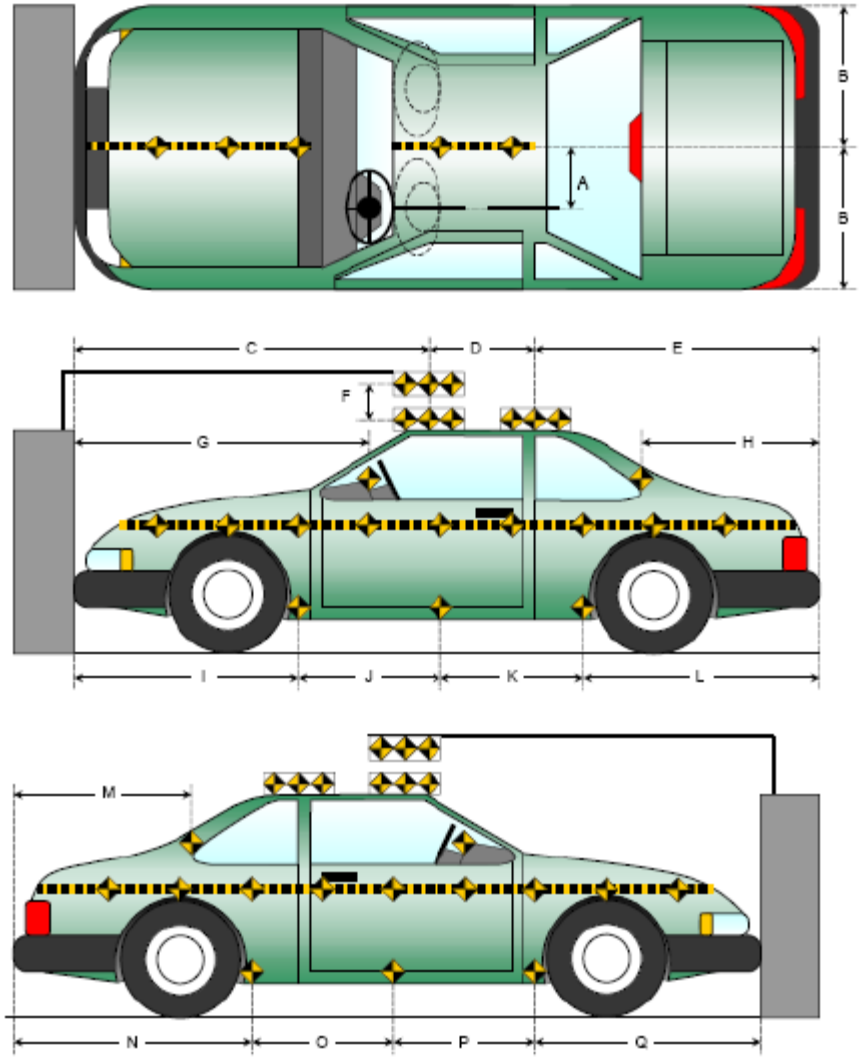
DATA SHEET NO. 8
PHOTOGRAPHIC REFERENCE TARGET LOCATIONS

Test Vehicle: 2021 Buick Envision Preferred SUV
Test Program: NCAP Frontal Barrier Impact Test

NHTSA No.: M20210100
Test Date: 3/10/2021

Item	Value
A	390
B	930
C	2526
D	751
E	1362
F	205
G	1823
H	944
I	1458
J	909
K	910
L	1362
M	949
N	1361
O	911
P	909
Q	1458

All units in millimeters



DATA SHEET NO. 9
LOAD CELL LOCATIONS ON FIXED BARRIER

Test Vehicle:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021

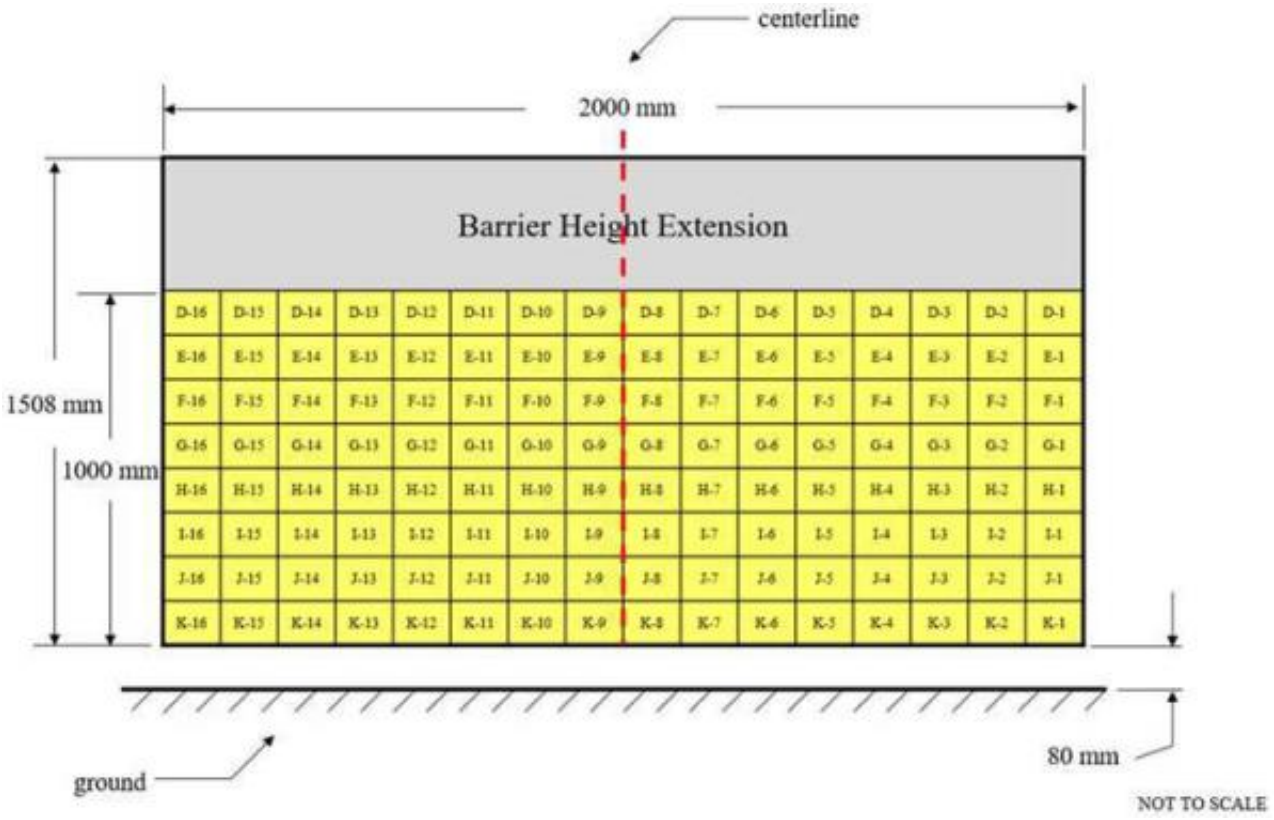


Figure 1 - Load Cell Locations on a 128-Load Cell Barrier with Plywood Height Extension*
Please note above diagram is not actual representation of load cell barrier used.

DATA SHEET NO. 10
TEST VEHICLE SUMMARY OF RESULTS

Test Vehicle: 2021 Buick Envision Preferred SUV
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20210100
Test Date: 3/10/2021

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: 2021 Buick Envision Preferred SUV NHTSA No.: M20210100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/10/2021

TEST DUMMY INFORMATION AND CONTACT LOCATIONS

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

DOOR OPENING AND SEAT TRACK INFORMATION

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

POST-TEST STRUCTURAL OBSERVATIONS

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

VEHICLE REBOUND FROM BARRIER

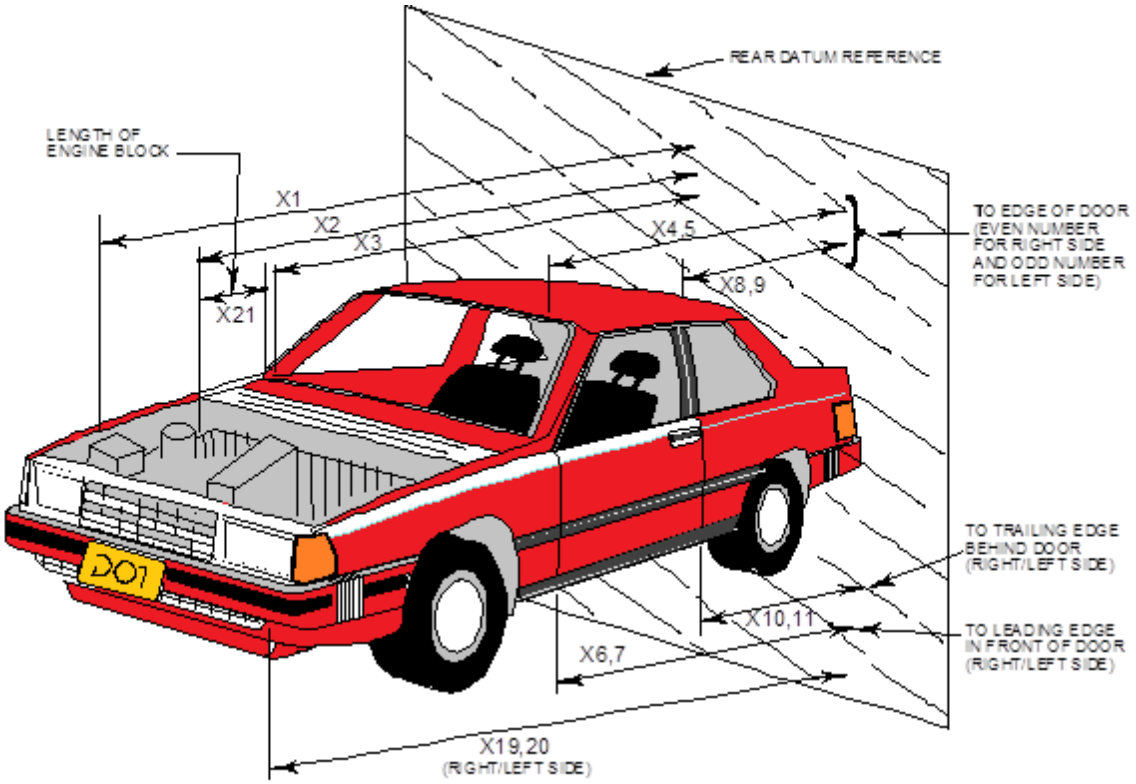
Measured Parameter	Units	Value
Left Side	mm	1095
Center	mm	990
Right Side	mm	1070
Average	mm	1052

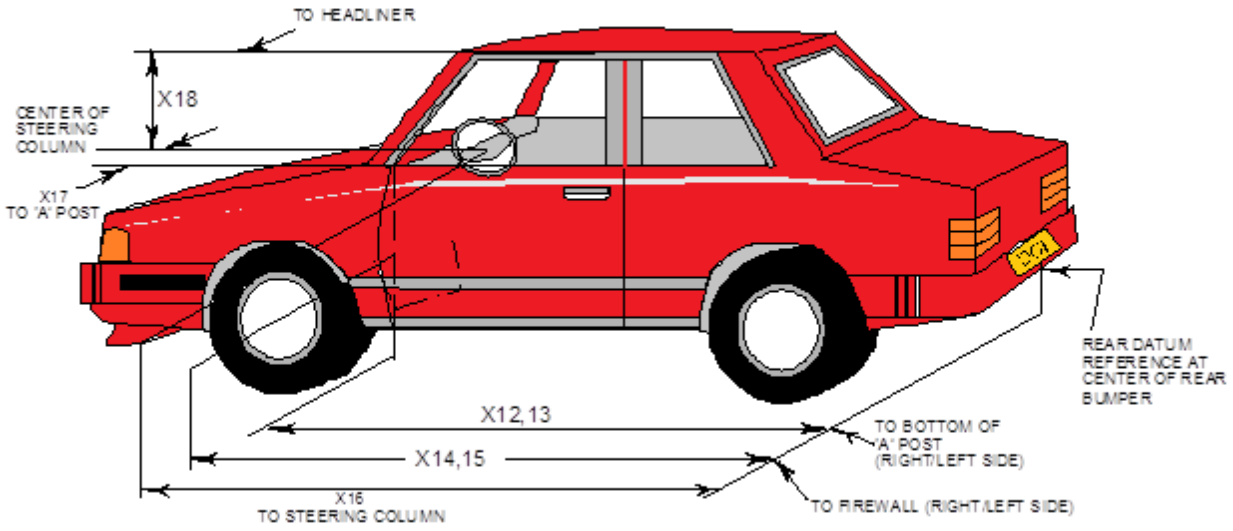
SUPPLEMENTAL RESTRAINT SYSTEM INFORMATION

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

DATA SHEET NO. 12
VEHICLE PROFILE MEASUREMENTS

Test Vehicle:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021





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

Test Vehicle: 2021 Buick Envision Preferred SUV NHTSA No.: M20210100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/10/2021

No.	Measurement Description	Pre-Test	Post-Test	Difference
1	Total Length of Vehicle at Centerline	4639	4182	-457
2	Rear Surface of Vehicle (RSOV) to Front of Engine	4010	3719	-291
3	RSOV to Firewall	3533	3516	-17
4	RSOV to Upper Leading Edge of Right Door	3137	3140	3
5	RSOV to Upper Leading Edge of Left Door	3136	3138	2
6	RSOV to Lower Leading Edge of Right Door	3142	3144	2
7	RSOV to Lower Leading Edge of Left Door	3141	3143	2
8	RSOV to Upper Trailing Edge of Right Door	2040	2041	1
9	RSOV to Upper Trailing Edge of Left Door	2036	2038	2
10	RSOV to Lower Trailing Edge of Right Door	2088	2090	2
11	RSOV to Lower Trailing Edge of Left Door	2084	2086	2
12	RSOV to Bottom of “A” Post of Right Side	3155	3157	2
13	RSOV to Bottom of “A” Post of Left Side	3151	3152	1
14	RSOV to Firewall, Right Side	3591	3588	-3
15	RSOV to Firewall, Left Side	3598	3594	-4
16	RSOV to Steering Column	2643	2718	75
17	Center of Steering Column to “A” Post	289	283	-6
18	Center of Steering Column to Headliner	455	481	26
19	RSOV to Right Side of Front Bumper	4563	4077	-486
20	RSOV to Left Side of Front Bumper	4564	4080	-484
21	Length of Engine Block	279	279	0
RD	RSOV to Right Side of Dash Panel	2836	2836	0
CD	RSOV to Center of Dash Panel	2763	2764	1
LD	RSOV to Left Side of Dash Panel	2877	2877	0

*UR= Unrecoverable data point
All Dimensions in mm

DATA SHEET NO. 13
ACCIDENT INVESTIGATION DIVISION DATA

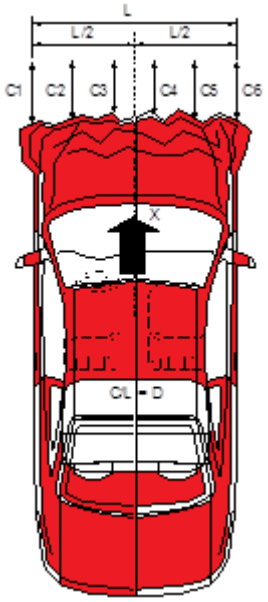
Test Vehicle:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021

VEHICLE INFORMATION

VIN:	LRBFZMR44MD074029	Wheelbase (mm):	2781
Vehicle Size Category:	MPV	Test Weight (kg):	2018

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):	56.34
Velocity Change (km/h):	66.96
Time of Separation (ms):	150



CRUSH PROFILE

Collision Deformation Classification:	12FDEW2
Midpoint of Damage:	C3
Damage Region Length (mm):	1335
Impact Mode:	Frontal

No.	Measurement Description	Units	Pre-Test	Post-Test	Difference
C1	Crush Zone 1 at Left Side	mm	4414	4089	325
C2	Crush Zone 2 at Left Side	mm	4584	4160	424
C3	Crush Zone 3 at Left Side	mm	4633	4178	455
C4	Crush Zone 4 at Right Side	mm	4633	4179	454
C5	Crush Zone 5 at Right Side	mm	4579	4154	425
C6	Crush Zone 6 at Right Side	mm	4406	4107	299
L	C1 to C6	mm	1335	1448	-113

DATA SHEET NO. 14
VEHICLE INTRUSION MEASUREMENTS

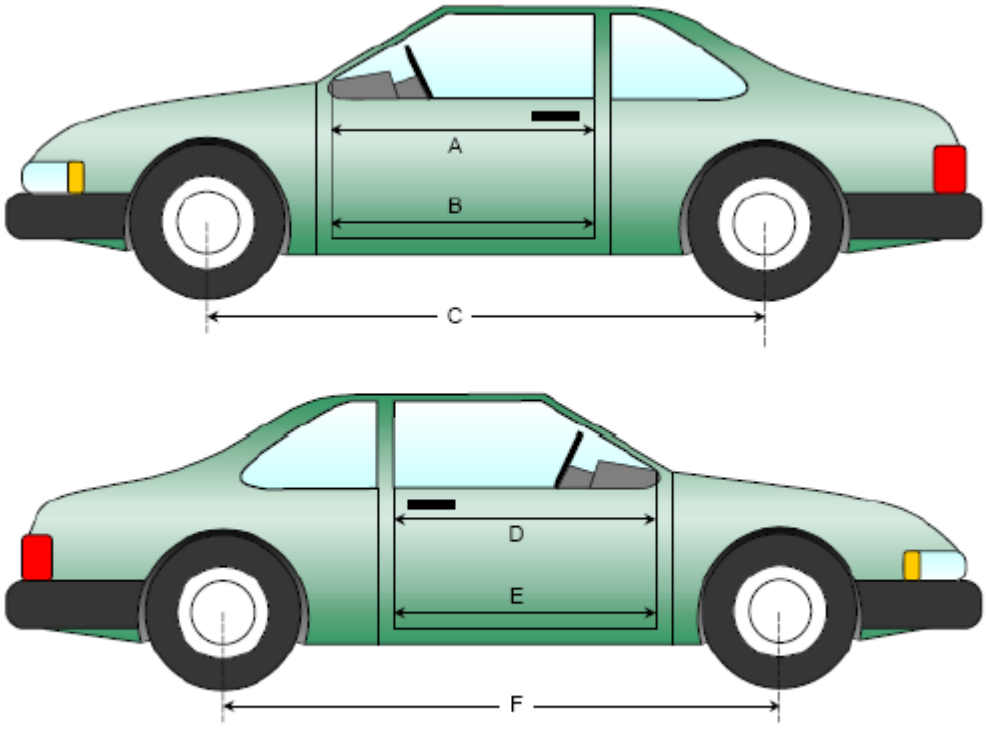
Test Vehicle: 2021 Buick Envision Preferred SUV
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20210100
Test Date: 3/10/2021

DOOR OPENING WIDTH

Item	Description	Units	Pre-Test	Post-Test	Difference
A	Left Side Upper	mm	987	986	-1
B	Left Side Lower	mm	860	861	1
D	Right Side Upper	mm	985	984	-1
E	Right Side Lower	mm	859	859	0

WHEELBASE MEASUREMENTS

Item	Description	Units	Pre-Test	Post-Test	Difference
C	Left Side Wheelbase	mm	2781	2715	-66
F	Right Side Wheelbase	mm	2781	2720	-61



Left & Right Side Views

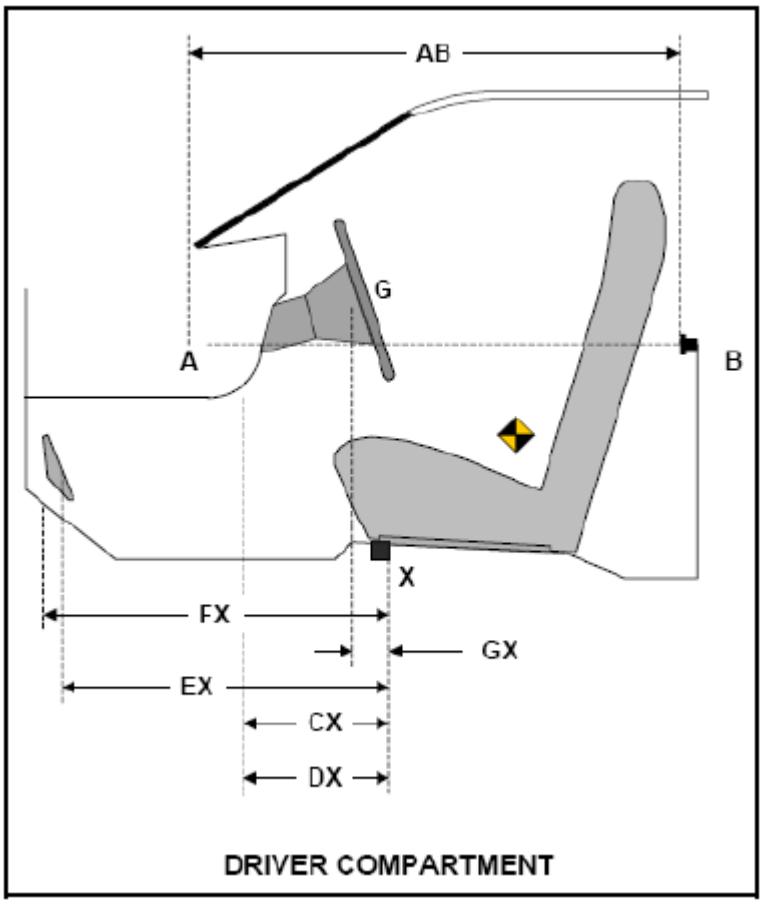
DATA SHEET NO.14 … (CONTINUED)
VEHICLE INTRUSION MEASUREMENTS

Test Vehicle: 2021 Buick Envision Preferred SUV NHTSA No.: M20210100
Test Program: NCAP Frontal Barrier Impact Test Test Date: 3/10/2021

DRIVER COMPARTMENT INTRUSION

Item	Description	Units	Pre-Test	Post-Test	Difference
AB	Door Opening (Inside Window Jam)	mm	719	720	1
CX	Left Knee Bolster to X	mm	368	368	0
DX	Right Knee Bolster to X	mm	368	367	-1
EX	Brake Pedal to X	mm	546	530	-16
FX	Foot Rest to X	mm	583	576	-7
GX	Center of Steering Column Wheel Hub to X	mm	93	171	78

X = Front of Seat Track (Stationary)



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

Test Vehicle:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021

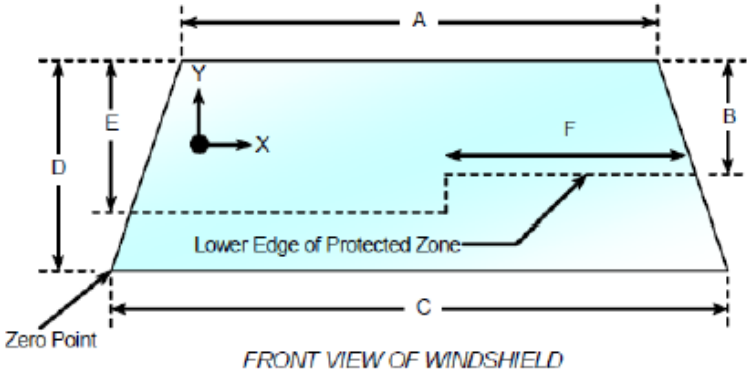
Windshield Mounting Details: A 0.8 mm trim surrounds the top and side of windshield while a plastic shroud is on the bottom.

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	2207.5	2207.5	100
Right Side	2207.5	2207.5	100
Total	4415	4415	100



FRONT VIEW OF WINDSHIELD

Item	Units	Value
A	mm	1235
B	mm	490
C	mm	1480
D	mm	850
E	mm	506
F	mm	590

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:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021

FMVSS 301 FUEL SYSTEM INTEGRITY POST IMPACT DATA

Temperature at Time of Impact: 21 ° C Test Time: 9:42 AM

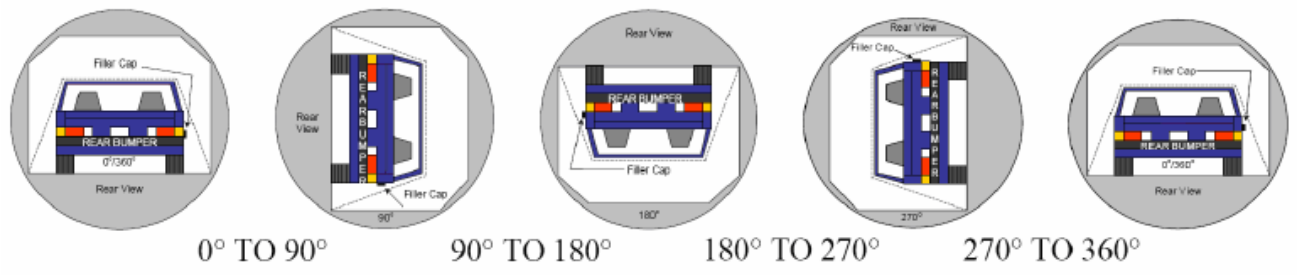
STODDARD SOLVENT SPILLAGE MEASUREMENTS

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: 2021 Buick Envision Preferred SUV
Test Program: NCAP Frontal Barrier Impact Test
NHTSA No.: M20210100
Test Date: 3/10/2021



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

SOLVENT COLLECTION TIME TABLE IN SECONDS

Test Phase	Rotation Time	Hold Time	Total Time
0° to 90°	69	300	369
90° to 180°	67	300	367
180° to 270°	72	300	372
270° to 360°	68	300	368

FMVSS 301 SPILLAGE TABLE

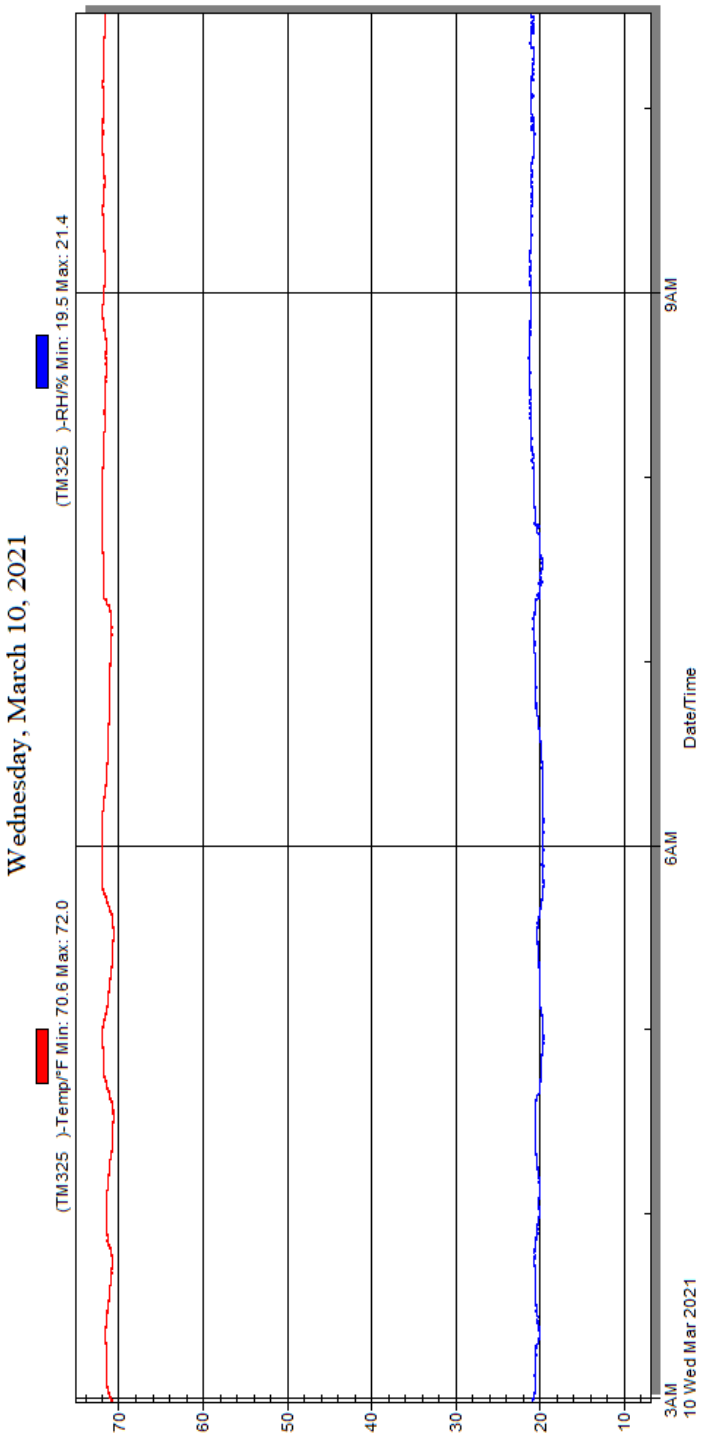
Test Phase	First 5 Minutes	Sixth Minute	Seventh Minute	Eighth Minute
0° to 90°	0	0	0	
90° to 180°	0	0	0	
180° to 270°	0	0	0	
270° to 360°	0	0	0	

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:	2021 Buick Envision Preferred SUV	NHTSA No.:	M20210100
Test Program:	NCAP Frontal Barrier Impact Test	Test Date:	3/10/2021



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

APPENDIX A

PHOTOGRAPHS

TABLE OF PHOTOGRAPHS

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

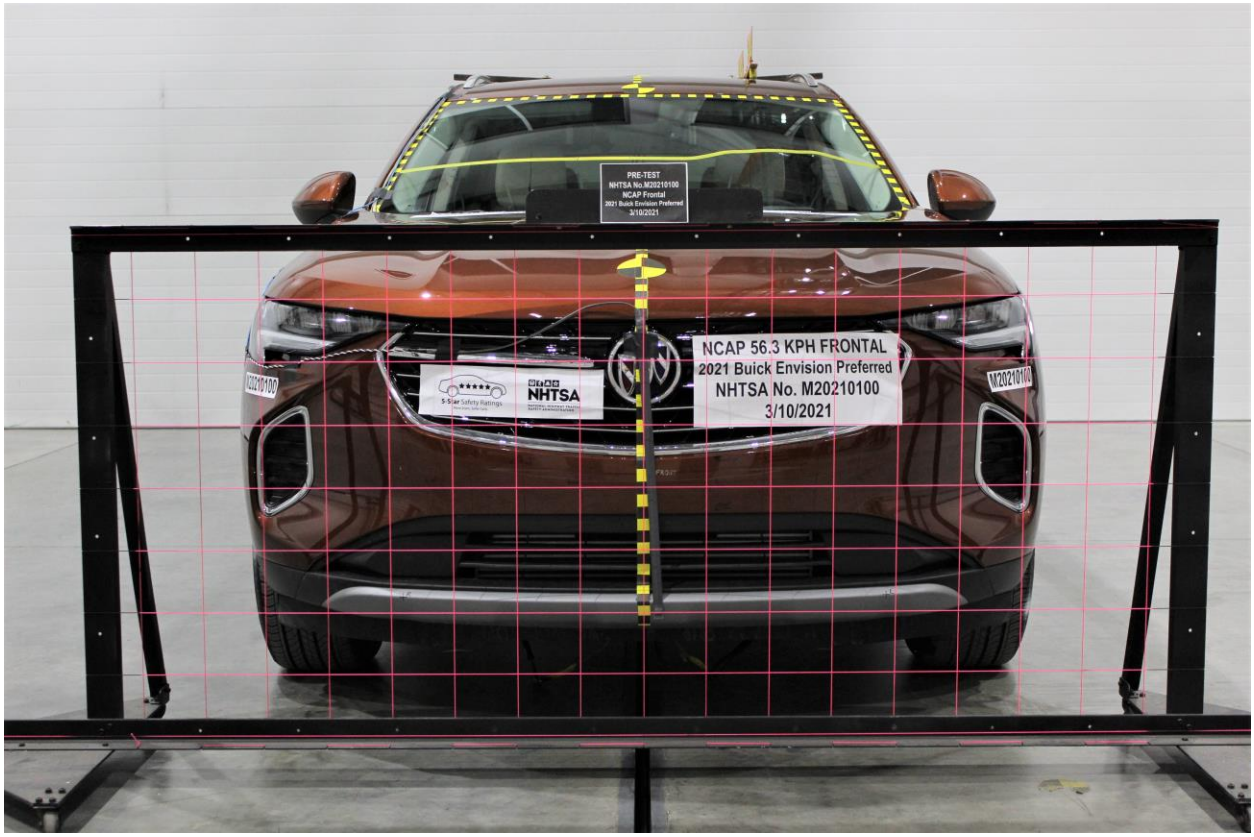


Figure A-1: Load Cell Location

Figure A-2: Pre-Test Load Cell Wall

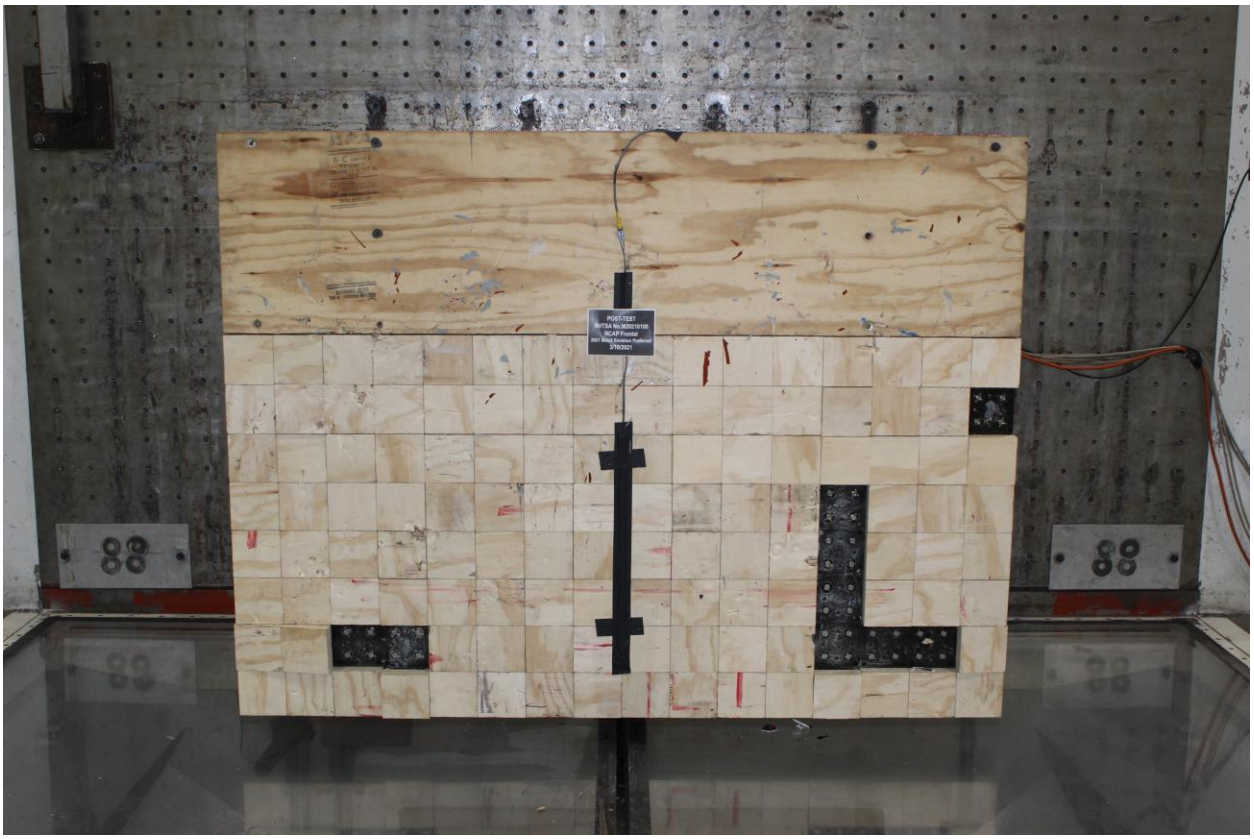


Figure A-3: Post-Test Load Cell Wall

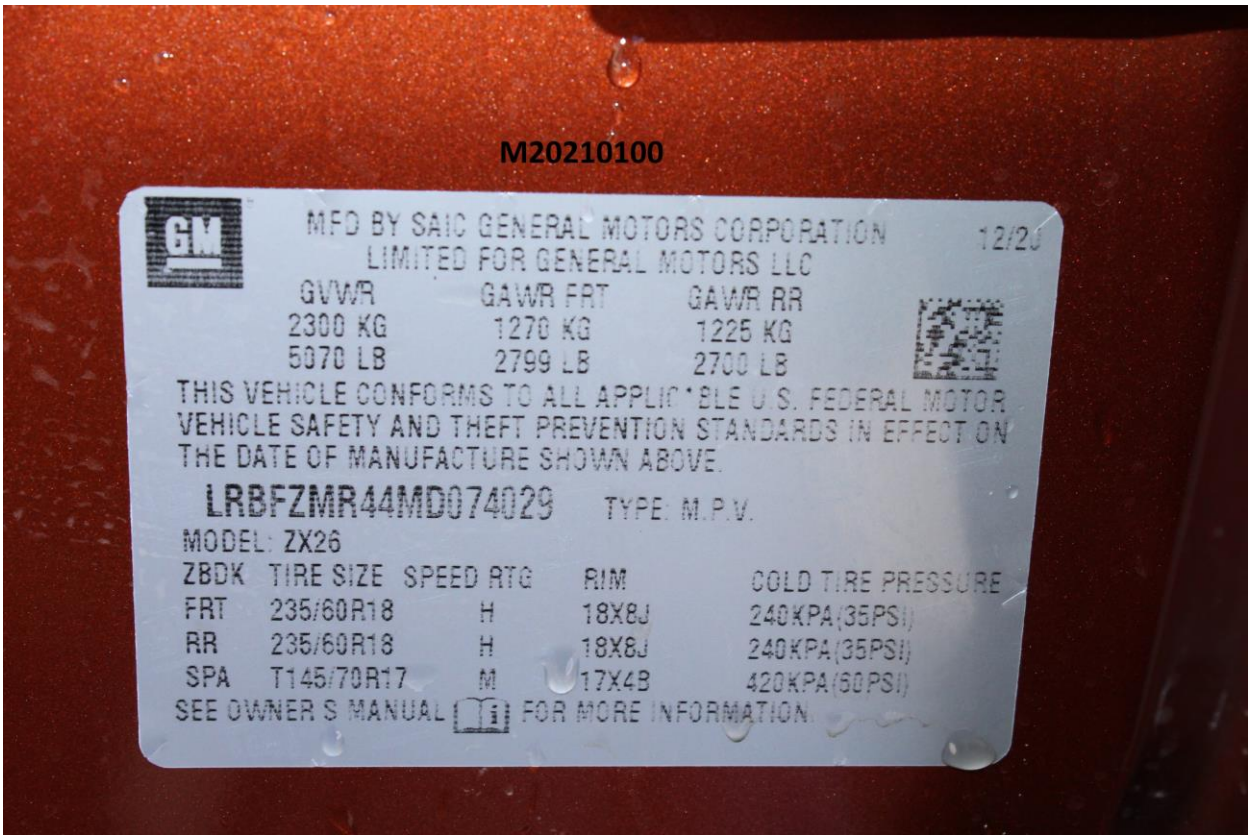


Figure A-4: Manufacturer's Label

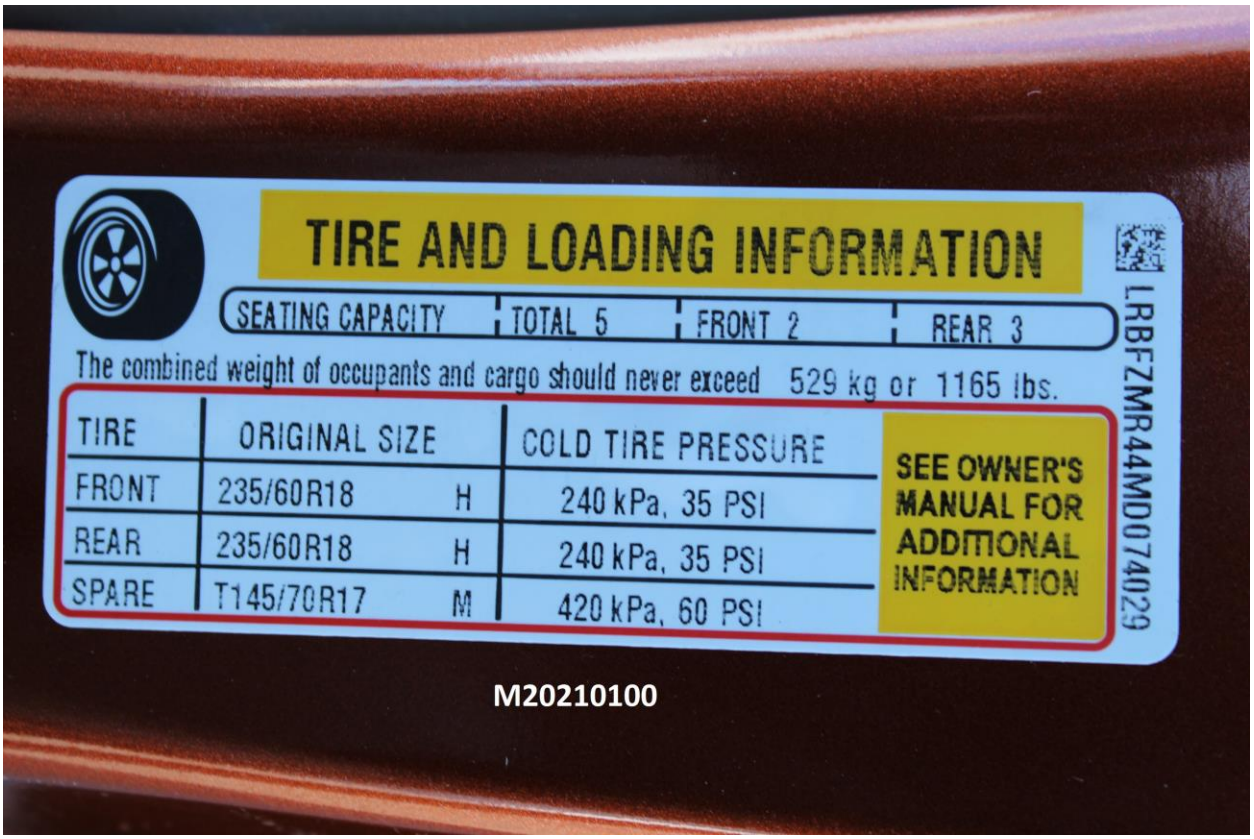


Figure A-5: Tire Placard

Figure A-6: 2021 Buick Envision 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

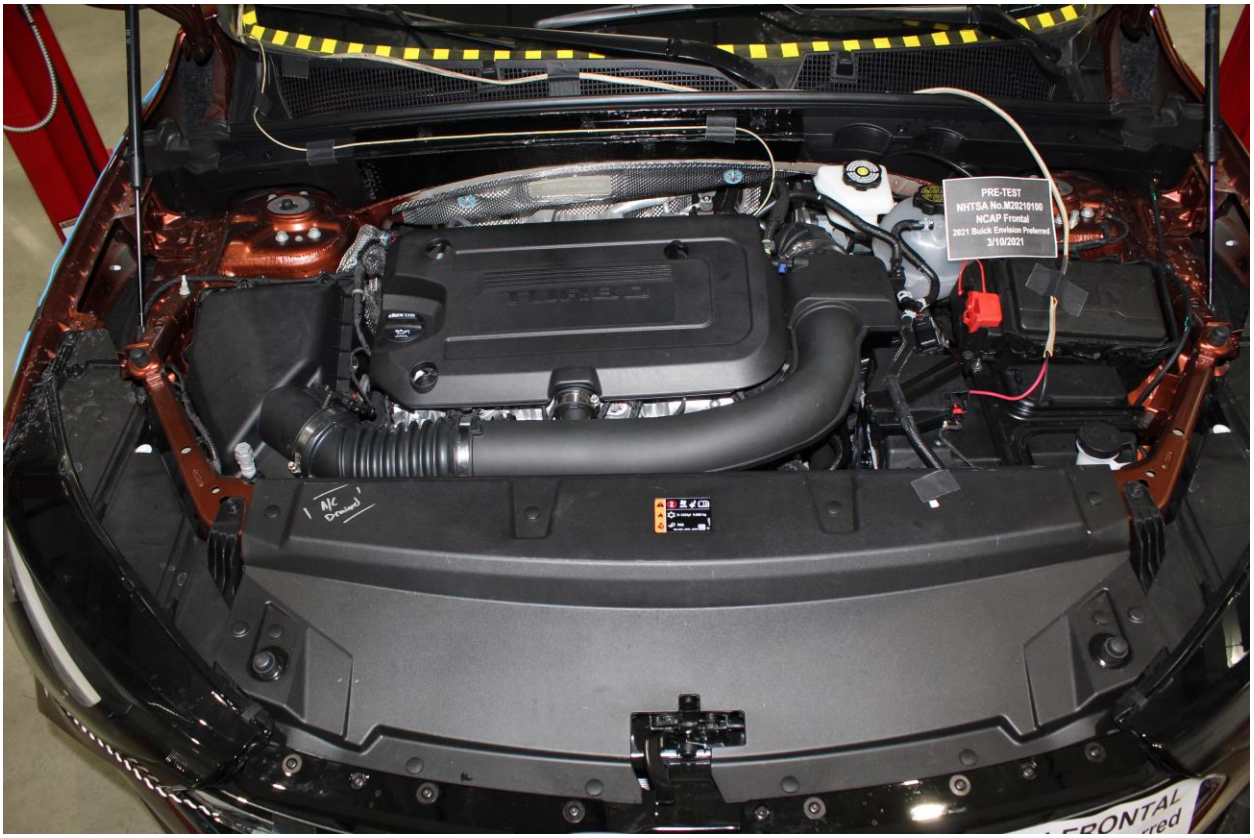


Figure A-20: Pre-Test Engine Compartment View

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

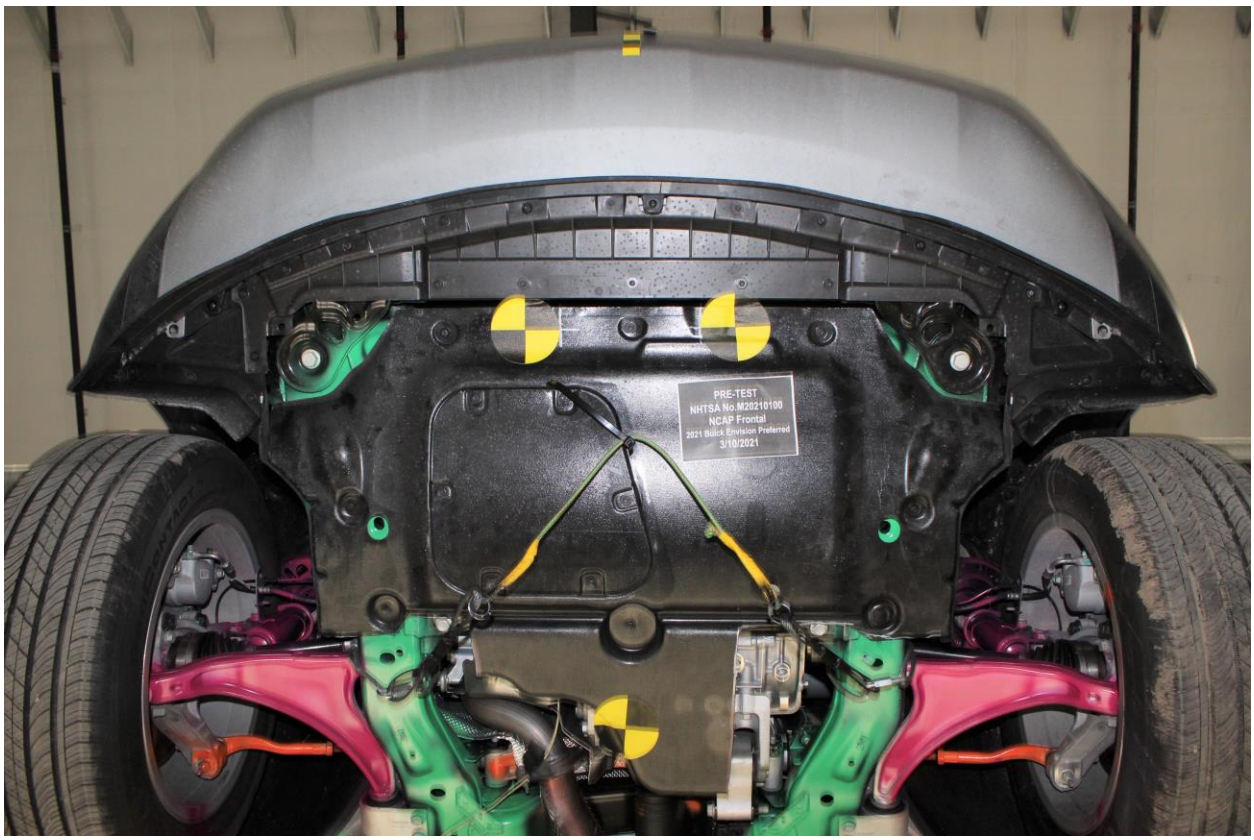


Figure A-24: Pre-Test Front Underbody View

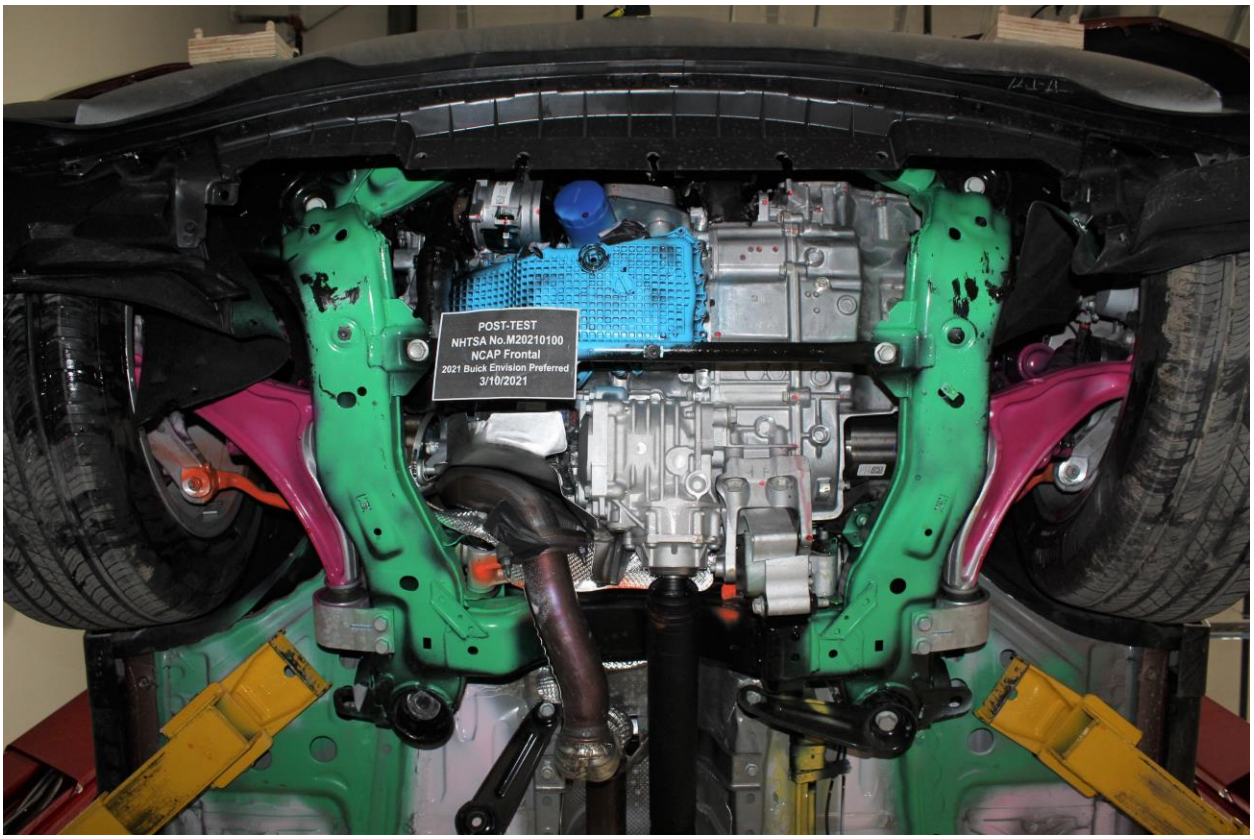


Figure A-25: Post-Test Front Underbody View

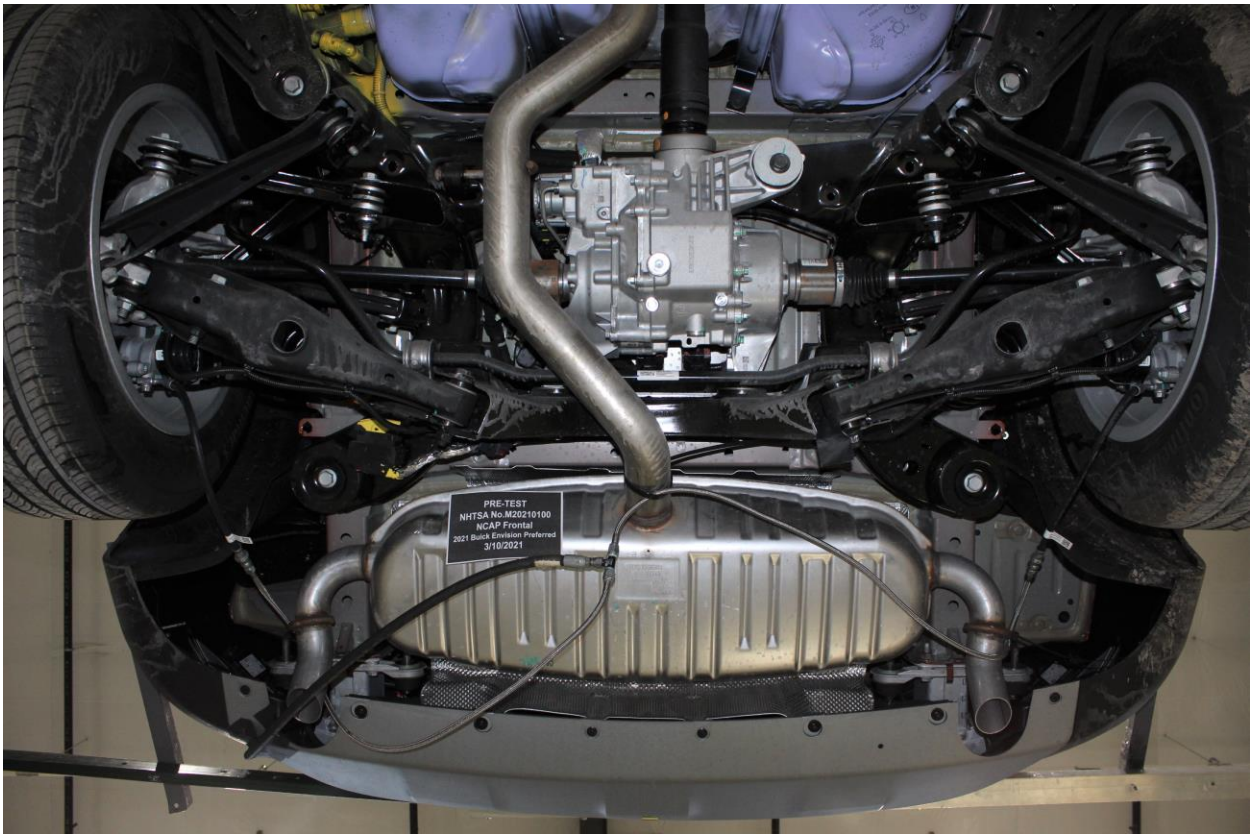


Figure A-26: Pre-Test Rear Underbody View

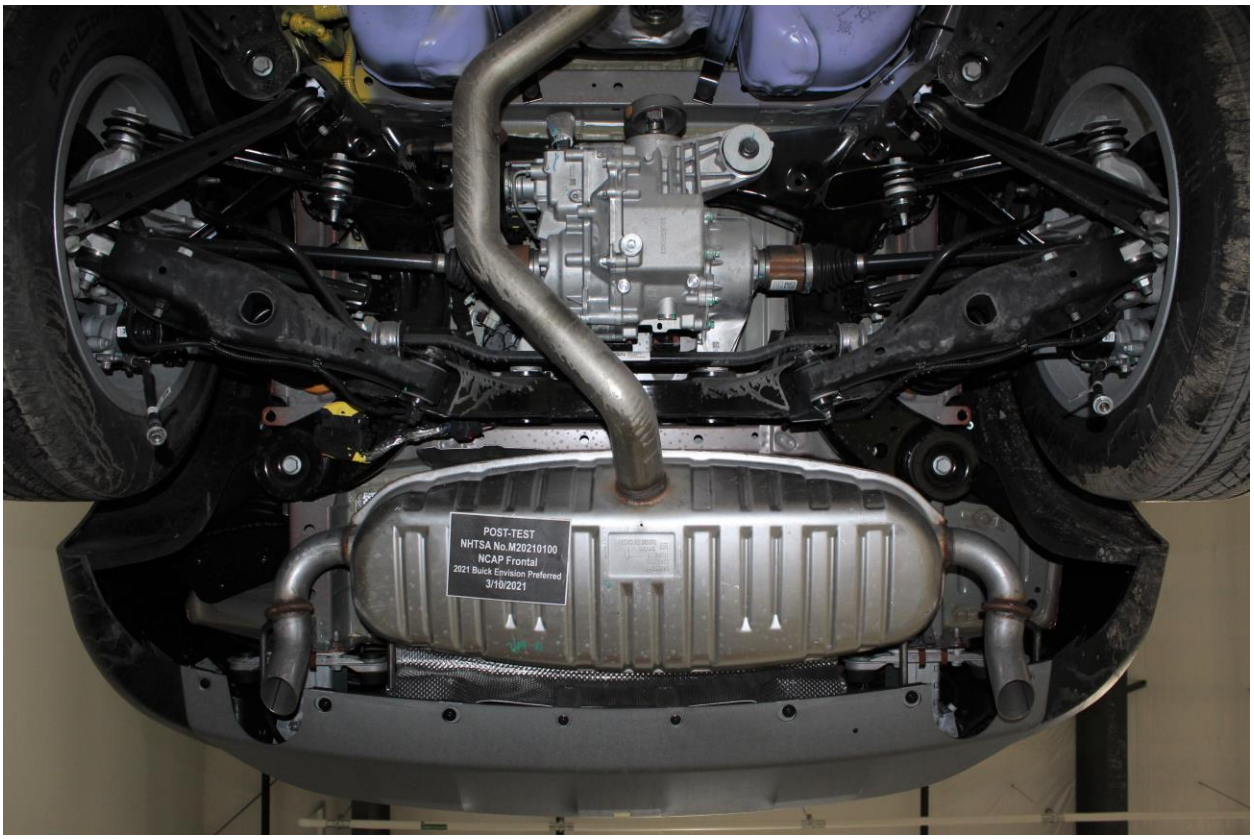


Figure A-27: Post-Test Rear Underbody View

Figure A-28: Pre-Test Dummy Cable Routing

Figure A-29: Post-Test Dummy Cable Routing

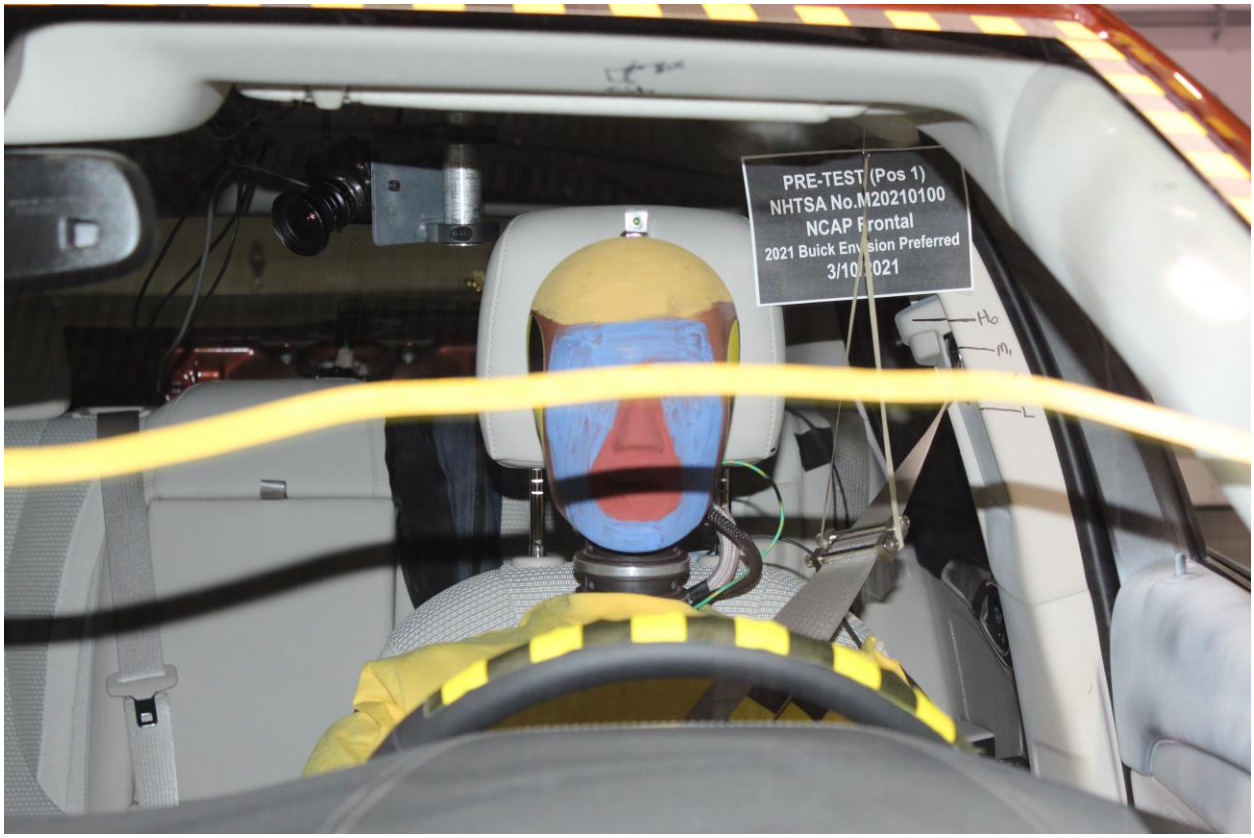


Figure A-30: Pre-Test Driver Dummy Front View

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

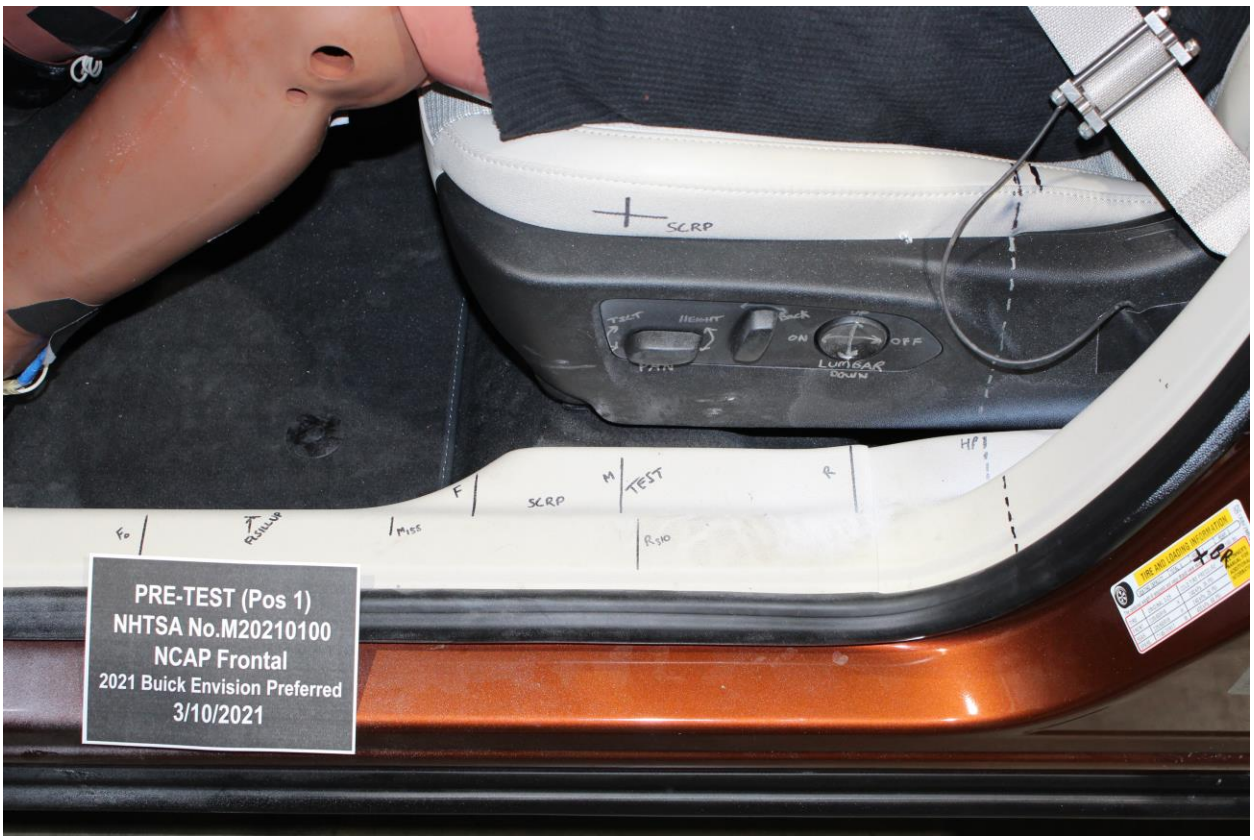


Figure A-36: Pre-Test Driver's Seat Fore-Aft Markings

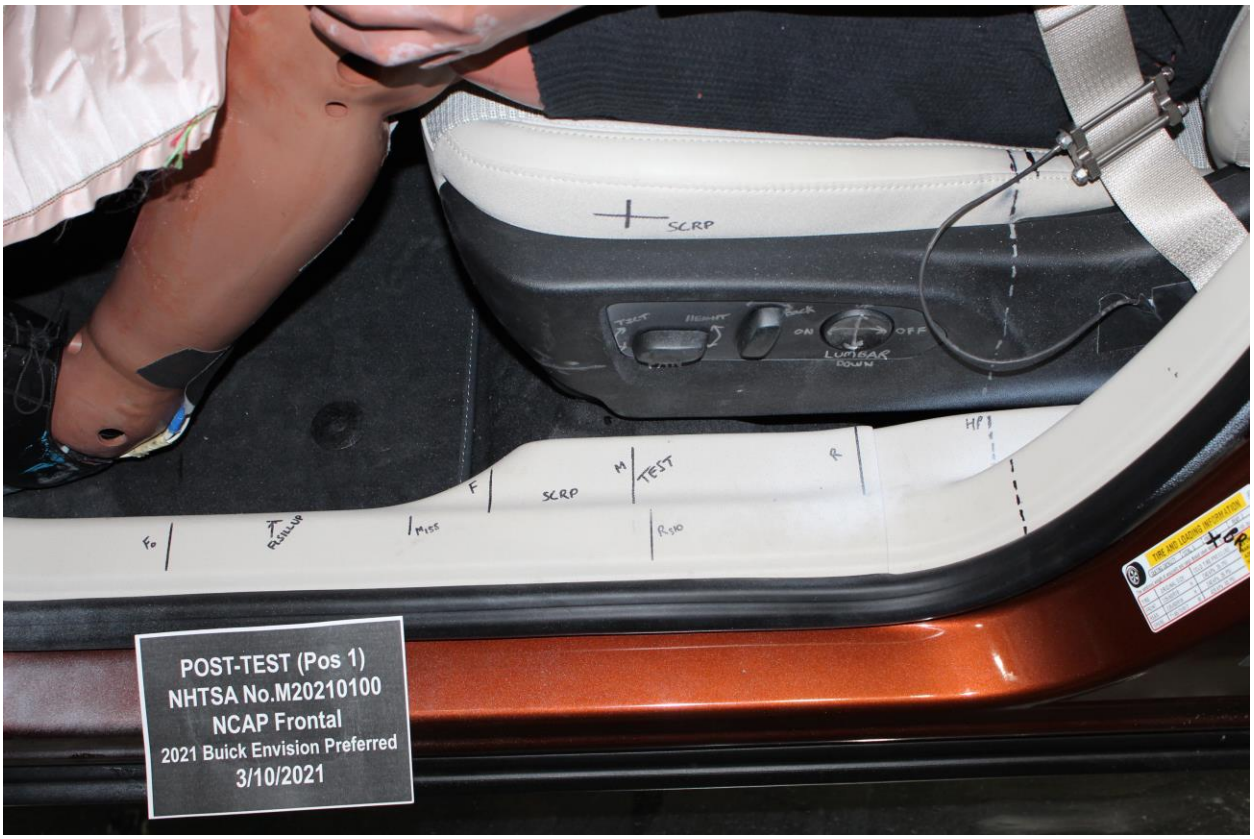


Figure A-37: Post-Test Driver's Seat Fore-Aft Markings

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

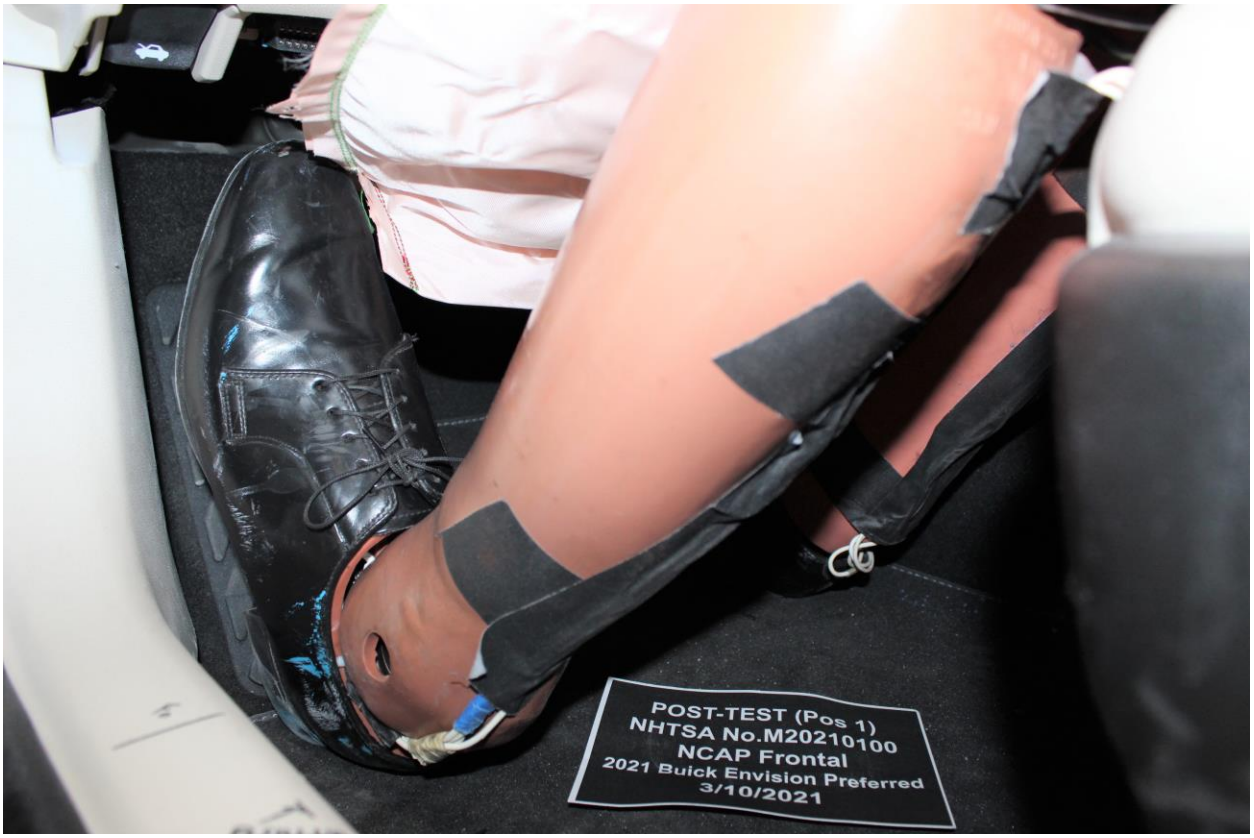


Figure A-43: Post-Test Driver Dummy Feet

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

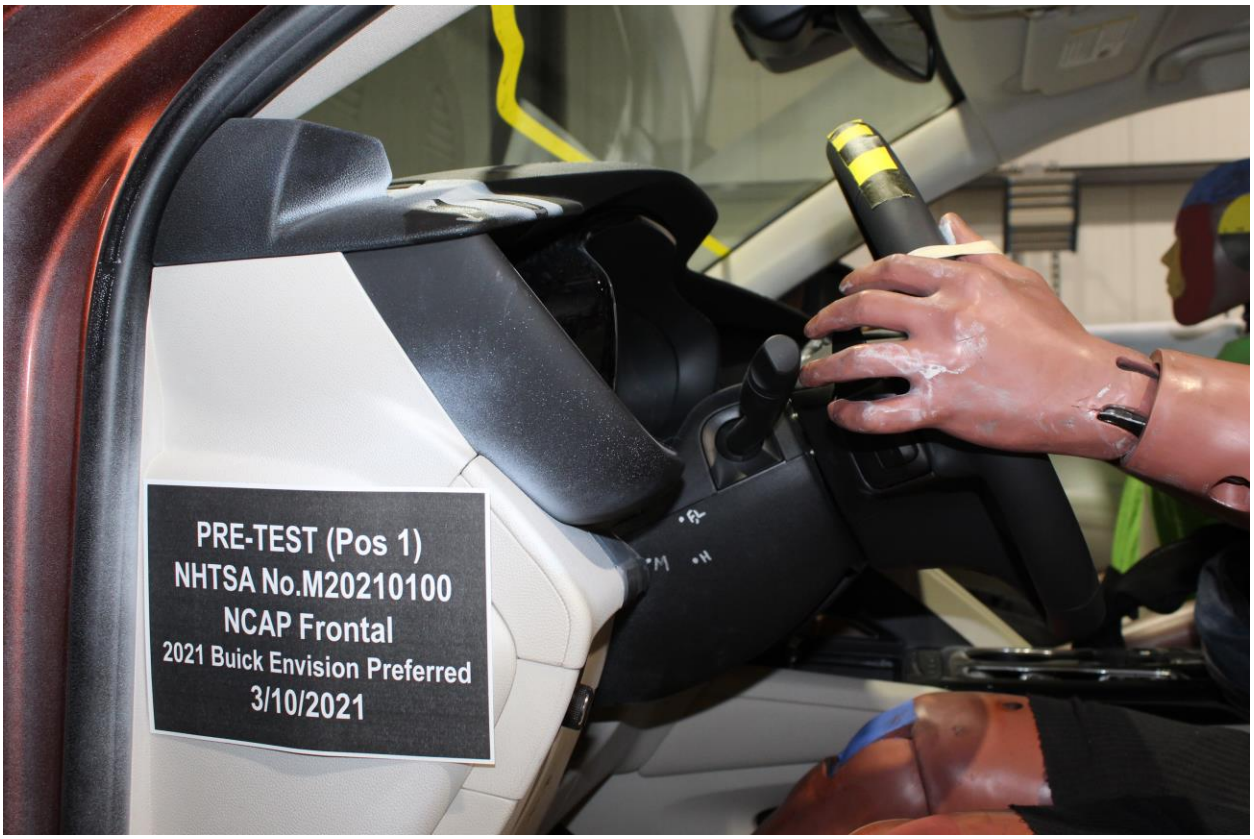


Figure A-51: Pre-Test View of the Steering Wheel

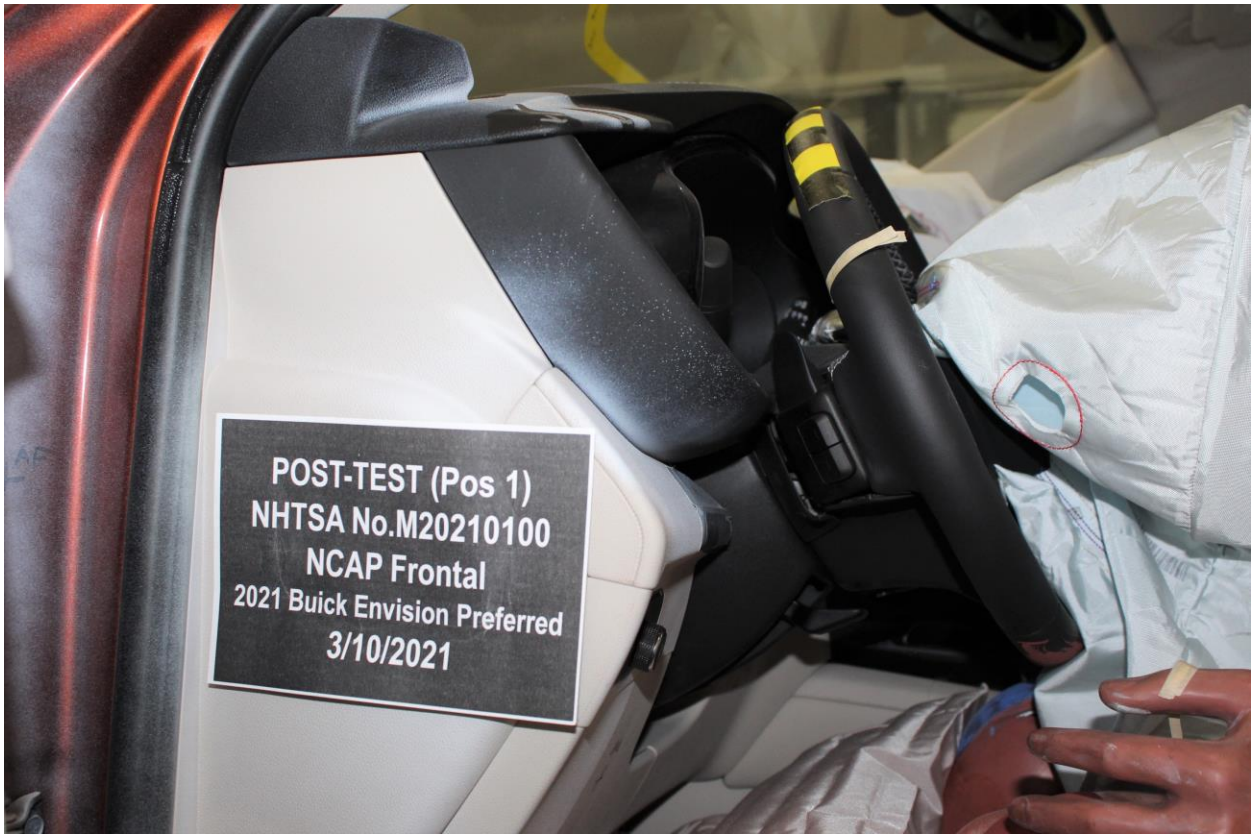


Figure A-52: Post-Test View of the Steering Wheel

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

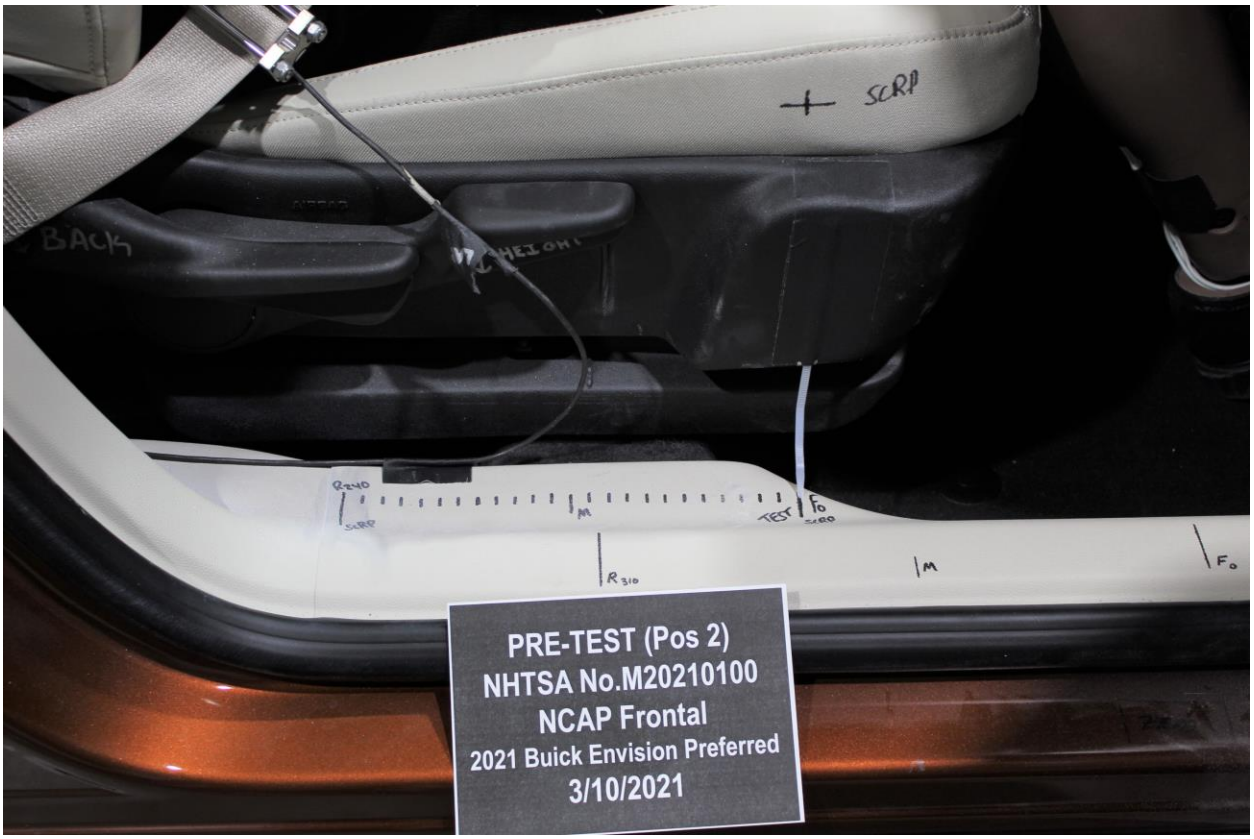


Figure A-59: Pre-Test Passenger's Seat Fore-Aft Markings

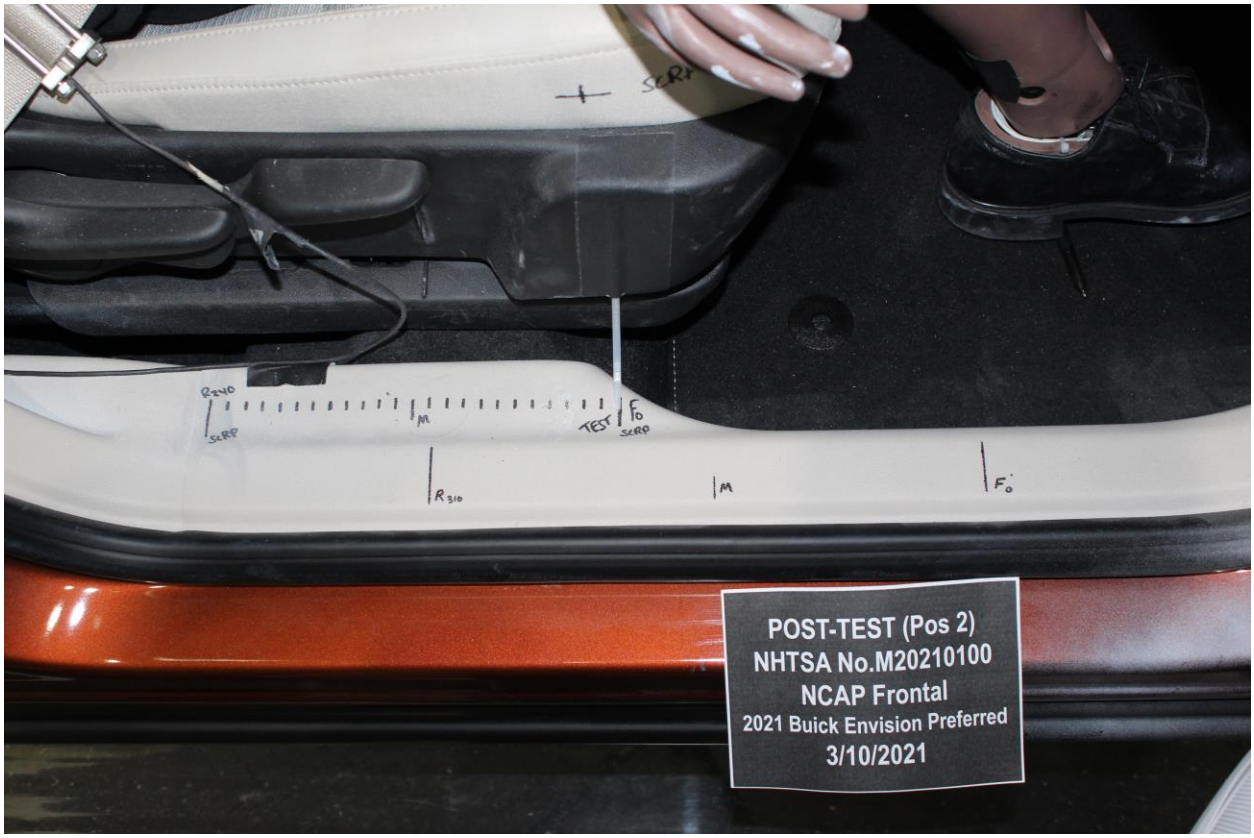


Figure A-60: Post-Test Passenger's Seat Fore-Aft Markings

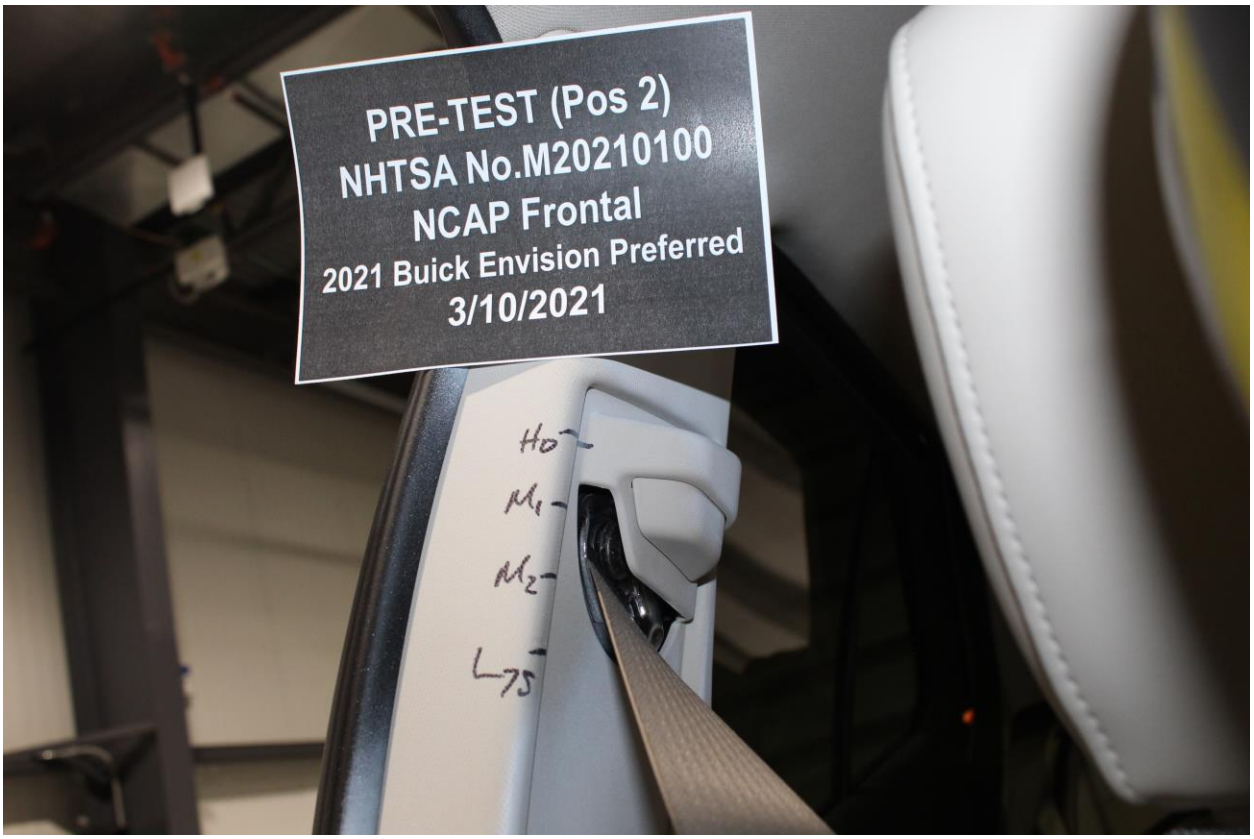


Figure A-61: Pre-Test View of Belt Anchorage for Passenger Dummy

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

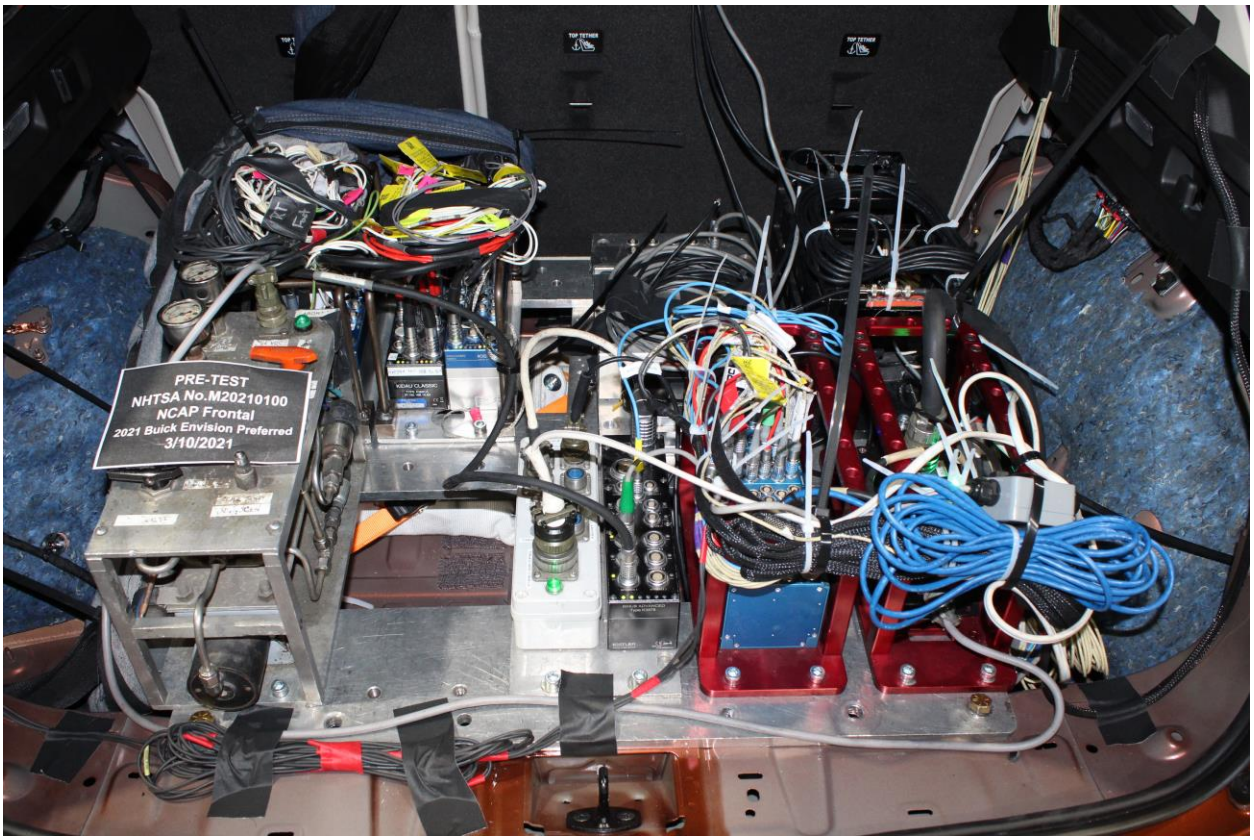


Figure A-74: Photograph of Ballast Installed in Vehicle

Photo Not Applicable

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

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

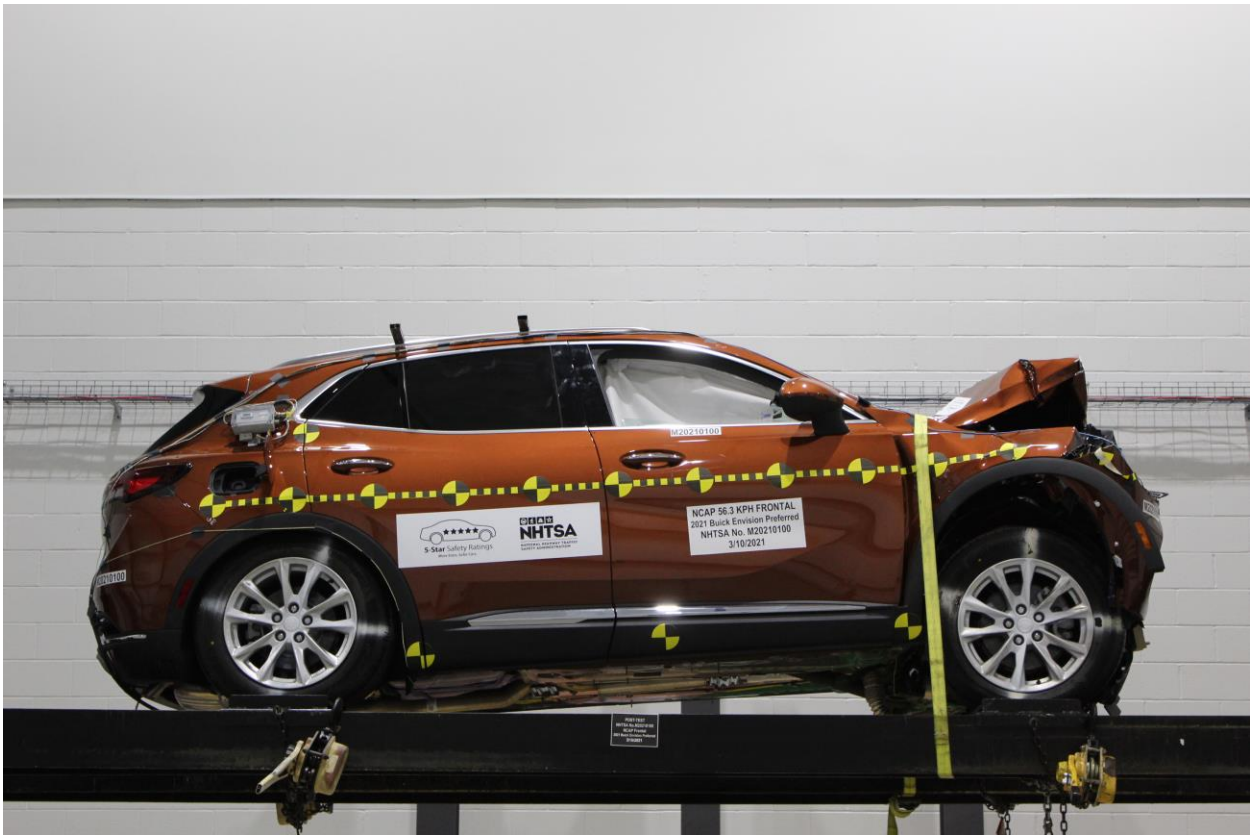


Figure A-77: Vehicle at 0º on Static Rollover Device

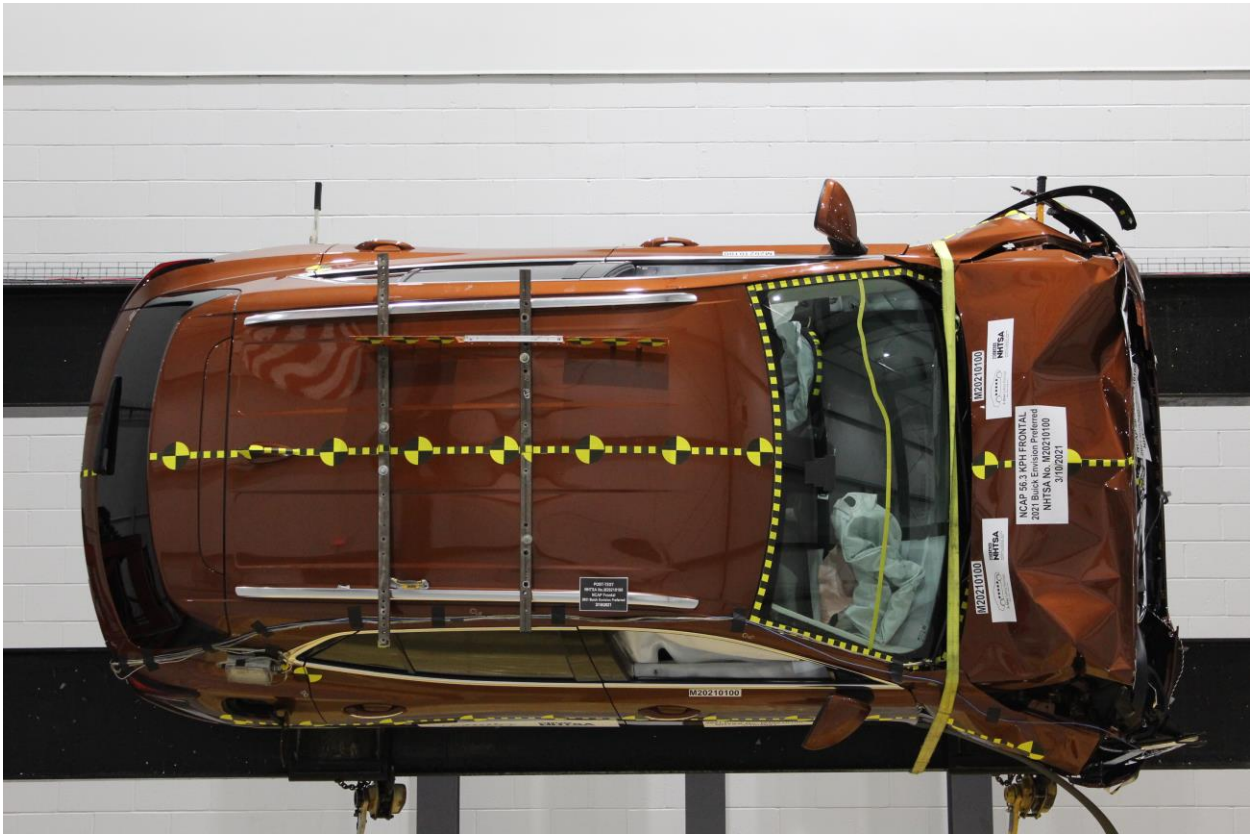


Figure A-78: Vehicle at 90º on Static Rollover Device

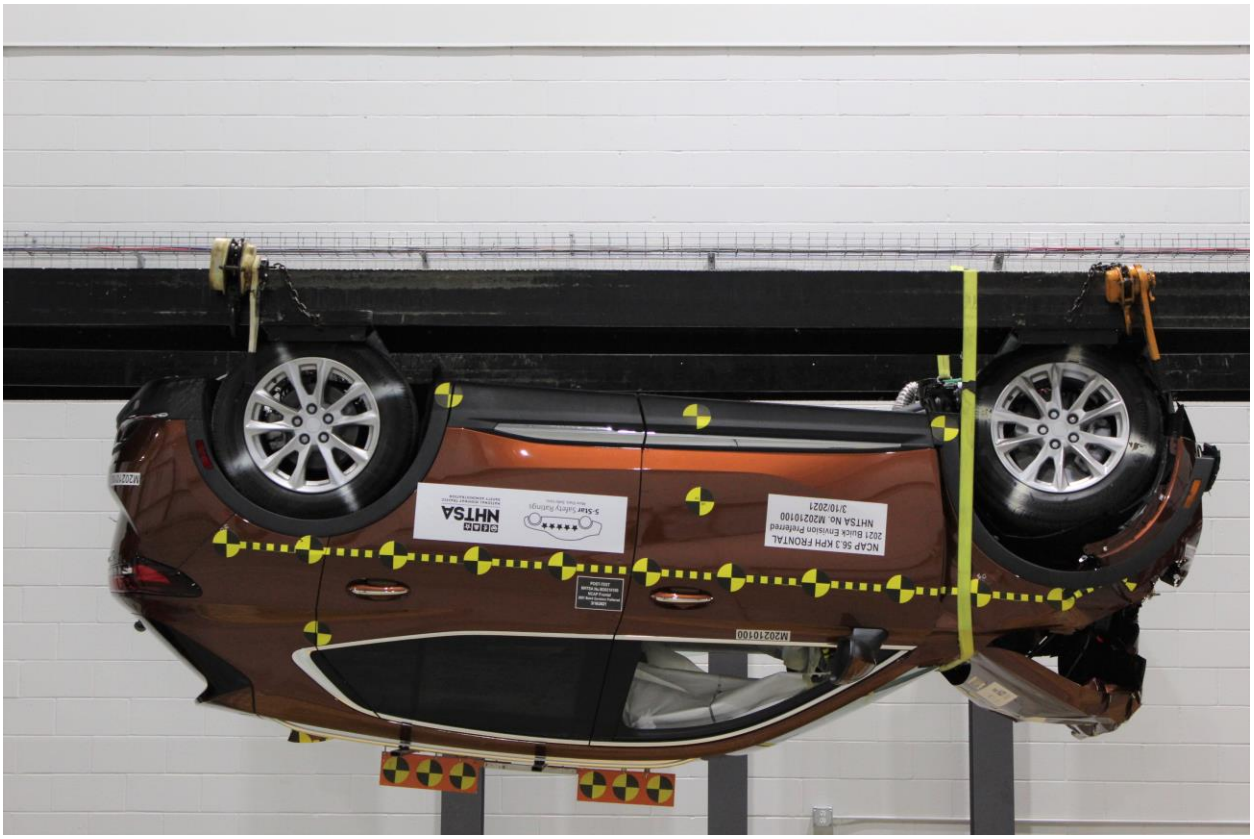


Figure A-79: Vehicle at 180º on Static Rollover Device

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

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

Figure A-82: 2021 Buick Envision Frontal Impact Event

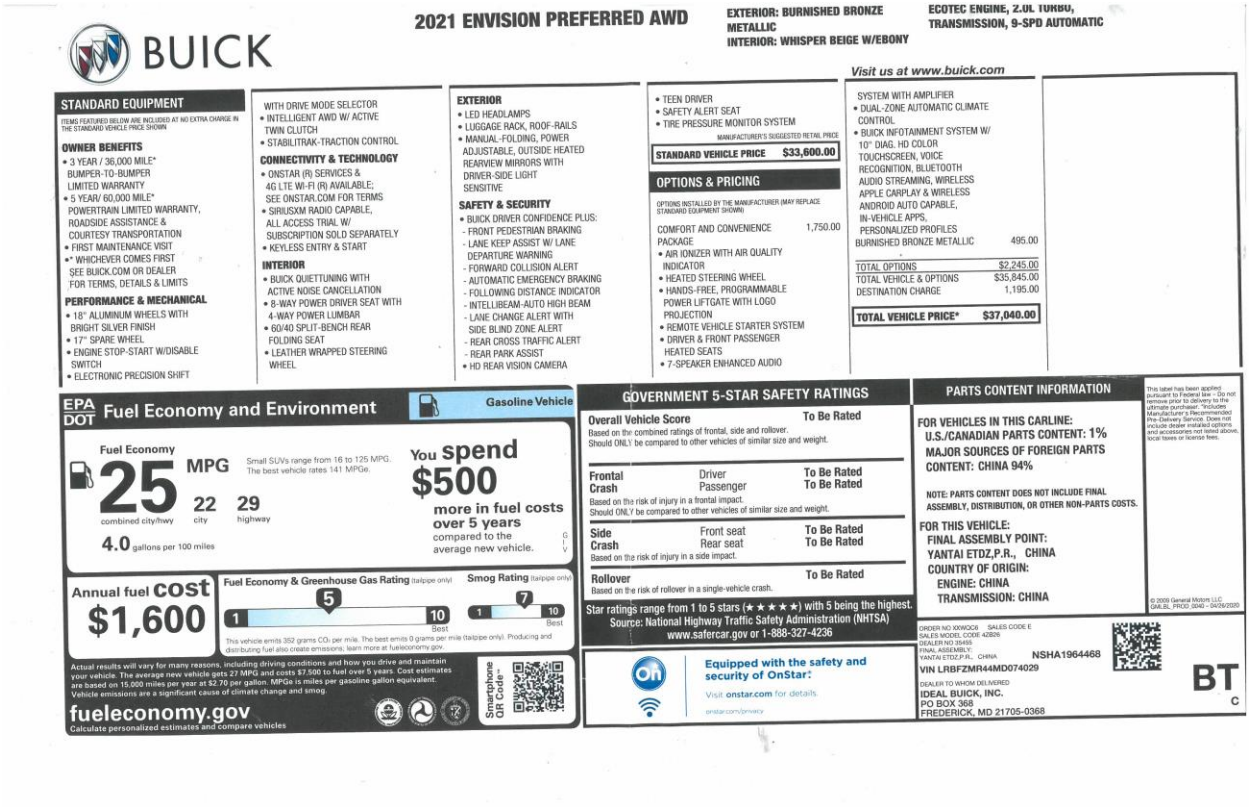


Figure A-83: Monroney Label Photograph

APPENDIX B
VEHICLE & DUMMY RESPONSE DATA TRACES

Table of Data Plots

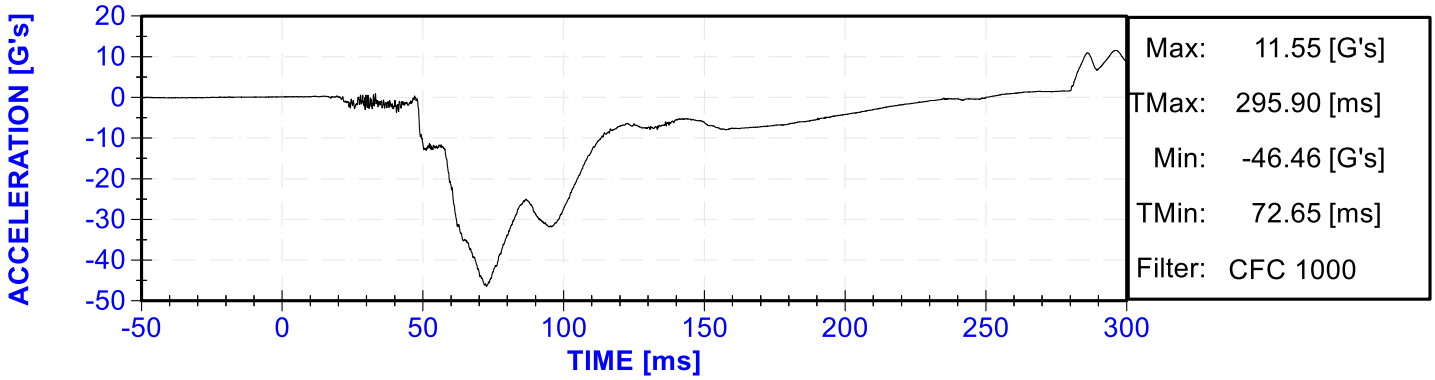
The following additional dummy and vehicle response data can be found in the R&D section of the NHTSA website at www.NHTSA.gov

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

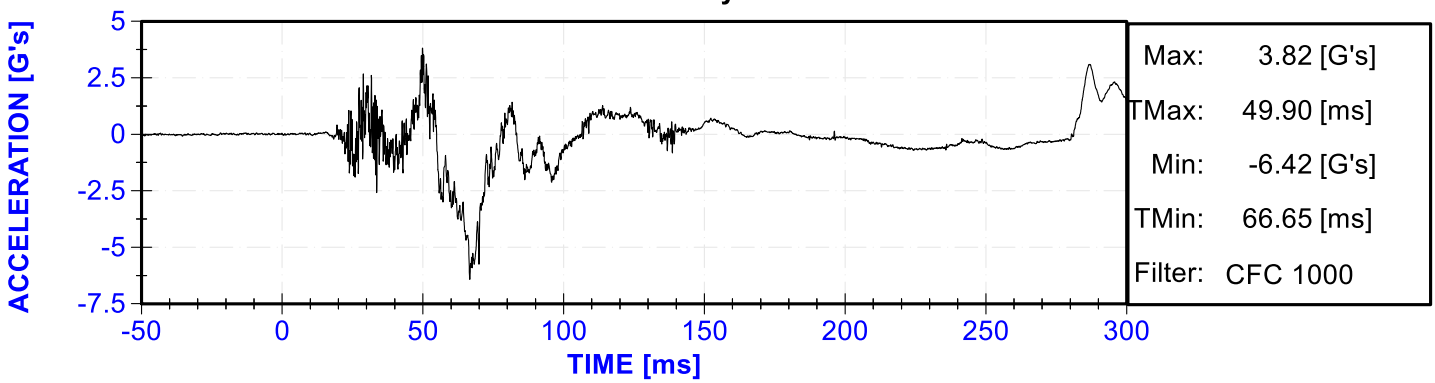
Driver Left Upper Tibia Force Z
Driver Left Lower Tibia Moment X
Driver Left Lower Tibia Moment Y
Driver Left Lower Tibia Force Z
Driver Right Upper Tibia Moment X
Driver Right Upper Tibia Moment Y
Driver Right Upper Tibia Force Z
Driver Right Lower Tibia Moment X
Driver Right Lower Tibia Moment Y
Driver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

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

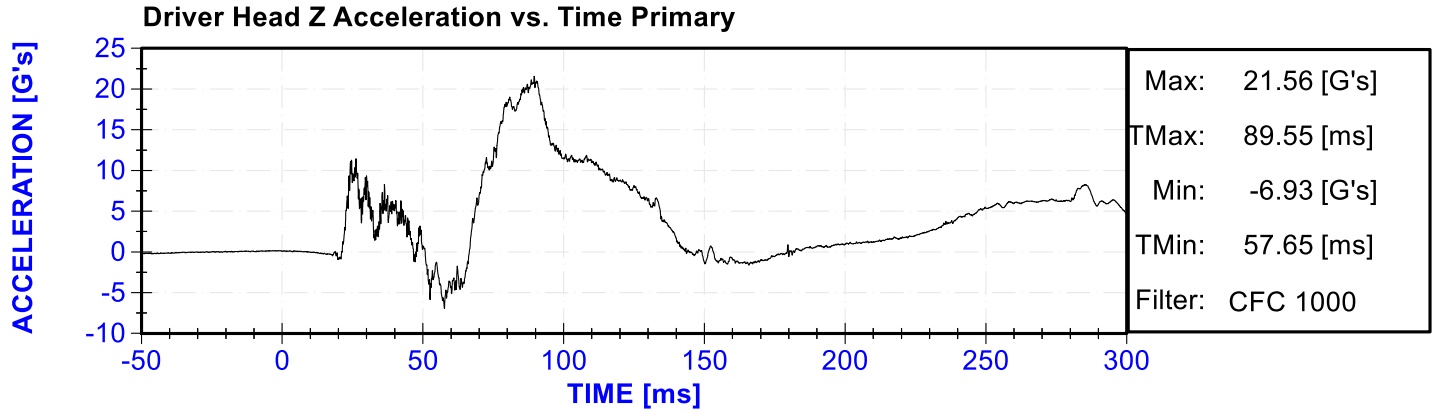
Driver Head X Acceleration vs. Time Primary



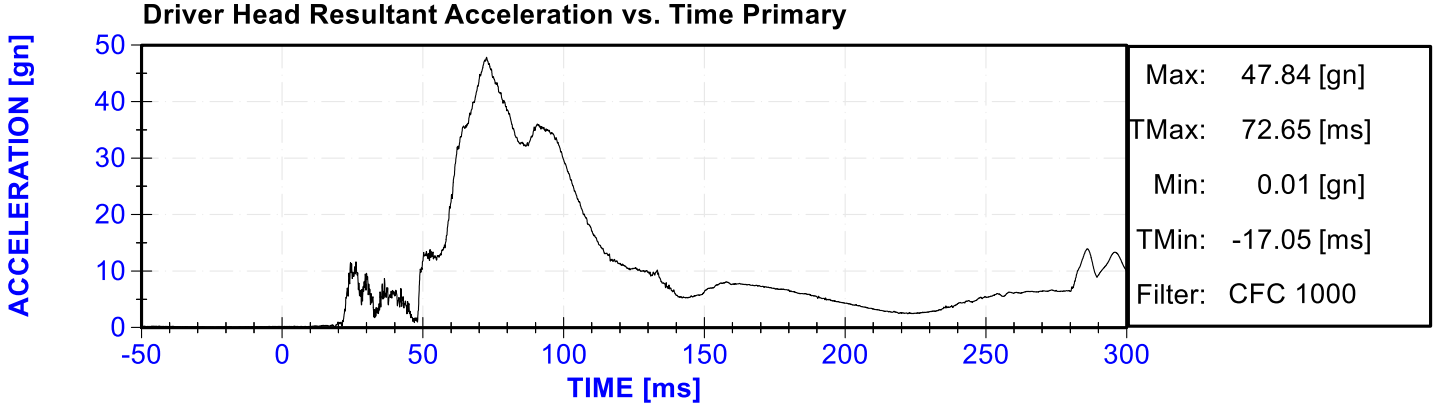
Driver Head Y Acceleration vs. Time Primary



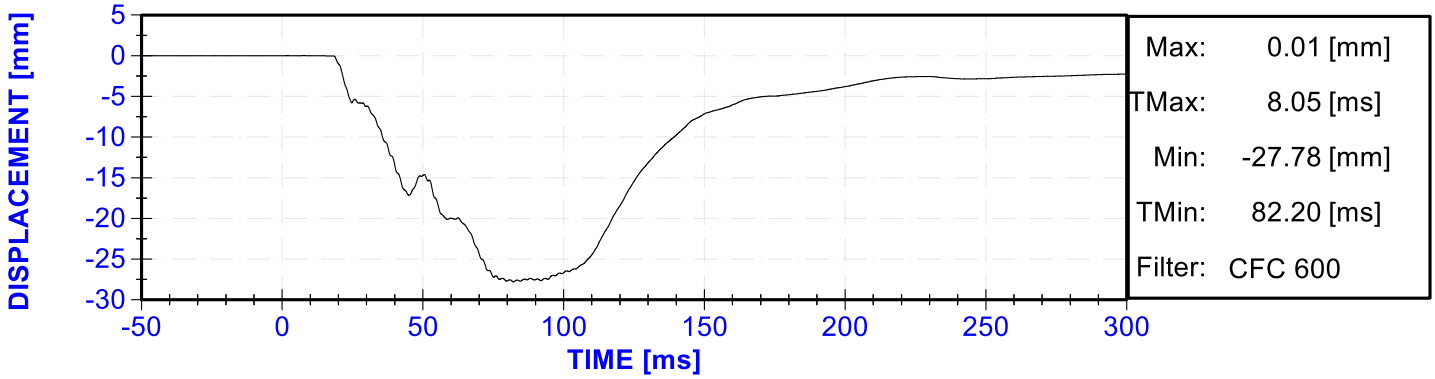
Driver Head Z Acceleration vs. Time Primary



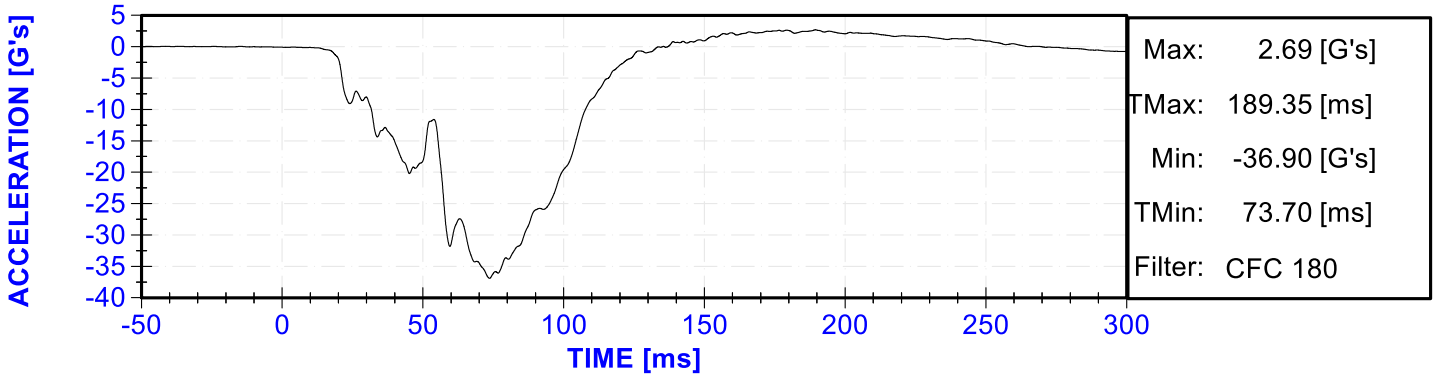
Driver Head Resultant Acceleration vs. Time Primary



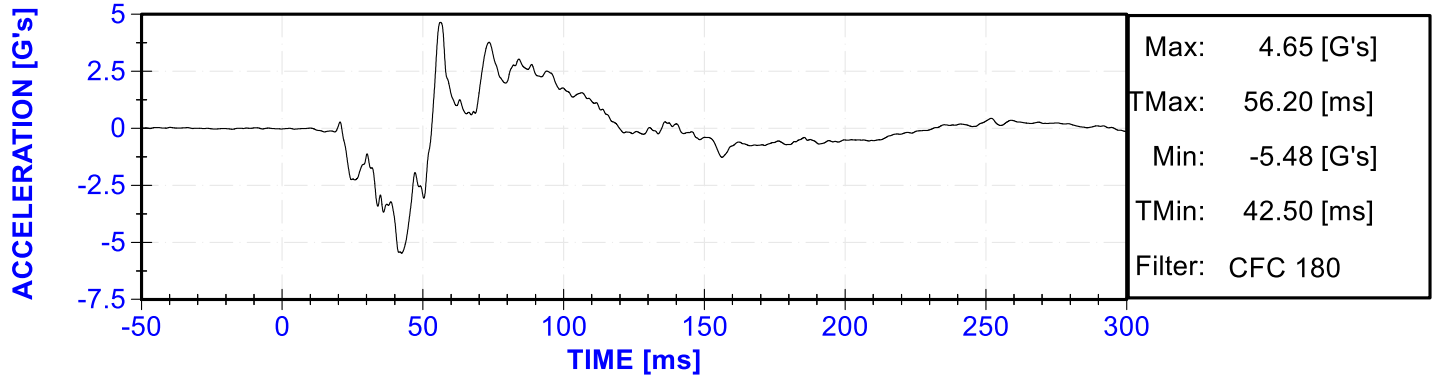
Driver Chest X Deflection vs. Time



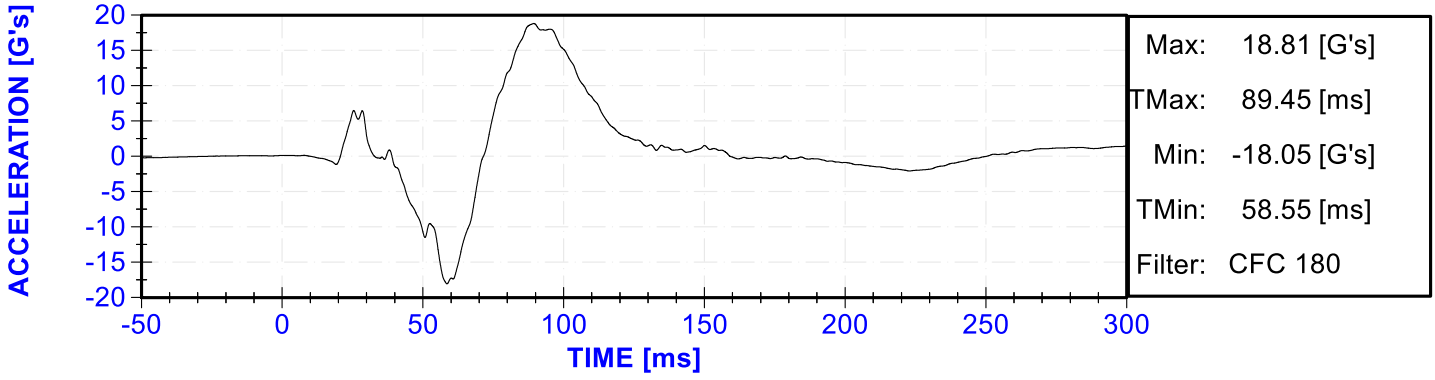
Driver Chest X Acceleration vs. Time Primary



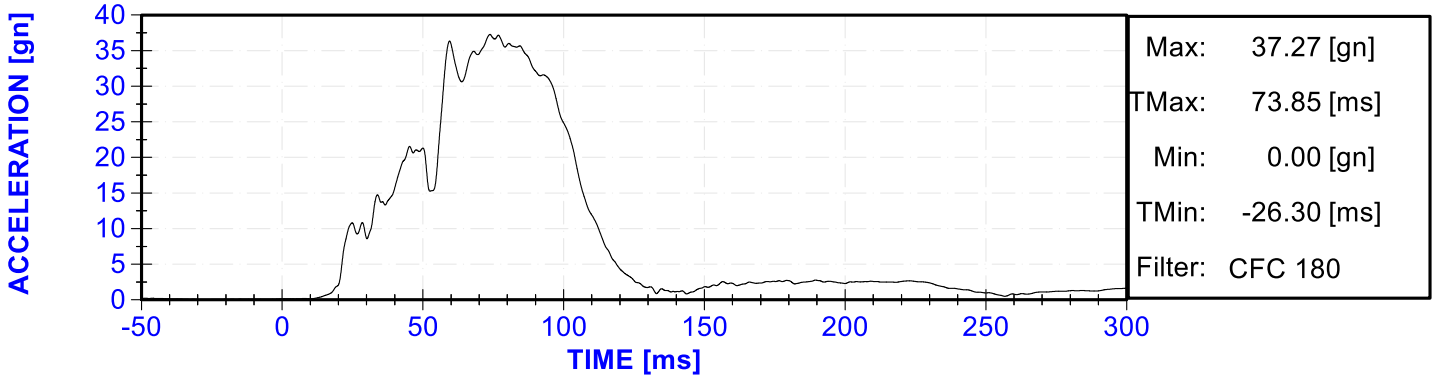
Driver Chest Y Acceleration vs. Time Primary



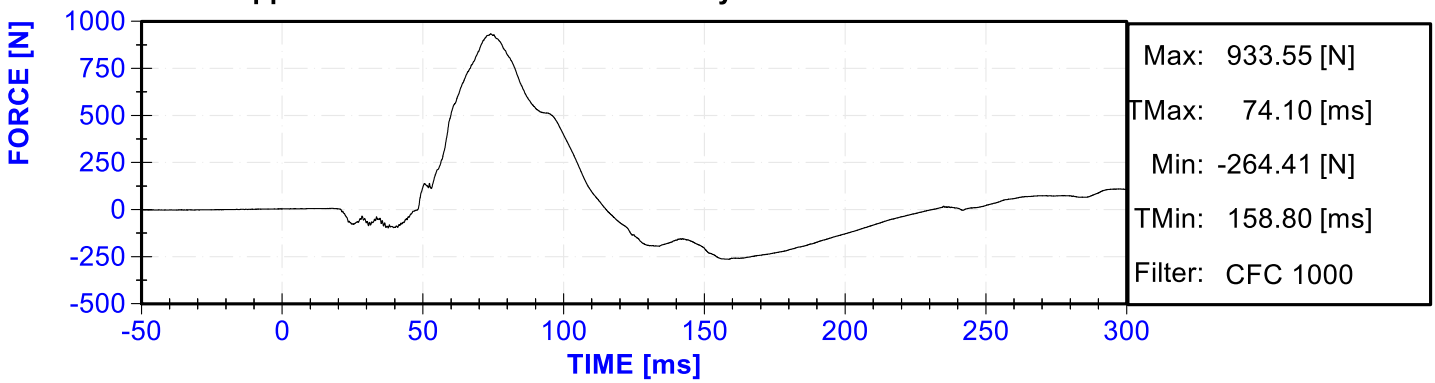
Driver Chest Z Acceleration vs. Time Primary



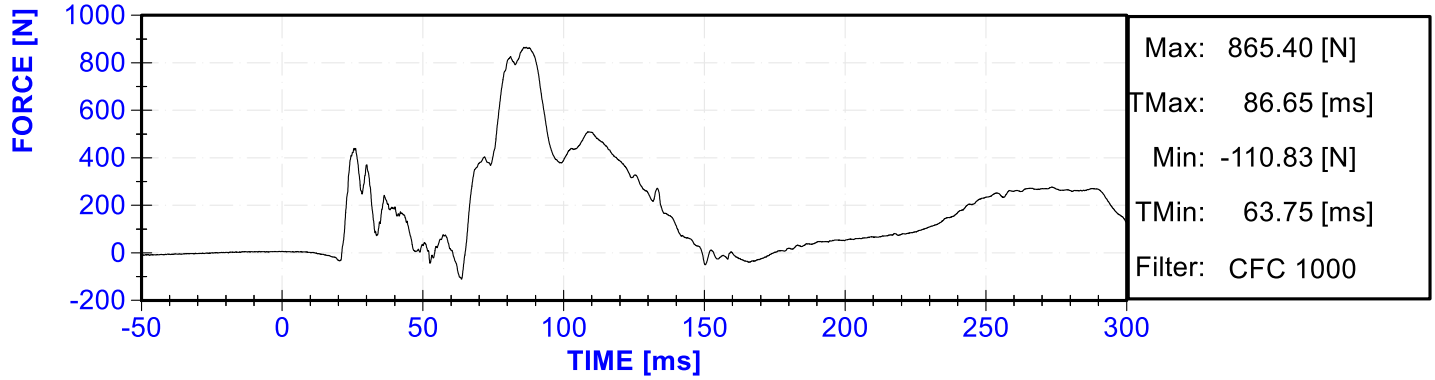
Driver Chest Resultant Acceleration vs. Time Primary



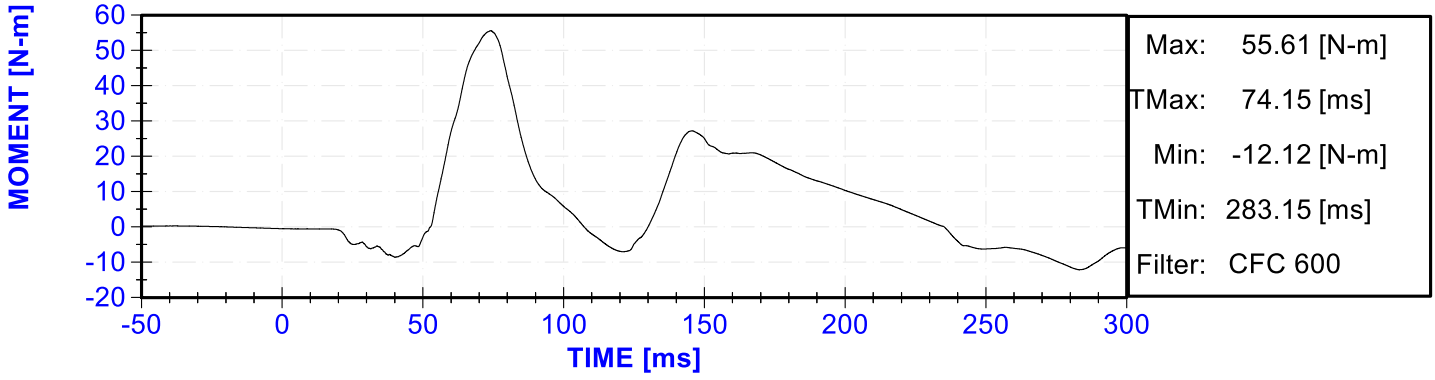
Driver Upper Neck Force X vs. Time Primary



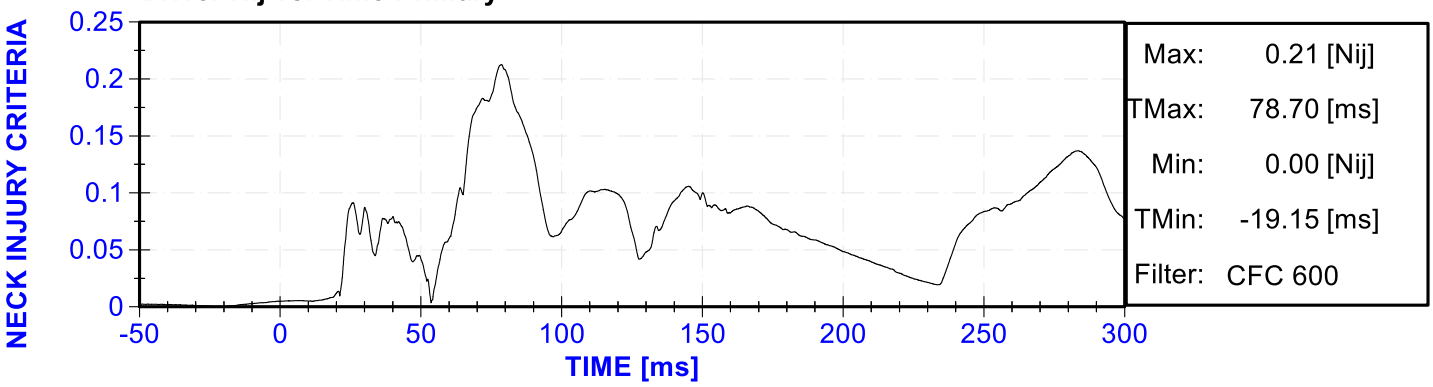
Driver Upper Neck Force Z vs. Time Primary



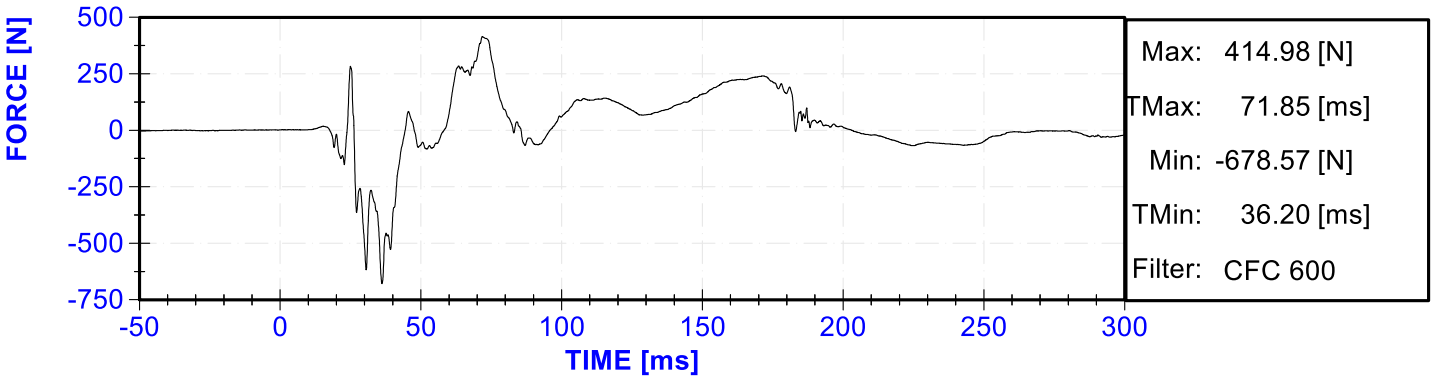
Driver Upper Neck Moment Y vs. Time Primary



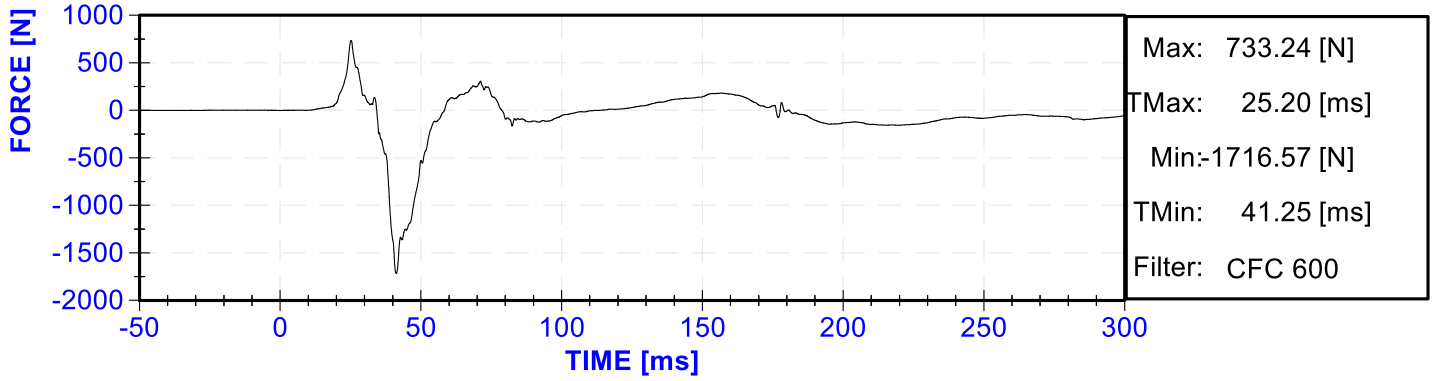
Driver Nij vs. Time Primary



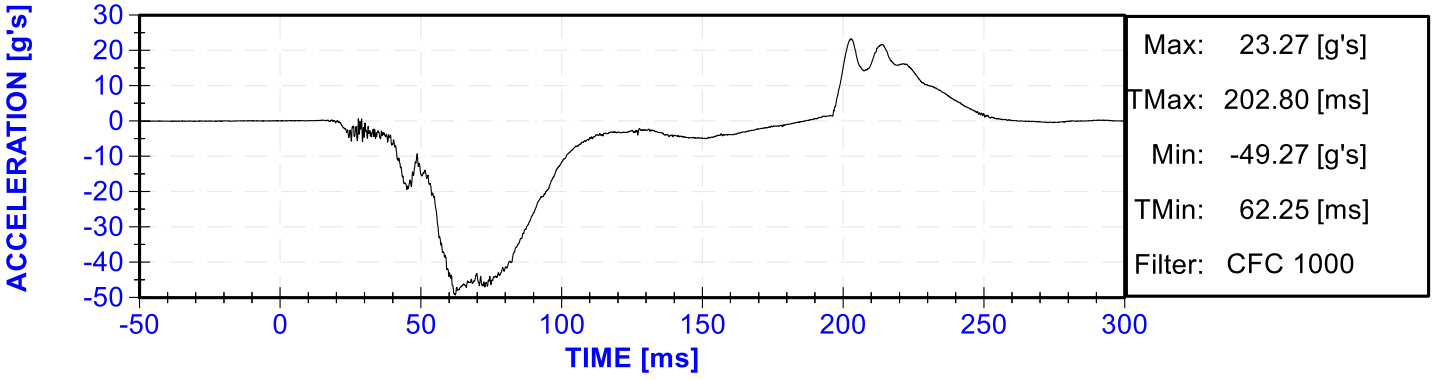
Driver Left Femur Force vs. Time



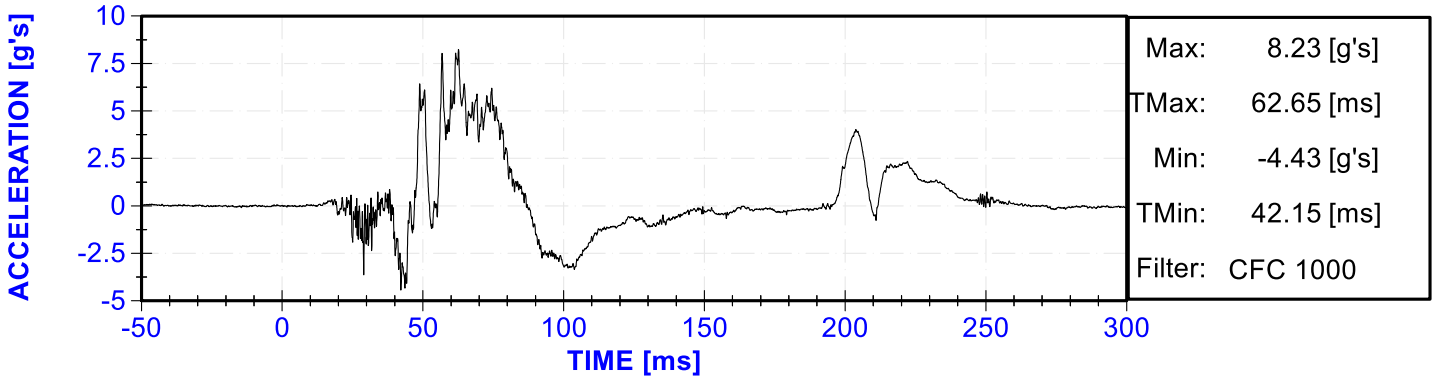
Driver Right Femur Force vs. Time



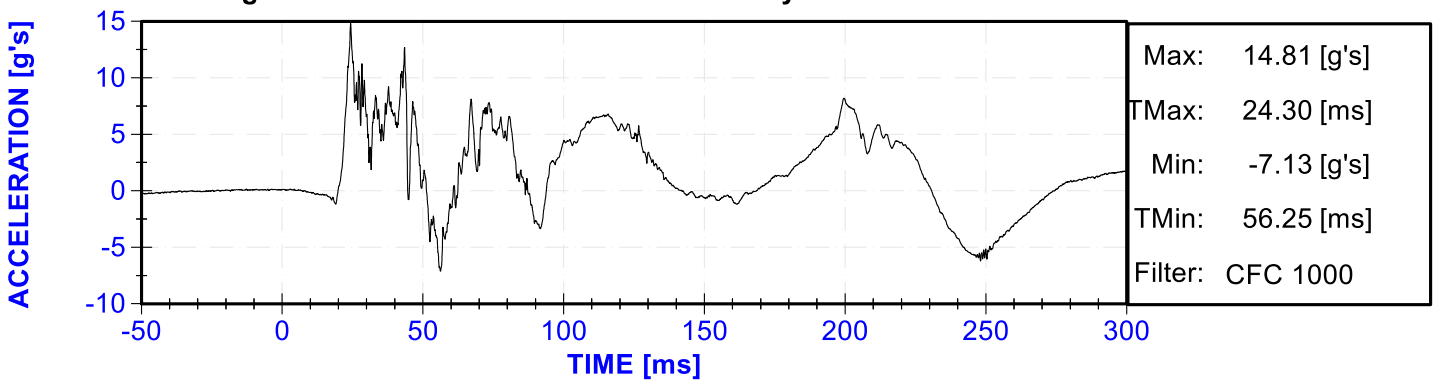
Passenger Head X Acceleration vs. Time Primary



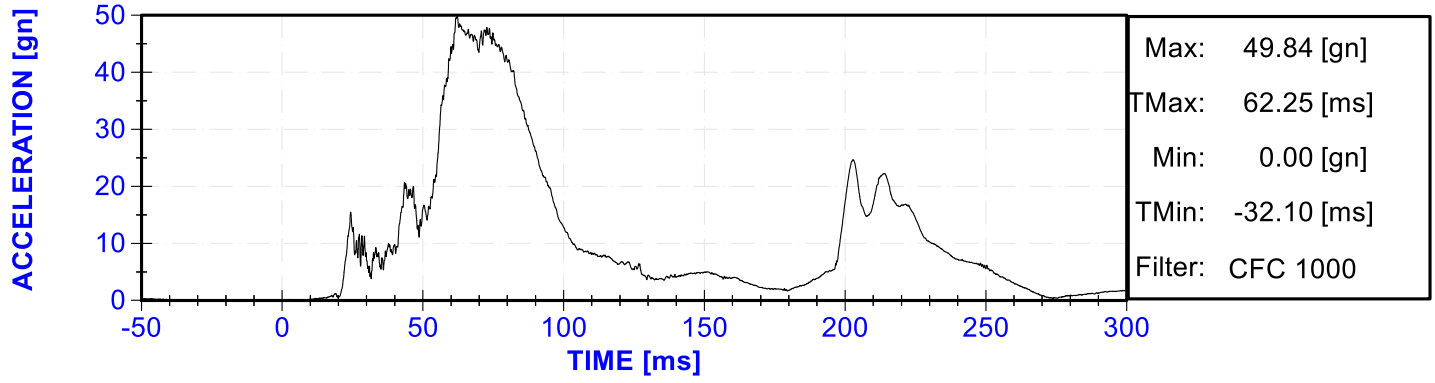
Passenger Head Y Acceleration vs. Time Primary



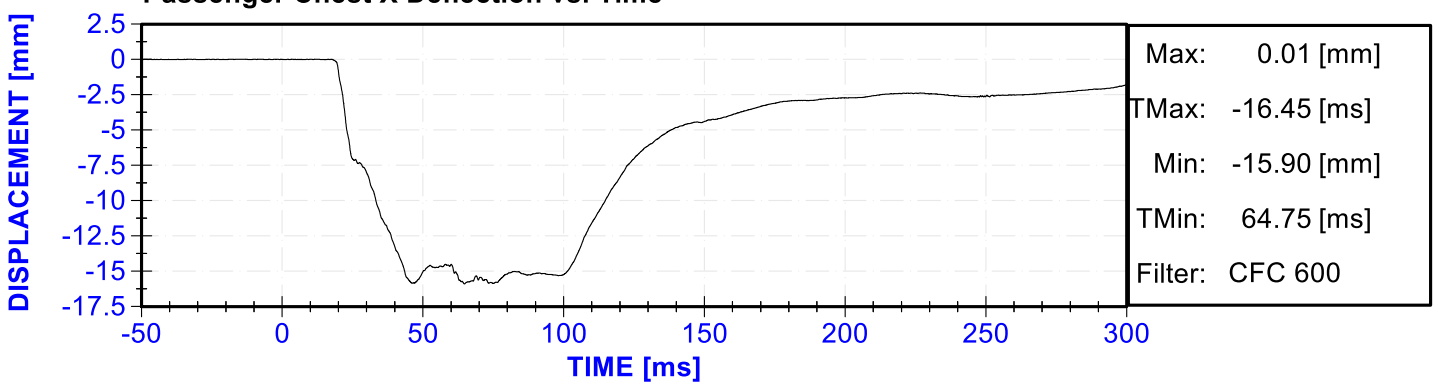
Passenger Head Z Acceleration vs. Time Primary



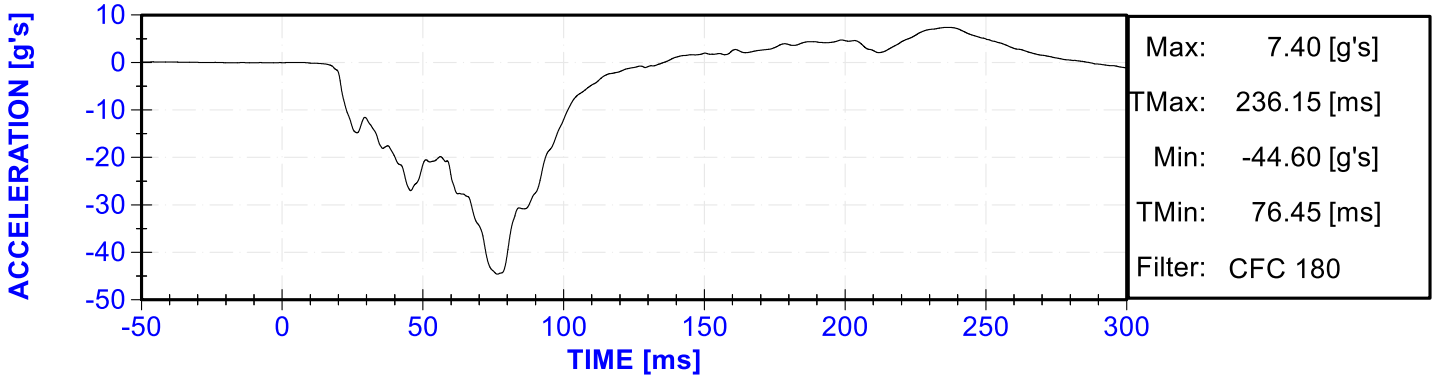
Passenger Head Resultant Acceleration vs. Time Primary



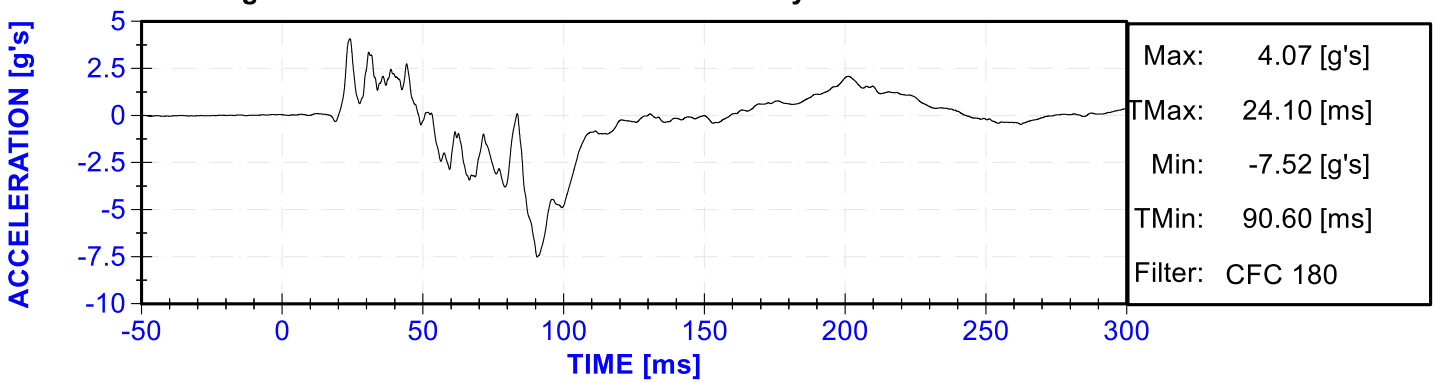
Passenger Chest X Deflection vs. Time



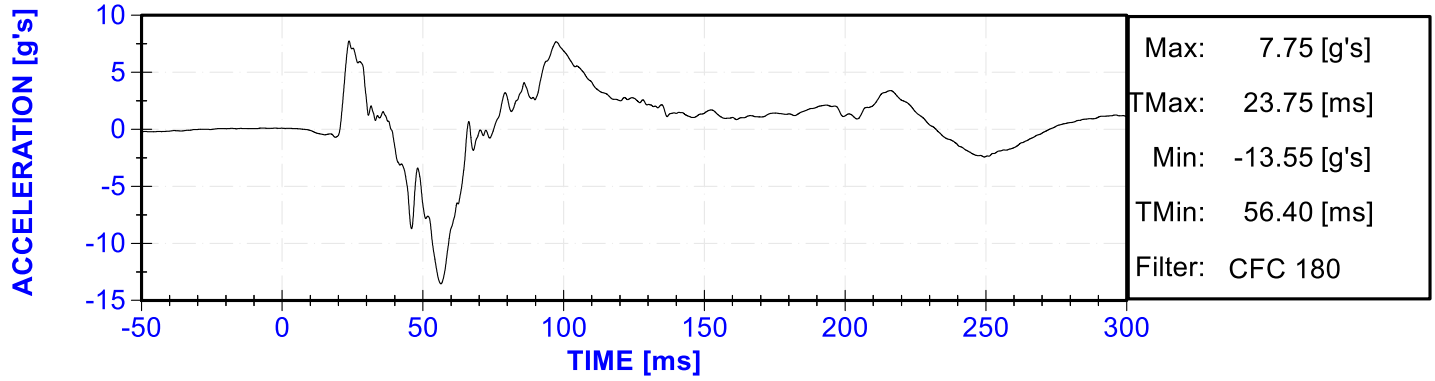
Passenger Chest X Acceleration vs. Time Primary



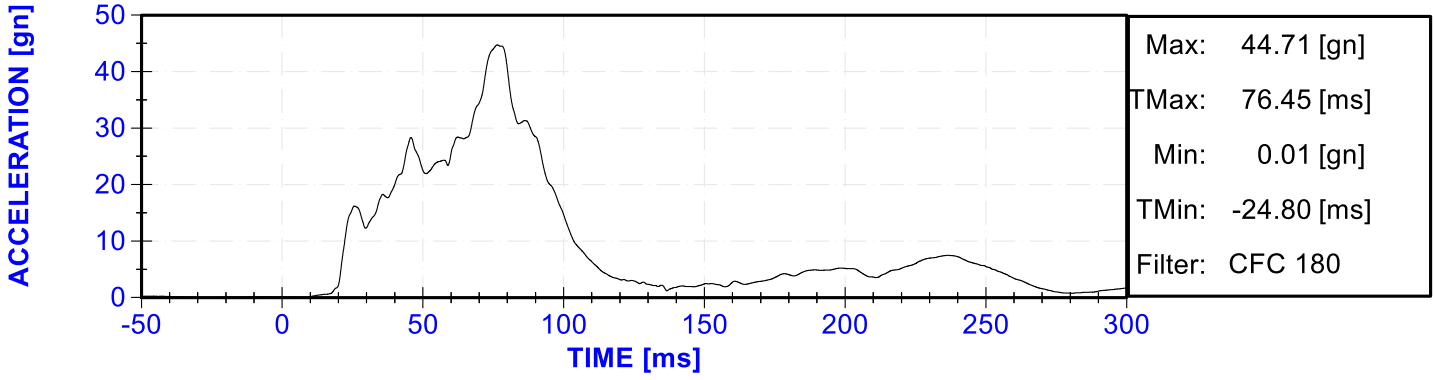
Passenger Chest Y Acceleration vs. Time Primary



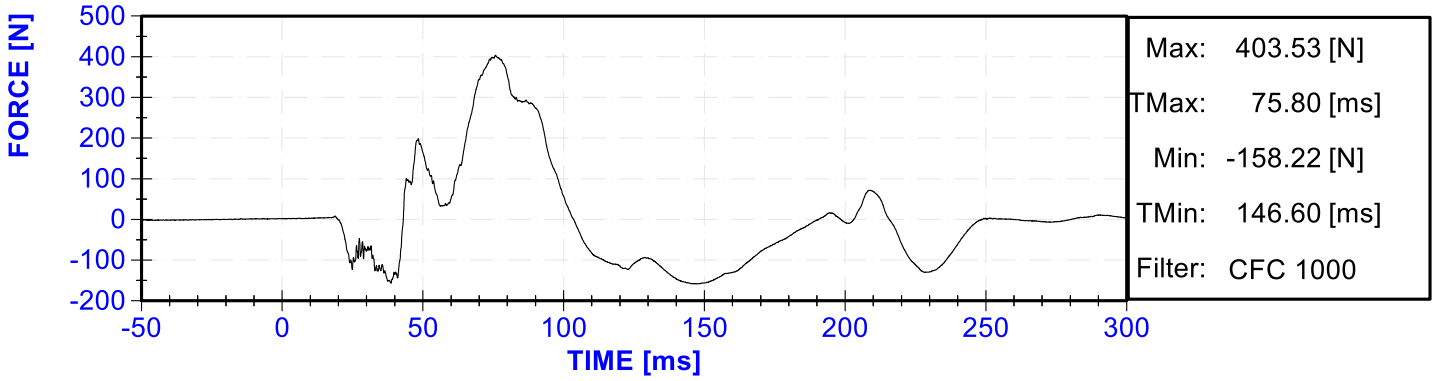
Passenger Chest Z Acceleration vs. Time Primary



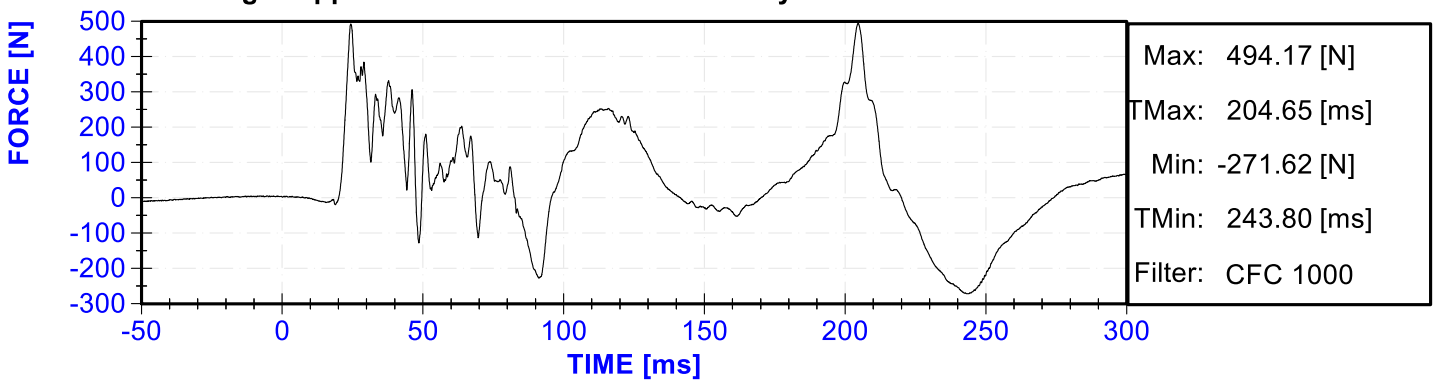
Passenger Chest Resultant Acceleration vs. Time Primary



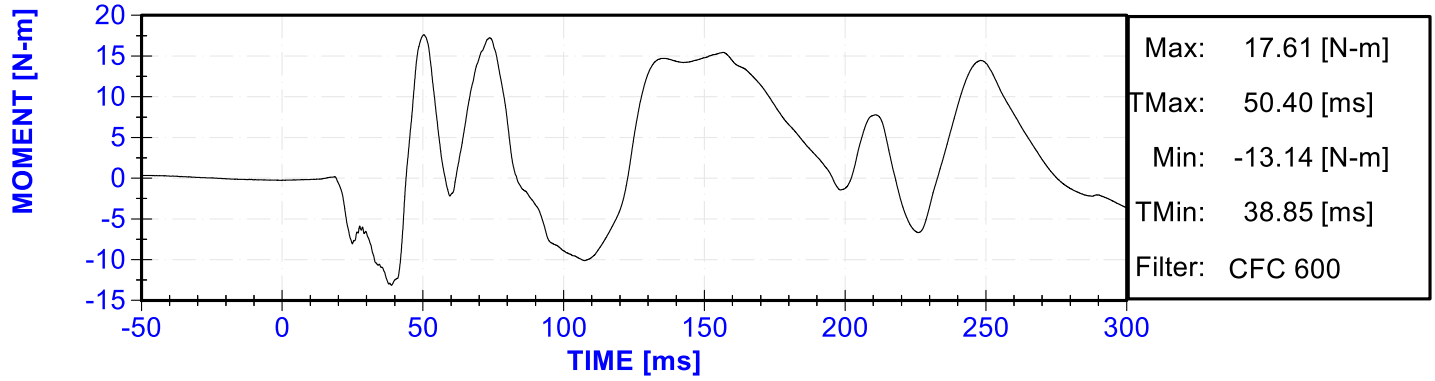
Passenger Upper Neck Force X vs. Time Primary



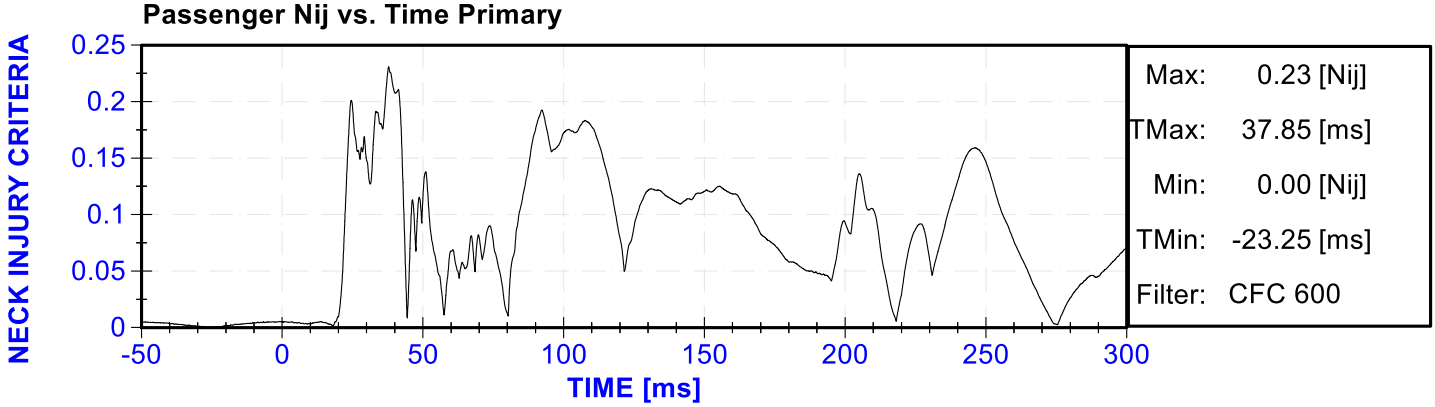
Passenger Upper Neck Force Z vs. Time Primary

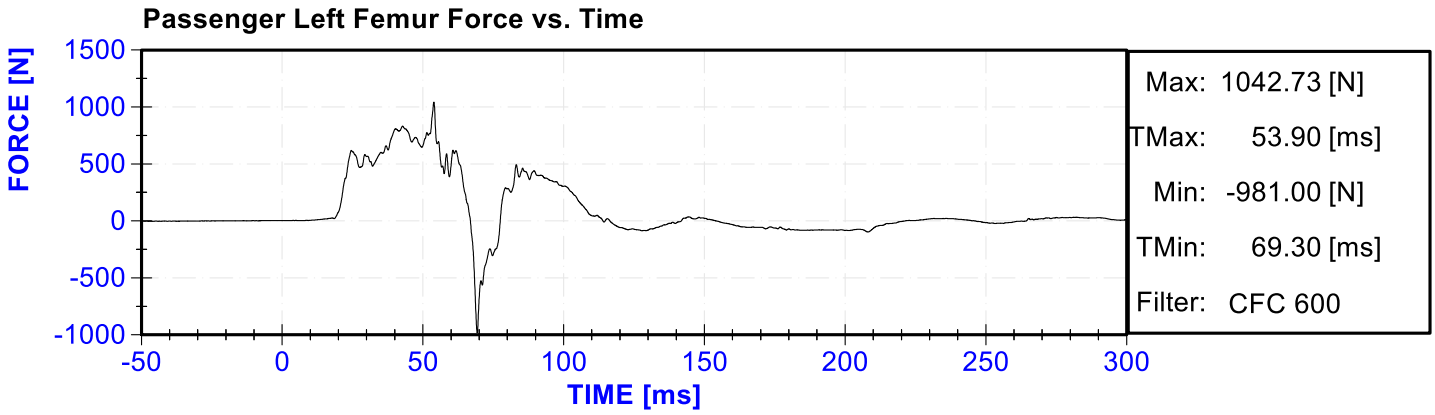


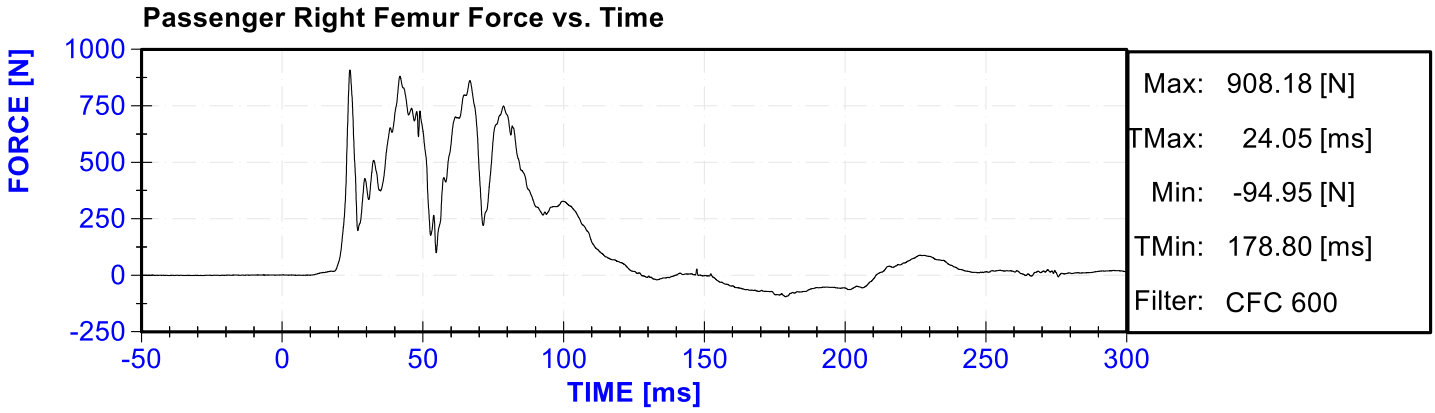
Passenger Upper Neck Moment Y vs. Time Primary



Passenger Nij vs. Time Primary




Passenger Left Femur Force vs. Time
FORCE [N]
1500
1000
500
0
-500
-1000
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 1042.73 [N]
TMax: 53.90 [ms]
Min: -981.00 [N]
TMin: 69.30 [ms]
Filter: CFC 600


Passenger Right Femur Force vs. Time
FORCE [N]
1000
750
500
250
0
-250
-50
0
50
100
150
200
250
300
TIME [ms]
Max: 908.18 [N]
TMax: 24.05 [ms]
Min: -94.95 [N]
TMin: 178.80 [ms]
Filter: CFC 600

APPENDIX C

DUMMY CALIBRATION AND PERFORMANCE VERIFICATION DATA

CALIBRATION TEST RESULTS

PRE-TEST

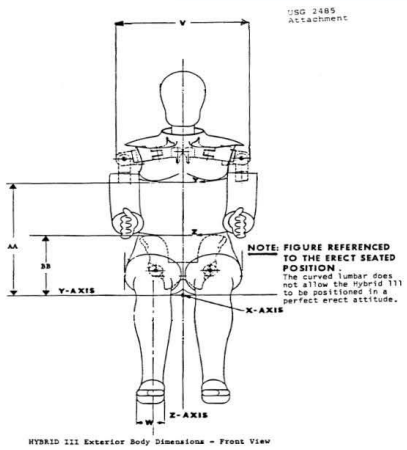
HYBRID III 50TH PERCENTILE MALE - DRIVER ATD

SERIAL NO: 142

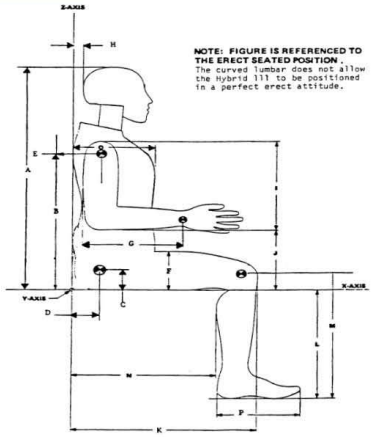
External Measurements - Hybrid 3 - 50th Male

Technician: K. Dutton Date: 02/15/2021

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	34.7	Pass
B	Shoulder Pivot Height	19.9	20.5	20.3	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	5.9	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	13.4	Pass
J	Elbow Rest Height	7.5	8.3	8.1	Pass
K	Buttock to Knee Length	22.8	23.8	23.0	Pass
L	Popliteal Height	16.9	17.9	17.5	Pass
M	Knee Pivot Height	19.1	19.7	19.4	Pass
N	Buttock Popliteal Length	17.8	18.8	18.3	Pass
O	Chest Depth without Jacket	8.4	9.0	8.6	Pass
P	Foot Length (right)	9.9	10.5	10.1	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

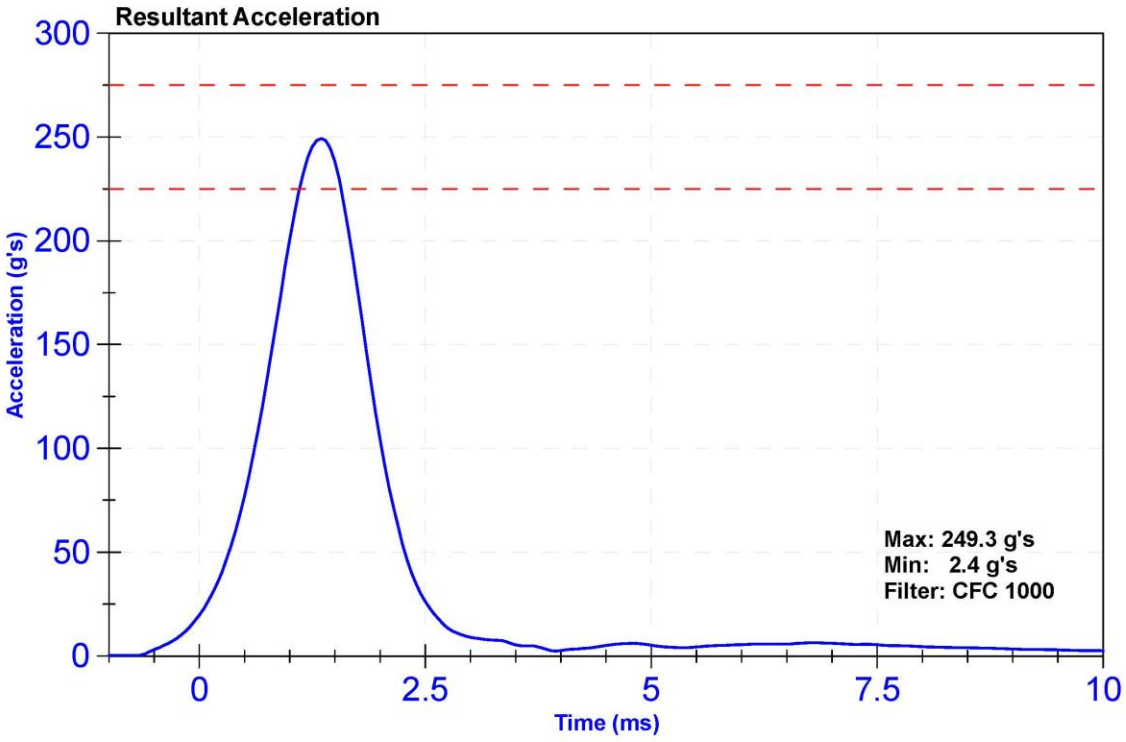
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

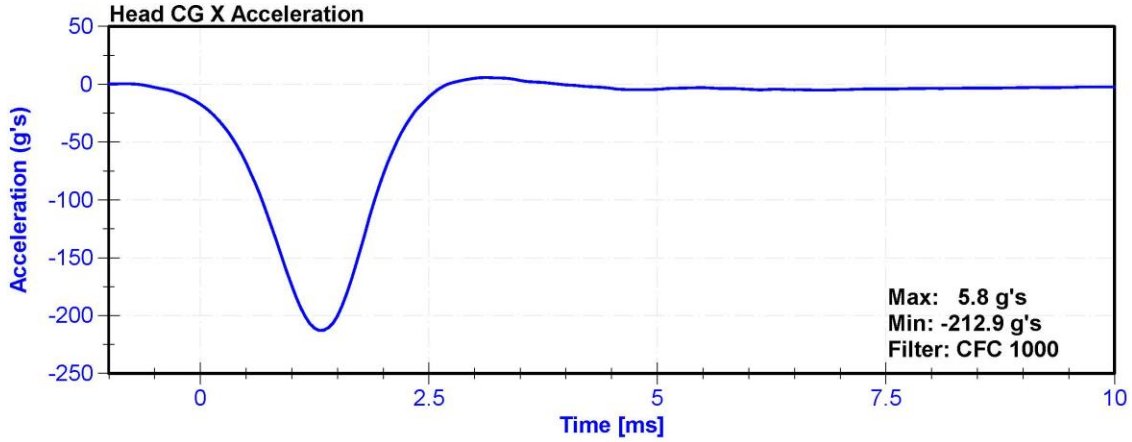
Results

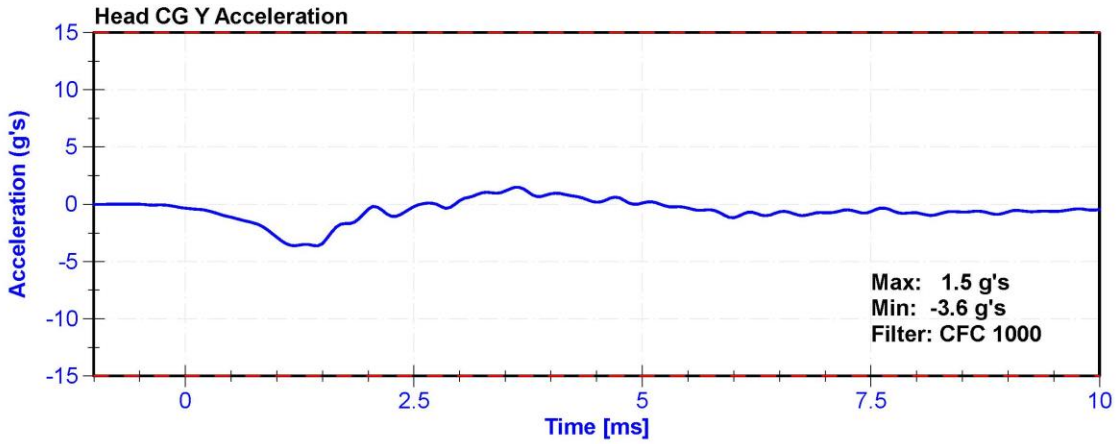
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21	Pass
Humidity	10	70	%	16.2	Pass
Resultant Acceleration	225	275	g's	249.3	Pass
Oscillation	0	10	%	2.5	Pass
Lateral Acceleration	-15	15	g's	-3.6	Pass

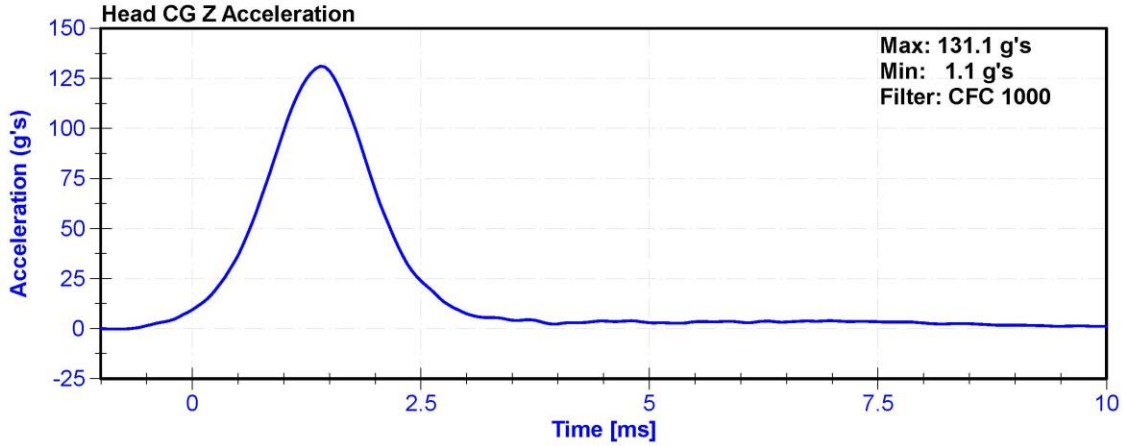
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264	P51681	11/3/2020	5/4/2021
Y Accelerometer	ENDEVCO 7264	P64151	11/3/2020	5/4/2021
Z Accelerometer	ENDEVCO 7264	P52114	11/3/2020	5/4/2021




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 5.8 g's
Min: -212.9 g's
Filter: CFC 1000


Head CG Y Acceleration
Acceleration (g's)
15
10
5
0
-5
-10
-15
0
2.5
5
7.5
10
Time [ms]
Max: 1.5 g's
Min: -3.6 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: 131.1 g's
Min: 1.1 g's
Filter: CFC 1000

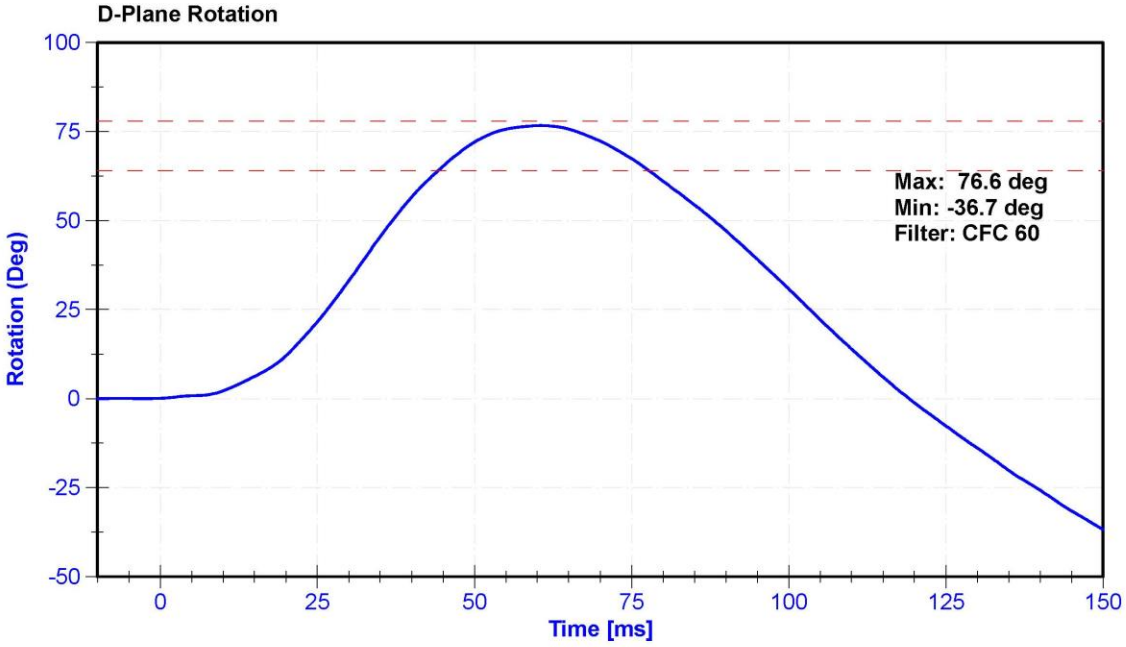
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

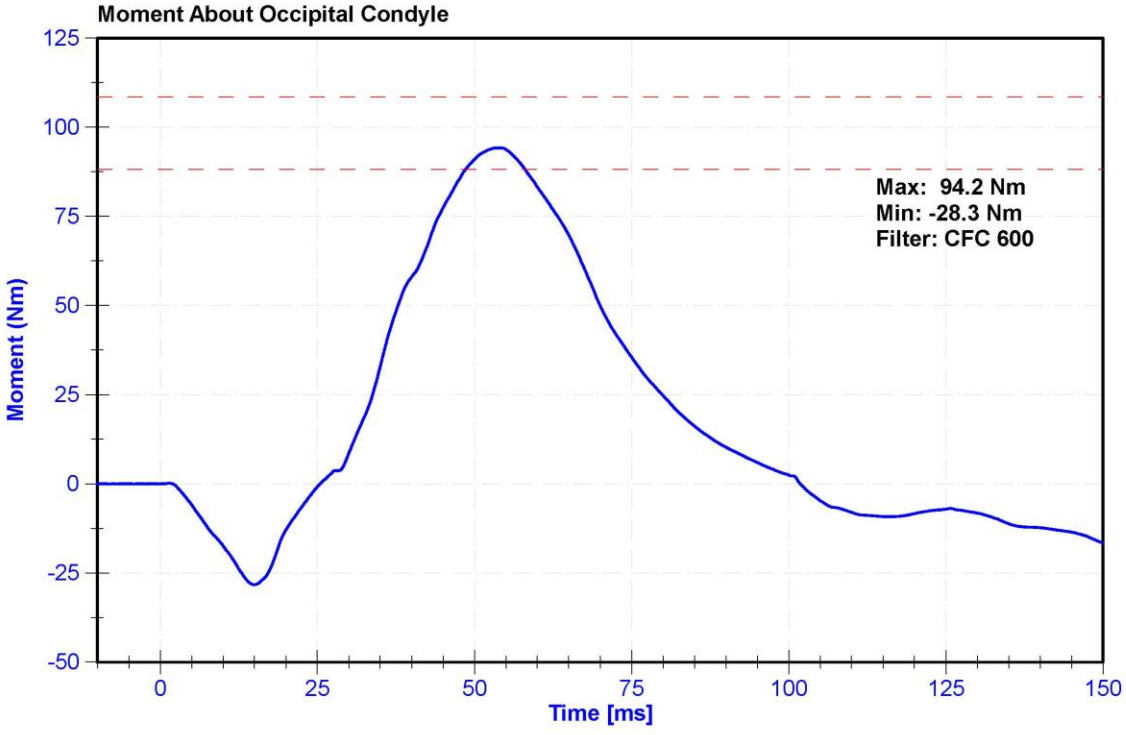
Results

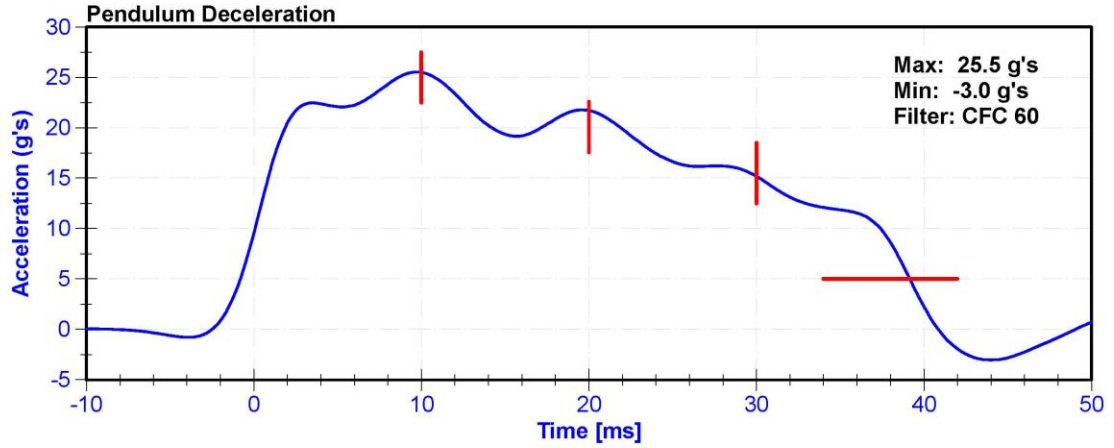
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	19.5	Pass
Velocity	6.89	7.13	m/s	6.958	Pass
Pendulum Deceleration at 10ms	22.5	27.5	g's	25.49	Pass
Pendulum Deceleration at 20ms	17.6	22.6	g's	21.71	Pass
Pendulum Deceleration at 30ms	12.5	18.5	g's	15.19	Pass
Max. Pendulum Deceleration After 30ms	0	29	g's	25.5	Pass
Pendulum Deceleration Time to 5 g's	34	42	ms	39.2	Pass
Maximum D Plane Rotation	64	78	deg	76.6	Pass
Time to Maximum Rotation	57	64	ms	60.5	Pass
Rotation Decay to Zero	113	127	ms	119.2	Pass
Moment About Occipital Condyle	88.1	108.4	Nm	94.18	Pass
Time to Maximum Moment	47	58	ms	54.2	Pass
Moment Decay to Zero	97	107	ms	101.8	Pass

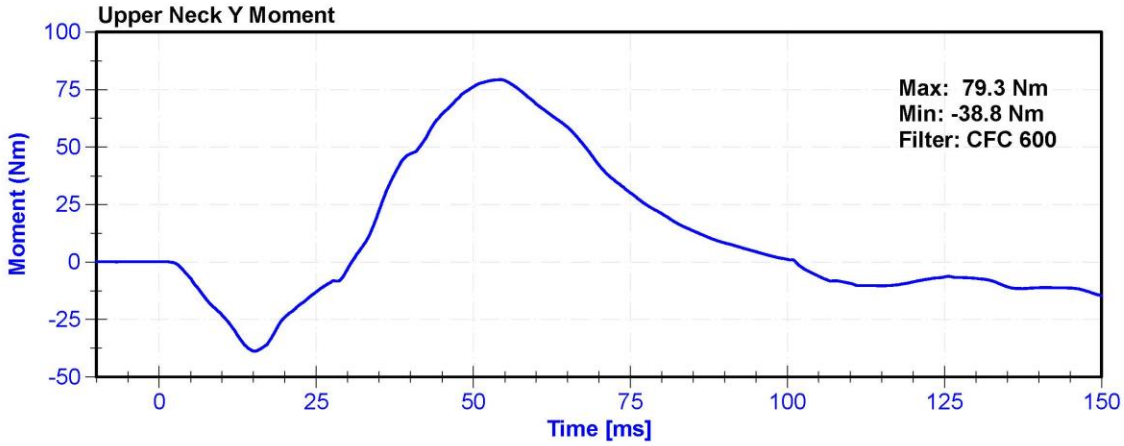
Transducer Calibrations

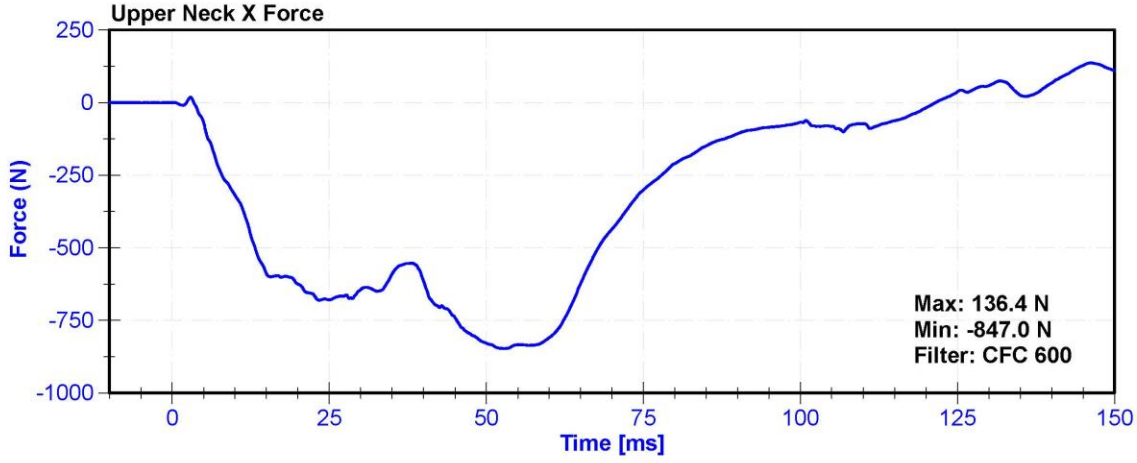
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-C16503	2/5/2021	2/5/2022
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/17/2020	9/17/2021
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/17/2020	9/17/2021
Upper Neck Load Cell	DENTON 1716A	LC-2186Fx	11/10/2020	11/10/2021


D-Plane Rotation
Rotation (Deg)
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 76.6 deg
Min: -36.7 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: 94.2 Nm
Min: -28.3 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 25.5 g's
Min: -3.0 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 79.3 Nm
Min: -38.8 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 136.4 N
Min: -847.0 N
Filter: CFC 600
Force (N)
Time [ms]

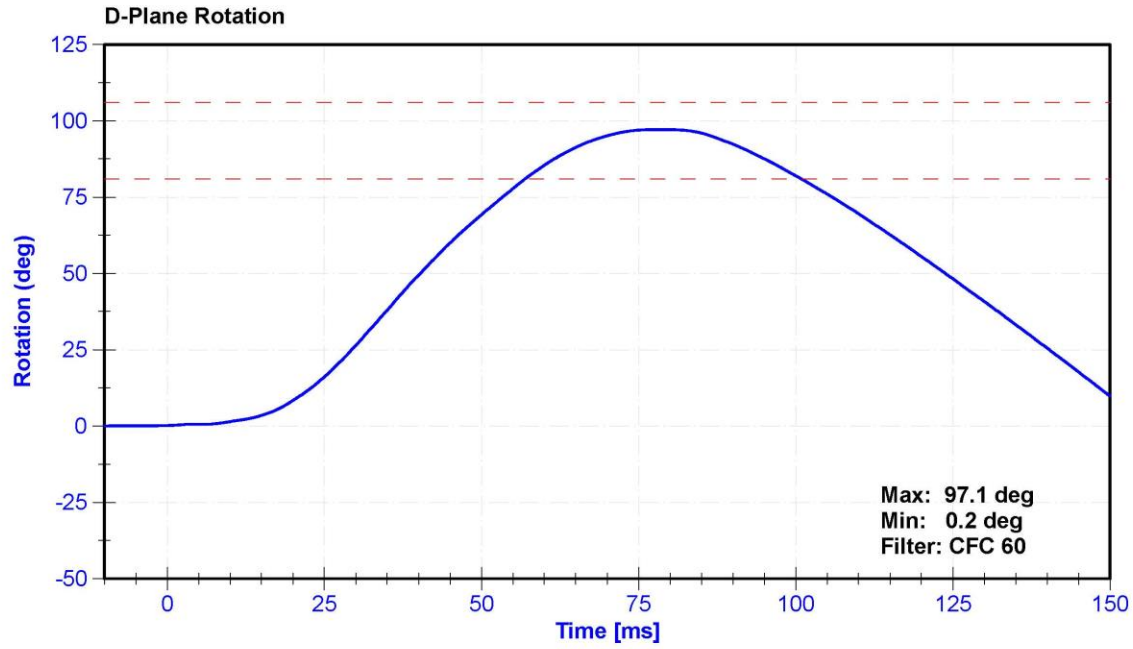
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

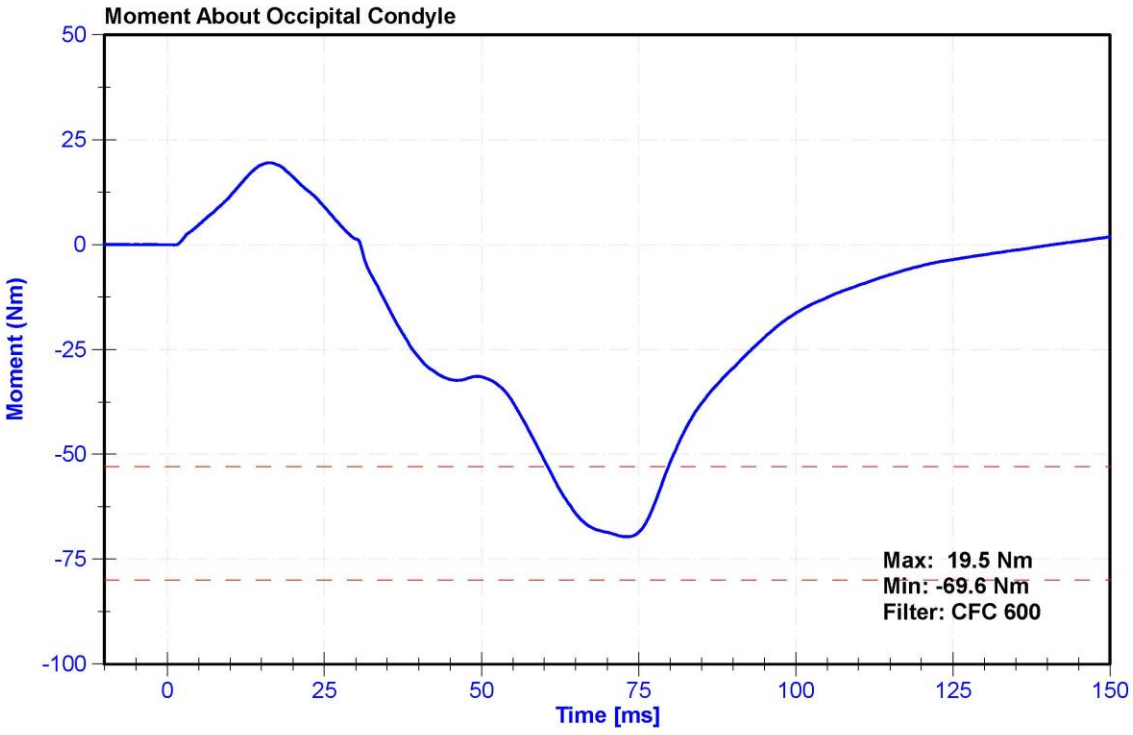
Results

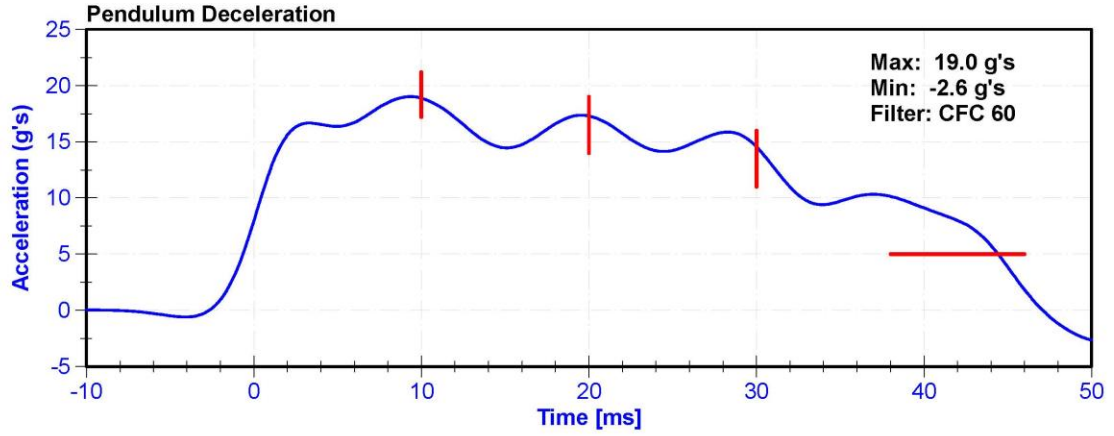
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.7	Pass
Humidity	10	70	%	24	Pass
Velocity	5.94	6.19	m/s	5.964	Pass
Pendulum Deceleration at 10ms	17.2	21.2	g's	18.88	Pass
Pendulum Deceleration at 20ms	14	19	g's	17.3	Pass
Pendulum Deceleration at 30ms	11	16	g's	14.6	Pass
Max. Pendulum Deceleration After 30ms	0	22	g's	19.0	Pass
Pendulum Deceleration Time to 5 g's	38	46	ms	44.4	Pass
Maximum D Plane Rotation	81	106	deg	97.1	Pass
Time to Maximum Rotation	72	82	ms	78.2	Pass
Rotation Decay to Zero	147	174	ms	156.6	Pass
Minimum Moment About OC	-80	-52.9	Nm	-69.60	Pass
Time to Minimum Moment	65	79	ms	73.1	Pass
Moment Decay to Zero	120	148	ms	141.1	Pass

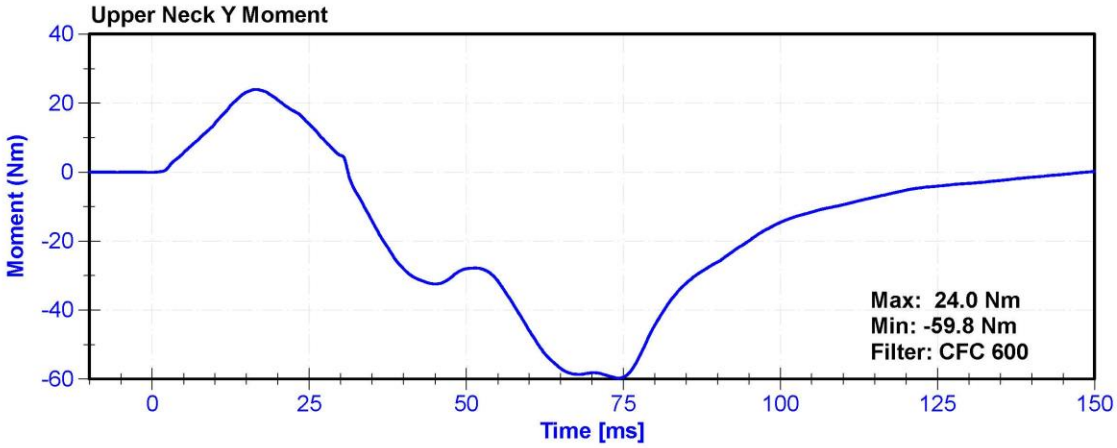
Transducer Calibrations

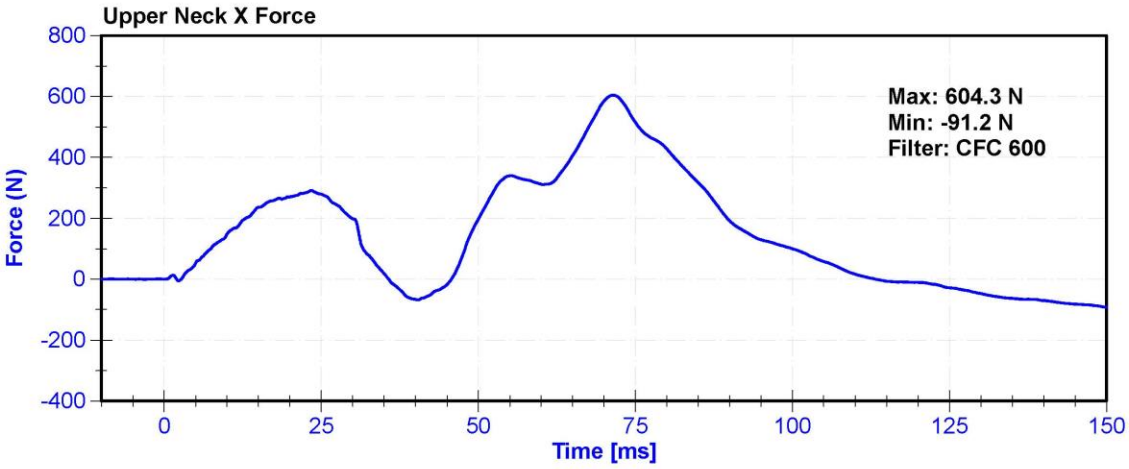
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-C16503 Striker	2/5/2021	2/5/2022
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/17/2020	9/17/2021
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/17/2020	9/17/2021
Upper Neck Load Cell	DENTON 1716A	LC-2186Fx	11/10/2020	11/10/2021


D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 97.1 deg
Min: 0.2 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
50
25
0
-25
-50
-75
-100
0
25
50
75
100
125
150
Time [ms]
Max: 19.5 Nm
Min: -69.6 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 19.0 g's
Min: -2.6 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 24.0 Nm
Min: -59.8 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 604.3 N
Min: -91.2 N
Filter: CFC 600
Force (N)
Time [ms]

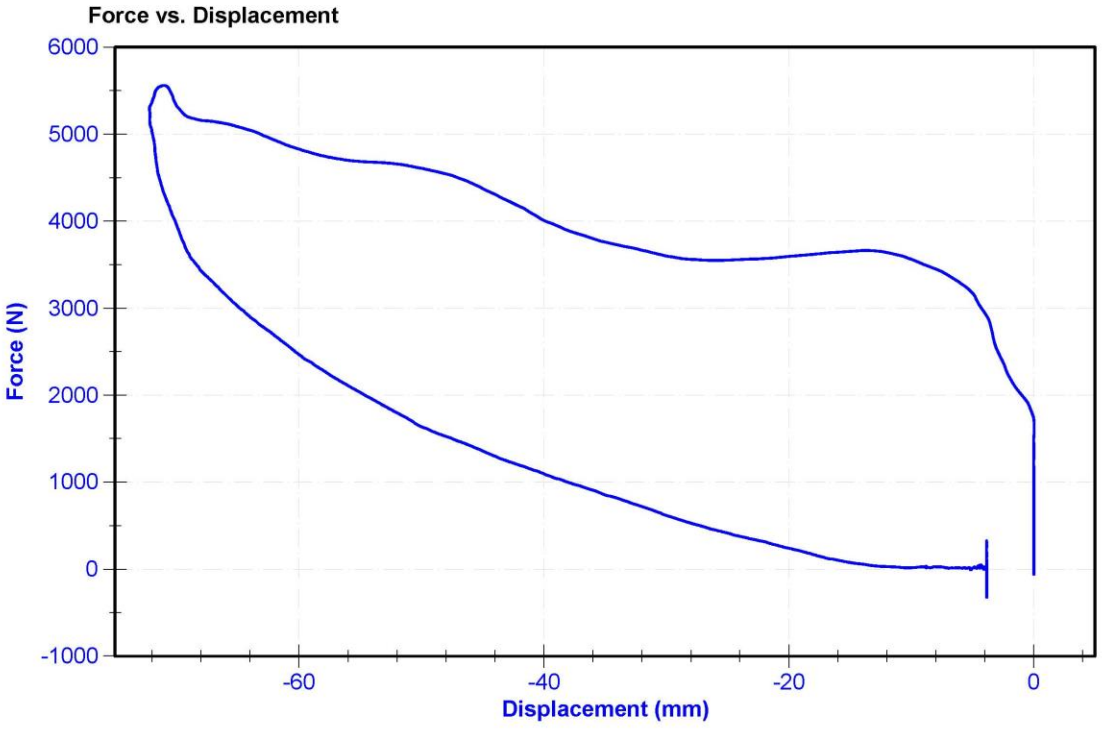
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

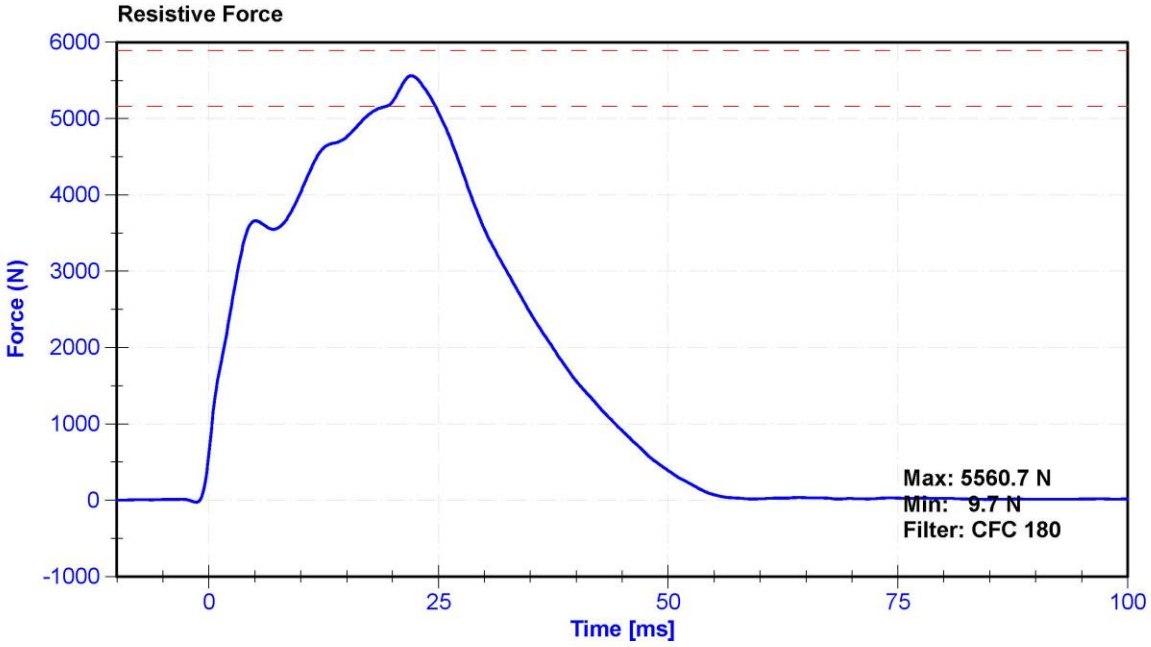
Results

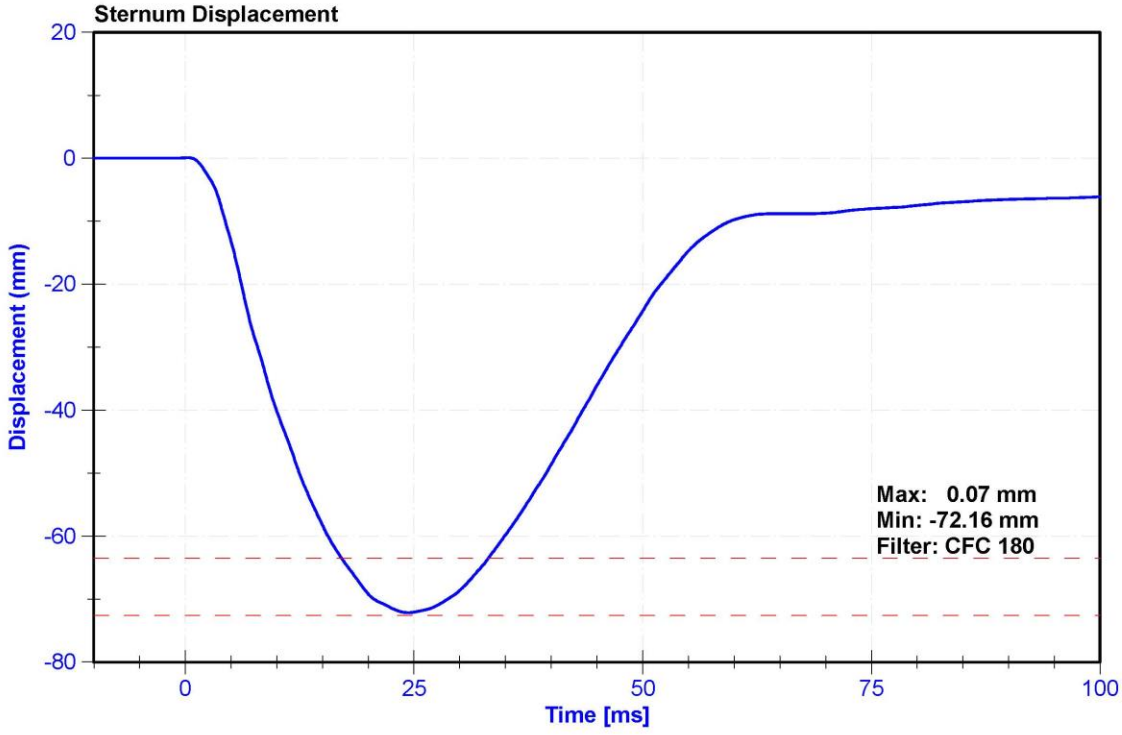
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	19.5	Pass
Velocity	6.59	6.83	m/s	6.699	Pass
Chest Displacement	-72.6	-63.5	mm	-72.16	Pass
Resistive Force	5160	5894	N	5560.7	Pass
Hysteresis	65	85	%	69.8	Pass

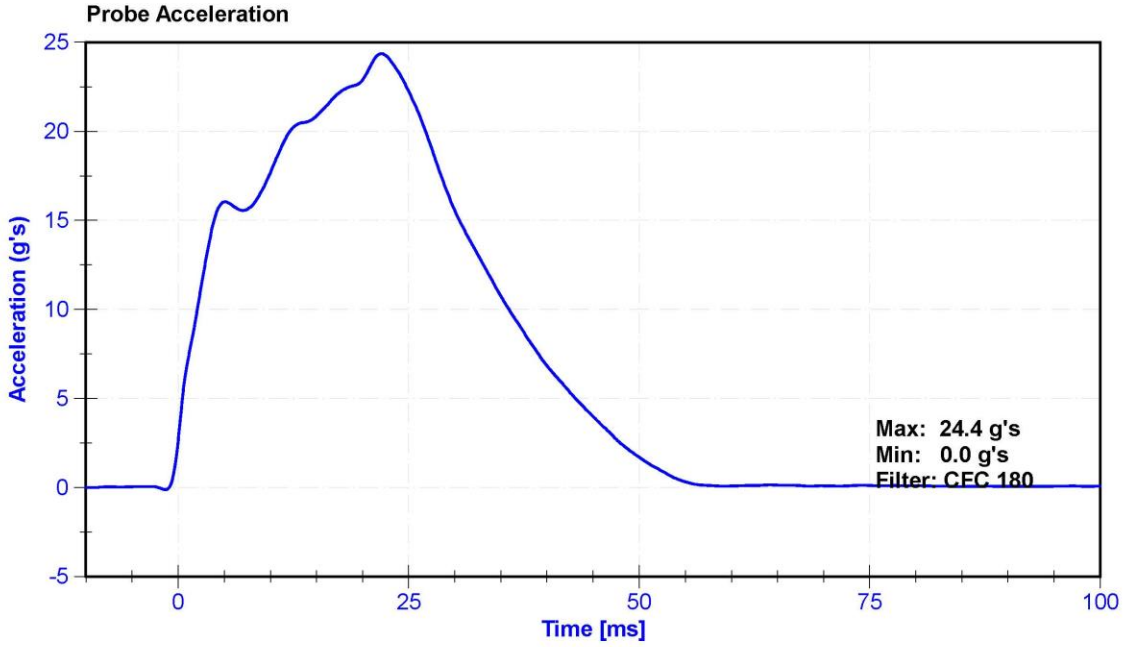
Transducer Calibrations

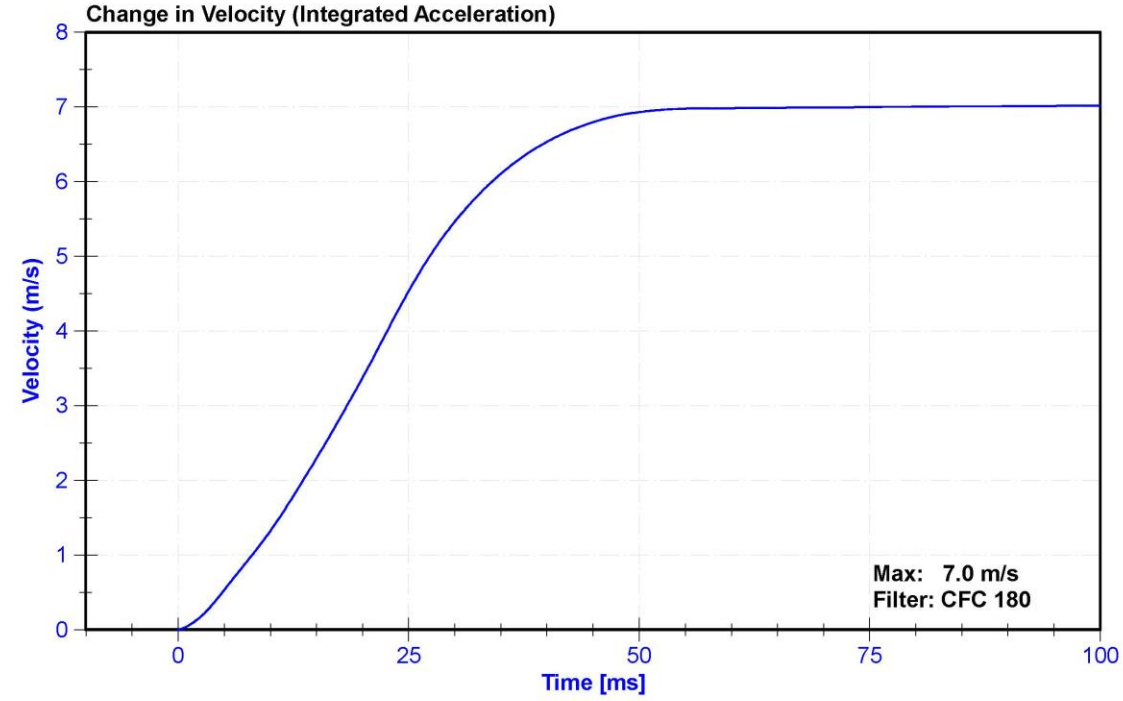
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7264C	T25885	2/2/2021	2/2/2022
Chest Potentiometer	Servo 6209-2038	DS-142	11/19/2020	5/20/2021




Resistive Force
Force (N)
6000
5000
4000
3000
2000
1000
0
-1000
0
25
50
75
100
Time [ms]
Max: 5560.7 N
Min: 9.7 N
Filter: CFC 180


Sternum Displacement
Displacement (mm)
20
0
-20
-40
-60
-80
0
25
50
75
100
Time [ms]
Max: 0.07 mm
Min: -72.16 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
25
20
15
10
5
0
-5
0
25
50
75
100
Time [ms]
Max: 24.4 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: 7.0 m/s
Filter: CFC 180

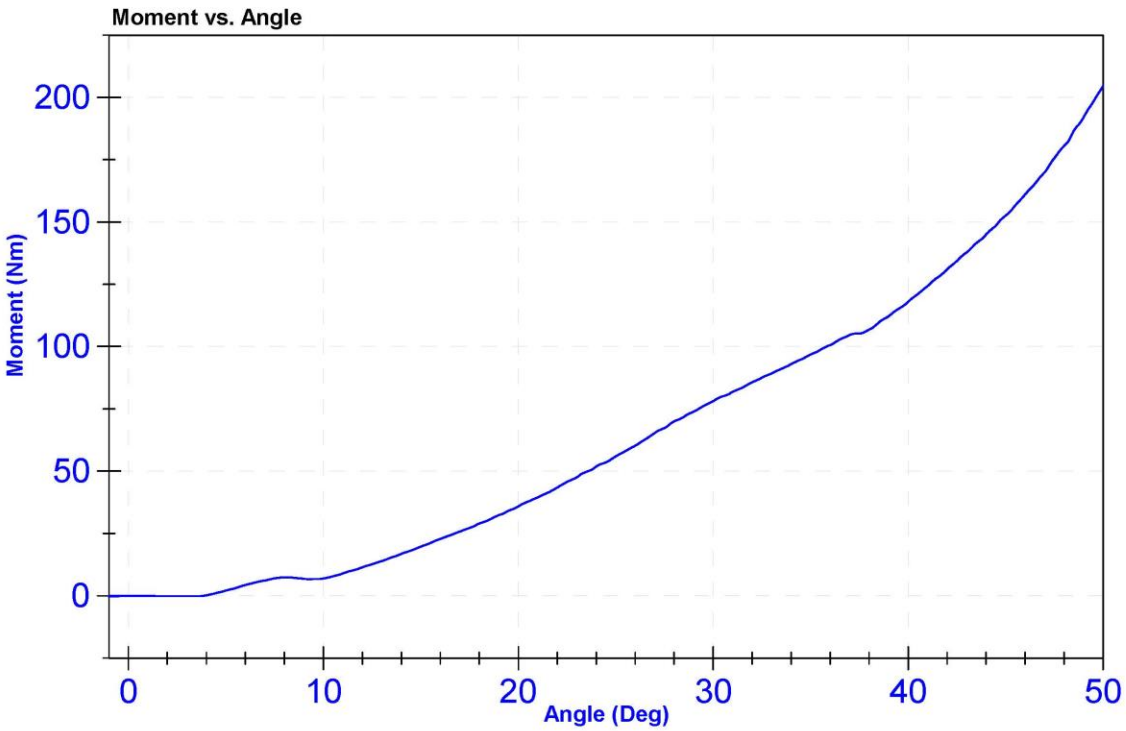
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	27.0	Pass
Average Velocity	5	10	deg/s	7.2	Pass
Angle at 203Nm	40	50	deg	49.9	Pass
Moment at 30 degrees	0	94.9	Nm	78.1	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	ETI SP22	DS-0008	9/18/2020	9/18/2021
Load Cell	Key Trans 2301-02	LC-115 My	2020-09-12	2021-09-12



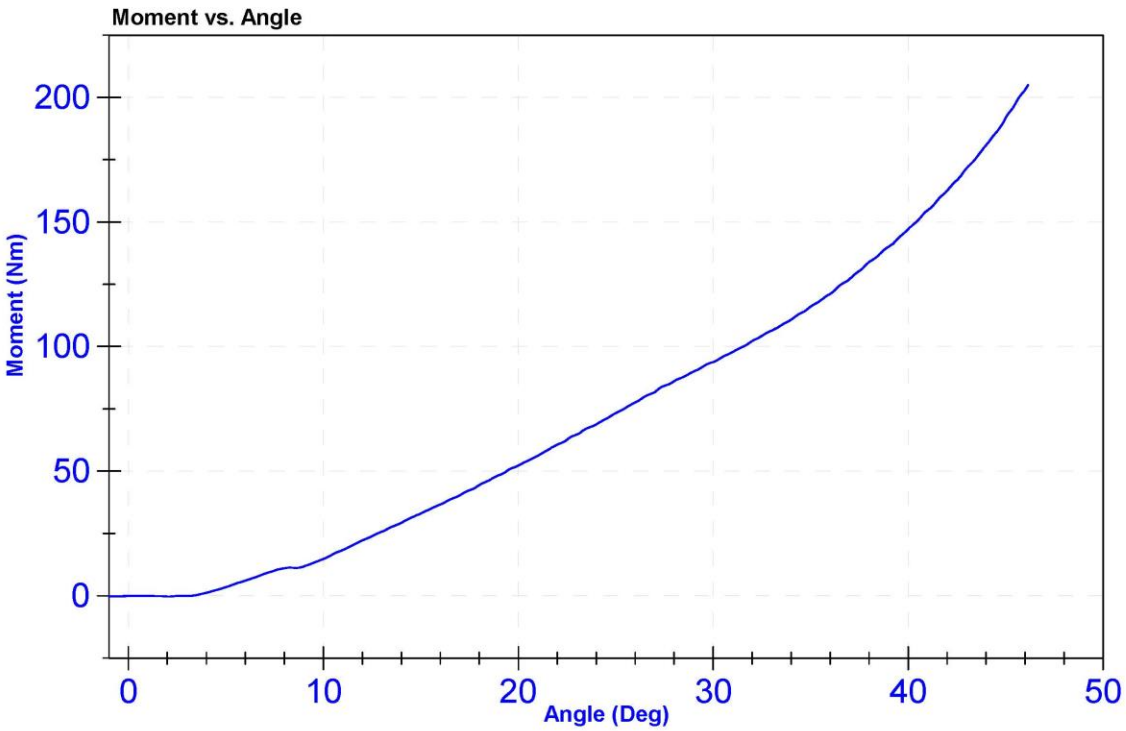
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	26.0	Pass
Average Velocity	5	10	deg/s	7.2	Pass
Angle at 203Nm	40	50	deg	46.0	Pass
Moment at 30 degrees	0	94.9	Nm	93.8	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	ETI SP22	DS-0008	9/18/2020	9/18/2021
Load Cell	Key Trans 2301-02	LC-115 My	2020-09-12	2021-09-12



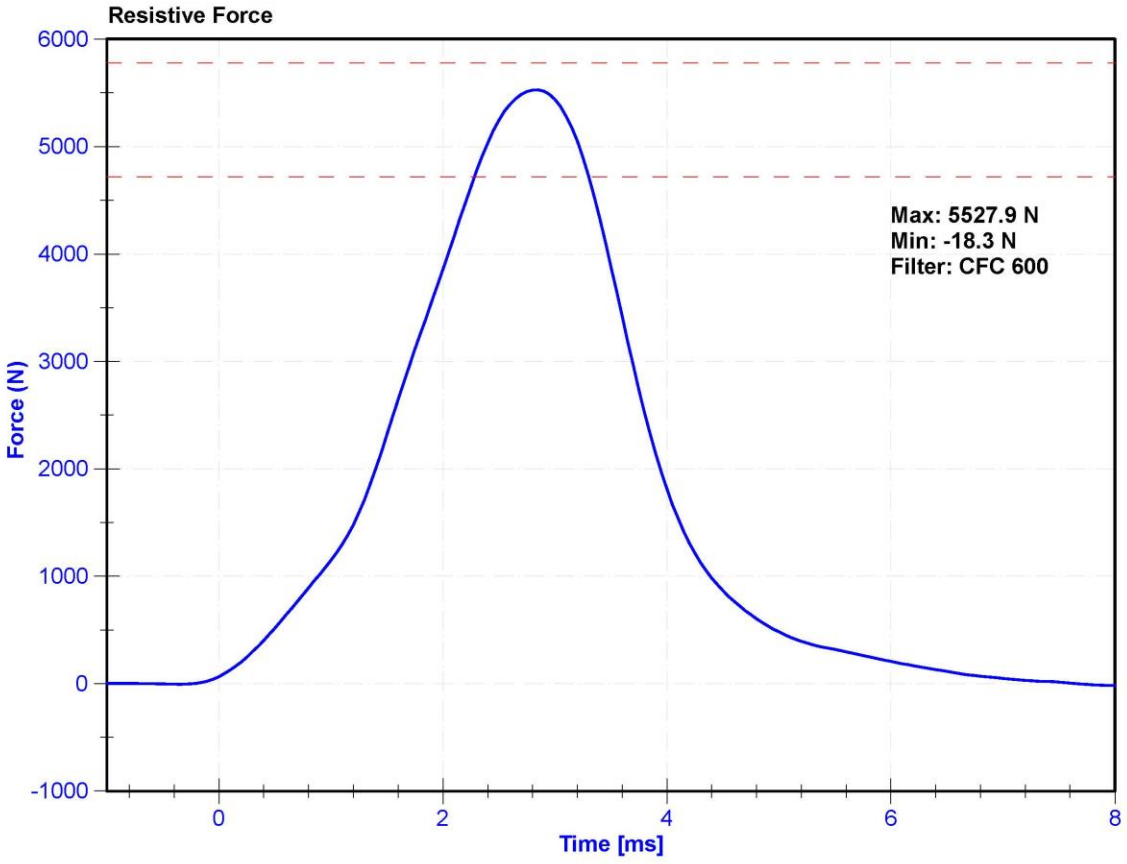
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

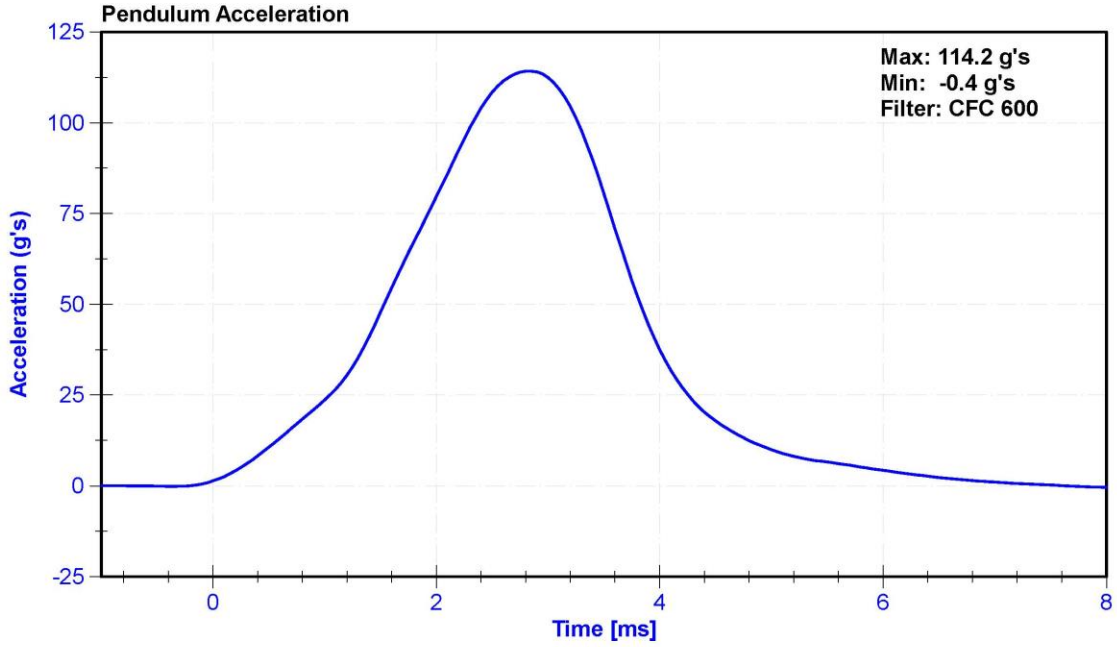
Results

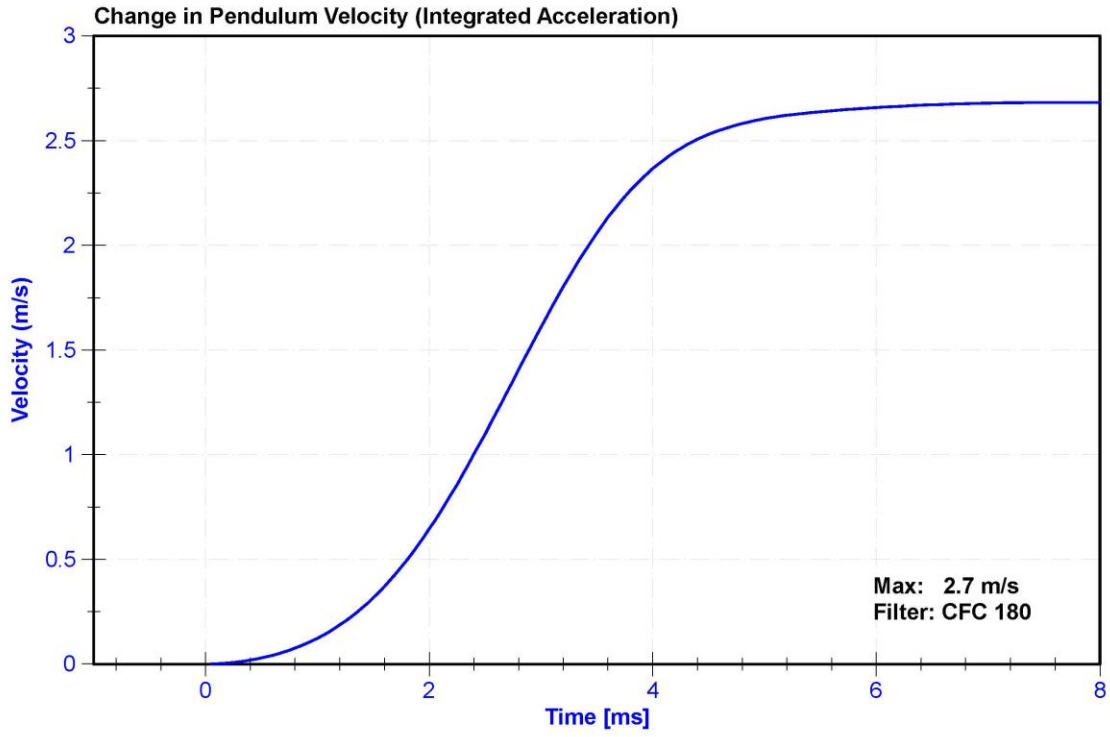
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	19.5	Pass
Velocity	2.07	2.13	m/s	2.111	Pass
Maximum Resistive Force	4720	5780	N	5527.9	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021




Pendulum Acceleration
Max: 114.2 g's
Min: -0.4 g's
Filter: CFC 600
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]


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

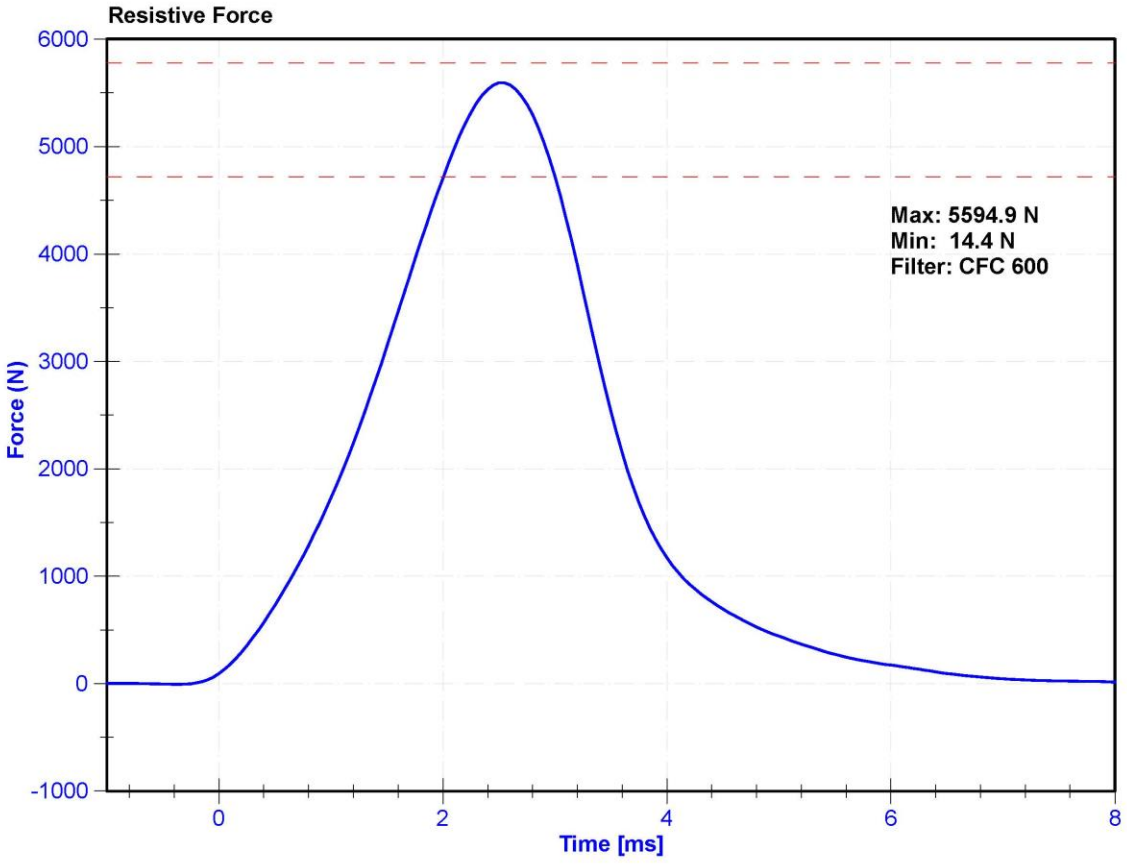
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

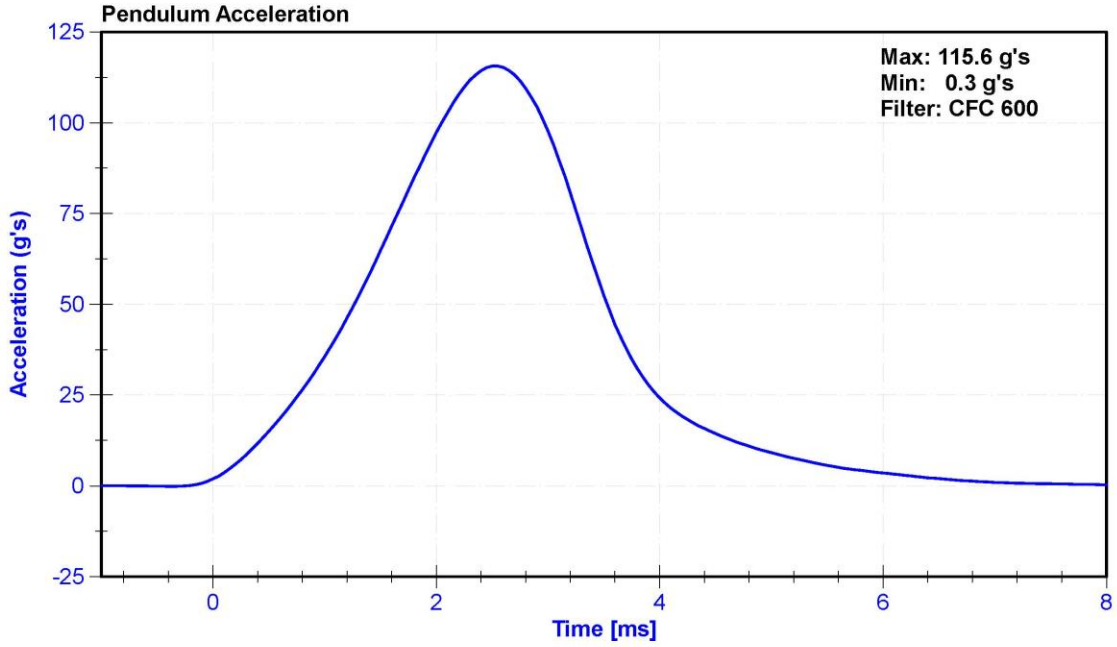
Results

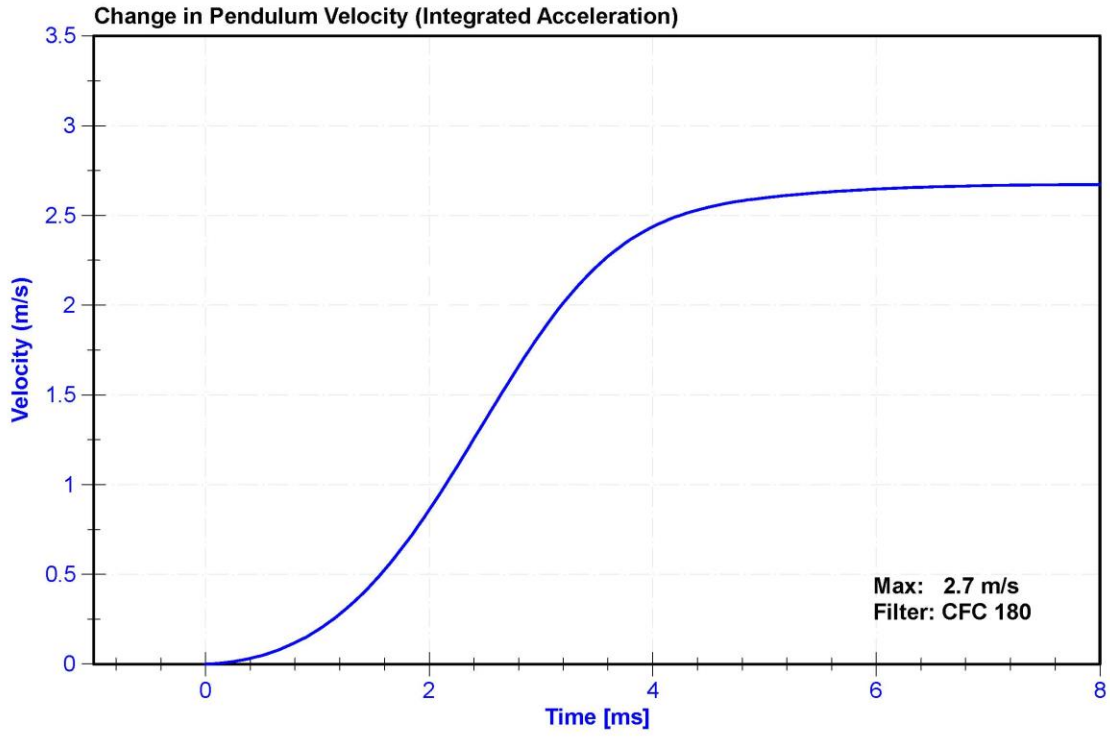
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	27	Pass
Velocity	2.07	2.13	m/s	2.096	Pass
Maximum Resistive Force	4720	5780	N	5594.9	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021




Pendulum Acceleration
Max: 115.6 g's
Min: 0.3 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)
3.5
3
2.5
2
1.5
1
0.5
0
Max: 2.7 m/s
Filter: CFC 180
0
2
4
6
8
Time [ms]

CALIBRATION TEST RESULTS

PRE-TEST

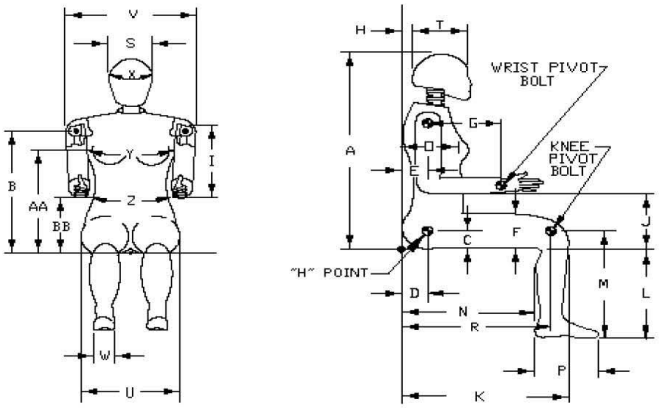
HYBRID III 5TH PERCENTILE - PASSENGER ATD

SERIAL NO: 140

External Measurements - Hybrid 3 - 5th Female

Technician: K. Brogan Date: 2/15/2021

Dummy Serial Number: 140



Symbol	Description	Specification (mm)		Result (mm)	Pass/Fail
A	Sitting Height	775	800	790	Pass
B	Shoulder Pivot Height	432	457	442	Pass
C	H-Point Height	81	86	83	Pass
D	H-Point from Backline	145	150	146	Pass
E	Shoulder Pivot from Backline	69	84	78	Pass
F	Thigh Clearance	119	135	127	Pass
G	Back of Elbow to Wrist Pivot	244	259	252	Pass
H	Head Back to Backline	43	48	45	Pass
I	Shoulder to Elbow Length	277	297	291	Pass
J	Elbow Rest Height	183	203	197	Pass
K	Buttock to Knee Length	521	546	541	Pass
L	Popliteal Height	356	376	366	Pass
M	Knee Pivot Height	394	419	410	Pass
N	Buttock Popliteal Length	414	439	428	Pass
O	Chest Depth without Jacket	175	191	182	Pass
P	Foot Length (right)	219	234	229	Pass
R	Buttock To Knee Pivot Length	457	483	465	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

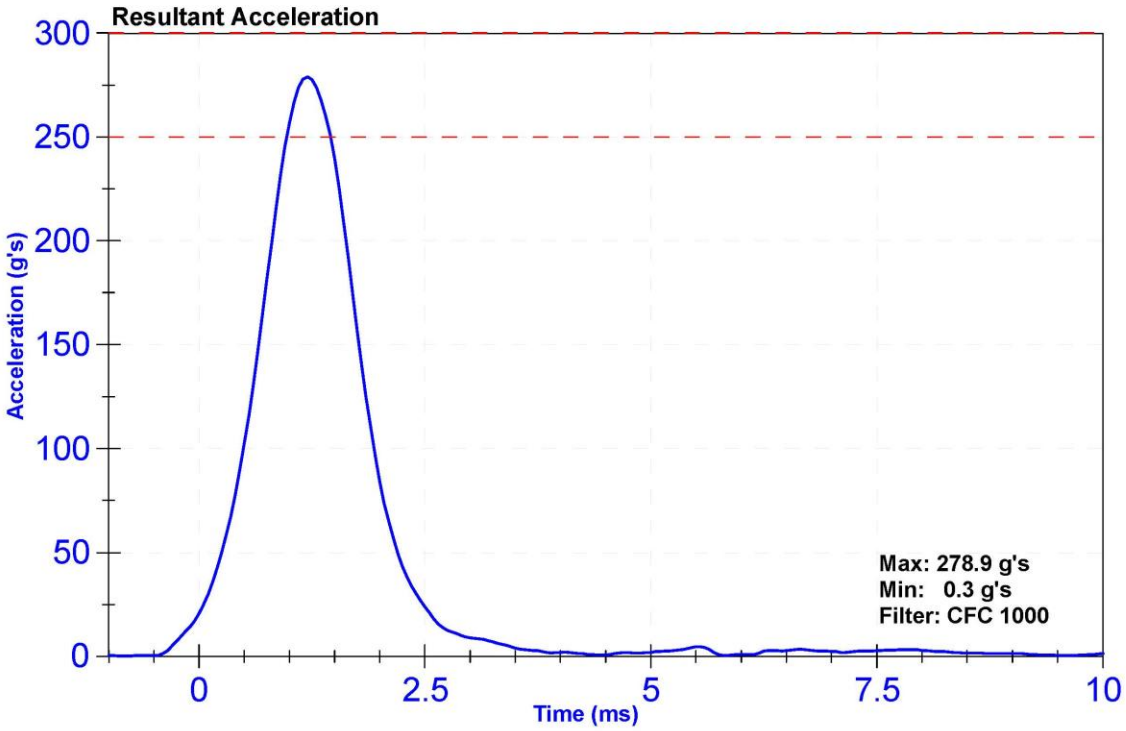
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

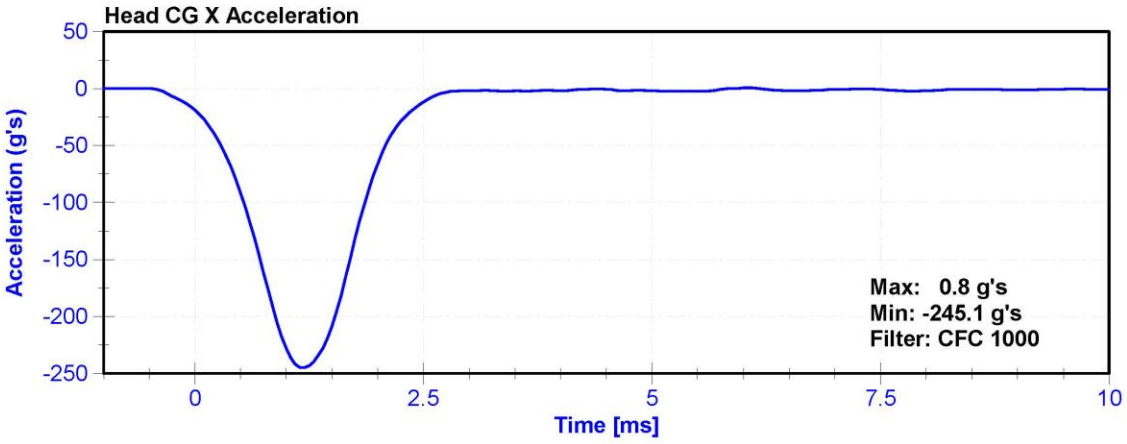
Results

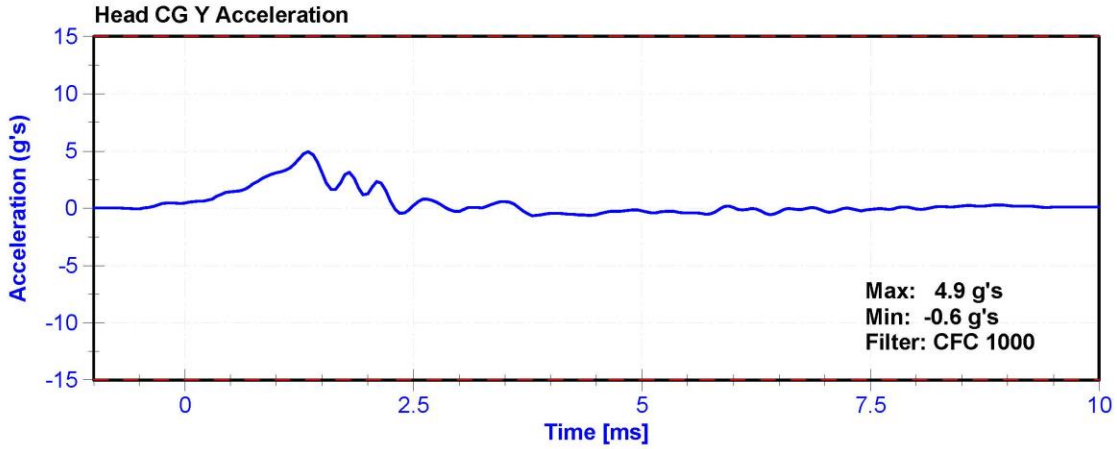
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.7	Pass
Humidity	10	70	%	23	Pass
Resultant Acceleration	250	300	g's	278.9	Pass
Oscillation	0	10	%	1.6	Pass
Lateral Acceleration	-15	15	g's	4.9	Pass

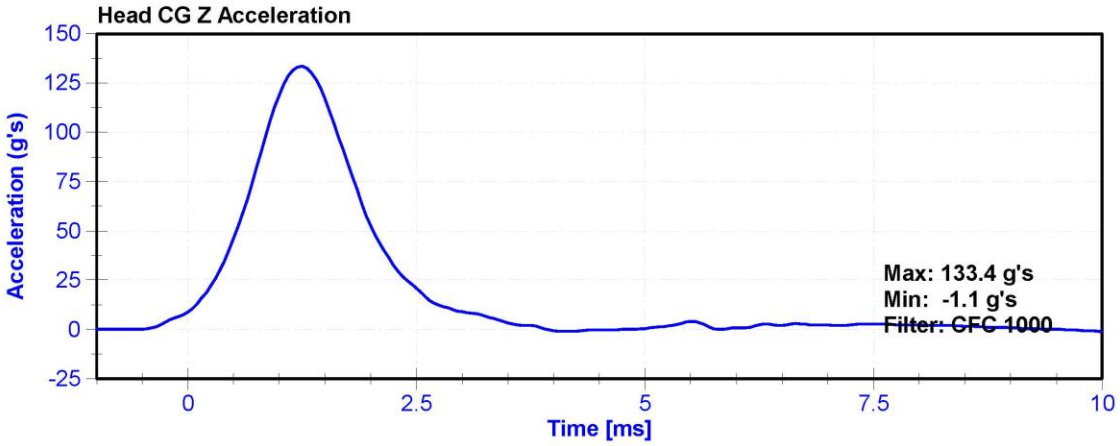
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	Endevco 7264C-2KTZ-2-240	P79417	9/22/2020	3/23/2021
Y Accelerometer	Endevco 7264C-2KTZ-2-240	P83335	9/22/2020	3/23/2021
Z Accelerometer	Endevco 7264C-2KTZ-2-240	T11252	9/22/2020	3/23/2021




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 0.8 g's
Min: -245.1 g's
Filter: CFC 1000


Head CG Y Acceleration
Acceleration (g's)
15
10
5
0
-5
-10
-15
0
2.5
5
7.5
10
Time [ms]
Max: 4.9 g's
Min: -0.6 g's
Filter: CFC 1000


Head CG Z Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2.5
5
7.5
10
Time [ms]
Max: 133.4 g's
Min: -1.1 g's
Filter: CFC 1000

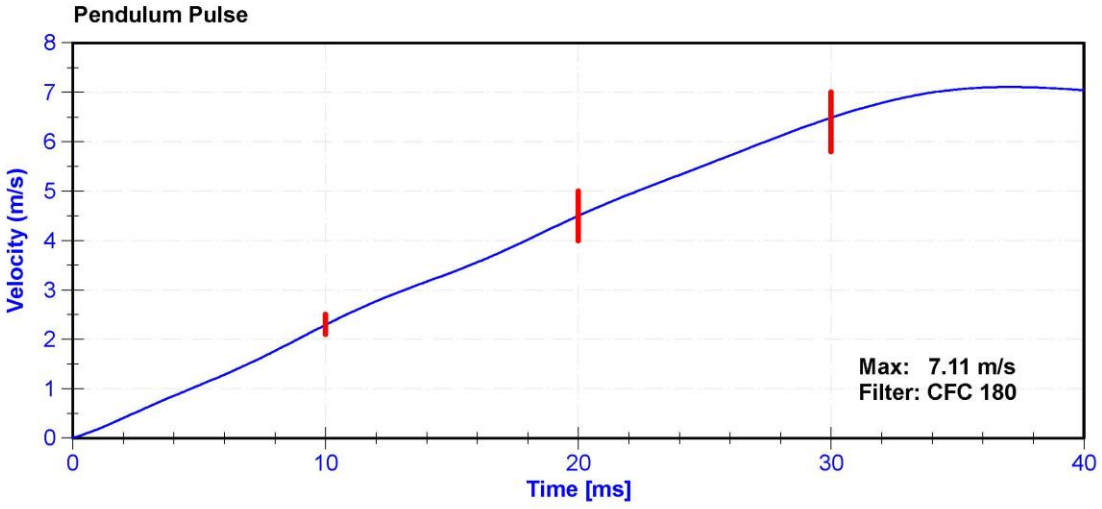
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

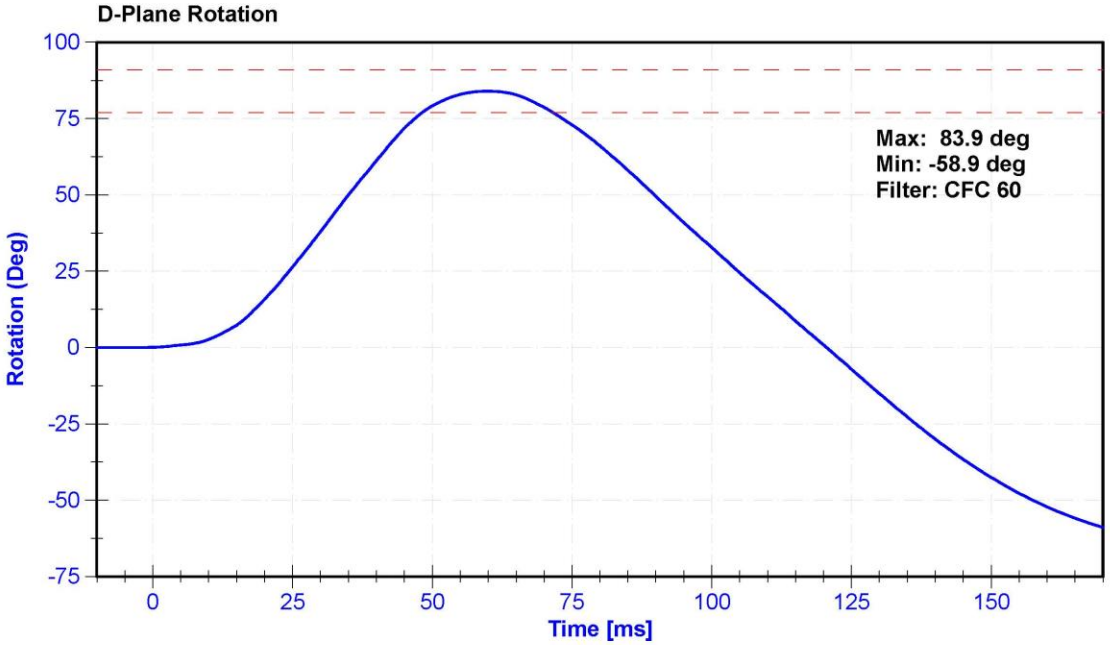
Results

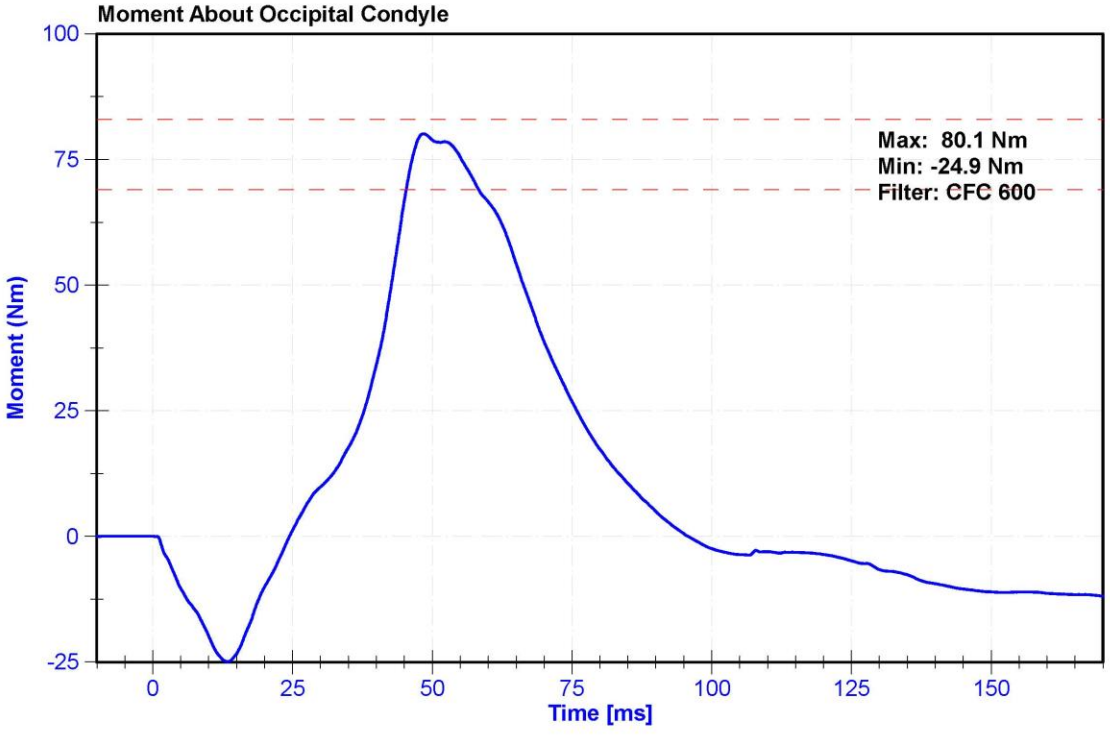
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.9	Pass
Humidity	10	70	%	29.0	Pass
Velocity	6.89	7.13	m/s	7.013	Pass
Pendulum Impulse at 10ms	2.1	2.5	m/s	2.29	Pass
Pendulum Impulse at 20ms	4.0	5.0	m/s	4.50	Pass
Pendulum Impulse at 30ms	5.8	7.0	m/s	6.49	Pass
Max D Plane Rotation	77	91	deg	83.9	Pass
Max Moment During Rotation Interval	69	83	Nm	80.1	Pass
Moment Decay to 10.0 Nm	80	100	ms	85.5	Pass

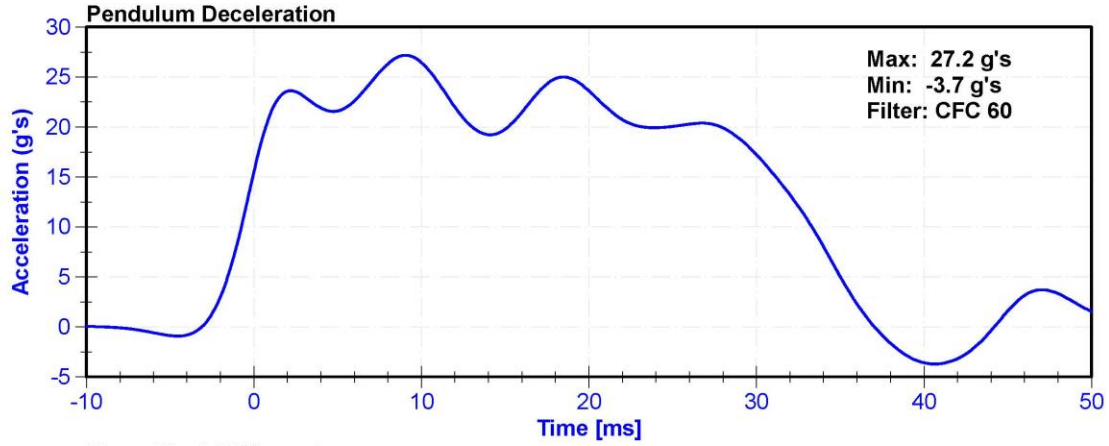
Transducer Calibrations

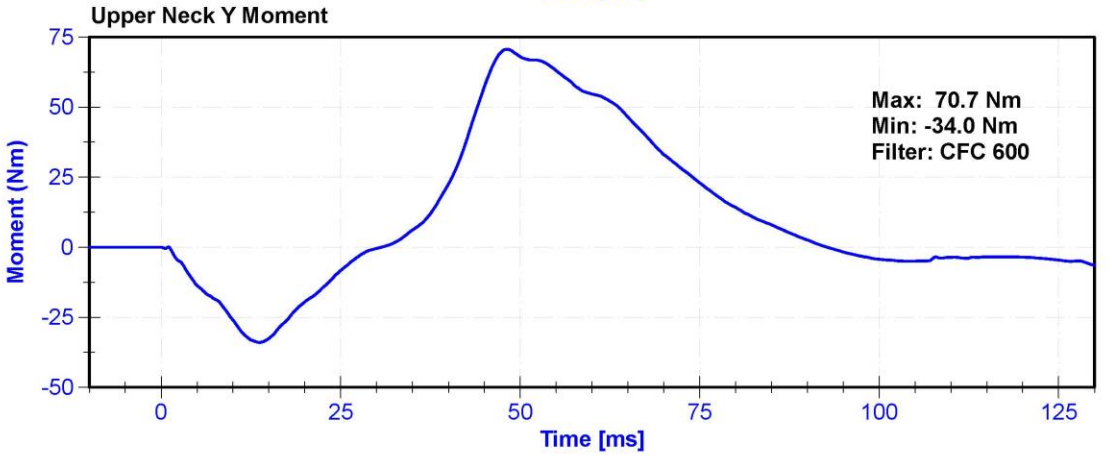
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-C16503 Striker	2/5/2021	2/5/2022
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/17/2020	9/17/2021
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/17/2020	9/17/2021
Upper Neck Load Cell	Denton 1716A	LC-1916Fx	11/23/2020	11/23/2021

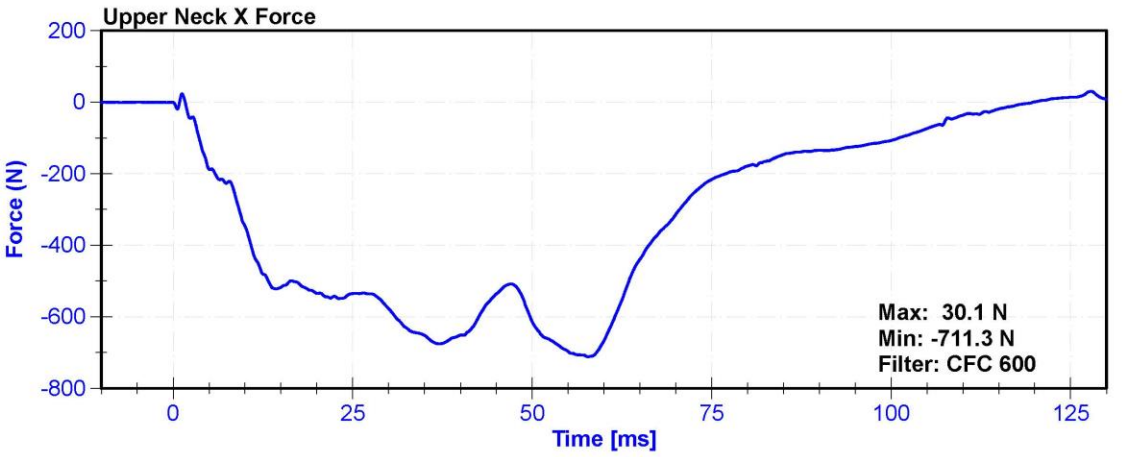



D-Plane Rotation
Max: 83.9 deg
Min: -58.9 deg
Filter: CFC 60
Rotation (Deg)
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150
Time [ms]


Moment About Occipital Condyle
Max: 80.1 Nm
Min: -24.9 Nm
Filter: CFC 600
Moment (Nm)
100
75
50
25
0
-25
0
25
50
75
100
125
150
Time [ms]


Pendulum Deceleration
Max: 27.2 g's
Min: -3.7 g's
Filter: CFC 60
Acceleration (g's)
30
25
20
15
10
5
0
-5
-10
0
10
20
30
40
50
Time [ms]


Upper Neck Y Moment
Max: 70.7 Nm
Min: -34.0 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: 30.1 N
Min: -711.3 N
Filter: CFC 600
Force (N)
200
0
-200
-400
-600
-800
0
25
50
75
100
125
Time [ms]

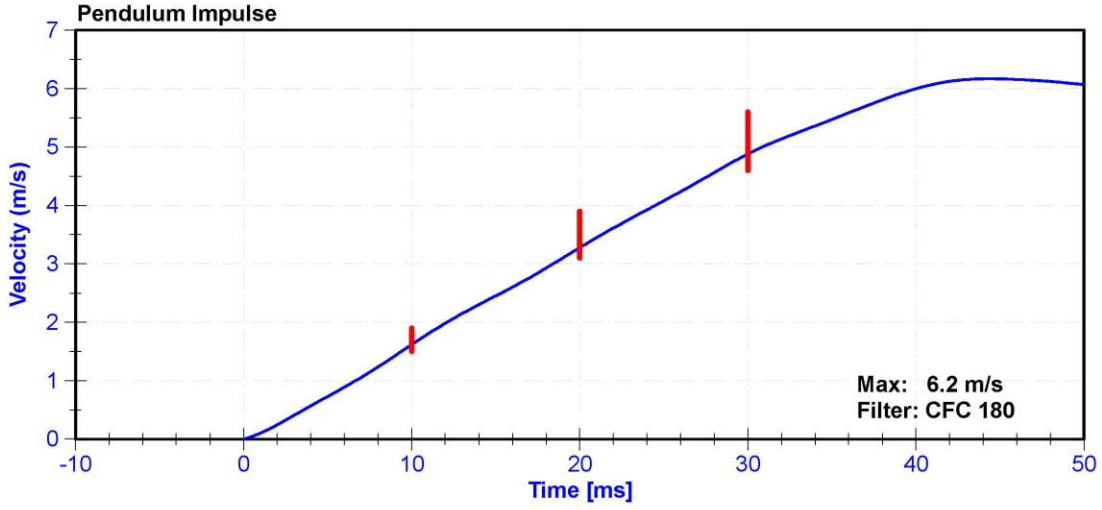
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

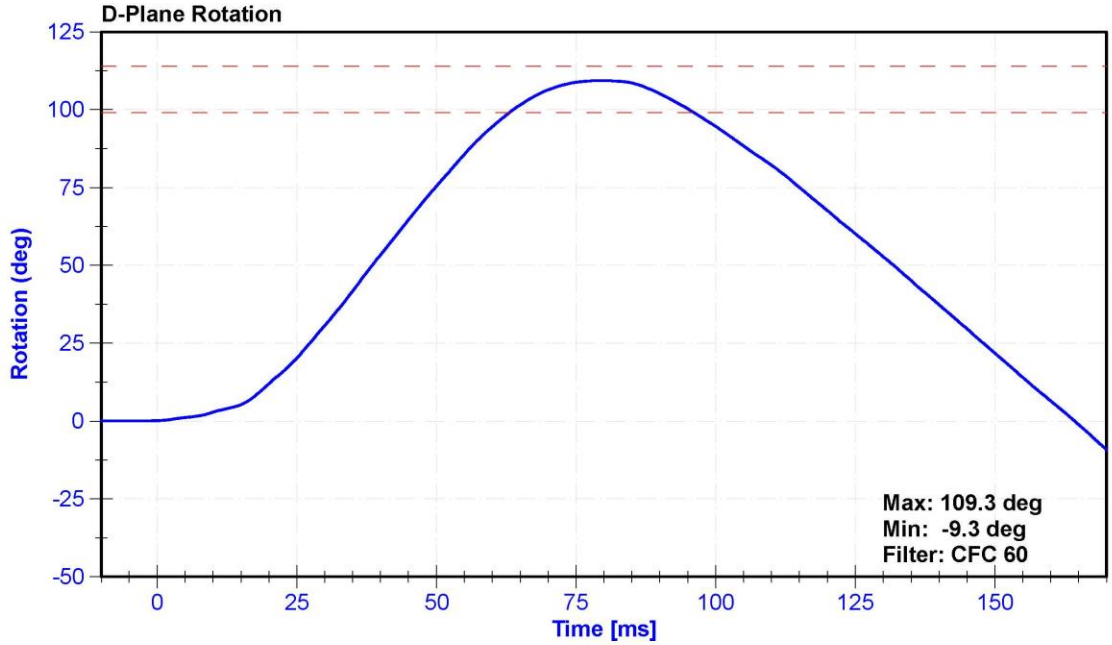
Results

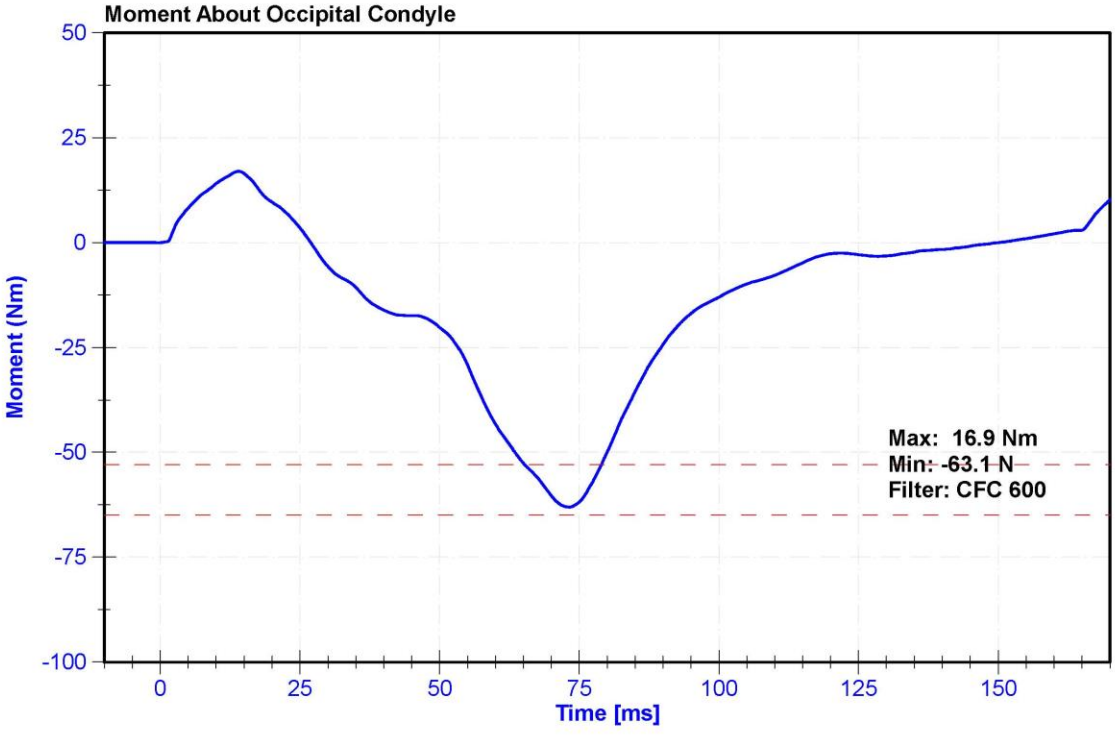
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	29.0	Pass
Velocity	5.95	6.19	m/s	6.046	Pass
Pendulum Impulse at 10ms	1.5	1.9	m/s	1.62	Pass
Pendulum Impulse at 20ms	3.1	3.9	m/s	3.28	Pass
Pendulum Impulse at 30ms	4.6	5.6	m/s	4.88	Pass
D Plane Rotation	99	114	deg	109.3	Pass
Moment During Rotation Interval	-65	-53	Nm	-63.1	Pass
Moment Decay to -10Nm	94	114	ms	104.8	Pass

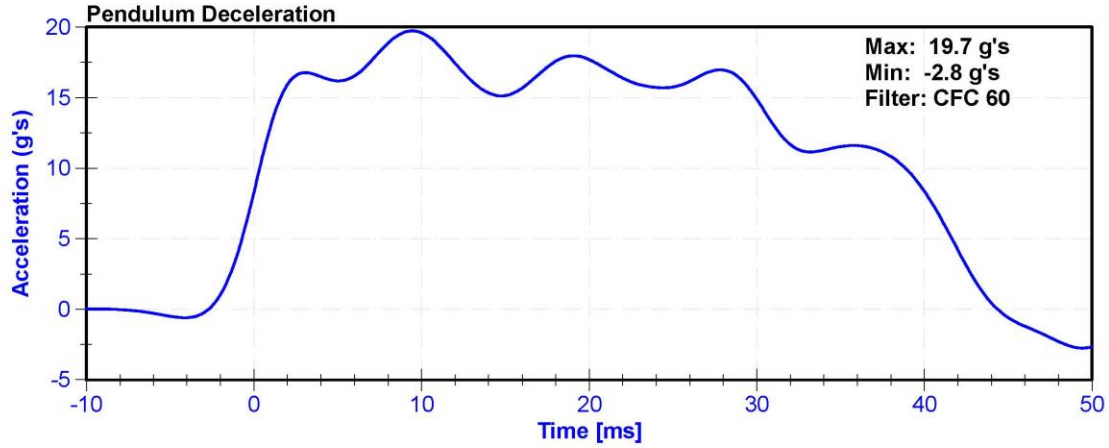
Transducer Calibrations

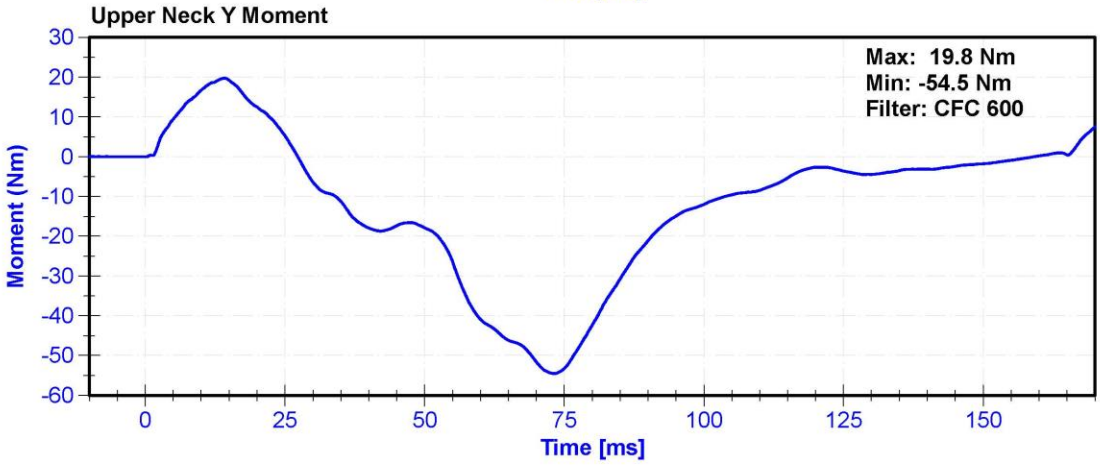
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-C16503 Striker	2/5/2021	2/5/2022
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/17/2020	9/17/2021
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/17/2020	9/17/2021
Upper Neck Load Cell	Denton 1716A	LC-1916Fx	11/23/2020	11/23/2021

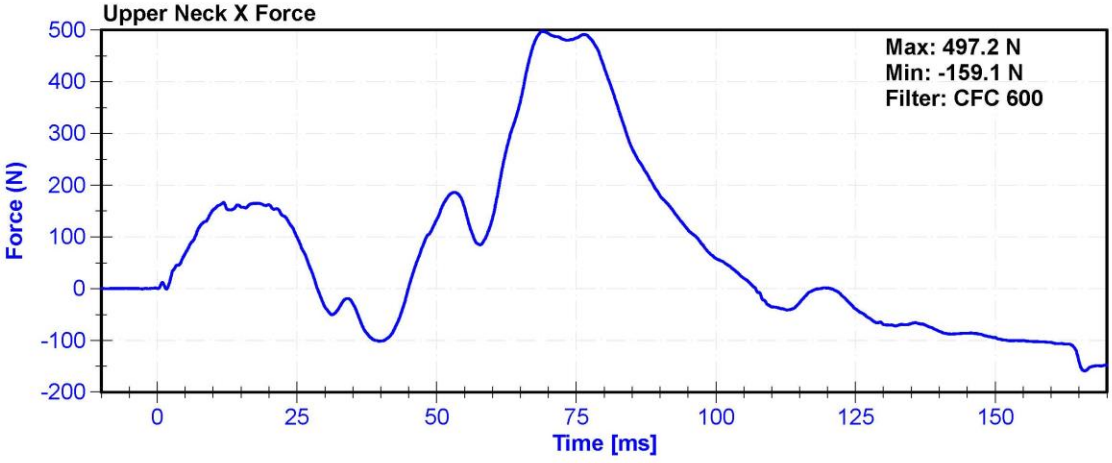



D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 109.3 deg
Min: -9.3 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
50
25
0
-25
-50
-75
-100
0
25
50
75
100
125
150
Time [ms]
Max: 16.9 Nm
Min: -63.1 N
Filter: CFC 600


Pendulum Deceleration
Max: 19.7 g's
Min: -2.8 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 19.8 Nm
Min: -54.5 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 497.2 N
Min: -159.1 N
Filter: CFC 600
Force (N)
Time [ms]

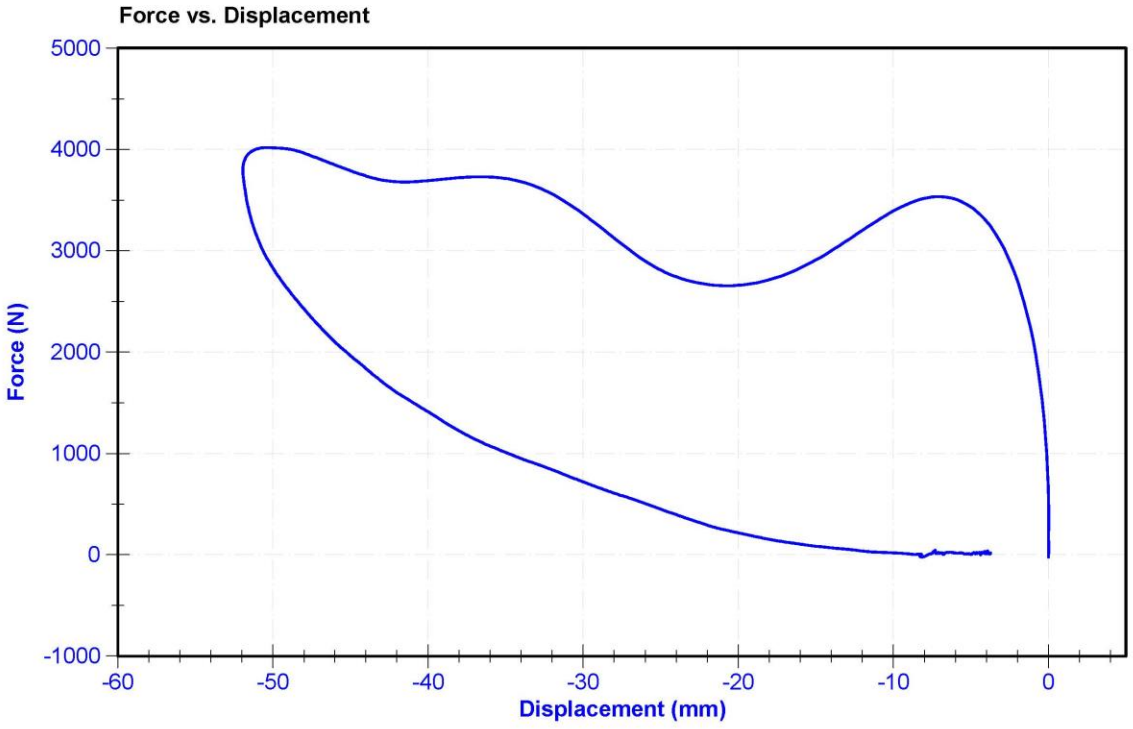
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

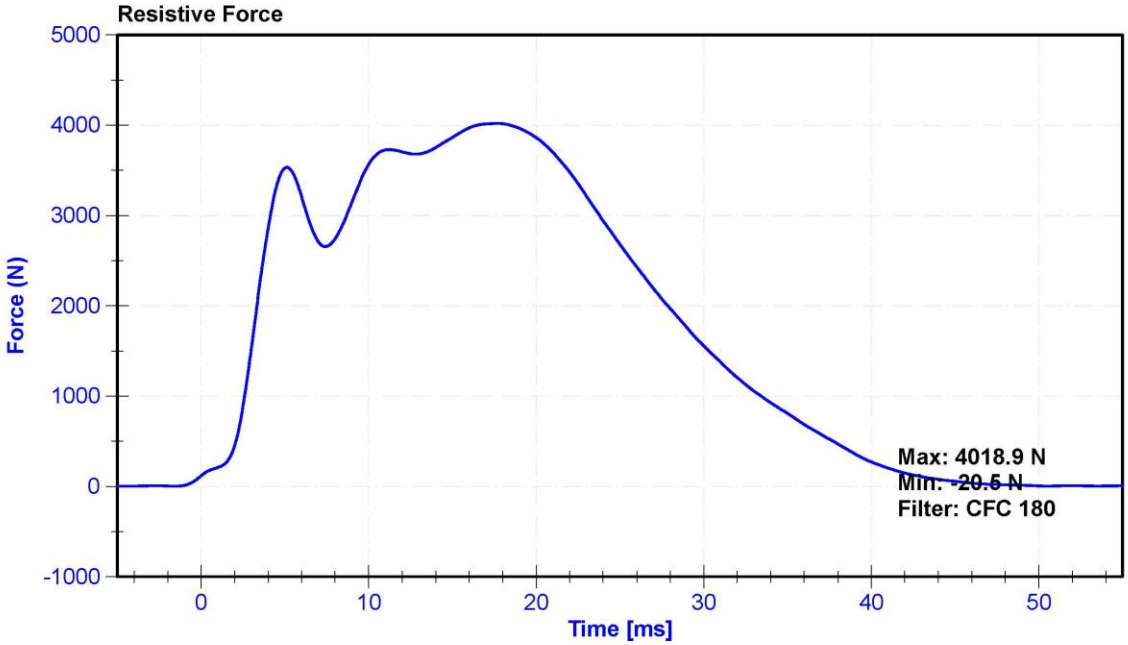
Results

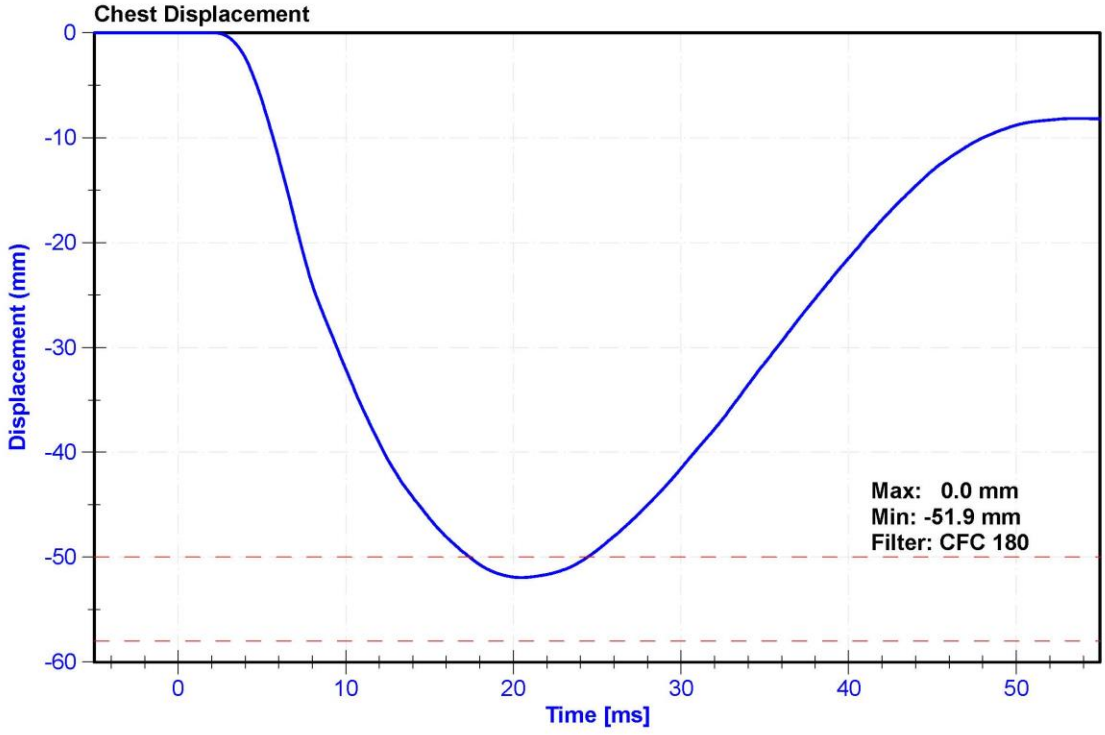
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	19.4	Pass
Velocity	6.59	6.83	m/s	6.699	Pass
Chest Deflection	-58	-50	mm	-51.9	Pass
Maximum Resistive Force (50 to 58mm)	3900	4400	N	4018.9	Pass
Maximum Resistive Force (18 to 50mm)	0	4600	N	4016.4	Pass
Hysteresis	69	85	%	75.5	Pass

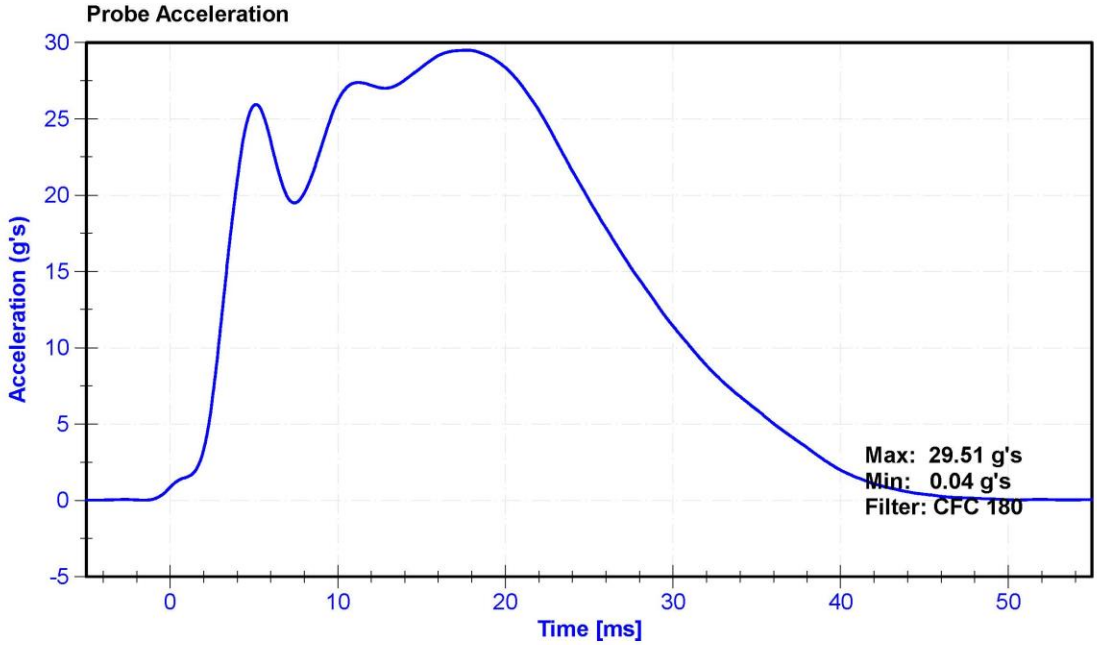
Transducer Calibrations

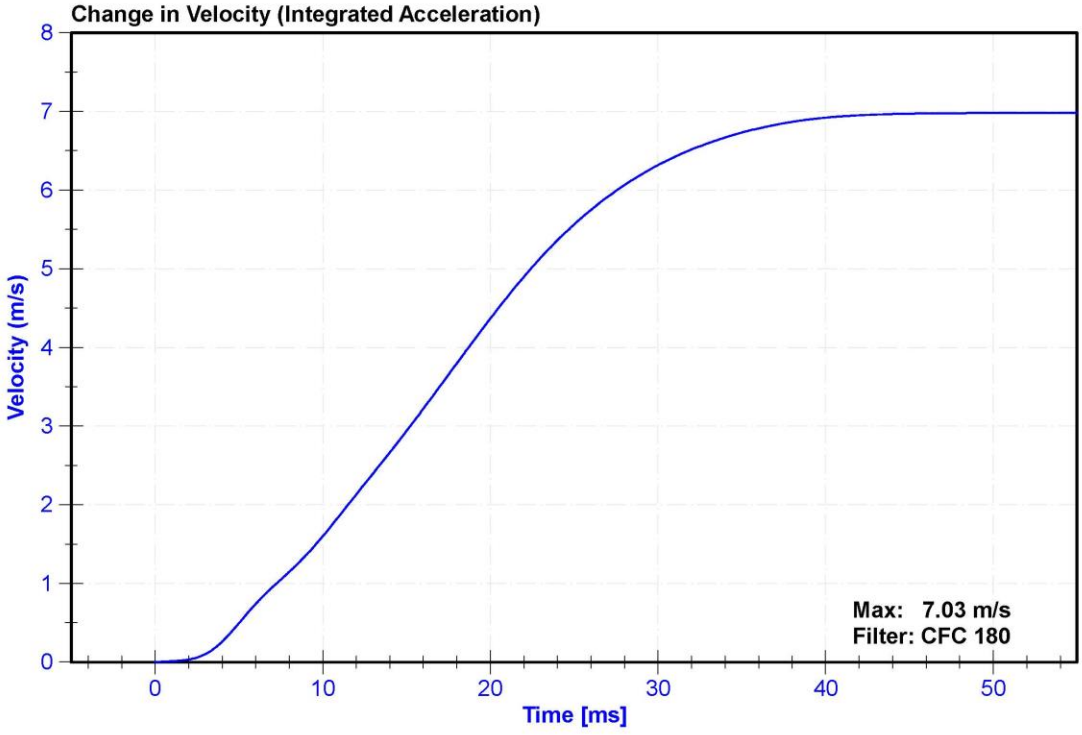
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7264C	T25885	2/2/2021	2/2/2022
Chest Potentiometer	SERVO 14CBI-3615	DS-140GFE	11/17/2020	5/18/2021




Resistive Force
Force (N)
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50
Time [ms]
Max: 4018.9 N
Min: -20.5 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: -51.9 mm
Filter: CFC 180


Probe Acceleration
Acceleration (g's)
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
Time [ms]
Max: 29.51 g's
Min: 0.04 g's
Filter: CFC 180


Change in Velocity (Integrated Acceleration)
Velocity (m/s)
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
Time [ms]
Max: 7.03 m/s
Filter: CFC 180

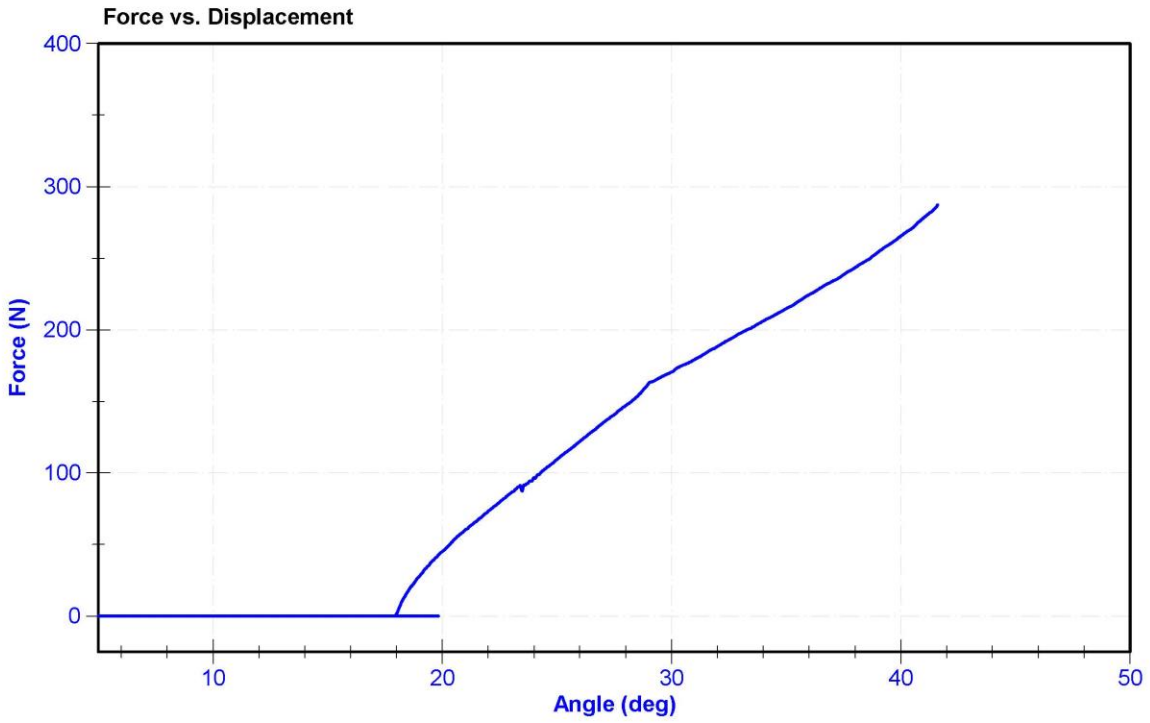
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.6	25.6	ºC	20.8	Pass
Humidity	10	70	%	19.9	Pass
Initial Angle	0	20	deg	17.9	Pass
Force at 45 Degrees	320	390	N	342.5	Pass
Return Angle Relative to Initial	0	8	deg	7.8	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	Seika.de N4C-1	DS-1905226	10/12/2020	10/12/2021
Load Cell	Interface SML-200	LC-493319	10/8/2020	10/8/2021



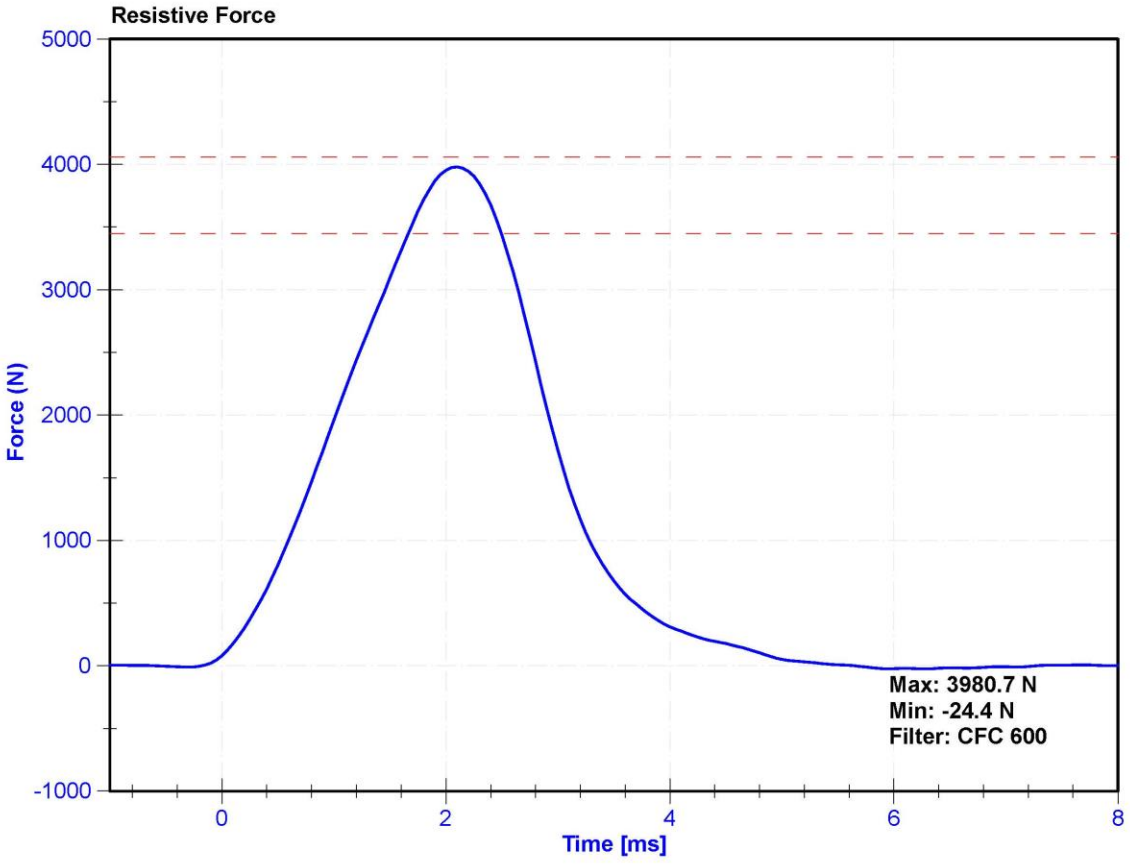
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

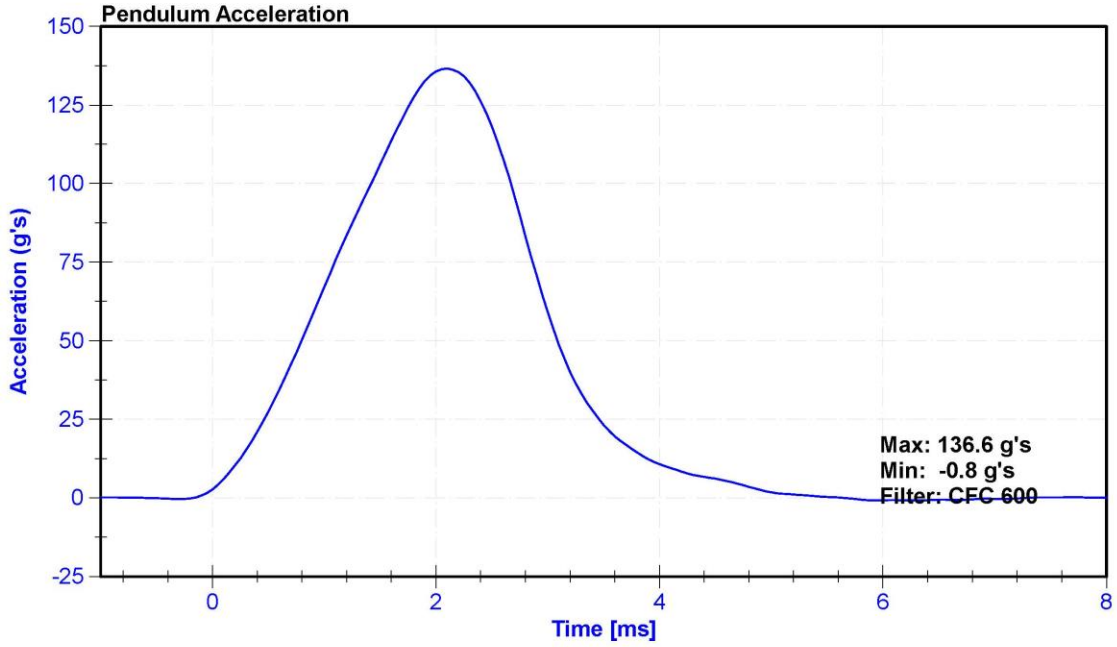
Results

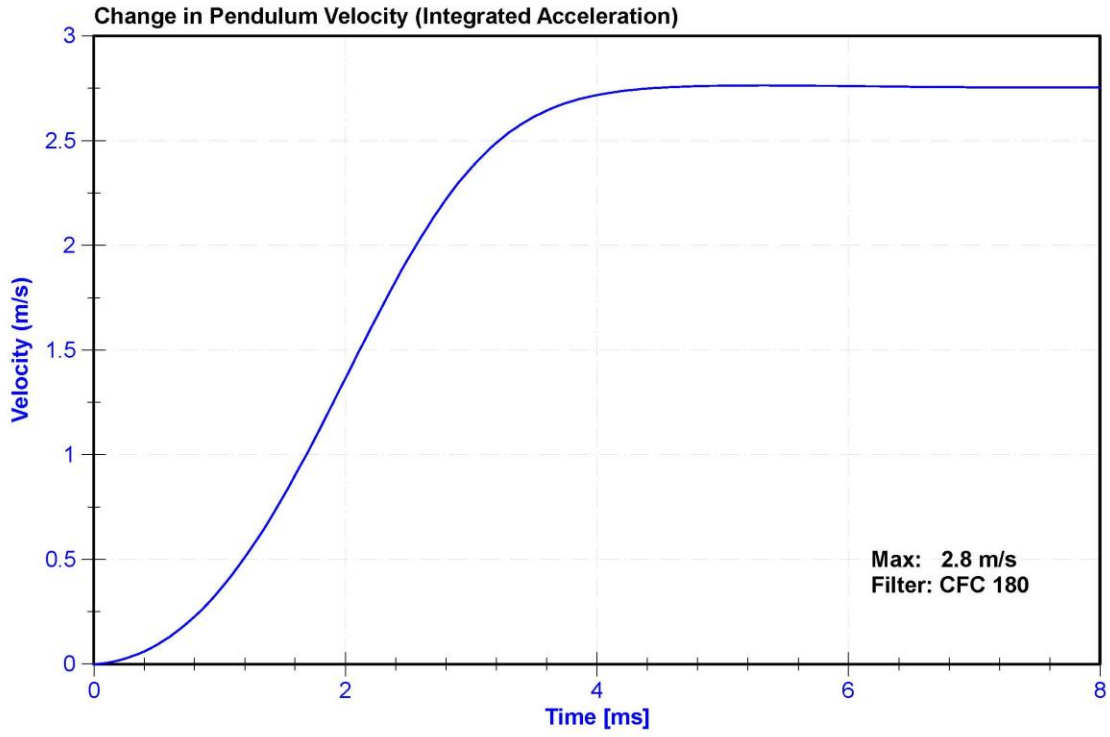
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	26.0	Pass
Velocity	2.07	2.13	m/s	2.102	Pass
Resistive Force	3450	4060	N	3980.7	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 136.6 g's
Min: -0.8 g's
Filter: CFC 600


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

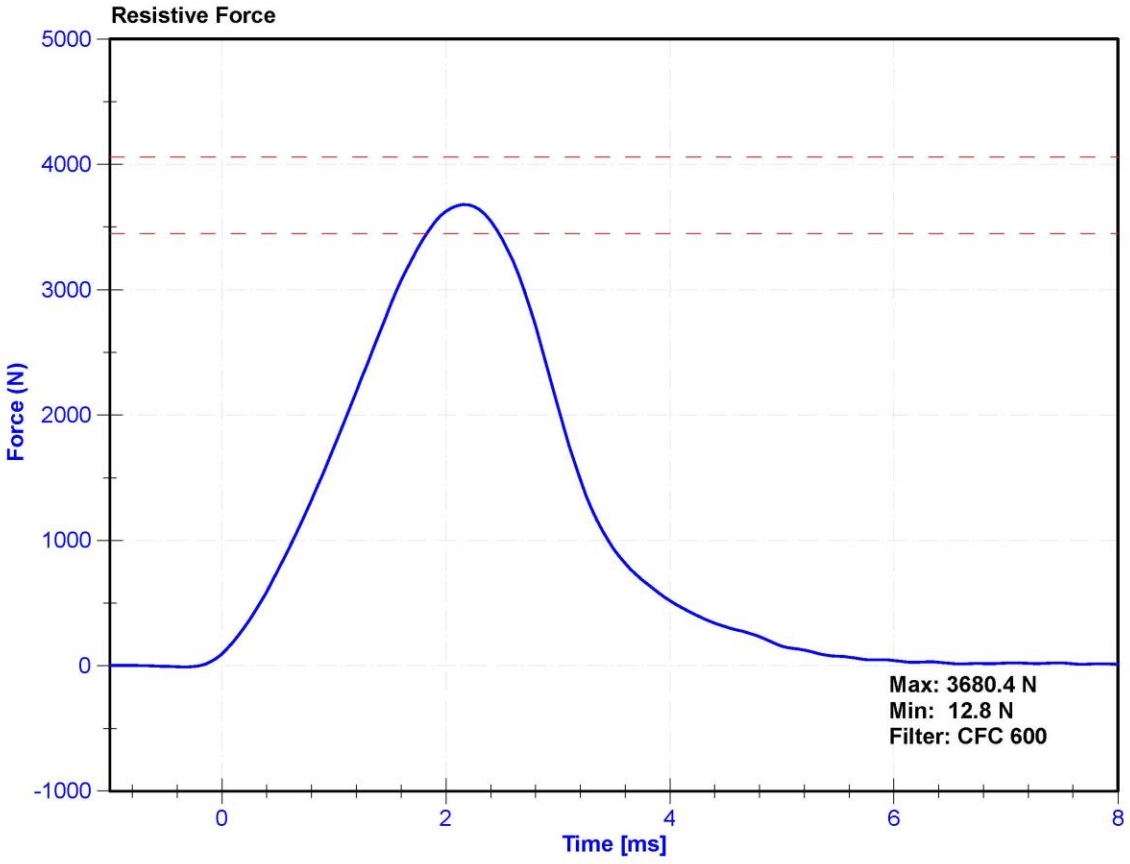
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

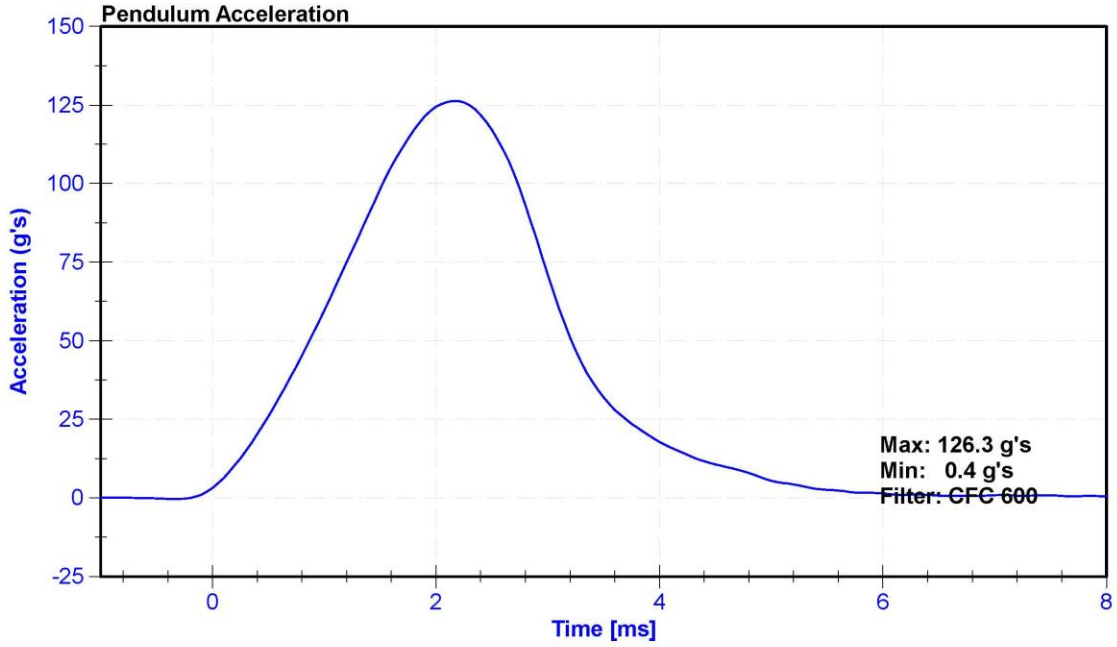
Results

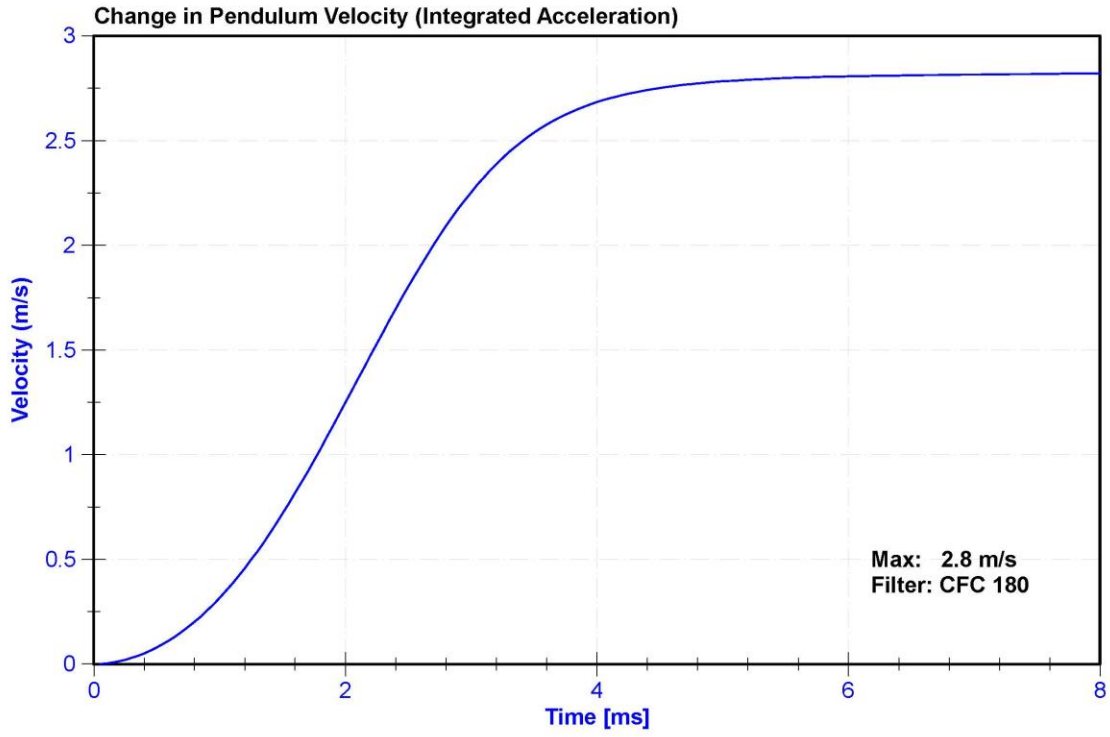
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.6	Pass
Humidity	10	70	%	26.0	Pass
Velocity	2.07	2.13	m/s	2.109	Pass
Resistive Force	3450	4060	N	3680.4	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 126.3 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: 2.8 m/s
Filter: CFC 180

CALIBRATION TEST RESULTS

POST-TEST

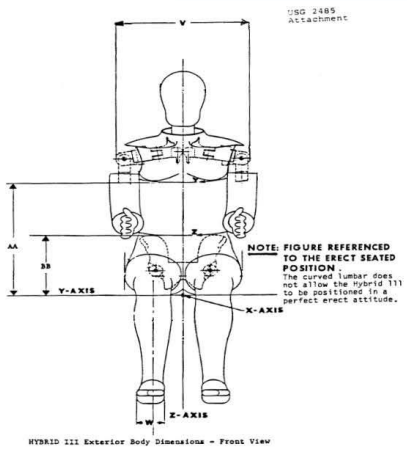
HYBRID III 50TH PERCENTILE MALE - DRIVER ATD

SERIAL NO: 142

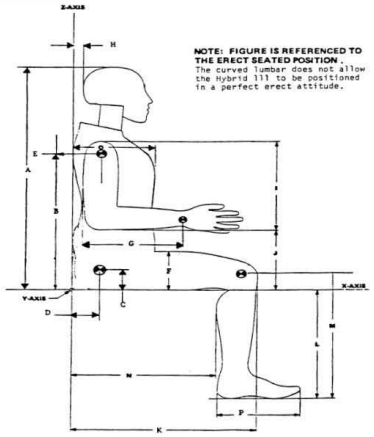
External Measurements - Hybrid 3 - 50th Male

Technician: K. Brogan Date: 03/11/2021

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	34.7	Pass
B	Shoulder Pivot Height	19.9	20.5	20.3	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	5.9	Pass
G	Back of Elbow to Wrist Pivot	11.4	12.0	11.7	Pass
H	Head Back to Backline	1.6	1.8	1.7	Pass
I	Shoulder to Elbow Length	13.0	13.6	13.4	Pass
J	Elbow Rest Height	7.5	8.3	8.1	Pass
K	Buttock to Knee Length	22.8	23.8	23.0	Pass
L	Popliteal Height	16.9	17.9	17.5	Pass
M	Knee Pivot Height	19.1	19.7	19.4	Pass
N	Buttock Popliteal Length	17.8	18.8	18.3	Pass
O	Chest Depth without Jacket	8.4	9.0	8.6	Pass
P	Foot Length (right)	9.9	10.5	10.1	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

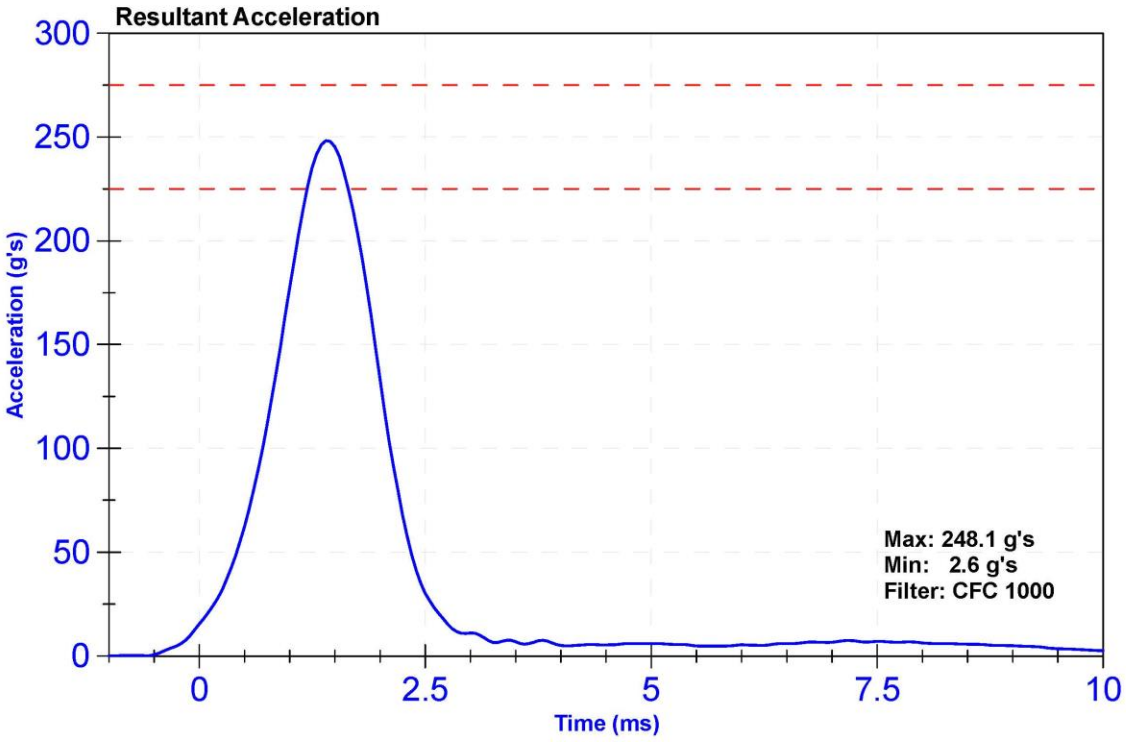
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

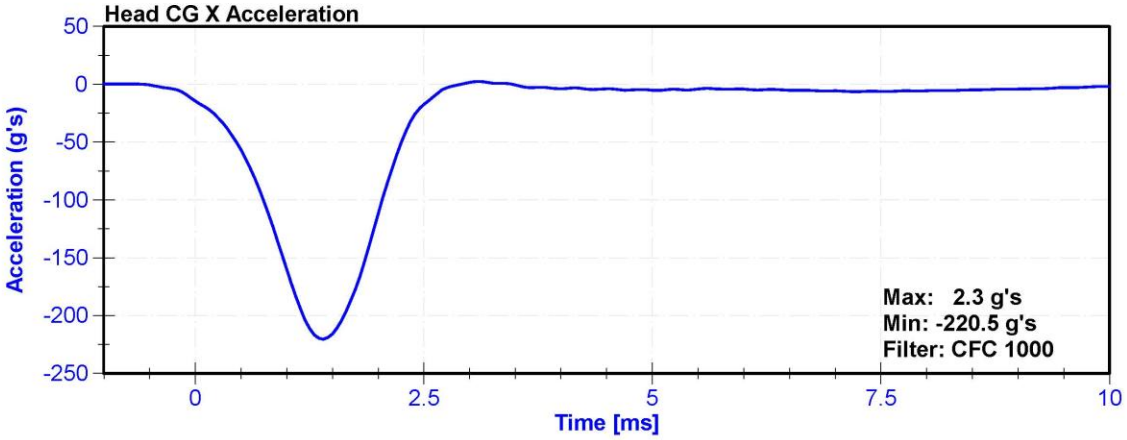
Results

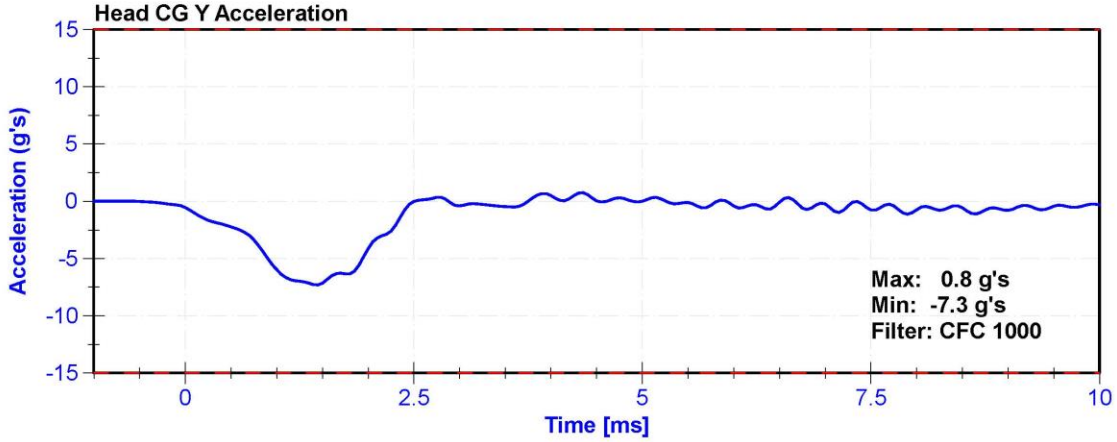
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	34.4	Pass
Resultant Acceleration	225	275	g's	248.1	Pass
Oscillation	0	10	%	4.4	Pass
Lateral Acceleration	-15	15	g's	-7.3	Pass

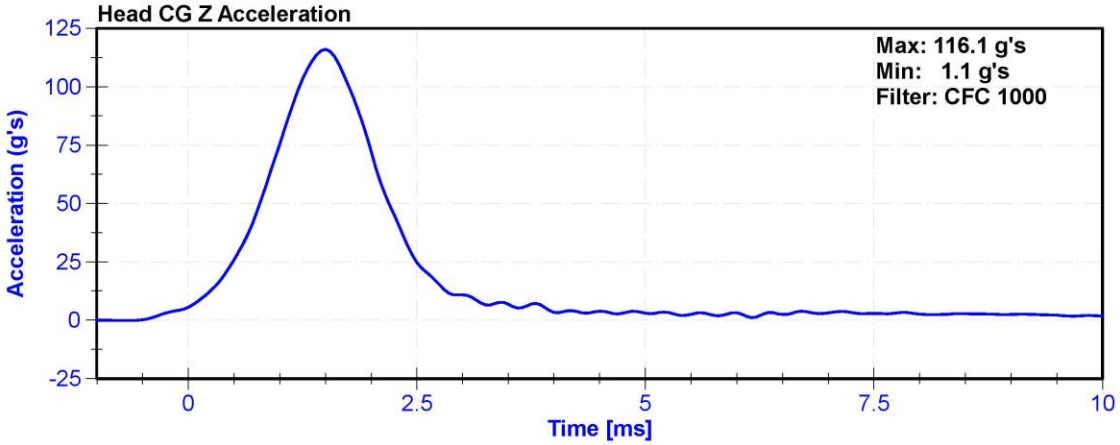
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	ENDEVCO 7264	P51681	11/3/2020	5/4/2021
Y Accelerometer	ENDEVCO 7264	P64151	11/3/2020	5/4/2021
Z Accelerometer	ENDEVCO 7264	P52114	11/3/2020	5/4/2021




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
0
2.5
5
7.5
10
Time [ms]
Max: 2.3 g's
Min: -220.5 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: 0.8 g's
Min: -7.3 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: 116.1 g's
Min: 1.1 g's
Filter: CFC 1000

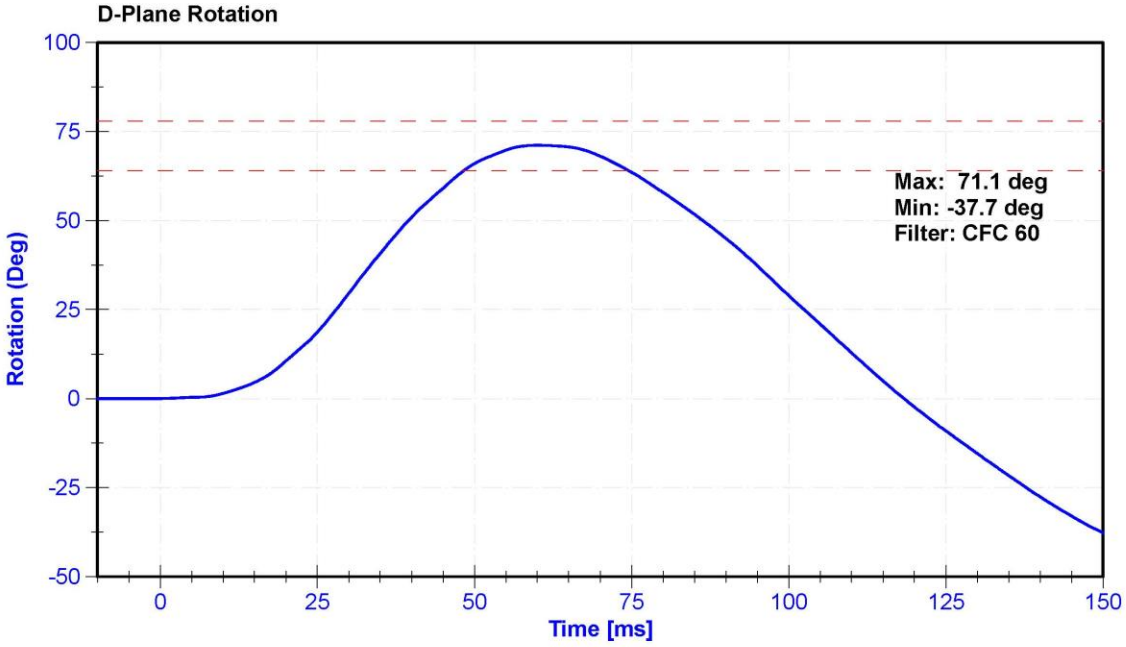
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

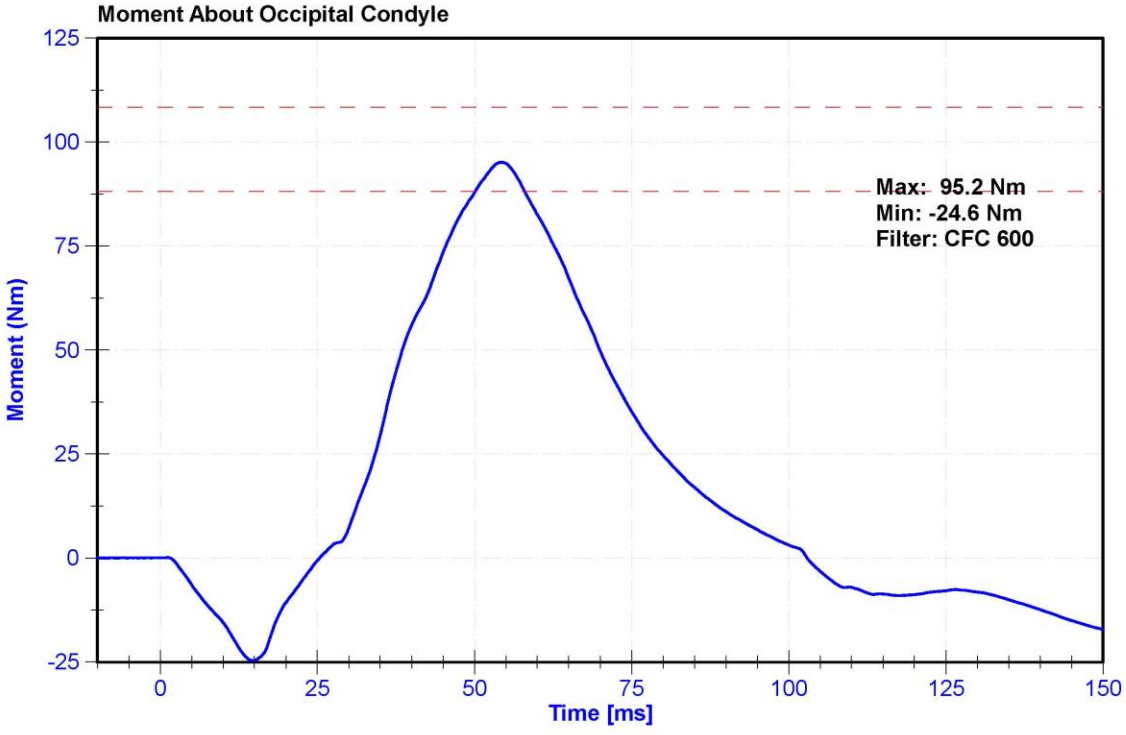
Results

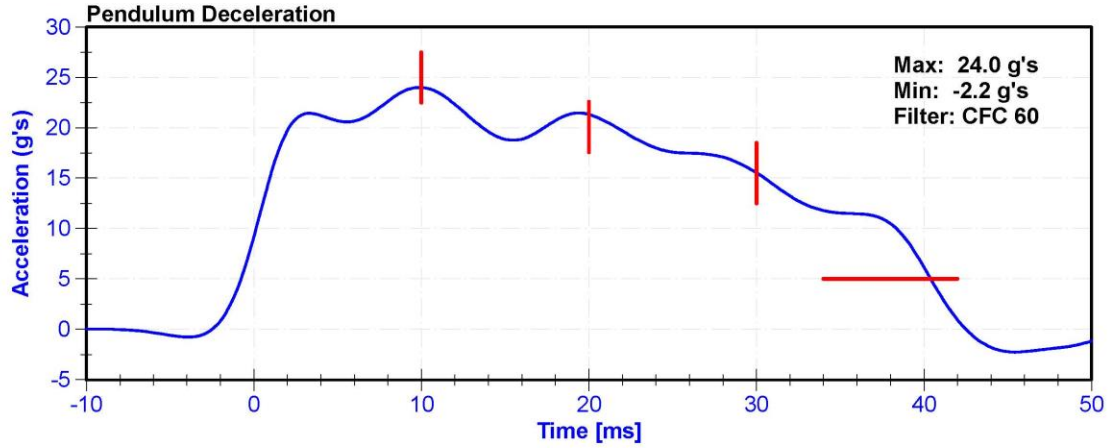
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.5	Pass
Humidity	10	70	%	34.0	Pass
Velocity	6.89	7.13	m/s	6.958	Pass
Pendulum Deceleration at 10ms	22.5	27.5	g's	24.01	Pass
Pendulum Deceleration at 20ms	17.6	22.6	g's	21.33	Pass
Pendulum Deceleration at 30ms	12.5	18.5	g's	15.55	Pass
Max. Pendulum Deceleration After 30ms	0	29	g's	24.0	Pass
Pendulum Deceleration Time to 5 g's	34	42	ms	40.5	Pass
Maximum D Plane Rotation	64	78	deg	71.1	Pass
Time to Maximum Rotation	57	64	ms	60.0	Pass
Rotation Decay to Zero	113	127	ms	118.4	Pass
Moment About Occipital Condyle	88.1	108.4	Nm	95.15	Pass
Time to Maximum Moment	47	58	ms	54.3	Pass
Moment Decay to Zero	97	107	ms	103.0	Pass

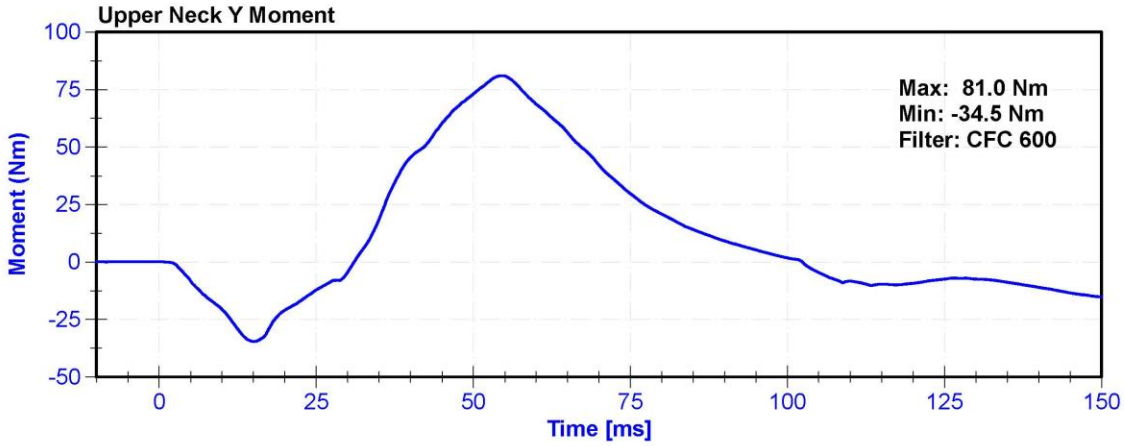
Transducer Calibrations

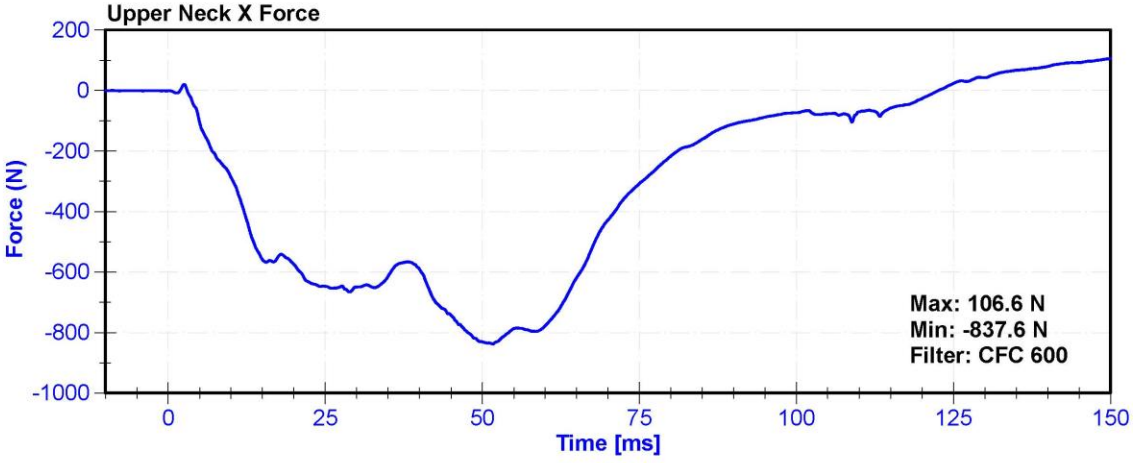
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-C16503 Striker	2/5/2021	2/5/2022
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/17/2020	9/17/2021
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/17/2020	9/17/2021
Upper Neck Load Cell	DENTON 1716A	LC-2186Fx	11/10/2020	11/10/2021


D-Plane Rotation
Rotation (Deg)
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 71.1 deg
Min: -37.7 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: 95.2 Nm
Min: -24.6 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 24.0 g's
Min: -2.2 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 81.0 Nm
Min: -34.5 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 106.6 N
Min: -837.6 N
Filter: CFC 600
Force (N)
Time [ms]

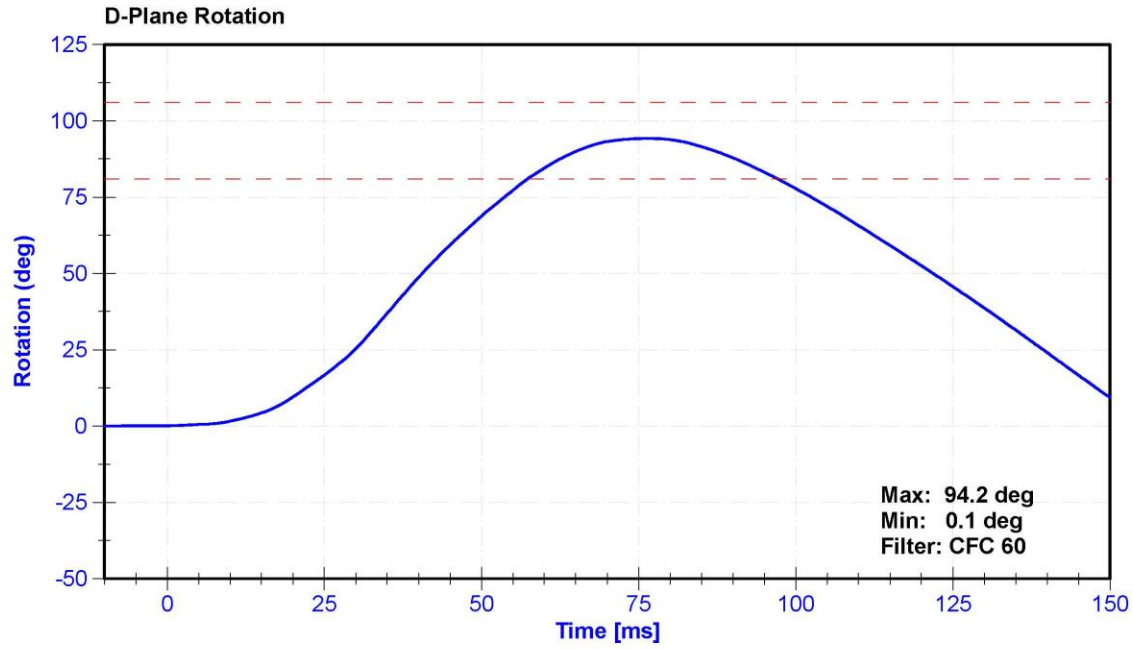
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

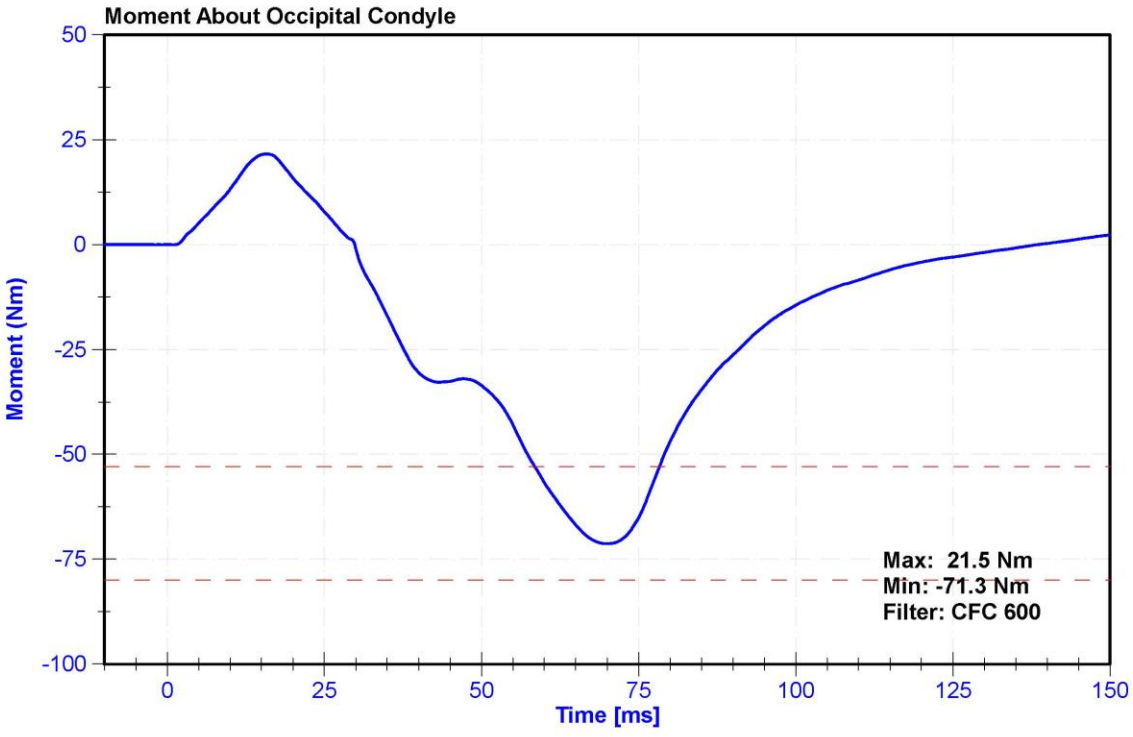
Results

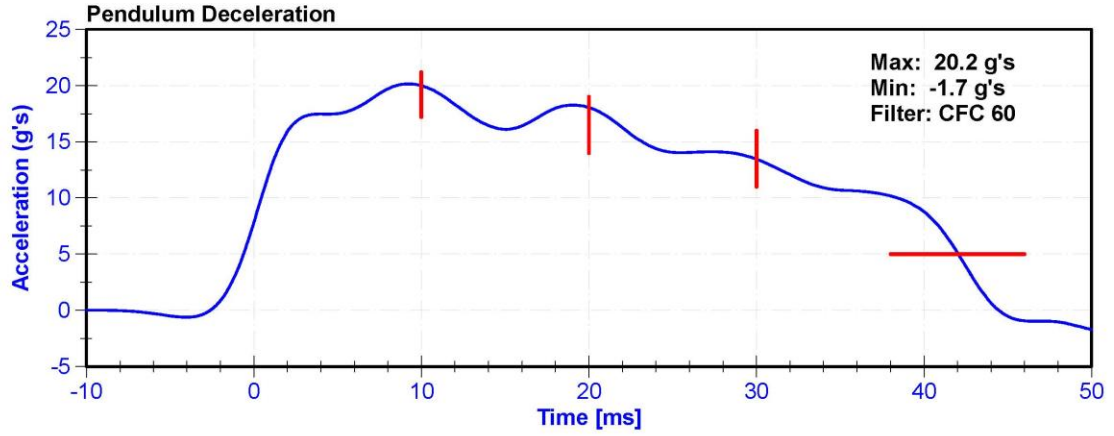
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	21.4	Pass
Humidity	10	70	%	32.2	Pass
Velocity	5.94	6.19	m/s	6.005	Pass
Pendulum Deceleration at 10ms	17.2	21.2	g's	20.01	Pass
Pendulum Deceleration at 20ms	14	19	g's	18.0	Pass
Pendulum Deceleration at 30ms	11	16	g's	13.5	Pass
Max. Pendulum Deceleration After 30ms	0	22	g's	20.2	Pass
Pendulum Deceleration Time to 5 g's	38	46	ms	42.1	Pass
Maximum D Plane Rotation	81	106	deg	94.2	Pass
Time to Maximum Rotation	72	82	ms	76.4	Pass
Rotation Decay to Zero	147	174	ms	156.2	Pass
Minimum Moment About OC	-80	-52.9	Nm	-71.32	Pass
Time to Minimum Moment	65	79	ms	69.6	Pass
Moment Decay to Zero	120	148	ms	138.7	Pass

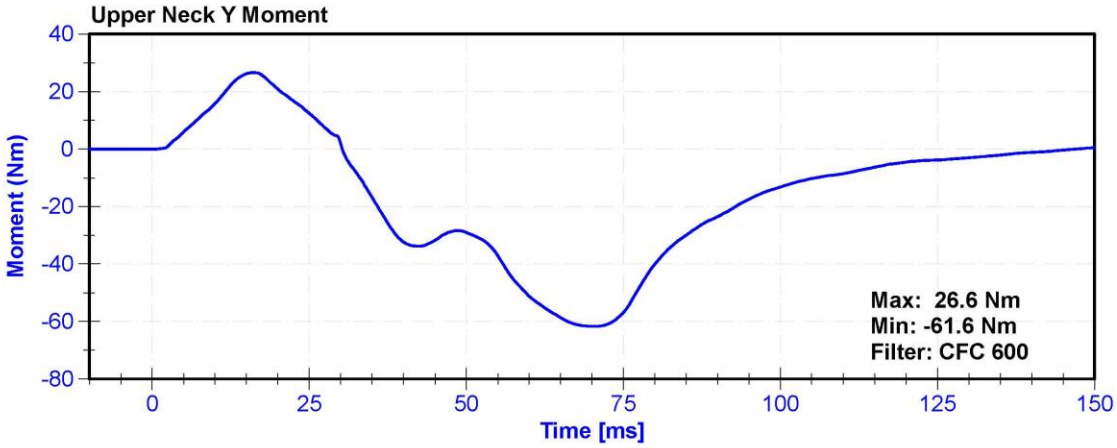
Transducer Calibrations

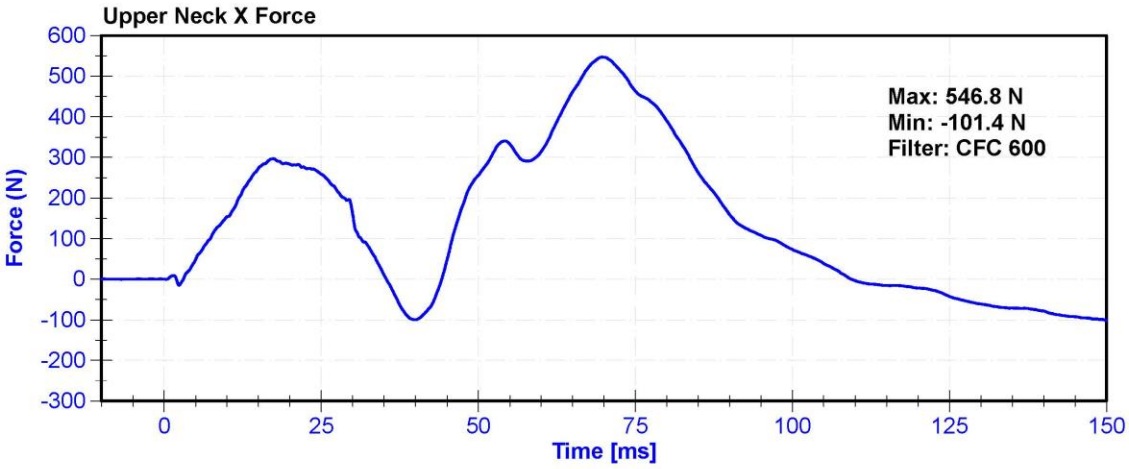
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-C16503 Striker	2/5/2021	2/5/2022
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/17/2020	9/17/2021
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/17/2020	9/17/2021
Upper Neck Load Cell	DENTON 1716A	LC-2186Fx	11/10/2020	11/10/2021


D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 94.2 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: 21.5 Nm
Min: -71.3 Nm
Filter: CFC 600


Pendulum Deceleration
Max: 20.2 g's
Min: -1.7 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 26.6 Nm
Min: -61.6 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 546.8 N
Min: -101.4 N
Filter: CFC 600
Force (N)
Time [ms]

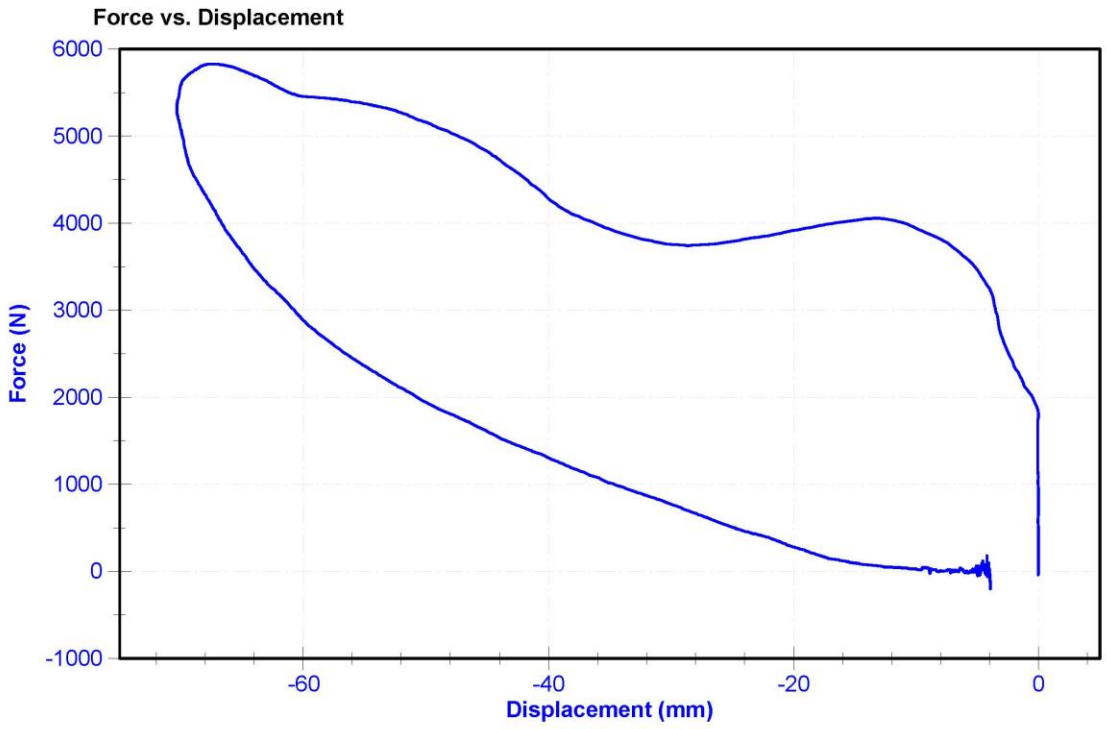
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

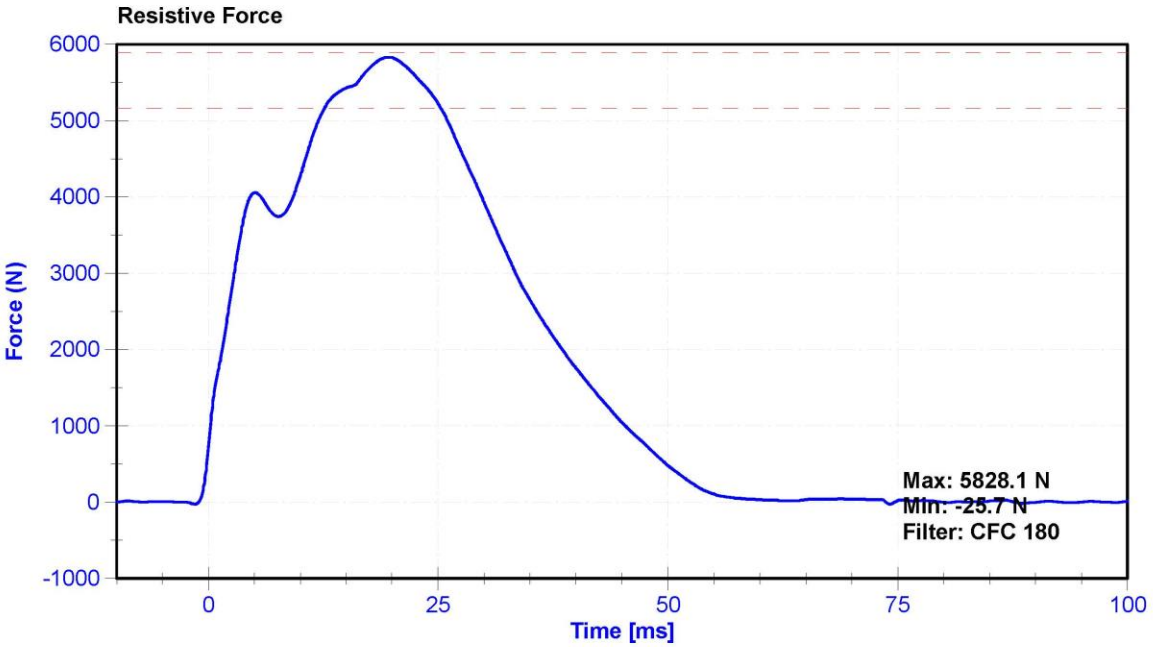
Results

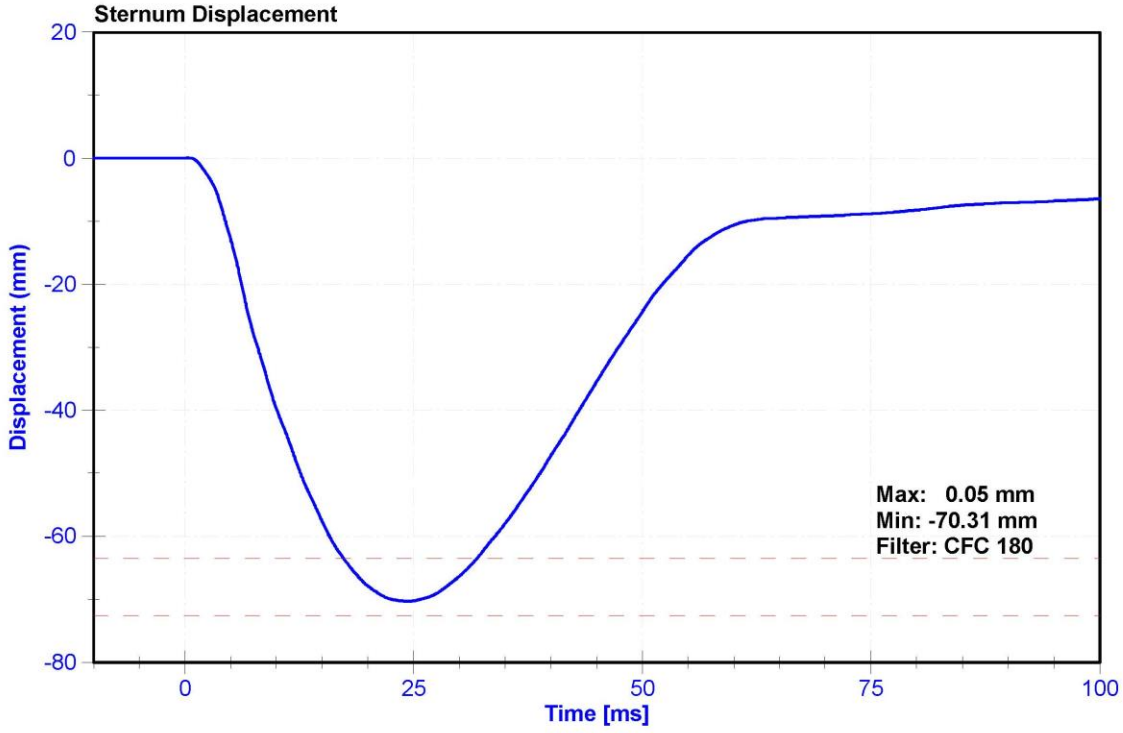
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	27	Pass
Velocity	6.59	6.83	m/s	6.655	Pass
Chest Displacement	-72.6	-63.5	mm	-70.31	Pass
Resistive Force	5160	5894	N	5828.1	Pass
Hysteresis	65	85	%	69.1	Pass

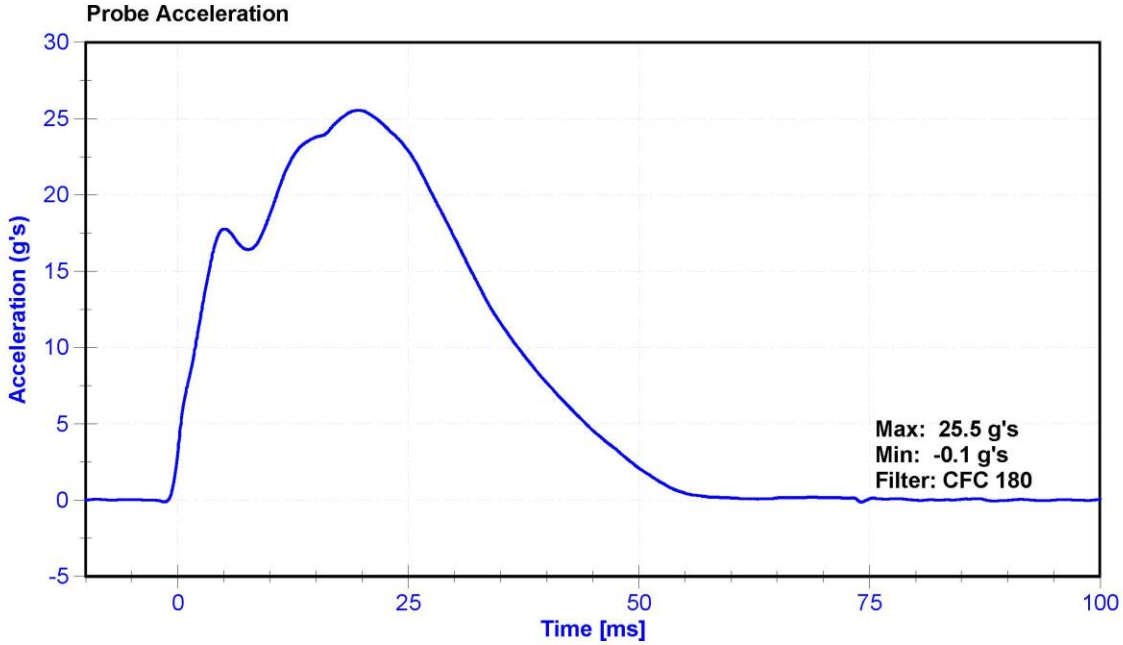
Transducer Calibrations

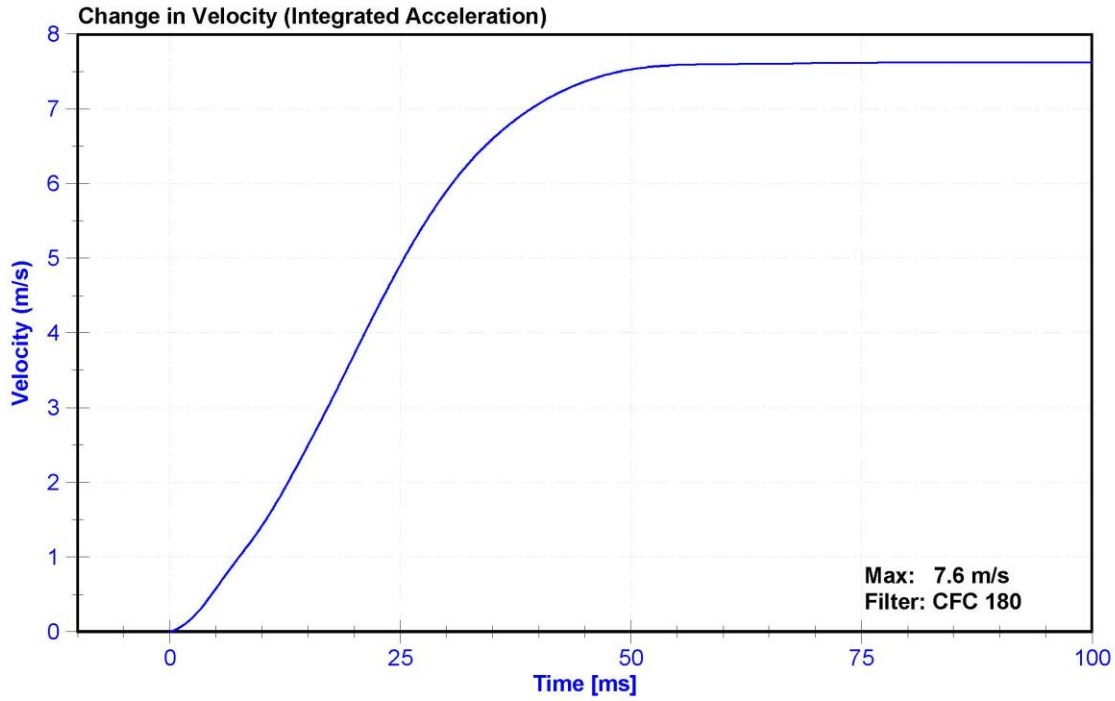
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021
Chest Potentiometer	Servo 6209-2038	DS-142	11/19/2020	5/20/2021




Resistive Force
Force (N)
6000
5000
4000
3000
2000
1000
0
-1000
0
25
50
75
100
Time [ms]
Max: 5828.1 N
Min: -25.7 N
Filter: CFC 180


Sternum Displacement
Displacement (mm)
20
0
-20
-40
-60
-80
0
25
50
75
100
Time [ms]
Max: 0.05 mm
Min: -70.31 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: -0.1 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

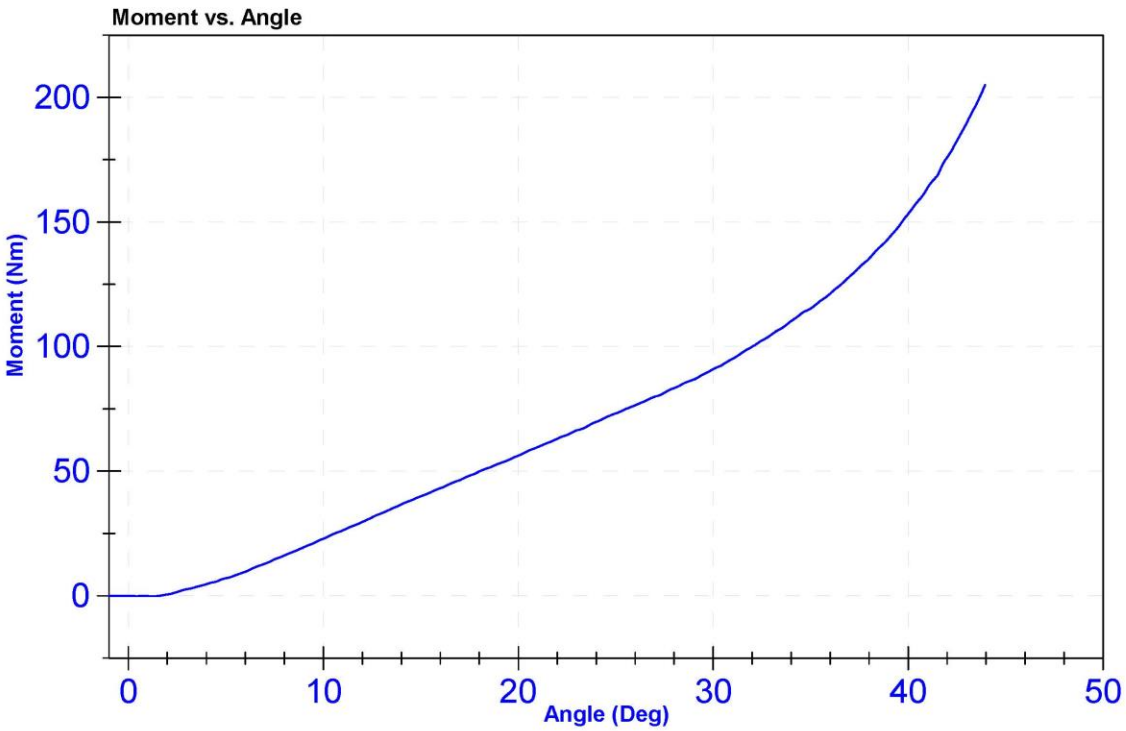
ATD Manufacturer	Humanetics	Test Technician	E. Helenbrook
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	25.7	Pass
Average Velocity	5	10	deg/s	7.3	Pass
Angle at 203Nm	40	50	deg	43.8	Pass
Moment at 30 degrees	0	94.9	Nm	91.0	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	ETI SP22	DS-0008	9/18/2020	9/18/2021
Load Cell	Key Trans 2301-02	LC-115 My	9/12/2020	9/12/2021



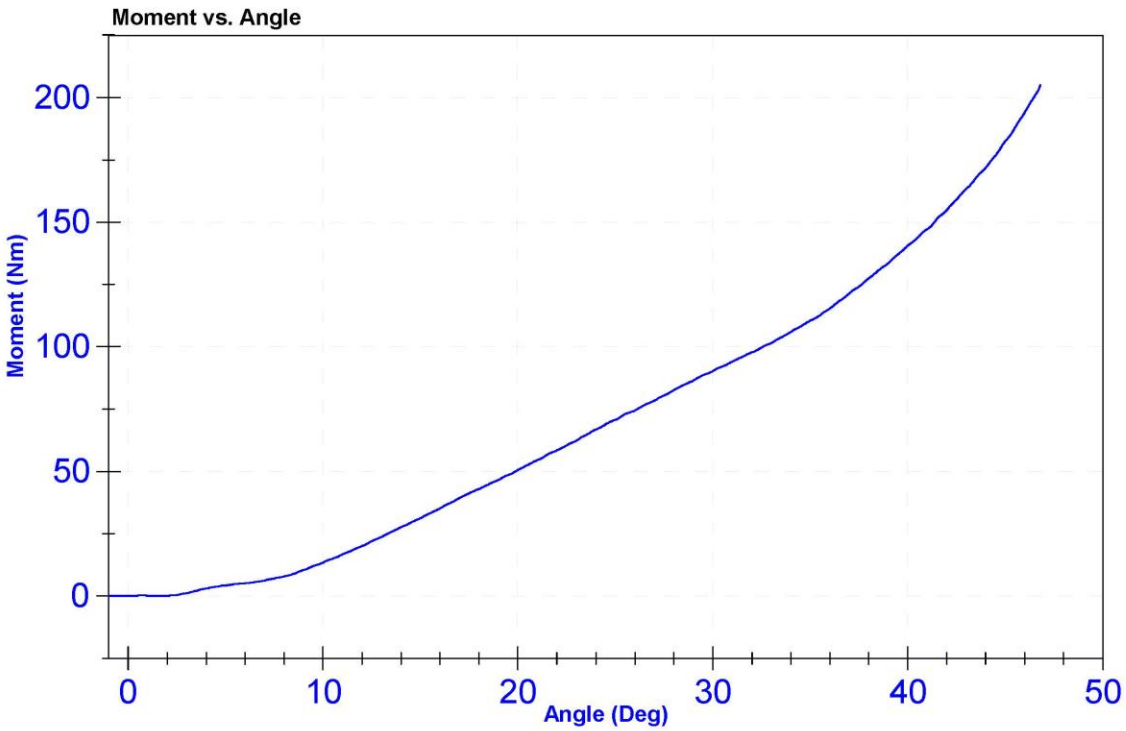
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	21.5	Pass
Humidity	10	70	%	34.1	Pass
Average Velocity	5	10	deg/s	7.2	Pass
Angle at 203Nm	40	50	deg	46.7	Pass
Moment at 30 degrees	0	94.9	Nm	90.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	ETI SP22	DS-0008	9/18/2020	9/18/2021
Load Cell	Key Trans 2301-02	LC-115 My	2020-09-12	2021-09-12



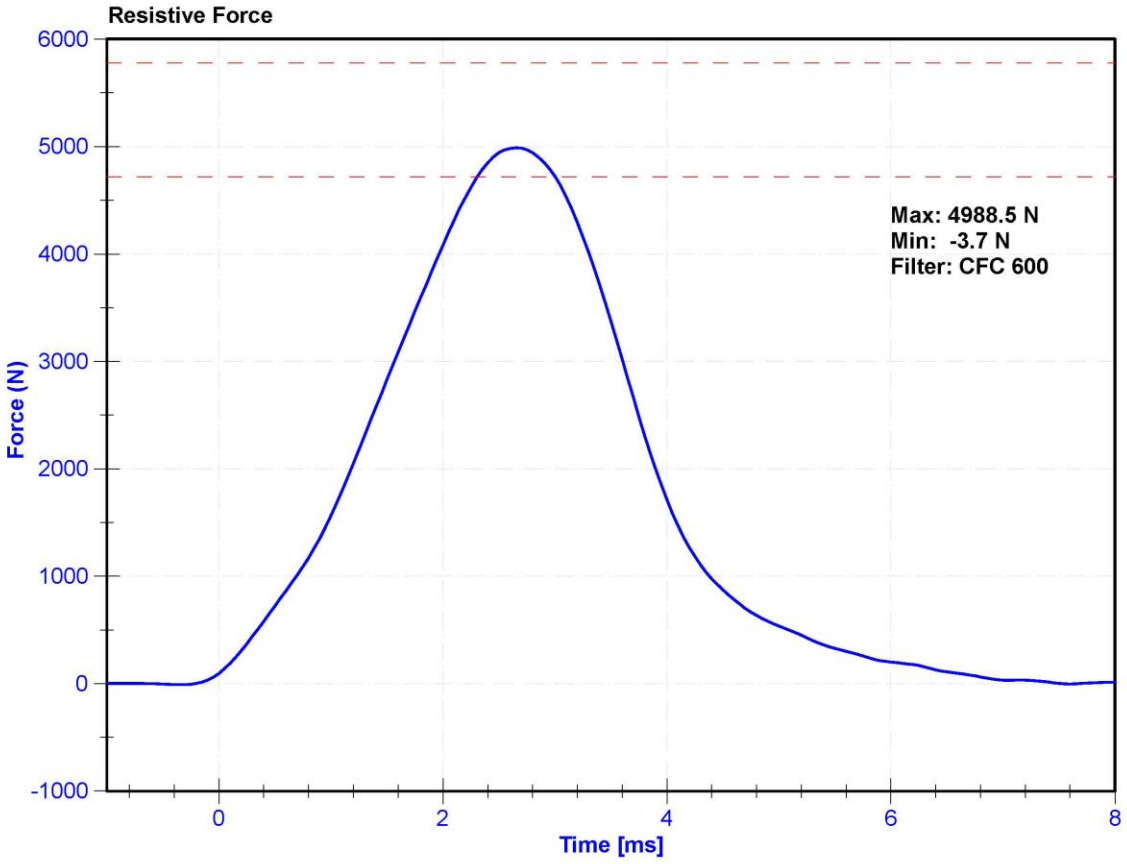
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

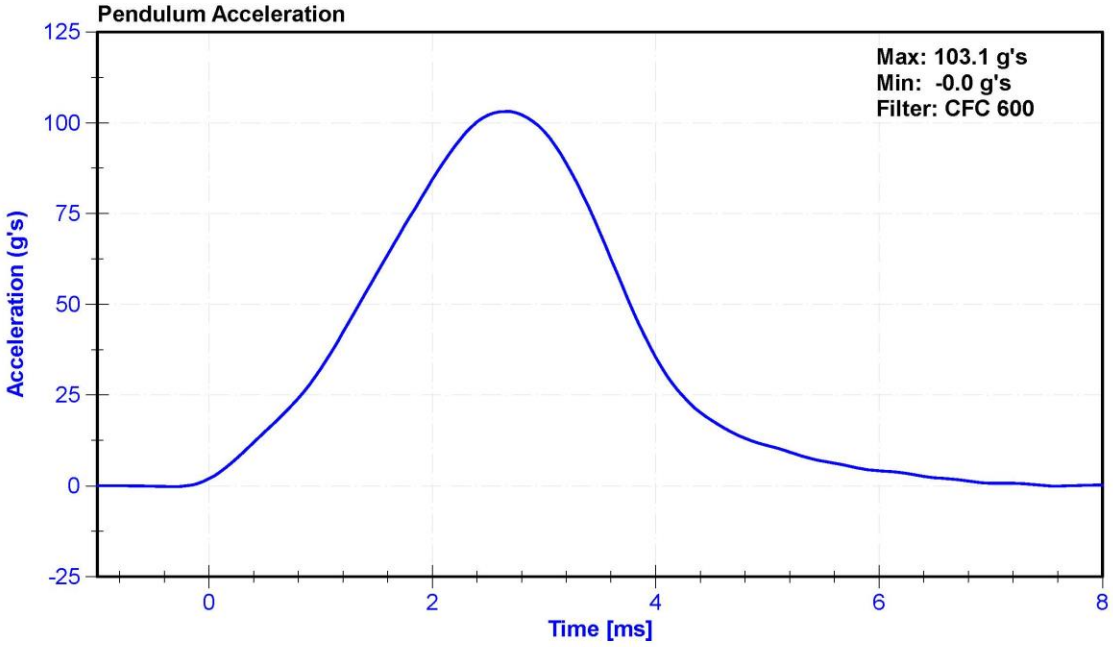
Results

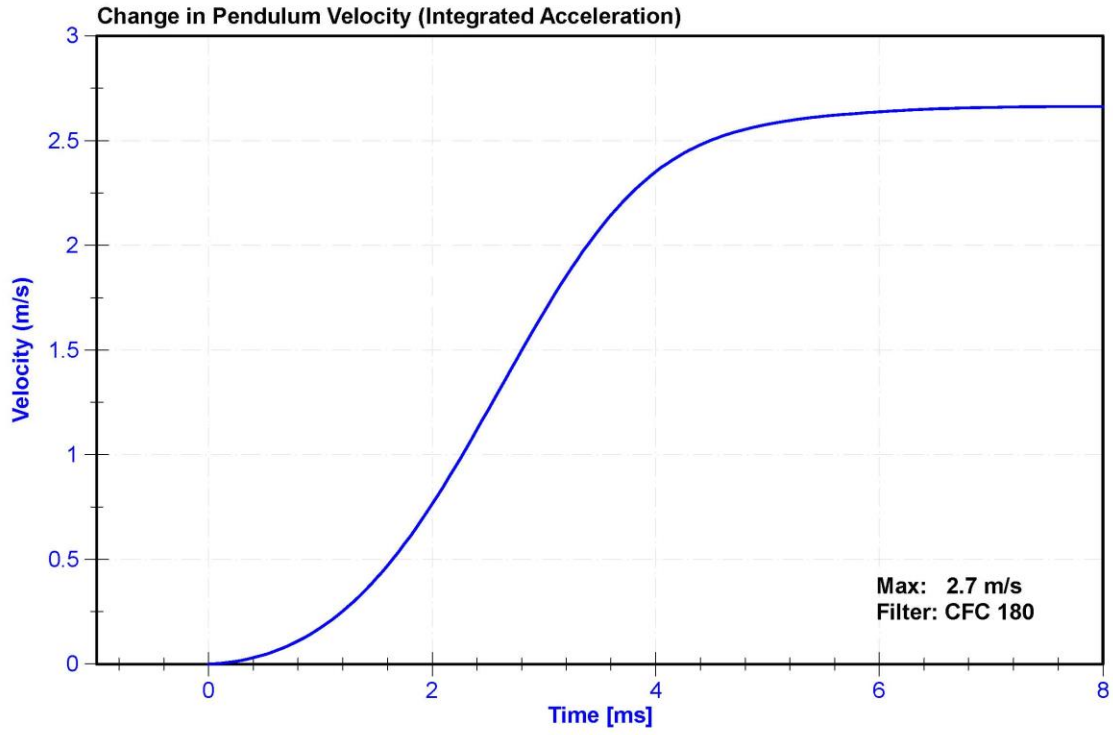
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.9	Pass
Humidity	10	70	%	24	Pass
Velocity	2.07	2.13	m/s	2.115	Pass
Maximum Resistive Force	4720	5780	N	4988.5	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021




Pendulum Acceleration
Max: 103.1 g's
Min: -0.0 g's
Filter: CFC 600
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]


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

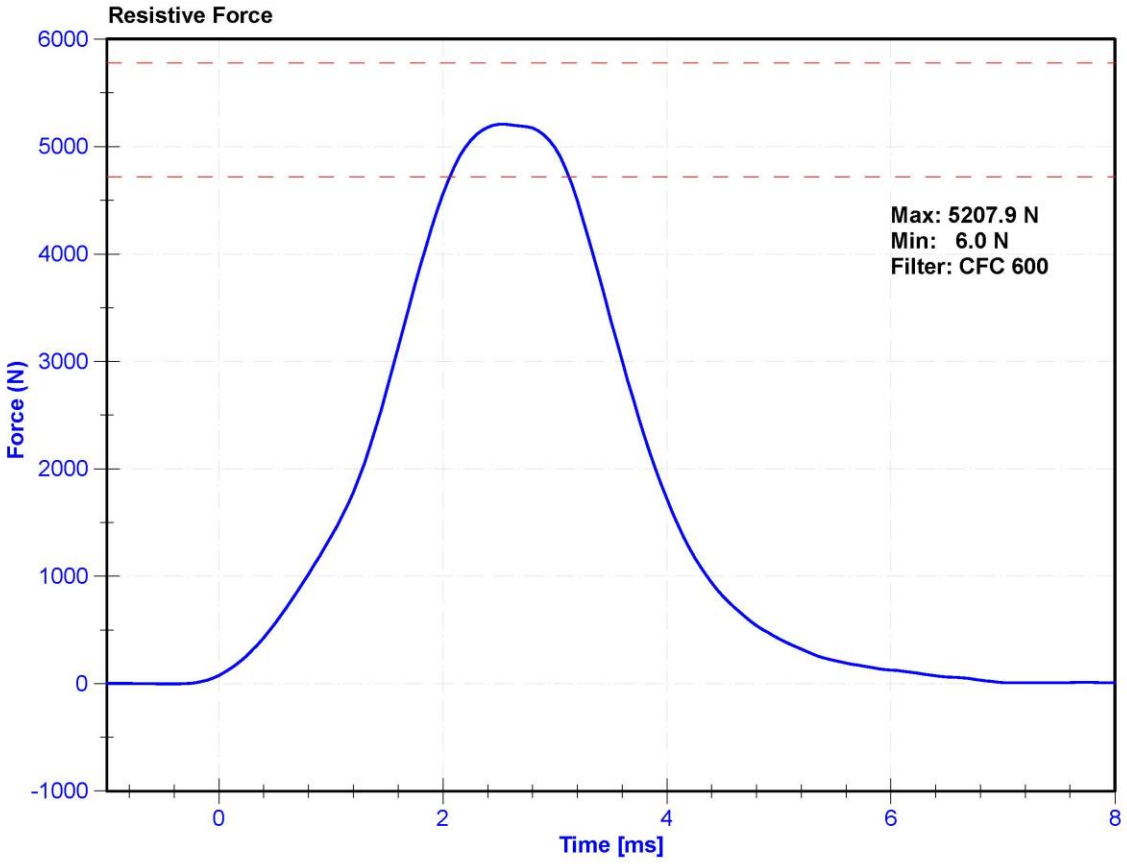
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	142	Laboratory Supervisor	K. Brogan

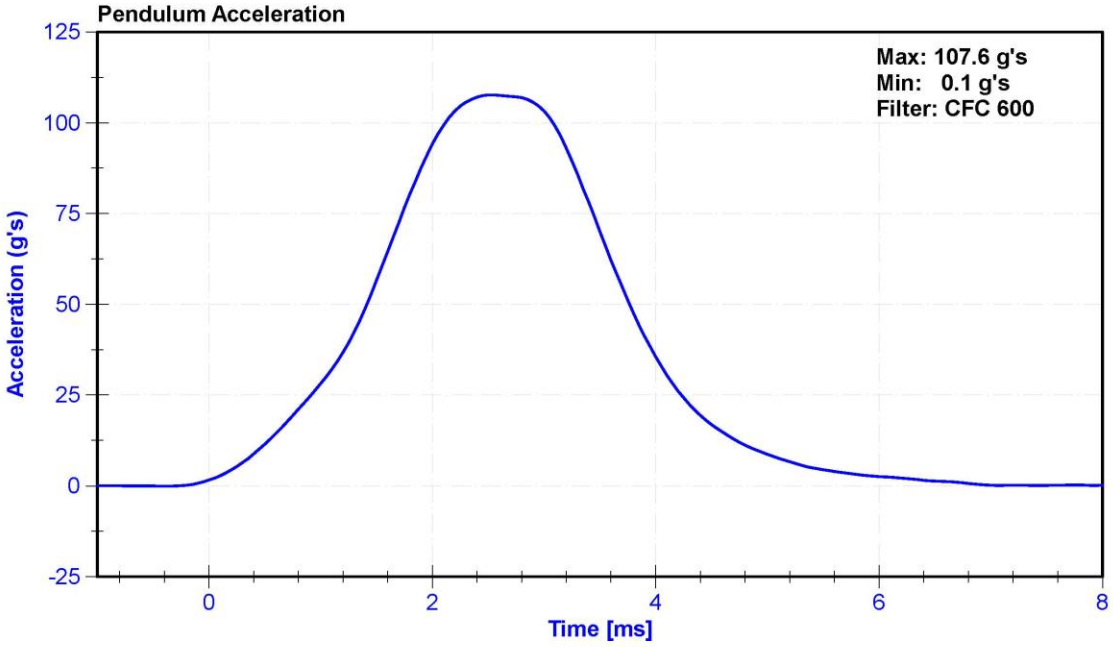
Results

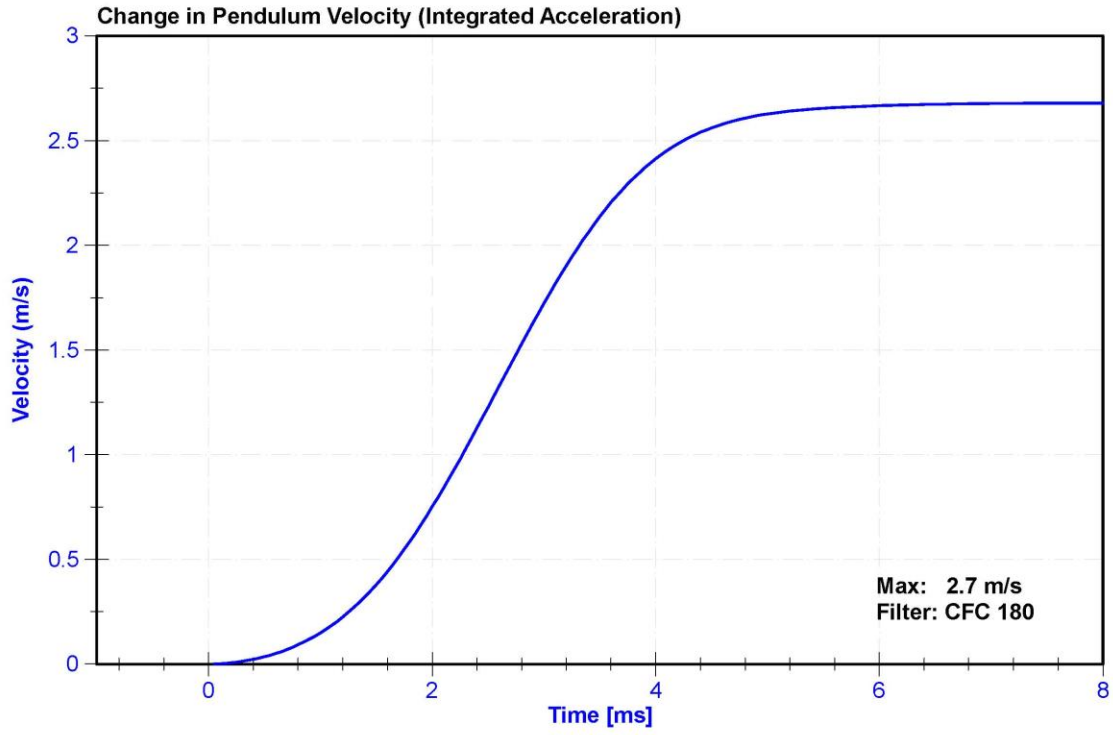
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.9	Pass
Humidity	10	70	%	24	Pass
Velocity	2.07	2.13	m/s	2.112	Pass
Maximum Resistive Force	4720	5780	N	5207.9	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021




Pendulum Acceleration
Max: 107.6 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: 2.7 m/s
Filter: CFC 180
0
2
4
6
8
Time [ms]

CALIBRATION TEST RESULTS

POST-TEST

HYBRID III 5TH PERCENTILE FEMALE - PASSENGER ATD

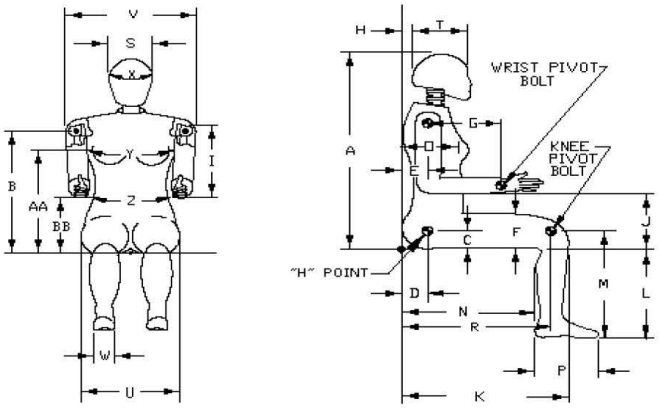
SERIAL NO: 140

Calspan

External Measurements - Hybrid 3 - 5th Female

Technician: K. Brogan Date: 3/10/2021

Dummy Serial Number: 140



Symbol	Description	Specification (mm)		Result (mm)	Pass/Fail
A	Sitting Height	775	800	790	Pass
B	Shoulder Pivot Height	432	457	443	Pass
C	H-Point Height	81	86	83	Pass
D	H-Point from Backline	145	150	146	Pass
E	Shoulder Pivot from Backline	69	84	78	Pass
F	Thigh Clearance	119	135	127	Pass
G	Back of Elbow to Wrist Pivot	244	259	252	Pass
H	Head Back to Backline	43	48	45	Pass
I	Shoulder to Elbow Length	277	297	291	Pass
J	Elbow Rest Height	183	203	197	Pass
K	Buttock to Knee Length	521	546	541	Pass
L	Popliteal Height	356	376	366	Pass
M	Knee Pivot Height	394	419	411	Pass
N	Buttock Popliteal Length	414	439	428	Pass
O	Chest Depth without Jacket	175	191	182	Pass
P	Foot Length (right)	219	234	229	Pass
R	Buttock To Knee Pivot Length	457	483	465	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

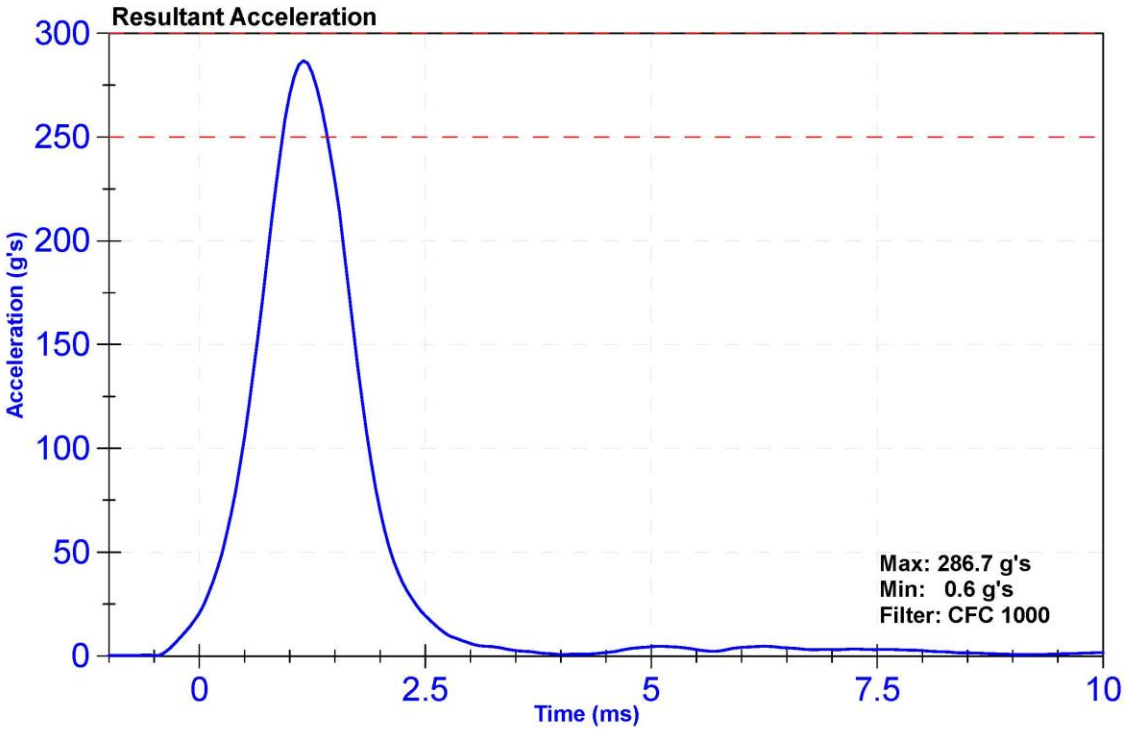
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

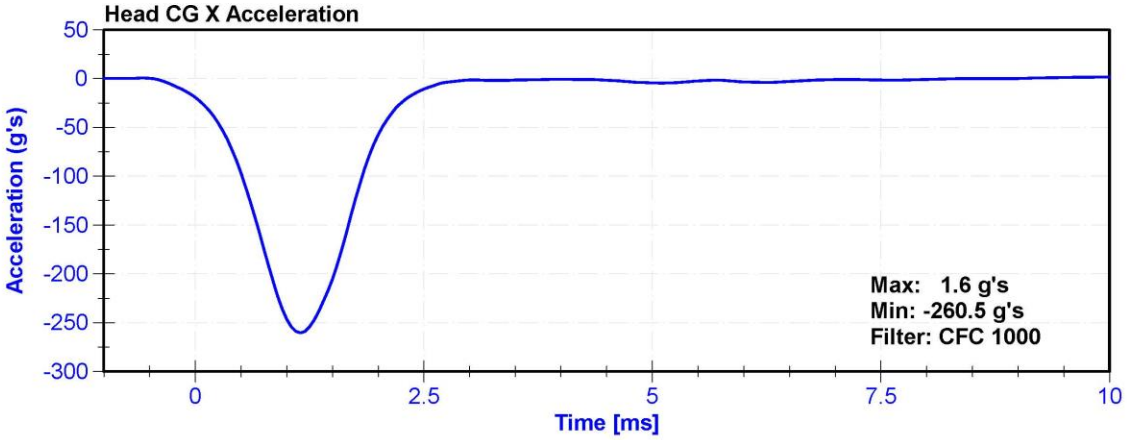
Results

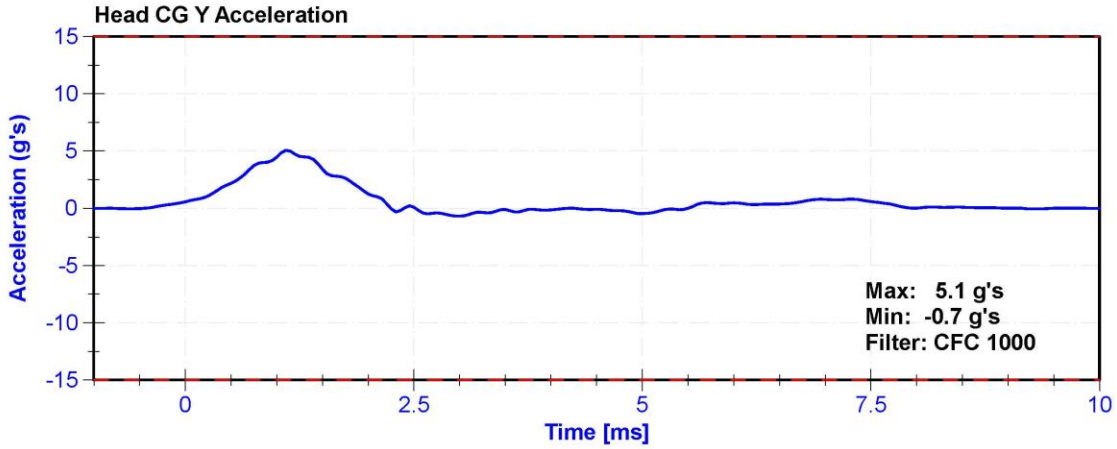
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	20.9	Pass
Humidity	10	70	%	24	Pass
Resultant Acceleration	250	300	g's	286.7	Pass
Oscillation	0	10	%	1.6	Pass
Lateral Acceleration	-15	15	g's	5.1	Pass

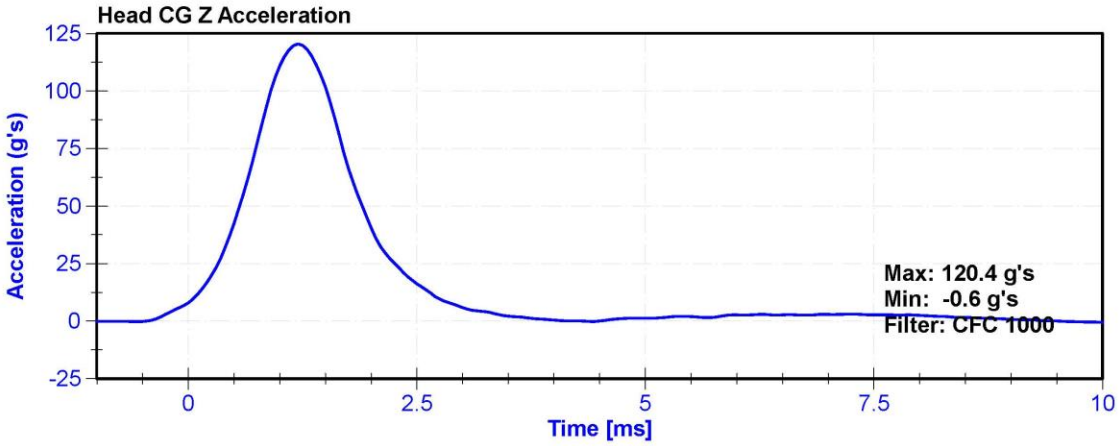
Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
X Accelerometer	Endevco 7264C-2KTZ-2-240	P79417	2/24/2021	8/25/2021
Y Accelerometer	Endevco 7264C-2KTZ-2-240	P83335	2/24/2021	8/25/2021
Z Accelerometer	Endevco 7264C-2KTZ-2-240	T11252	2/24/2021	8/25/2021




Head CG X Acceleration
Acceleration (g's)
50
0
-50
-100
-150
-200
-250
-300
0
2.5
5
7.5
10
Time [ms]
Max: 1.6 g's
Min: -260.5 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: 5.1 g's
Min: -0.7 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: 120.4 g's
Min: -0.6 g's
Filter: CFC 1000

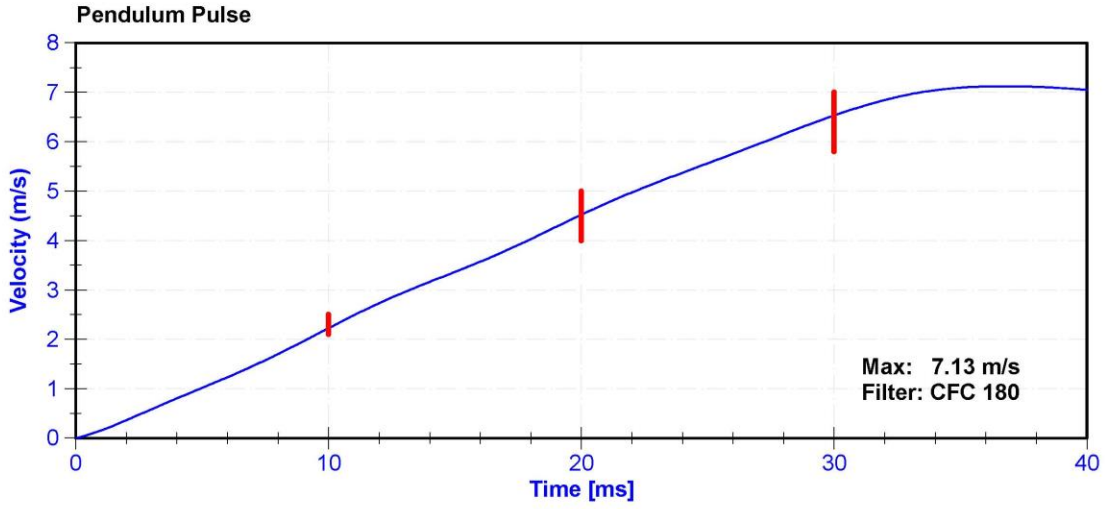
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

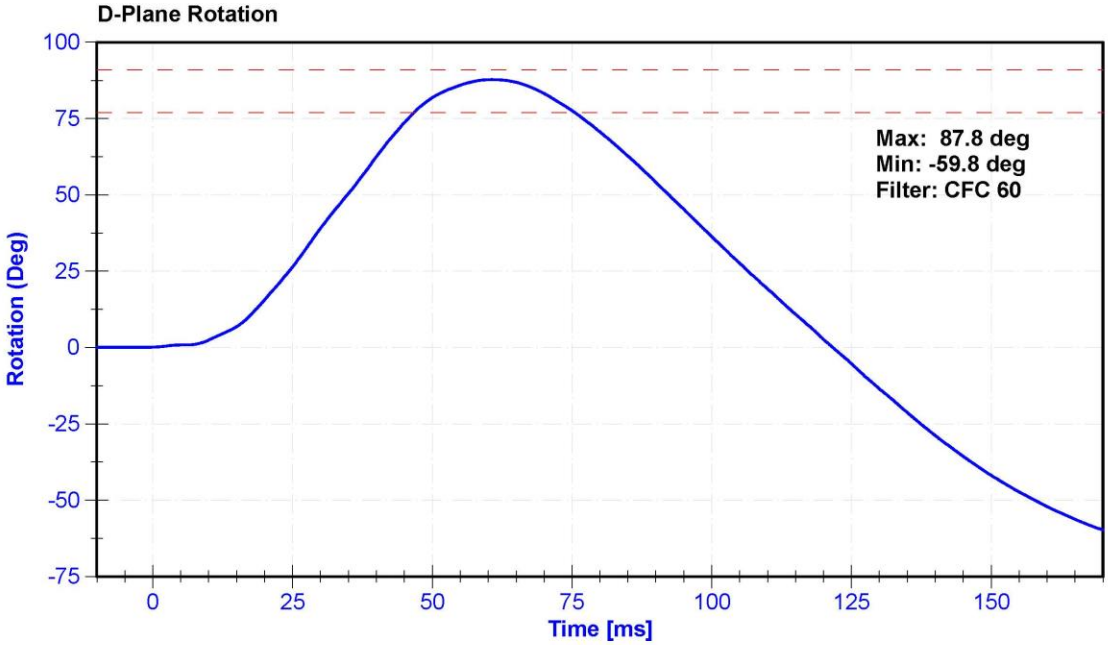
Results

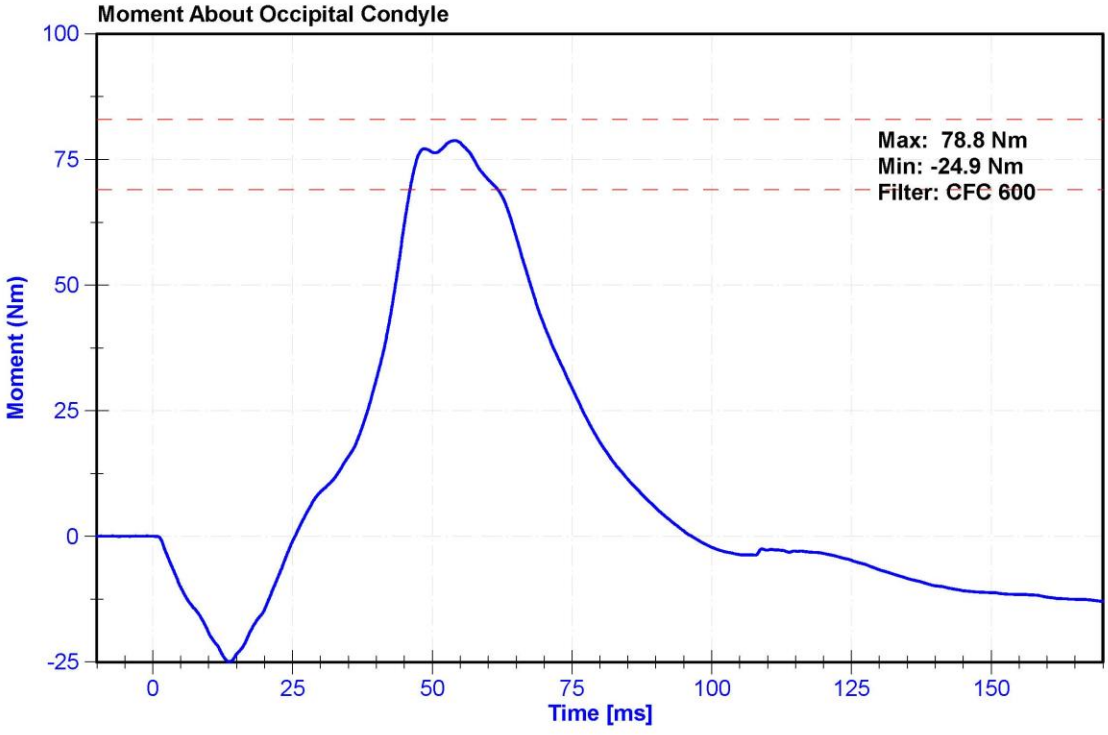
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	22.0	Pass
Humidity	10	70	%	29.3	Pass
Velocity	6.89	7.13	m/s	7.013	Pass
Pendulum Impulse at 10ms	2.1	2.5	m/s	2.22	Pass
Pendulum Impulse at 20ms	4.0	5.0	m/s	4.52	Pass
Pendulum Impulse at 30ms	5.8	7.0	m/s	6.53	Pass
Max D Plane Rotation	77	91	deg	87.8	Pass
Max Moment During Rotation Interval	69	83	Nm	78.8	Pass
Moment Decay to 10.0 Nm	80	100	ms	86.1	Pass

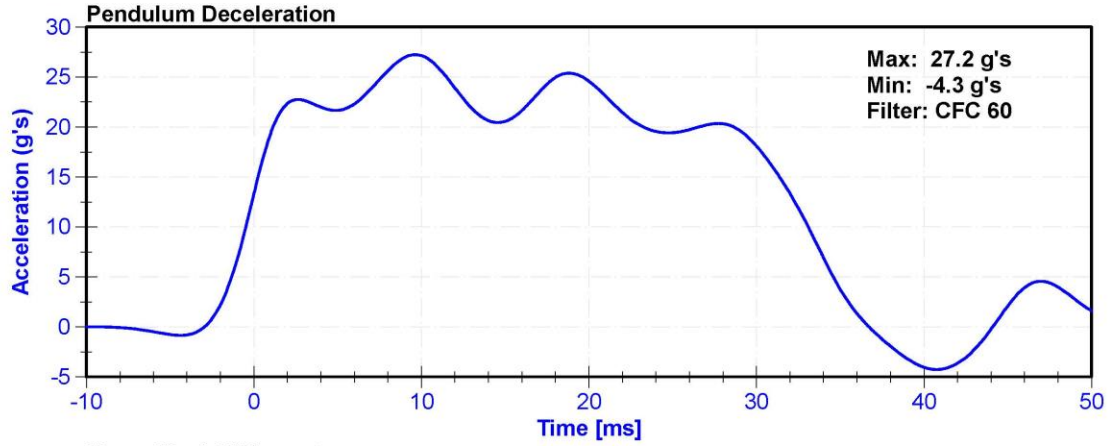
Transducer Calibrations

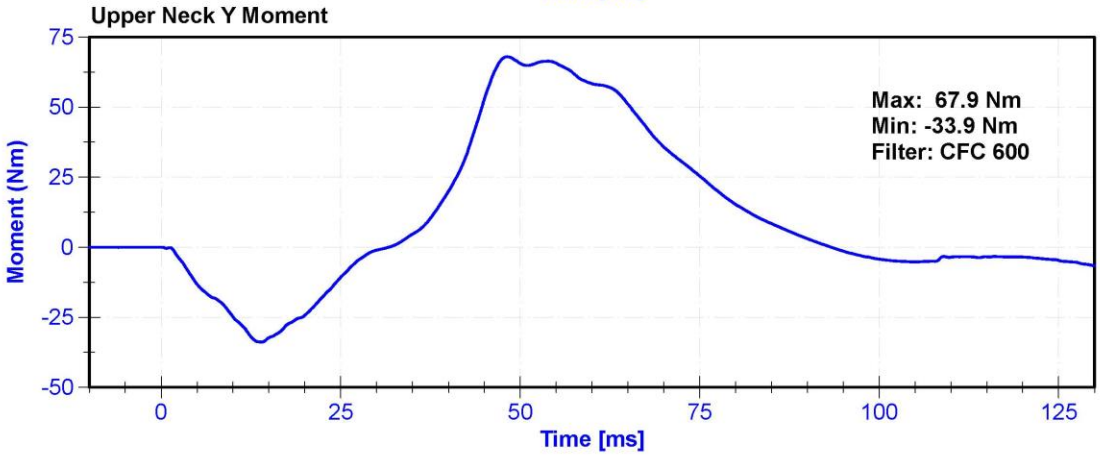
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-C16503 Striker	2/5/2021	2/5/2022
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/17/2020	9/17/2021
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/17/2020	9/17/2021
Upper Neck Load Cell	Denton 1716A	LC-1916Fx	11/23/2020	11/23/2021

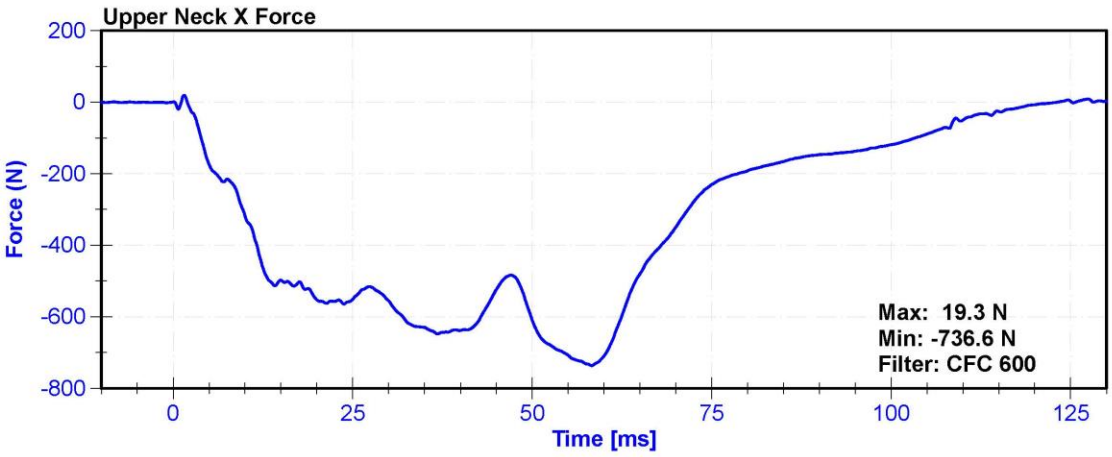



D-Plane Rotation
Max: 87.8 deg
Min: -59.8 deg
Filter: CFC 60
Rotation (Deg)
100
75
50
25
0
-25
-50
-75
0
25
50
75
100
125
150
Time [ms]


Moment About Occipital Condyle
Max: 78.8 Nm
Min: -24.9 Nm
Filter: CFC 600
Moment (Nm)
100
75
50
25
0
-25
0
25
50
75
100
125
150
Time [ms]


Pendulum Deceleration
Max: 27.2 g's
Min: -4.3 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 67.9 Nm
Min: -33.9 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 19.3 N
Min: -736.6 N
Filter: CFC 600
Force (N)
Time [ms]

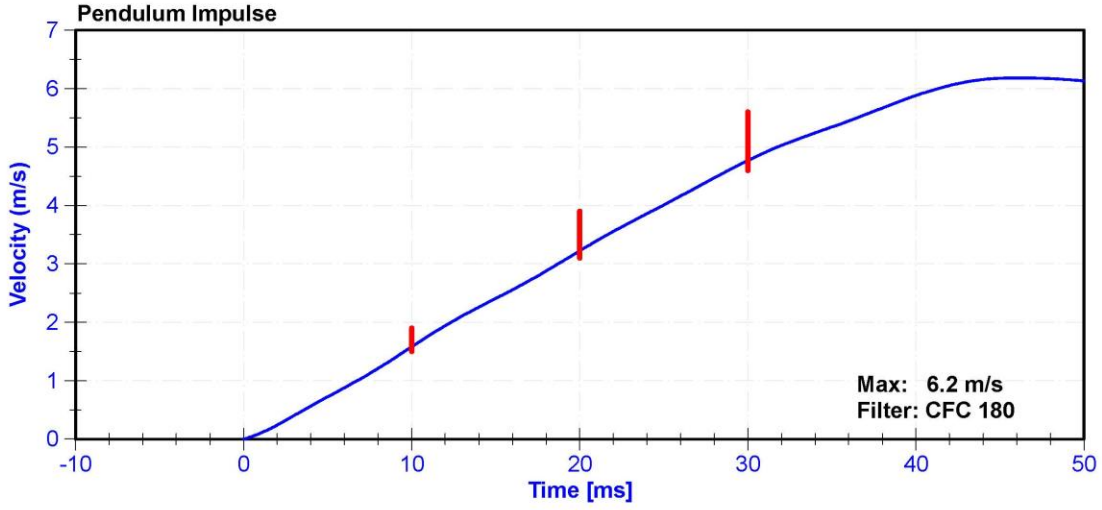
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

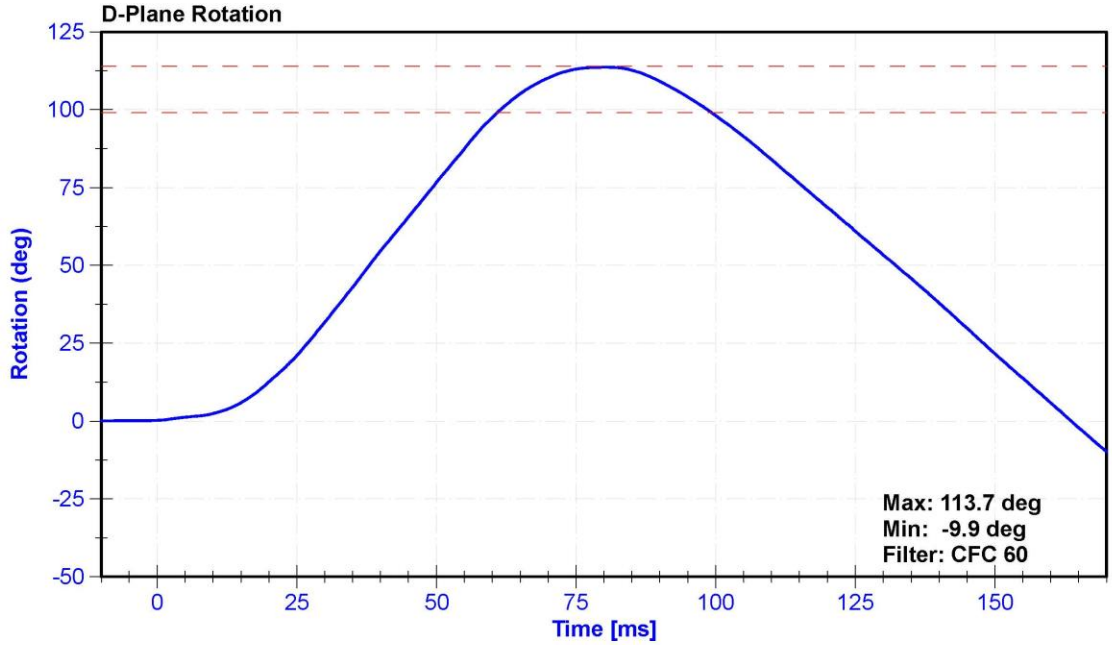
Results

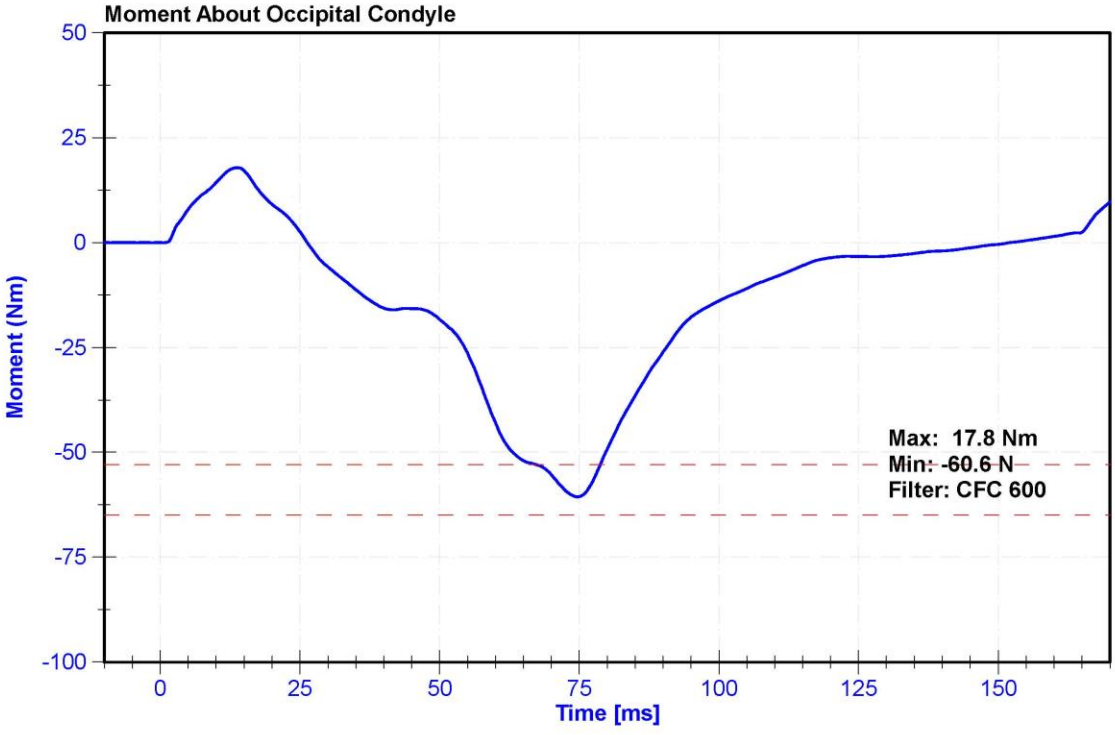
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	22.0	Pass
Humidity	10	70	%	29.3	Pass
Velocity	5.95	6.19	m/s	6.088	Pass
Pendulum Impulse at 10ms	1.5	1.9	m/s	1.58	Pass
Pendulum Impulse at 20ms	3.1	3.9	m/s	3.22	Pass
Pendulum Impulse at 30ms	4.6	5.6	m/s	4.77	Pass
D Plane Rotation	99	114	deg	113.7	Pass
Moment During Rotation Interval	-65	-53	Nm	-60.6	Pass
Moment Decay to -10Nm	94	114	ms	106.6	Pass

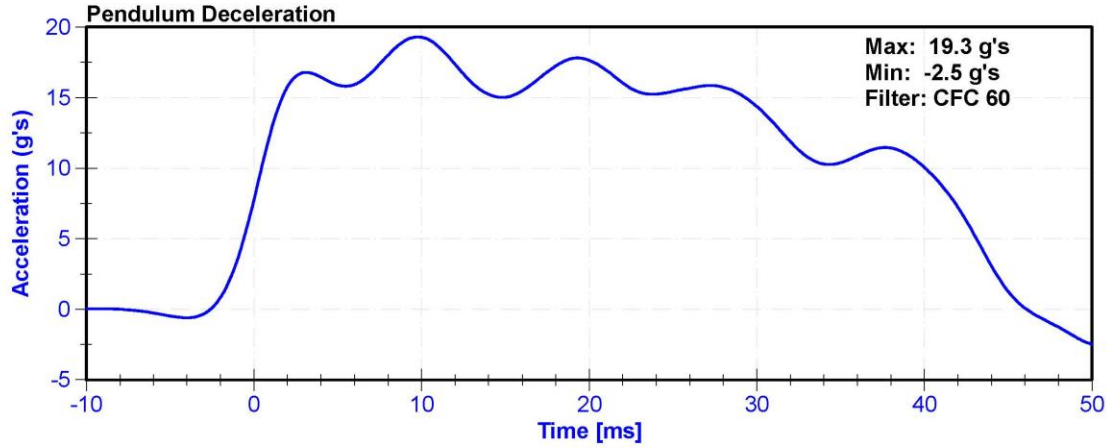
Transducer Calibrations

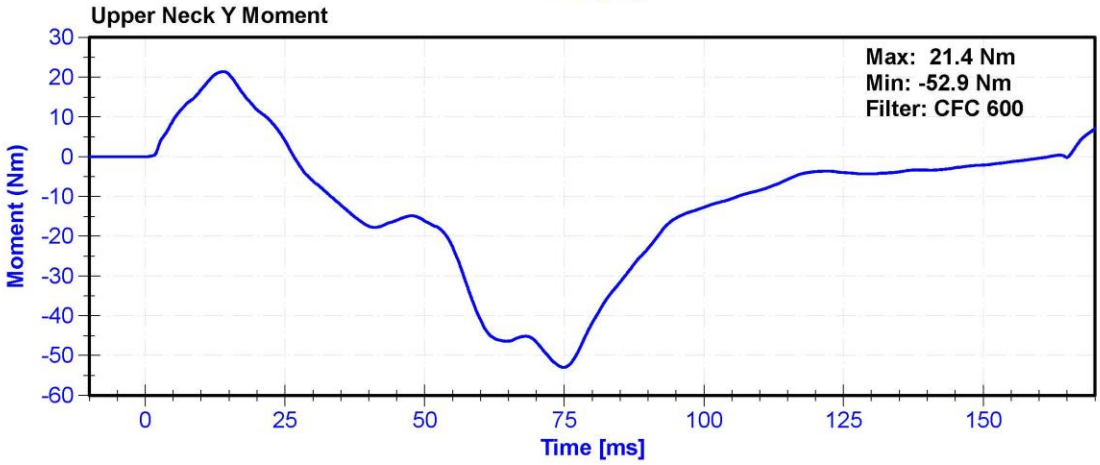
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	ENDEVCO 7231CT	AC-C16503 Striker	2/5/2021	2/5/2022
Pendulum Potentiometer	ETI SP22G	DS-LABPOT1	9/17/2020	9/17/2021
Condyle Potentiometer	ETI SP22G	DS-LABPOT2	9/17/2020	9/17/2021
Upper Neck Load Cell	Denton 1716A	LC-1916Fx	11/23/2020	11/23/2021

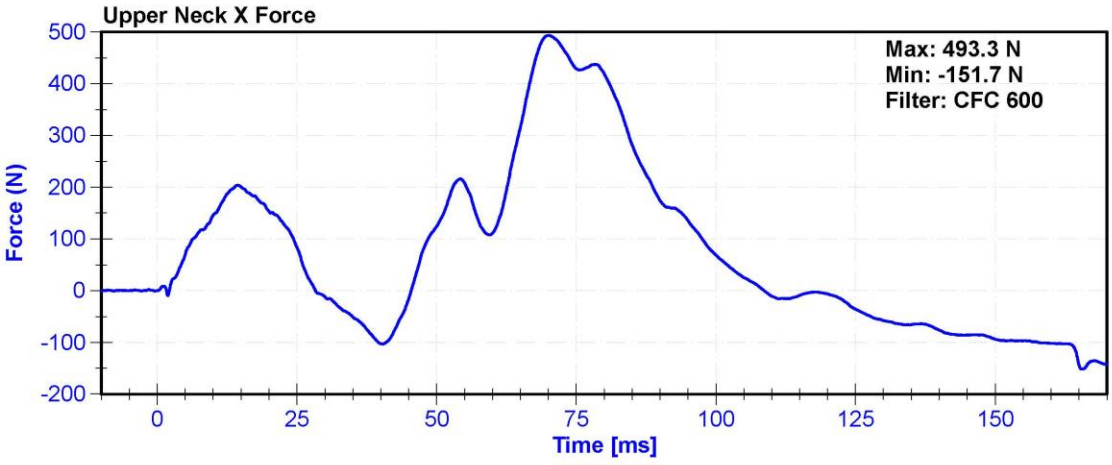



D-Plane Rotation
Rotation (deg)
125
100
75
50
25
0
-25
-50
0
25
50
75
100
125
150
Time [ms]
Max: 113.7 deg
Min: -9.9 deg
Filter: CFC 60


Moment About Occipital Condyle
Moment (Nm)
50
25
0
-25
-50
-75
-100
0
25
50
75
100
125
150
Time [ms]
Max: 17.8 Nm
Min: -60.6 N
Filter: CFC 600


Pendulum Deceleration
Max: 19.3 g's
Min: -2.5 g's
Filter: CFC 60
Acceleration (g's)
Time [ms]


Upper Neck Y Moment
Max: 21.4 Nm
Min: -52.9 Nm
Filter: CFC 600
Moment (Nm)
Time [ms]


Upper Neck X Force
Max: 493.3 N
Min: -151.7 N
Filter: CFC 600
Force (N)
Time [ms]

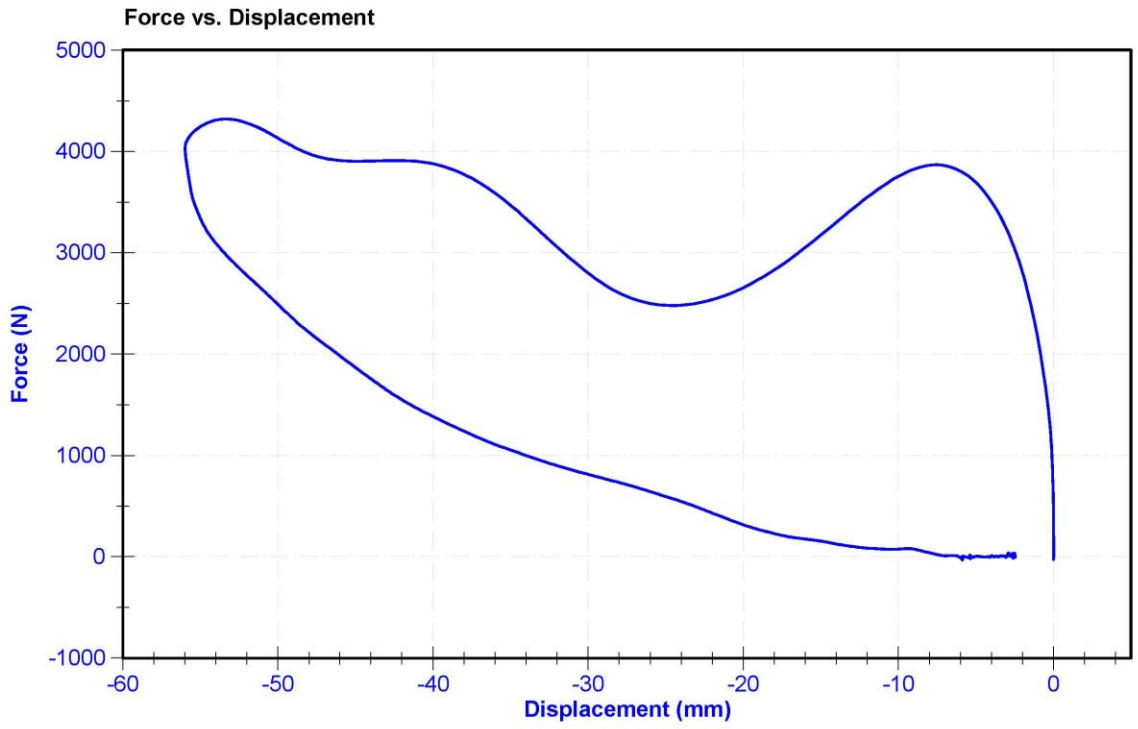
ATD Manufacturer	Humanetics	Test Technician	D.Reinhard
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

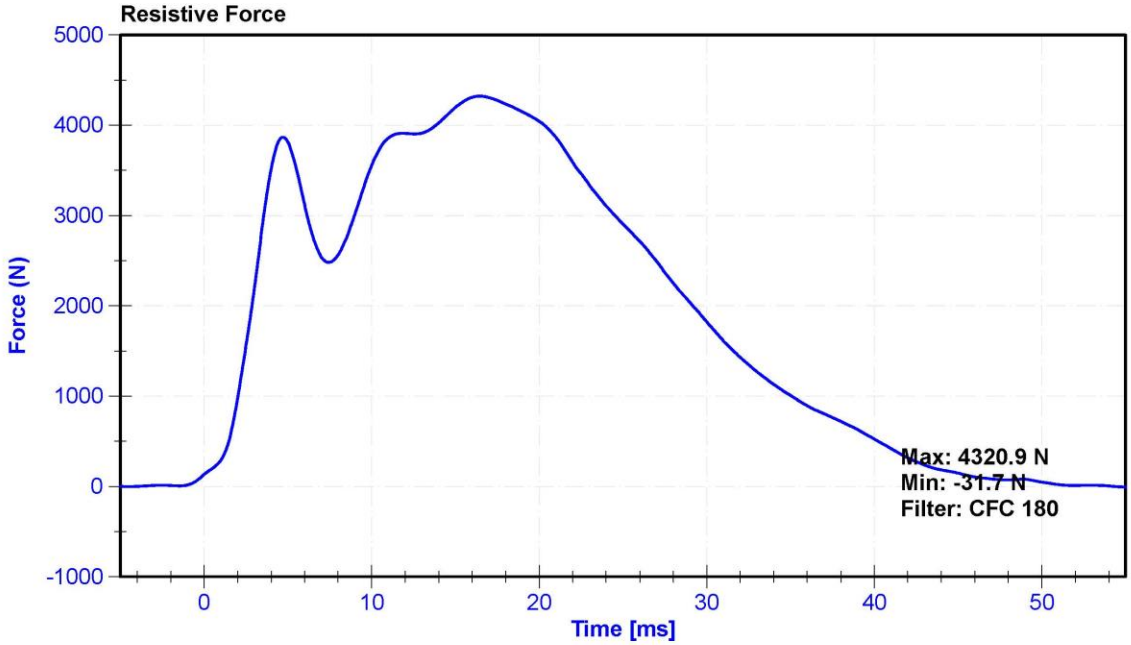
Results

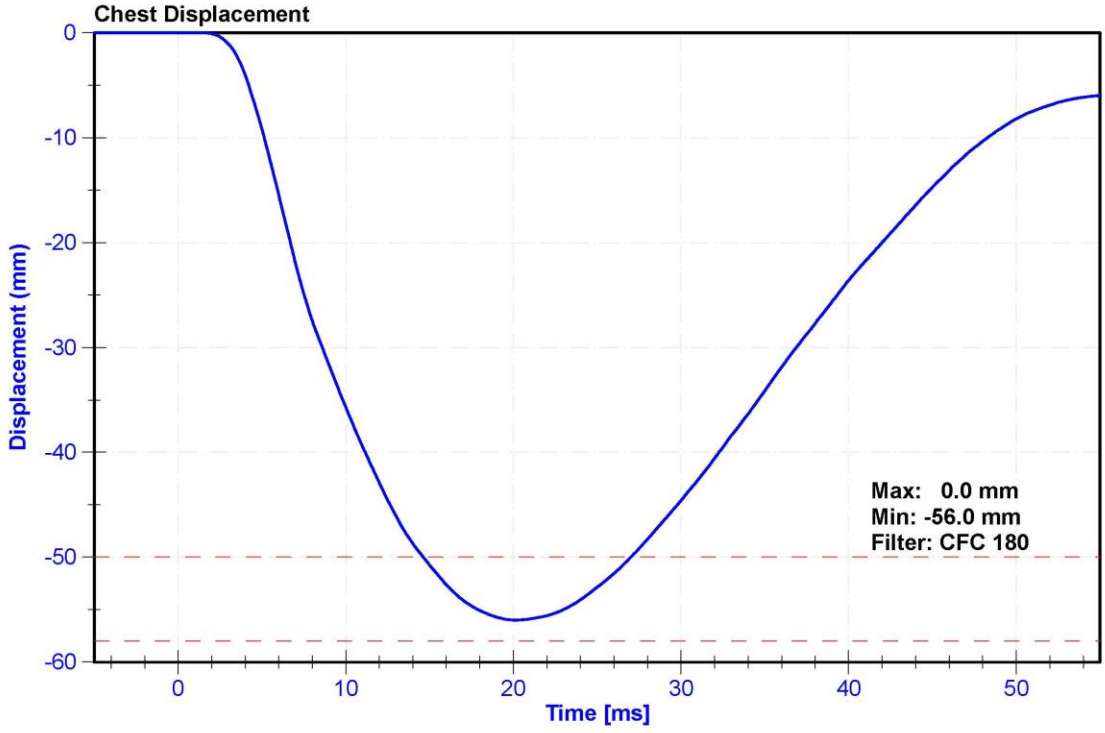
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	20.6	22.2	ºC	20.8	Pass
Humidity	10	70	%	27	Pass
Velocity	6.59	6.83	m/s	6.728	Pass
Chest Deflection	-58	-50	mm	-56.0	Pass
Maximum Resistive Force (50 to 58mm)	3900	4400	N	4320.9	Pass
Maximum Resistive Force (18 to 50mm)	0	4600	N	4128.6	Pass
Hysteresis	69	85	%	71.0	Pass

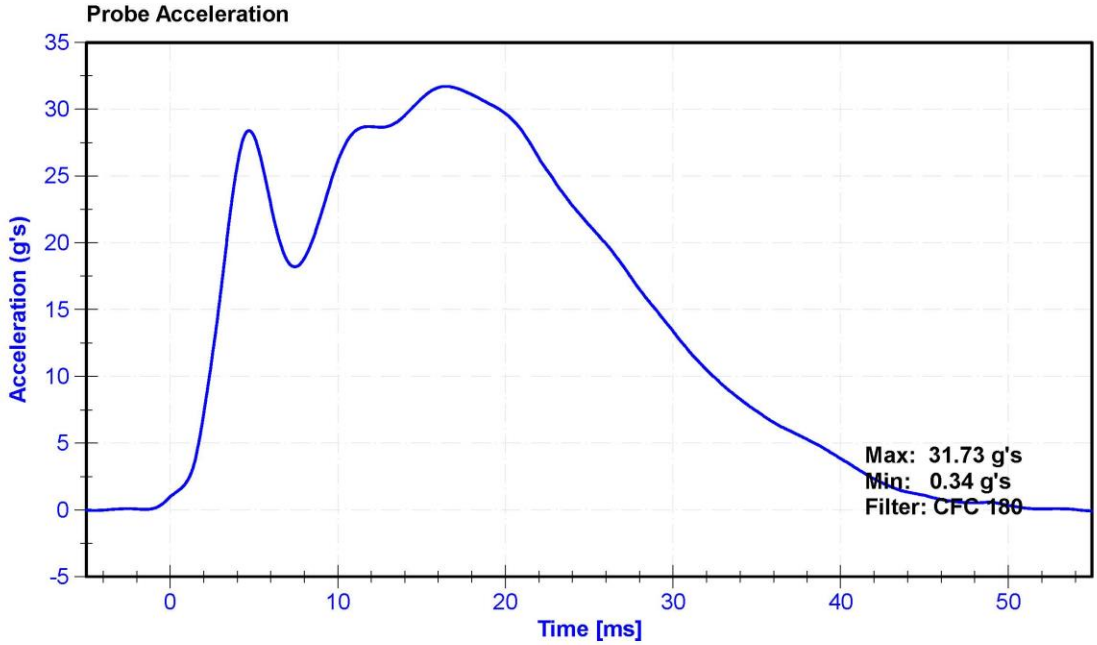
Transducer Calibrations

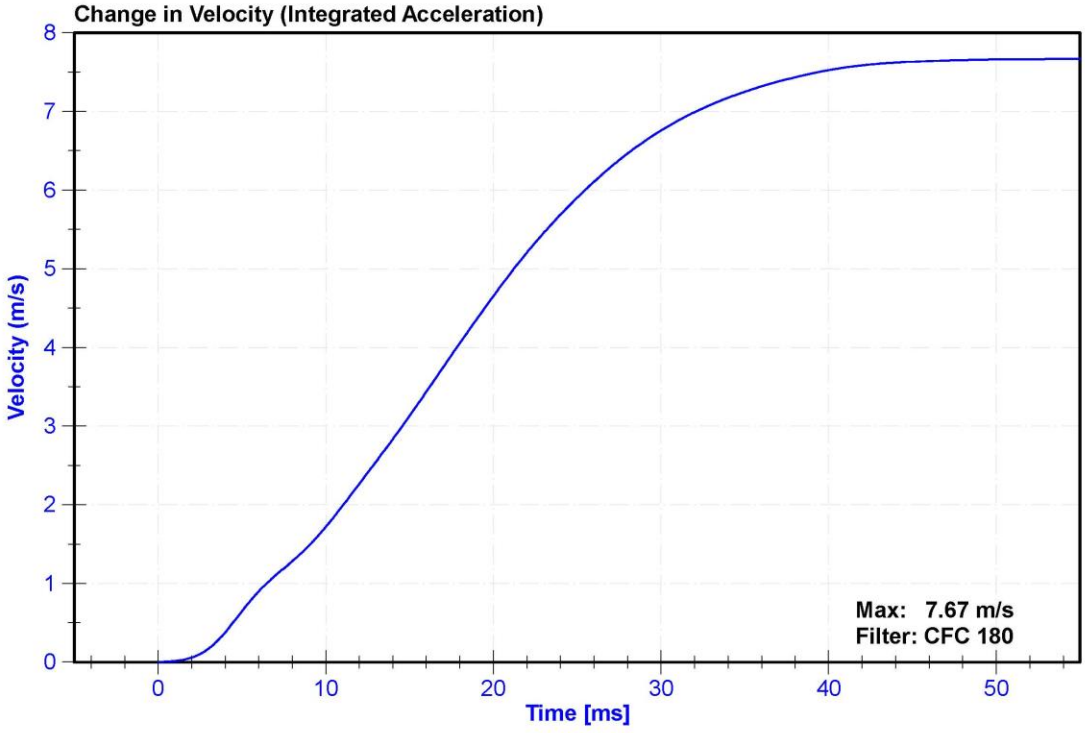
Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021
Chest Potentiometer	SERVO 14CBI-3615	DS-140GFE	2/24/2021	8/25/2021




Resistive Force
Force (N)
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50
Time [ms]
Max: 4320.9 N
Min: -31.7 N
Filter: CFC 180


Chest Displacement
Displacement (mm)
0
-10
-20
-30
-40
-50
-60
0
10
20
30
40
50
Time [ms]
Max: 0.0 mm
Min: -56.0 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: 31.73 g's
Min: 0.34 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: 7.67 m/s
Filter: CFC 180

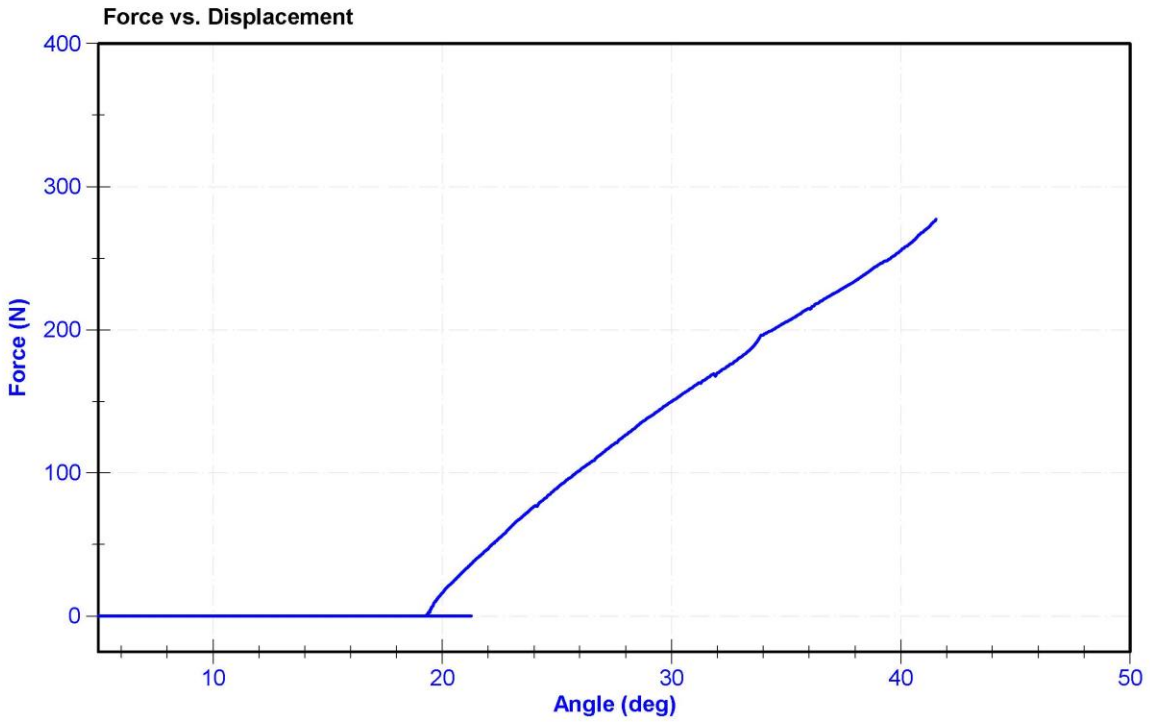
ATD Manufacturer	Humanetics	Test Technician	S. Vacanti
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

Results

Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.6	25.6	ºC	20.9	Pass
Humidity	10	70	%	24	Pass
Initial Angle	0	20	deg	19.2	Pass
Force at 45 Degrees	320	390	N	330.7	Pass
Return Angle Relative to Initial	0	8	deg	8.0	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Potentiometer	Seika.de N4C-1	DS-1905226	10/12/2020	10/12/2021
Load Cell	Interface SML-200	LC-493319	10/8/2020	10/8/2021



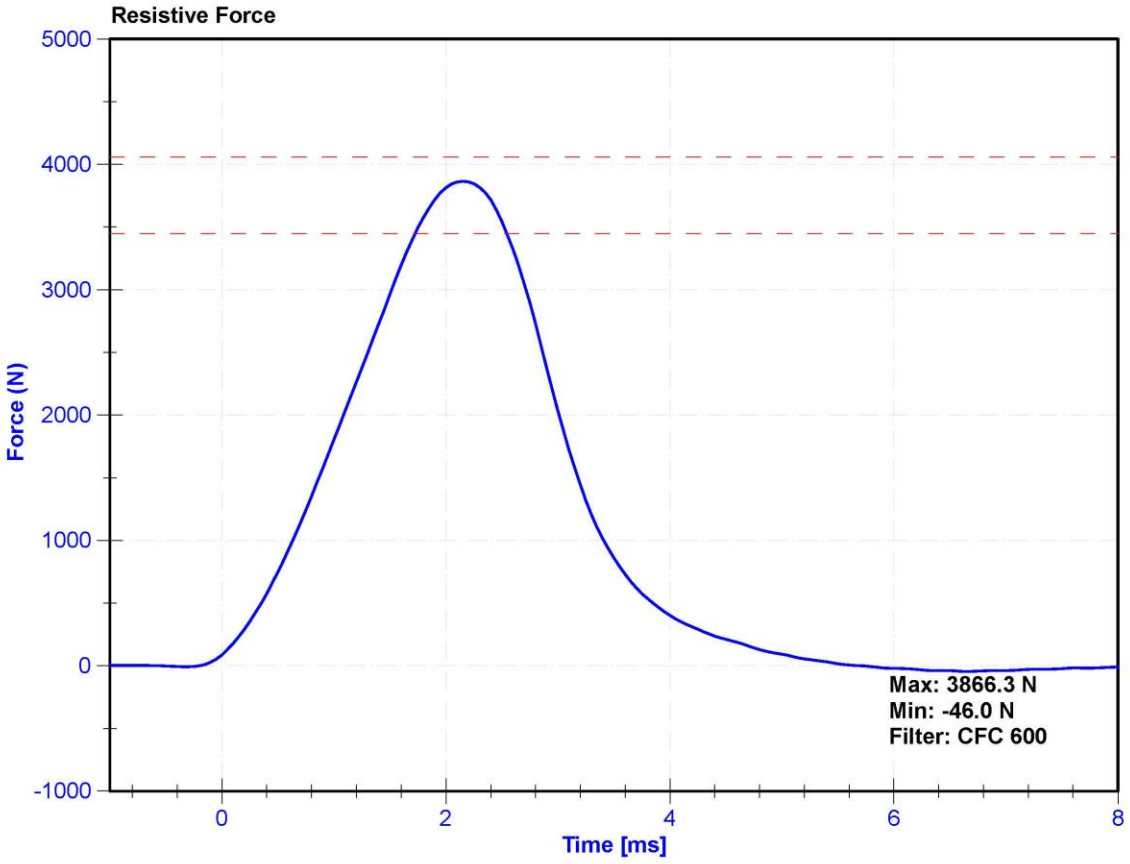
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

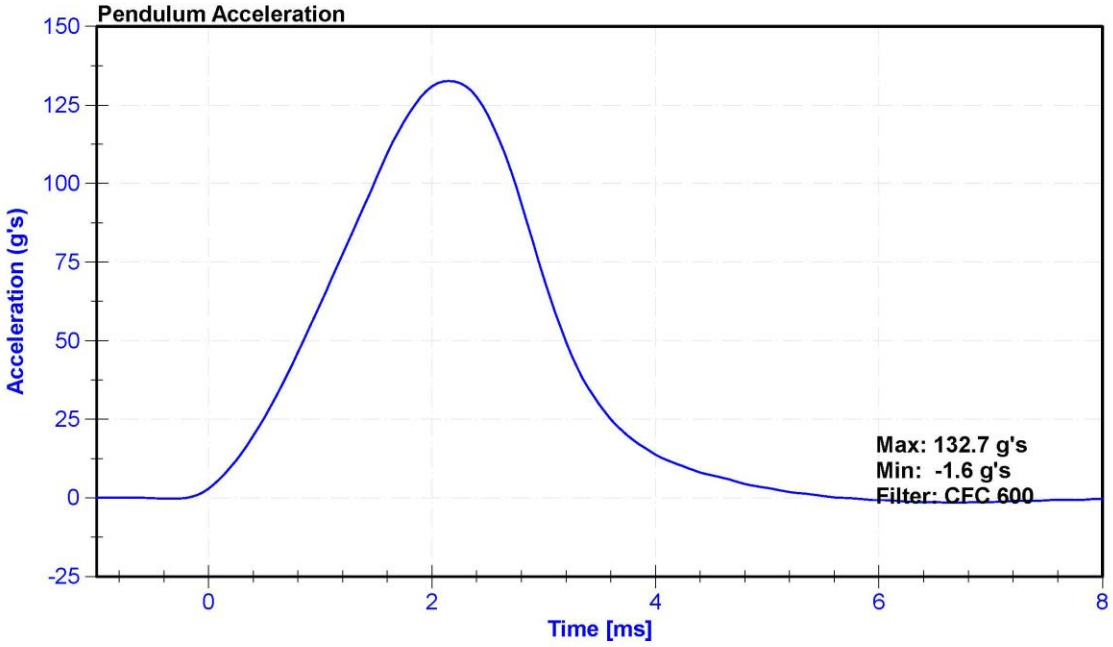
Results

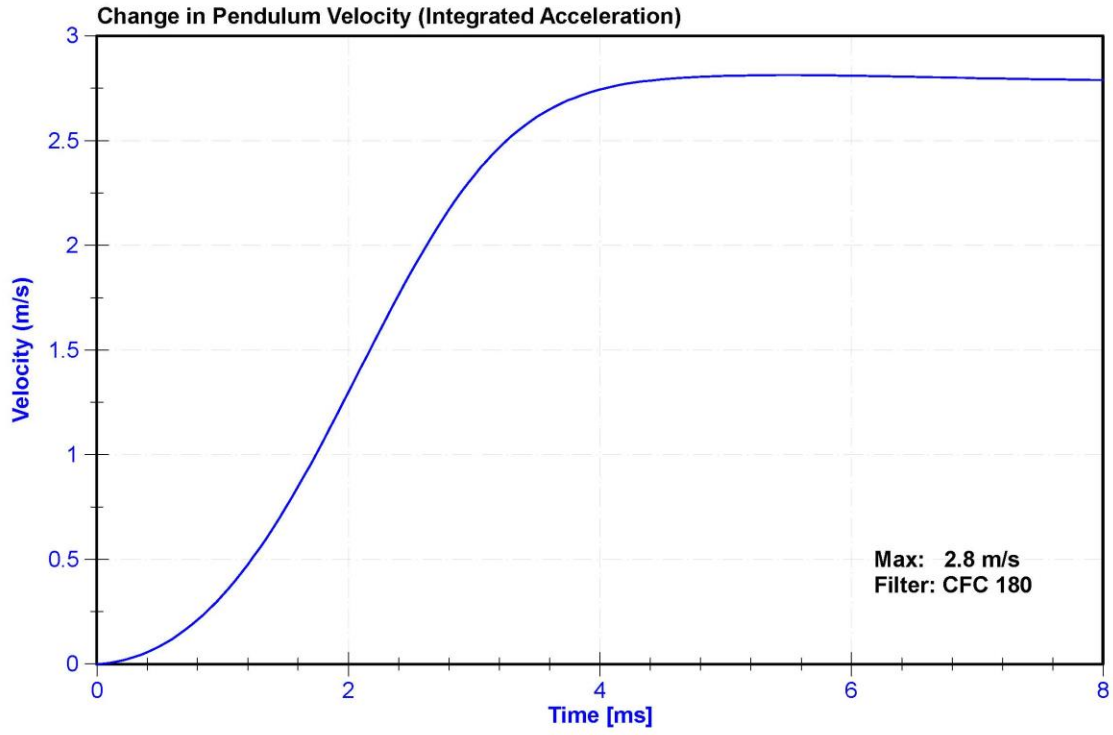
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	22.0	Pass
Humidity	10	70	%	29.3	Pass
Velocity	2.07	2.13	m/s	2.099	Pass
Resistive Force	3450	4060	N	3866.3	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021




Pendulum Acceleration
Acceleration (g's)
150
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 132.7 g's
Min: -1.6 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: 2.8 m/s
Filter: CFC 180

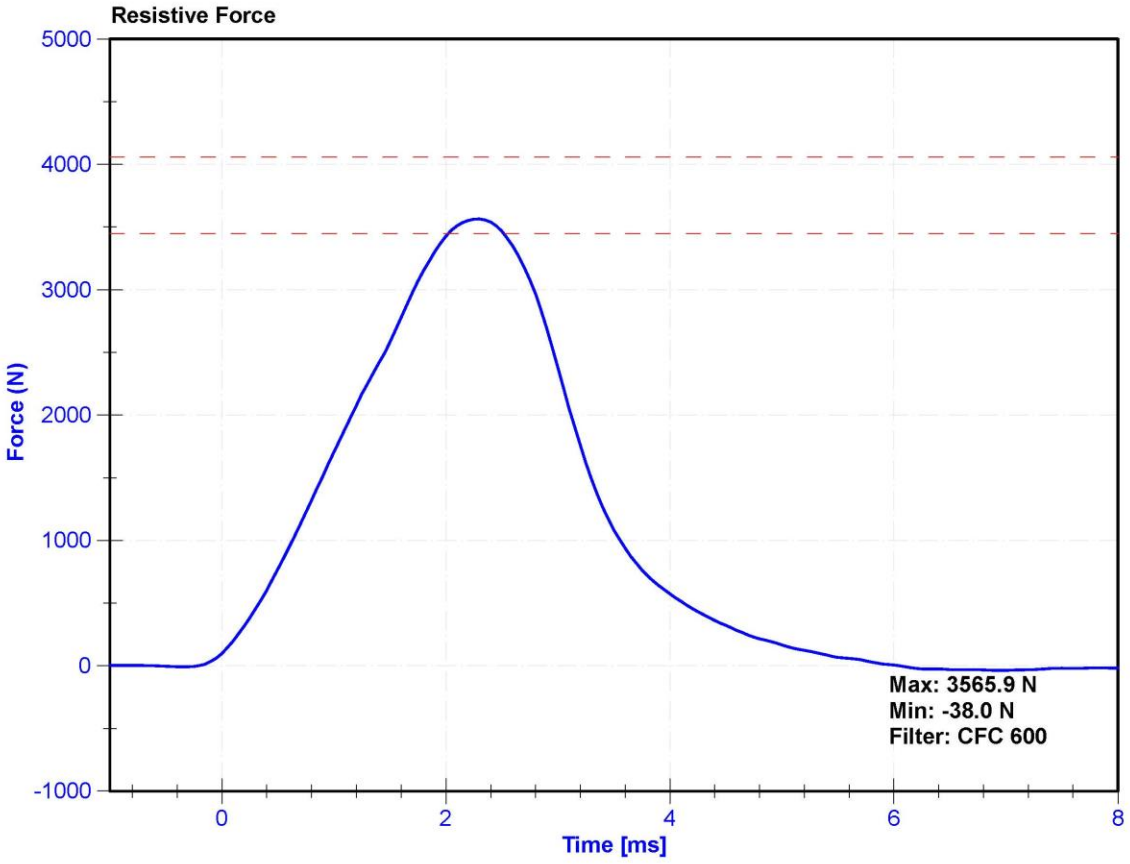
ATD Manufacturer	Humanetics	Test Technician	M. Dudek
ATD Serial Number	140	Laboratory Supervisor	K. Brogan

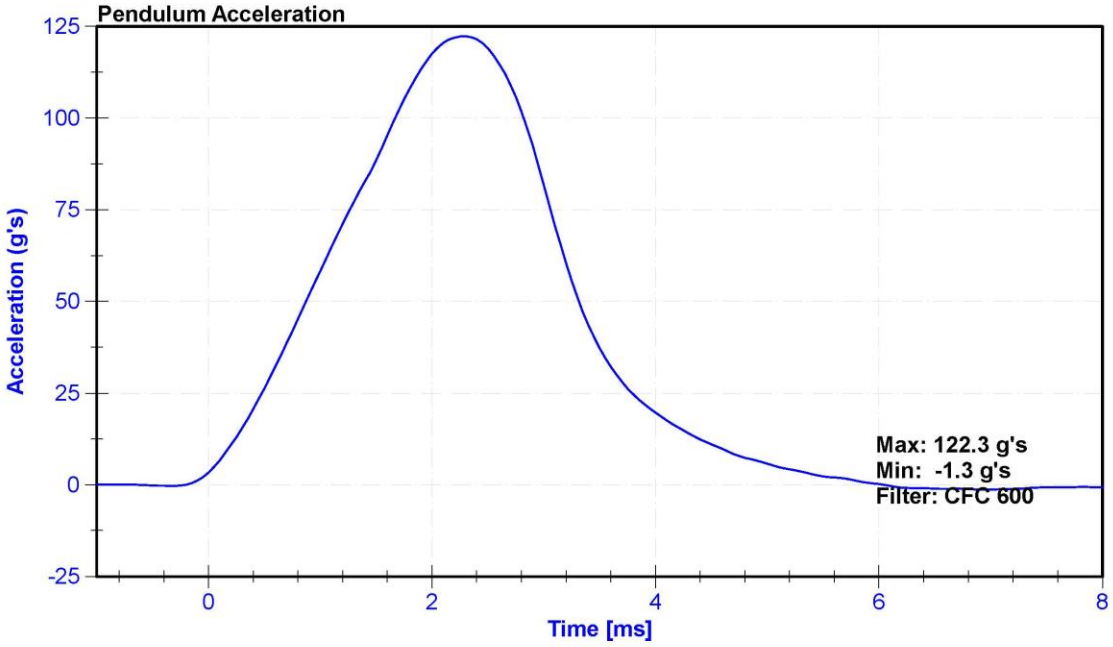
Results

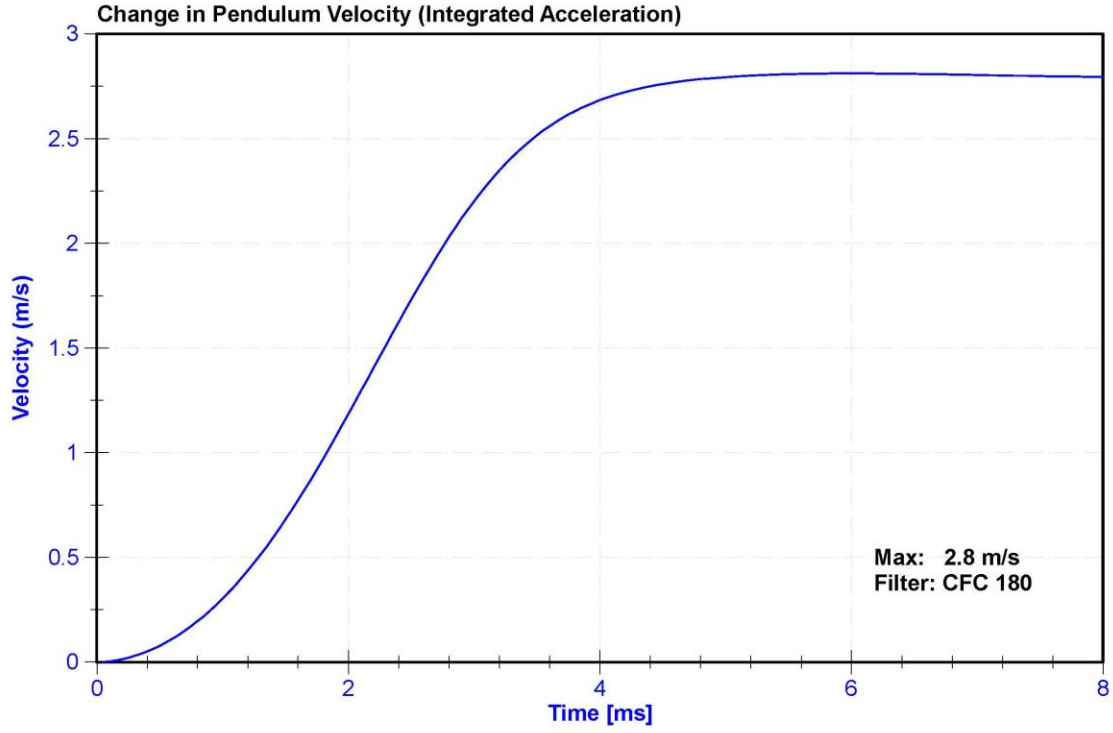
Test Parameter	Minimum Specification	Maximum Specification	Unit	Result	Pass/Fail
Temperature	18.9	25.6	ºC	22.0	Pass
Humidity	10	70	%	29.3	Pass
Velocity	2.07	2.13	m/s	2.102	Pass
Resistive Force	3450	4060	N	3565.9	Pass

Transducer Calibrations

Channel	Manufacturer	Serial Number	Calibration Date	Calibration Due Date
Pendulum Accelerometer	MSI 64C-2000	A278994	12/3/2020	12/3/2021




Pendulum Acceleration
Acceleration (g's)
125
100
75
50
25
0
-25
0
2
4
6
8
Time [ms]
Max: 122.3 g's
Min: -1.3 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: 2.8 m/s
Filter: CFC 180

APPENDIX D

DUMMY CALIBRATION AND PERFORMANCE VERIFICATION DATA

Table 1 – Driver Dummy Instrumentation

Instrumentation		Axis/Location	Hybrid III 50th S/N: 142		
			Serial Number	Manufacturer	Calibration Date
Head Accelerometers	Primary	X	P51681	ENDEVCO	11/3/2020
		Y	P64151	ENDEVCO	11/3/2020
		Z	P52114	ENDEVCO	11/3/2020
	Redundant	X	P58833	ENDEVCO	11/3/2020
		Y	P58905	ENDEVCO	11/3/2020
		Z	P63996	ENDEVCO	11/3/2020
Head Angular Rate Sensors		X	ARS-7603 GFE	DTS ARS-PRO-8K	8/4/2020
		Y	ARS-4718 GFE	DTS ARS-PRO-8K	8/4/2020
		Z	ARS-7521 GFE	DTS ARS-PRO-8K	8/4/2020
Upper Neck Load Cell		FX, Fy, Fz MX,MY, MZ	LC-2186Fx	DENTON	11/10/2020
Chest Accelerometers	Primary	X	AC-P51994	ENDEVCO	11/3/2020
		Y	AC-P51991	ENDEVCO	11/3/2020
		Z	AC-P49185	ENDEVCO	11/3/2020
	Redundant	X	AC-P51713	ENDEVCO	11/3/2020
		Y	AC-P68059	ENDEVCO	11/3/2020
		Z	AC-P78824	ENDEVCO	11/3/2020
Chest Potentiometer		X	DS-142	Servo	11/19/2020
Pelvis Accelerometer		X	AC-P58800	ENDEVCO	11/3/2020
		Y	AC-P52157	ENDEVCO	11/3/2020
		Z	AC-P52156	ENDEVCO	11/3/2020
Femur Load Cells - Left	Primary	Z	LC-136Fz1	DENTON	11/10/2020
	Redundant	Z	LC-136Fz2	DENTON	11/10/2020
Femur Load Cells - Right	Primary	Z	LC-DI4211FZ1	DENTON	11/10/2020
	Redundant	Z	LC-DI4211FZ2	DENTON	11/10/2020
Tibia Load Cells - Left	Upper	MX, MY, FZ	3643-93 Fz	DENTON	11/20/2020
	Lower	MX, MY, FZ	36440495-FZ	DENTON	11/20/2020
Tibia Load Cells – Right	Upper	MX, MY, FZ	36430362-FZ	DENTON	11/20/2020
	Lower	MX, MY, FZ	LC-672 FZ	DENTON	7/8/2020
Foot Accelerometers - Left	Rear	X	AC-P50084	ENDEVCO	11/3/2020
	Front	Z	AC-P58779	ENDEVCO	11/3/2020
Foot Accelerometers - Right	Rear	X	AC-P51872	ENDEVCO	11/3/2020
	Front	Z	AC-P58893	ENDEVCO	11/3/2020
Seat belt Load Cells	Lap		IF-964-174-F0	FTSS IF-964	5/4/2019
	Shoulder		LC-292	GFE IF-964	5/12/2020

Table 2 – Front Passenger Dummy Instrumentation

Instrumentation		Axis/Location	Hybrid III 5th S/N: 140		
			Serial Number	Manufacturer	Calibration Date
Head Accelerometers	Primary	X	P79417	ENDEVCO	2/24/2021
		Y	P83335	ENDEVCO	2/24/2021
		Z	T11252	ENDEVCO	2/24/2021
	Redundant	X	P52008	ENDEVCO	2/24/2021
		Y	P52045	ENDEVCO	2/24/2021
		Z	P64149	ENDEVCO	2/24/2021
Head Angular Rate Sensors		X	ARS7370GFE	DTS ARS PRO-18K	8/4/2020
		Y	ARS14921GFE	DTS ARS PRO-18K	8/4/2020
		Z	ARS15212GFE	DTS PRO-8K 2KHz	8/4/2020
Upper Neck Load Cell		FX, Fy, Fz MX,MY, MZ	LC-1916Fx	DENTON	11/23/2020
Chest Accelerometers	Primary	X	T21142	ENDEVCO	2/24/2021
		Y	P83346	ENDEVCO	2/24/2021
		Z	P49190	ENDEVCO	2/24/2021
	Redundant	X	P58794	ENDEVCO	2/24/2021
		Y	AC-P79602	ENDEVCO	2/24/2021
		Z	T11253	ENDEVCO	2/24/2021
Chest Potentiometer		X	DS-140GFE	SERVO	2/24/2021
Pelvis Accelerometer		X	P58735	ENDEVCO	2/24/2021
		Y	P51285	ENDEVCO	2/24/2021
		Z	AC-P77587	ENDEVCO	2/24/2021
Femur Load Cells - Left	Primary	Z	LC-140Fz1	DENTON	7/9/2020
	Redundant	Z	LC-140Fz2	DENTON	7/9/2020
Femur Load Cells - Right	Primary	Z	LC-124Fz1	DENTON	11/23/2020
	Redundant	Z	LC-124Fz2	DENTON	11/23/2020
Tibia Load Cells - Left	Upper	MX, MY, FZ	LC-404Fz	DENTON	11/20/2020
	Lower	MX, MY, FZ	LC-398Fz	DENTON	11/20/2020
Tibia Load Cells – Right	Upper	MX, MY, FZ	LC-364Fz	DENTON	11/20/2020
	Lower	MX, MY, FZ	LC-396Fz	DENTON	11/20/2020
Foot Accelerometers - Left	Rear	X	AC-P78959	ENDEVCO	2/24/2021
	Front	Z	AC-P83418	ENDEVCO	2/24/2021
Foot Accelerometers - Right	Rear	X	P83428	ENDEVCO	11/20/2020
	Front	Z	AC-P80265	ENDEVCO	2/24/2021
Seat belt Load Cells	Lap		IF-964_278	GFE IF-964	5/12/2020
	Shoulder		IF-964_290	GFE IF-964	5/12/2020

Table 3 – Vehicle Instrumentation

Instrumentation			Axis	Serial Number	Manufacturer	Calibration Date
Crossmember/Rear Seat Accelerometers	Left	Primary	X	1201-1000_A280904	Measurement Specialties	11/4/2020
			Z	1201-1000_A335493	Measurement Specialties	11/4/2020
		Redundant	X	1201-1000_A301873	Measurement Specialties	11/4/2020
	Right	Primary	X	1201-1000_A280022	Measurement Specialties	11/4/2020
			Z	1201-1000_A284899	Measurement Specialties	11/4/2020
		Redundant	X	1201-1000_A281004	Measurement Specialties	11/19/2020
Engine Accelerometers	Top		X	1201-1000_A280010	Measurement Specialties	12/17/2020
	Bottom		X	1201-1000_A280352	Measurement Specialties	12/3/2020