REPORT NUMBER: NCAP-MGA-2010-006

NEW CAR ASSESSMENT PROGRAM
FRONTAL BARRIER IMPACT TEST

FUJI HEAVY INDUSTRIES LTD.
2010 SUBARU LEGACY 4-DR SEDAN
NHTSA NUMBER: MA5500

PREPARED BY:
MGA RESEARCH CORPORATION
5000 WARREN ROAD
BURLINGTON, WI 53105

Test Date: October 12, 2009

Final Report Date: June 18, 2010

FINAL REPORT

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

This final test report was prepared for the U.S. Department of Transportation, National Highway Traffic Safety Administration, in response to Contract Number DTNH22-06-D-00028.

Prepared by: Joe Fleck Date: 6/18/10
Joe Fleck, Project Engineer

Reviewed by: David Winkelbauer Date: 6/18/10
David Winkelbauer, Director of Operations

Technical Report Documentation Page

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15. Supplementary Notes			

16. Abstract

A frontal barrier impact was conducted on a 2010 Subaru Legacy 4-Dr Sedan at MGA Research Corporation on October 12, 2009. This test was conducted to obtain data indicant of FMVSS 208, 212, 219 (partial), 301, and foot well intrusion performance. The impact velocity was 56.3 km/h. The ambient temperature at the barrier face at the time of impact was 21 degrees Celsius. The vehicle's maximum post test static crush is 545 mm located at the vehicle's centerline. The test vehicle is equipped with a 3-point continuous belt system and an airbag in both front outboard seating positions. With respect to FMVSS 208 "Occupant Crash Protection", the occupant injury criteria summary is as follows:

Measurement Description	Units	Threshold	Driver ATD	Pass. ATD
Head Injury Criteria (HIC_{36})	N/A	1000	343	311
Max. Thorax Accel. (3ms Clip)	G's	60	46	41
Left Femur Force	Newton	10009	-1059	-2421
Right Femur Force	Newton	10009	-544	-1210

17. Key Words 56.3 km/h NCAP Frontal Barrier Impact Test New Car Assessment Program (NCAP) 2010 Subaru Legacy 4-Dr Sedan NHTSA No: MA5500		*18. Distribution Statement* Copies of this report are available from: National Highway Traffic Safety Adm. Technical Ref. Division, 1200 New Jersey Ave, SE Washington, D.C. 20590	
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SECTION 1

PURPOSE AND SUMMARY OF TEST

PURPOSE

This frontal barrier impact test is part of the Vehicle Barrier Impact Testing Program sponsored by the National Highway Traffic Safety Administration (NHTSA) under contract number DTNH22-06-D-00028. The purpose of this test was to obtain vehicle crashworthiness and occupant restraint system performance data for an impact in excess of the current 48.3 kph requirements.

SUMMARY

A load cell barrier was impacted by a 2010 Subaru Legacy 4-Dr Sedan at a velocity of 56.3 kph. The test was performed at MGA Research Corporation on October 12, 2009. Pre-and post-test photographs of the vehicle and dummies can be found in Appendix A.

One real-time camera and fourteen high-speed cameras were used to document the frontal barrier impact event. Camera locations and other pertinent camera information can be found in this report.

Two Part 572E, 50th percentile male anthropomorphic test devices (ATDs), were placed in the driver and right-front passenger seating positions according to dummy placement instructions specified in the Laboratory Indicant Test Procedure.

Both ATDs were fully instrumented with head, chest and pelvis tri-axial accelerometers, chest displacement potentiometer, upper neck transducers, right/left femur load cells, and lower leg instrumentation. The driver (position 1) ATD (Serial No. 066) and right-front passenger (position 2) ATD (Serial No. 065) were calibrated previous to this test. Certification details, along with instrumentation calibration data, are found in Appendix C.

The 102 channels of data were recorded on an on-board data acquisition system. Appendix B contains the dummy head, chest, and femur response data traces.

There was 100 percent windshield retention and no intrusion into the protected zone of the windshield during the event. There was no Stoddard Solvent leakage after the event or during any phase of the static rollover.

The maximum static crush of the vehicle was 545 mm and both the driver and passenger side door remained closed and latched during the impact event and were operable after the impact.

The driver's head and chest contacted the airbag. The driver's head also contacted the headrest. The driver's knees contacted the knee bolster. The passenger's head and chest contacted the airbag. The passenger's knees contacted the glove box and frontal airbag.

The occupant data is summarized below:

ATD position	HIC	T^1	T^2	Clip (g)	T^1	T^2	Chest Disp. (mm)	Left Femur (N)	Right Femur (N)
Driver	343	52.5	88.5	46	70.2	73.2	-20	-1059	-544
Passenger	311	60.5	96.5	41	69.2	72.2	-19	-2421	-1210

The test data can be found on the NHTSA website at www.nhtsa.dot.gov.

TEST NOTES

There was no valid data collected for:

Passenger Chest Z Redundant after 120 msec.
Top of Engine X after 40 msec.
Bottom of Engine X after 40 msec.
Left Brake Caliper X
Right Brake Caliper X

SECTION 2

OCCUPANT AND VEHICLE INFORMATION / DATA SHEETS

DATA SHEET NO. 1

CRASH TEST SUMMARY

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan
Test Program: 35mph Frontal Impact
NHTSA No.: MA5500
Test Date: 10/12/2009

DOOR OPENING AND SEAT TRACK INFORMATION

Description	Driver	Passenger
Locked/Unlocked Doors	Doors were unlocked	Doors were unlocked
Front Door Opening	Door remained closed and latched; Door opened without tools	Door remained closed and latched; Door opened without tools
Rear Door Opening	Door remained closed and latched; Door opened without tools	Door remained closed and latched; Door opened without tools
Seat Track Shift (mm)	None	None
Seat Back Failure	None	None
Glazing Damage	None	

VEHICLE REBOUND FROM BARRIER

Measured Parameter	Units	Value
Left Side	mm	1105
Center	mm	1165
Right Side	mm	1120
Average	mm	1130

BELT LENGTH DATA

Measurement Description	Units	Driver	Passenger
Shoulder belt length as measured on ATD	mm	845	845
Lap belt length as measured on ATD	mm	760	820
Remainder of belt on reel	mm	995	955
Total belt length for continuous webbing systems	mm	2600	2620

DATA SHEET NO. 2

GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan
Test Program: 35mph Frontal Impact
NHTSA No.: MA5500
Test Date: 10/12/2009

TEST VEHICLE INFORMATION

Manufacturer	Subaru
Model	Legacy
Body Style	Sedan
NHTSA No.	MA5500
VIN	4S3BMBA6XA3214750
Color	Ruby Red Pearl
Delivery Date	9/24/2009
Odometer Reading (mile)	175 miles
Dealer	Wilde Subaru
Transmission	Automatic
Final Drive	AWD
Number of Cylinders	4
Engine Displacement (L)	2.5
Engine Placement	Longitudinal
Automatic Door Lock (ADL)	No
Owners Manual Details Instructions on Disabling ADLs	N/A
Bucket Seats	Yes

TEST VEHICLE OPTIONS

Front Airbag	Yes
Driver Side Curtain Airbag	Yes
Driver Side Torso Airbag	Yes
Driver Knee Airbag	No
Passenger Side Curtain Airbag	Yes
Passenger Side Torso Airbag	Yes
Passenger Knee Airbag	No
Force Limiter	Yes
Pretensioner	Yes
Power Steering	Yes
Power Door Locks	Yes
Tilt Wheel	Yes
Air Conditioning	Yes
Anti-lock Brakes	Yes
Traction Control	Yes
All Wheel Drive	Yes
Power Seats	No

DATA FROM CERTIFICATION LABEL

Manufactured By	Fuji Heavy Industries Ltd.
Date of Manufacture	07/09

GVWR (kg)	2010
GAWR Front (kg)	1070
GAWR Rear (kg)	1060

Measured Parameter	Front	Rear	Third	Total
Type of Seats	Bucket	Bucket		
Number of Occupants	2	3		5
Capacity Wt. (VCW) (kg)				385
Cargo Wt. (RCLW) (kg)				45

DATA SHEET NO. 2... (CONTINUED)

GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

TEST VEHICLE WEIGHTS

	Units	As Delivered (UVW) (Axle)			As Tested (ATW) (Axle)		
		Front	Rear	Total	Front	Rear	Total
Left	kg	452.2	332.5		492.1	386.9	
Right	kg	441.4	315.7		476.3	379.2	
Ratio	%	58.0	42.0		55.8	44.2	
Totals	kg	893.6	648.2	1541.8	968.4	766.1	1734.5

TARGET TEST WEIGHT CALCULATION

Measured Parameter	Units	Value
Total Delivered Weight (UVW)	kg	1541.8
Weight of 2 P572E ATDs	kg	156.0
Rated Cargo/Luggage Weight (RCLW)	kg	45
Calculated Vehicle Target Weight (TVTW)	kg	1742.8

TEST VEHICLE ATTITUDES AND CG

	Units	LF	RF	LR	RR	CG (aft of front axle)
As Delivered	mm	700	710	705	715	1156
As Tested	mm	687	692	685	687	1215
Post Test	mm	714	763	664	690	

Vehicle Wheelbase (mm): 2750

Weight of Ballast secured in trunk (kg): 11.3

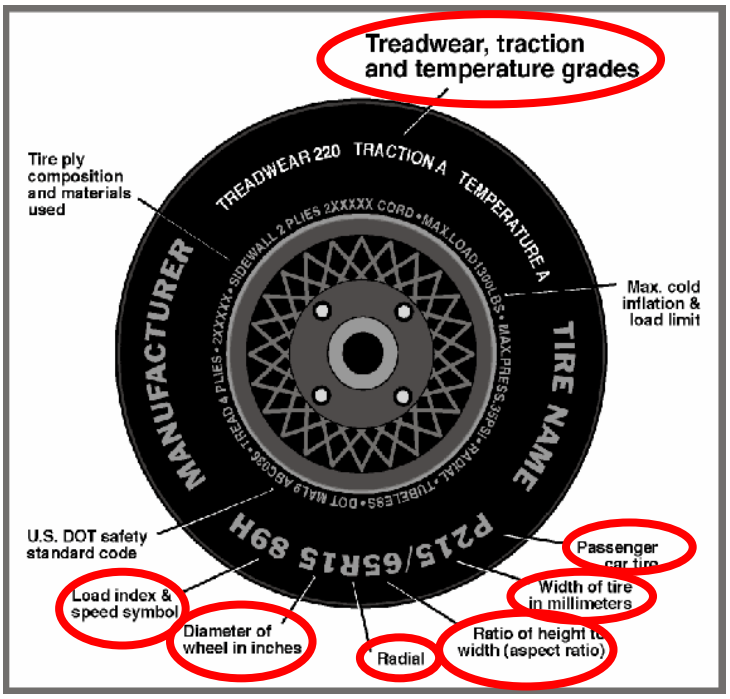
Vehicle Components Removed: Spare tire, trunk interior, right rear taillight

Ballast weight does not include instrumentation and data acquisition system.

DATA SHEET NO. 3

TEST VEHICLE TIRE INFORMATION

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009



DATA FROM TIRE AND TIRE PLACARD

Measured Parameter	Front	Rear
Maximum Tire Pressure (kPa)	350	350
Cold Pressure (kPa)	230	220
Recommended Tire Size	P205/60R16	P205/60R16
Tire Size on Vehicle	P205/60R16	P205/60R16
Tire Manufacturer	Bridgestone	Bridgestone
Tire Name	Turanza	Turanza
Tire Type	P	P
Tire Width (mm)	205	205
Ratio of Height to Width (aspect ratio)	60	60
Radial	R	R
Wheel Diameter	16	16
Load Index & Speed Symbol	91V	91V
Treadwear	260	260
Traction Grade	A	A
Temperature Grade	A	A

DATA SHEET NO. 4

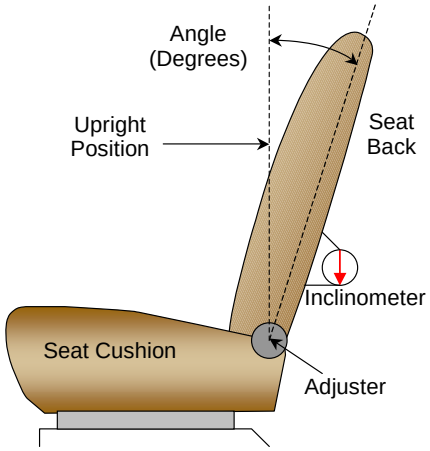
TEST VEHICLE INFORMATION

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

NOMINAL DESIGN RIDING POSITION

The driver and passenger seat back is positioned to the manufacturer's designated angle/detent. The procedure is as follows: Set the driver seat back in the 8th detent; passenger seat back in the 9th detent (forward-most detent defined as 0).

Driver seat back angle: 8th detent (forward-most as 0)
Passenger seat back angle: 9th detent (forward-most as 0)



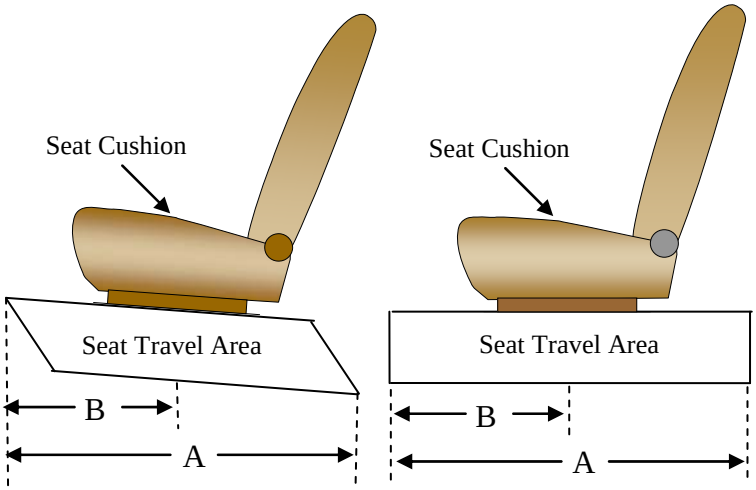
FRONT SEAT ASSEMBLY

SEAT FORE/AFT POSITIONING

	Total Fore/Aft Travel	Placed in Position #
Driver Seat	26 detents	10th detent (forward-most as 0)
Passenger Seat	26 detents	13th detent (forward-most as 0)

ADJUSTABLE D-RING POSITION

The driver and passenger D-rings were set in the first notch (uppermost position as 0).



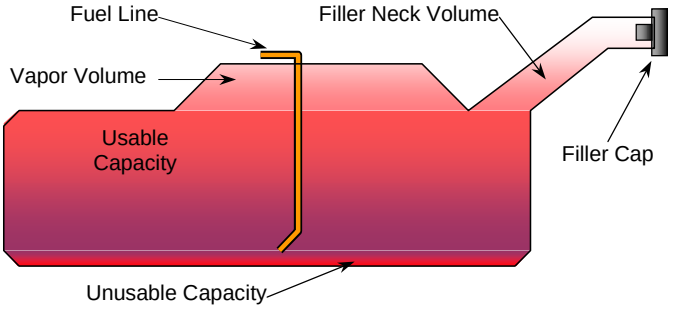
DATA SHEET NO. 4…(CONTINUED)
TEST VEHICLE INFORMATION

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

FUEL TANK CAPACITY

	Liters
Usable Capacity of "Standard Tank"	70.0
Usable Capacity of "Optional" Tank	
92-94% of Usable Capacity	64.4 to 65.8
Actual Amount of Solvent used	65.5
1/3 of Usable Capacity	23.3

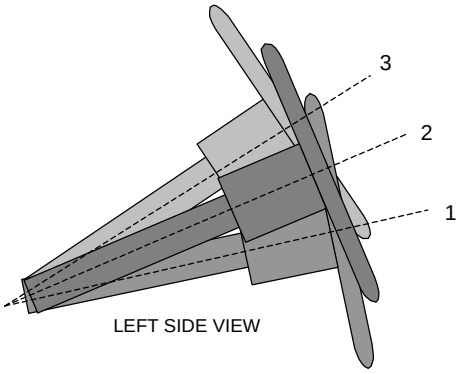
The test vehicle is equipped with an electric fuel pump. Pump operates a few seconds after an ignition switch is turned ON. After that, pump operates only while engine is running.



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. An aluminum plate is placed across the rim of the steering wheel, an inclinometer is placed on the plate and the angle is measured.



STEERING COLUMN ASSEMBLY

STEERING COLUMN POSITIONS

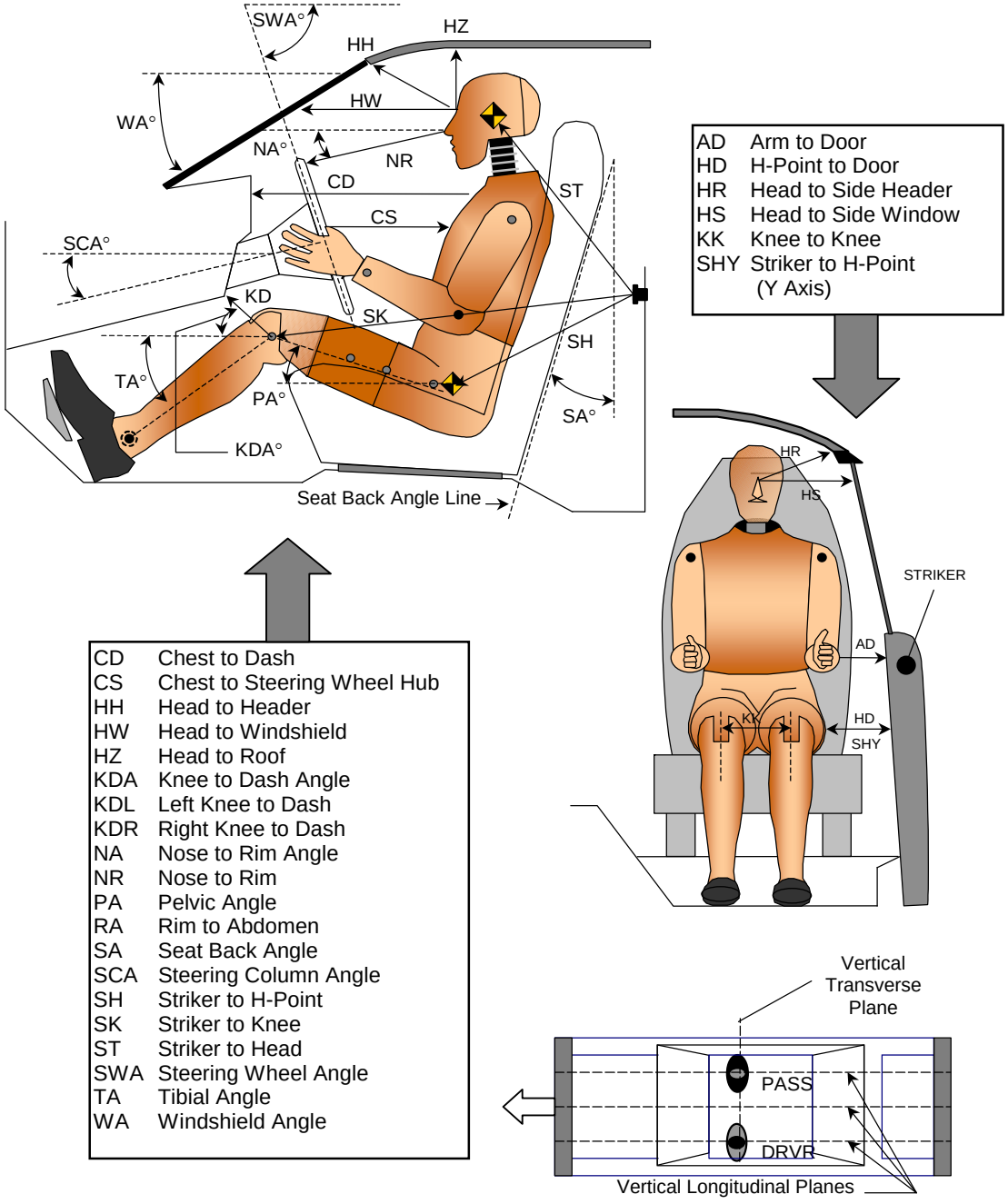
	Fore/Aft Position (mm)	Degrees
Lowermost position No. 1	130	65.6
Geometric center position No. 2	150	67.3
Uppermost position No. 3	170	68.8

DATA SHEET NO. 5

DUMMY POSITIONING IN VEHICLE

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

DUMMY MEASUREMENTS FOR FRONT SEAT OCCUPANTS



DATA SHEET NO. 5... (CONTINUED)

DUMMY POSITIONING IN VEHICLE

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

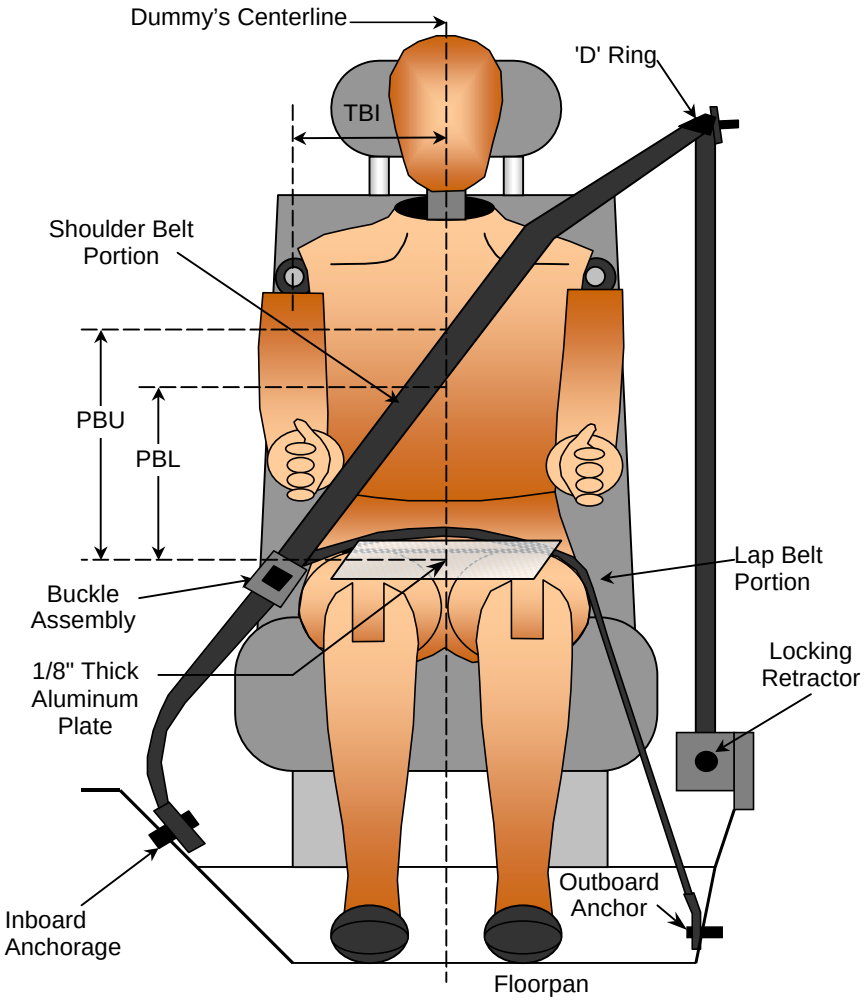
TEST DUMMY POSITION MEASUREMENTS

Code	Measurement Description	Driver		Passenger	
		Length (mm)	Angle (°)	Length (mm)	Angle (°)
WA	Windshield Angle		29.0		
SWA	Steering Wheel Angle		67.3		
SCA	Steering Column Angle		22.8		
SA	Seat Back Angle (headrest post)		7.5		8.6
HZ	Head to Roof (Z)	227	90	221	90
HH	Head to Header	348	29.8	369	26.3
HW	Head to Windshield	735	0	690	0
HR	Head to Side Header (Y)	247		243	
NR	Nose to Rim	395	5.6		
CD	Chest to Dash	518		575	
CS	Chest to Steering Hub	317	1.7		
RA	Rim to Abdomen	202	0		
KDL	Left Knee to Dash	178	24.5	185	
KDR	Right Knee to Dash	170		182	22.3
PA	Pelvic Angle		24.4		24.6
TA	Tibia Angle		41.7		37.3
KK	Knee to Knee (Y)	310		270	
SK	Striker to Knee	618	98.9	612	97.9
ST	Striker to Head	487	14.2	472	8.8
SH	Striker to H-Point	305	129.0	286	126.4
SHY	Striker to H-Point (Y)	255		240	
HS	Head to Side Window	348		340	
HD	H-Point to Door (Y)	151		132	
AD	Arm to Door (Y)	112		122	
AA	Ankle to Ankle	315		235	

DATA SHEET NO. 6

SEAT BELT POSITIONING DATA

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan
Test Program: 35mph Frontal Impact
NHTSA No.: MA5500
Test Date: 10/12/2009



SEAT BELT POSITIONING MEASUREMENTS

Measurement Description	Units	Driver	Passenger
PBU - Top surface of reference to belt upper edge	mm	340	320
PBL - To surface of reference to belt lower edge	mm	265	295

DATA SHEET NO. 7

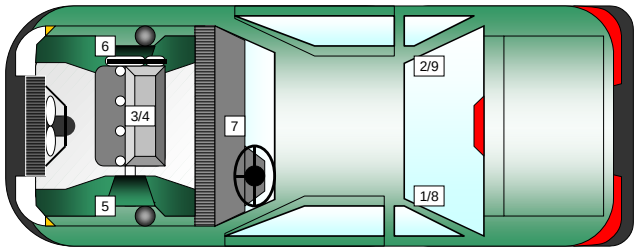
VEHICLE ACCELEROMETER LOCATIONS

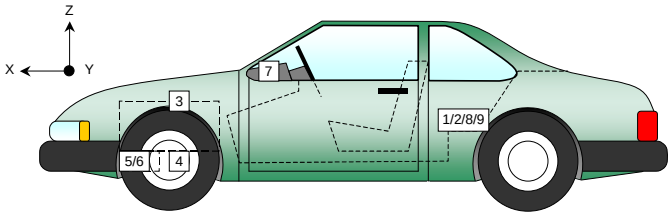
Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan
Test Program: 35mph Frontal Impact
NHTSA No.: MA5500
Test Date: 10/12/2009

VEHICLE ACCELEROMETER PRE-TEST LOCATIONS

No.	Accelerometer Location	Measurements (mm)		
		X	Y	Z
1	Left Rear X-Member X	1887	-381	-386
2	Right Rear X-Member X	1885	370	-394
3	Engine Top X	3988	-5	-850
4	Engine Bottom X	3980	0	-215
5	Left Brake Caliper X	3625	-695	-255
6	Right Brake Caliper X	3625	695	-255
7	Instrument Panel X			
8	Left Rear X-Member Z	1887	-381	-386
9	Right Rear X-Member Z	1885	370	-394

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





DATA SHEET NO. 8

SUMMARY OF FMVSS 212 AND FMVSS 219 (Partial) DATA

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

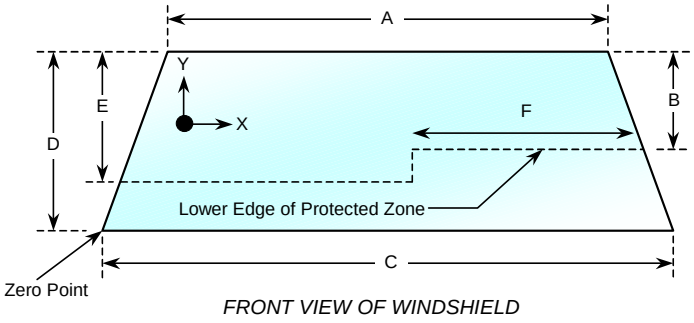
Windshield Mounting Details:
Windshield glass is secured to the vehicle frame with a rubber trim and glue.

The standard requires that the post-test retention measurement be a minimum of 75 percent of the pretest total periphery measurement for vehicles not equipped with occupant passive restraints and 50 percent 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)	% of Retention
Left Side	2157	2157	100
Right Side	2157	2157	100
Total	4314	4314	100



FRONT VIEW OF WINDSHIELD

Item	Units	Value
A	mm	1240
B	mm	509
C	mm	1440
D	mm	817
E	mm	563
F	mm	511

AREA OF PROTECTED ZONE FAILURES - NONE

A. Provide coordinates of the area that the protected zone was penetrated more than 0.25 inches by a vehicle component other than one that is normally in contact with the windshield. **None**

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. **None**

X	Y

DATA SHEET NO. 9

SUMMARY OF FMVSS 301 DATA

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

FMVSS 301 FUEL SYSTEM INTEGRITY POST IMPACT DATA

Temperature at Time of Impact: 21° C Test Time: 11:04 am

Stoddard Solvent Spillage Measurements

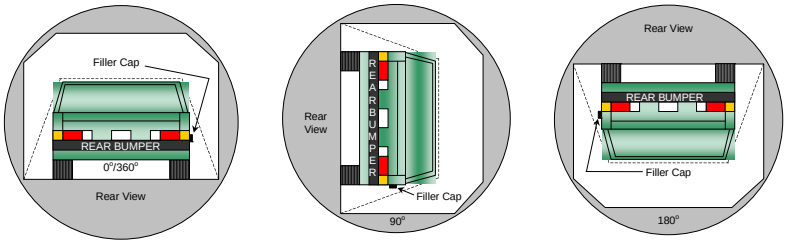
A. From impact until vehicle motion ceases: 0 oz.
(Maximum Allowable = 1 ounce)

B. For the 5 minute period after motion ceases: 0 oz.
(Maximum Allowable = 5 ounces)

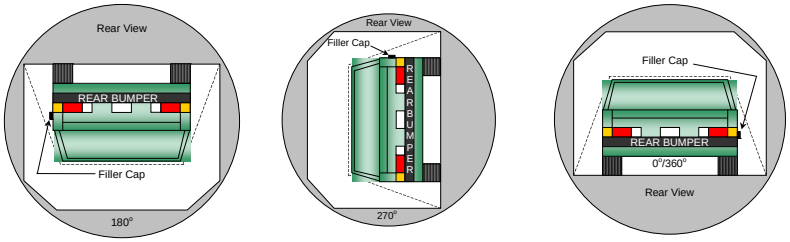
C. For the following 25 minutes: 0 oz.
(Maximum Allowable = 1 oz. /minute)

D. Spillage: None

FMVSS 301 STATIC ROLLOVER DATA



0° to 90° 90° to 180°



180° to 270° 270° to 360°

1. The specified fixture rollover rate for each 90° of rotation is 60 to 180 seconds.

2. The position hold time at each position is 300 seconds (minimum).

3. Details of Stoddard Solvent spillage locations:

None

Test Phase	Rotation Time (sec.)	Hold Time (sec.)	Spillage (oz.)
0° to 90°	114	300	0
90° to 180°	110	300	0
180° to 270°	105	300	0
270° to 360°	116	300	0

DATA SHEET NO. 10

VEHICLE MEASUREMENTS

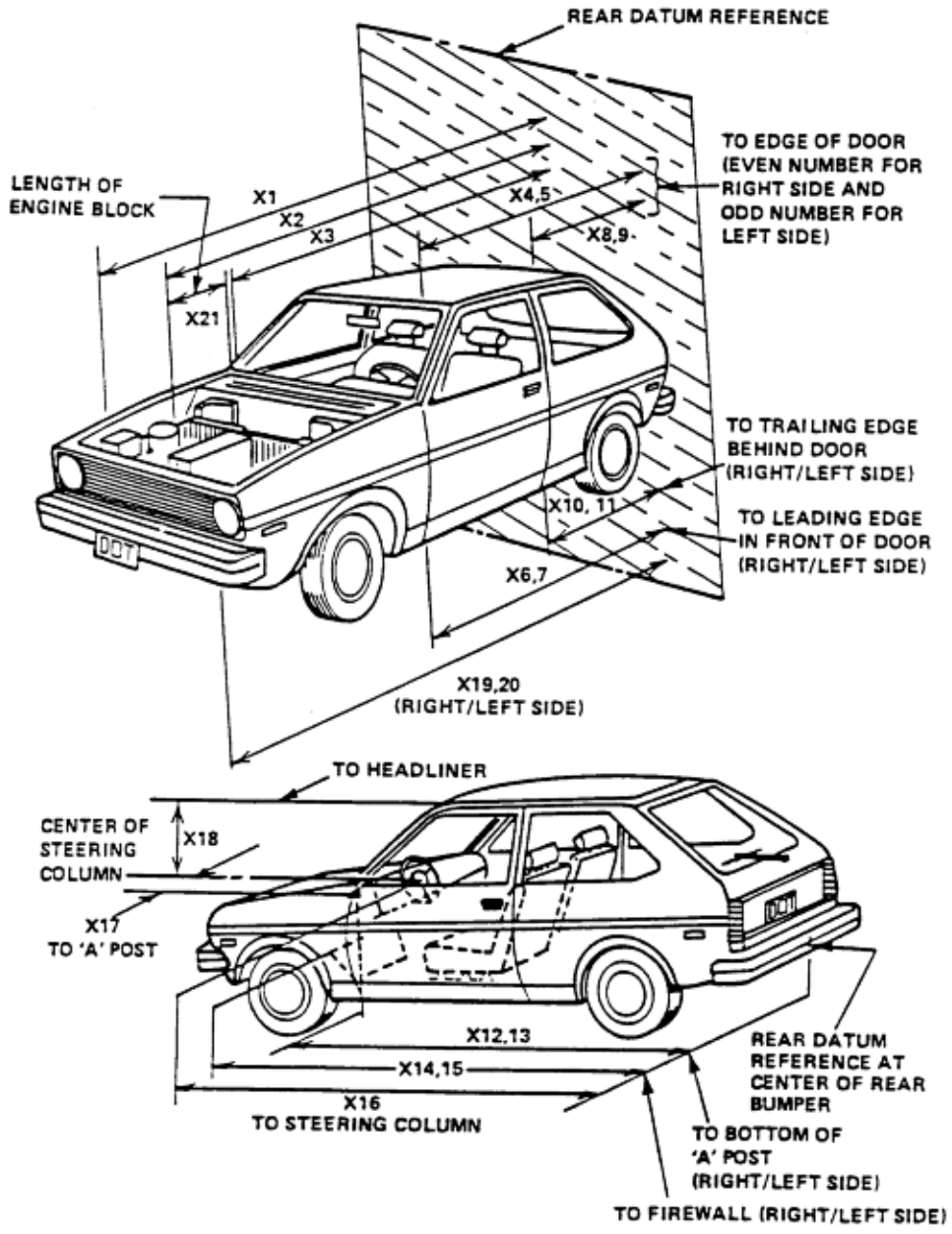
Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

No.	Measurement Description	Units	Pre-Test	Post-Test	Difference
1	Total length of vehicle at centerline	mm	4715	4170	545
2	RSOV to front of engine	mm	4195	3942	253
3	RSOV to firewall centerline	mm	3594	3528	66
4	RSOV to leading edge of right door	mm	3237	3235	2
5	RSOV to leading edge of left door	mm	3245	3240	5
6	RSOV to lower leading edge of right door	mm	3251	3251	0
7	RSOV to lower leading edge of left door	mm	3252	3251	1
8	RSOV to upper leading edge of right door	mm	2132	2126	6
9	RSOV to upper leading edge of left door	mm	2130	2133	-3
10	RSOV to lower trailing edge of right door	mm	2153	2150	3
11	RSOV to lower trailing edge of left door	mm	2153	2150	3
12	RSOV to bottom of right 'A' pillar	mm	3253	3260	-7
13	RSOV to bottom of left 'A' pillar	mm	3255	3256	-1
14	RSOV to firewall on right side	mm	3565	3555	10
15	RSOV to firewall on left side	mm	3553	3540	13
16	RSOV to steering column	mm	2765	2800	-35
17	Center of steering column to left 'A' pillar	mm	375	348	27
18	Center of steering column to headlining	mm	437	440	-3
19	RSOV to right side of front bumper	mm	4560	4114	446
20	RSOV to left side of front bumper	mm	4572	4122	450
21	Length of engine block	mm	430	430	0
RD	RSOV to right side of dash panel	mm	2968	2969	-1
CD	RSOV to center of dash panel	mm	2946	2950	-4
LD	RSOV to left side of dash panel	mm	2968	2974	-6

DATA SHEET NO. 10... (continued)

VEHICLE MEASUREMENTS

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009



DATA SHEET NO. 10... (continued)

VEHICLE MEASUREMENTS

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

Target Vehicle Structural Measurement

	Elements	Pre-Test (mm)
1	Total Length	4715
2	Total Width	1820
3	Bumper Top Height	555
4	Bumper Bottom Height	410
5	Longitudinal Member Top Height	470
6	Distance between Longitudinal Members	1017
7	Longitudinal Member Width	64
8	Engine Top Height	846
9	Engine Bottom Height	219
10	Engine and gearbox width	740
11	Front bumper-engine distance	465
12	Front shock absorber fixing height	860
13	Bonnet leading edge height	788
14	Front shock absorber fixing width	1145
15	Front bumper – front axle distance	954
16	Front axle – a pillar distance	470
17	A-pillar – B-pillar distance	1115
18	B-Pillar – rear axle distance	1164
19	B-pillar – C-pillar distance	1110
20	Roof sill bottom height	1344
21	Roof sill top height	1456
22	Floor sill bottom height	195
23	Floor sill top height	344

DATA SHEET NO. 11

CAMERA LOCATIONS

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

No.	Camera View	Location (mm) *			Lens (mm)	Speed (fps)
		X	Y	Z		
1	Real-Time Left Side View				13	24
2	Left Front View	1080	-5230	-1040	24	1000
3	Steering Column Top	825	-5660	-1280	25	1000
4	Steering Column Bottom	810	-5670	-850	25	1000
5	Driver Close-up	1530	-6490	-1490	35	1000
6	Driver Angle	5290	-5230	-1890	50	1000
7	On board Driver Side					
8	On board Passenger Side					
9	Right Overall	2020	6720	-1200	20	1000
10	Right Passenger Half	1120	5190	-1020	24	1000
11	Right Close-up	1560	6450	-1410	35	1000
12	Right Angle	5420	5190	-1840	50	1000
13	Windshield	-285	0	-2860	12.5	1000
14	Top Driver	-135	-470	-2180	24	1000
15	Top Passenger	-110	420	-2180	24	1000
16	Pit Front	1260	0	3150	24	1000
17	Pit Rear	3280	0	3150	24	1000

*COORDINATES:

+X = forward of impact plane
+Y = right of monorail centerline
+Z = below ground level

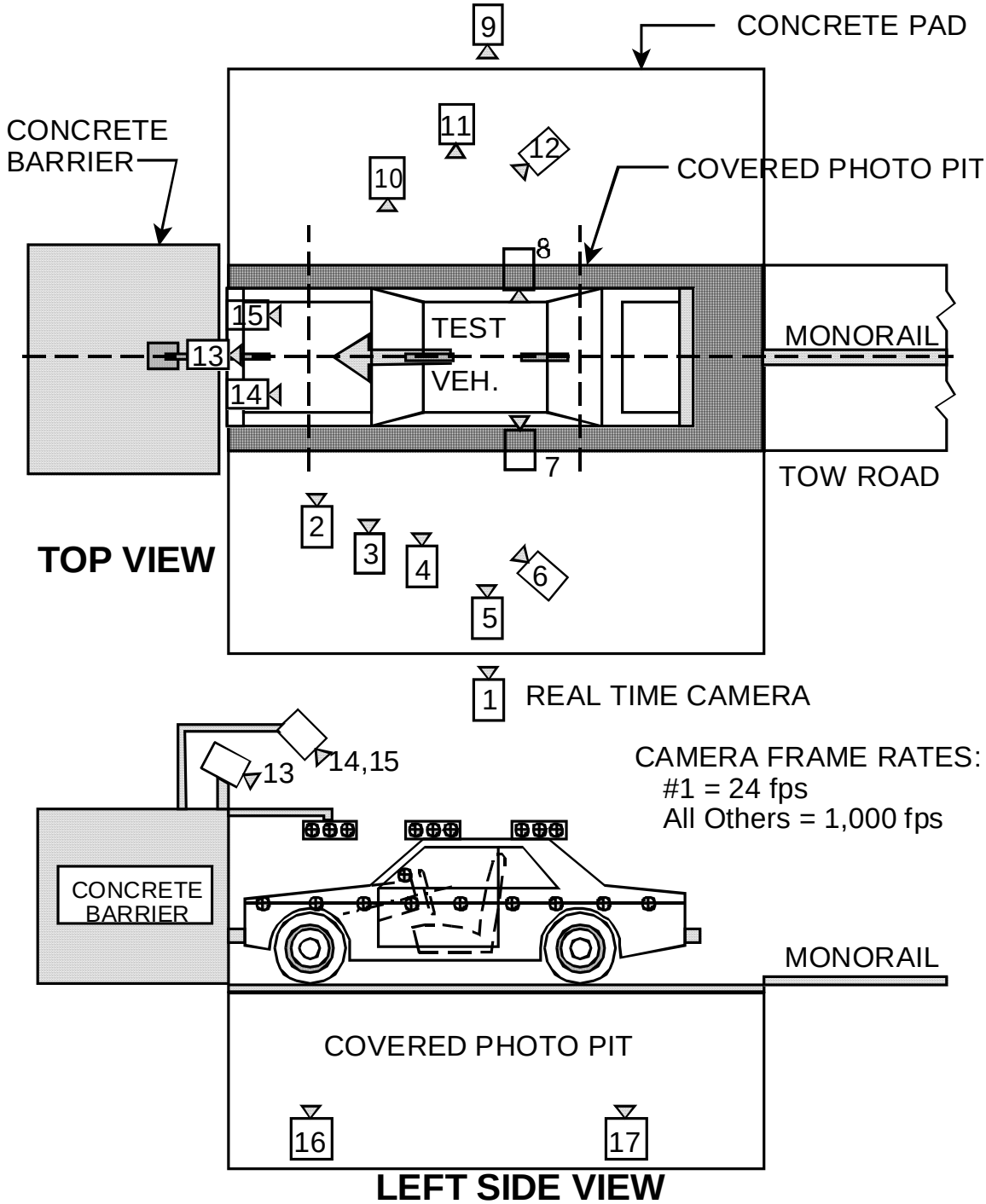
Cameras 7 & 8 were not used for this test.

DATA SHEET NO. 11... (continued)

CAMERA LOCATIONS

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

CAMERA POSITIONS FOR FRONTAL IMPACTS



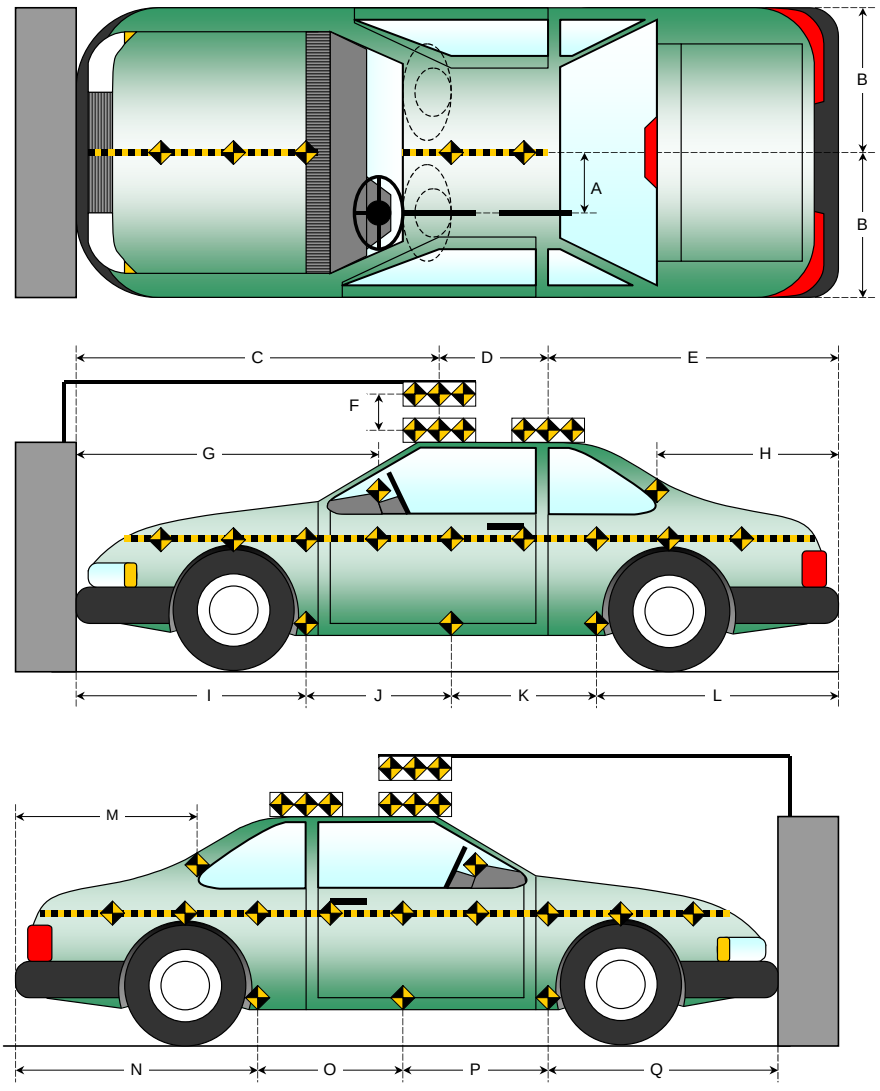
DATA SHEET NO. 12

PHOTOGRAPHIC REFERENCE TARGET LOCATIONS

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan
Test Program: 35mph Frontal Impact

NHTSA No.: MA5500
Test Date: 10/12/2009

Item	Value
A	375
B	910
C	2415
D	915
E	1385
F	105
G	
H	1045
I	1396
J	941
K	938
L	1440
M	1020
N	1440
O	939
P	941
Q	1395



DATA SHEET NO. 13

VEHICLE INTRUSION MEASUREMENTS

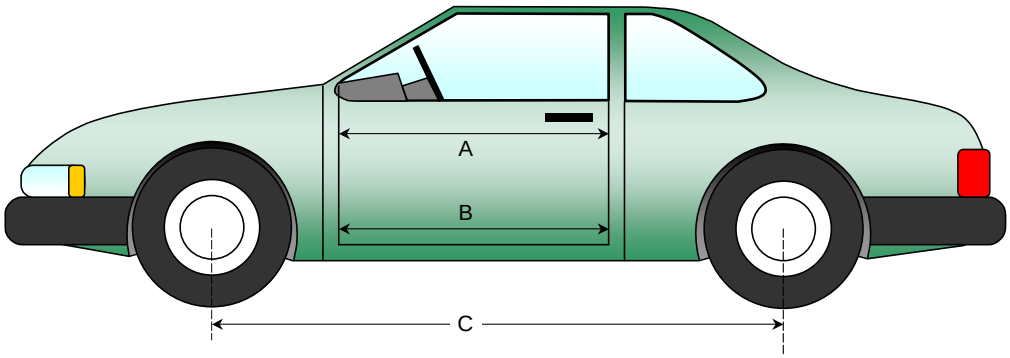
Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan
Test Program: 35mph Frontal Impact
NHTSA No.: MA5500
Test Date: 10/12/2009

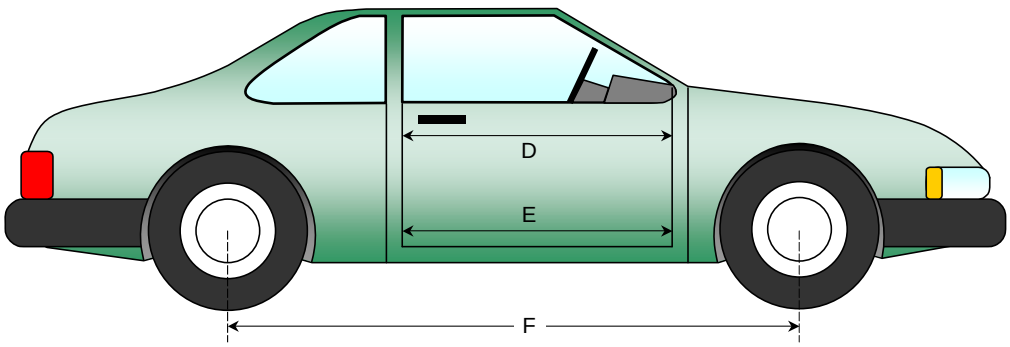
DOOR OPENING WIDTH

Item	Description	Units	Pre-Test	Post-Test	Difference
A	Left Side Upper	mm	1025	1023	2
B	Left Side Lower	mm	845	845	0
D	Right Side Upper	mm	1027	1025	2
E	Right Side Lower	mm	835	834	1

WHEELBASE MEASUREMENTS

Item	Description	Units	Pre-Test	Post-Test	Difference
C	Left Side Wheelbase	mm	2750	2745	5
F	Right Side Wheelbase	mm	2750	2729	21





DATA SHEET NO. 13... (continued)

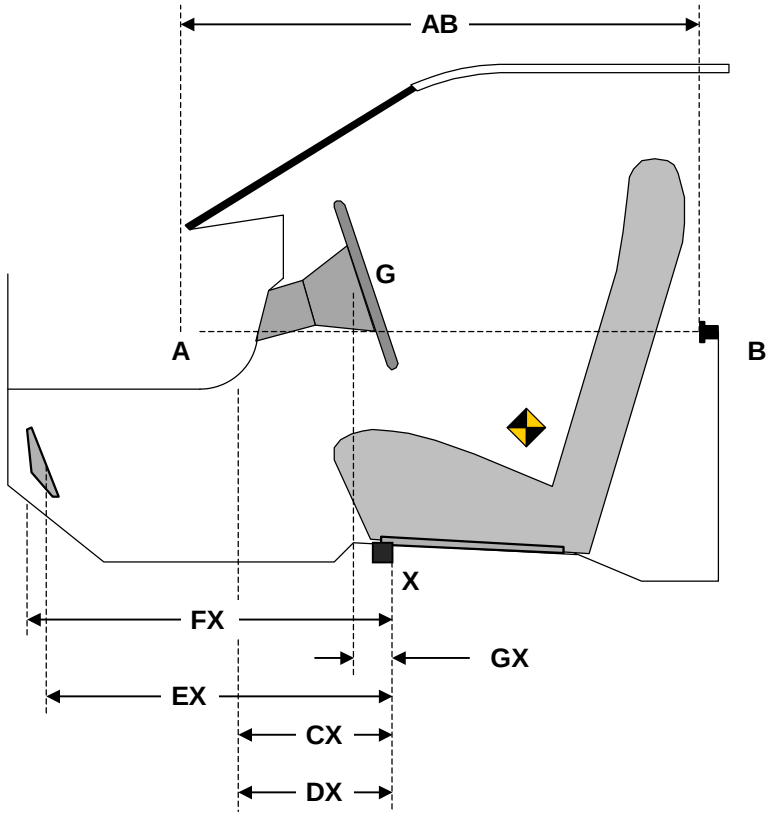
VEHICLE INTRUSION MEASUREMENTS

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

DRIVER COMPARTMENT INTRUSION

Item	Description	Units	Pre-Test	Post-Test	Difference
AB	Door Opening (Inside window jam)	mm	842	840	2
CX	Left Knee Bolster to X	mm	266	272	-6
DX	Right Knee Bolster to X	mm	271	266	5
EX	Brake Pedal to X	mm	564	555	9
FX	Foot Rest to X	mm	568	563	5
GX	Center of Steering Column Wheel Hub to X	mm	40	74	-34

X = Front of Seat Track (stationary)

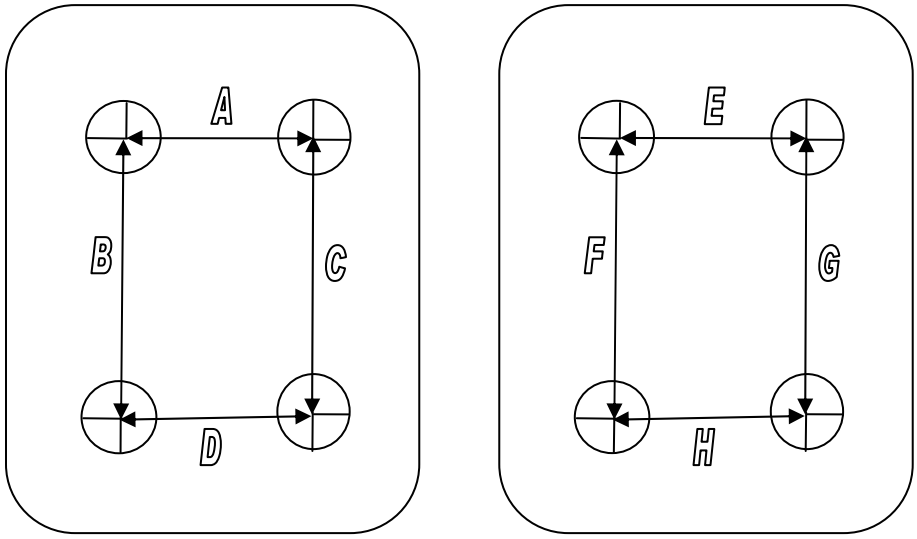


DRIVER COMPARTMENT

DATA SHEET NO. 13... (continued)

VEHICLE INTRUSION MEASUREMENTS

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009



Driver Passenger

UNDERBODY FLOORBOARD DEFORMATION

Measurement	Pre-Test	Post-Test	Difference
A	308	302	6
B	430	432	-2
C	442	444	-2
D	302	302	0
E	330	330	0
F	325	325	0
G	305	305	0
H	330	330	0

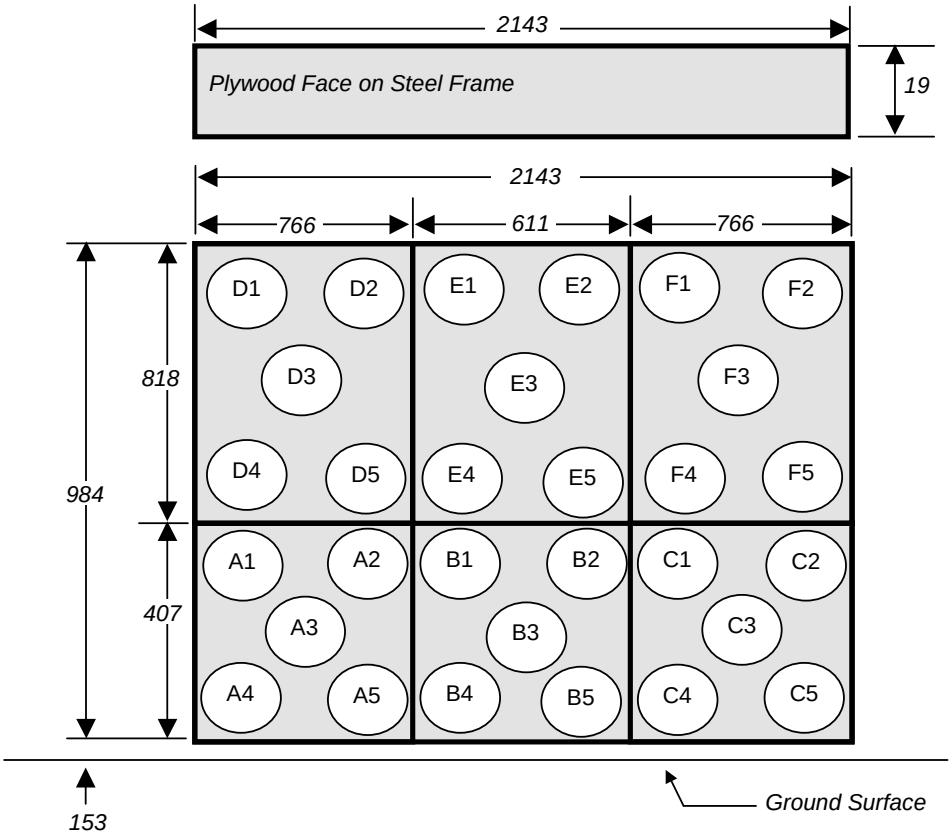
DATA SHEET NO. 14

LOAD CELL LOCATIONS ON FIXED BARRIER

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

30 Load Cell Rigid Barrier

Load Cell Locations on Fixed Barrier



Group 4 D1-D5	Group 5 E1-E5	Group 6 F1-F5
Group 1 A1-A5	Group 2 B1-B5	Group 3 C1-C5

6 Groups of 5 Load Cells Each

DATA SHEET NO. 15

ACCIDENT INVESTIGATION DIVISION DATA

Test Vehicle: 2010 Subaru Legacy 4-Dr Sedan NHTSA No.: MA5500
Test Program: 35mph Frontal Impact Test Date: 10/12/2009

VEHICLE INFORMATION

VIN: 4S3BMBA6XA3214750 Wheelbase (mm): 2750
Vehicle Size Category: Sedan Test Weight (kg): 1734.5

ACCELEROMETER DATA

Accelerometer Locations: As per measurements on Page 12
Cal. Procedure/Interval: MGA procedure / 6 month
Integration Algorithm: Trapezoidal Linearity: > 99%
Impact Velocity (km/h): 56.3
Velocity Change (km/h): 60.9 Time of Separation (msec): 87

CRUSH PROFILE

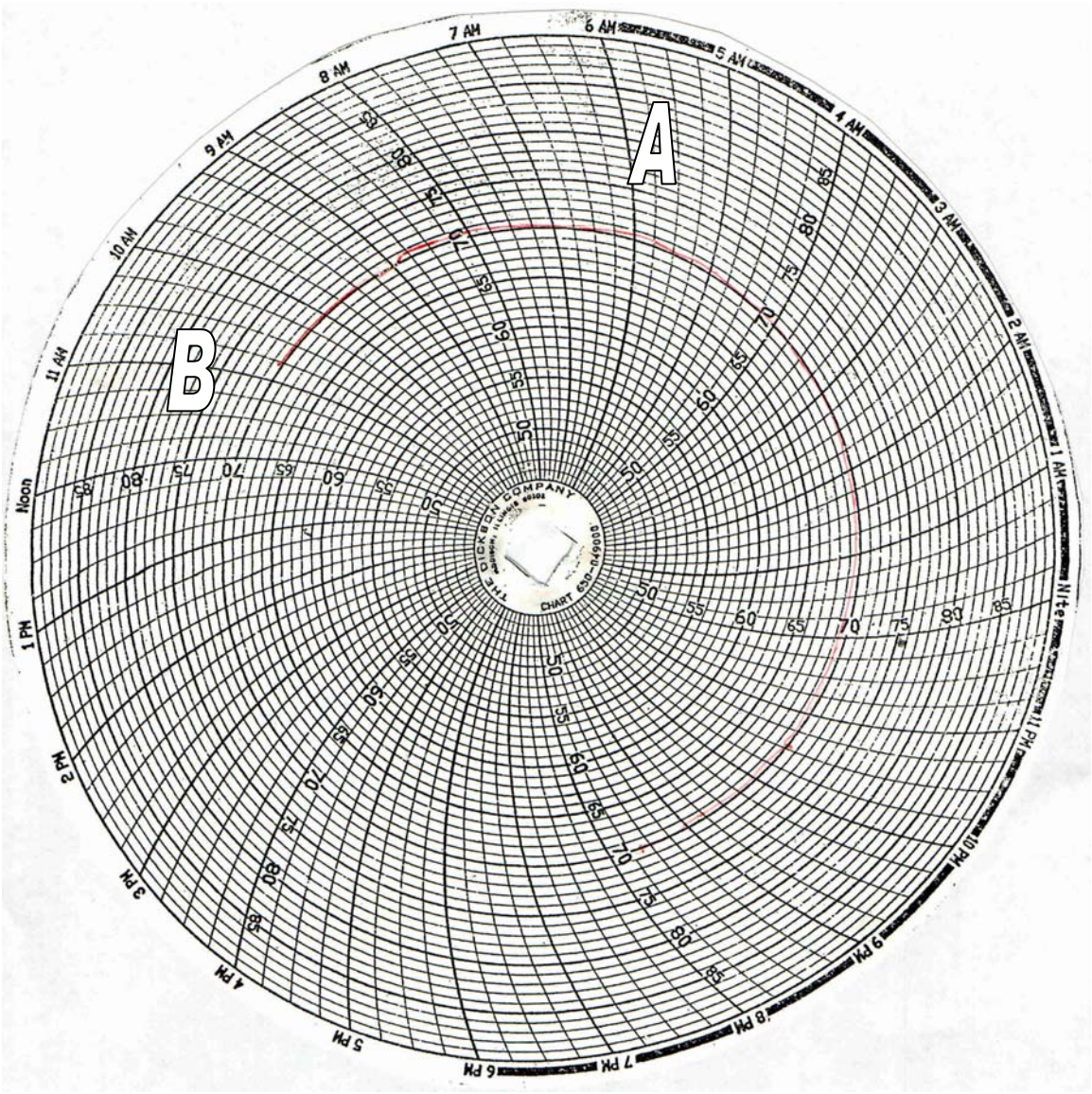
Collision Deformation Classification: Frontal Midpoint of Damage: Centerline
Damage Region Length (mm): 1435 Impact Mode: Frontal

No.	Measurement Description	Units	Pre-Test	Post-Test	Difference
C1	Crush zone 1 at left side	mm	4572	4122	450
C2	Crush zone 2 at left side	mm	4680	4171	509
C3	Crush zone 3 at left side	mm	4711	4175	536
C4	Crush zone 4 at right side	mm	4712	4183	529
C5	Crush zone 5 at right side	mm	4674	4156	518
C6	Crush zone 6 at right side	mm	4560	4114	446
L	C1 TO C6	mm	1435	1270	165

DATA SHEET NO. 16

DUMMY / VEHICLE TEMPERATURE STABILIZATION CHART

Test Vehicle:	2010 Subaru Legacy 4-Dr Sedan	NHTSA No.:	MA5500
Test Program:	35mph Frontal Impact	Test Date:	10/12/2009



A = Dummies installed in vehicle at 6:00 am

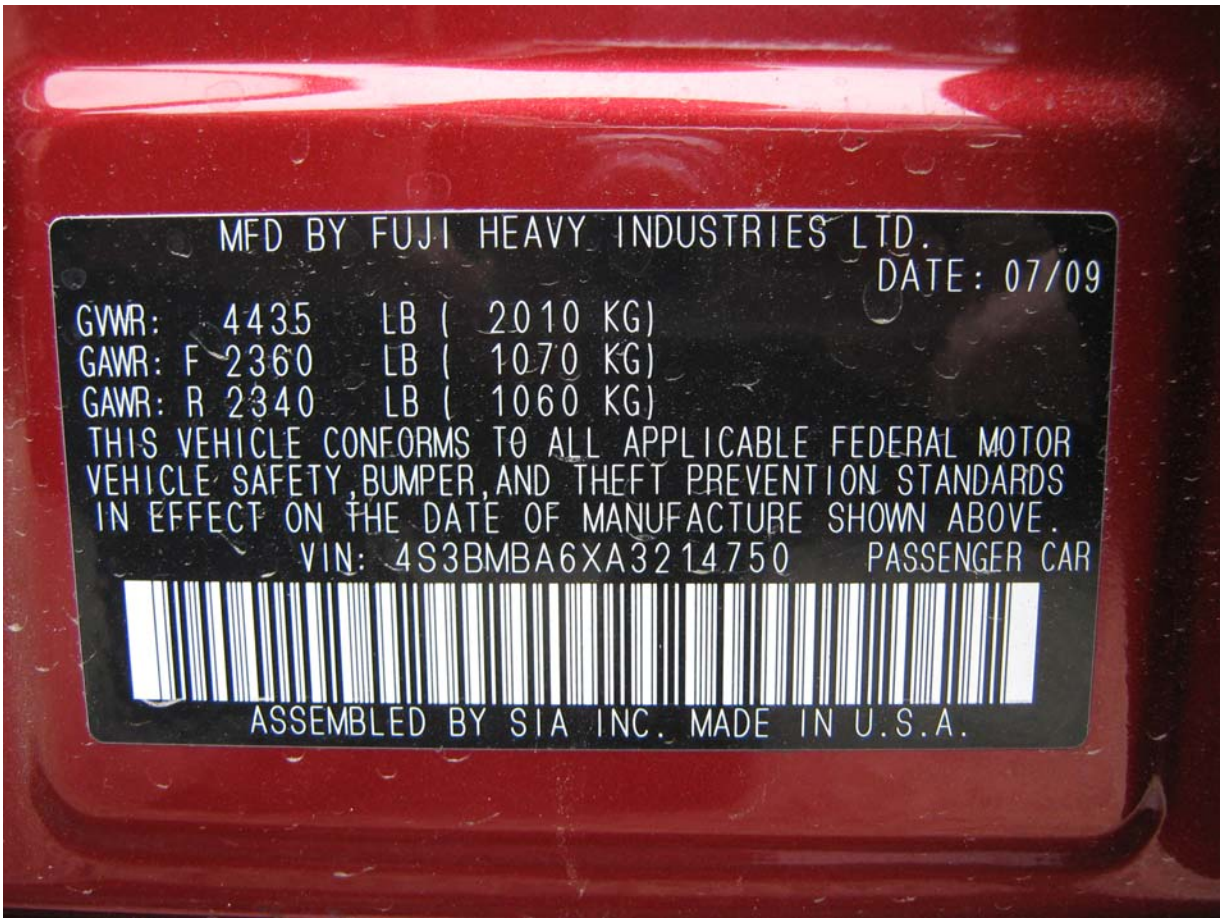
B = Test conducted at 11:04 am

APPENDIX A

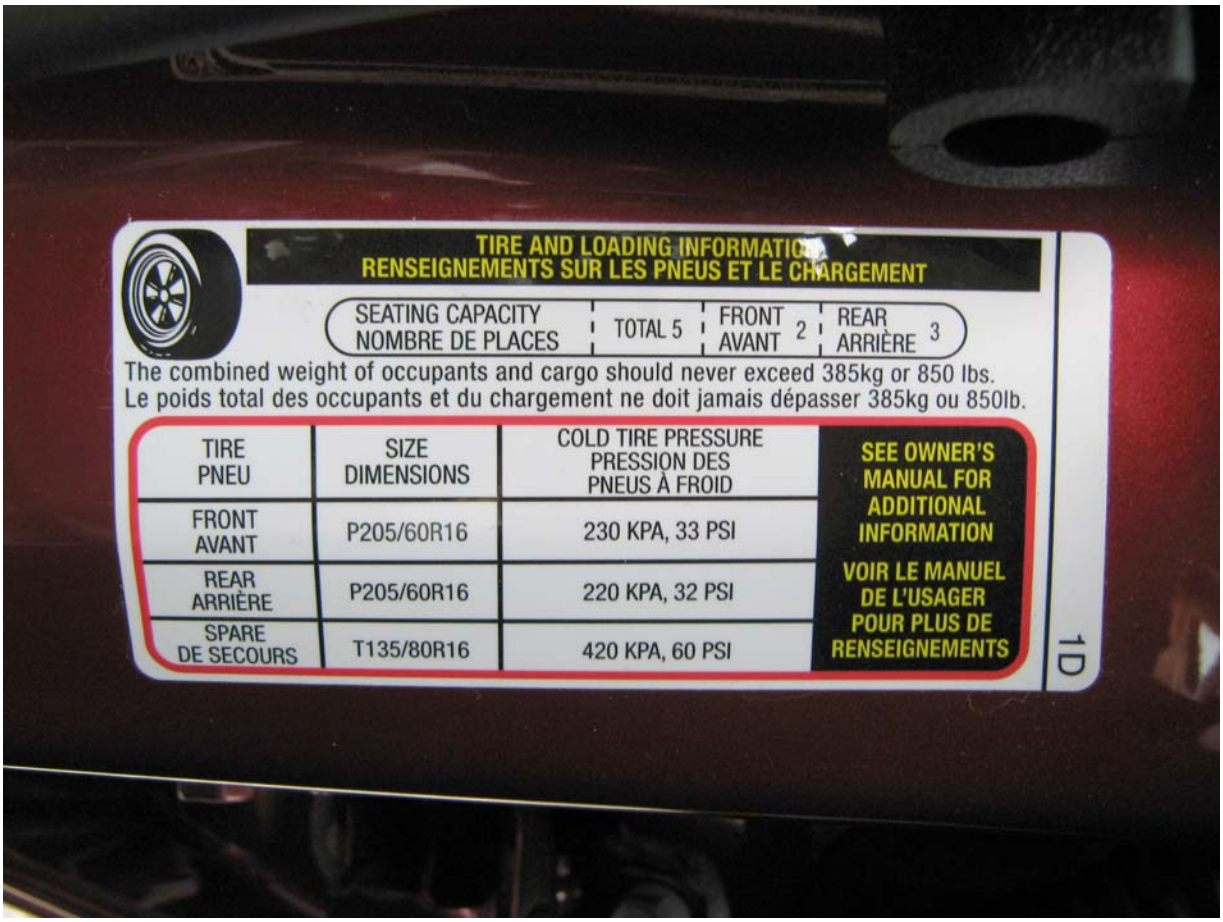
PHOTOGRAPHS

TABLE OF PHOTOGRAPHS

Load Cell Location



Manufacturer's Label



Tire Placard

Right Front ¾ View, As Received

Left Rear ¾ View, As Received

Pre-Test Front View

Post-Test Front View

Pre-Test Left Side View

Post-Test Left Side View

Pre-Test Right Side View

Post-Test Right Side View

Pre-Test Right Front ¾ View

Post-Test Right Front ¾ View

Pre-Test Left Rear ¾ View

Post-Test Left Rear ¾ View

Pre-Test Left Side ¾ View of Doors

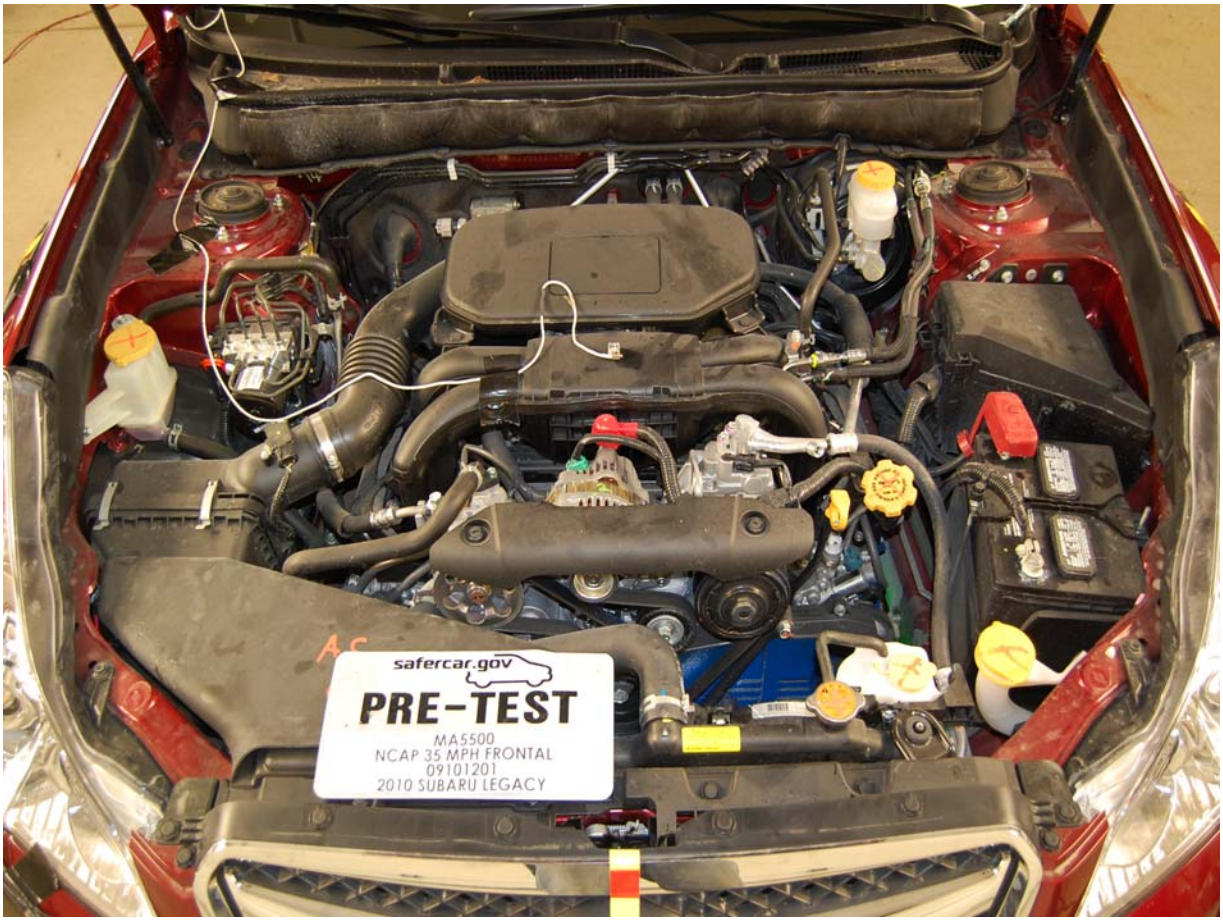
Post-Test Left Side ¾ View of Doors After Impact

Pre-Test Right Side ¾ View of Doors

Post-Test Right Side ¾ View of Doors After Impact

Pre-Test Windshield View

Post-Test Windshield View

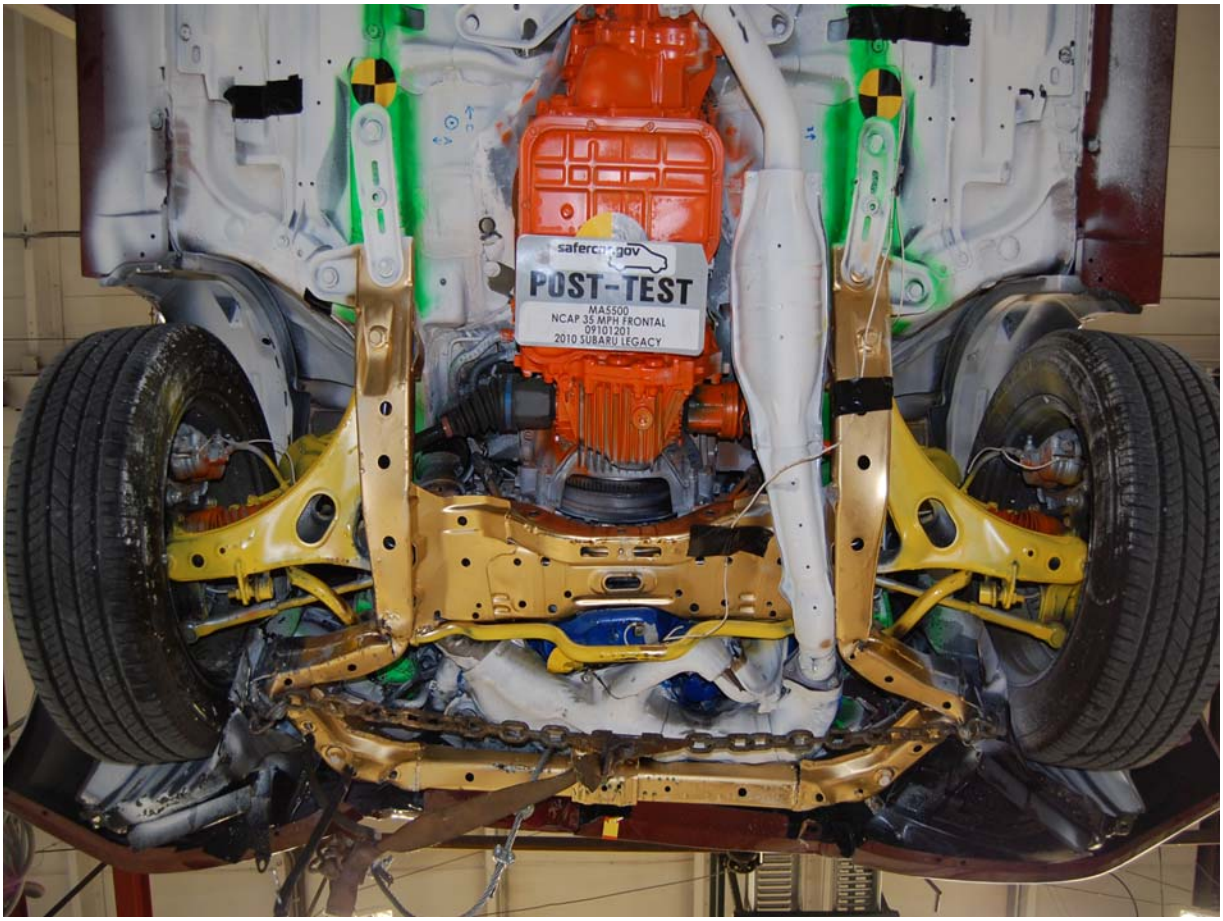


Pre-Test Engine Compartment View

Post-Test Engine Compartment View

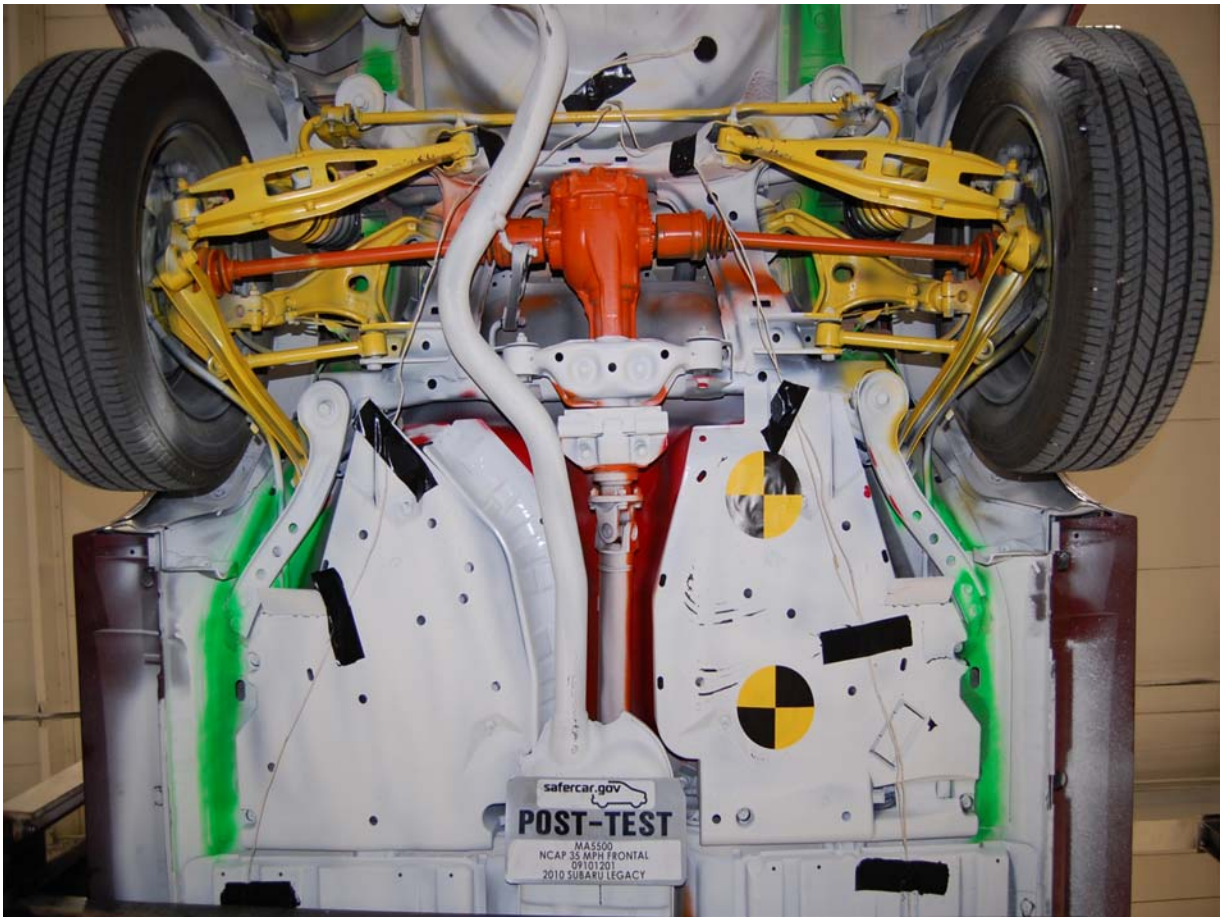
Pre-Test Fuel Cap View

Post-Test Fuel Cap View

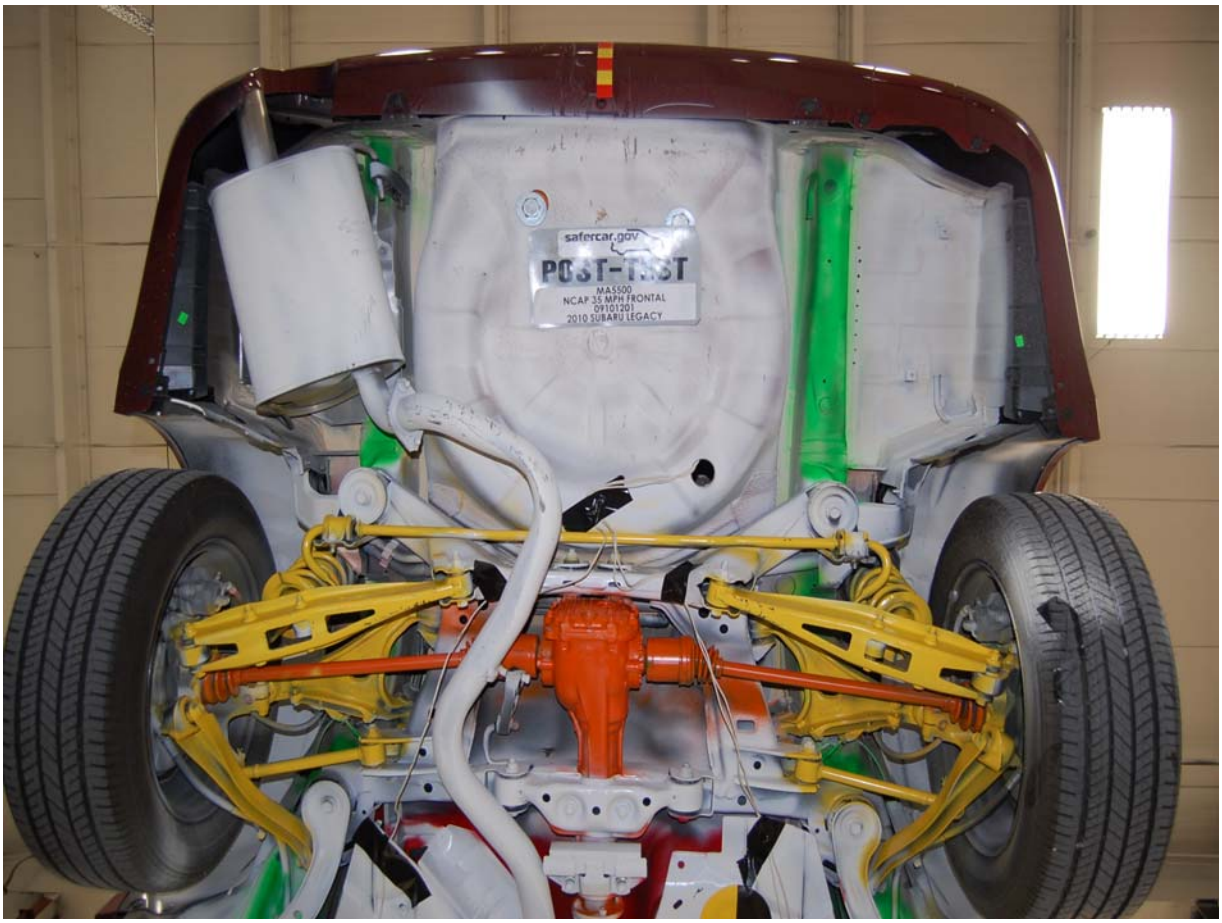


Post-Test Front Underbody View

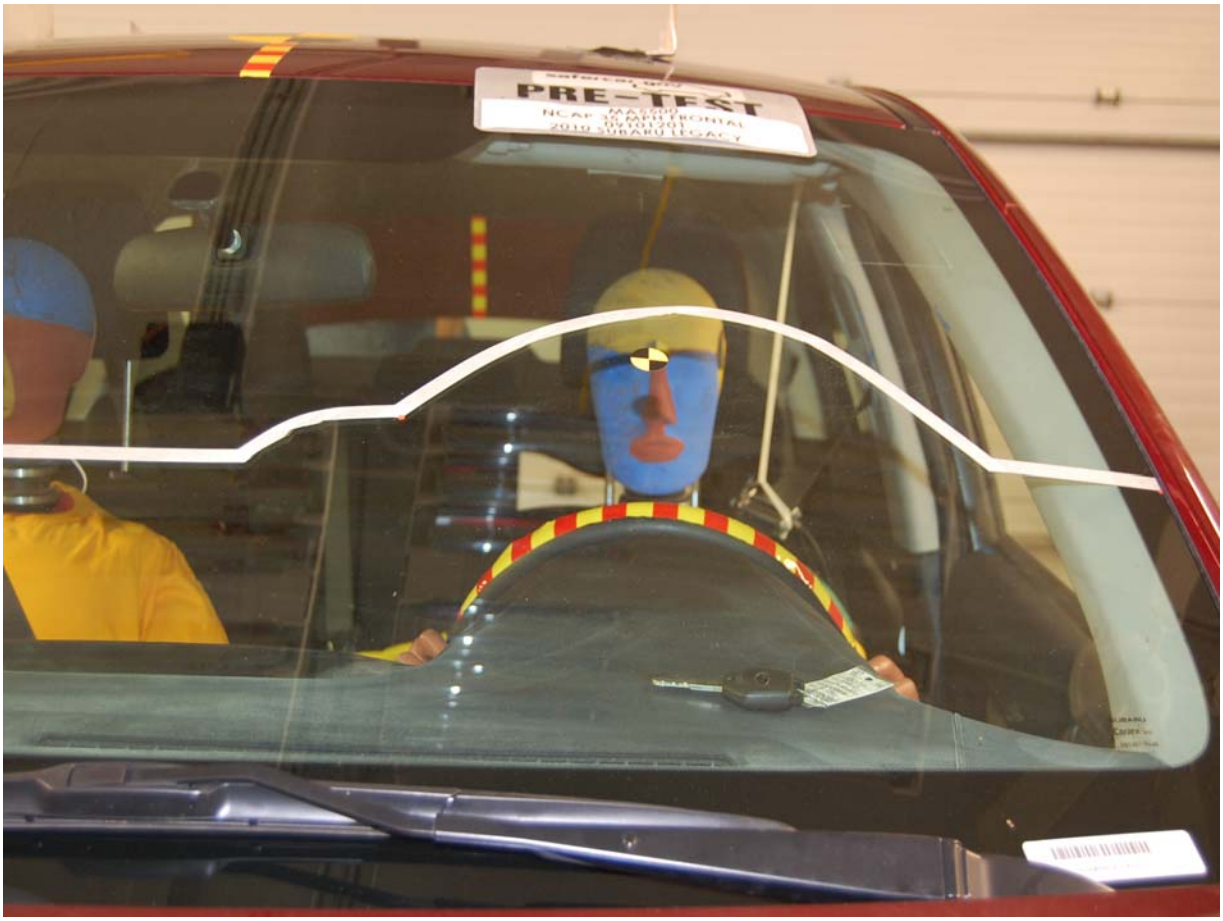
Post-Test Mid Underbody View



Post-Test Mid Underbody View



Post-Test Rear Underbody View



Pre-Test Driver Dummy Front View (Head Position)

Post-Test Driver Dummy Front View (Head Position)

Pre-Test Driver Dummy (Through Window)

Post-Test Driver Dummy (Through Window)

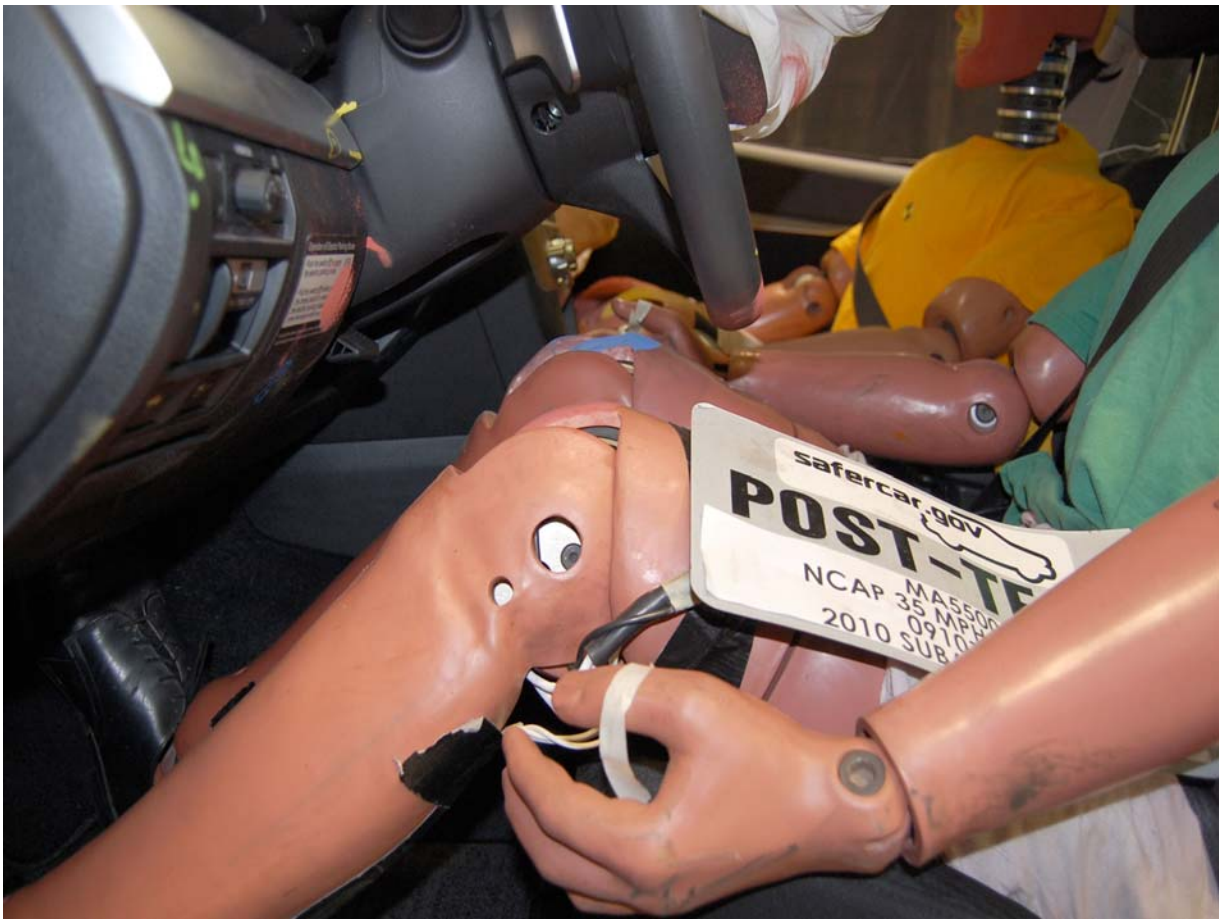
Pre-Test Driver Dummy (Door Open)


Post-Test Driver Dummy (Door Open)

Pre-Test Driver Dummy Feet

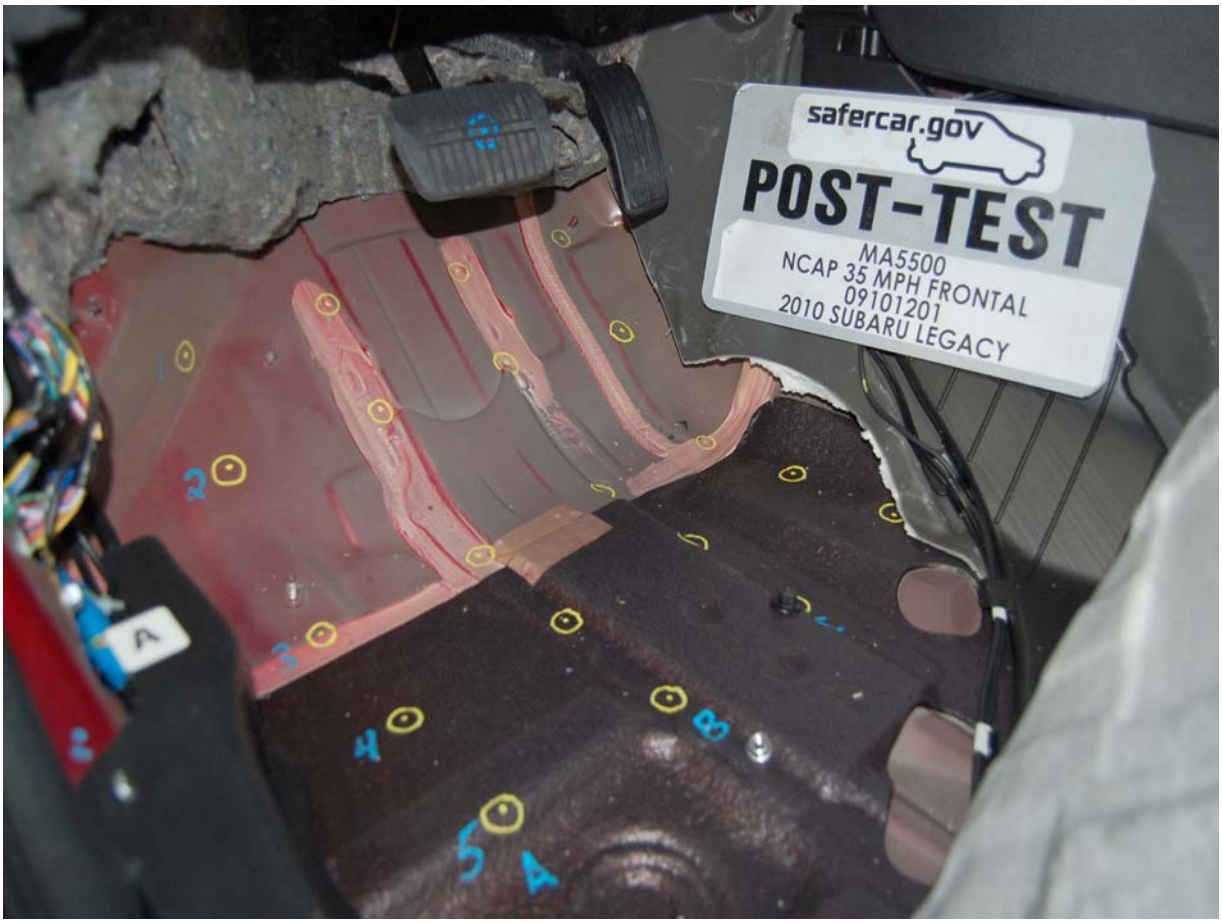
Post-Test Driver Dummy Feet

Pre-Test Driver Side Knee Bolster



Post-Test Driver Side Knee Bolster

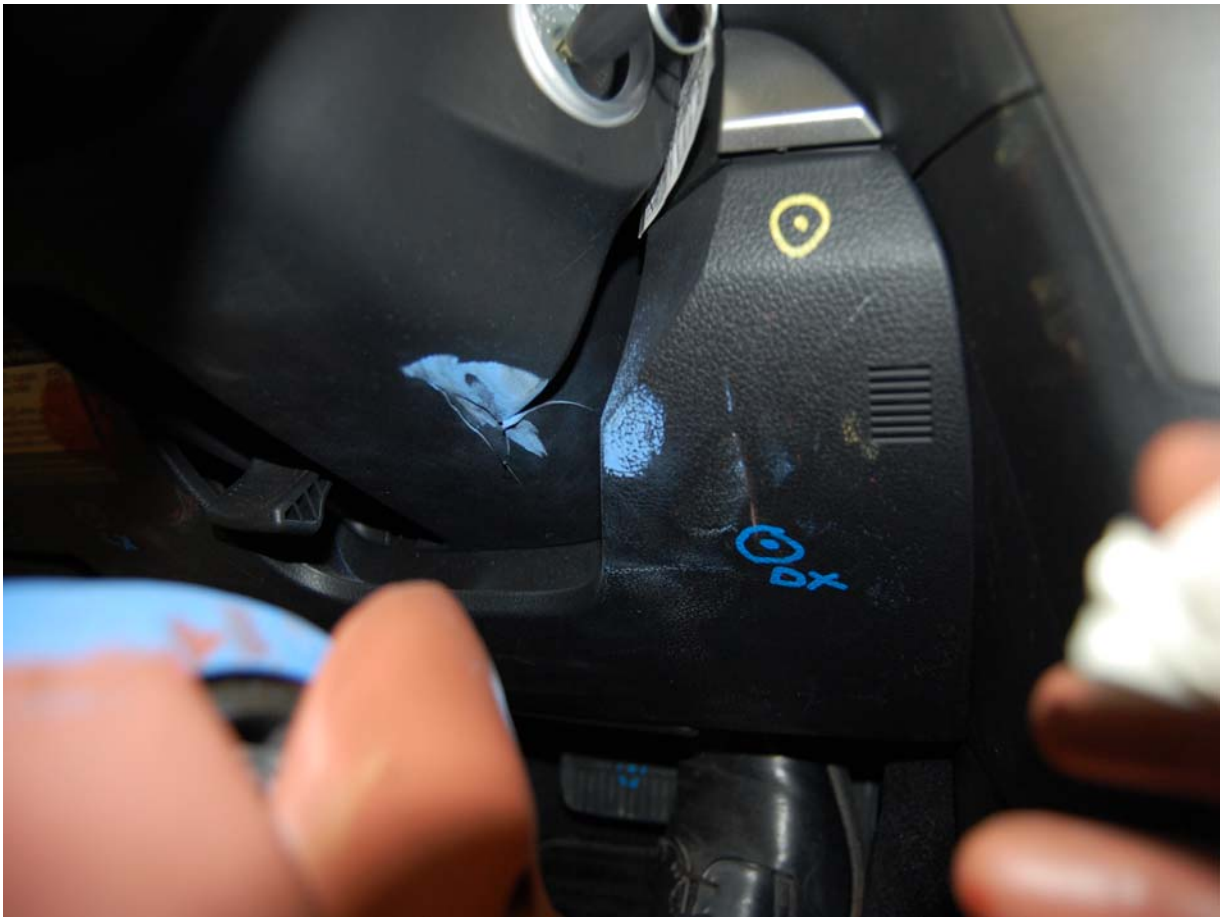
Pre-Test Driver Side Floor Pan



Post-Test Driver Side Floor Pan

Post-Test Driver Dummy Head Contact

Post-Test Driver Dummy Left Knee Contact



Post-Test Driver Dummy Right Knee Contact

Post-Test Driver Dummy Airbag Contact

Pre-Test Passenger Dummy Front View (Head Position)

Post-Test Passenger Dummy Front View (Head Position)

Pre-Test Passenger Dummy (Through Window)

Post-Test Passenger Dummy (Through Window)

Pre-Test Passenger Dummy (Door Open)

Post-Test Passenger Dummy (Door Open)

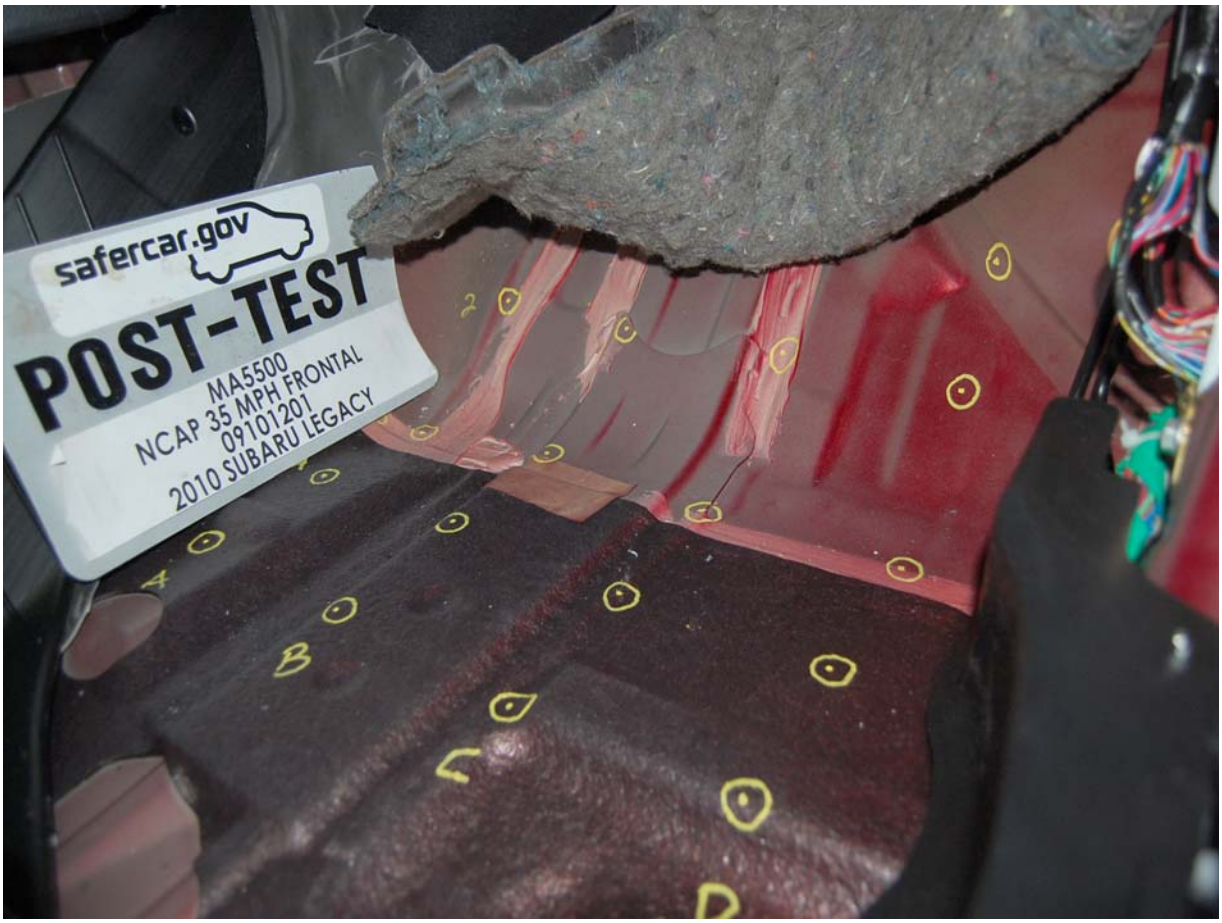
Pre-Test Passenger Dummy Feet

Post-Test Passenger Dummy Feet

Pre-Test Passenger Side Glove Box

Post-Test Passenger Side Glove Box

Pre-Test Passenger Side Floor Pan



Post-Test Passenger Side Floor Pan

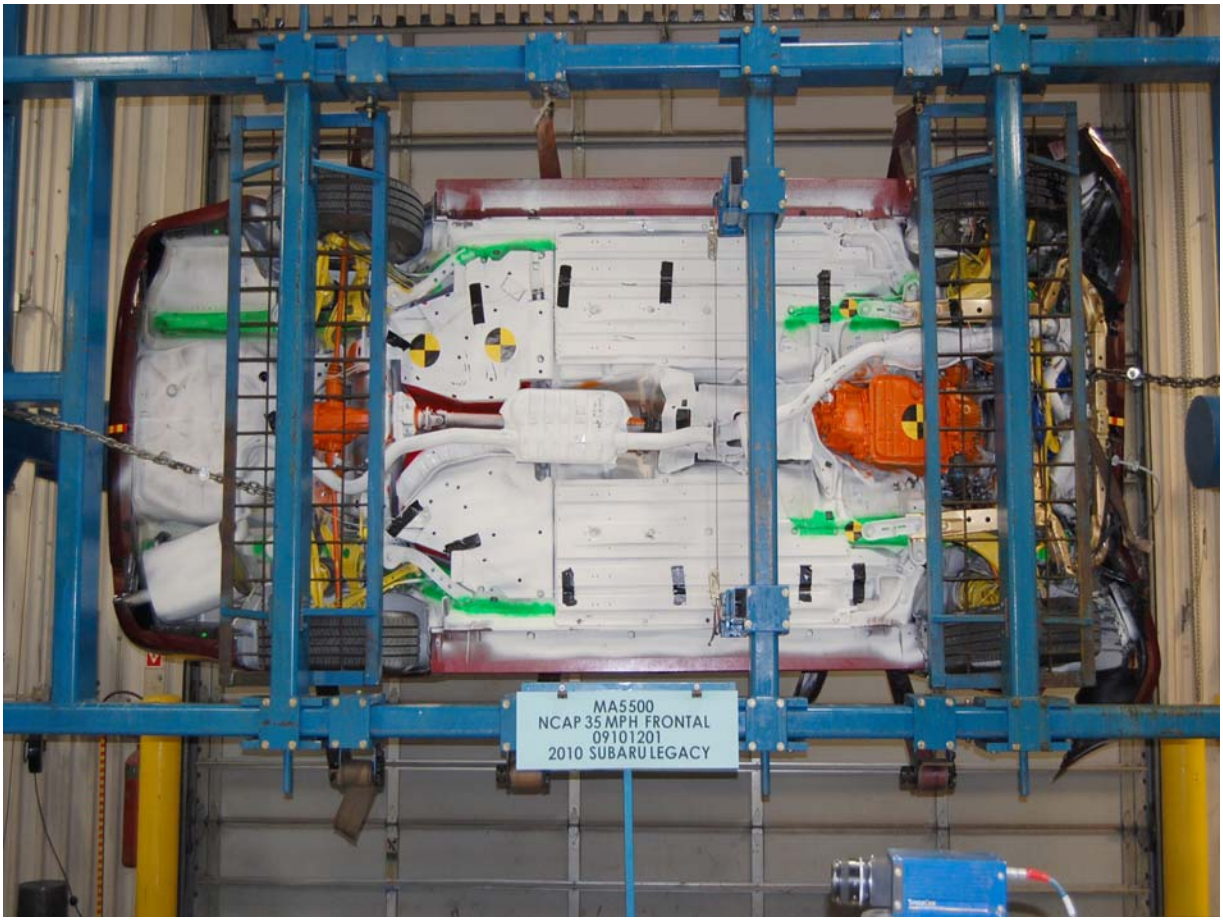
Post-Test Passenger Dummy Knee Contact

Post-Test Passenger Dummy Knee Contact w/Airbag

Post-Test Passenger Dummy Airbag Contact

Rollover 90 Degrees

Rollover 180 Degrees



Rollover 270 Degrees

Rollover 360 Degrees

Vehicle Impact

APPENDIX B

DUMMY RESPONSE DATA TRACES

TABLE OF DATA PLOTS

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

Driver Head X Redundant

Driver Head Y Redundant

Driver Head Z Redundant

Driver Upper Neck Force X

Driver Upper Neck Force Y

Driver Upper Neck Force Z

Driver Upper Neck Moment X

Driver Upper Neck Moment Y

Driver Upper Neck Moment Z

Driver Chest X Redundant

Driver Chest Y Redundant

Driver Chest Z Redundant

Driver Chest Displacement

Driver Pelvis X

Driver Pelvis Y

Driver Pelvis Z

Driver Lap Belt Force

Driver Shoulder Belt Force

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

Passenger Head X Redundant

Passenger Head Y Redundant

Passenger Head Z Redundant

Passenger Upper Neck Force X

Passenger Upper Neck Force Y

Passenger Upper Neck Force Z

Passenger Upper Neck Moment X

Passenger Upper Neck Moment Y

Passenger Upper Neck Moment Z

Passenger Chest X Redundant

Passenger Chest Y Redundant

Passenger Chest Z Redundant

Passenger Chest Displacement

Passenger Pelvis X

Passenger Pelvis Y

Passenger Pelvis Z

Passenger Lap Belt Force

Passenger Shoulder Belt Force

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 Foot Fore Z

Passenger Right Foot Aft X

Passenger Right Foot Aft Z

Left Rear Seat Crossmember X

Left Rear Seat Crossmember Z

Right Rear Seat Crossmember X

Right Rear Seat Crossmember Z

Vehicle Engine Top X

Vehicle Engine Bottom X

Vehicle Left Brake Caliper X

Vehicle Right Brake Caliper X

Barrier Force – Upper Left

Barrier Force – Upper Center

Barrier Force – Upper Right

Barrier Force – Lower Left

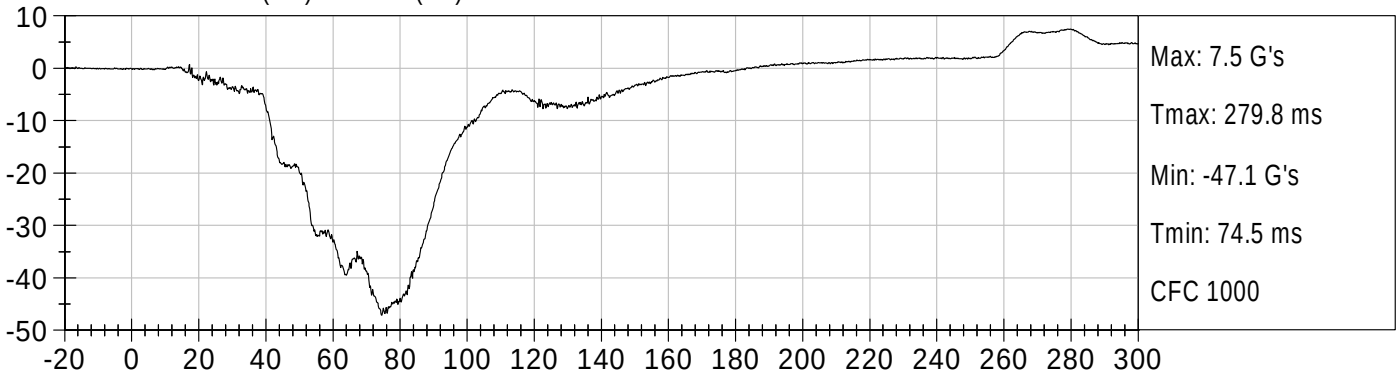
Barrier Force – Lower Center

Barrier Force – Lower Right

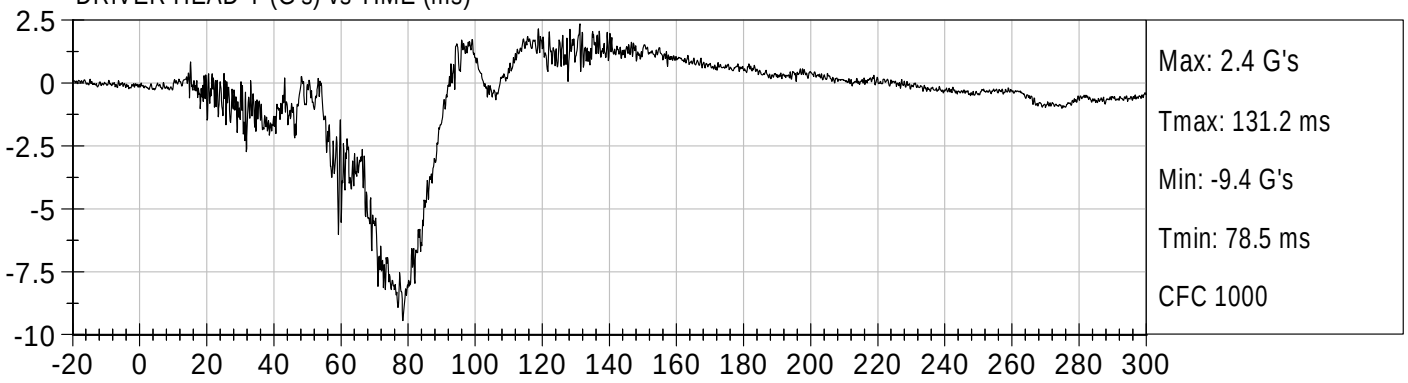
35mph NCAP Frontal
2010 Subaru Legacy - MA5500

Test Date: 10/12/2009
Speed: 35.0 mph (56.3 km/h)

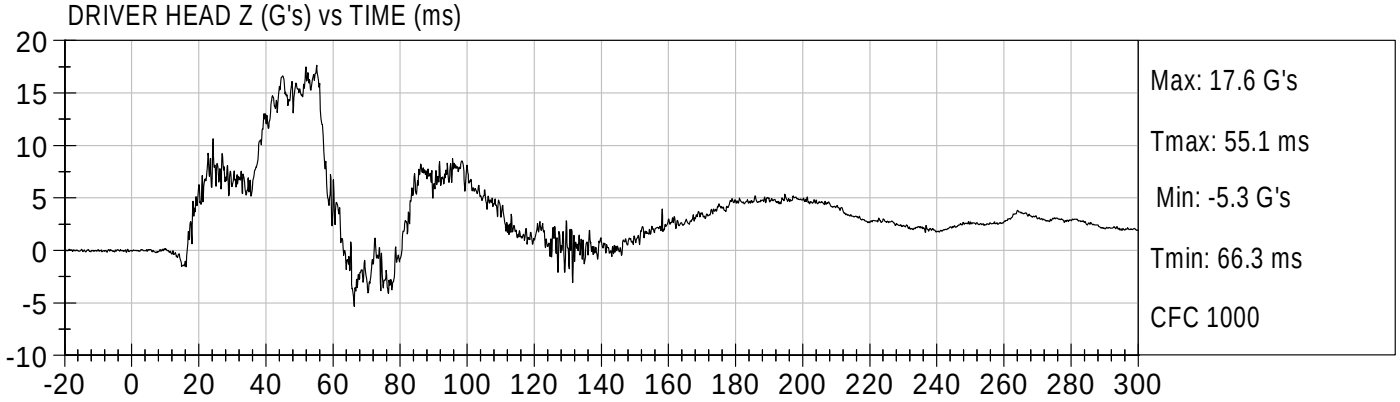
DRIVER HEAD X (G's) vs TIME (ms)



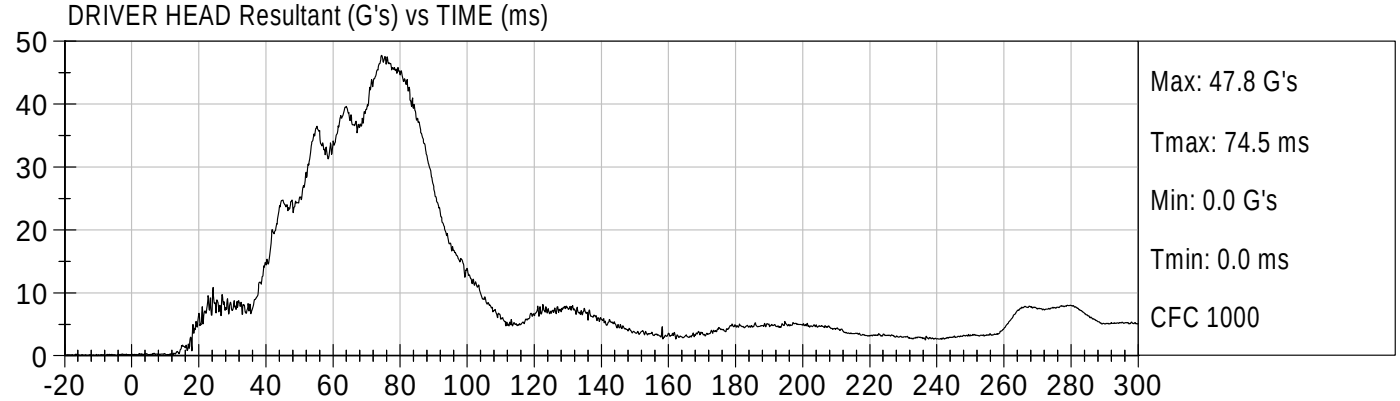
DRIVER HEAD Y (G's) vs TIME (ms)



DRIVER HEAD Z (G's) vs TIME (ms)



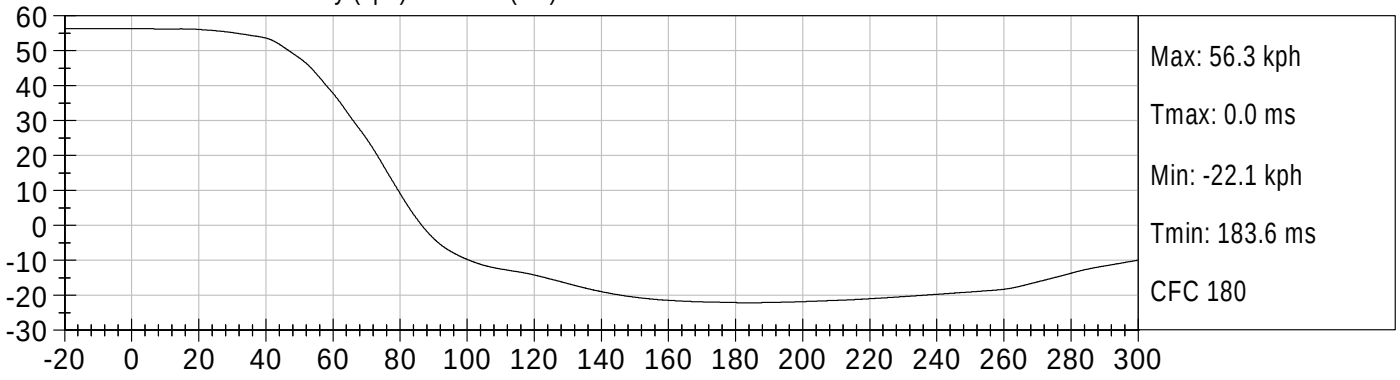
DRIVER HEAD Resultant (G's) vs TIME (ms)



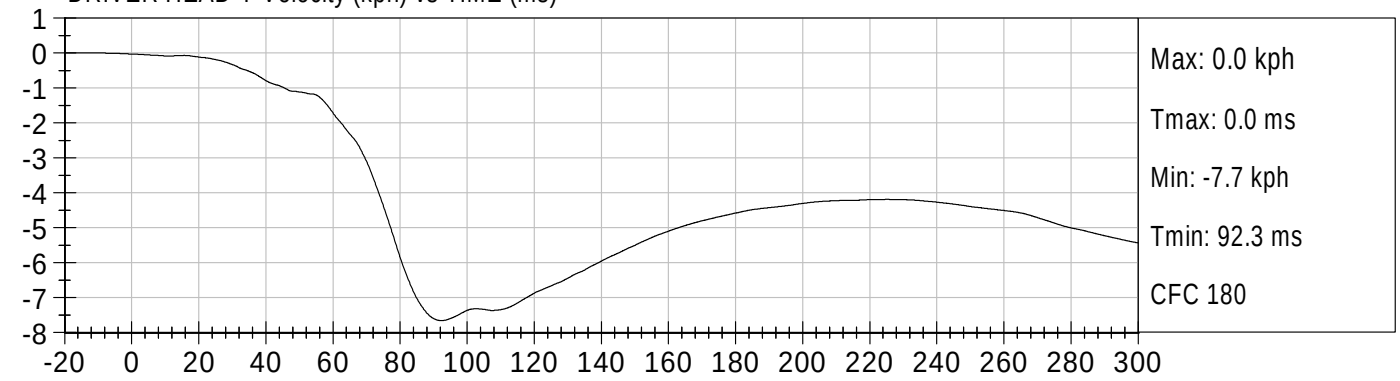
35mph NCAP Frontal
2010 Subaru Legacy - MA5500

Test Date: 10/12/2009
Speed: 35.0 mph (56.3 km/h)

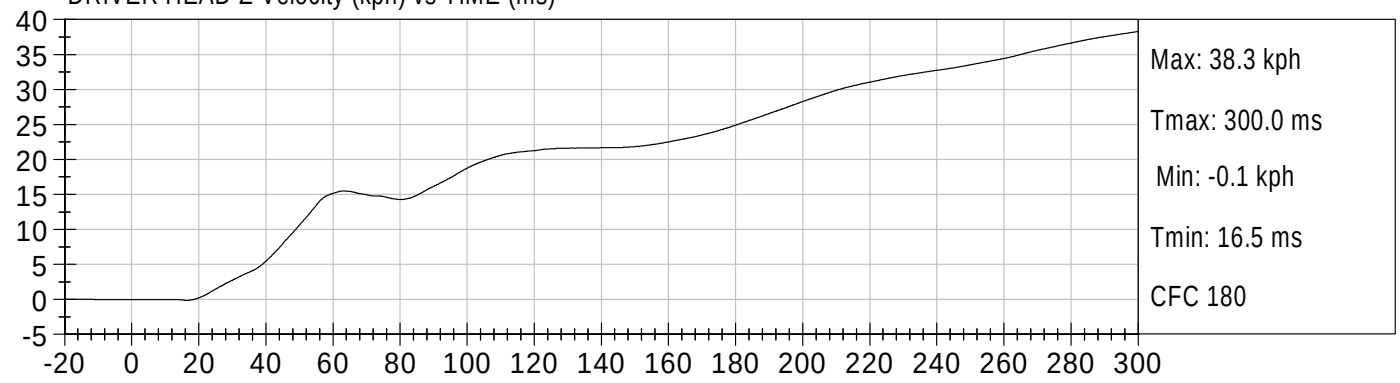
DRIVER HEAD X Velocity (kph) vs TIME (ms)



DRIVER HEAD Y Velocity (kph) vs TIME (ms)



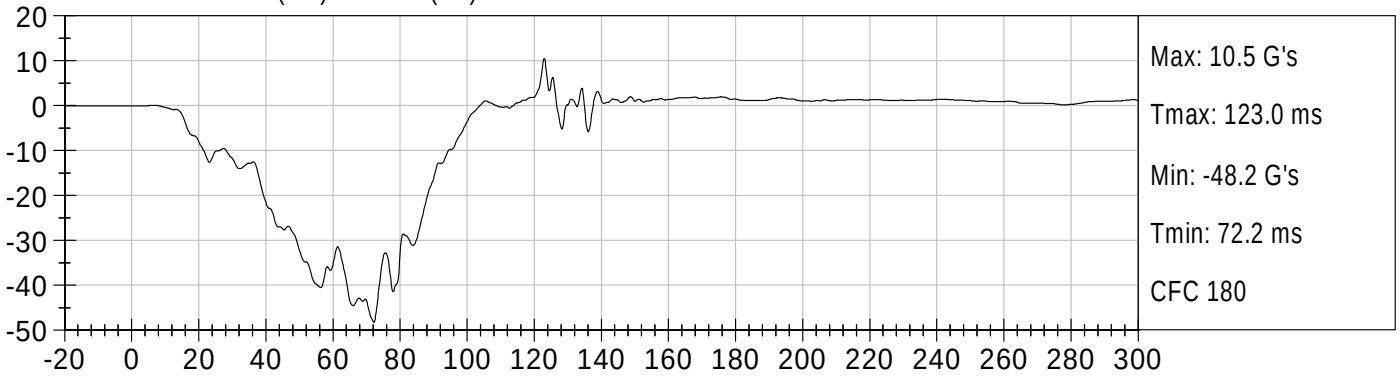
DRIVER HEAD Z Velocity (kph) vs TIME (ms)



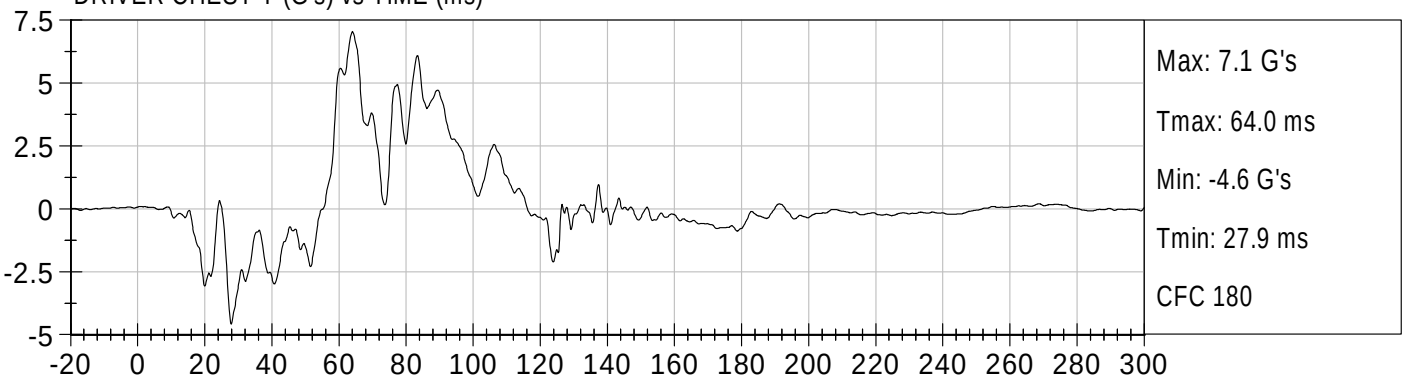
35mph NCAP Frontal
2010 Subaru Legacy - MA5500

Test Date: 10/12/2009
Speed: 35.0 mph (56.3 km/h)

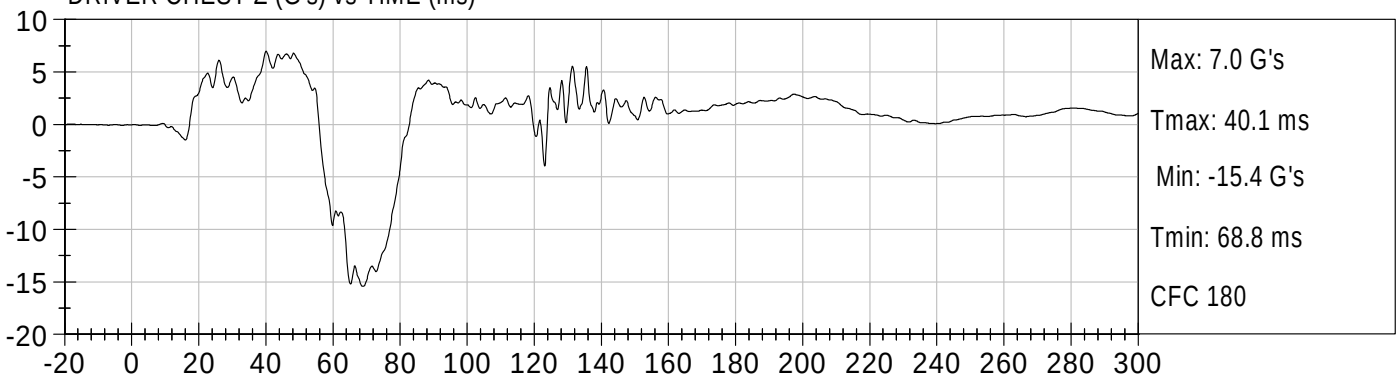
DRIVER CHEST X (G's) vs TIME (ms)



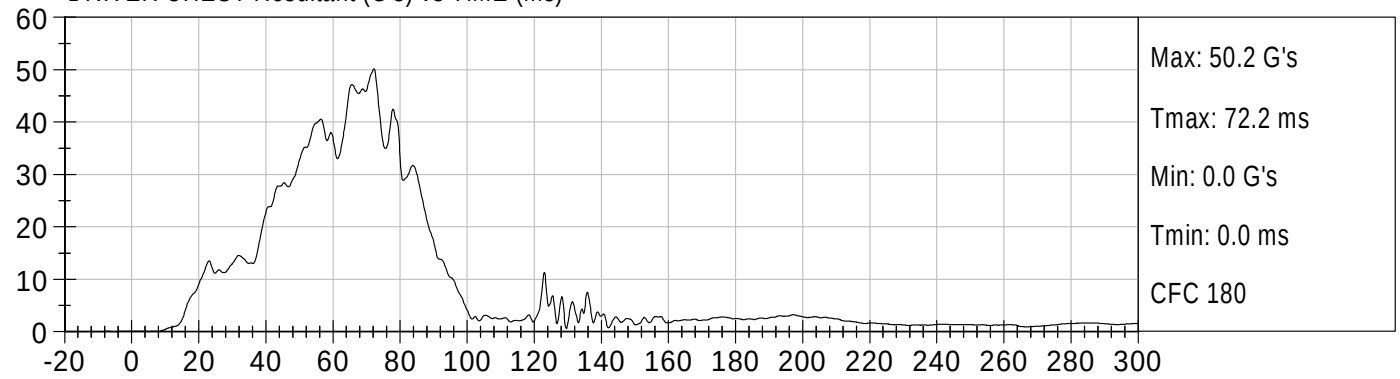
DRIVER CHEST Y (G's) vs TIME (ms)



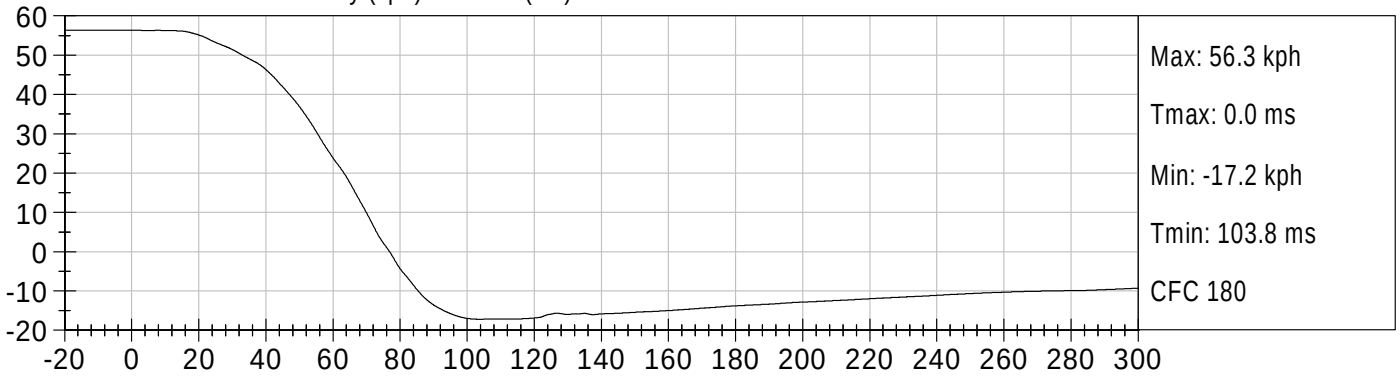
DRIVER CHEST Z (G's) vs TIME (ms)



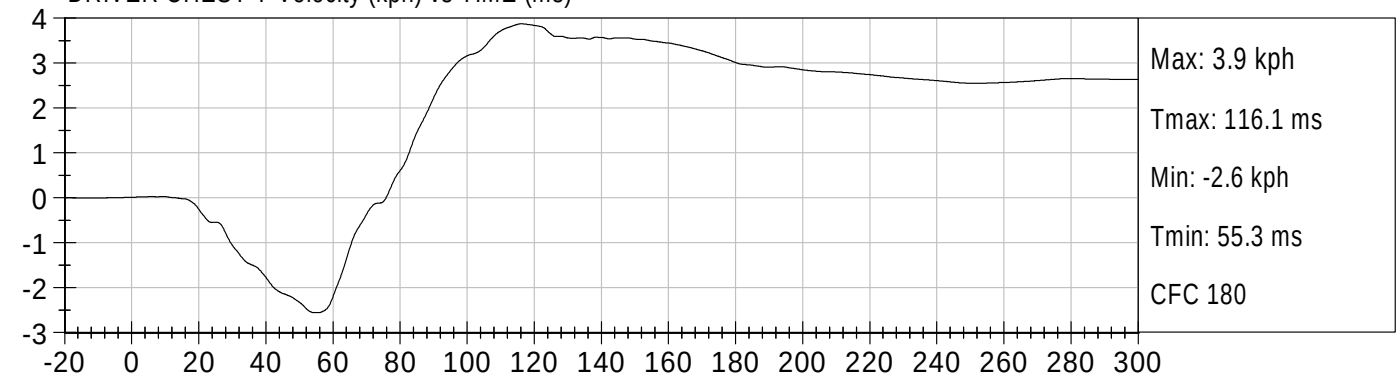
DRIVER CHEST Resultant (G's) vs TIME (ms)



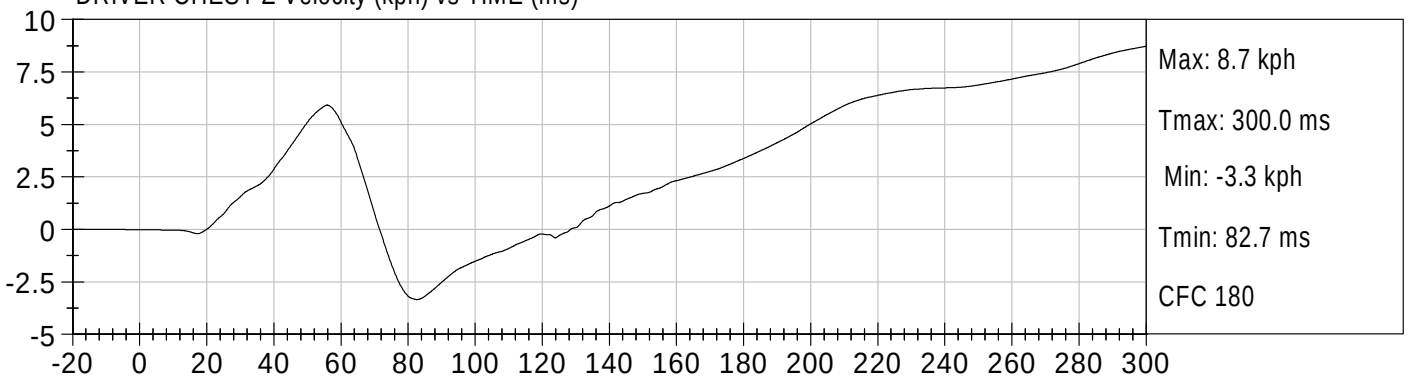
DRIVER CHEST X Velocity (kph) vs TIME (ms)



DRIVER CHEST Y Velocity (kph) vs TIME (ms)



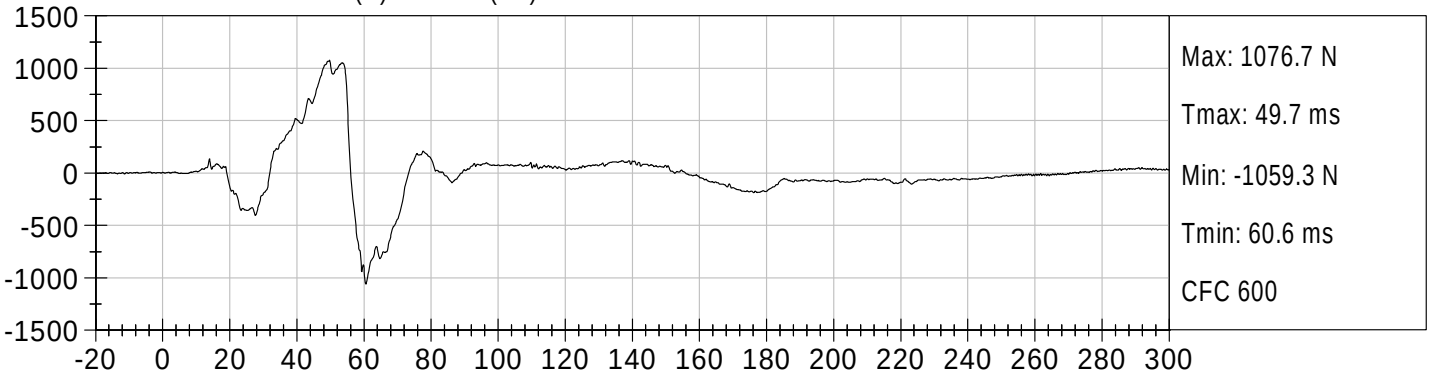
DRIVER CHEST Z Velocity (kph) vs TIME (ms)



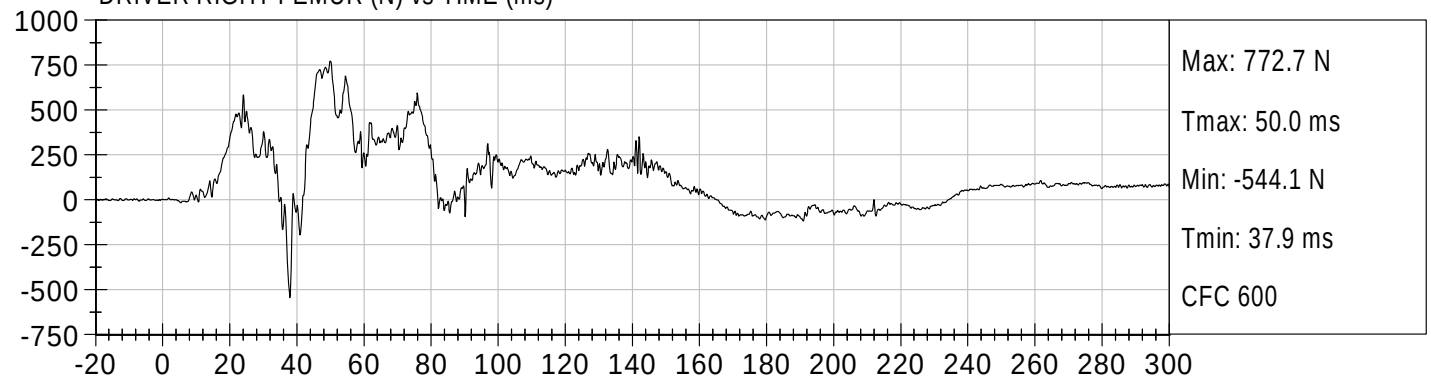
35mph NCAP Frontal
2010 Subaru Legacy - MA5500

Test Date: 10/12/2009
Speed: 35.0 mph (56.3 km/h)

DRIVER LEFT FEMUR (N) vs TIME (ms)



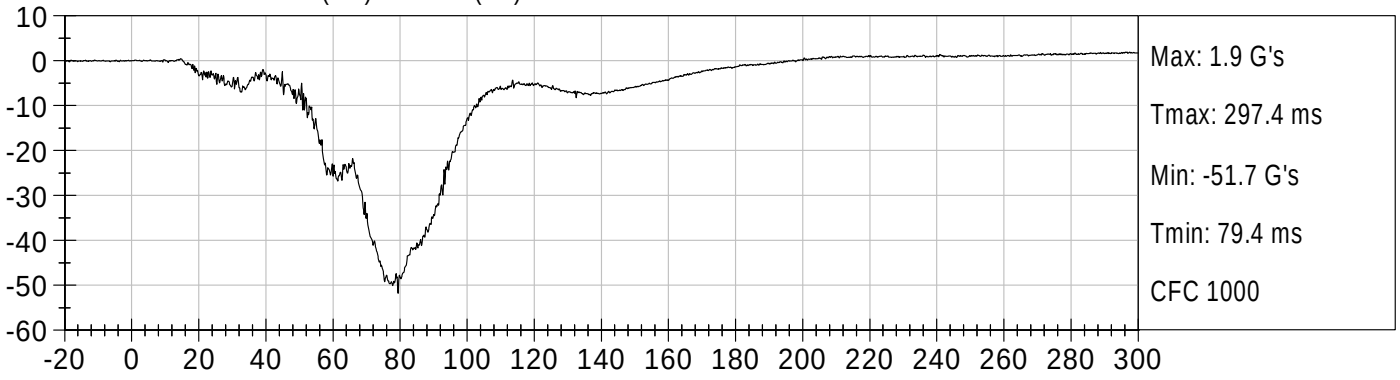
DRIVER RIGHT FEMUR (N) vs TIME (ms)



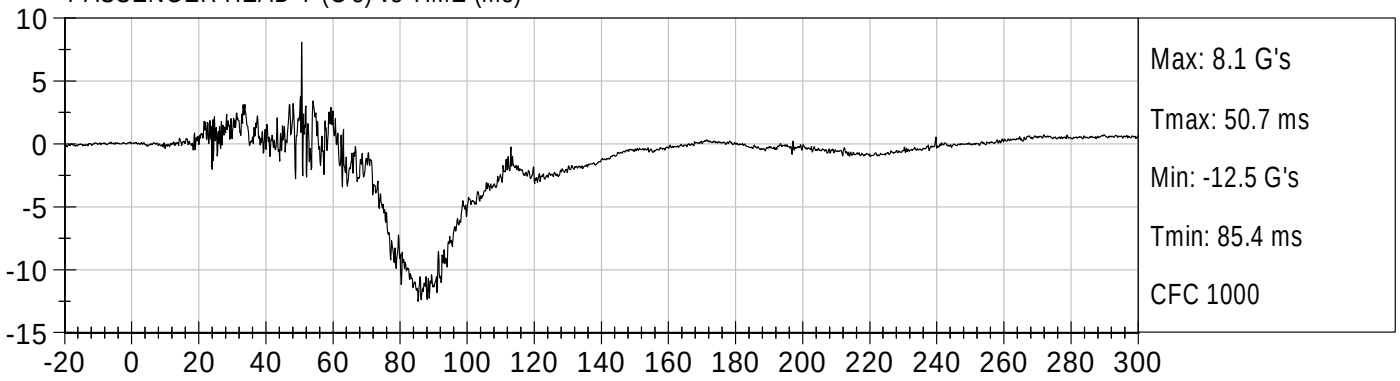
35mph NCAP Frontal
2010 Subaru Legacy - MA5500

Test Date: 10/12/2009
Speed: 35.0 mph (56.3 km/h)

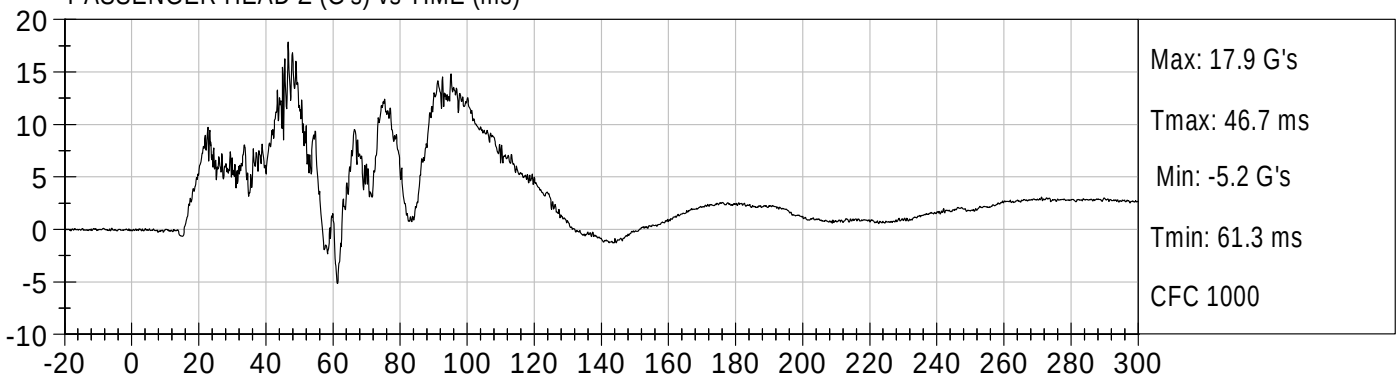
PASSENGER HEAD X (G's) vs TIME (ms)



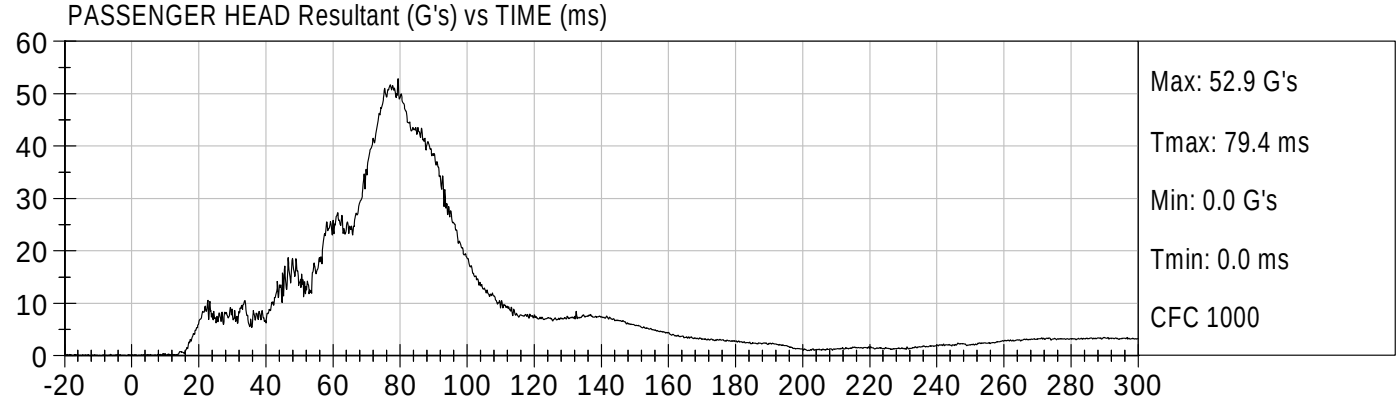
PASSENGER HEAD Y (G's) vs TIME (ms)



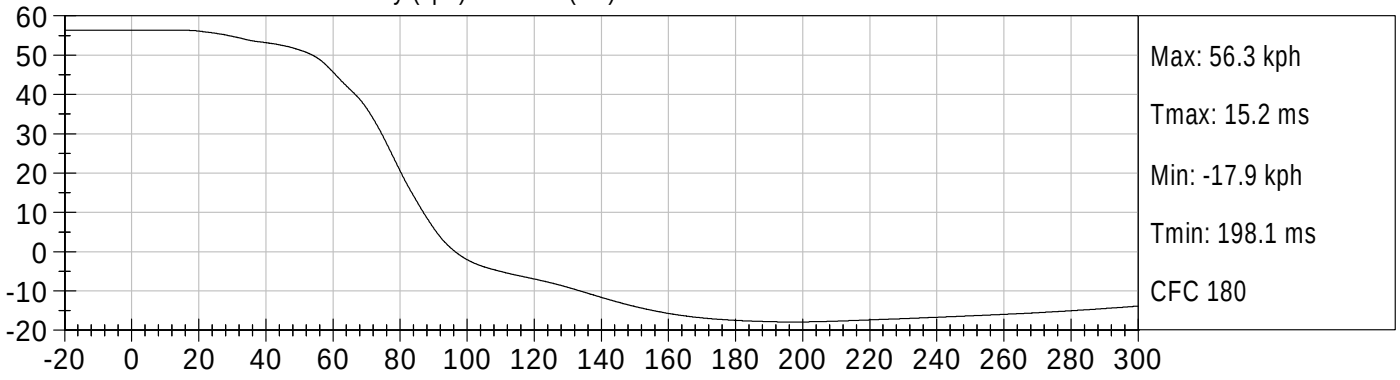
PASSENGER HEAD Z (G's) vs TIME (ms)



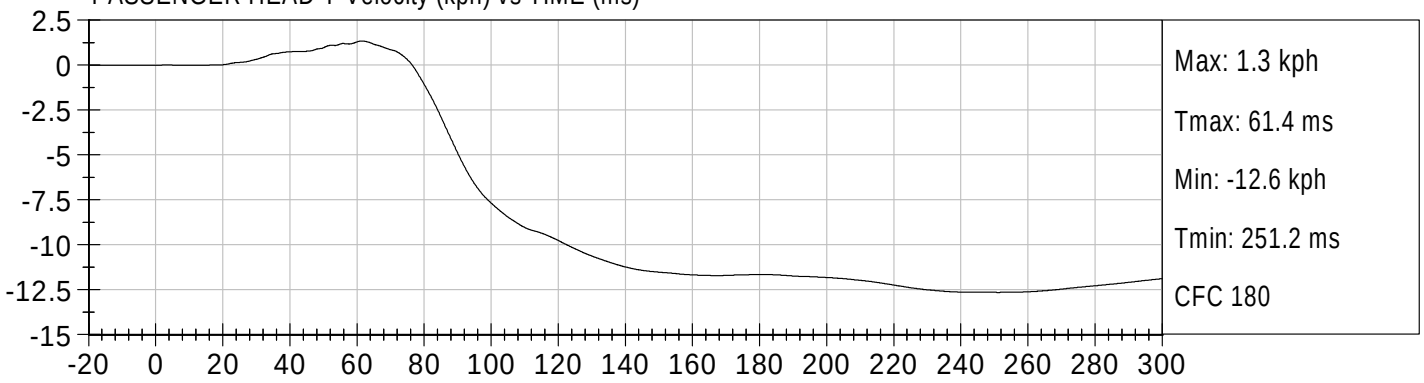
PASSENGER HEAD Resultant (G's) vs TIME (ms)



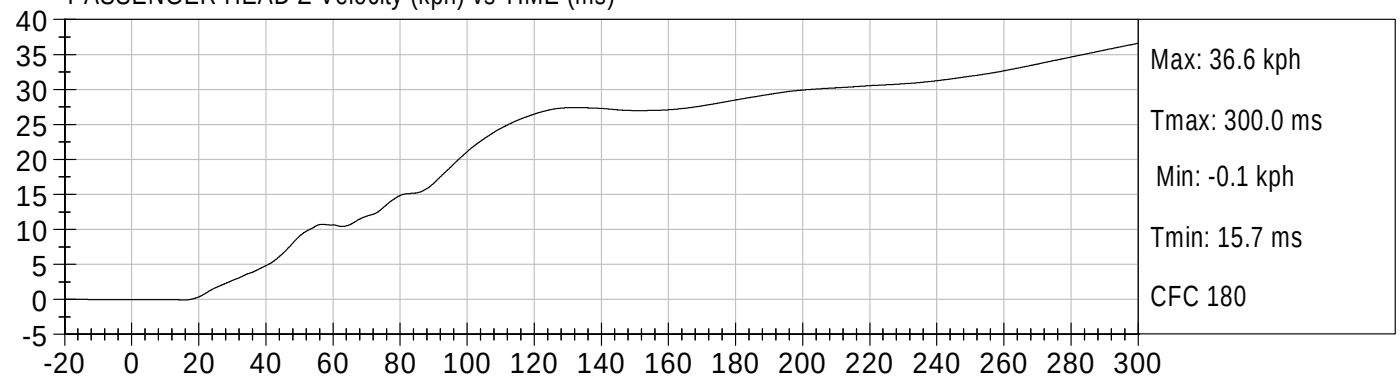
PASSENGER HEAD X Velocity (kph) vs TIME (ms)



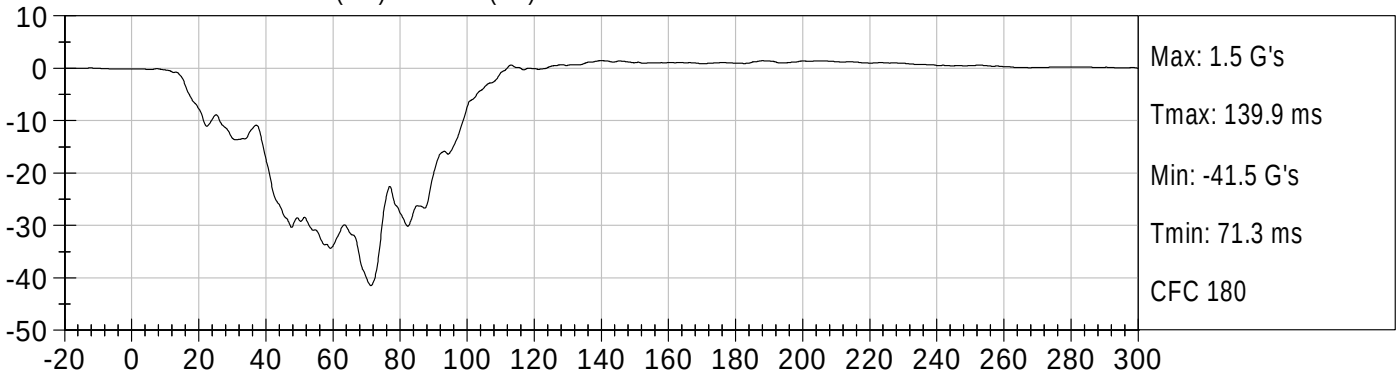
PASSENGER HEAD Y Velocity (kph) vs TIME (ms)



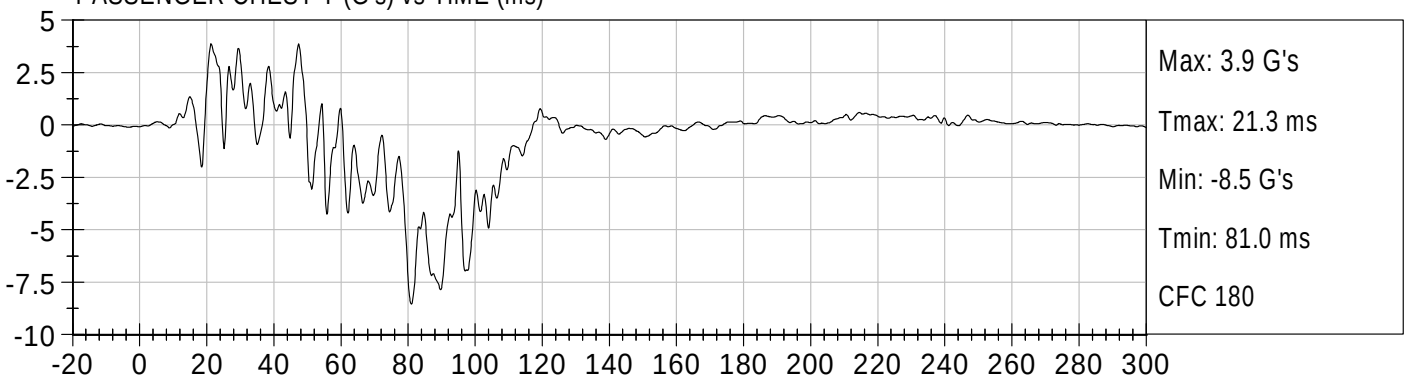
PASSENGER HEAD Z Velocity (kph) vs TIME (ms)



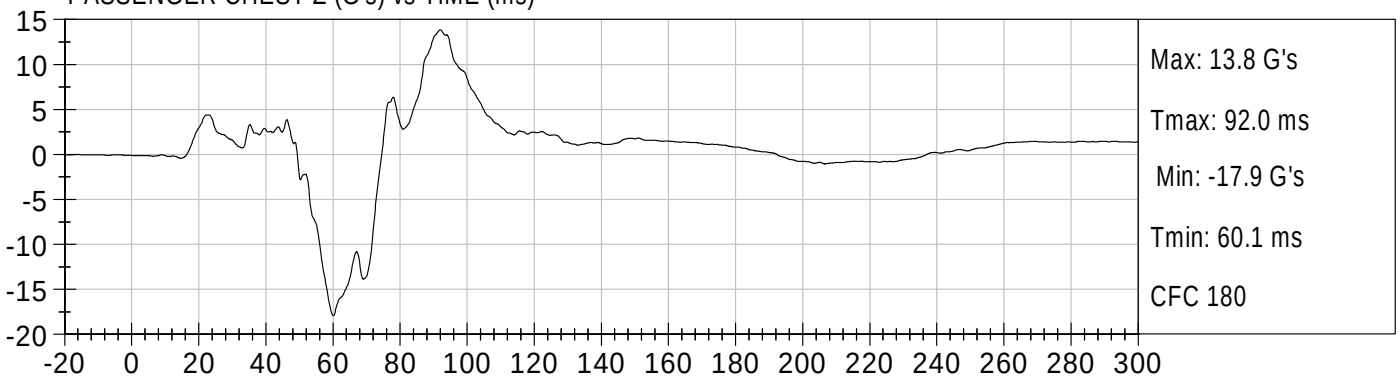
PASSENGER CHEST X (G's) vs TIME (ms)



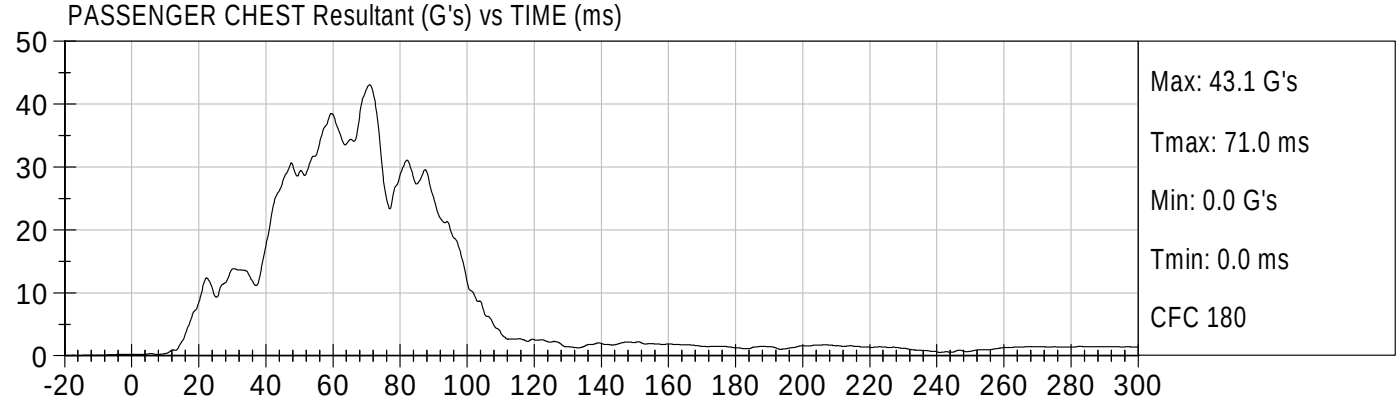
PASSENGER CHEST Y (G's) vs TIME (ms)



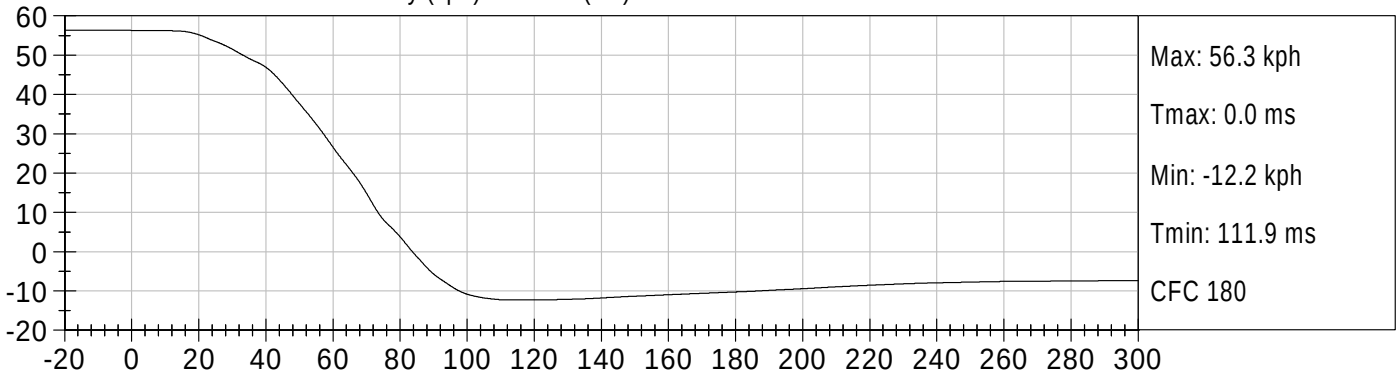
PASSENGER CHEST Z (G's) vs TIME (ms)



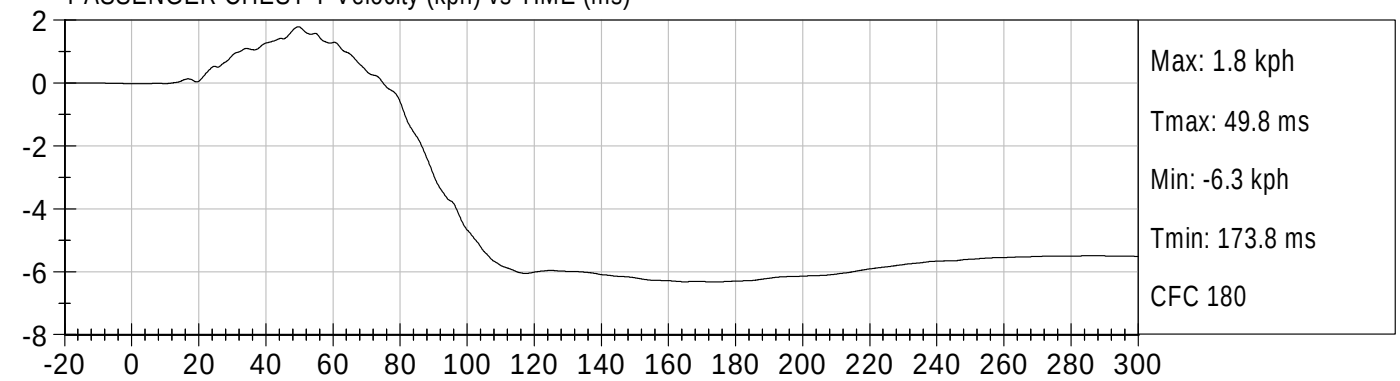
PASSENGER CHEST Resultant (G's) vs TIME (ms)



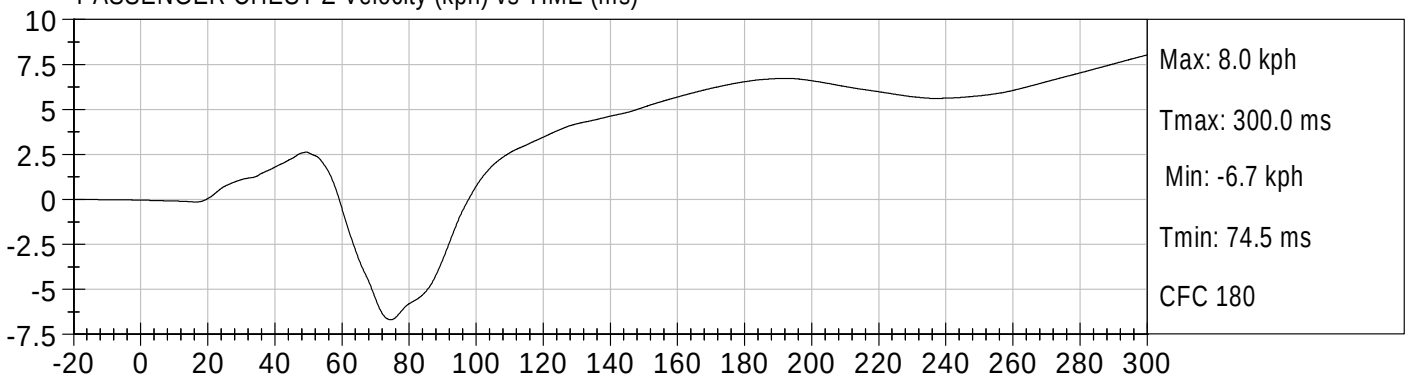
PASSENGER CHEST X Velocity (kph) vs TIME (ms)



PASSENGER CHEST Y Velocity (kph) vs TIME (ms)



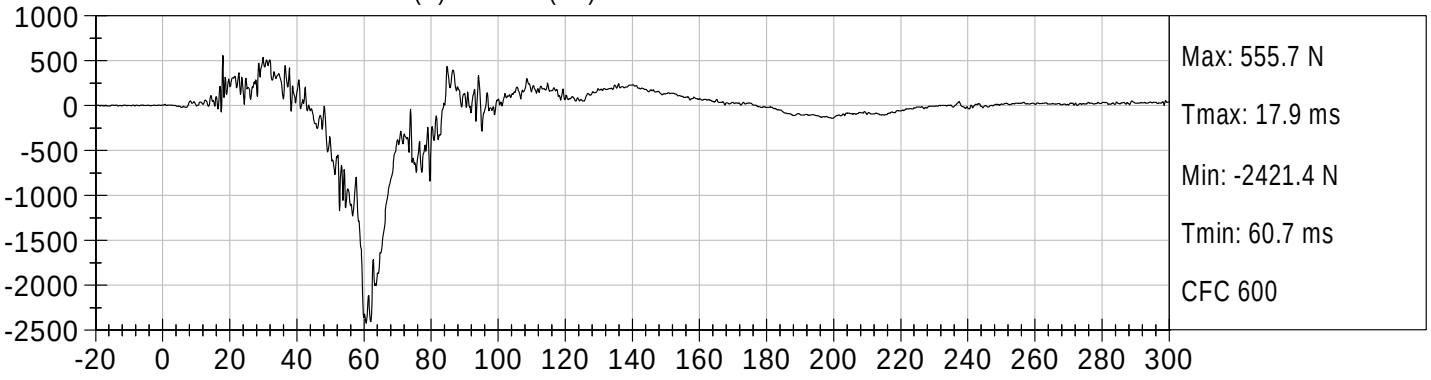
PASSENGER CHEST Z Velocity (kph) vs TIME (ms)



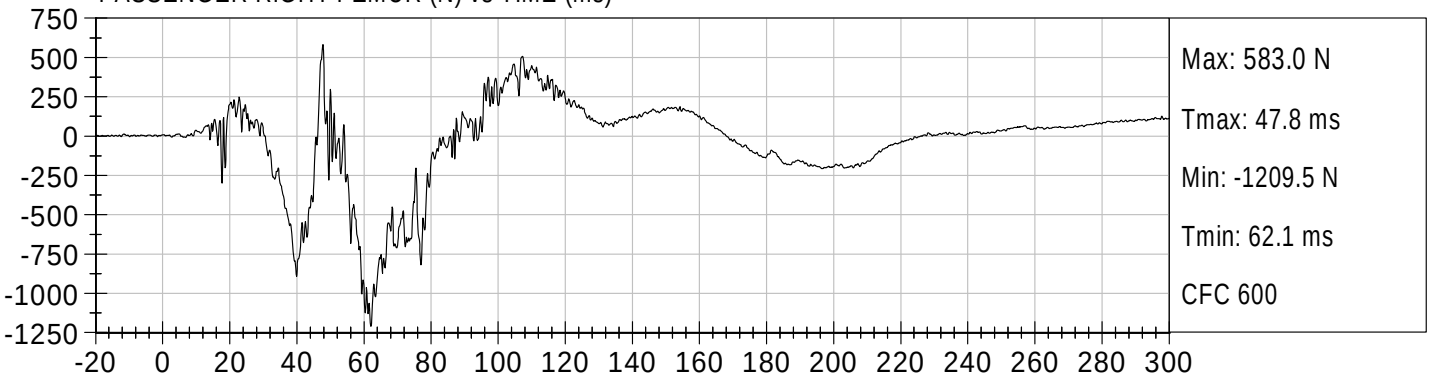
35mph NCAP Frontal
2010 Subaru Legacy - MA5500

Test Date: 10/12/2009
Speed: 35.0 mph (56.3 km/h)

PASSENGER LEFT FEMUR (N) vs TIME (ms)



PASSENGER RIGHT FEMUR (N) vs TIME (ms)



APPENDIX C

DUMMY CALIBRATION DATA

MGA RESEARCH CORPORATION

HEAD DROP TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 066 **Test ID:** D092391

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 - 25.6	20.7	Pass
Laboratory Relative Humidity	%	10 to 70	56	Pass
Peak Resultant Acceleration	G's	225 - 275	257	Pass
Peak Lateral Acceleration	G's	<= +/- 15.0	-10.8	Pass
Unimodal	N/A	Yes	Yes	Pass
Oscillations	N/A	within 10% of peak	Yes	Pass
		Overall Test Results		Pass

Jessica Gall
Laboratory Technician

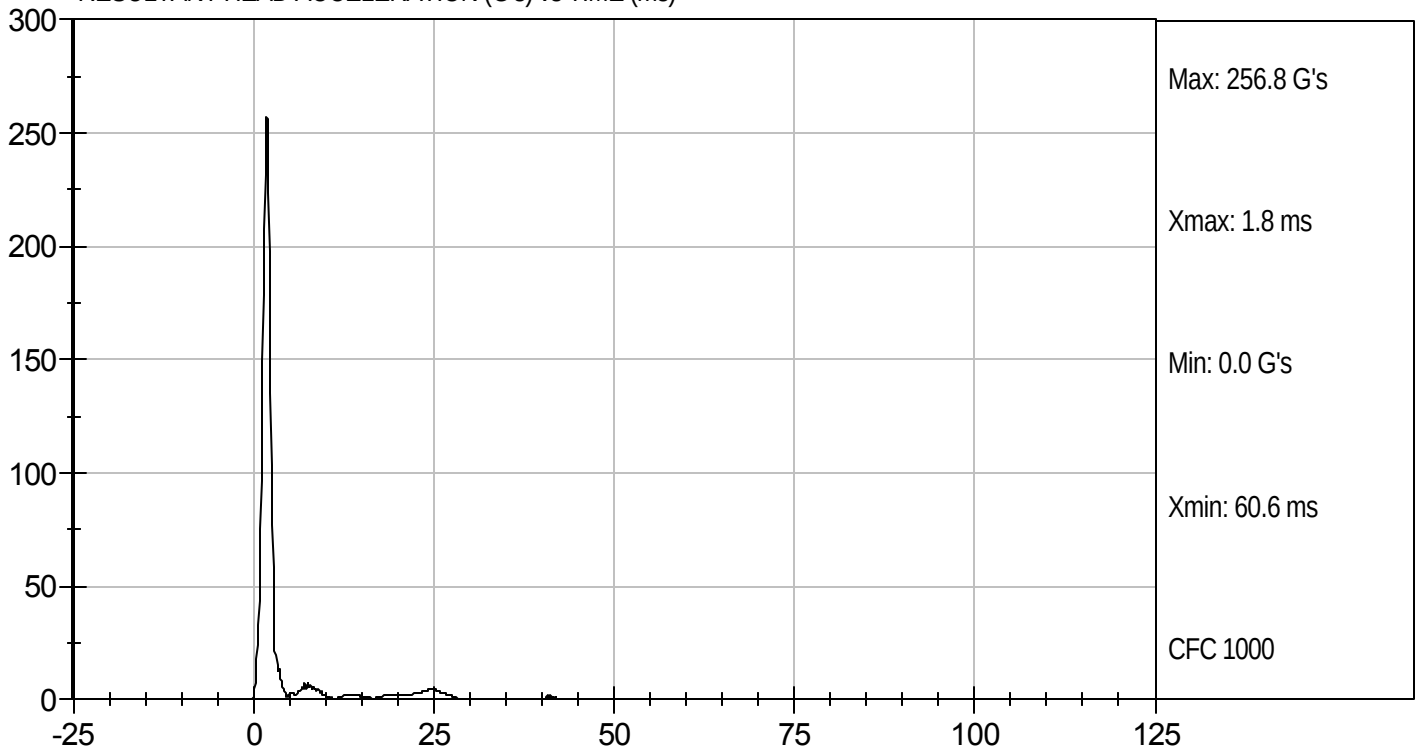
9/22/09
Test Date

David Winhelbauer
Approved By

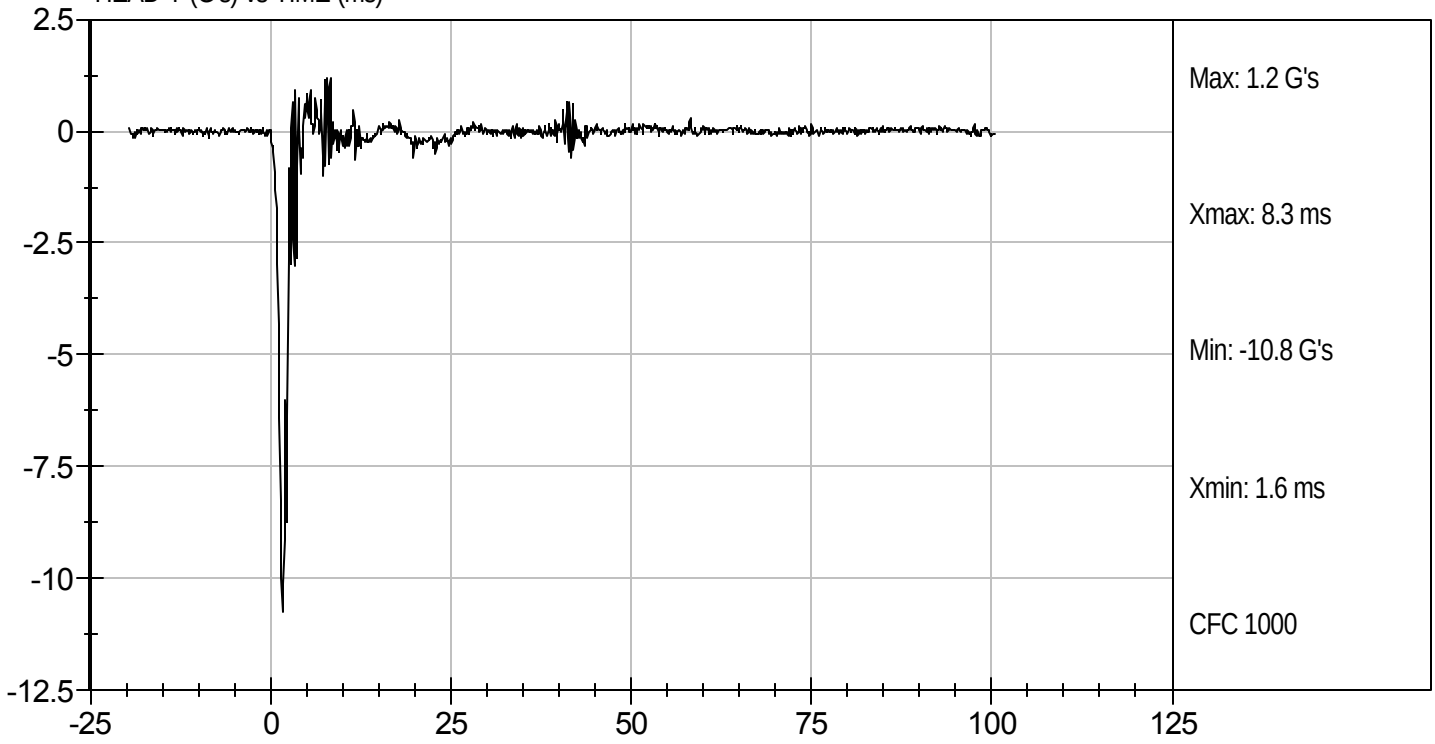
Test Desc: Head Drop
Component ID: D092391

Test Date: 9/22/09
Velocity: 0 ft/s, 0.00 m/s

RESULTANT HEAD ACCELERATION (G's) vs TIME (ms)



HEAD Y (G's) vs TIME (ms)



MGA RESEARCH CORPORATION

NECK FLEXION TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 066 **Test I.D:** D092392

Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	20.6 to 22.2	21.1	Pass
Laboratory Relative Humidity		%	10 to 70	54	Pass
Pendulum Velocity		m/s	6.89 to 7.13	7.06	Pass
Pendulum Deceleration	10 ms	m/s	22.50 to 27.50	23.46	Pass
	20 ms	m/s	17.60 to 22.60	20.58	Pass
	30 ms	m/s	12.50 to 18.50	15.11	Pass
Peak Pendulum Deceleration After 30 ms		m/s	<= 29.0	15.07	Pass
Deceleration Decay Time to Cross 5 G's		ms	34.0 to 42.0	35.5	Pass
Maximum "D" Plane Rotation	Maximum	Degrees	64.0 to 78.0	66.0	Pass
	Time	ms	57.0 to 64.0	58.3	Pass
"D" Plane Rotation Decay Time To Zero Crossing		ms	113.0 to 128.0	113.7	Pass
Moment About Occipital Condyle	Maximum	N m	88.1 to 108.5	98.6	Pass
	Time	ms	47.0 to 58.0	47.6	Pass
Positive Moment Decay Time To Zero Crossing		ms	97.0 to 107.0	101.7	Pass
			Overall Test Results		Pass

Jessica Gall
Laboratory Technician

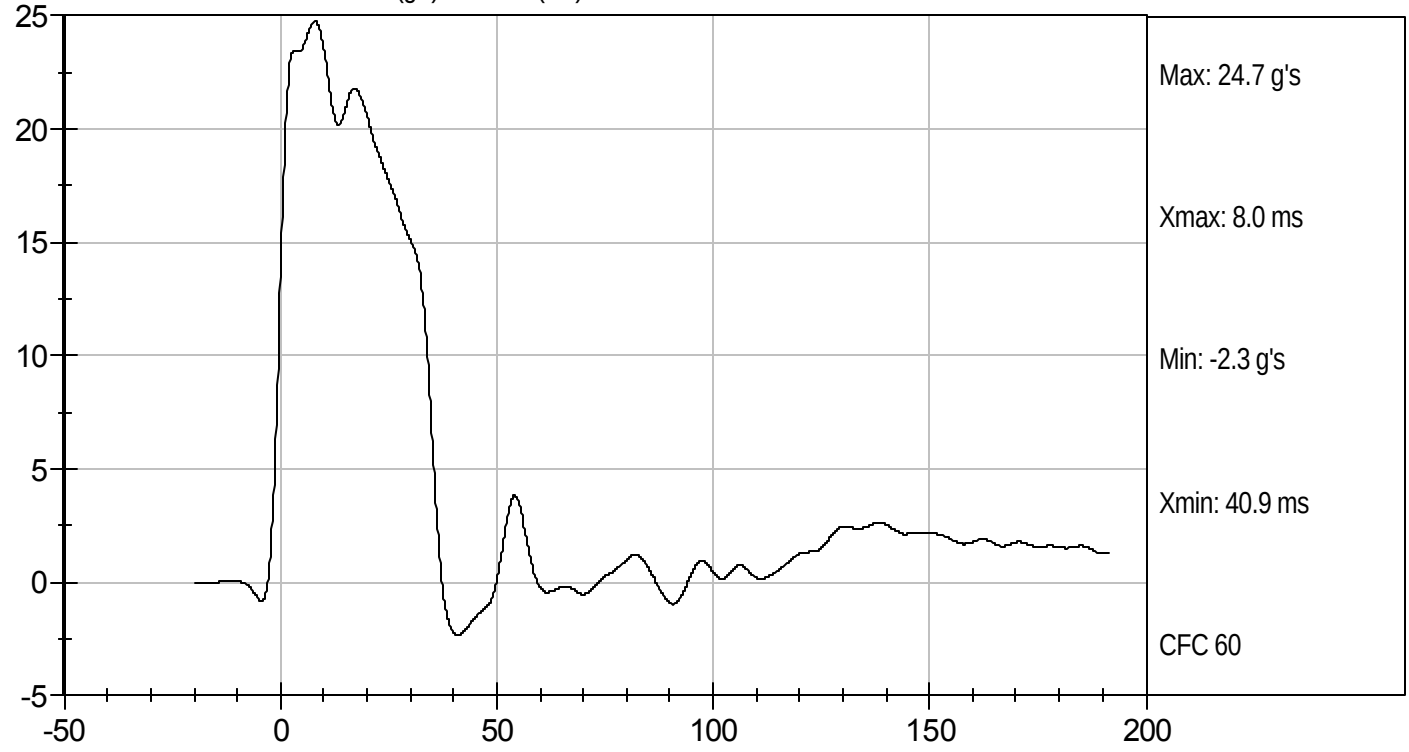
9/23/09
Test Date

David Winkelbauer
Approved By

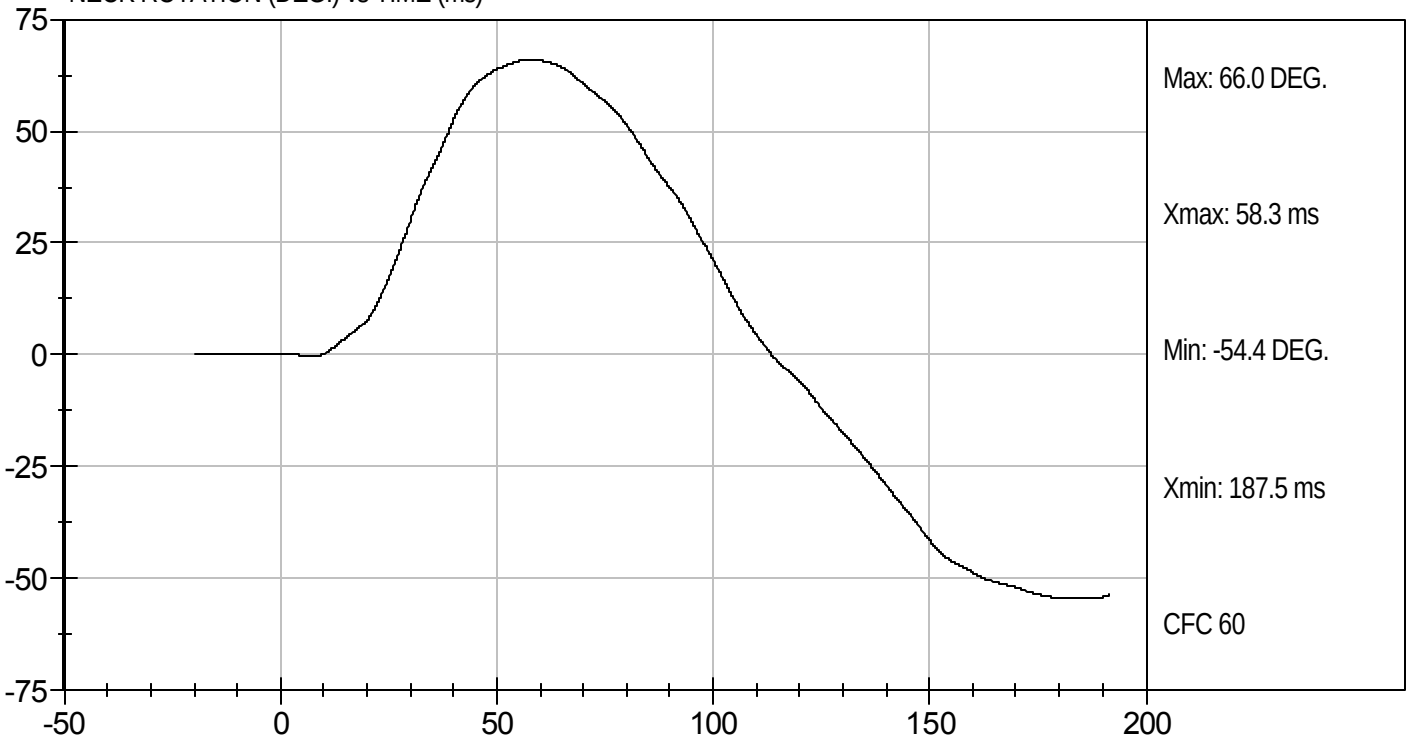
Test Desc: Neck Flexion
Component ID: D092392

Test Date: 9/23/09
Velocity: 23.15 ft/s, 7.06 m/s

PENDULUM DECELERATION (g's) vs TIME (ms)

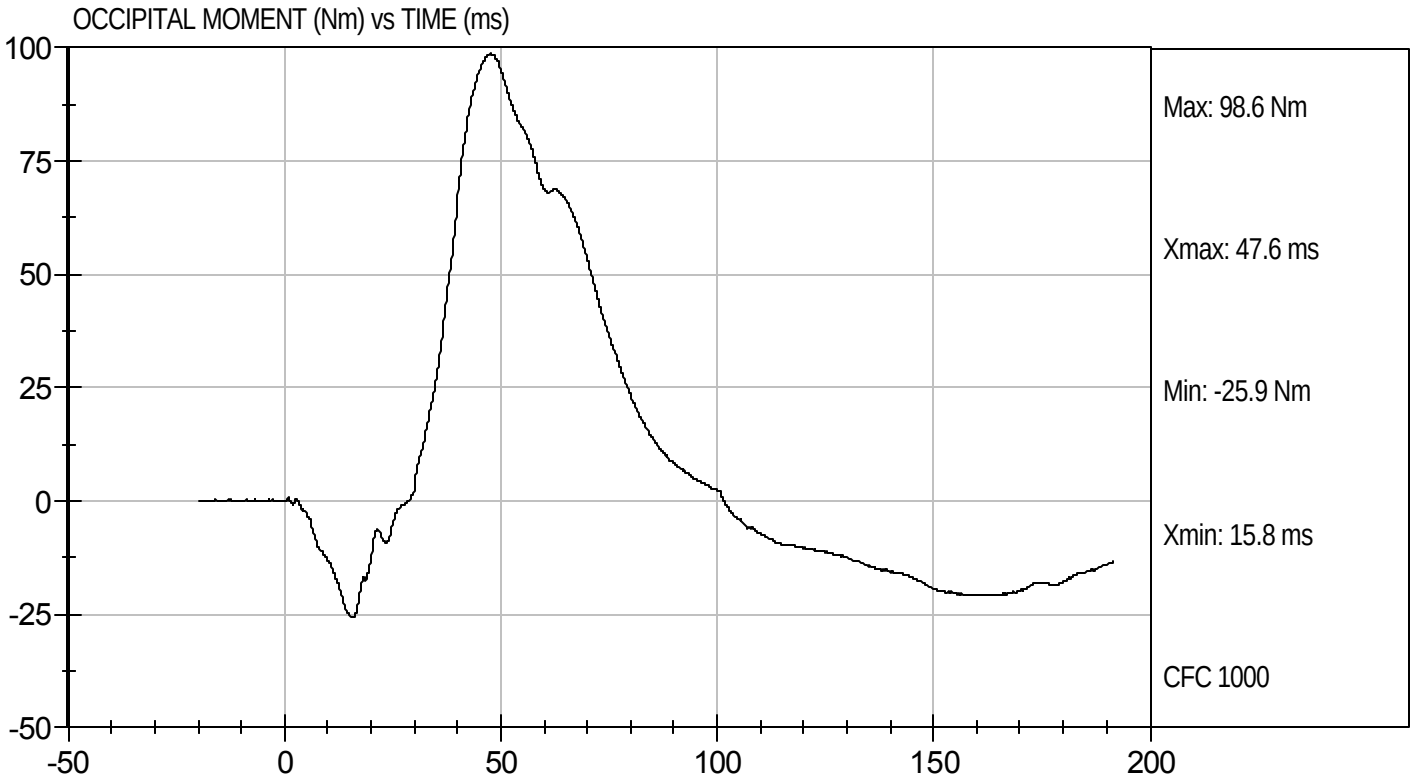


NECK ROTATION (DEG.) vs TIME (ms)



Test Desc: Neck Flexion
Component ID: D092392

Test Date: 9/23/09
Velocity: 23.15 ft/s, 7.06 m/s



MGA RESEARCH CORPORATION

NECK EXTENSION TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 066 **Test I.D:** D092393

Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	20.6 to 22.2	21.1	Pass
Laboratory Relative Humidity		%	10 to 70	54	Pass
Pendulum Velocity		m/s	5.95 to 6.19	6.16	Pass
Pendulum Deceleration	10 ms	m/s	17.20 to 21.20	18.25	Pass
	20 ms	m/s	14.00 to 19.00	14.22	Pass
	30 ms	m/s	11.00 to 16.00	11.56	Pass
Peak Pendulum Deceleration After 30 ms		m/s	<= 22.0	11.76	Pass
Deceleration Decay Time to Cross 5 G's		ms	38.0 to 46.0	41.5	Pass
Maximum "D" Plane Rotation	Maximum	Degrees	81.0 to 106.0	93.0	Pass
	Time	ms	72.0 to 82.0	81.7	Pass
"D" Plane Rotation Decay Time To Zero Crossing		ms	147.0 to 174.0	157.3	Pass
Moment About Occipital Condyle	Maximum	Nm	-52.9 to -79.9	-61.4	Pass
	Time	ms	65.0 to 79.0	72.2	Pass
Negative Moment Decay Time To Zero Crossing		ms	120.0 to 148.0	144.8	Pass
			Overall Test Results		Pass

Jessica Hall
Laboratory Technician

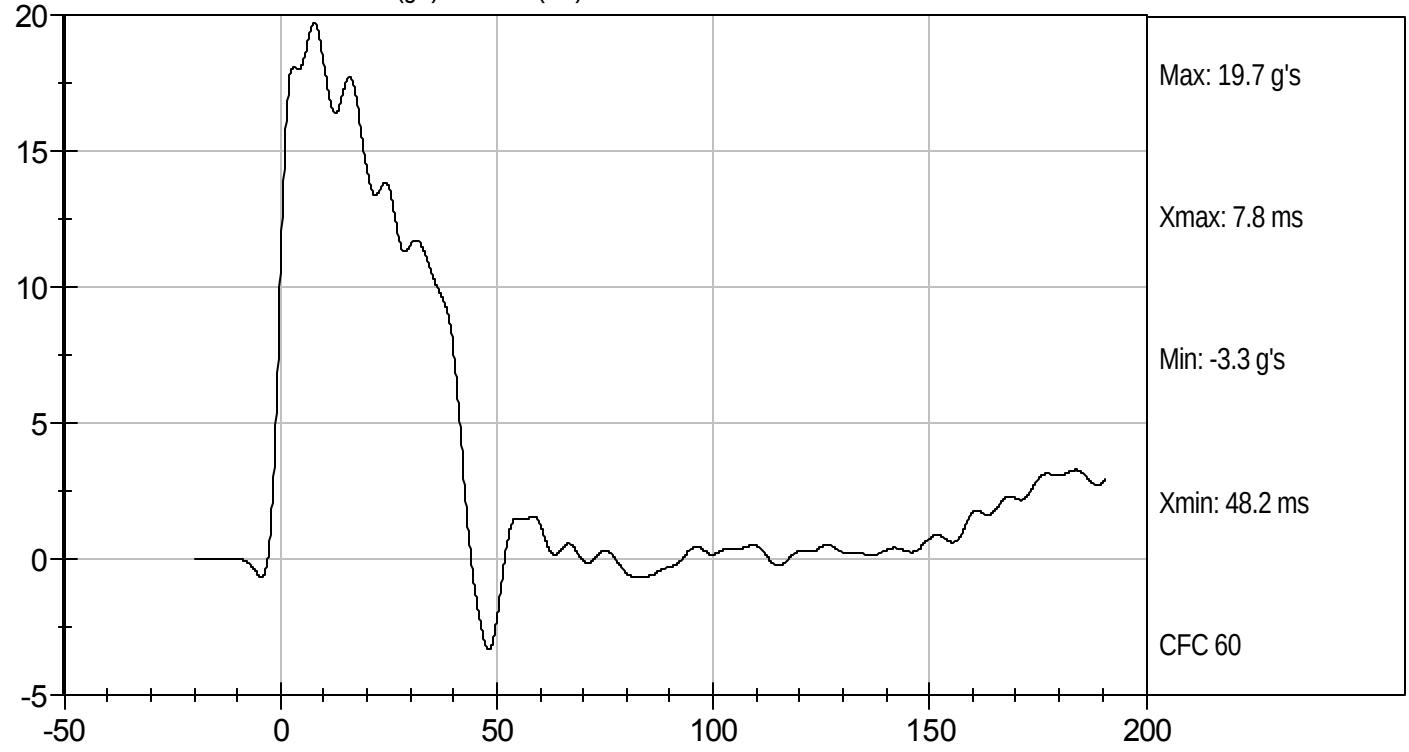
9/23/09
Test Date

David Winkelbauer
Approved By

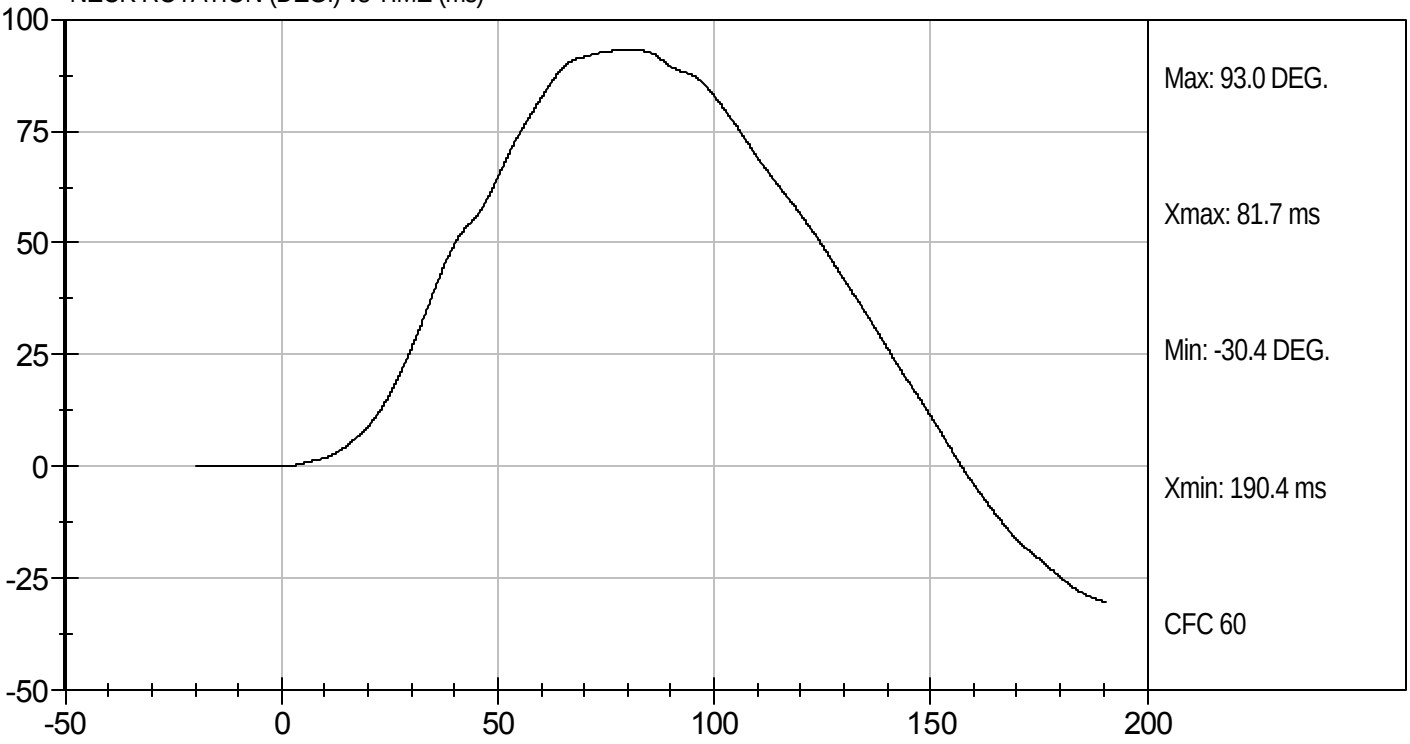
Test Desc: Neck Extension
Component ID: D092393

Test Date: 9/23/09
Velocity: 20.20 ft/s, 6.16 m/s

PENDULUM DECELERATION (g's) vs TIME (ms)

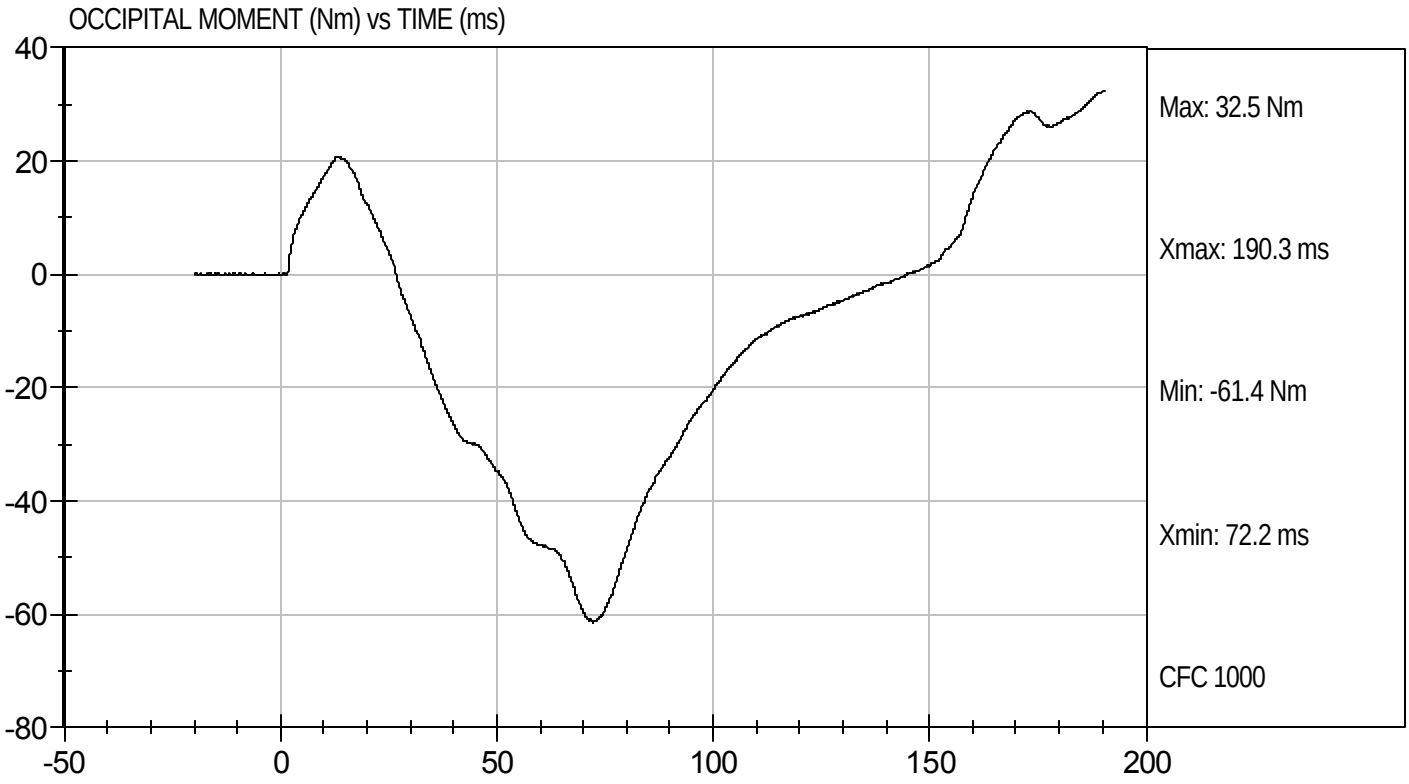


NECK ROTATION (DEG.) vs TIME (ms)



Test Desc: Neck Extension
Component ID: D092393

Test Date: 9/23/09
Velocity: 20.20 ft/s, 6.16 m/s



MGA RESEARCH CORPORATION

THORAX IMPACT

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 066 **Test I.D:** D092394

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	21.4	Pass
Laboratory Relative Humidity	%	10 to 70	54	Pass
Probe Velocity	m/s	6.58 to 6.82	6.77	Pass
Peak Probe Force	N	5159 to 5893	5,402	Pass
Peak Sternum Displacement	cm	6.35 to 7.26	6.73	Pass
Internal Hysteresis	%	69 to 85	71	Pass
		Overall Test Results		Pass

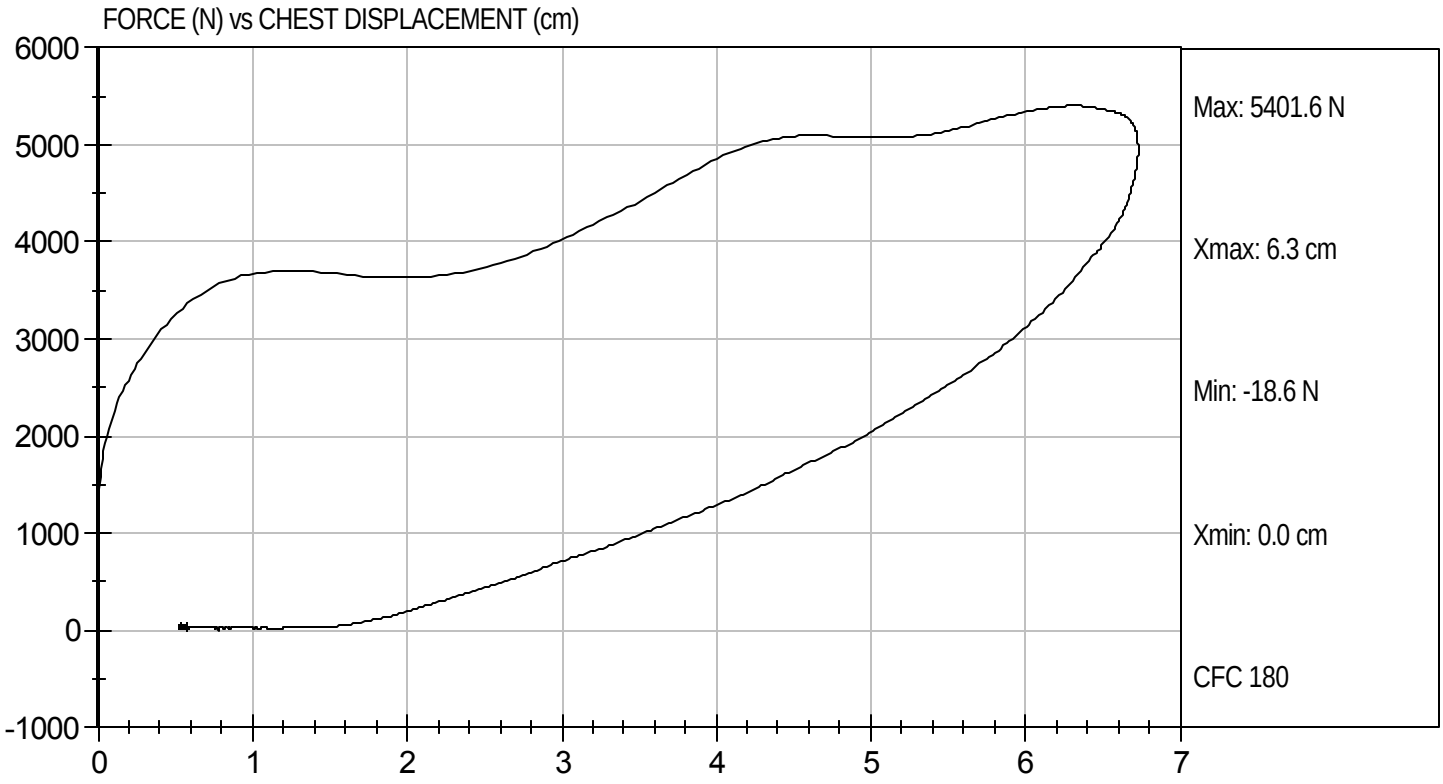
Jessica Hall
Laboratory Technician

9/23/09
Test Date

David Winkelbauer
Approved By

Test Desc: Thorax Impact
Component ID: D092394

Test Date: 9/23/09
Velocity: 22.22 ft/s, 6.77 m/s



MGA RESEARCH CORPORATION

RIGHT KNEE IMPACT TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 066 **Test I.D:** D092395

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.5	21.1	Pass
Laboratory Relative Humidity	%	10 to 70	53	Pass
Probe Velocity	m/s	2.07 to 2.13	2.08	Pass
Peak Probe Force	Newtons	4715 to 5782	5,342	Pass
		Overall Test Results		Pass

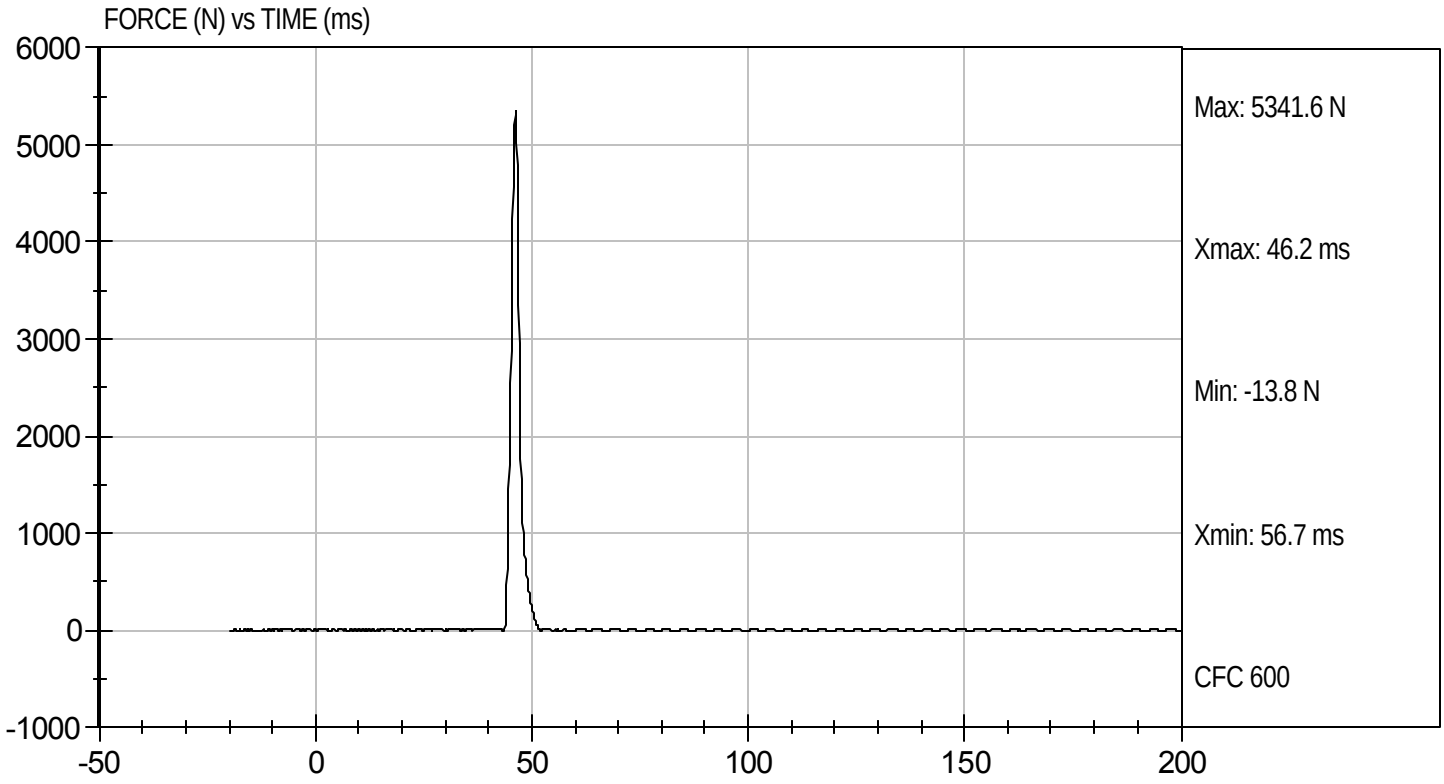
Jessica Hall
Laboratory Technician

9/23/09
Test Date

David Winkelbauer
Approved By

Test Desc: Right Knee
Component ID: D092395

Test Date: 9/23/09
Velocity: 6.82 ft/s, 2.08 m/s



MGA RESEARCH CORPORATION

LEFT KNEE IMPACT TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 066 **Test I.D:** D092396

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.5	21.1	Pass
Laboratory Relative Humidity	%	10 to 70	53	Pass
Probe Velocity	m/s	2.07 to 2.13	2.12	Pass
Peak Probe Force	Newtons	4715 to 5782	5,373	Pass
		Overall Test Results		Pass

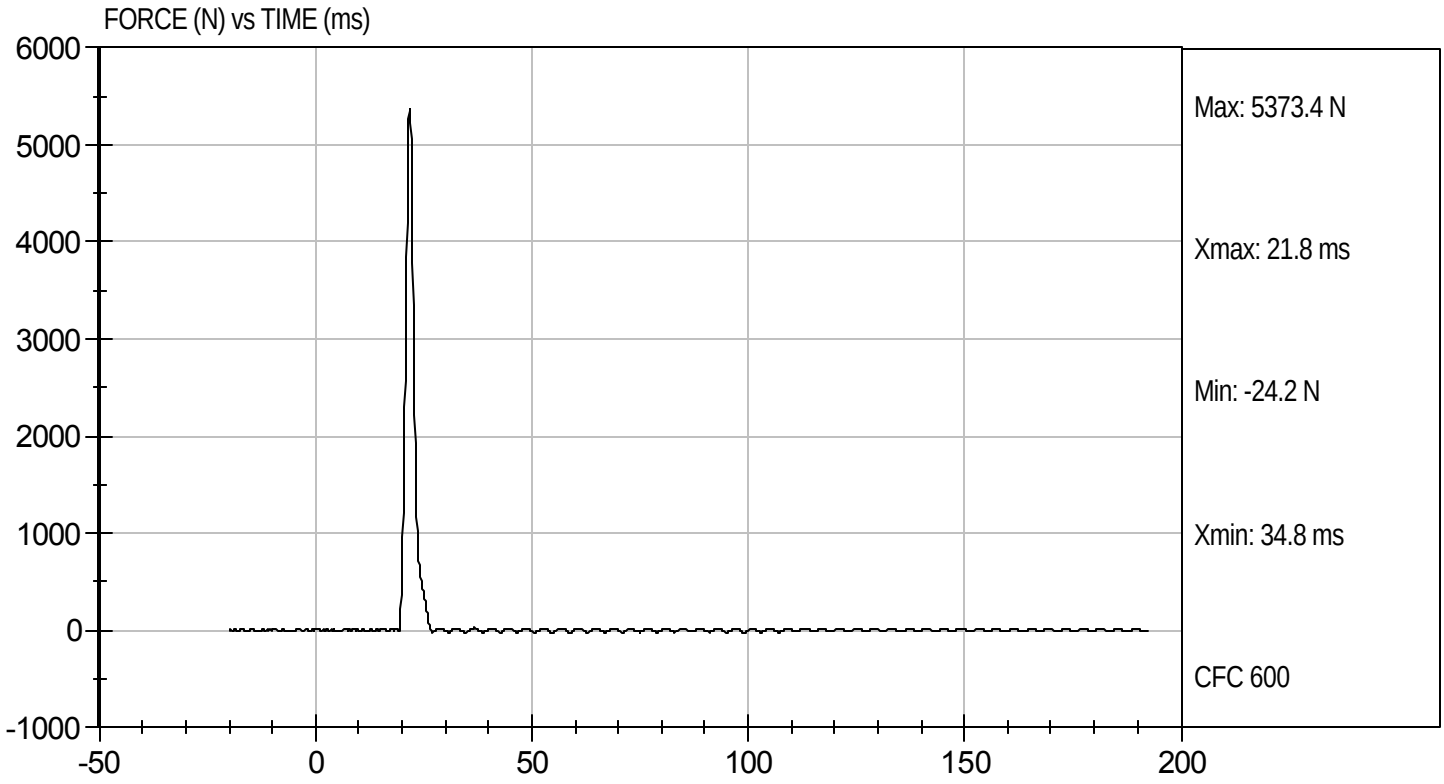
Jessica Hall
Laboratory Technician

9/23/09
Test Date

David Winkelbauer
Approved By

Test Desc: Left Knee
Component ID: D092396

Test Date: 9/23/09
Velocity: 6.94 ft/s, 2.12 m/s



MGA RESEARCH CORPORATION

HIP-FEMUR FLEXION TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 066 **Test I.D:** D092390

Tested Parameter	Units	Specification	Result		Pass/Fail
			Right	Left	
Laboratory Temperature	deg C	18.9 to 25.6	21.3	21.3	Pass
Laboratory Relative Humidity	%	10 to 70	55	55	Pass
Rotation Rate	deg/s	5 -10	8	8	Pass
30 Degrees	Nm	94.9 Nm Max	66.2	65.6	Pass
150 ft-lbf / 203.4 Nm	Deg	40- 50 Degree Max Rotation	42	41	Pass
		Overall Test Results			Pass

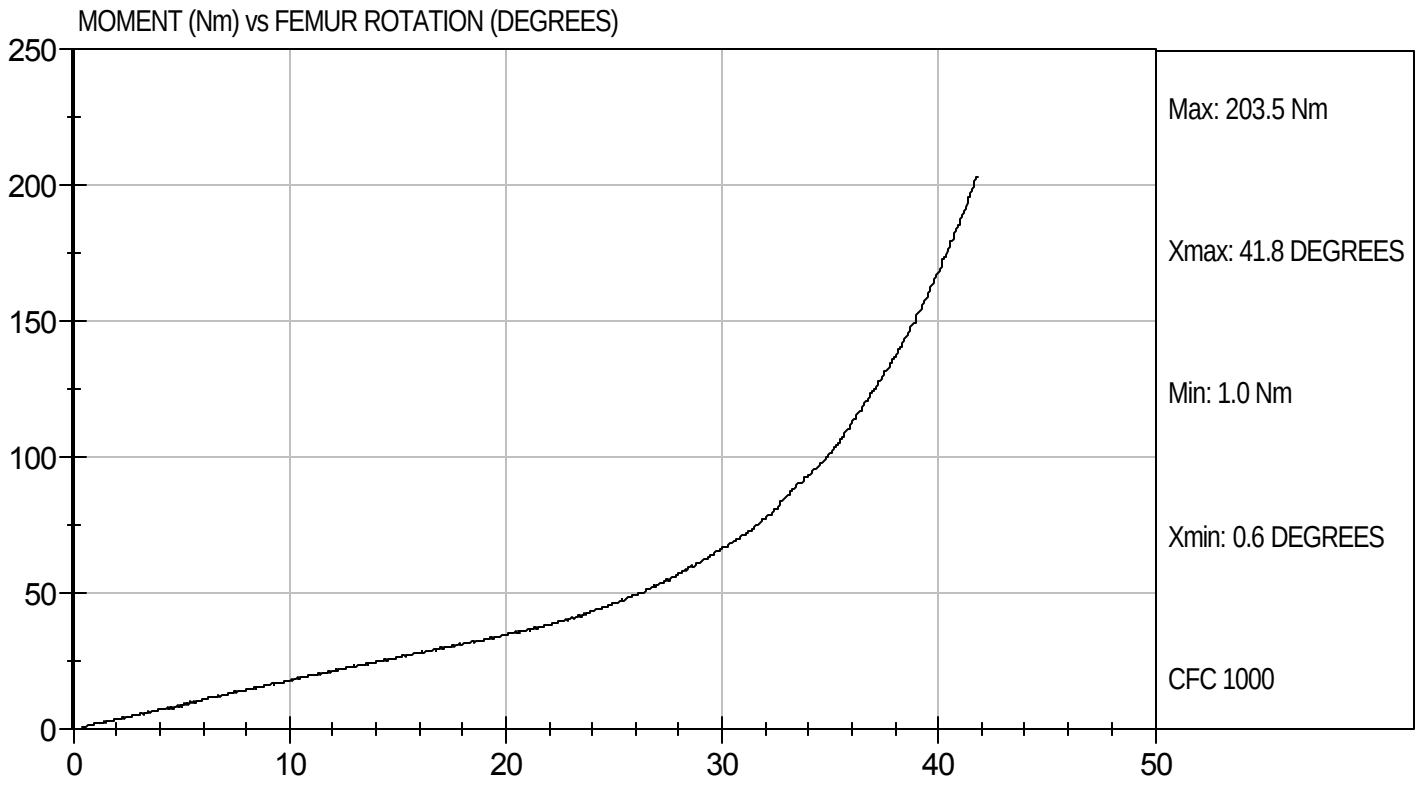
Jessica Hall
Laboratory Technician

9/23/09
Test Date

David Winkelbauer
Approved By

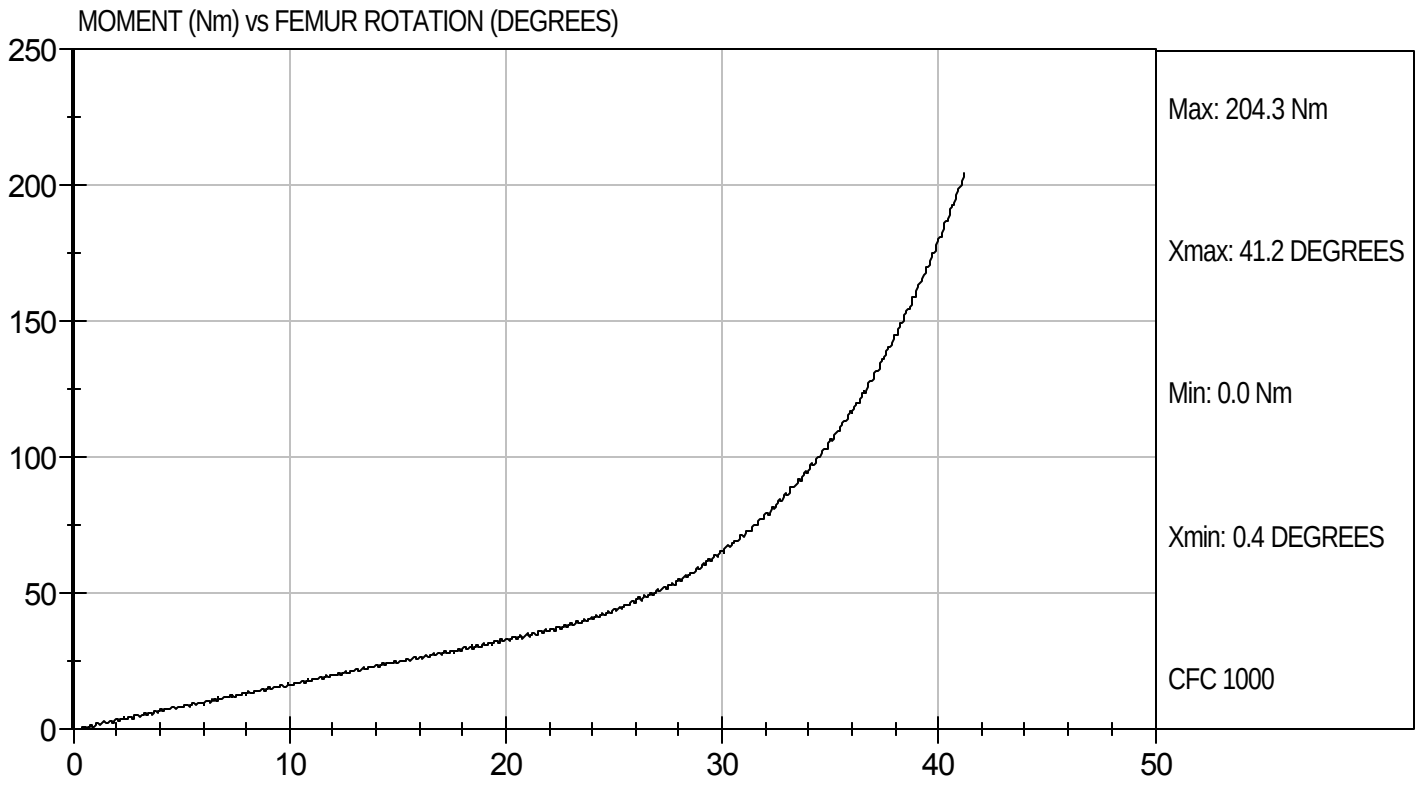
Test Desc: Hip Femur Flexion
Component ID: D092399

Test Date: 9/23/09
Velocity: 0 ft/s, 0.00 m/s



Test Desc: Hip Femur Flexion
Component ID: D092390

Test Date: 9/23/09
Velocity: 0 ft/s, 0.00 m/s



MGA RESEARCH CORPORATION

HEAD DROP TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 065 **Test ID:** D092381

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 - 25.6	20.7	Pass
Laboratory Relative Humidity	%	10 to 70	56	Pass
Peak Resultant Acceleration	G's	225 - 275	239	Pass
Peak Lateral Acceleration	G's	<= +/- 15.0	-7.2	Pass
Unimodal	N/A	Yes	Yes	Pass
Oscillations	N/A	within 10% of peak	Yes	Pass
		Overall Test Results		Pass

Jessica Gall
Laboratory Technician

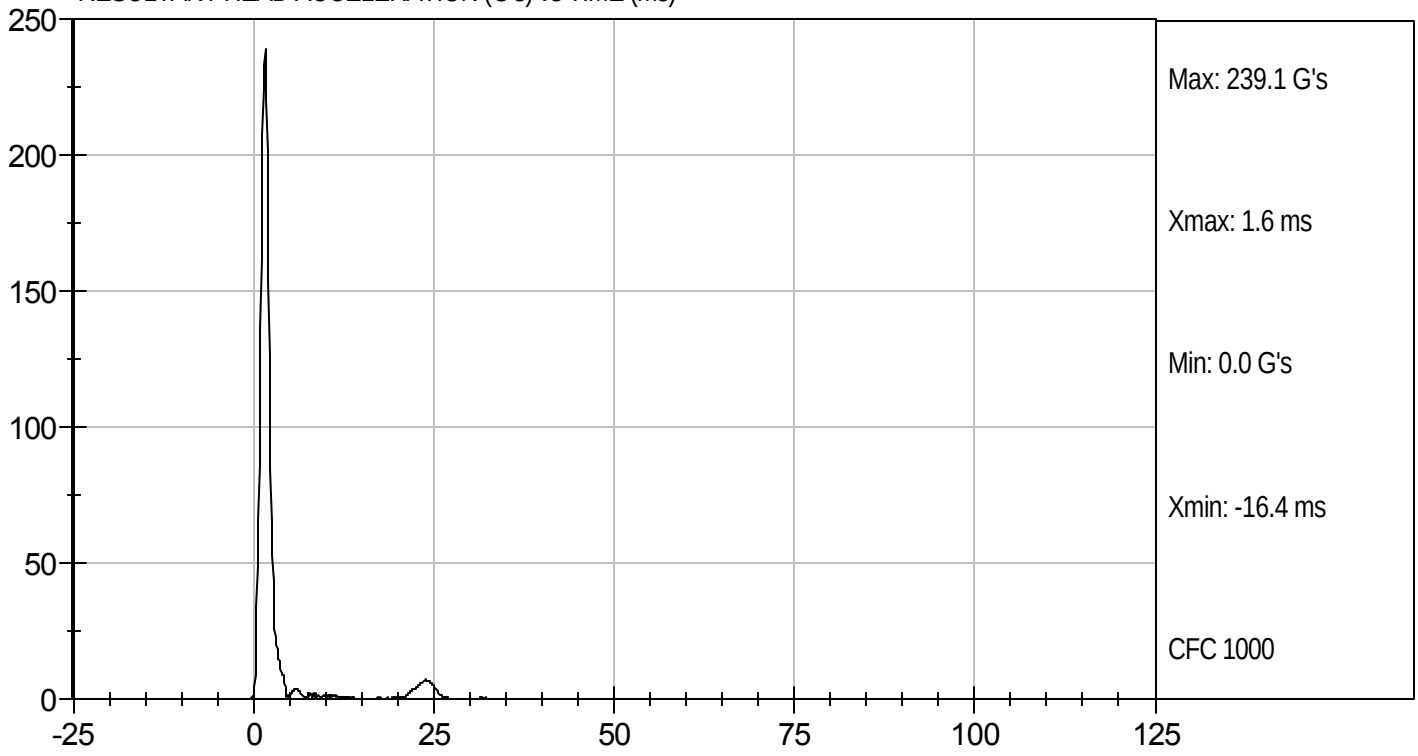
9/22/09
Test Date

David Winkelbauer
Approved By

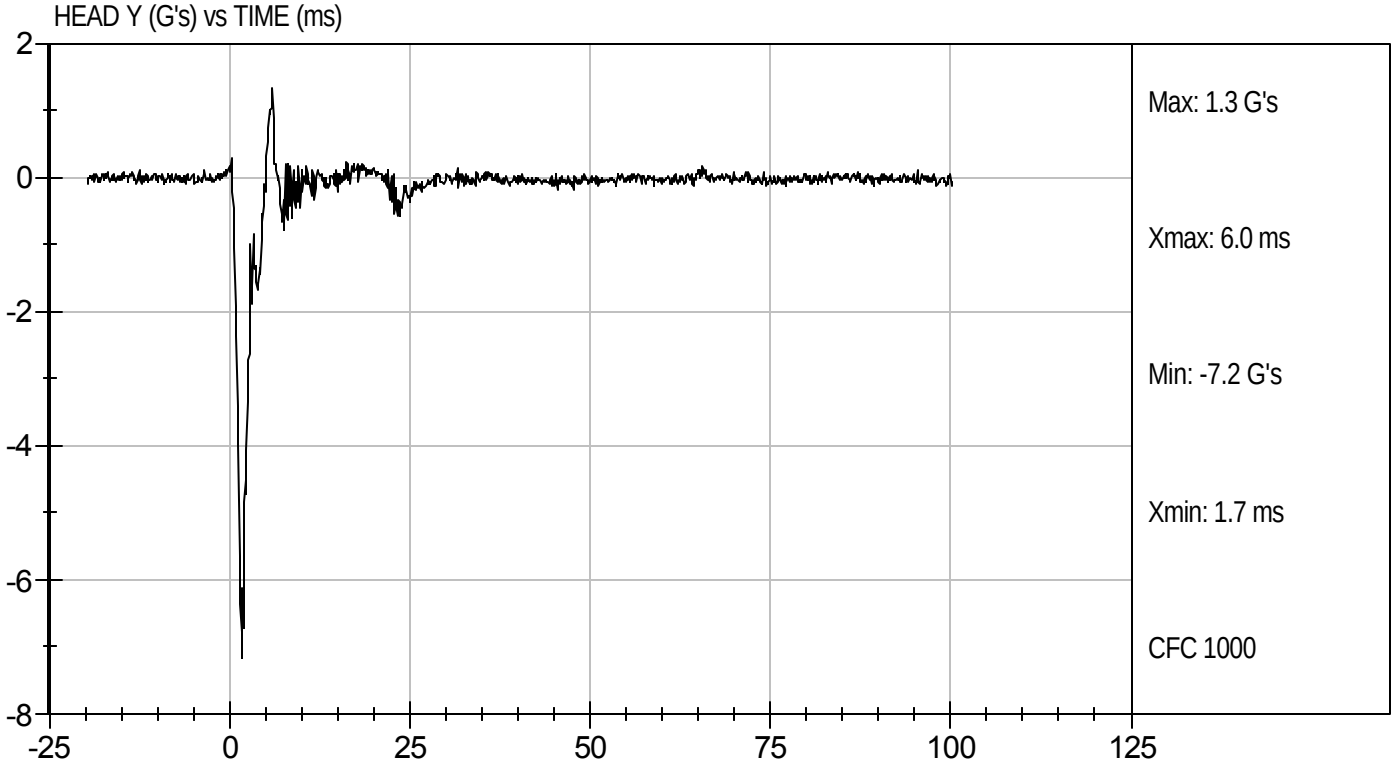
Test Desc: Head Drop
Component ID: D092381

Test Date: 9/22/09
Velocity: 0 ft/s, 0.00 m/s

RESULTANT HEAD ACCELERATION (G's) vs TIME (ms)



HEAD Y (G's) vs TIME (ms)



MGA RESEARCH CORPORATION

NECK FLEXION TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 065 **Test I.D:** D092382

Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	20.6 to 22.2	21.1	Pass
Laboratory Relative Humidity		%	10 to 70	54	Pass
Pendulum Velocity		m/s	6.89 to 7.13	7.06	Pass
Pendulum Deceleration	10 ms	m/s	22.50 to 27.50	23.77	Pass
	20 ms	m/s	17.60 to 22.60	20.75	Pass
	30 ms	m/s	12.50 to 18.50	14.88	Pass
Peak Pendulum Deceleration After 30 ms		m/s	<= 29.0	14.80	Pass
Deceleration Decay Time to Cross 5 G's		ms	34.0 to 42.0	34.4	Pass
Maximum "D" Plane Rotation	Maximum	Degrees	64.0 to 78.0	65.2	Pass
	Time	ms	57.0 to 64.0	57.5	Pass
"D" Plane Rotation Decay Time To Zero Crossing		ms	113.0 to 128.0	118.2	Pass
Moment About Occipital Condyle	Maximum	N m	88.1 to 108.5	95.2	Pass
	Time	ms	47.0 to 58.0	47.7	Pass
Positive Moment Decay Time To Zero Crossing		ms	97.0 to 107.0	101.2	Pass
			Overall Test Results		Pass

Jessica Hall
Laboratory Technician

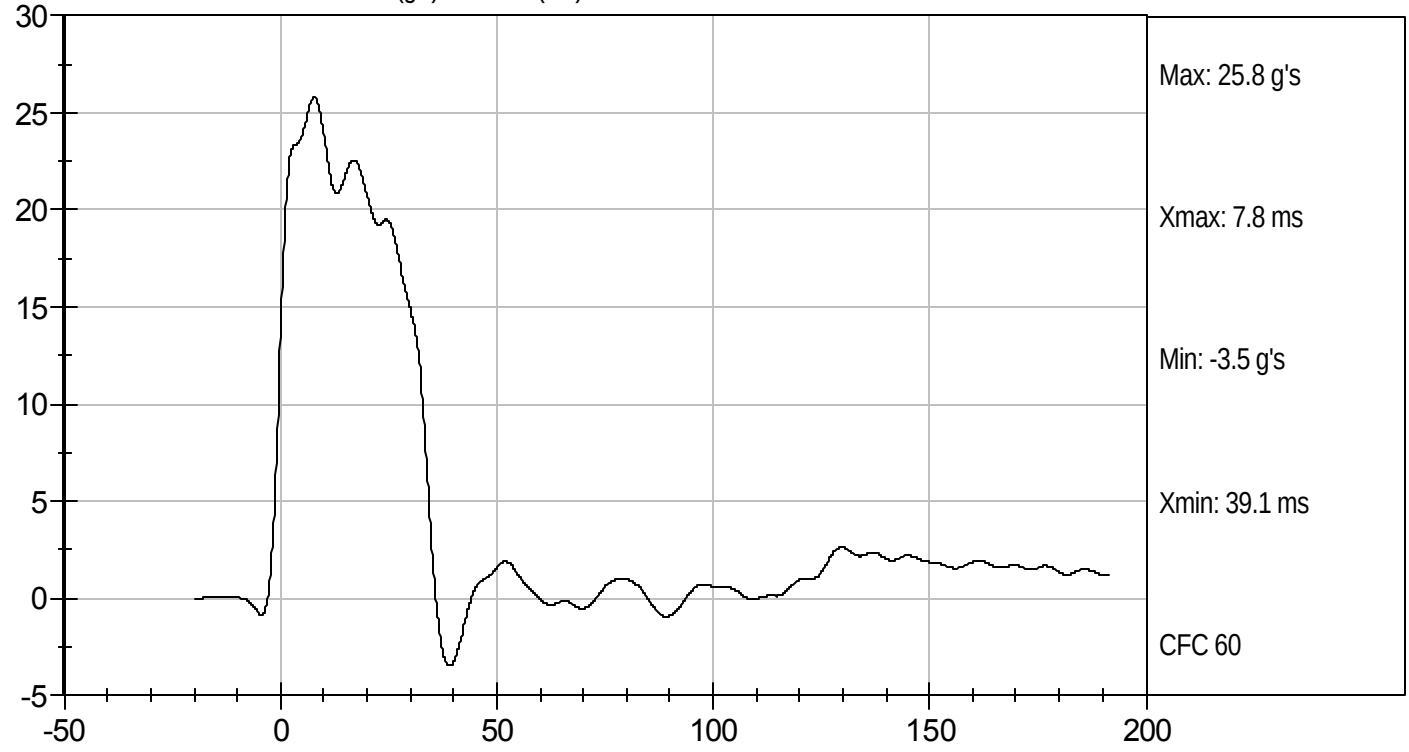
9/23/09
Test Date

David Winkelbauer
Approved By

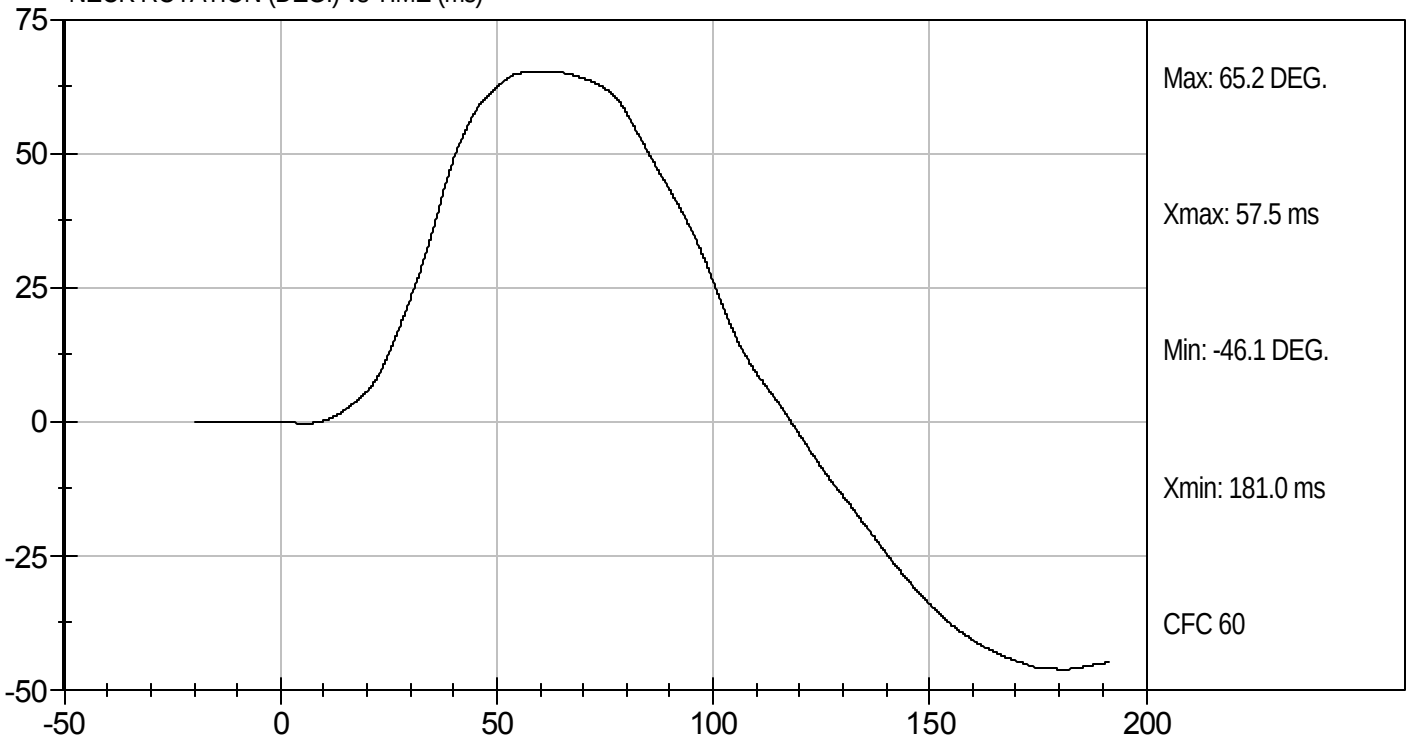
Test Desc: Neck Flexion
Component ID: D092382

Test Date: 9/23/09
Velocity: 23.15 ft/s, 7.06 m/s

PENDULUM DECELERATION (g's) vs TIME (ms)

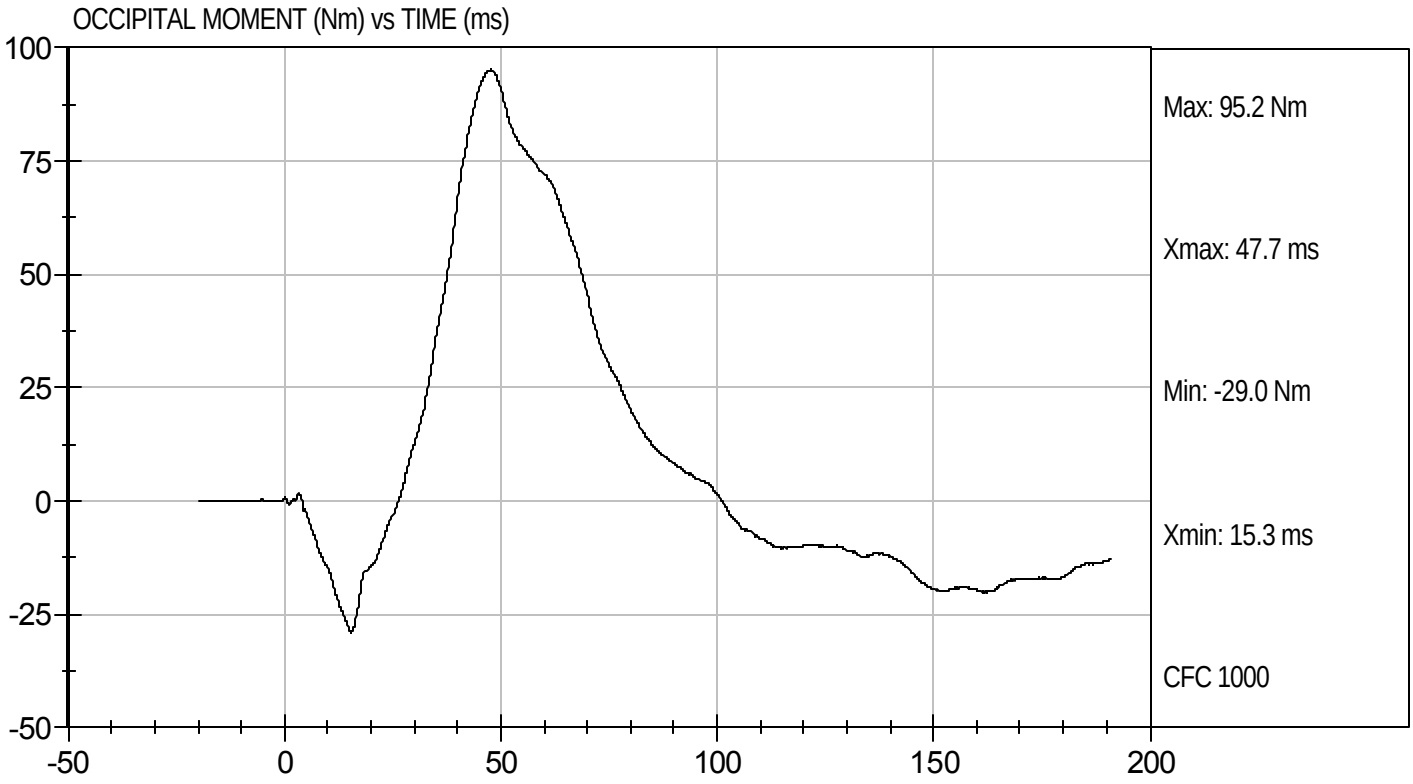


NECK ROTATION (DEG.) vs TIME (ms)



Test Desc: Neck Flexion
Component ID: D092382

Test Date: 9/23/09
Velocity: 23.15 ft/s, 7.06 m/s



MGA RESEARCH CORPORATION

NECK EXTENSION TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 065 **Test I.D:** D092383

Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	20.6 to 22.2	21.1	Pass
Laboratory Relative Humidity		%	10 to 70	54	Pass
Pendulum Velocity		m/s	5.95 to 6.19	6.16	Pass
Pendulum Deceleration	10 ms	m/s	17.20 to 21.20	17.86	Pass
	20 ms	m/s	14.00 to 19.00	15.57	Pass
	30 ms	m/s	11.00 to 16.00	12.73	Pass
Peak Pendulum Deceleration After 30 ms		m/s	<= 22.0	12.69	Pass
Deceleration Decay Time to Cross 5 G's		ms	38.0 to 46.0	39.6	Pass
Maximum "D" Plane Rotation	Maximum	Degrees	81.0 to 106.0	89.1	Pass
	Time	ms	72.0 to 82.0	73.9	Pass
"D" Plane Rotation Decay Time To Zero Crossing		ms	147.0 to 174.0	157.7	Pass
Moment About Occipital Condyle	Maximum	Nm	-52.9 to -79.9	-61.6	Pass
	Time	ms	65.0 to 79.0	71.1	Pass
Negative Moment Decay Time To Zero Crossing		ms	120.0 to 148.0	140.8	Pass
			Overall Test Results		Pass

Jessica Hall
Laboratory Technician

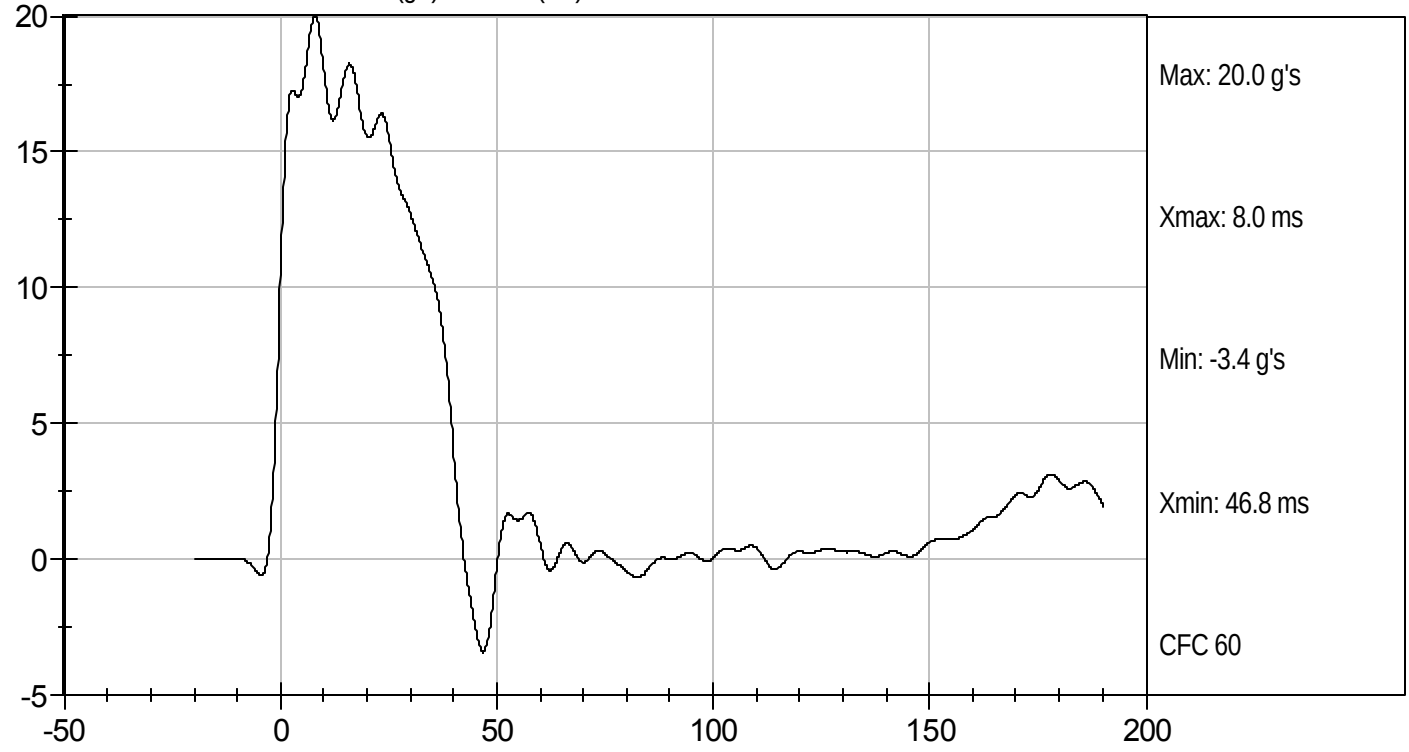
9/23/09
Test Date

David Winkelbauer
Approved By

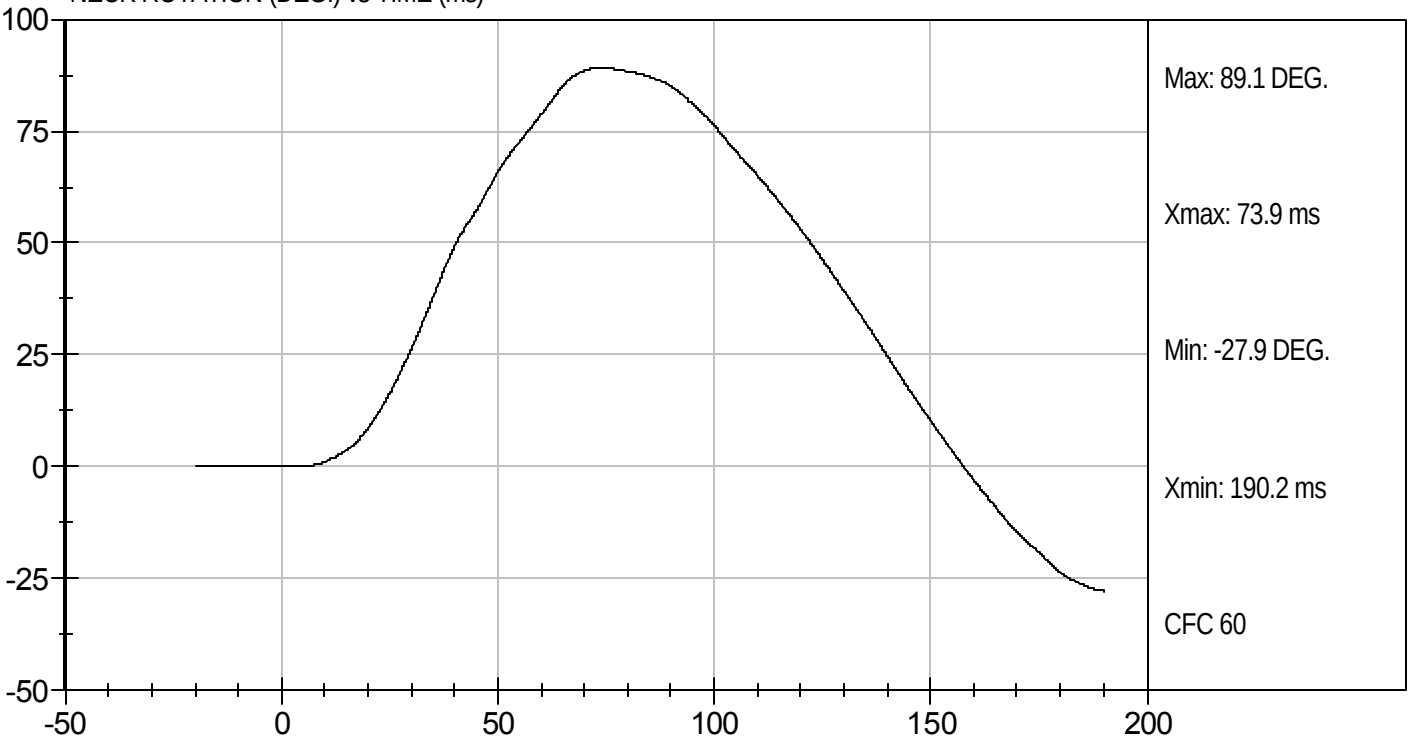
Test Desc: Neck Extension
Component ID: D092383

Test Date: 9/23/09
Velocity: 20.20 ft/s, 6.16 m/s

PENDULUM DECELERATION (g's) vs TIME (ms)

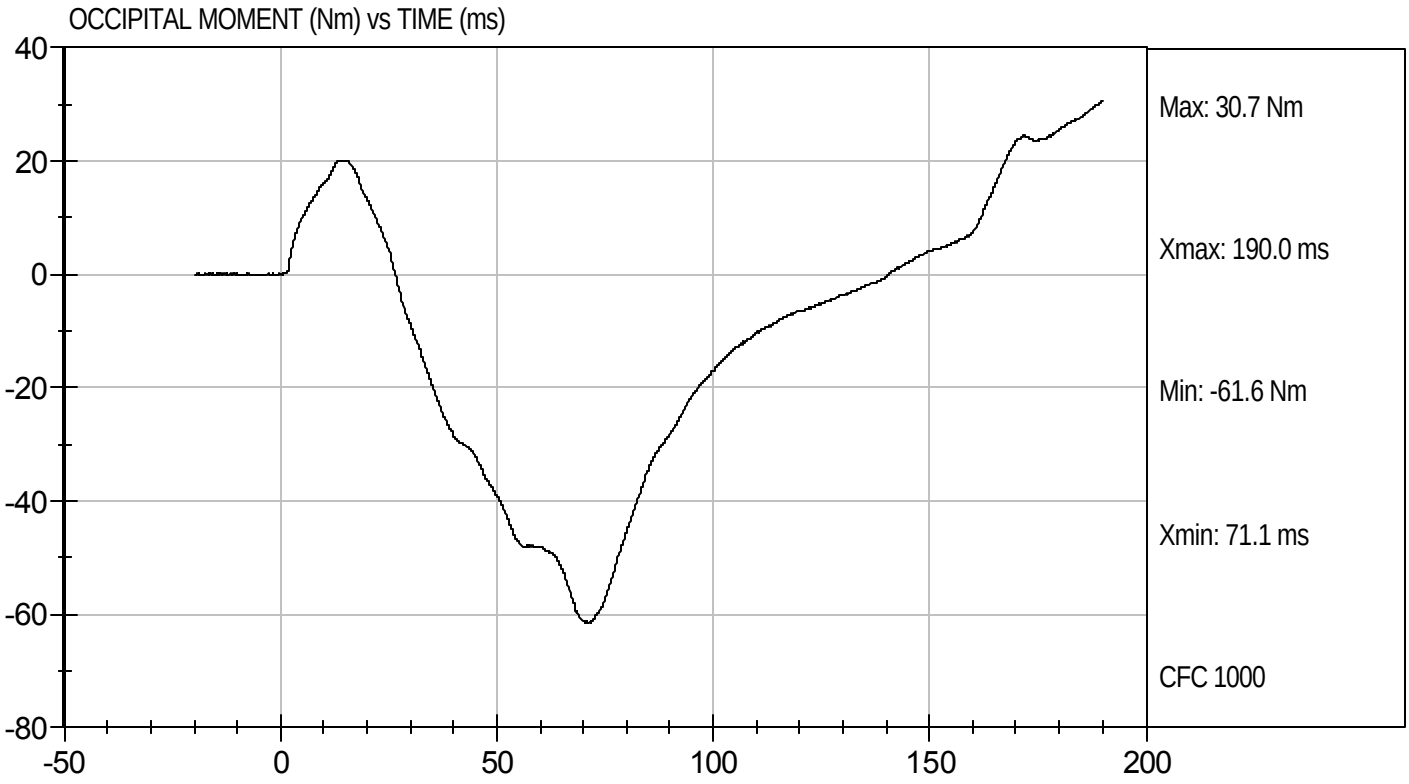


NECK ROTATION (DEG.) vs TIME (ms)



Test Desc: Neck Extension
Component ID: D092383

Test Date: 9/23/09
Velocity: 20.20 ft/s, 6.16 m/s



MGA RESEARCH CORPORATION

THORAX IMPACT

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 065 **Test I.D:** D092384

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	21.3	Pass
Laboratory Relative Humidity	%	10 to 70	54	Pass
Probe Velocity	m/s	6.58 to 6.82	6.77	Pass
Peak Probe Force	N	5159 to 5893	5,413	Pass
Peak Sternum Displacement	cm	6.35 to 7.26	6.97	Pass
Internal Hysteresis	%	69 to 85	71	Pass
		Overall Test Results		Pass

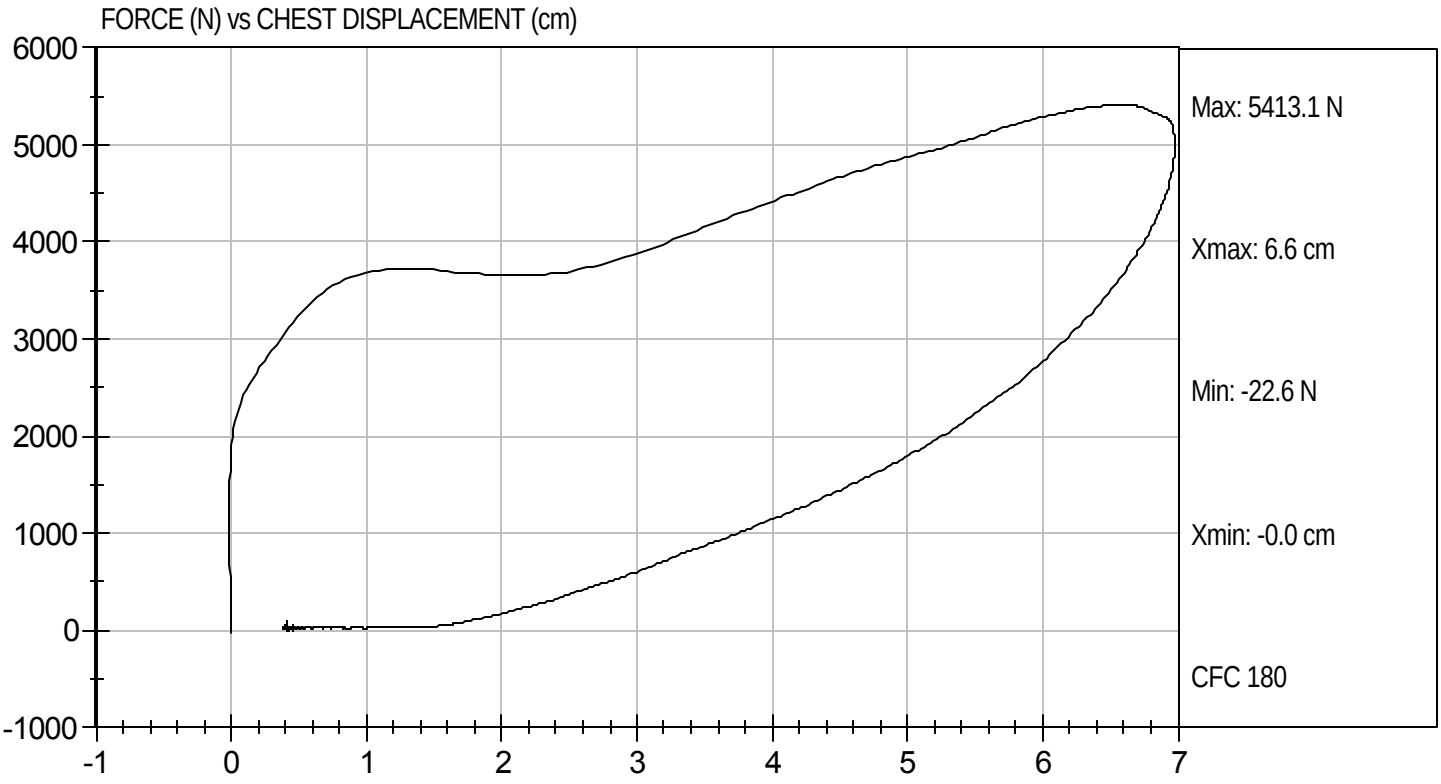
Jessica Gall
Laboratory Technician

9/23/09
Test Date

David Winkelbauer
Approved By

Test Desc: Thorax Impact
Component ID: D092384

Test Date: 9/23/09
Velocity: 22.22 ft/s, 6.77 m/s



MGA RESEARCH CORPORATION

RIGHT KNEE IMPACT TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 065 **Test I.D:** D092385

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.5	21.4	Pass
Laboratory Relative Humidity	%	10 to 70	61	Pass
Probe Velocity	m/s	2.07 to 2.13	2.10	Pass
Peak Probe Force	Newtons	4715 to 5782	5,081	Pass
		Overall Test Results		Pass

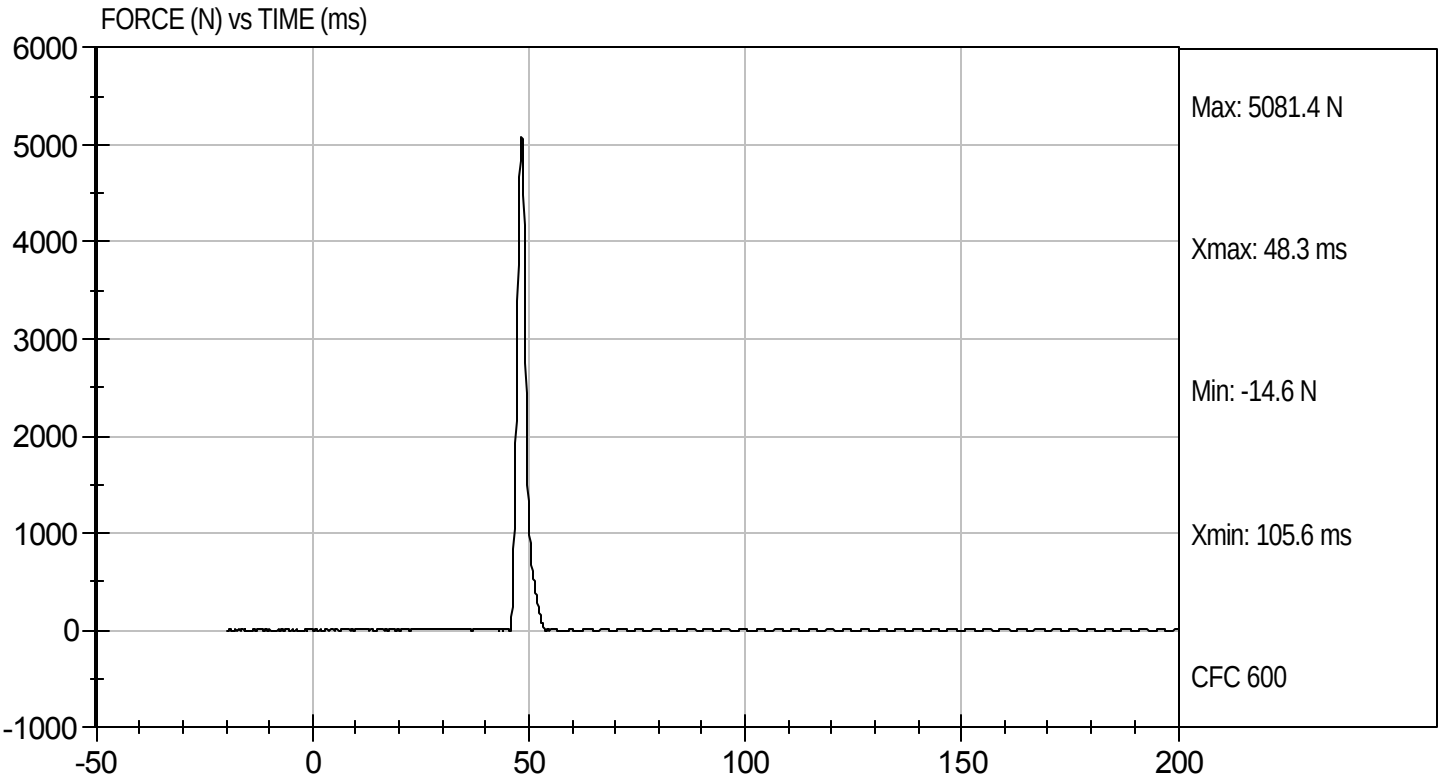
Jessica Hall
Laboratory Technician

9/22/09
Test Date

David Winkelbauer
Approved By

Test Desc: Right Knee
Component ID: D092385

Test Date: 9/22/09
Velocity: 6.89 ft/s, 2.10 m/s



MGA RESEARCH CORPORATION

LEFT KNEE IMPACT TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 065 **Test I.D:** D092386

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.5	21.4	Pass
Laboratory Relative Humidity	%	10 to 70	61	Pass
Probe Velocity	m/s	2.07 to 2.13	2.10	Pass
Peak Probe Force	Newtons	4715 to 5782	5,234	Pass
		Overall Test Results		Pass

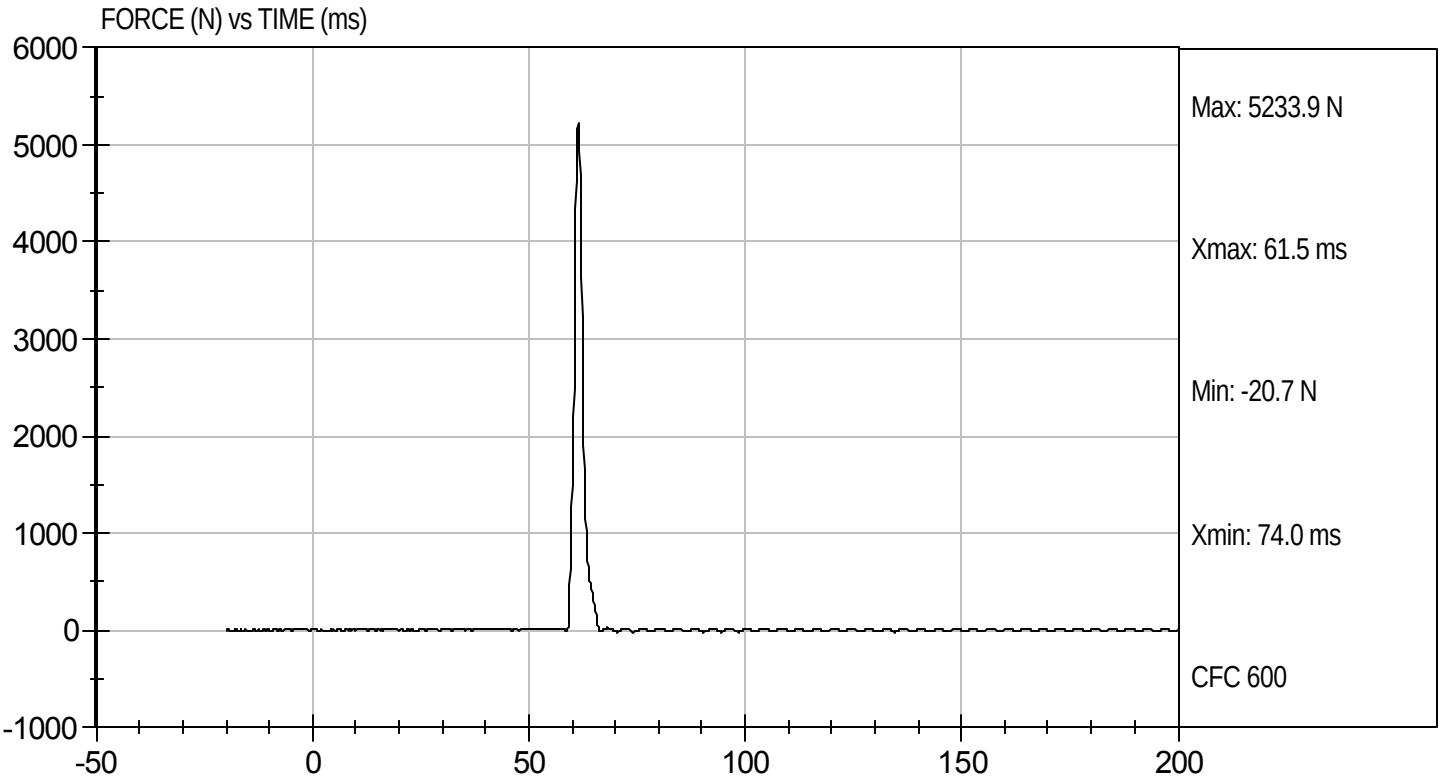
Jessica Gall
Laboratory Technician

9/22/09
Test Date

David Winkelbauer
Approved By

Test Desc: Left Knee
Component ID: D092386

Test Date: 9/22/09
Velocity: 6.88 ft/s, 2.10 m/s



MGA RESEARCH CORPORATION

HIP-FEMUR FLEXION TEST

HYBRID III 50TH PERCENTILE MALE

ATD Serial No: 065 **Test I.D:** D092380

Tested Parameter	Units	Specification	Result		Pass/Fail
			Right	Left	
Laboratory Temperature	deg C	18.9 to 25.6	21.2	21.2	Pass
Laboratory Relative Humidity	%	10 to 70	59	59	Pass
Rotation Rate	deg/s	5 -10	8	8	Pass
30 Degrees	Nm	94.9 Nm Max	63.1	55.3	Pass
150 ft-lbf / 203.4 Nm	Deg	40- 50 Degree Max Rotation	42	42	Pass
		Overall Test Results			Pass

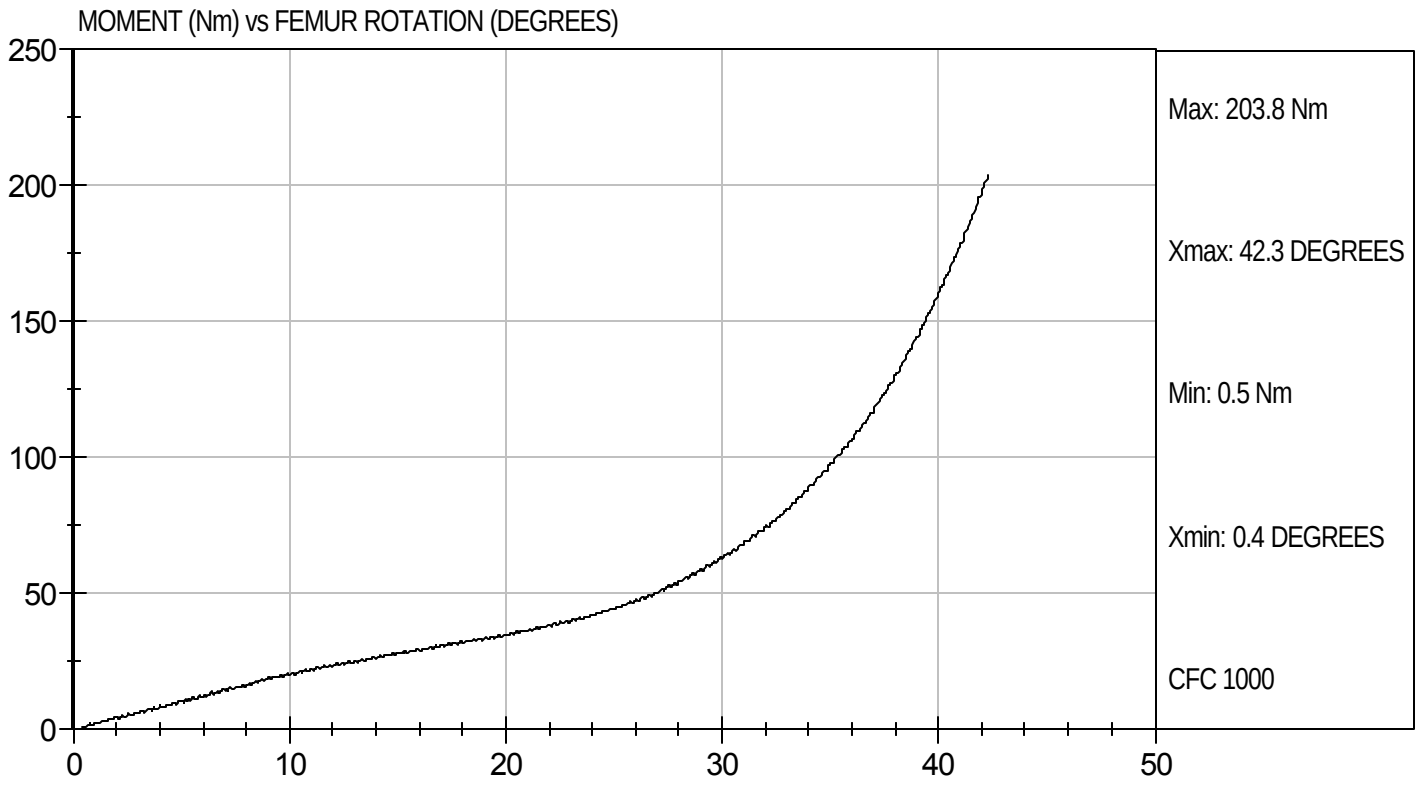
Jessica Gall
Laboratory Technician

9/22/09
Test Date

David Winkelbauer
Approved By

Test Desc: Hip Femur Flexion
Component ID: D092389

Test Date: 9/22/09
Velocity: 0 ft/s, 0.00 m/s



Test Desc: Hip Femur Flexion
Component ID: D092380

Test Date: 9/22/09
Velocity: 0 ft/s, 0.00 m/s