REPORT NUMBER: 214P-MGA-2011-018

SAFETY COMPLIANCE TESTING FOR FMVSS 214
DYNAMIC SIDE IMPACT PROTECTION
RIGID POLE

VOLVO CAR CORPORATION
2011 VOLVO S60 4-DR SEDAN
NHTSA NUMBER: CB5901

PREPARED BY:
MGA RESEARCH CORPORATION
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BURLINGTON, WI 53105

Test Date: May 5, 2011

Report Date: June 6, 2011

FINAL REPORT

PREPARED FOR:
U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
ENFORCEMENT
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FINAL REPORT ACCEPTANCE BY OVSC:

Accepted by: James A. Jones

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Technical Report Documentation Page

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7. Author(s) Donna Janovicz, Project Manager Joe Fleck, Project Engineer		*8. Performing Organization Report No.* 214P-MGA-2011-018
9. Performing Organization Name and Address MGA Research Corporation 5000 Warren Road Burlington, WI 53105		*10. Work Unit No.* *11. Contract or Grant No.* DTNH22-07-D-00062
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Office of Vehicle Safety Compliance (NVS-220) 1200 New Jersey Ave, SE Washington, DC 20590		*13. Type of Report and Period Covered:* Final Test Report 5/05/2011 to 6/06/2011 *14. Sponsoring Agency Code* NVS-220
15. Supplementary Notes		

16. Abstract

A 32 km/h (20 mph), 75° oblique impact compliance test was conducted on the subject 2011 Volvo S60 4-Dr Sedan in accordance with the specifications of the Office of Vehicle Safety Compliance TP-214P-01 for the determination of FMVSS No. 214 Side Impact Protection compliance. The test was conducted at MGA Research Corporation, in Burlington, Wisconsin, on May 5, 2011.

The impact velocity was 31.6 km/h, and the ambient temperature at the struck (driver's) side of the test vehicle at the time of impact was 21°C. The test vehicle post-test maximum crush was 347 mm at level 3. The test vehicle's performance follows:

Measurement Description	Units	Result
Head Injury Criteria (HIC_{36})	N/A	331
Max. Rib Deflection	mm	35
Sum of Abdomen Forces	N	1486
Pubic Symphysis Force	N	1764

The doors on the struck side of the vehicle did not separate from the body at the hinges or latches and the opposite side doors did not open during the side impact event.

17. Key Words Compliance Testing Side Impact Protection Pole Test ES-2re SID-IIs		*18. Distribution Statement* Copies of this report are available from: National Highway Traffic Safety Administration Technical Information Services (TIS) Room E12-100 East Building 1200 New Jersey Ave. Washington, D.C. 20590 Telephone No. (202) 366-2588	
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Form DOT F1700.7 (8-72)

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PURPOSE AND SUMMARY OF TEST

PURPOSE

This side impact test is part of the FY 2011 FMVSS 214 Side Impact Protection Compliance Test Program sponsored by the National Highway Traffic Safety Administration (NHTSA), under Contract No. DTNH22-07-D-00062. The purpose of this test was to evaluate side impact protection in a 2011 Volvo S60 4-Dr Sedan. The side impact test was conducted in accordance with the Office of Vehicle Safety Compliance's Laboratory Test Procedure (TP-214P-01, dated January 2010).

SUMMARY

A rigid pole side impact test was conducted on a 2011 Volvo S60 4-Dr Sedan. The subject vehicle was towed into the rigid pole at an angle of 75° and a velocity of 31.6 km/h. The test was conducted by MGA Research Corporation in Burlington, Wisconsin, on May 5, 2011. Pre-test and post-test photographs of the test vehicle and side impact dummy are included in Appendix A of this report.

One Part 572U dummy was placed in the left front outboard designated seating position according to instructions specified in TP-214P-01, dated January 2010. The side impact event was documented by ten (10) cameras.

The ES-2re male dummy was instrumented with a triaxial accelerometer pack located in the head, 3 rib displacement transducers located in the chest, 3 load cells located in the abdomen and a load cell located in the pubic symphysis.

A summary of the test results follows:

DUMMY INJURY VALUES

Dummy	HIC (36ms)	Thorax Deflection (mm)		Abdomen Forces (N)		Pubic Symphysis (N)
ES-2re 50th Percentile Male	331	Upper	34.5	Front	301.2	1763.9
		Middle	32.2	Mid	568.0	
		Lower	31.1	Rear	622.1	
		Max.	34.5	Sum	1485.6	

GENERAL COMMENTS

There was no valid data collected for:

Left Floor Sill Y after 50 msec.
A Pillar Sill Y after 45 msec.
B Pillar Low Y after 20 msec.
B Pillar Mid Y after 40 msec.
Seat Y after 10 msec.

SECTION 2

OCCUPANT AND VEHICLE INFORMATION

DATA SHEET NO. 1

TEST VEHICLE INFORMATION AND OPTIONS

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

VEHICLE INFORMATION	
Make	Volvo
Model	S60
Body Style	Sedan
VIN	YV1902FH6B2014194
Body Color	Electric Silver
Engine Displacement (L)	3.0
# of Cylinders	6
Engine Placement	Lateral
Transmission Type	Automatic
Transmission Speeds	6
Overdrive	Yes
Final Drive	AWD
Odometer Reading	177 miles

OPTIONS	
ESC	Yes
All Wheel Drive	Yes
Power Steering	Yes
Tilt Steering Wheel	Yes
Driver Side Curtain Airbag	Yes
Driver Side Torso/Pelvis Airbag	Yes
Driver Knee Bag	No
Driver Seat Belt Pretentioners	Yes
Driver Seat Belt Load Limiters	Yes
Driver Power Seat	Yes
Rear Pass. Curtain Airbag	Yes
Rear Pass. Side Torso Airbag	No
Rear Pass. Seat Belt Pretentioners	Yes
Rear Pass. Seat Belt Load Limiters	Yes
Rear Pass. Power Seats	No
Power Windows	Yes
Air Conditioning	Yes
AM/FM CD	Yes
Automatic Door Locks (ADL)	Yes
Does owner's manual provide instructions to disable ADL's?	Yes
Anti-Lock Brakes	Yes

DATA FROM CERTIFICATION LABEL

Manufactured By	Volvo Car Corporation
Date of Manufacture	10/10

GVWR (kg)	2290
GAWR Front (kg)	1250
GAWR Rear (kg)	1130

VEHICLE SEATING AND CAPACITY WEIGHT INFORMATION

Measured Parameter	Front	Rear	Third	Total
Type of Seats	Bucket	Split Bench		
Number of Occupants	2	3		5
Capacity Weight (VCW) (kg)				545
Cargo Weight (RCLW) (kg)				205

DATA SHEET NO. 2

GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

TIRE PRESSURES

	Units	LF	RF	RR	LR
As Delivered	kPa	260	260	260	260
As Tested	kPa	260	260	260	260

TEST VEHICLE WEIGHTS

	Units	As Delivered			Fully Loaded			As Tested		
		Front Axle	Rear Axle	Total	Front Axle	Rear Axle	Total	Front Axle	Rear Axle	Total
Left	kg	556.5	340.7		580.8	487.4		575.2	484.4	
Right	kg	532.1	339.7		527.7	455.2		528.0	456.3	
Ratio	%	61.5	38.5		54.0	46.0		54.0	46.0	
Totals	kg	1088.6	680.4	1769.0	1108.5	942.6	2051.1	1103.2	940.7	2043.9

TEST VEHICLE TARGET WEIGHT (TVTW) CALCULATION

Measured Parameter	Units	Value
As Delivered Weight	kg	1769.0
Weight of 1 P572U ATD (ES-2re) Dummy	kg	77.1
Rated Cargo/Luggage Weight (RCLW)	kg	205
Calculated Target Vehicle Test Weight (TVTW)	kg	2051.1

TEST VEHICLE ATTITUDES

	Units	LF	RF	RR	LR
Fully Loaded	mm	682	693	664	651
As Tested	mm	683	692	665	670
Difference	mm	-1	1	-1	-19

CALCULATION OF THE VERTICAL IMPACT REFERENCE LINE

Measurement Parameter	Units	Value
Test Vehicle Wheel Base	mm	2776
Vertical Impact Reference Line (Aft of Front Axle)	mm	1385

WEIGHT of BALLAST and VEHICLE COMPONENTS REMOVED TO MEET VEHICLE TEST WEIGHT

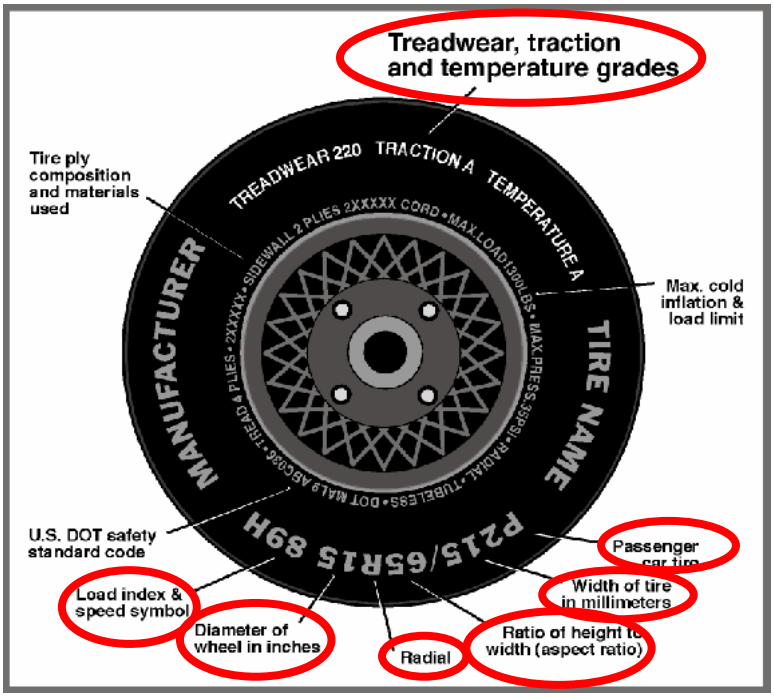
Description of Component	Weight (kg)
Ballast	133.4
No vehicle components removed to meet VTW	0

DATA SHEET NO. 3

VEHICLE TIRE INFORMATION

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

VEHICLE TIRE INFORMATION



Measured Parameter	Front	Rear
Max. Tire Pressure (kPa)	350	350
Cold Pressure (kPa)	260	260
Recommended Tire Size	235/40R18	235/40R18
Tire Size on Vehicle	235/40R18	235/40R18
Tire Manufacturer	Continental	Continental
Tire Name	Conti pro contact	Conti pro contact
Tire Type	Passenger	Passenger
Tire Width	235	235
Aspect Ratio	40	40
Radial	Yes	Yes
Wheel Diameter	18	18
Load Index/Speed Symbol	95V	95V
Treadwear	400	400
Traction Grade	AA	AA
Temperature Grade	A	A

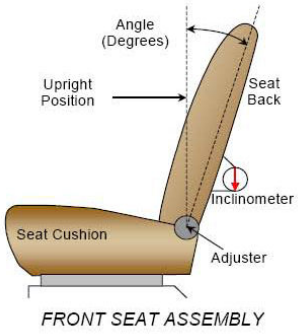
DATA SHEET NO. 4

SEAT AND SEAT BELT ADJUSTMENT DATA

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

NORMAL DESIGN RIDING POSITION

The driver seat back is positioned to the manufacturer's designated angle. The procedure is as follows: From the forward-most position, adjust the seat back 26.2° rearward. The reference plane is the door sill. The angle of the door sill is 0 degree.



FRONT SEAT ASSEMBLY

SEAT BACK ANGLE

	Degrees	Detents
Driver with Seated Dummy	Forward-most angle: -5.7° Test Angle: 20.9°	

SEAT FORE/AFT POSITION

The method used for determining seat fore/aft position is as follows: For seat track adjustments, set in mid track position.

SEAT FORE/AFT POSITIONING

	Total Fore/Aft Travel	Placed in Position #
Front Seat	252 mm	126 mm (forward-most as 0)

SEAT BELT UPPER ANCHORAGE

The method of positioning the seat belt upper anchorage is as follows: Detents to the nominal design position are measured with respect to the uppermost detent. Place in the 1st detent for the 50th percentile male.

SEAT BELT UPPER ANCHORAGE

	Total # of Positions	Placed in Position #
Driver Seat	4 detents	1st detent (uppermost detent defined as 0)

HEADREST RESTRAINT

The headrest is non-adjustable.

DATA SHEET NO. 5

FUEL SYSTEMS AND STEERING WHEEL POSITION DATA

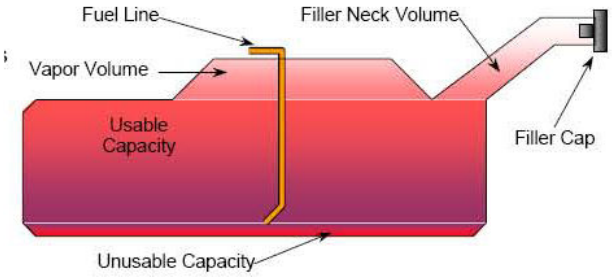
Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

FUEL TANK CAPACITY

	Liters
Usable Capacity (Form 1)	67.4
Volume (Owner's Manual)	70.0
92-94% of Usable Capacity	62.0 to 63.4
Actual Amount of Solvent Used	62.5

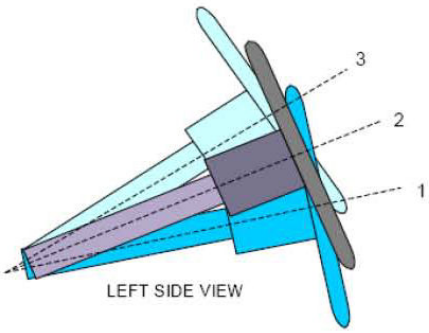
FUEL PUMP

Describe the fuel pump type, its behavior, and the location of the fuel filler pipe. The test vehicle is equipped with an electric fuel pump. The fuel pump is only pumping fuel when engine is running. VCC is using a special equipment to run the fuel pump and pressurize the fuel system before test. The fuel pipe is on the right side.



STEERING COLUMN ADJUSTMENT

Steering wheel and column adjustments are made so that the steering wheel hub is at the center of its geometric locus it describes when it moves 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

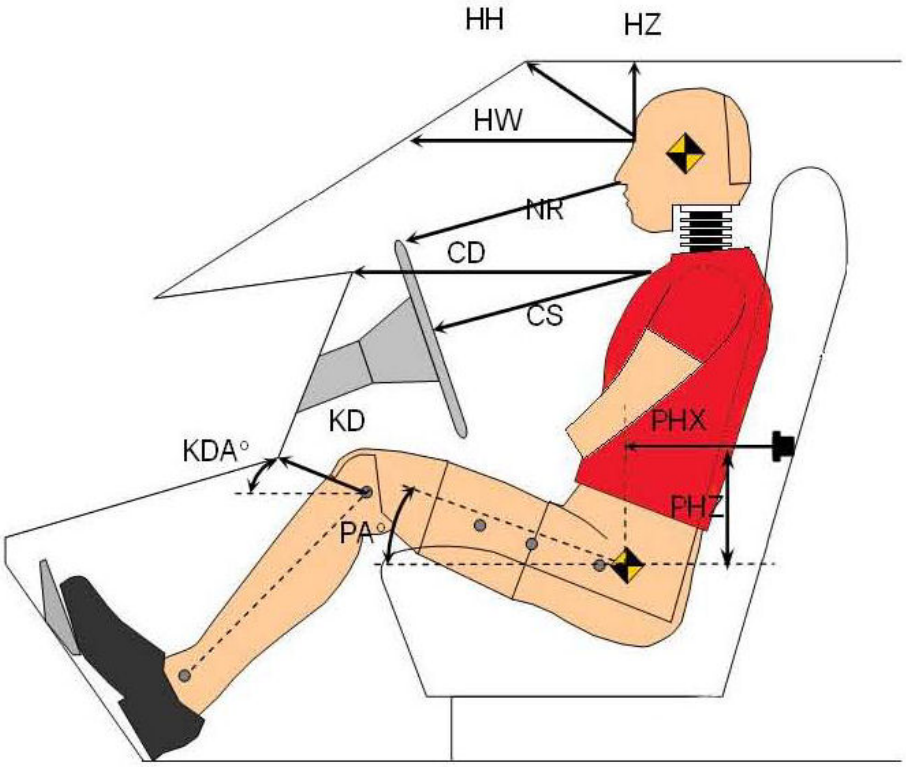
STEERING COLUMN POSITIONING

	Degrees	Fore/Aft Position (mm)
Lowermost - Position 1	69.5	224
Geometric Center – Position 2	66.5	201
Uppermost – Position 3	63.5	178
Telescoping Steering Wheel Travel		46
Test Position	66.5	201

.DATA SHEET NO. 6

DUMMY LONGITUDINAL CLEARANCE DIMENSIONS

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

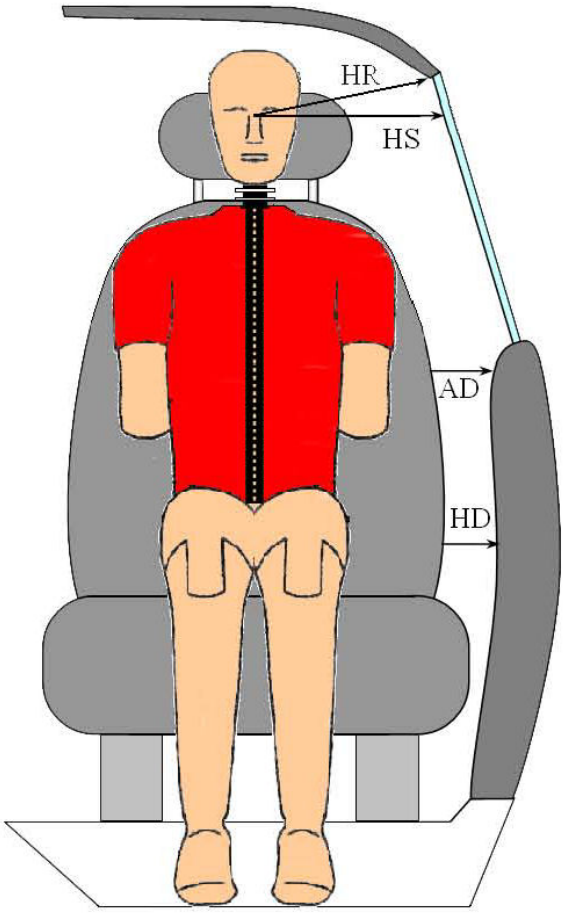


Driver Code	Measurement Description	Length (mm)	Angle (°)
HH	Head to Header	384	
HW	Head to Windshield	675	
HZ	Head to Roof	142	
NR	Nose to Rim	463	
CD	Chest to Dash	634	
CS	Chest to Steering Wheel	376	
KDL	Left Knee to Dash	204	31.8
KDR	Right Knee to Dash	185	30.4
PA	Pelvis Angle X		27.4
	Torso Angle Y		0.9
PHX	H-Point to Striker (X-Axis)	143	
PHZ	H-Point to Striker (Z-Axis)	106	

DATA SHEET NO. 7

DUMMY LATERAL CLEARANCE DIMENSIONS

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

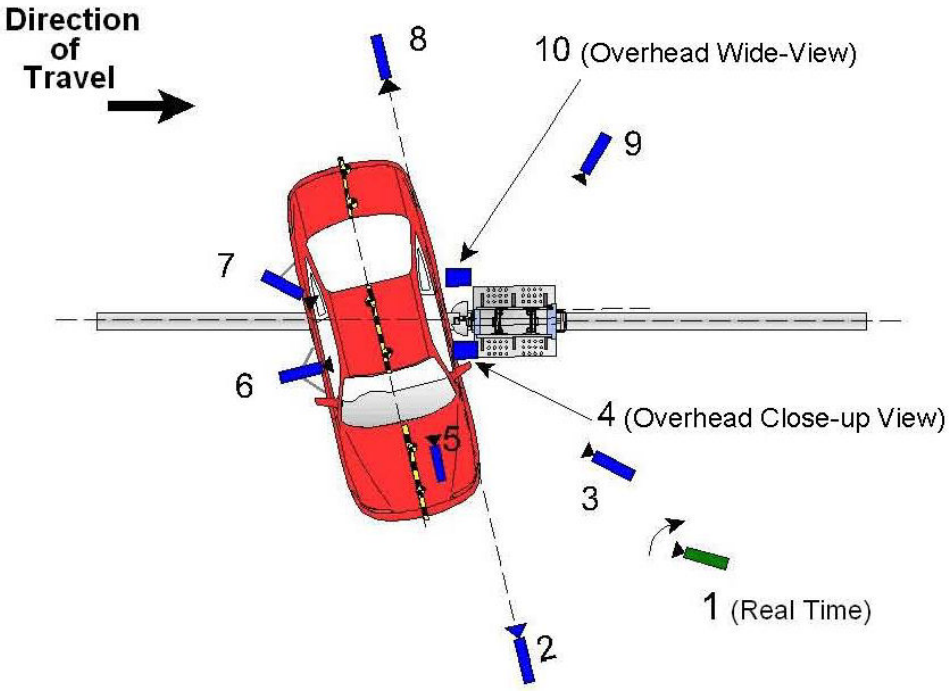


Code	Measurement Description	Units	Front Occupant
HR	Head to Side Header	mm	192
HS	Head to Side Window	mm	331
AD	Arm to Door	mm	107
HD	H-Point to Door	mm	156

DATA SHEET NO. 8

HIGH SPEED CAMERA LOCATIONS AND DATA

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011



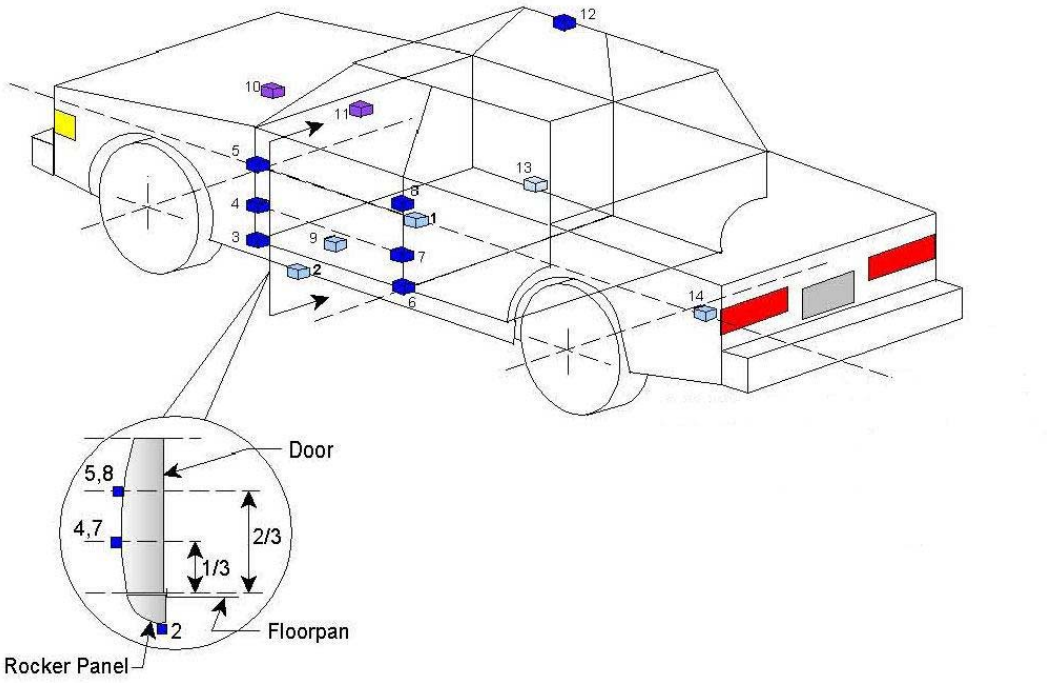
Reference: From Point of Impact for X and Y; from Ground for Z):
+X = Right of Impact, + Y = Forward of Impact, +Z = Up

Camera No.	View	Coordinates (mm)			Lens (mm)	Film Speed (fps)
		X	Y	Z		
1	Real-Time					30
2	Front Ground Level	5580	-40	1770	24	1000
3	Impact Side 45° Forward	4160	2110	1910	20	1000
4	Overhead Closeup	0	50	4460	50	1000
5	Onboard – Driver Front				16	1000
6	Onboard – Driver Side				8	1000
7	Onboard – Driver Rear				8	1000
8	Rear Ground Level	-6120	-40	1770	24	1000
9	Impact Side 45° Rearward	-3060	3740	1910	20	1000
10	Overhead Wide	110	280	4960	14	1000

DATA SHEET NO. 9

TEST VEHICLE ACCELEROMETER LOCATIONS

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011



Loc. No.	Accelerometer Location			
	ID	Coordinates (mm)		
		X	Y	Z
1	Vehicle CG	2387	-180	-215
2	Left Floor Sill	2582	-735	-205
3	A Pillar Sill	3230	-730	-170
4	A Pillar Low	3093	-746	-560
5	A Pillar Mid	3160	-822	-752
6	B Pillar Sill	2103	-730	-205
7	B Pillar Low	2045	-753	-530
8	B Pillar Mid	2045	-772	-765
9	Seat	2145	-533	-280
10	Engine	3890	0	-810
11	Firewall	3695	-15	-900
12	Roof	2030	560	-1480
13	Floor Sill	2035	730	-215
14	Rear Deck	210	0	-440

Reference: X – Test Vehicle Rear Bumper (+ forward)
Y – Test Vehicle Centerline (+ to right)
Z – Ground Plane (+ down)

DATA SHEET NO. 10

TEST VEHICLE ACCELEROMETER DATA SUMMARY

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

Loc. No.	Description	Peak Values (g's)			
		Max	Time (ms)	Min	Time (ms)
1	Vehicle CG (X)	2.7	140.5	-10.3	22.2
	Vehicle CG (Y)	30.1	17.8	-3.9	64.4
	Vehicle CG (Z)	16.3	25.2	-11.5	42.3
	Resultant	31.4	17.9		
2	Left Floor Sill (Y)	(1)	(1)	(1)	(1)
3	A Pillar Sill (Y)	(2)	(2)	(2)	(2)
4	A Pillar Low (Y)	14.2	18.9	-3.5	12.0
5	A Pillar Mid (Y)	17.0	49.6	-3.1	5.7
6	B Pillar Sill (Y)	85.1	20.5	-22.6	26.5
7	B Pillar Low (Y)	(3)	(3)	(3)	(3)
8	B Pillar Mid (Y)	(4)	(4)	(4)	(4)
9	Seat (Y)	(5)	(5)	(5)	(5)
10	Engine (X)	4.2	125.7	-18.0	42.3
	Engine (Y)	9.6	120.8	-2.2	248.4
11	Firewall (Y)	10.5	63.6	-0.6	38.4
12	Roof (Y)	27.1	45.2	-0.6	300.0
13	Floor Sill (Y)	14.3	54.7	-1.3	278.1
14	Rear Deck (X)	3.1	124.1	-8.5	70.2
	Rear Deck (Y)	15.9	58.2	-2.3	232.4

(1) No valid data collected for Left Floor Sill Y after 50 msec.
(2) No valid data collected for A Pillar Sill Y after 45 msec.
(3) No valid data collected for B Pillar Low Y after 20 msec.
(4) No valid data collected for B Pillar Mid Y after 40 msec.
(5) No valid data collected for Seat Y after 10 msec.

DATA SHEET NO. 11

DUMMY INJURY RESPONSE DATA

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

Dummy S/N	Positive		Negative	
	MAX	**TIME (ms)**	**MAX**	**TIME (ms)**
HEAD ACCELERATION (G)				
Longitudinal (X)	10.2	167.4	37.5	62.3
Lateral (Y)	48.4	61.1	9.9	150.7
Vertical (Z)	11.7	39.6	7.6	64.9
Resultant (R)	59.8	62.1		
HIC36 (t1, t2)	331		t1 = 50.8	t2 = 71.0
THORAX DEFLECTION (mm)				
Upper Rib			34.5	61.5
Middle Rib			32.2	61.4
Lower Rib			31.1	59.9
ABDOMINAL FORCES (N)				
Front	301.2	50.9		
Middle	568.0	51.9		
Rear	622.1	52.8		
Sum	1485.6	51.9		
PELVIS FORCE (N)				
Pubic Symphysis			1763.9	64.5

Reference: Positive Direction -Longitudinal (X) = forward
-Lateral (Y) = to right
-Vertical (Z) = down

DATA SHEET NO. 12

POST TEST OBSERVATIONS

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

TEST DUMMY INFORMATION AND CONTACT

Description	Front Occupant
Dummy Type / Serial No.	ES-2re / 016
Head Contact	Curtain Airbag, Headrest
Upper Torso Contact	Side Airbag
Lower Torso Contact	Side Airbag, Door Panel
Left Knee Contact	Door Panel
Right Knee Contact	Left Knee

POST TEST DOOR OPENING AND SEAT TRACK INFORMATION

Description	Front	Rear
Left Side Doors	Remained closed and jammed shut	Remained closed and jammed shut
Right Side Doors	Remained closed and operational	Remained closed and operational
Hatch and Other Doors		
Seat Movement	0	0
Seat Back Failure	None	None

POST-TEST STRUCTURAL OBSERVATIONS

Critical Areas of Performance	Observations and Conclusions
Pillar Performance	No Separation
Sill Separation	None
Windshield Damage	Cracked
Window Damage	Left Front Window Broke
Other Notable Effects	None

SUPPLEMENTAL RESTRAINT SYSTEM INFORMATION

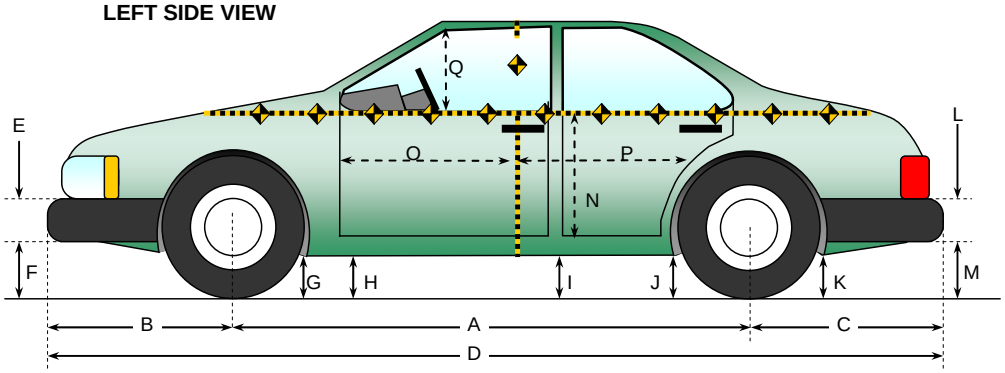
Restraint Type	Front Occupant	
	Installed	Operated
Frontal Airbag	Yes	No
Side Torso/Pelvis Airbag	Yes	Yes
Head Airbag	No	
Curtain Airbag	Yes	Yes
Knee Airbag	No	
Seat Belt Pretensioner	Yes	Yes
Seat Belt Load Limiter	Yes	

DATA SHEET NO. 13

VEHICLE PRE TEST AND POST TEST MEASUREMENTS

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

LEFT SIDE VIEW

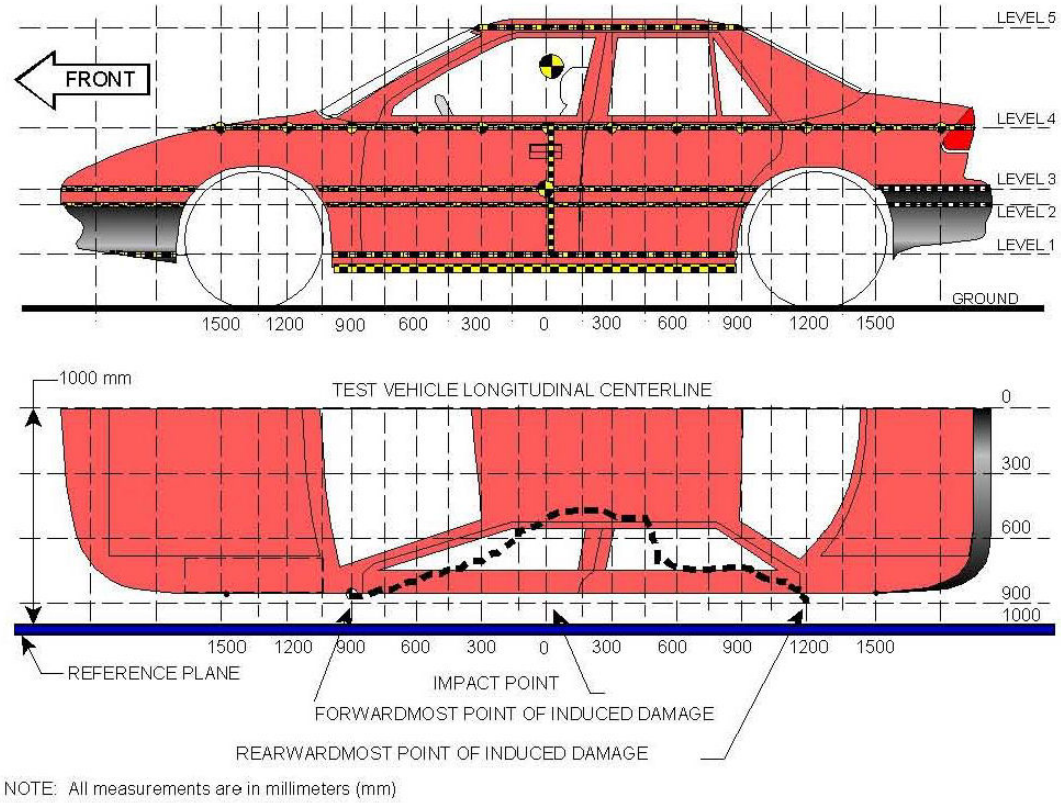


Code	Measurement Description	Pre-Test (mm)	Post-Test (mm)	Difference (mm)
A	Wheelbase	2776	2700	76
B	Front Axle to FSOV	952	952	0
C	Rear Axle to RSOV	902	902	0
D	Total Vehicle Length at Centerline	4630	4554	76
E	Front Bumper Thickness	110	110	0
F	Front Bumper Bottom to Ground	221	252	-31
G	Sill Height at Front Wheel Well	136	138	-2
H	Sill Height at Front Door Leading Edge	140	137	3
I	Sill Height at B Pillar	138	112	26
J1	Sill Height at Rear Wheel Well	157	170	-13
J2	Pinch Weld Height at Rear Wheel Well	166	185	-19
K	Sill Height Aft of Rear Wheel Well	210	213	-3
L	Rear Bumper Thickness	130	130	0
M	Rear Bumper Bottom to Ground	318	322	-4
N	Sill Height to Window Bottom Sill	733	722	11
O	Front Door Leading Edge to Impact CL	854	852	2
P	Rear Door Trailing Edge to Impact CL	1106	1145	-39
Q	Front Window Opening	446	400	46
R	Right Side Length	3768	3770	-2
S	Left Side Length	3768	3680	88
T	Vehicle Width at B Post	1825	1587	238

DATA SHEET NO. 14

EXTERIOR CRUSH MEASUREMENTS

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011



NOTE: All measurements are in millimeters (mm)

Maximum Exterior Crush Measurements

Level	Measurement Description	Maximum Exterior Static Crush	Distance from Impact	Height Above Ground (mm)
1	Sill Top	302	75	246
2	Occupant H-Point	345	0	551
3	Mid-Door	347	0	616
4	Window Sill	297	0	948
5	Window Top	99	0	1378

DATA SHEET NO. 15

VEHICLE EXTERIOR CRUSH PROFILES

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

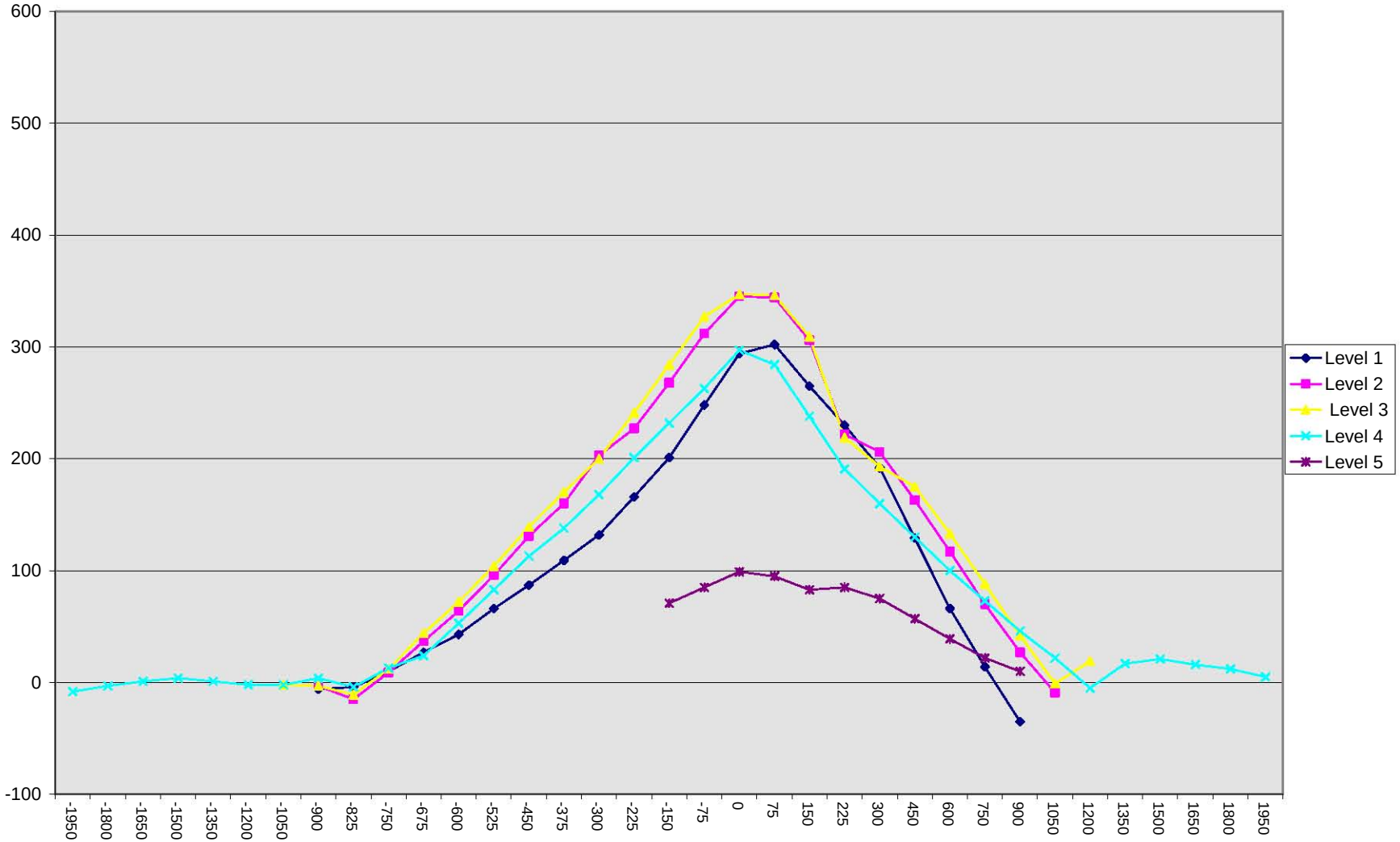
	Level 1	Level 2	Level 3	Level 4	Level 5
Maximum Crush (mm)	302	345	347	297	99
Distance From Impact (mm)	75	0	0	0	0

	Pre-Test					Post-Test					Difference				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
-1950				450					430					-8	
-1800				390					387					-3	
-1650				358					359					1	
-1500				329					333					4	
-1350				310					311					1	
-1200				295					293					-2	
-1050			190	283				188	281				-2	-2	
-900	245	196	196	269		239	193	193	273		-6	-3	-3	4	
-825	241	199	198	265		237	184	187	261		-4	-15	-11	-4	
-750	241	200	198	263		251	209	210	276		10	9	12	13	
-675	238	199	197	260		265	236	241	284		27	37	44	24	
-600	236	198	195	258		279	262	267	311		43	64	72	53	
-525	233	196	193	253		299	292	297	336		66	96	104	83	
-450	233	194	191	251		320	325	330	364		87	131	139	113	
-375	231	193	190	250		340	353	360	388		109	160	170	138	
-300	230	192	188	247		362	385	388	415		132	203	200	168	
-225	227	191	187	246		393	418	428	447		166	227	241	201	
-150	227	190	187	244	494	428	458	471	476	565	201	268	284	232	71
-75	225	190	186	244	491	473	502	513	507	576	248	312	327	263	85
0	223	190	186	243	488	517	535	533	540	587	294	345	347	297	99
75	222	190	186	244	489	524	534	532	528	584	302	344	346	284	95
150	221	190	186	244	490	486	496	495	482	573	265	306	309	238	83
225	220	191	187	244	491	450	413	406	435	576	230	222	219	191	85
300	219	192	188	246	491	411	398	381	406	566	192	206	193	160	75
450	219	195	191	248	491	348	358	366	378	548	129	163	175	130	57
600	219	199	195	251	495	285	316	328	351	534	66	117	133	100	39
750	218	202	198	256	503	232	272	286	329	525	14	70	88	73	22
900	218	201	198	260	516	183	228	240	306	526	-35	27	42	46	10
1050		195	194	261			186	193	283			-9	-1	22	
1200			187	262				206	257				19	-5	
1350				269					286					17	
1500				279					300					21	
1650				294					310					16	
1800				311					323					12	
1950				335					340					5	

DATA SHEET NO. 15 (CONTINUED)

VEHICLE EXTERIOR CRUSH PROFILES

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011



DATA SHEET NO. 16

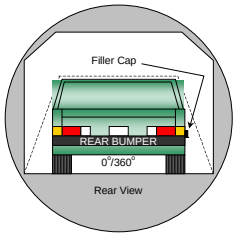
SUMMARY OF FMVSS 301 FUEL SYSTEM DATA

Test Vehicle: 2011 Volvo S60 4-Dr Sedan
Test Program: FMVSS 214 Pole
NHTSA No. CB5901
Test Date: 5/05/2011

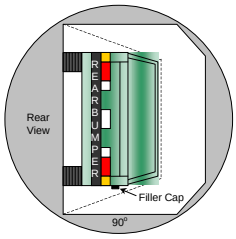
FUEL SYSTEM INTEGRITY POST IMPACT DATA

Time Interval	FMVSS 301 Maximum Allowable Spillage	Spillage (g)
Impact Until Motion Ceases	28 g	0
First Five Minutes Following Impact	142 g	0
Next 25 Minutes	28 g / 1 minute	0

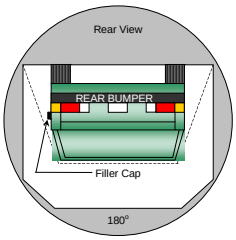
STATIC ROLLOVER DATA



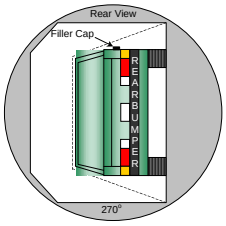
0/360



90



180



270

REAR VIEW

Rollover Stage	Rotation Time (spec. 1-3 min)				FMVSS 301 Hold Time		Total Time				Next Whole Minute Interval	
0° - 90°	2	minutes	03	seconds	5	minutes	7	minutes	03	seconds	8	minutes
90° - 180°	1	minutes	53	seconds	5	minutes	6	minutes	53	seconds	7	minutes
180° - 270°	1	minutes	49	seconds	5	minutes	6	minutes	49	seconds	7	minutes
270° - 360°	1	minutes	57	seconds	5	minutes	6	minutes	57	seconds	7	minutes

Rollover Stage	Spillage (g)			
	First 5 min. from onset of rotation	6th min.	7th min.	8th min. (if required)
0° - 90°	0	0	0	
90° - 180°	0	0	0	
180° - 270°	0	0	0	
270° - 360°	0	0	0	
FMVSS 301 Maximum Allowable (for each 90° stage)	142	28	28	28

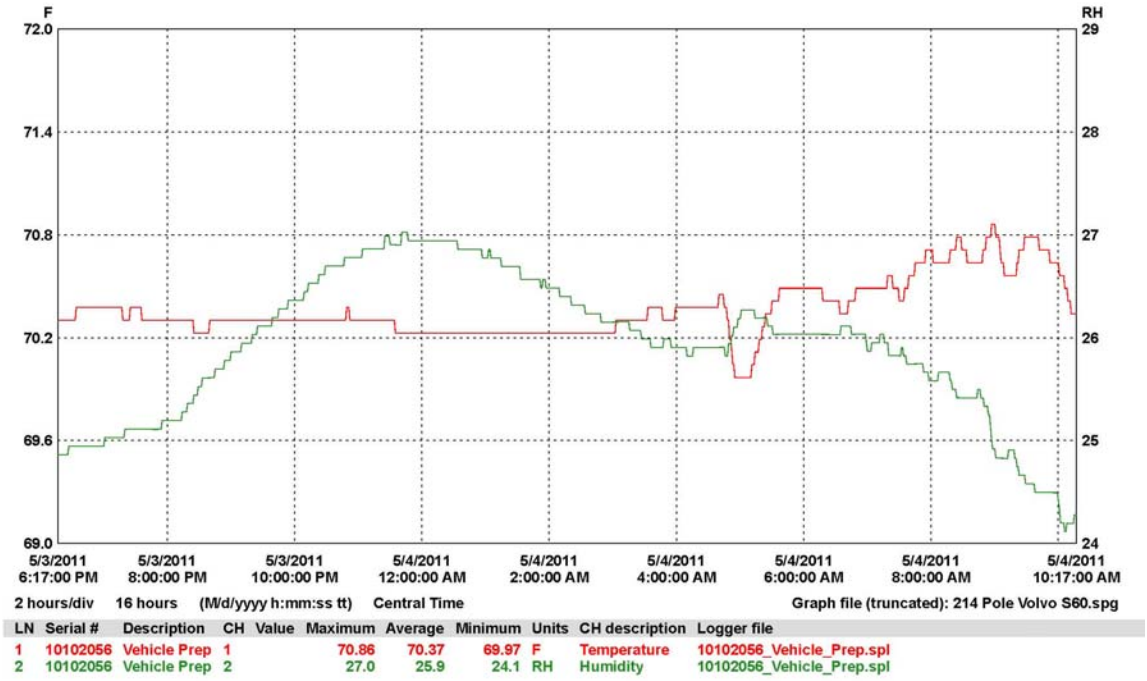
Rollover Stage	Spillage Location(s)
0° to 90°	None
90° to 180°	None
180° to 270°	None
270° to 360°	None

DATA SHEET NO. 17

TEMPERATURE AND HUMIDITY TRACES

Test Vehicle: 2011 Volvo S60 4-Dr Sedan NHTSA No. CB5901
Test Program: FMVSS 214 Pole Test Date: 5/05/2011

Time of Impact: 10:17 am



LN	Serial #	Description	CH	Value	Maximum	Average	Minimum	Units	CH description	Logger file
1	10102056	Vehicle Prep	1		70.86	70.37	69.97	F	Temperature	10102056_Vehicle_Prep.spl
2	10102056	Vehicle Prep	2		27.0	25.9	24.1	RH	Humidity	10102056_Vehicle_Prep.spl

APPENDIX A

PHOTOGRAPHS

TABLE OF PHOTOGRAPHS

Pre-Test Frontal View of Test Vehicle

Post-Test Frontal View of Test Vehicle

Pre-Test Rear View of Test Vehicle

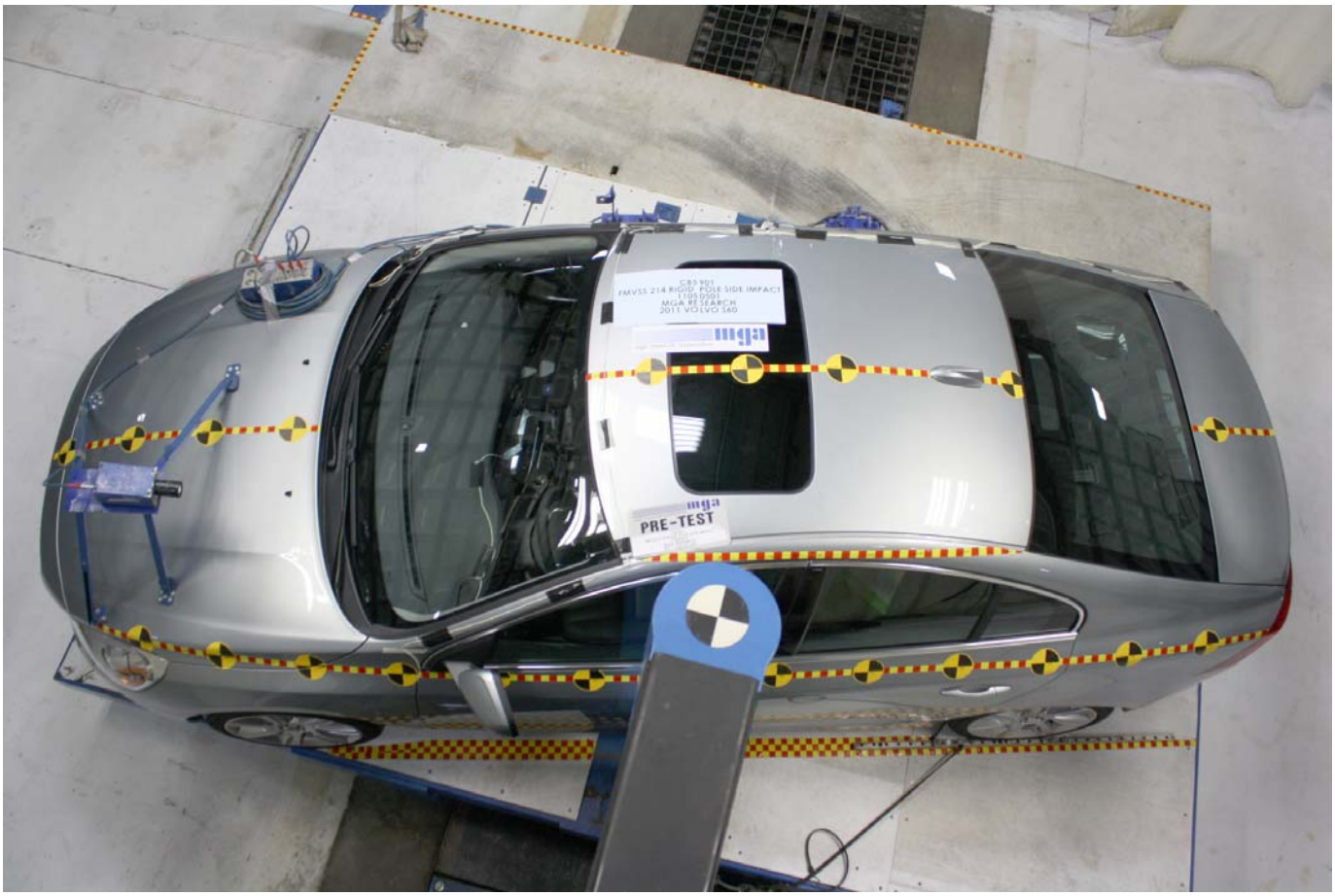
Post-Test Rear View of Test Vehicle

Pre-Test Impacted Side View of Test Vehicle

Post-Test Impacted Side View of Test Vehicle

Pre-Test Left ¾ Front View of Vehicle and Pole

Pre-Test Left ¾ Rear View of Vehicle and Pole



Pre-Test Overhead View of Test Vehicle

Post-Test Overhead View of Test Vehicle

Pre-Test Dummy Through Opposite Window

Post-Test Dummy Through Opposite Window

Pre-Test Close-up of Dummy with Door Closed (Impact Side)

Post-Test Dummy with Door Closed (Impact Side)

Pre-Test Dummy Door Open

Pre-Test Dummy Shoulder and Door Top View

Post-Test Dummy Shoulder and Door Top View

Pre-Test Interior of Front Door Closed

Post-Test Interior of Front Door Showing Dummy Impact Locations

Impact Event

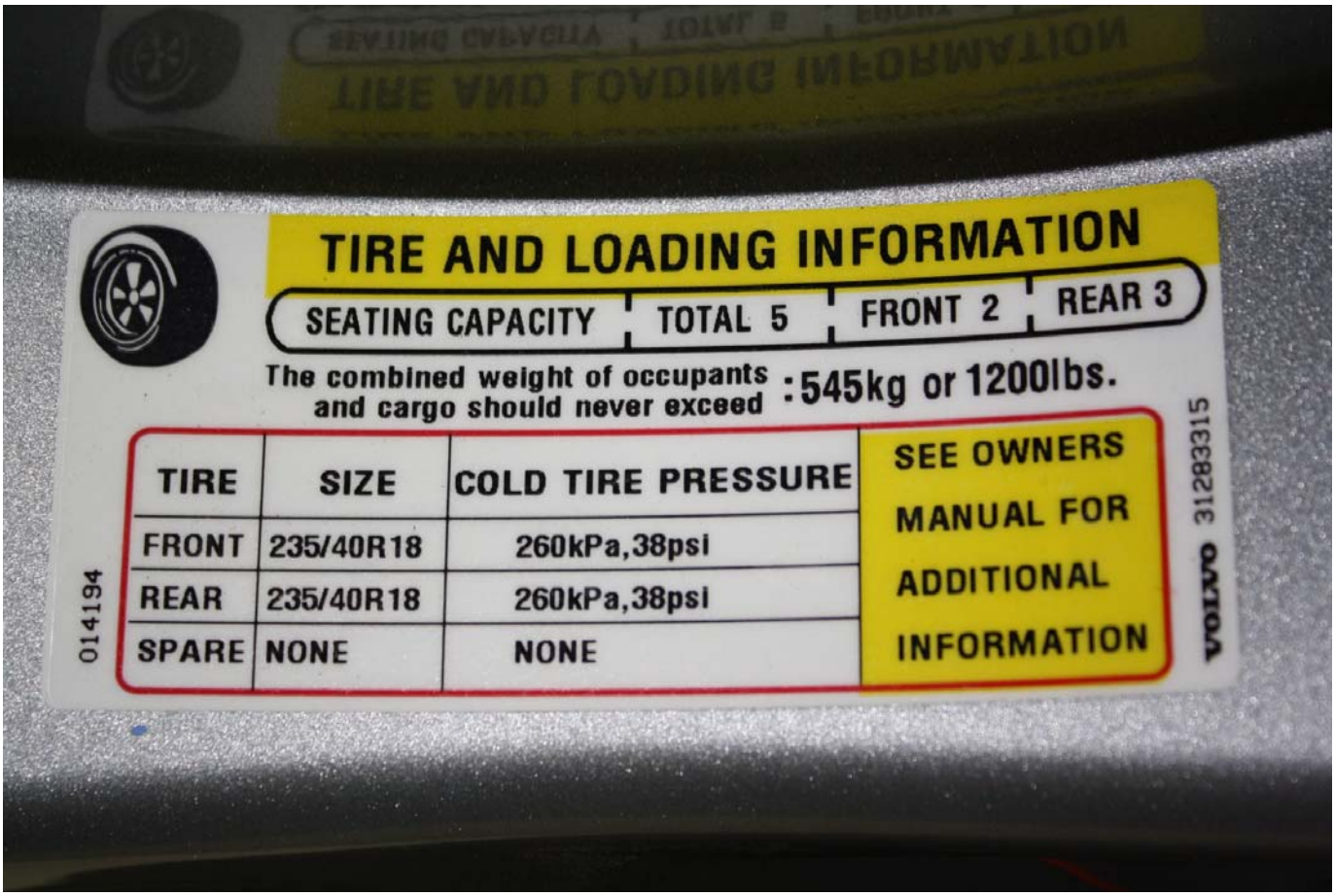
Post-Test Impact Zone Close-up View

Post-Test ¾ Front View of Impact Zone

Post-Test ¾ Rear View of Impact Zone

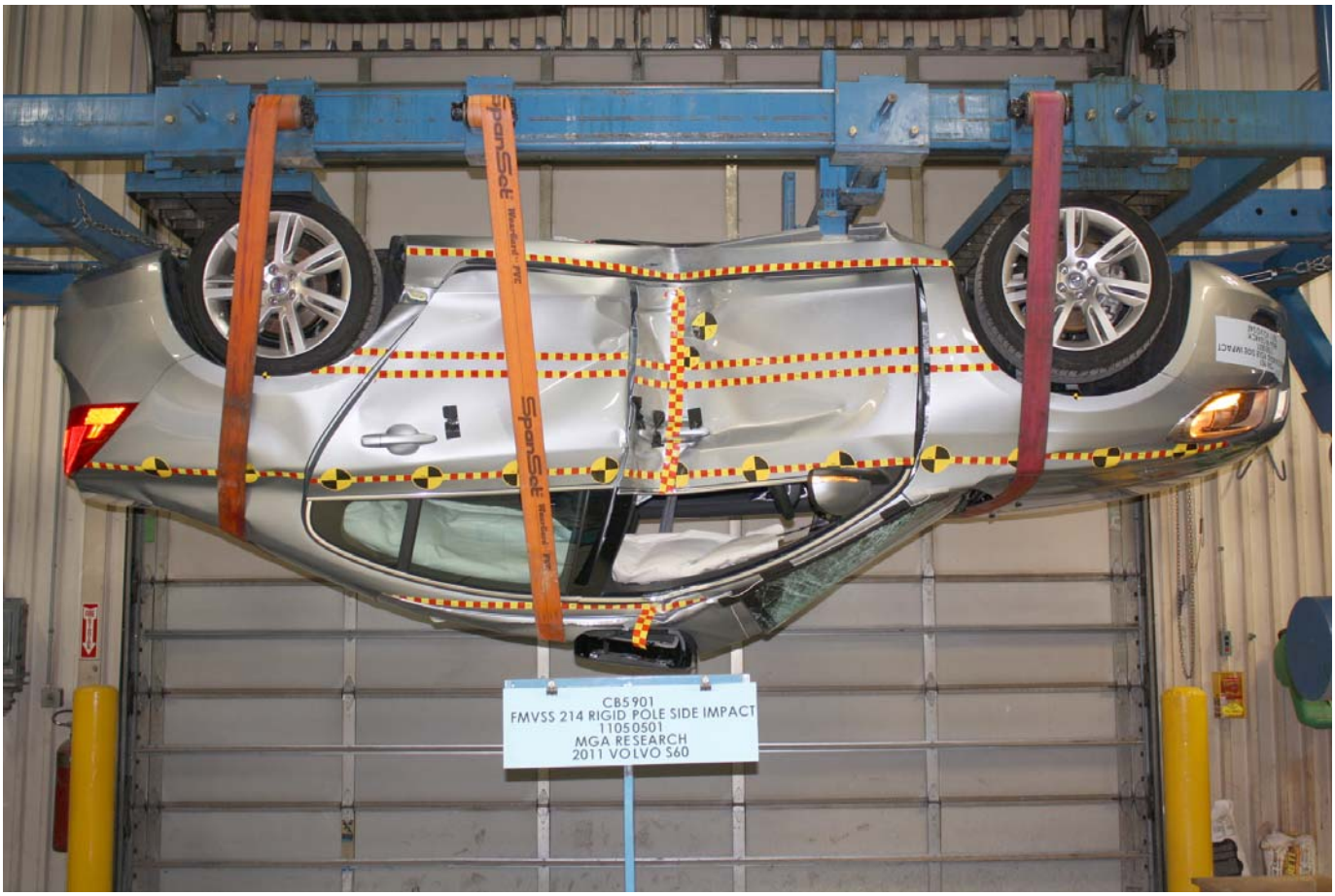
Post-Test Close-up View of Impact Point Target

Close-up View of Vehicle's Certification Label



Close-up View of Vehicle's Tire Placard Label

Post-Test Vehicle at 90 Degree Rollover



Post-Test Vehicle at 180 Degree Rollover

Post-Test Vehicle at 270 Degree Rollover

Post-Test Vehicle at 360 Degree Rollover

APPENDIX B

DUMMY RESPONSE DATA

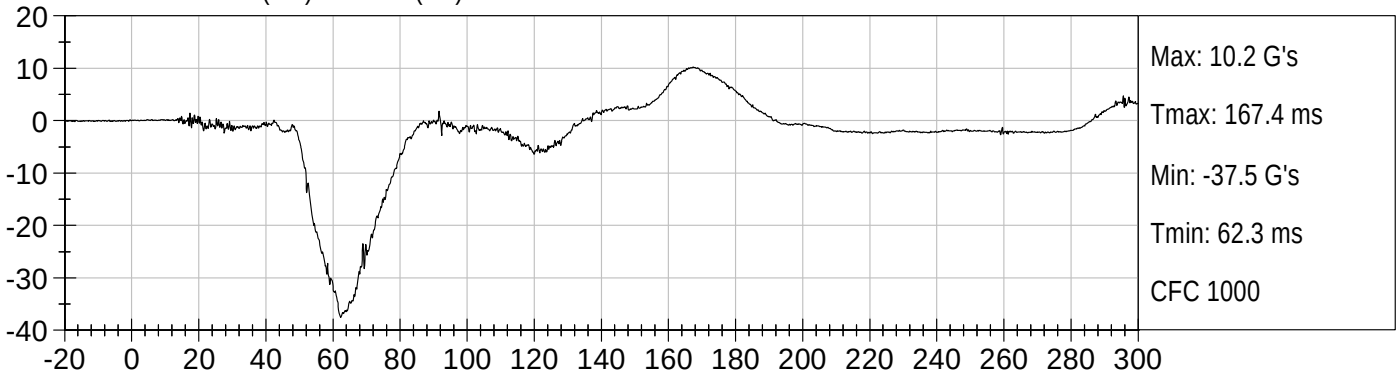
TABLE OF DATA PLOTS

Dummy Instrumentation Plots
FILTERED DATA

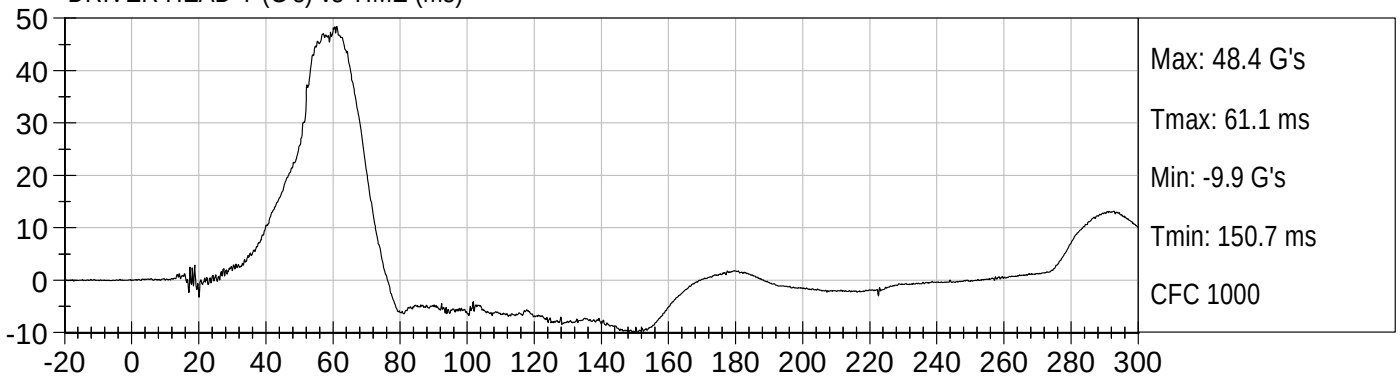
FMVSS 214 Rigid Pole Side Impact
2011 Volvo S60 - CB5901

Test Date: 05/05/2011
Speed: 19.6 mph (31.6 km/h)

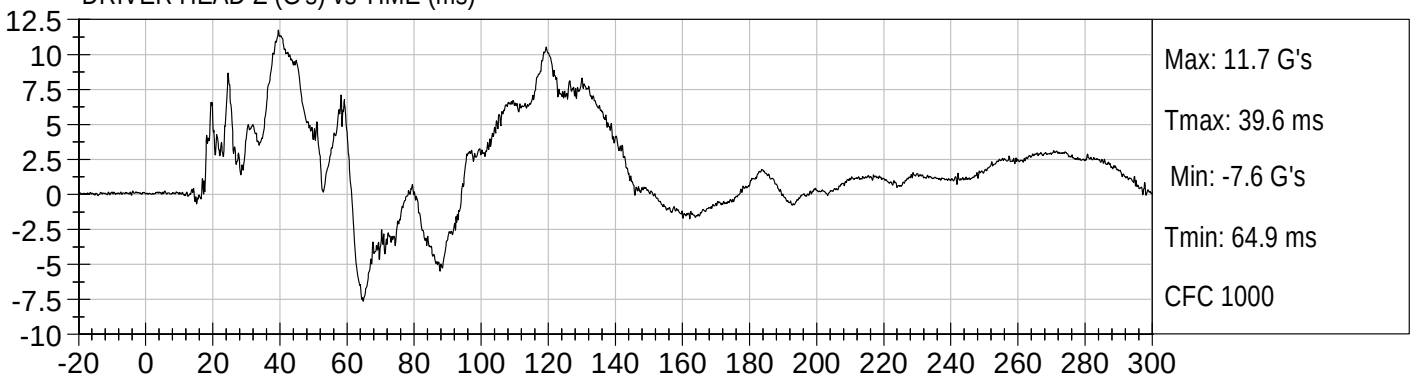
DRIVER HEAD X (G's) vs TIME (ms)



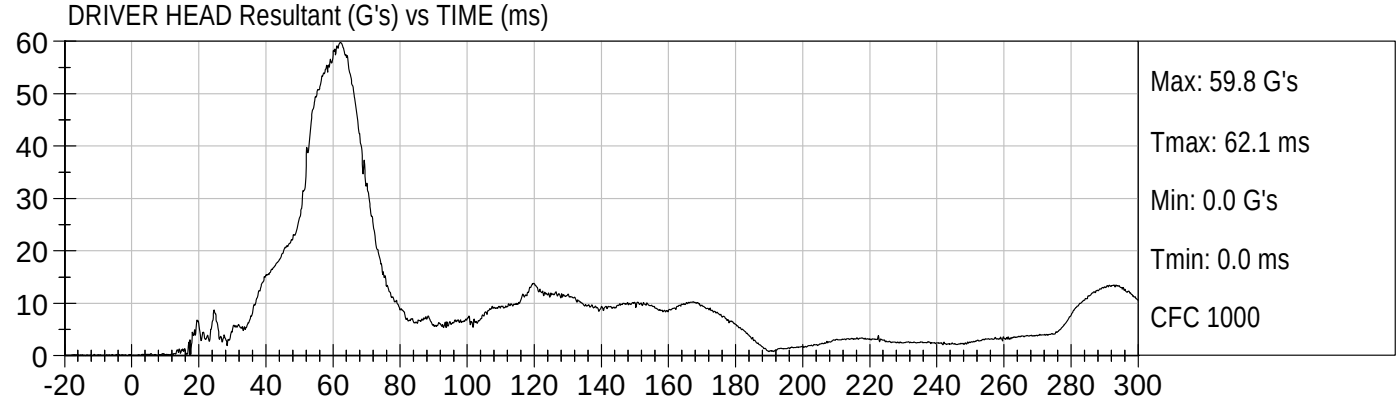
DRIVER HEAD Y (G's) vs TIME (ms)



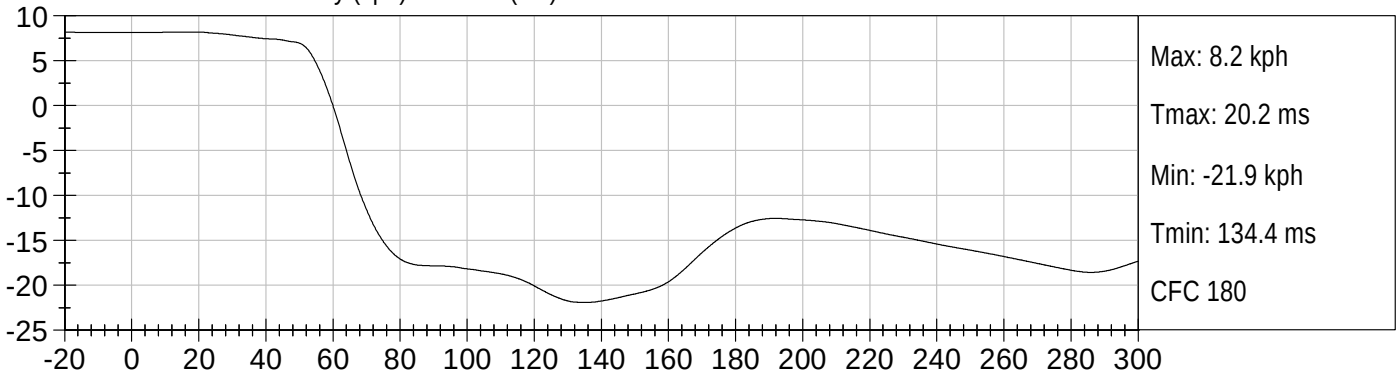
DRIVER HEAD Z (G's) vs TIME (ms)



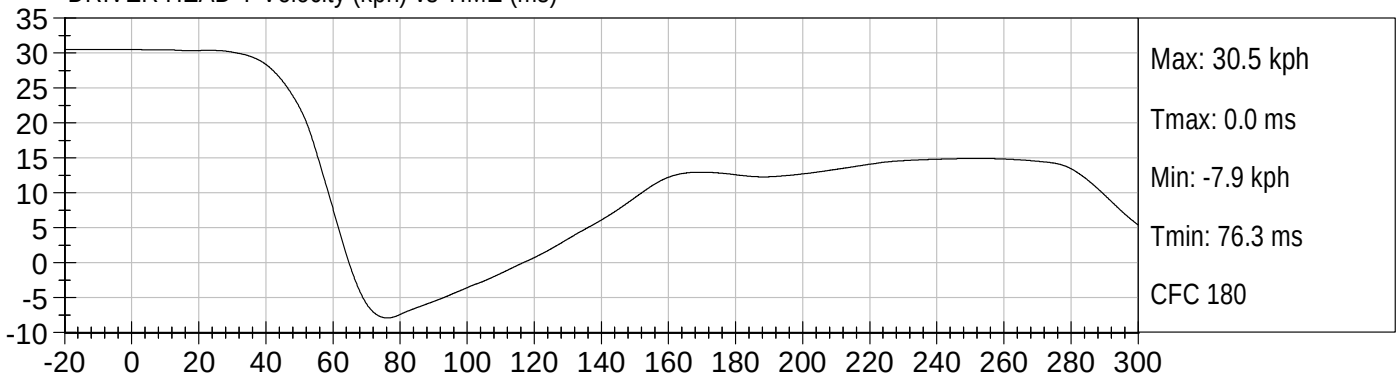
DRIVER HEAD Resultant (G's) vs TIME (ms)



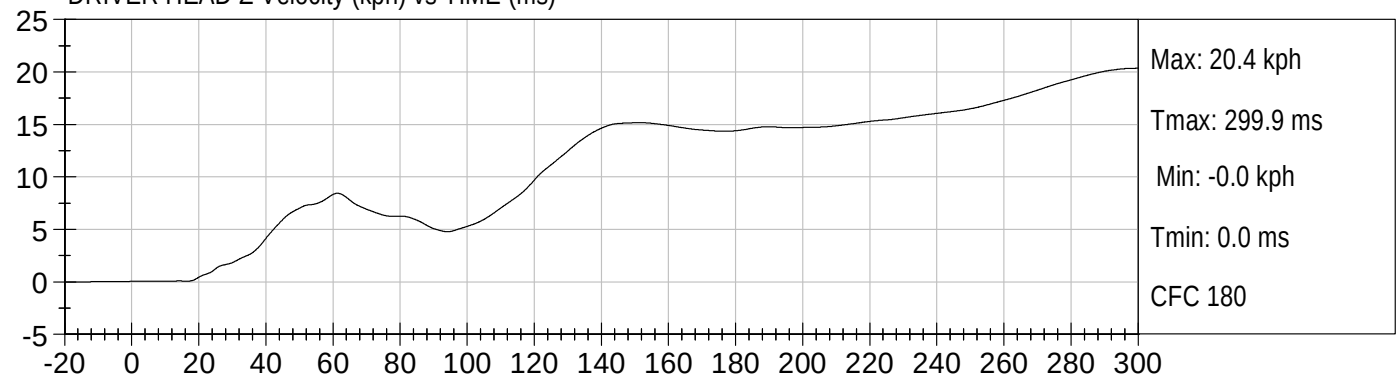
DRIVER HEAD X Velocity (kph) vs TIME (ms)



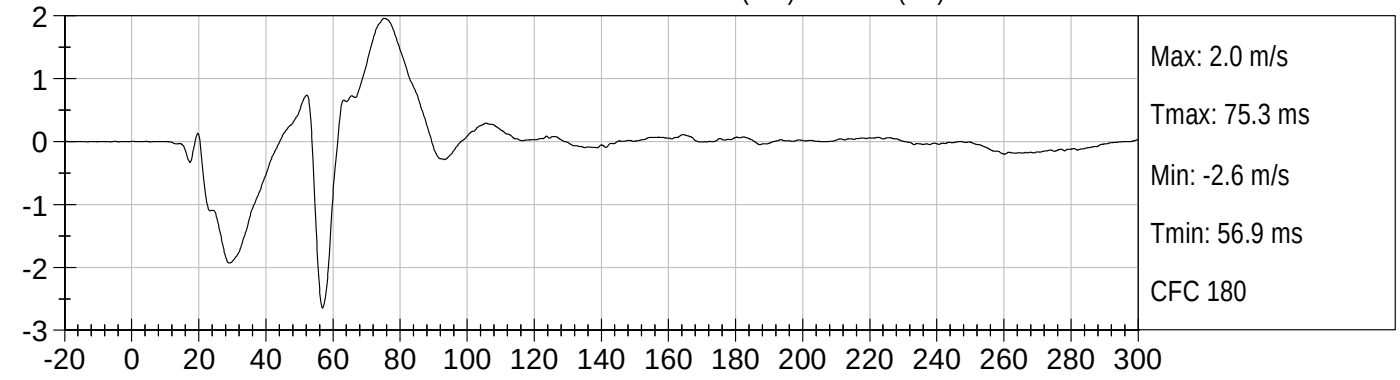
DRIVER HEAD Y Velocity (kph) vs TIME (ms)



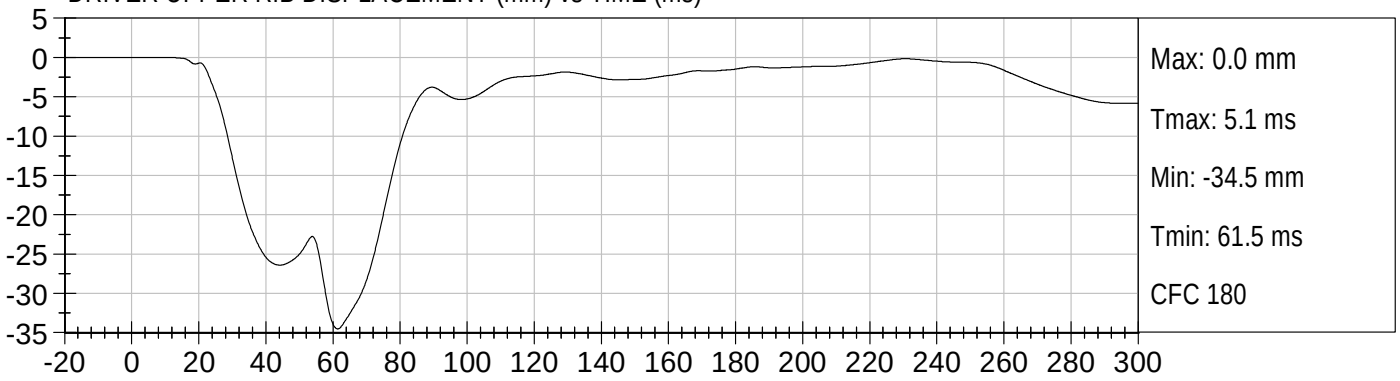
DRIVER HEAD Z Velocity (kph) vs TIME (ms)



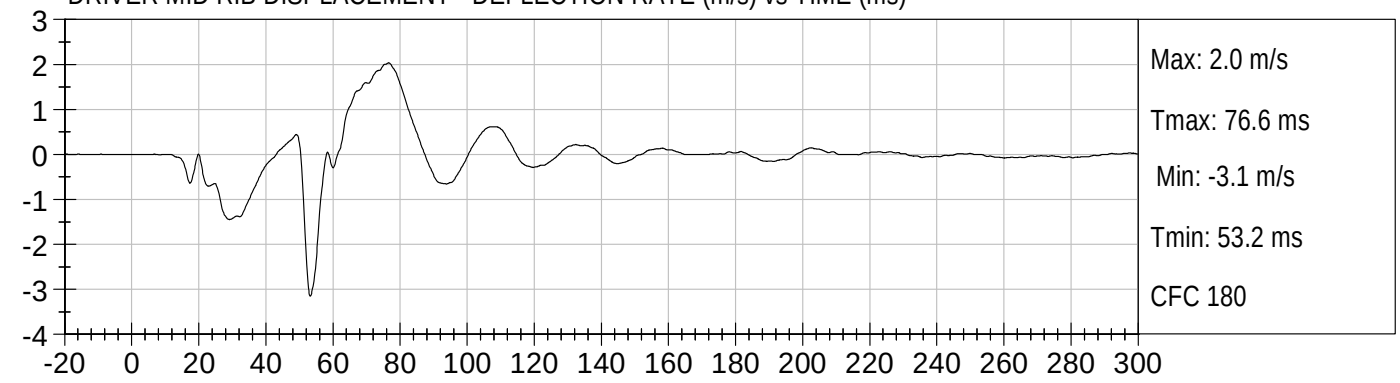
DRIVER UPPER RIB DISPLACEMENT - DEFLECTION RATE (m/s) vs TIME (ms)



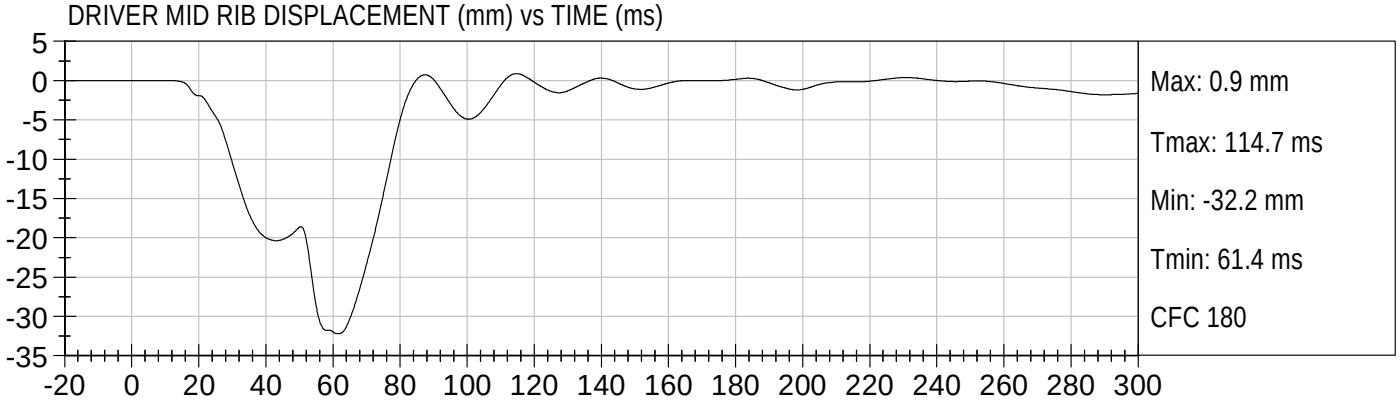
DRIVER UPPER RIB DISPLACEMENT (mm) vs TIME (ms)



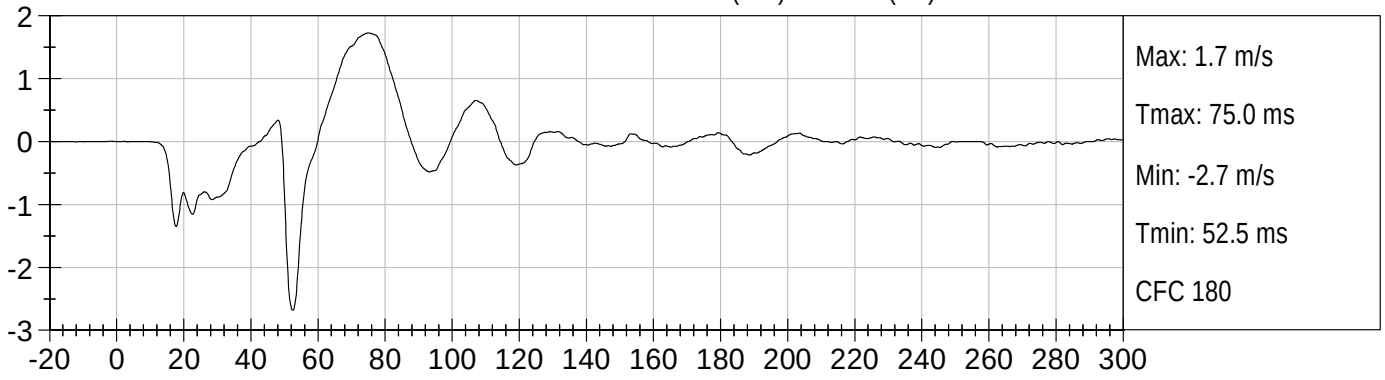
DRIVER MID RIB DISPLACEMENT - DEFLECTION RATE (m/s) vs TIME (ms)



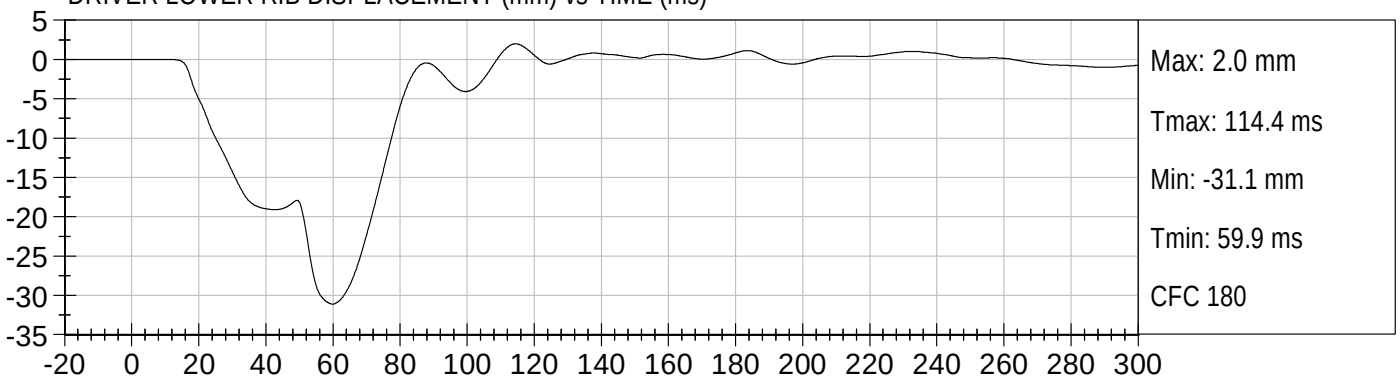
DRIVER MID RIB DISPLACEMENT (mm) vs TIME (ms)



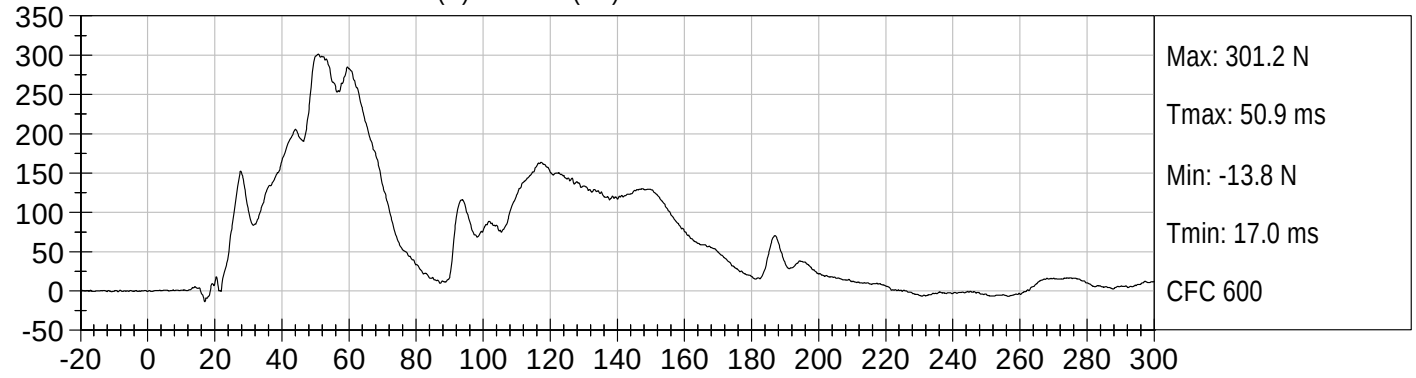
DRIVER LOWER RIB DISPLACEMENT - DEFLECTION RATE (m/s) vs TIME (ms)



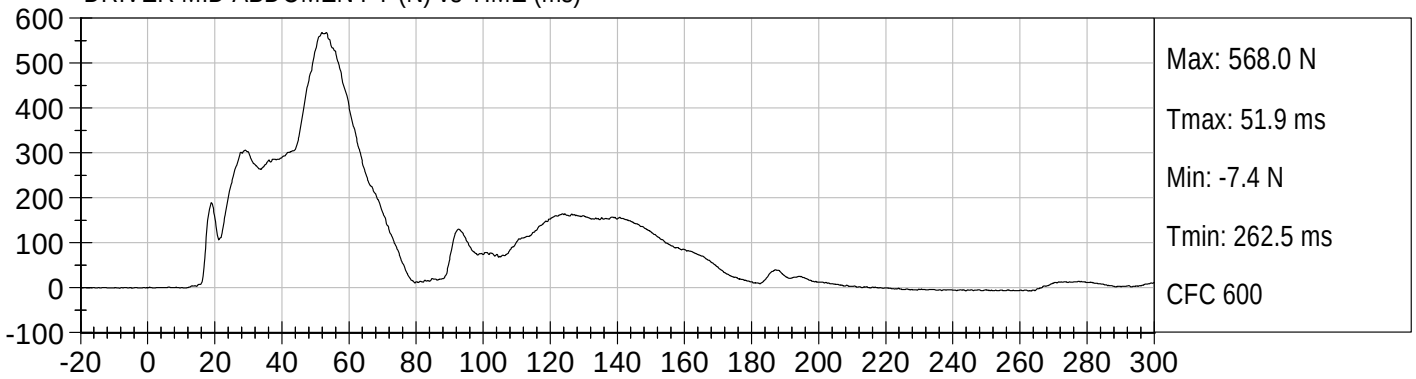
DRIVER LOWER RIB DISPLACEMENT (mm) vs TIME (ms)



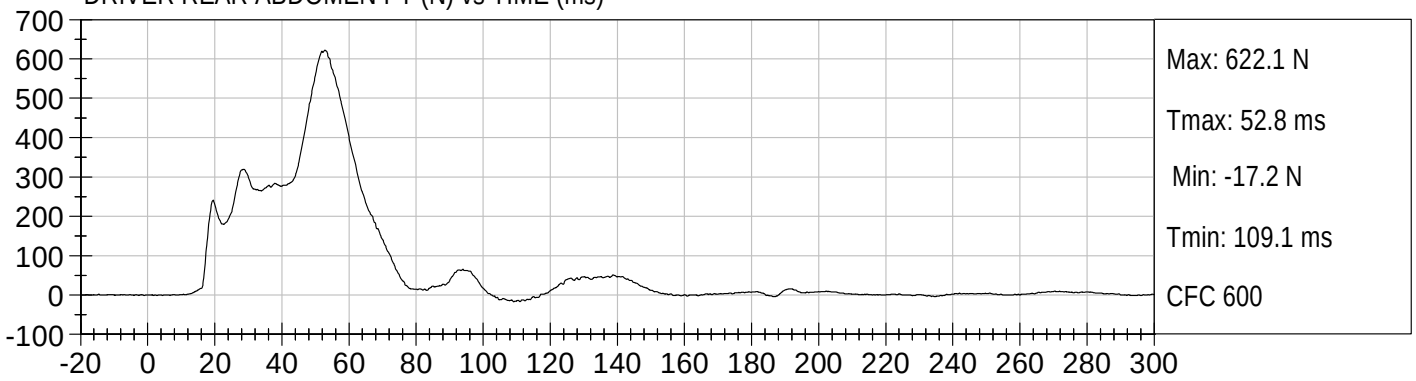
DRIVER FRONT ABDOMEN FY (N) vs TIME (ms)



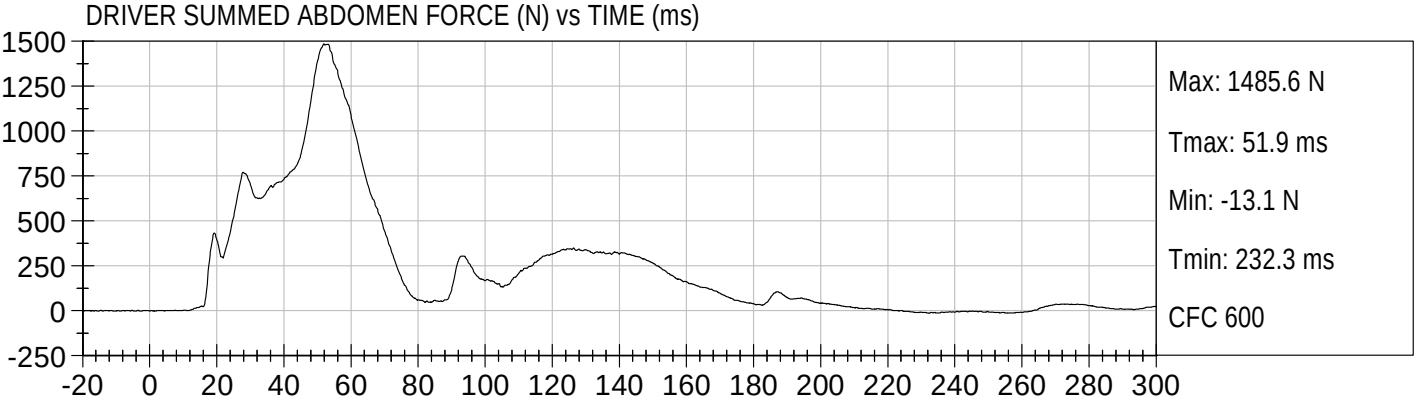
DRIVER MID ABDOMEN FY (N) vs TIME (ms)



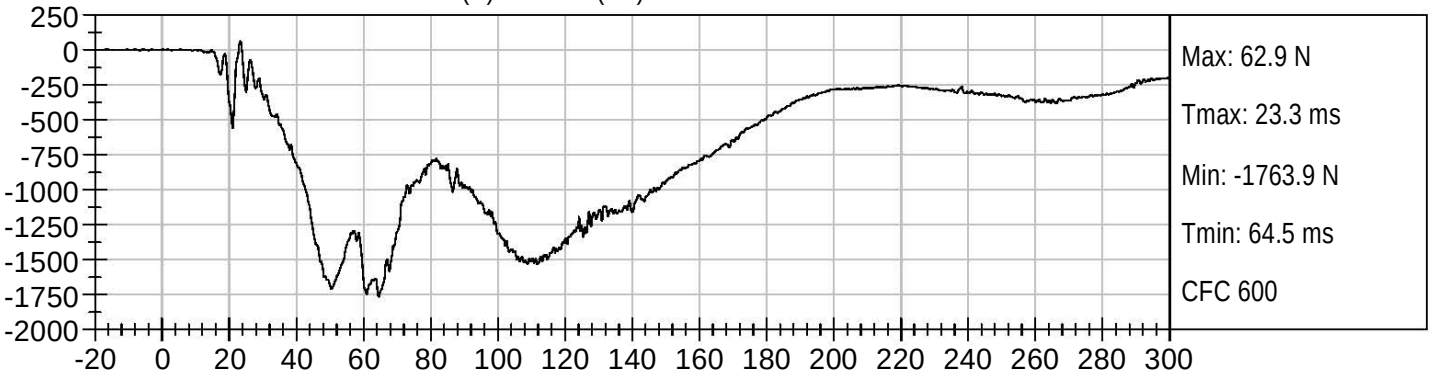
DRIVER REAR ABDOMEN FY (N) vs TIME (ms)



DRIVER SUMMED ABDOMEN FORCE (N) vs TIME (ms)



DRIVER PUBIC SYMPHYSIS FY (N) vs TIME (ms)



APPENDIX C

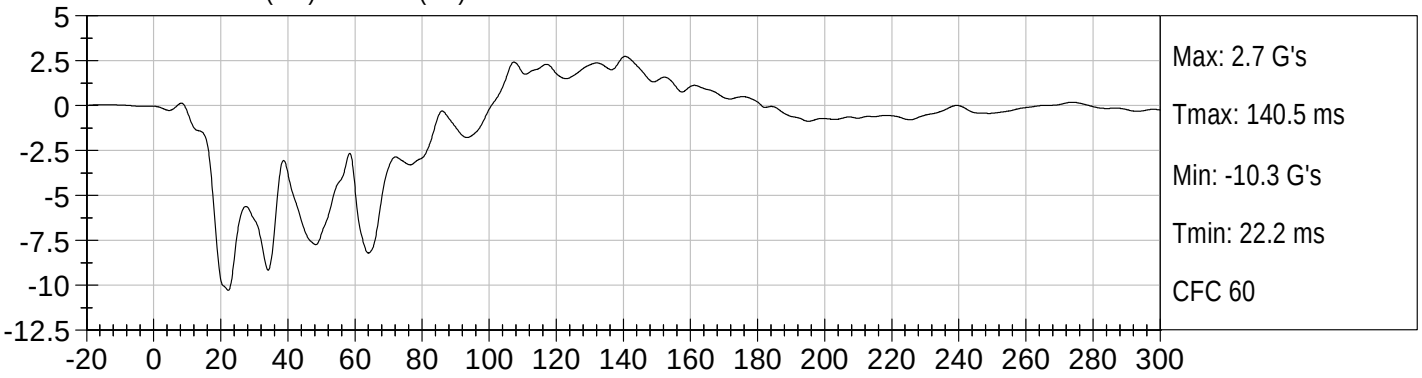
VEHICLE ACCELEROMETER RESPONSE DATA

TABLE OF DATA PLOTS

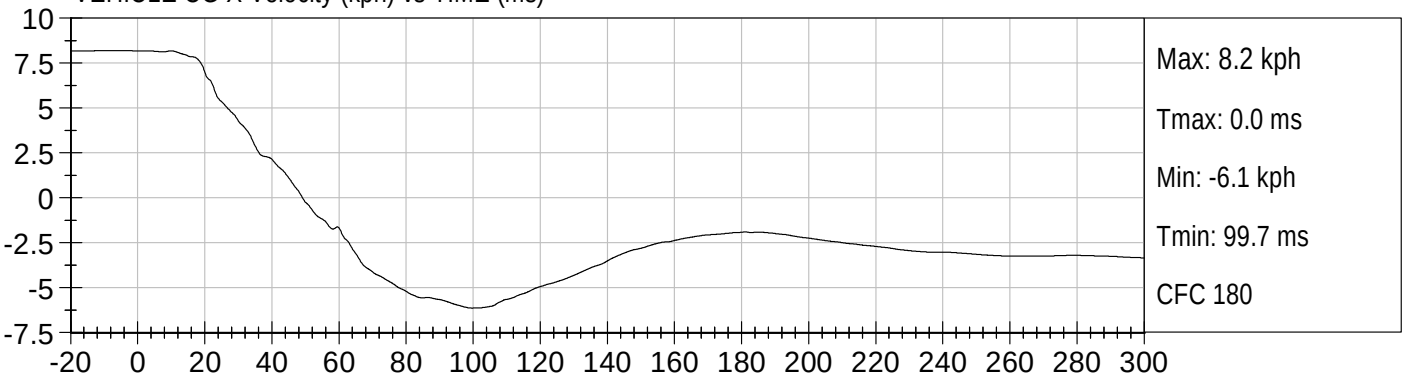
FMVSS 214 Rigid Pole Side Impact
2011 Volvo S60 - CB5901

Test Date: 05/05/2011
Speed: 19.6 mph (31.6 km/h)

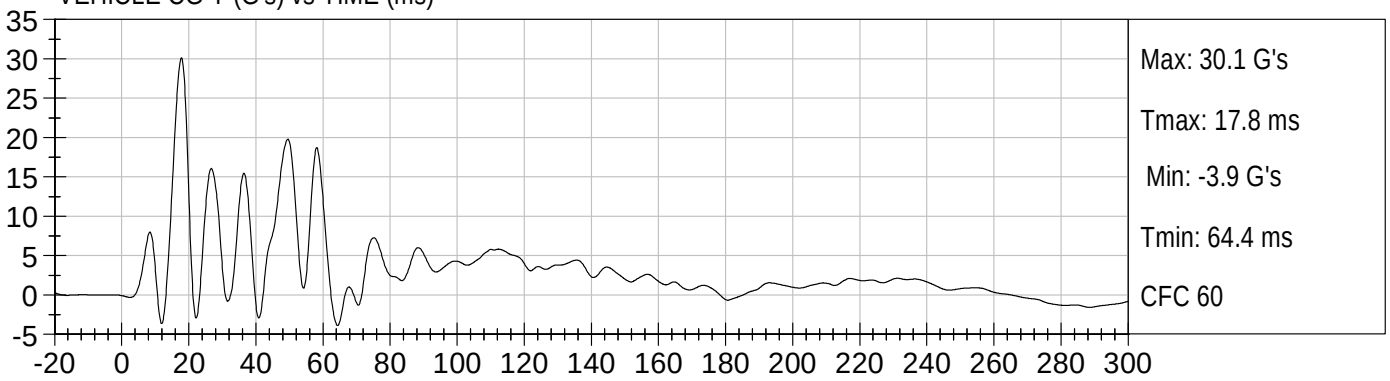
VEHICLE CG X (G's) vs TIME (ms)



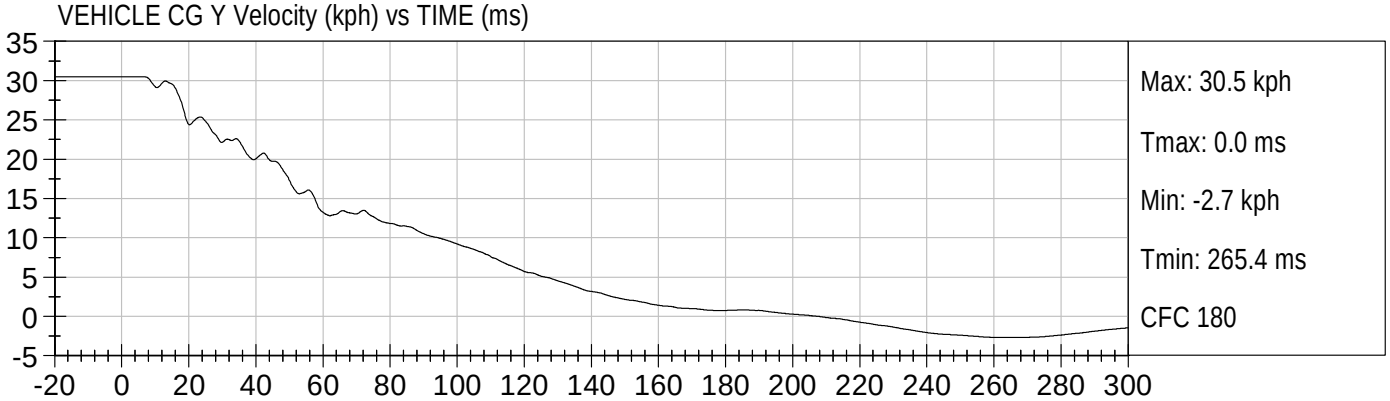
VEHICLE CG X Velocity (kph) vs TIME (ms)



VEHICLE CG Y (G's) vs TIME (ms)



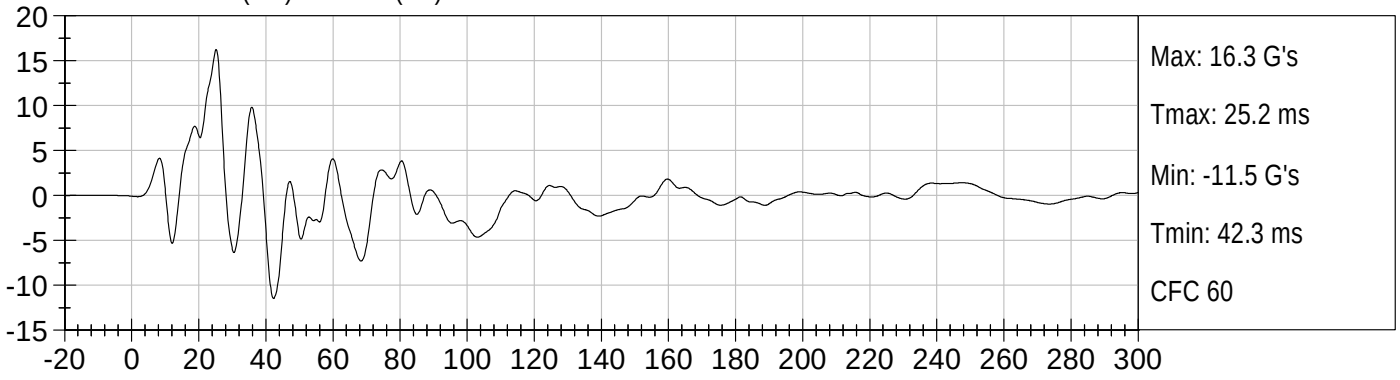
VEHICLE CG Y Velocity (kph) vs TIME (ms)



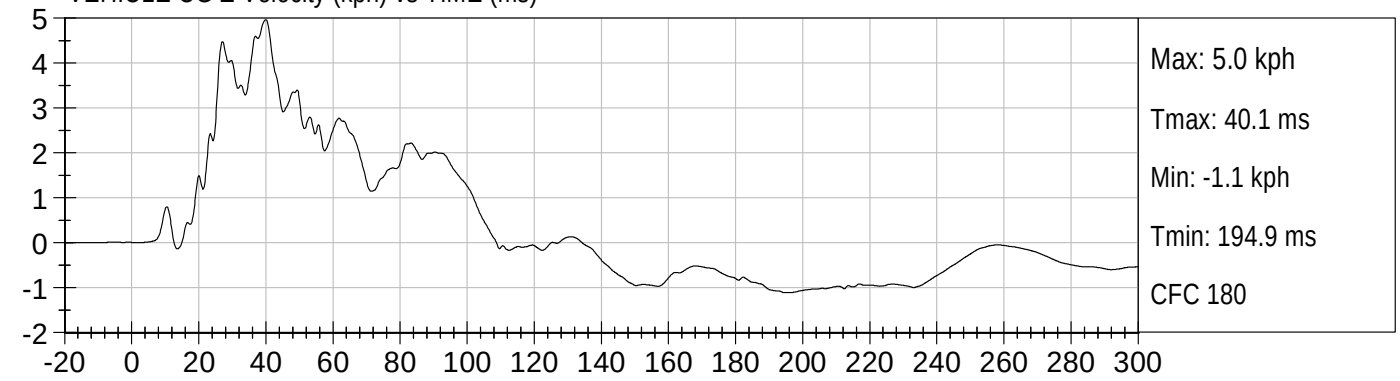
FMVSS 214 Rigid Pole Side Impact
2011 Volvo S60 - CB5901

Test Date: 05/05/2011
Speed: 19.6 mph (31.6 km/h)

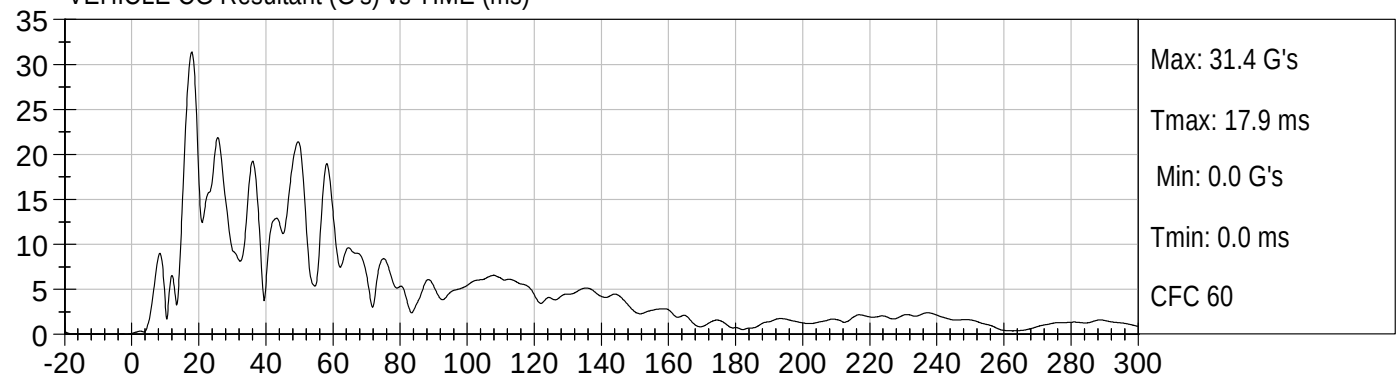
VEHICLE CG Z (G's) vs TIME (ms)



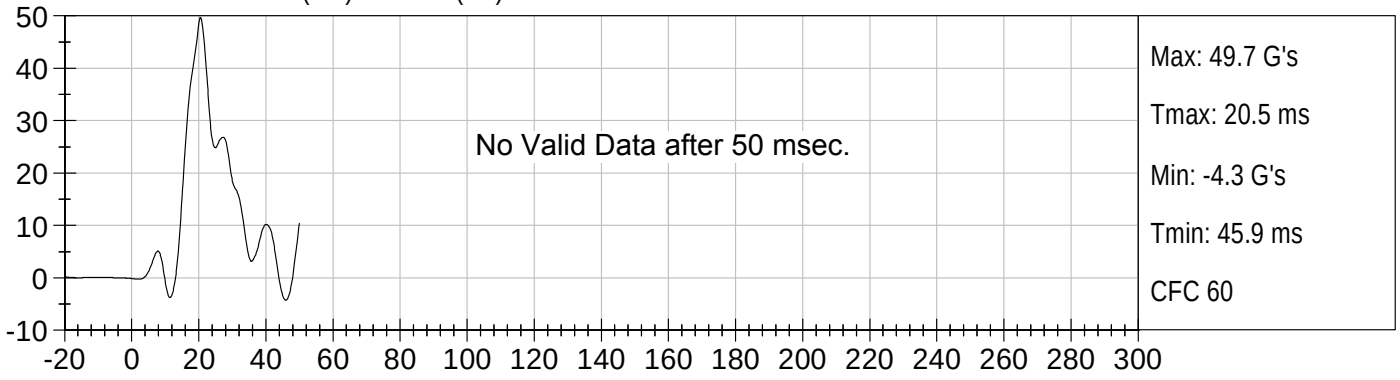
VEHICLE CG Z Velocity (kph) vs TIME (ms)



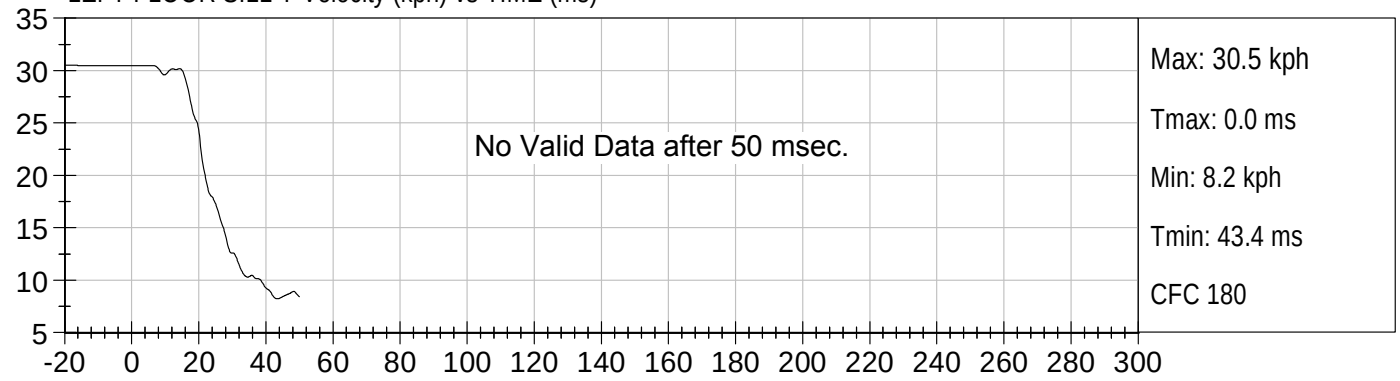
VEHICLE CG Resultant (G's) vs TIME (ms)



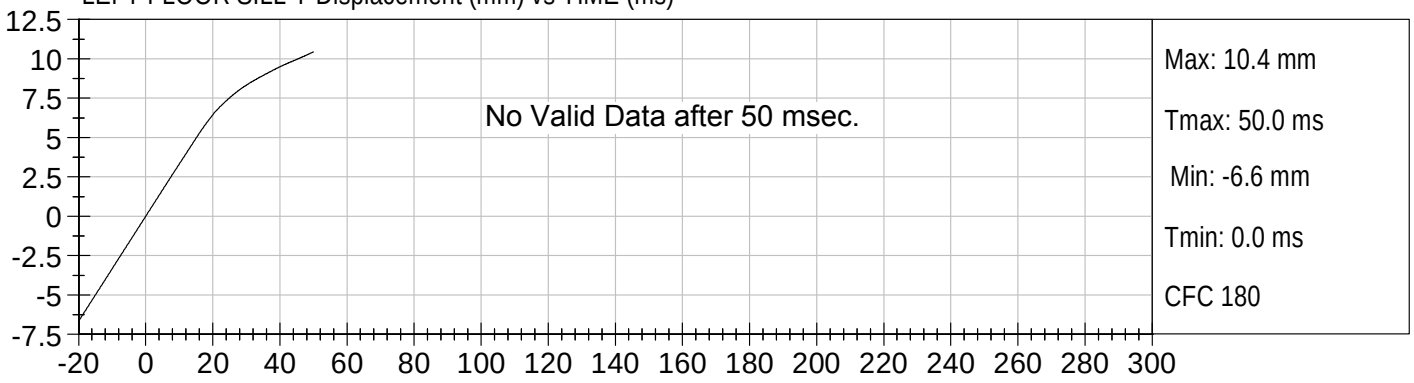
LEFT FLOOR SILL Y (G's) vs TIME (ms)



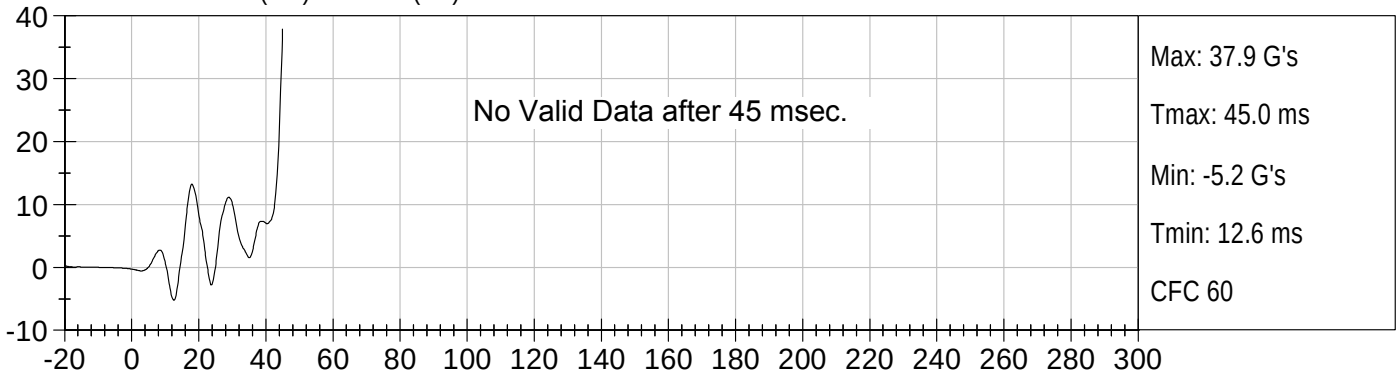
LEFT FLOOR SILL Y Velocity (kph) vs TIME (ms)



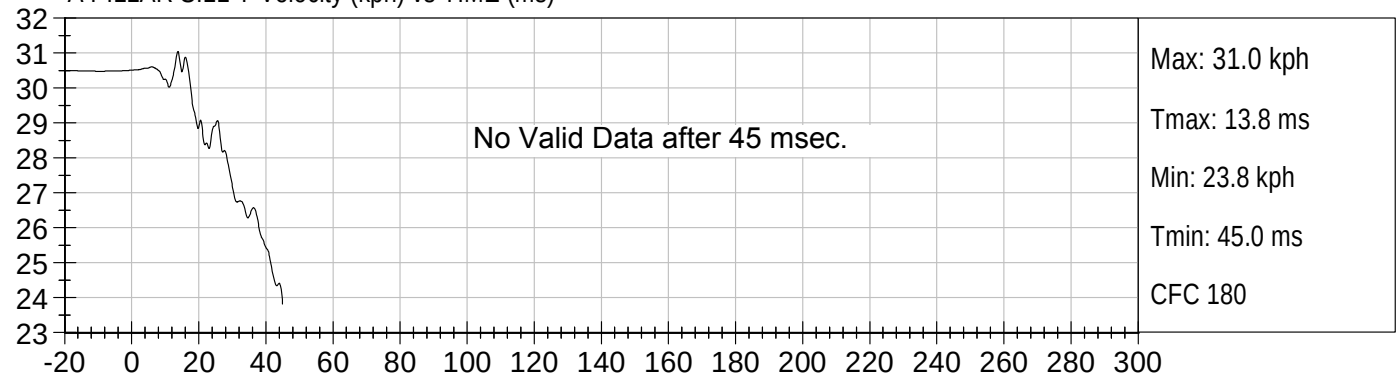
LEFT FLOOR SILL Y Displacement (mm) vs TIME (ms)



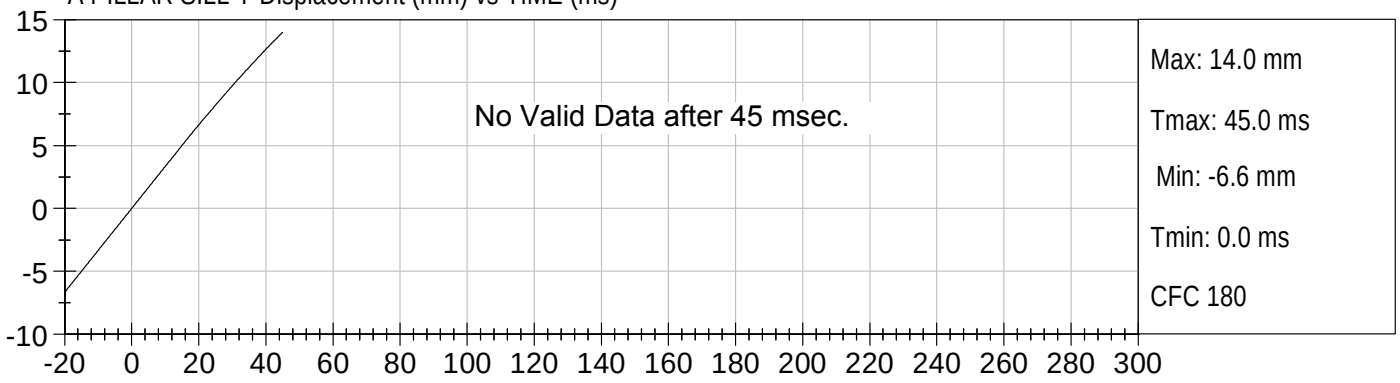
A PILLAR SILL Y (G's) vs TIME (ms)



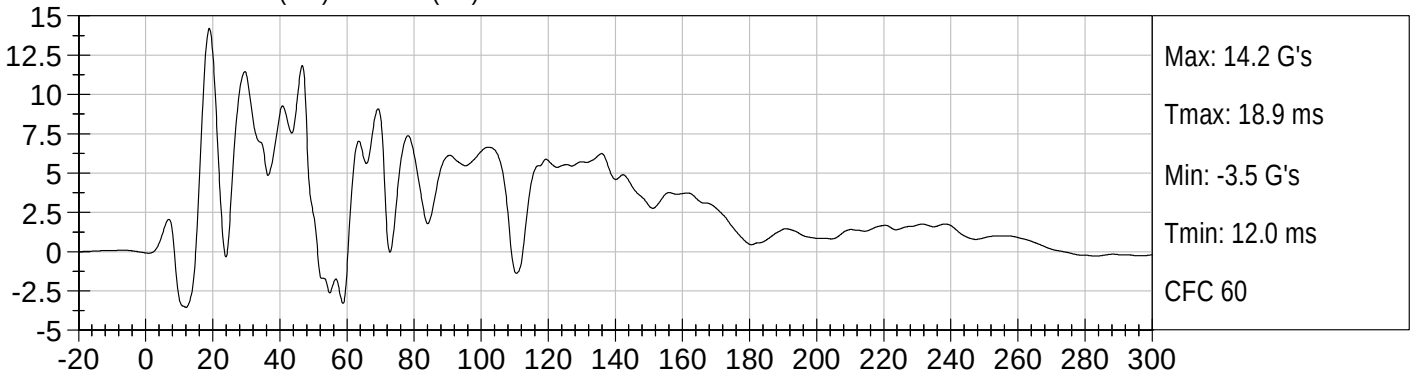
A PILLAR SILL Y Velocity (kph) vs TIME (ms)



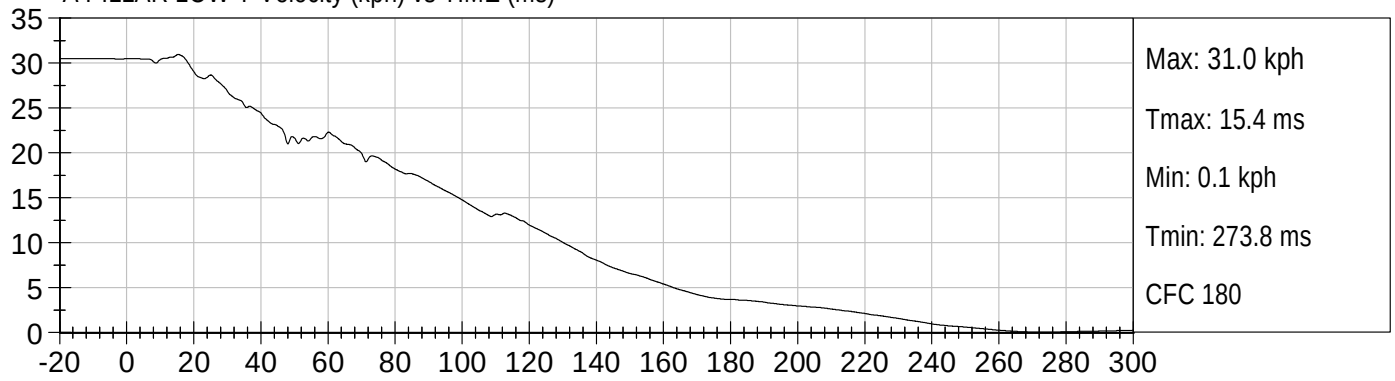
A PILLAR SILL Y Displacement (mm) vs TIME (ms)



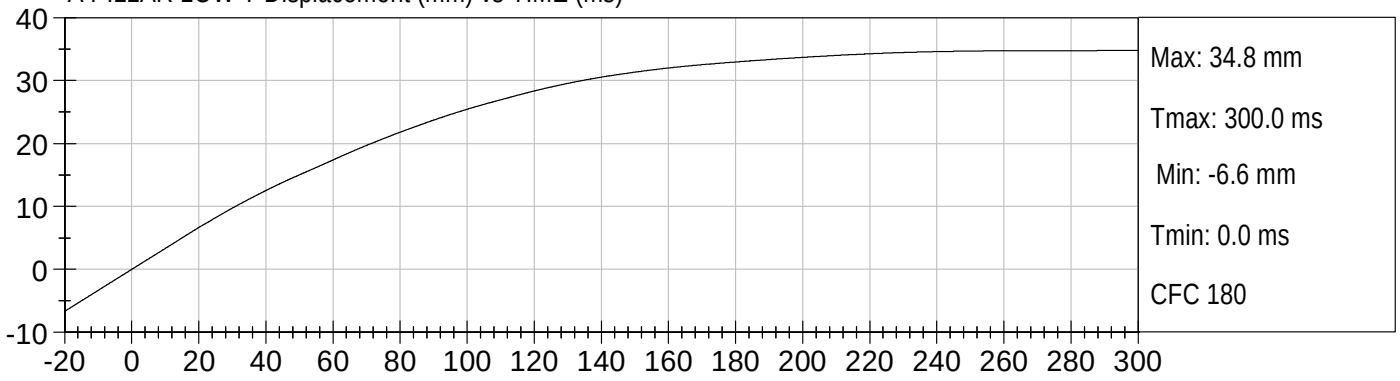
A PILLAR LOW Y (G's) vs TIME (ms)



A PILLAR LOW Y Velocity (kph) vs TIME (ms)



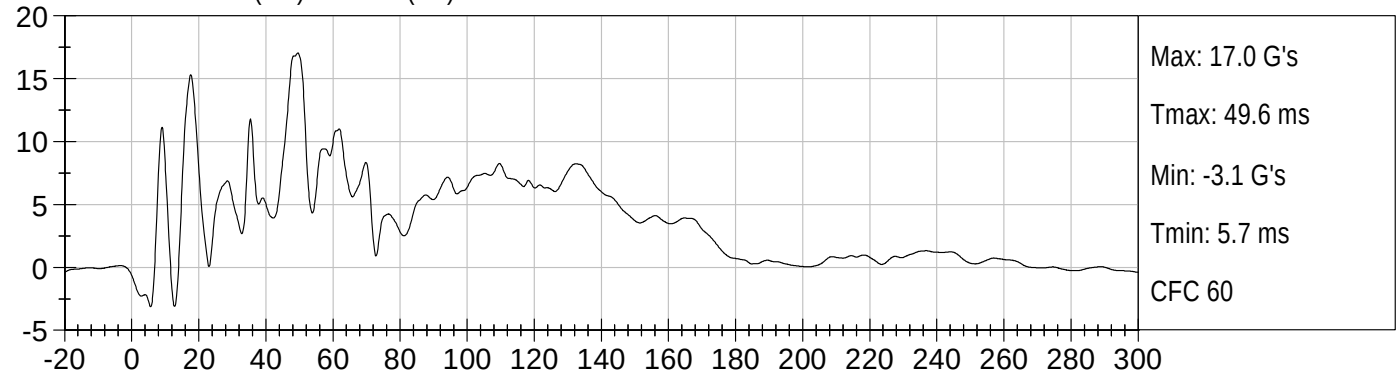
A PILLAR LOW Y Displacement (mm) vs TIME (ms)



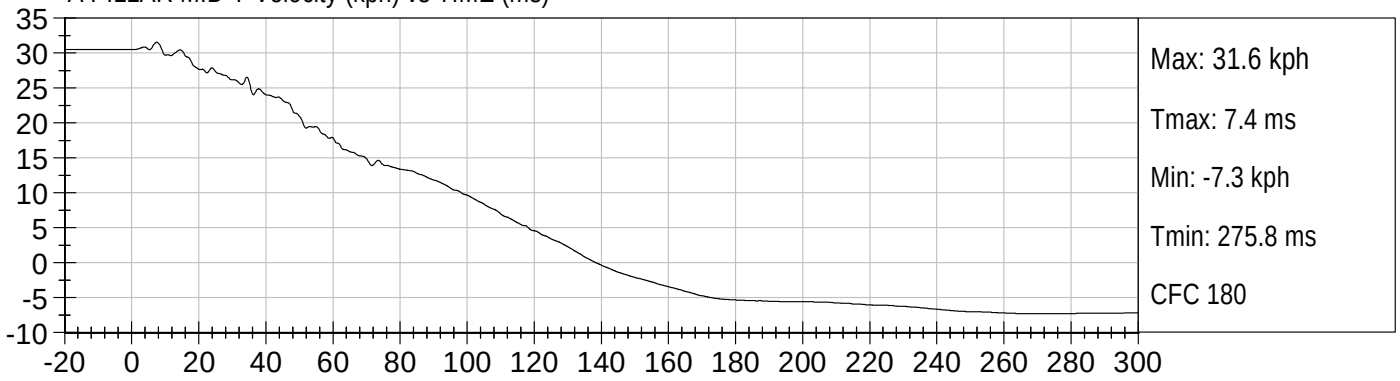
FMVSS 214 Rigid Pole Side Impact
2011 Volvo S60 - CB5901

Test Date: 05/05/2011
Speed: 19.6 mph (31.6 km/h)

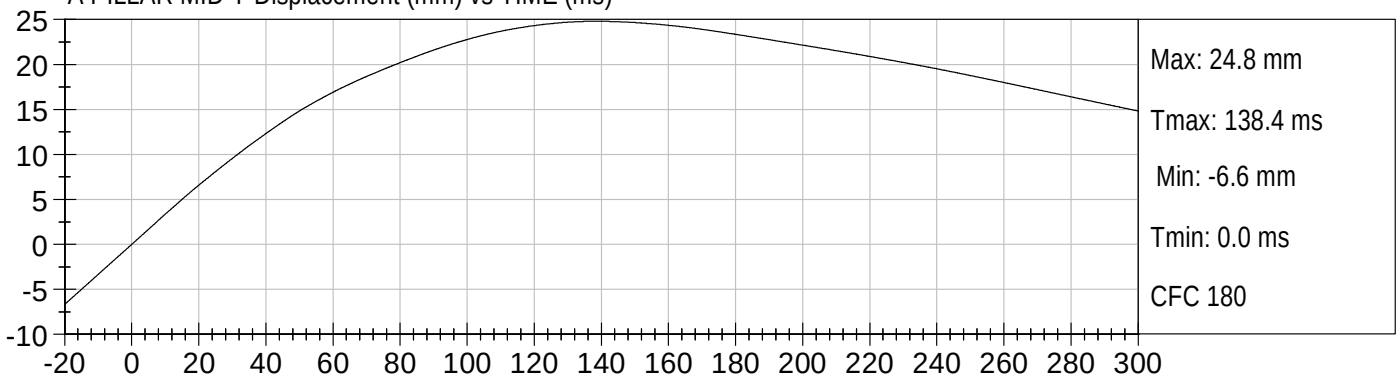
A PILLAR MID Y (G's) vs TIME (ms)



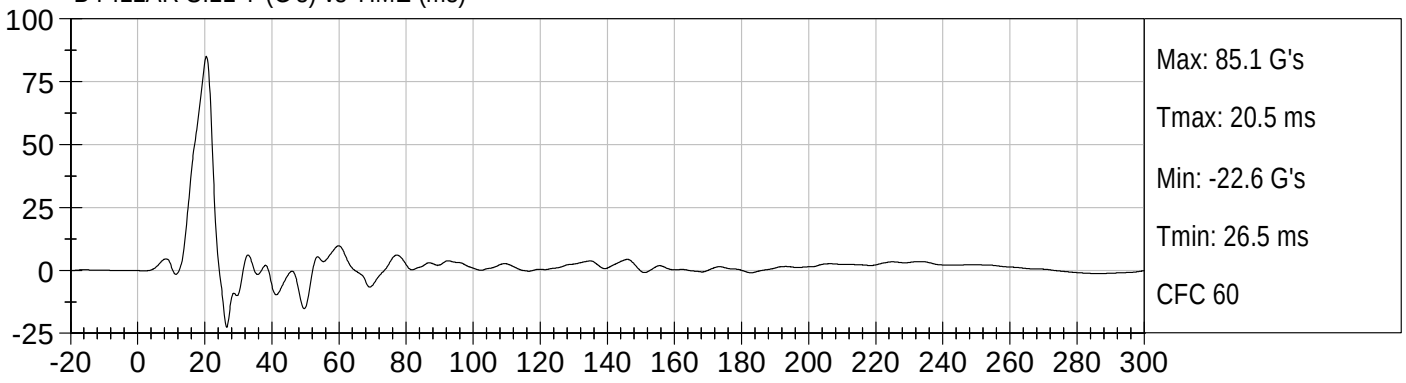
A PILLAR MID Y Velocity (kph) vs TIME (ms)



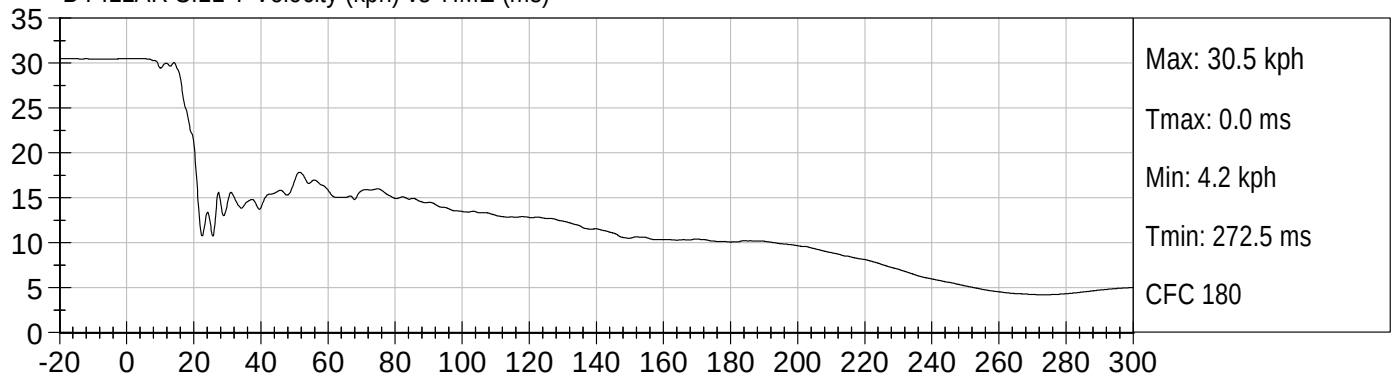
A PILLAR MID Y Displacement (mm) vs TIME (ms)



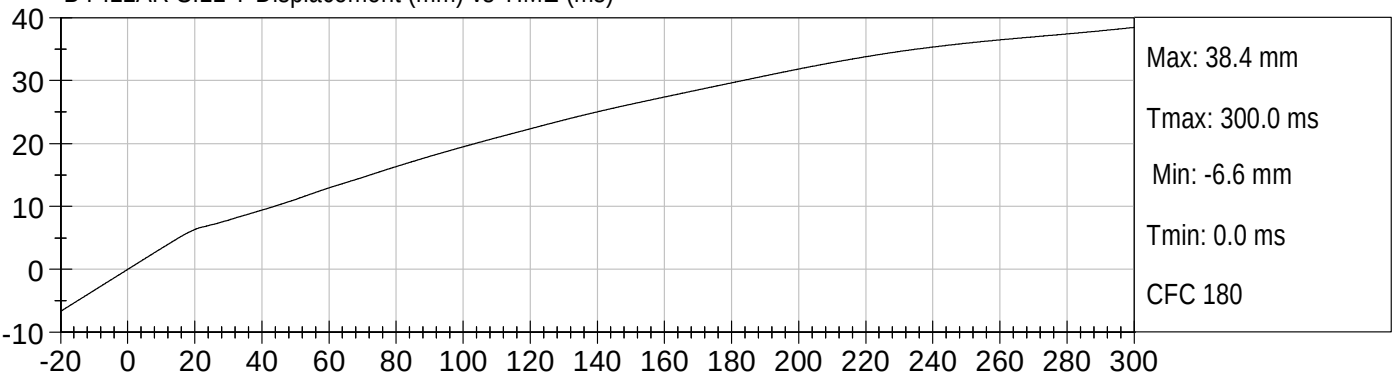
B PILLAR SILL Y (G's) vs TIME (ms)



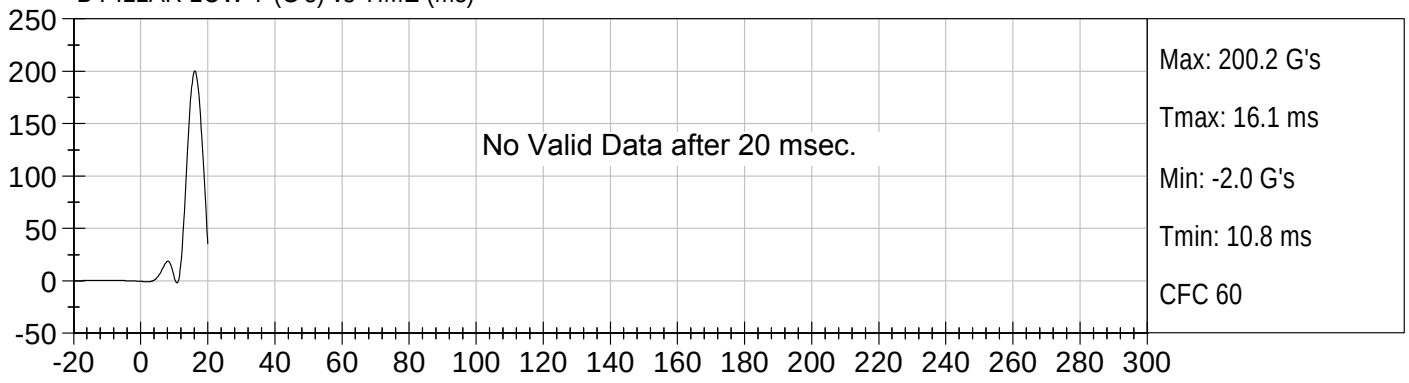
B PILLAR SILL Y Velocity (kph) vs TIME (ms)



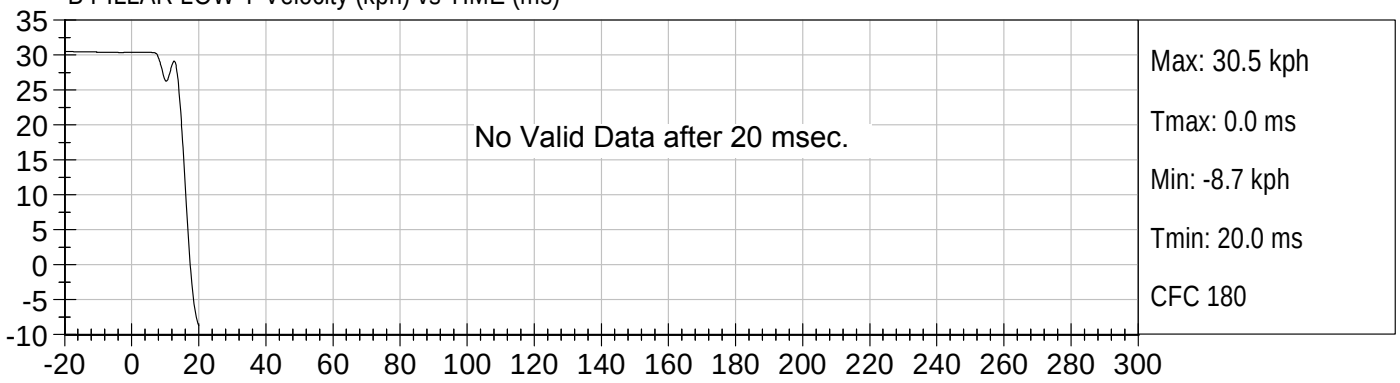
B PILLAR SILL Y Displacement (mm) vs TIME (ms)



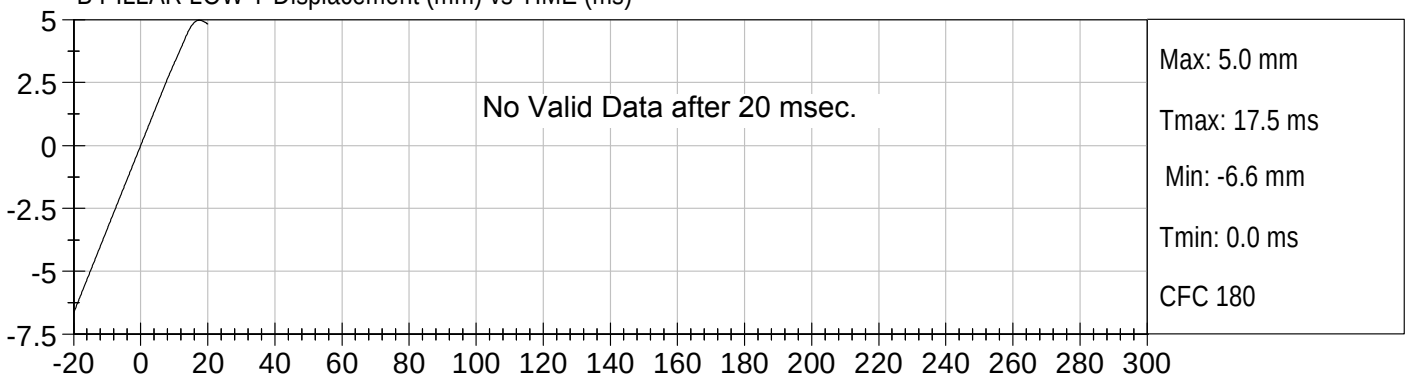
B PILLAR LOW Y (G's) vs TIME (ms)



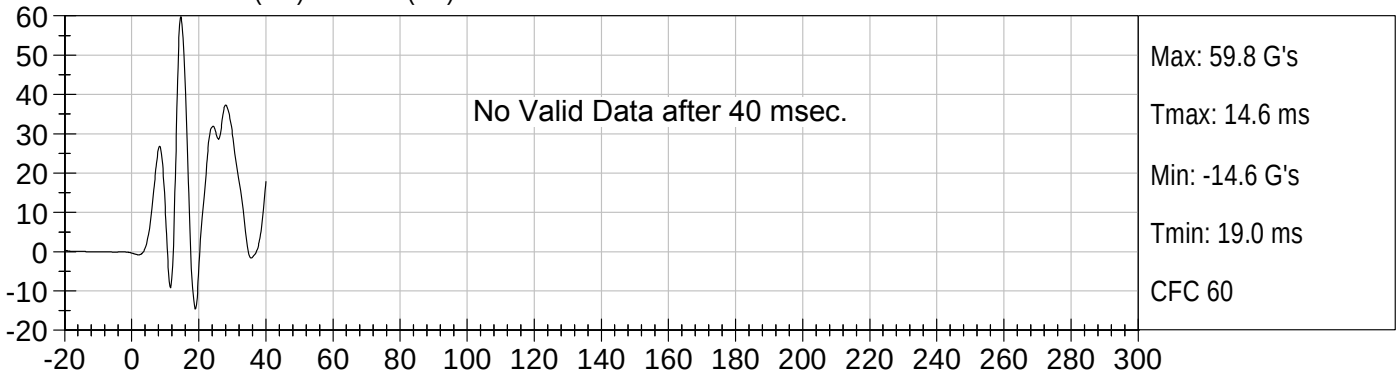
B PILLAR LOW Y Velocity (kph) vs TIME (ms)



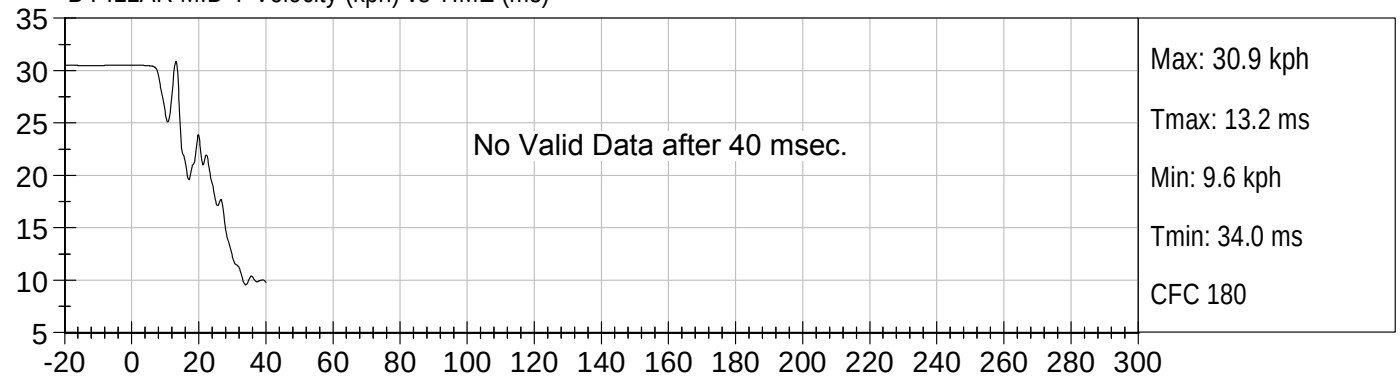
B PILLAR LOW Y Displacement (mm) vs TIME (ms)



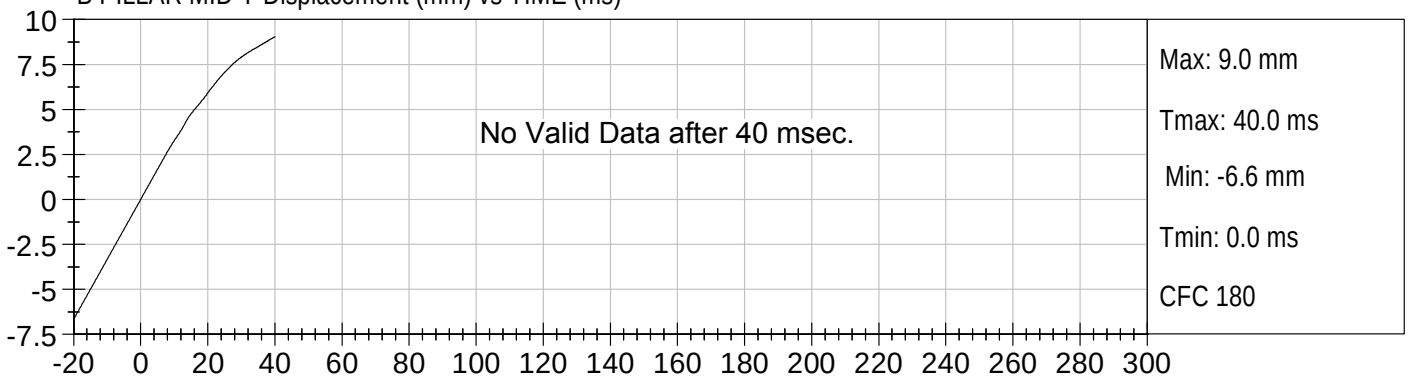
B PILLAR MID Y (G's) vs TIME (ms)



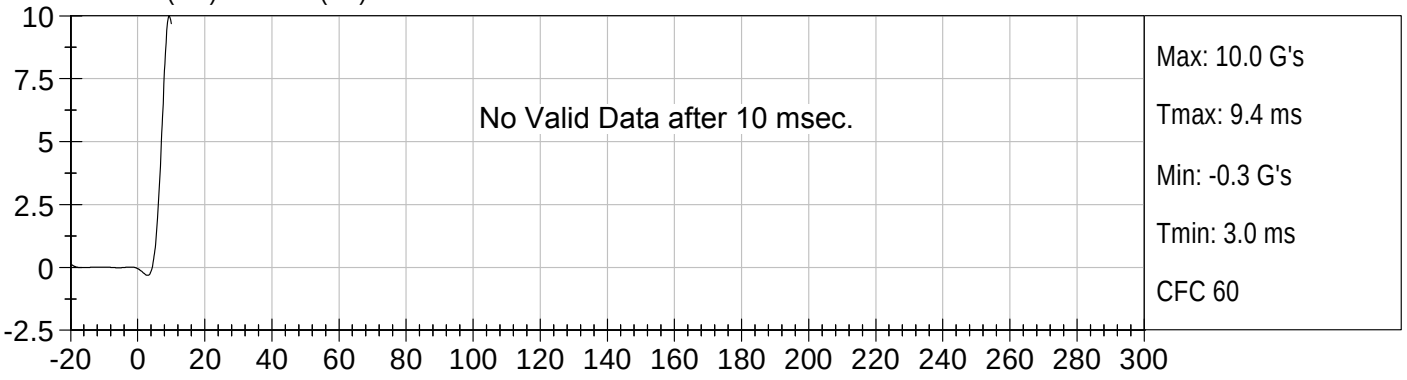
B PILLAR MID Y Velocity (kph) vs TIME (ms)



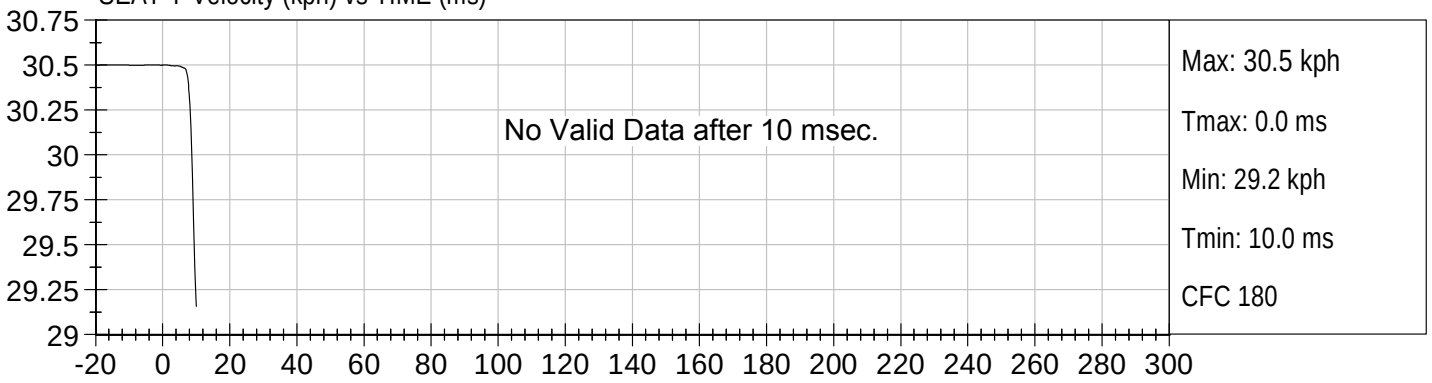
B PILLAR MID Y Displacement (mm) vs TIME (ms)



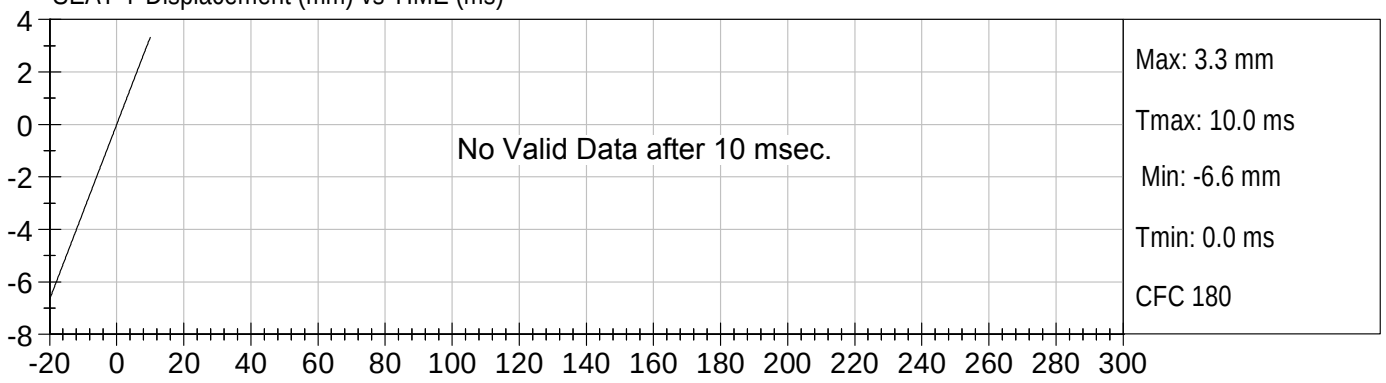
SEAT Y (G's) vs TIME (ms)



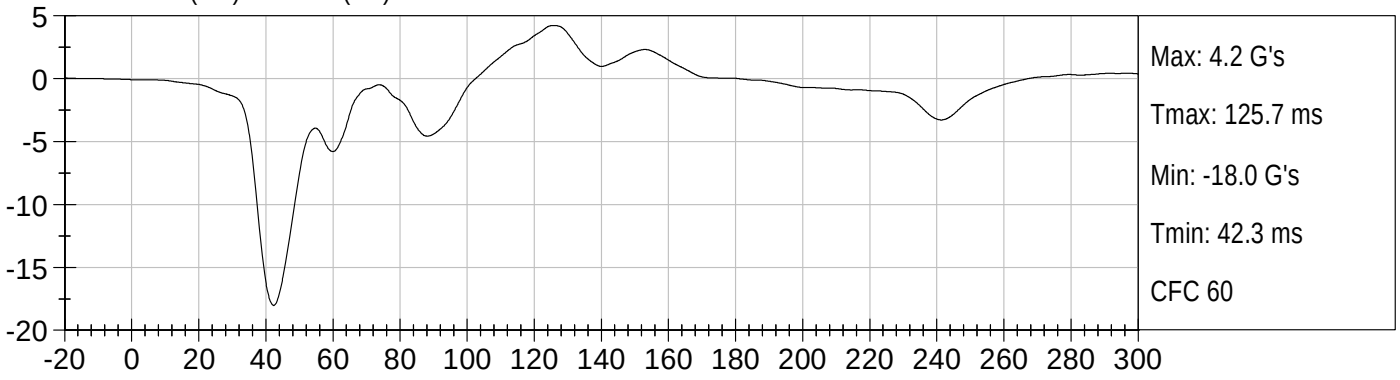
SEAT Y Velocity (kph) vs TIME (ms)



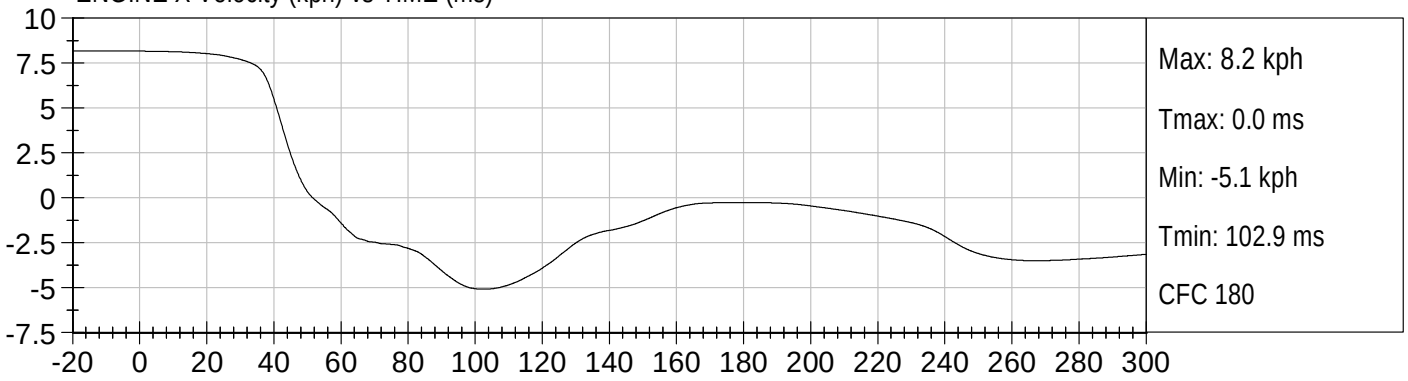
SEAT Y Displacement (mm) vs TIME (ms)



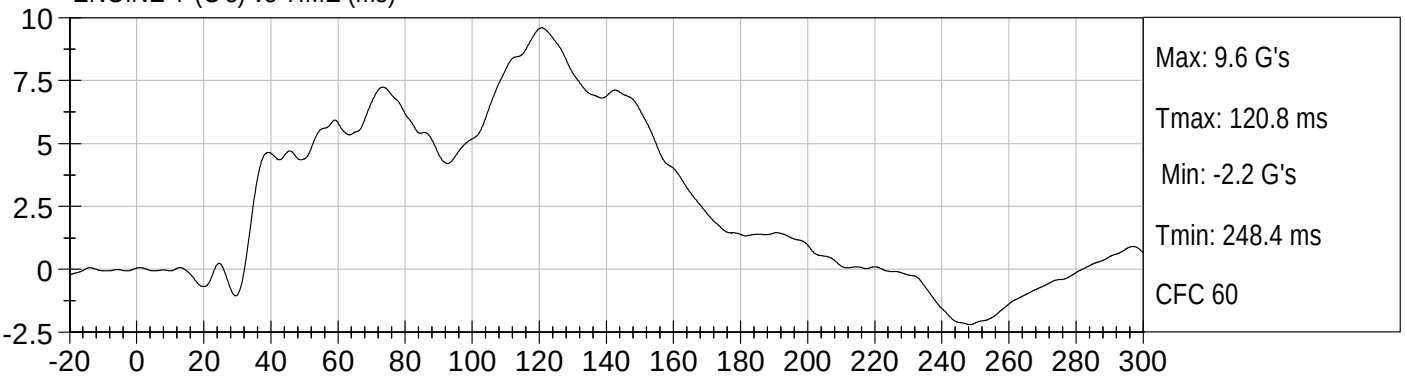
ENGINE X (G's) vs TIME (ms)



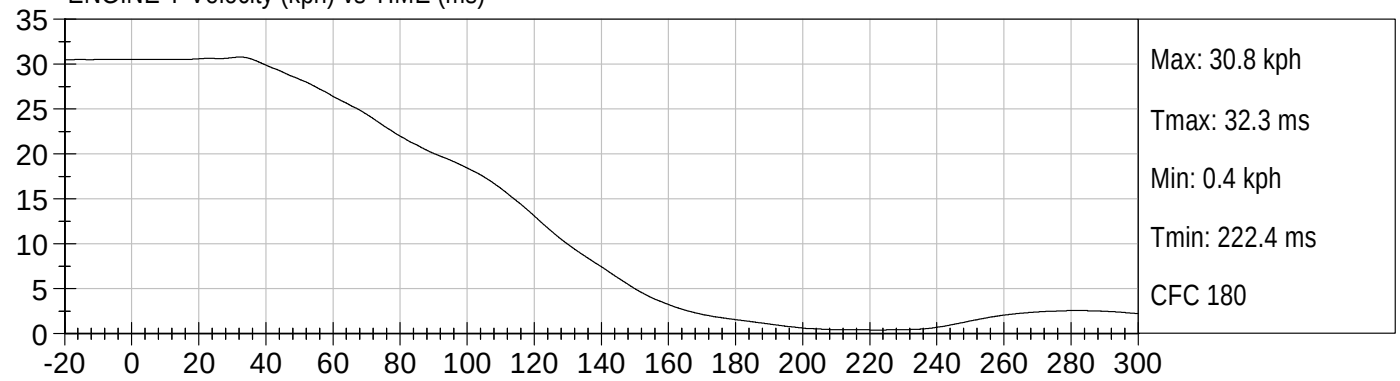
ENGINE X Velocity (kph) vs TIME (ms)



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



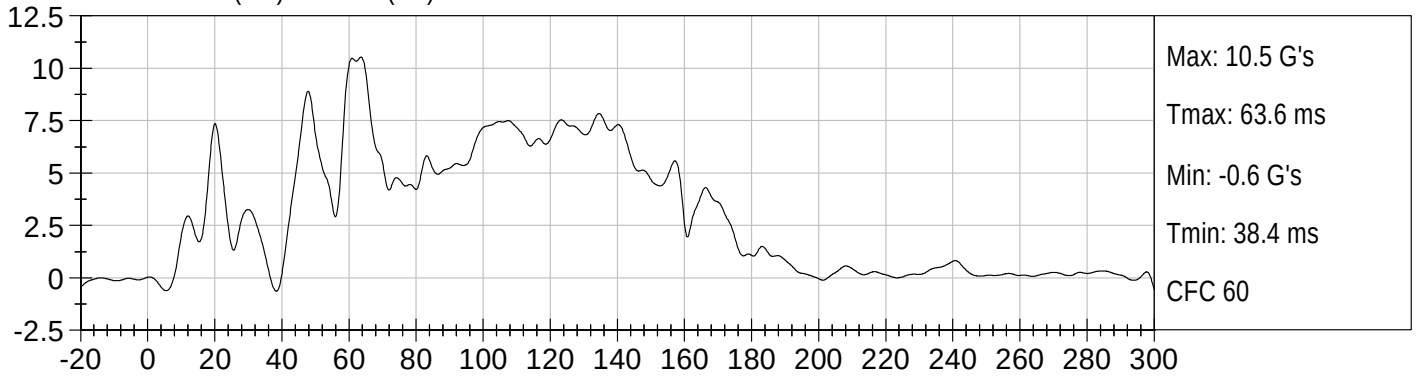
ENGINE Y Velocity (kph) vs TIME (ms)



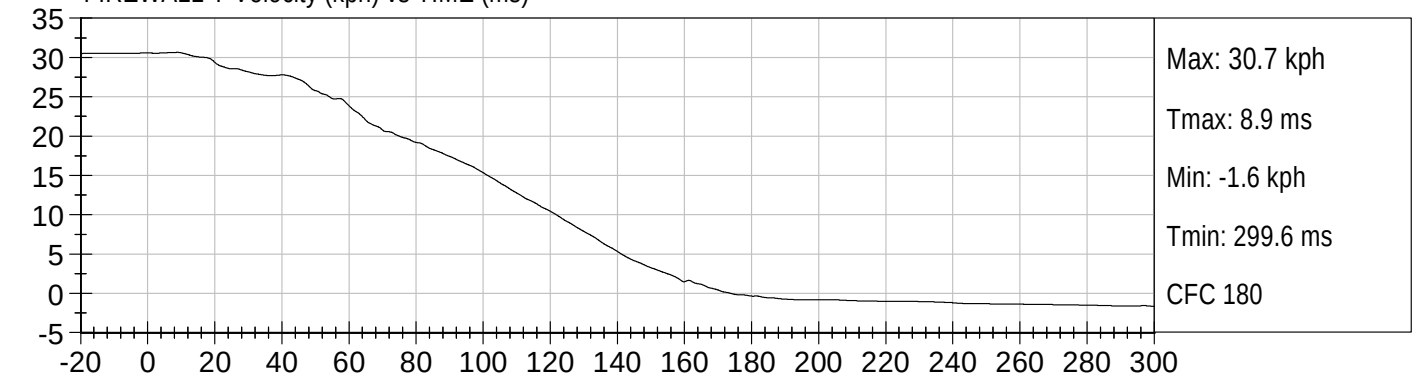
FMVSS 214 Rigid Pole Side Impact
2011 Volvo S60 - CB5901

Test Date: 05/05/2011
Speed: 19.6 mph (31.6 km/h)

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



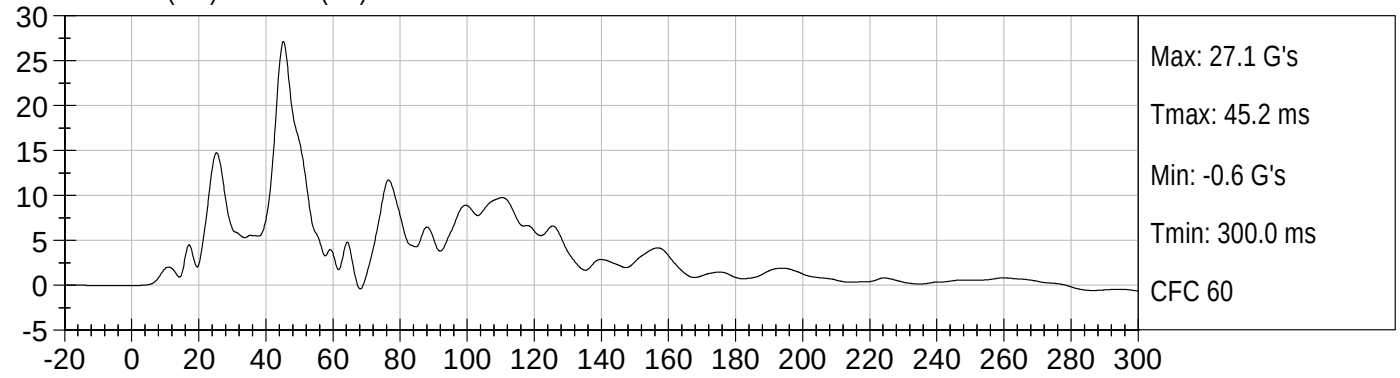
FIREWALL Y Velocity (kph) vs TIME (ms)



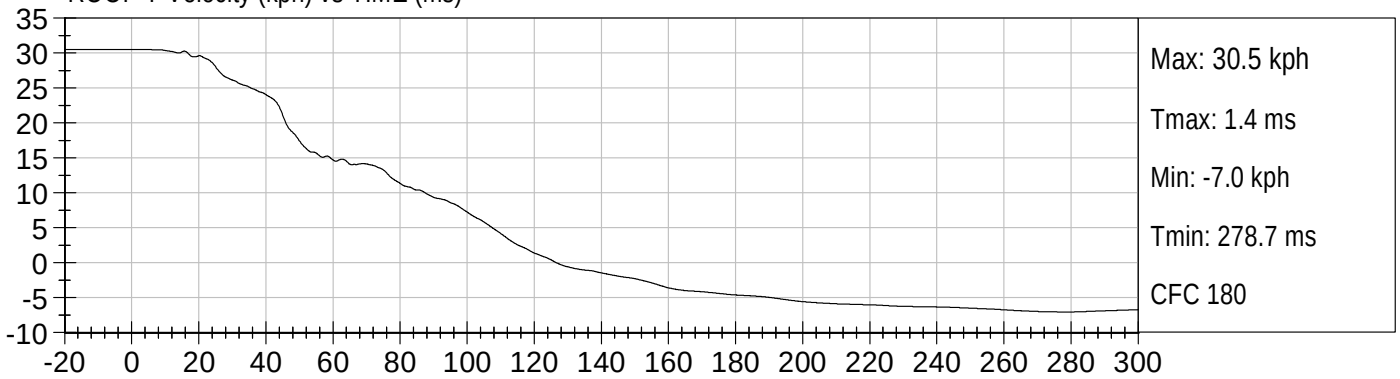
FMVSS 214 Rigid Pole Side Impact
2011 Volvo S60 - CB5901

Test Date: 05/05/2011
Speed: 19.6 mph (31.6 km/h)

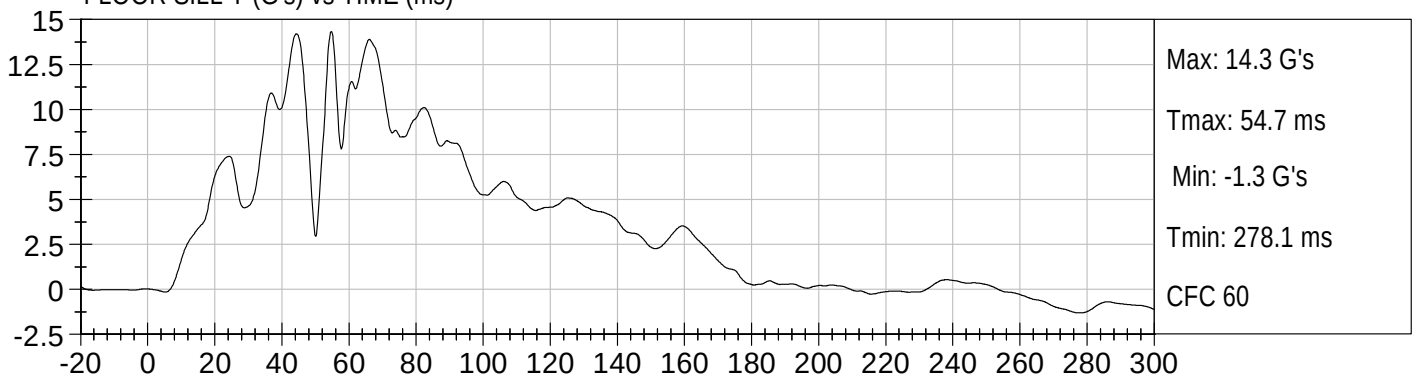
ROOF Y (G's) vs TIME (ms)



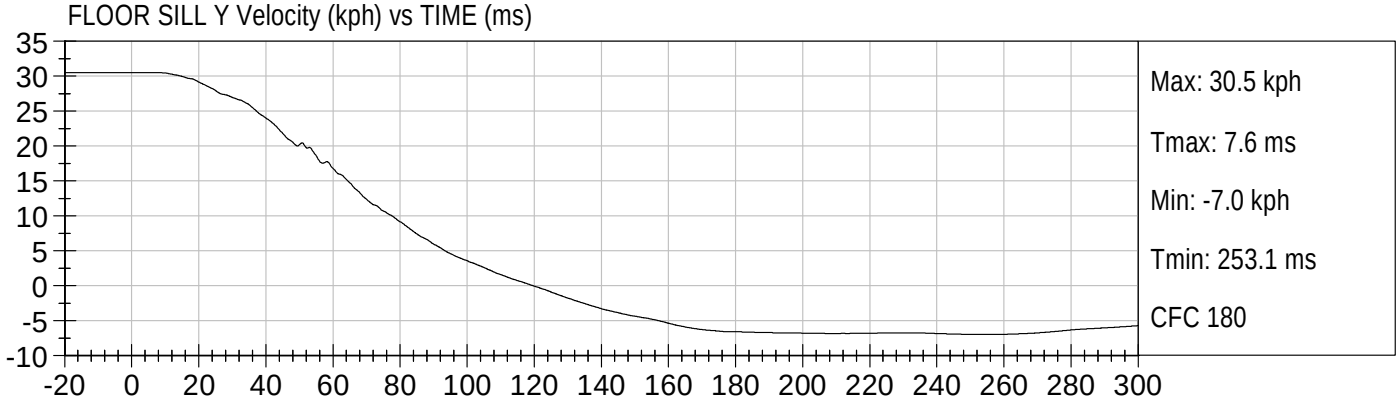
ROOF Y Velocity (kph) vs TIME (ms)



FLOOR SILL Y (G's) vs TIME (ms)



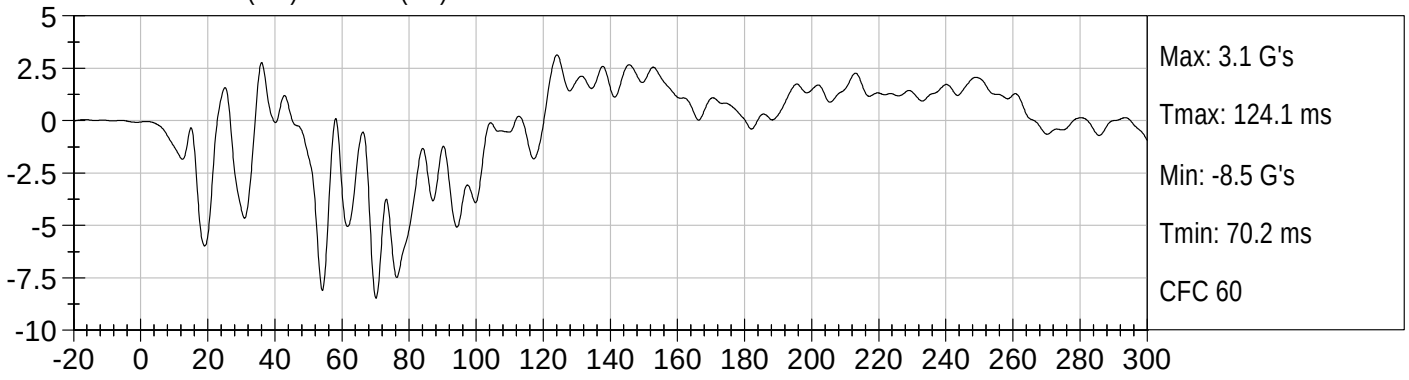
FLOOR SILL Y Velocity (kph) vs TIME (ms)



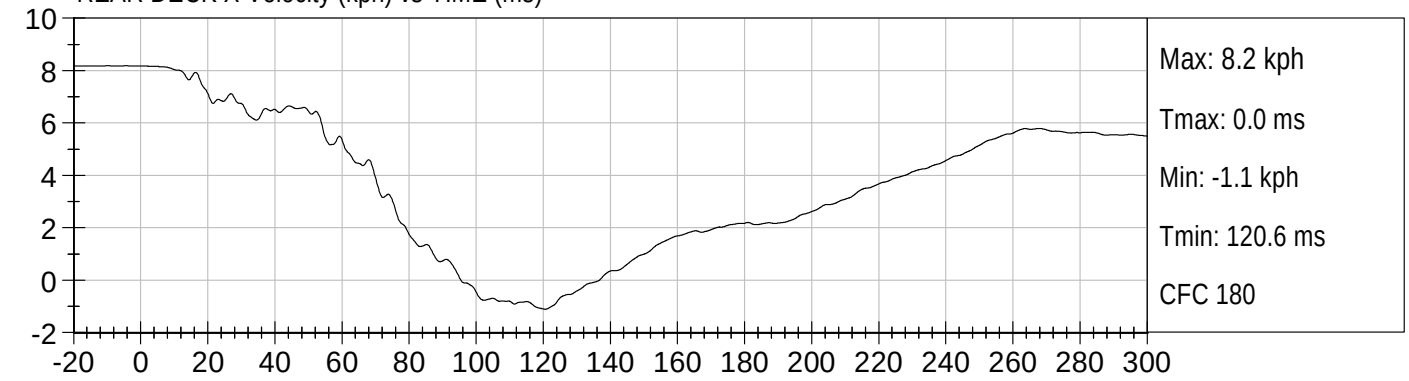
FMVSS 214 Rigid Pole Side Impact
2011 Volvo S60 - CB5901

Test Date: 05/05/2011
Speed: 19.6 mph (31.6 km/h)

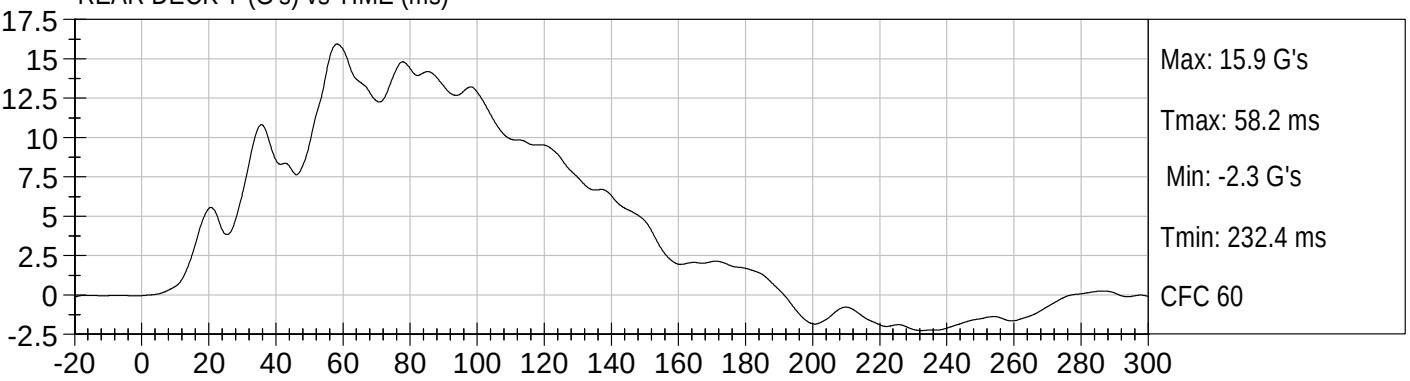
REAR DECK X (G's) vs TIME (ms)



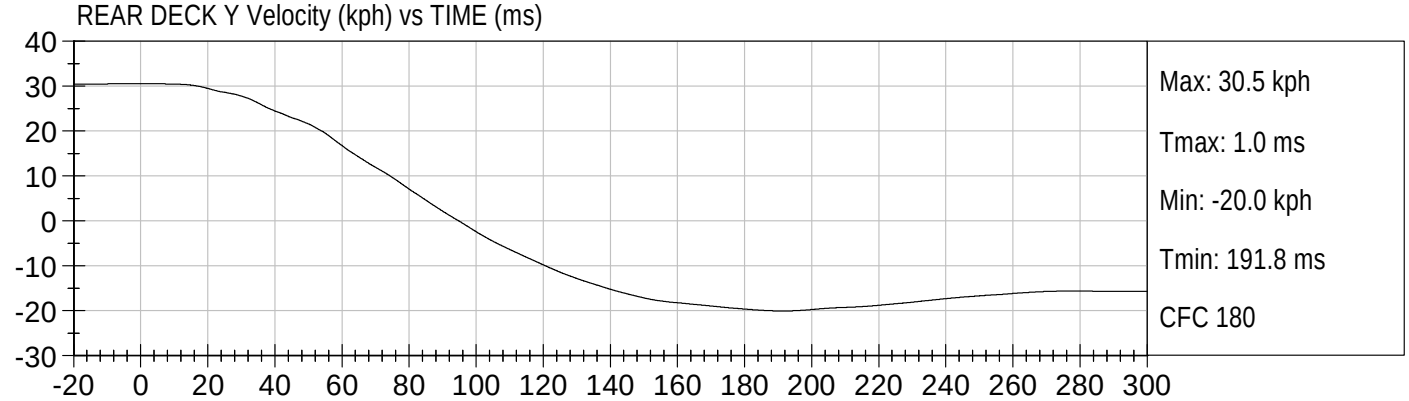
REAR DECK X Velocity (kph) vs TIME (ms)



REAR DECK Y (G's) vs TIME (ms)



REAR DECK Y Velocity (kph) vs TIME (ms)



APPENDIX D

DUMMY PERFORMANCE CALIBRATION TEST DATA

MGA RESEARCH CORPORATION

HEAD DROP TEST

ES-2re DUMMY

ATD Serial No: 016 **Test ID:** D111641

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.6	21.4	Pass
Laboratory Relative Humidity	%	10 to 70	27	Pass
Peak Resultant Acceleration	G's	125 to 155	149	Pass
Peak Lateral Acceleration	G's	+/- 15	-7.7	Pass
Unimodal	N/A	Yes	Yes	Pass
Oscillations	N/A	within 15% of peak	Yes	Pass
		Overall Test Results		Pass

Jessica Hall
Laboratory Technician

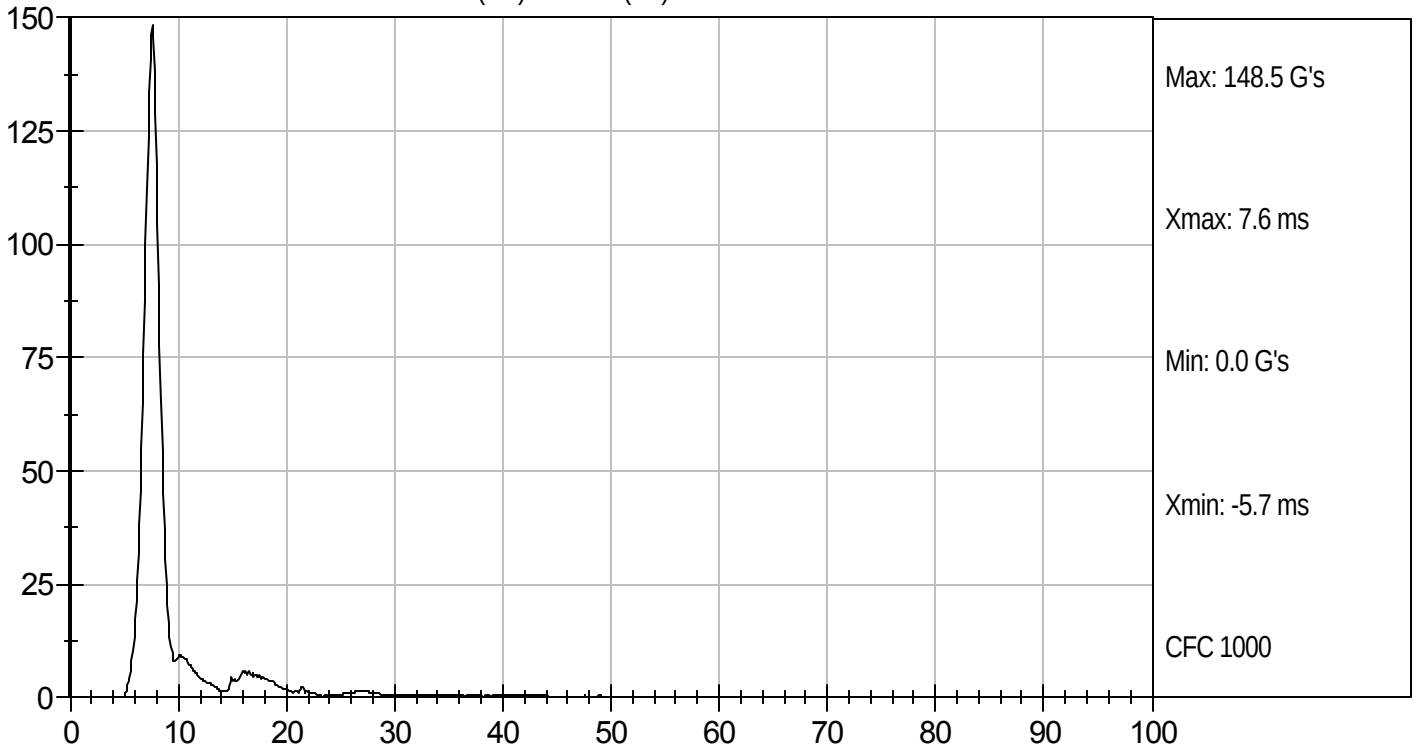
5/3/11
Test Date

David Winkelbauer
Approved By

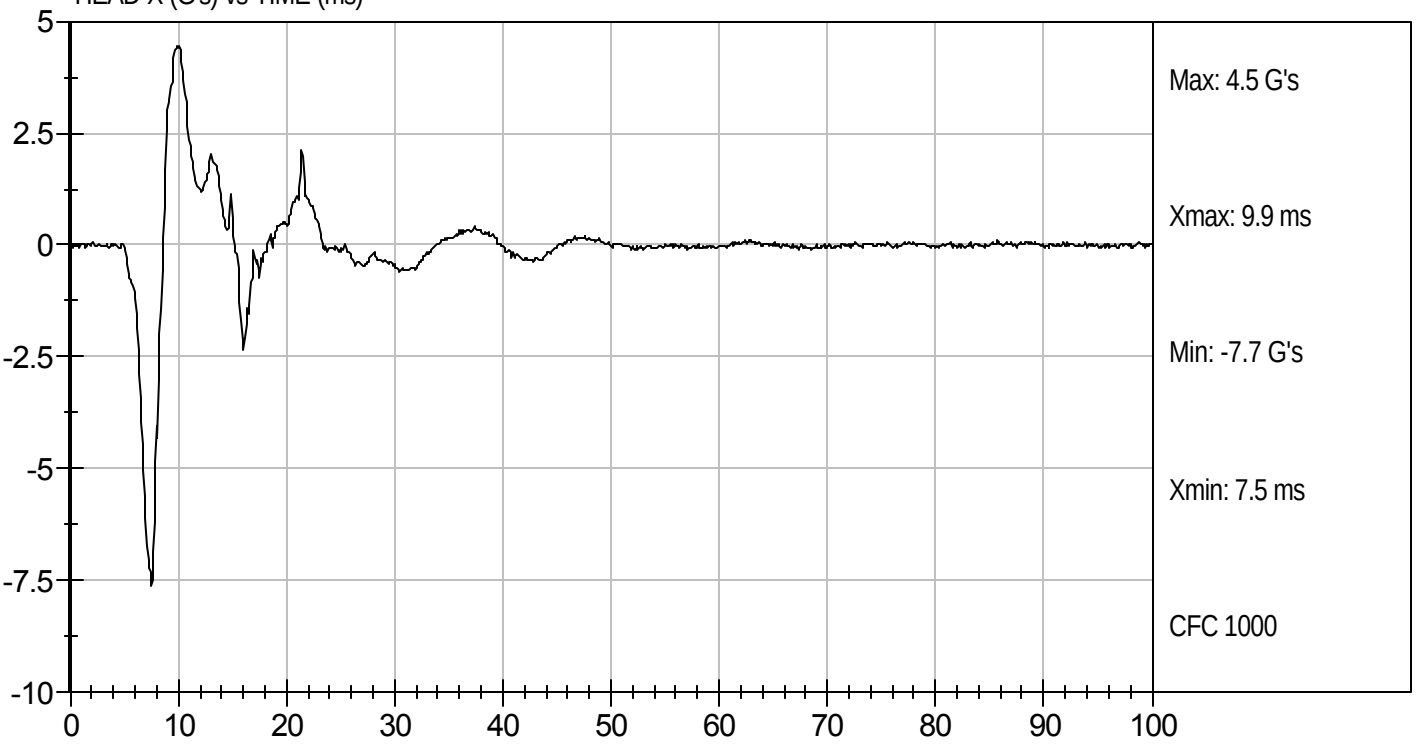
Test Desc: Head Drop
Component ID: D111641

Test Date: 5/3/11
Velocity: 0 ft/s, 0 m/s

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



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



MGA RESEARCH CORPORATION

NECK PENDULUM TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111642

Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	18.0 to 22.0	21.7	Pass
Laboratory Relative Humidity		%	10 to 70	25	Pass
Pendulum Speed		m/s	3.3 to 3.5	3.5	Pass
Pendulum Deceleration	1 ms	m/s	0.00 to -0.05	-0.02	Pass
	3 ms	m/s	-0.25 to -0.375	-0.34	Pass
	14 ms	m/s	-3.20 to -3.70	-3.32	Pass
Maximum Flexion Angle		deg	49.0 to 59.0	50.0	Pass
Time of Maximum Flexion Angle		ms	54.0 to 66.0	60.7	Pass
Head Rotation Decay Time to 0 degree		ms	53.0 to 88.0	60.9	Pass
			Overall Test Results		Pass

Jessica Gall
Laboratory Technician

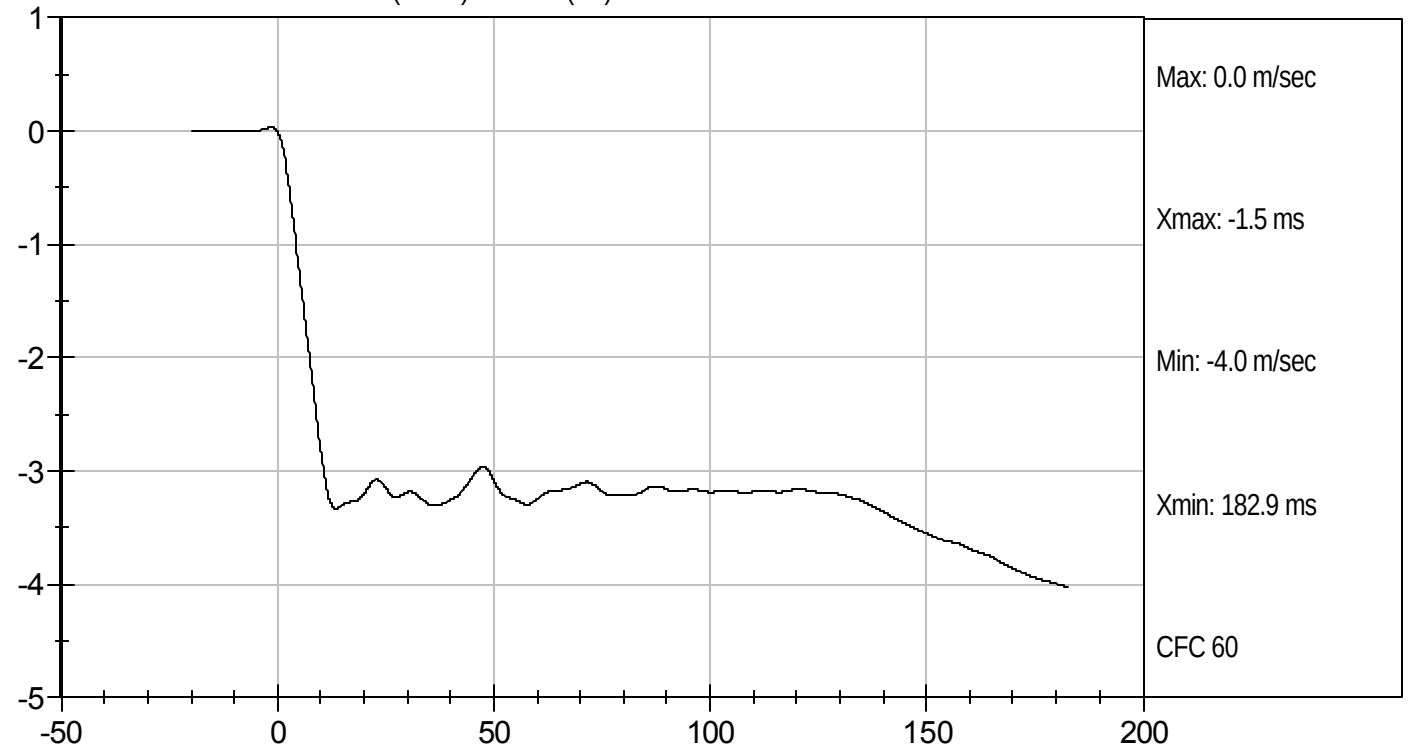
5/3/11
Test Date

David Winkelbauer
Approved By

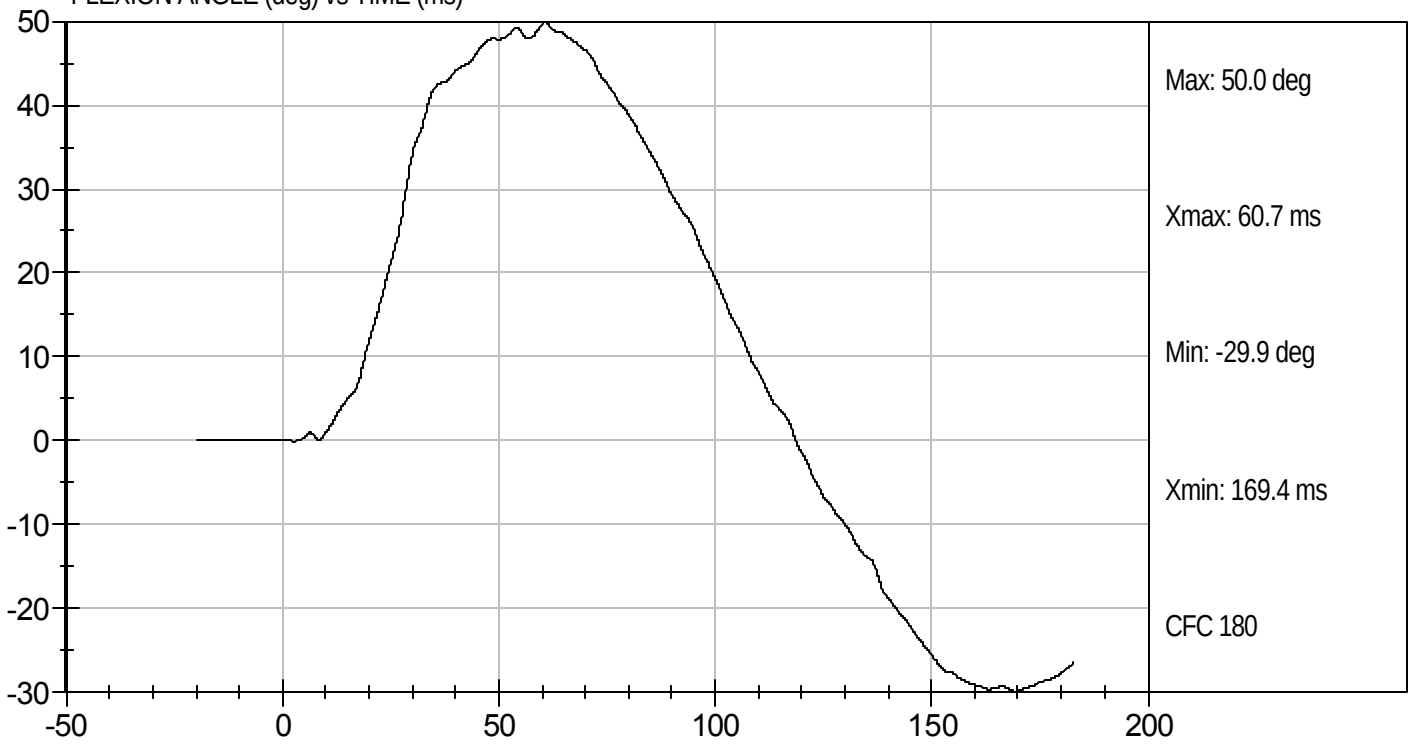
Test Desc: Neck Bending
Component ID: D111642

Test Date: 5/3/11
Velocity: 11.42 ft/s, 3.5 m/s

PENDULUM DECELERATION (m/sec) vs TIME (ms)

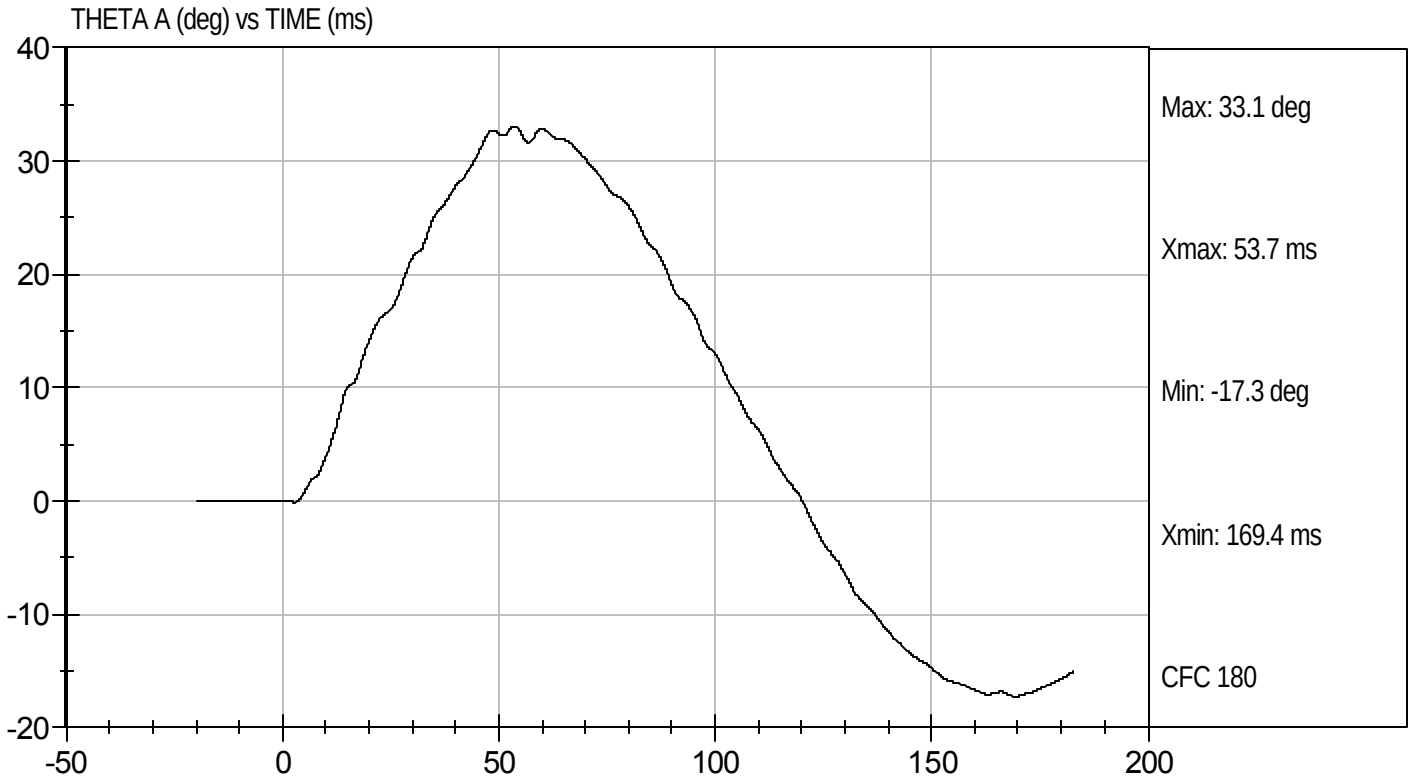


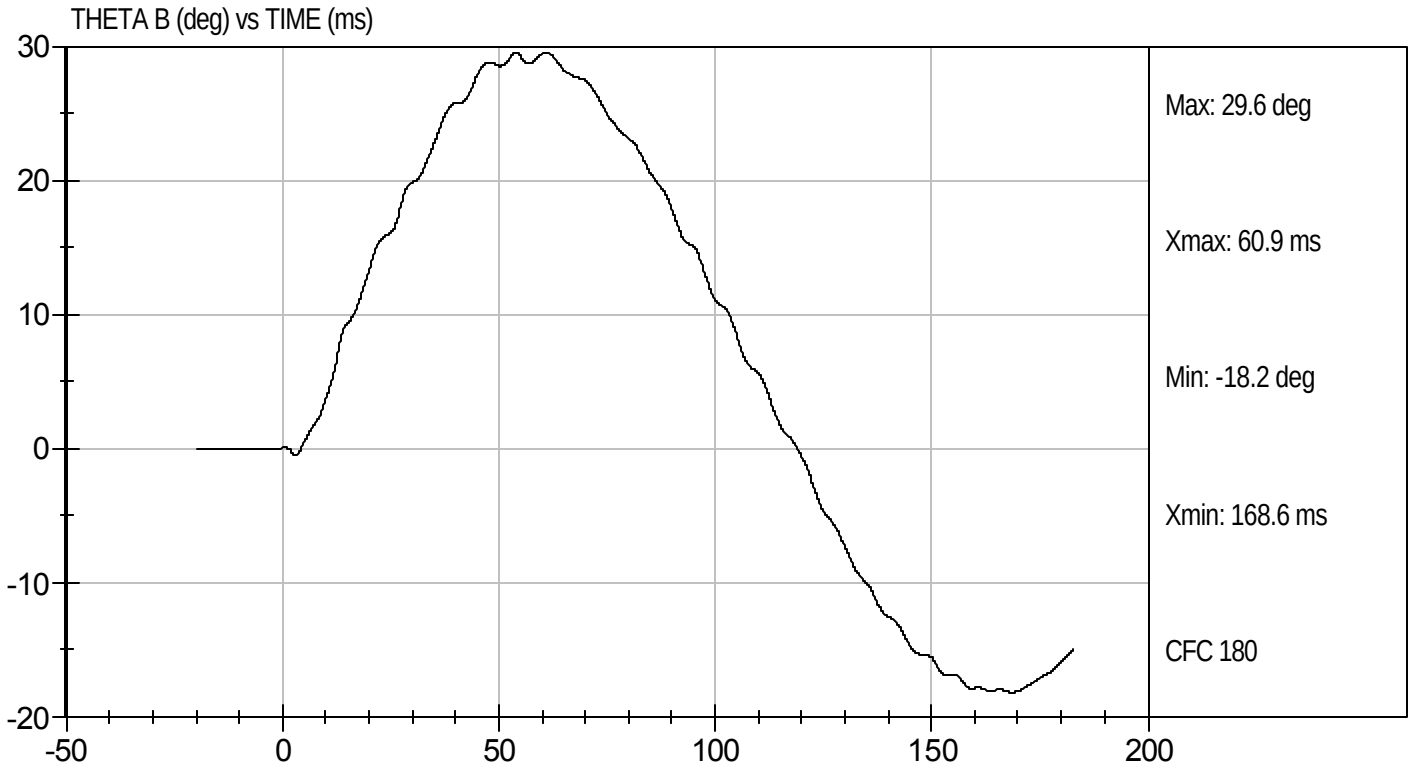
FLEXION ANGLE (deg) vs TIME (ms)



Test Desc: Neck Bending
Component ID: D111642

Test Date: 5/3/11
Velocity: 11.42 ft/s, 3.5 m/s





MGA RESEARCH CORPORATION

SHOULDER IMPACT TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111643

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	26	Pass
Pendulum Speed	m/s	4.2 to 4.4	4.3	Pass
Peak Shoulder Acceleration	G's	7.5 to 10.5	9.4	Pass
Time of Peak Shoulder Acceleration	ms	NA	18.6	Pass
		Overall Test Results		Pass

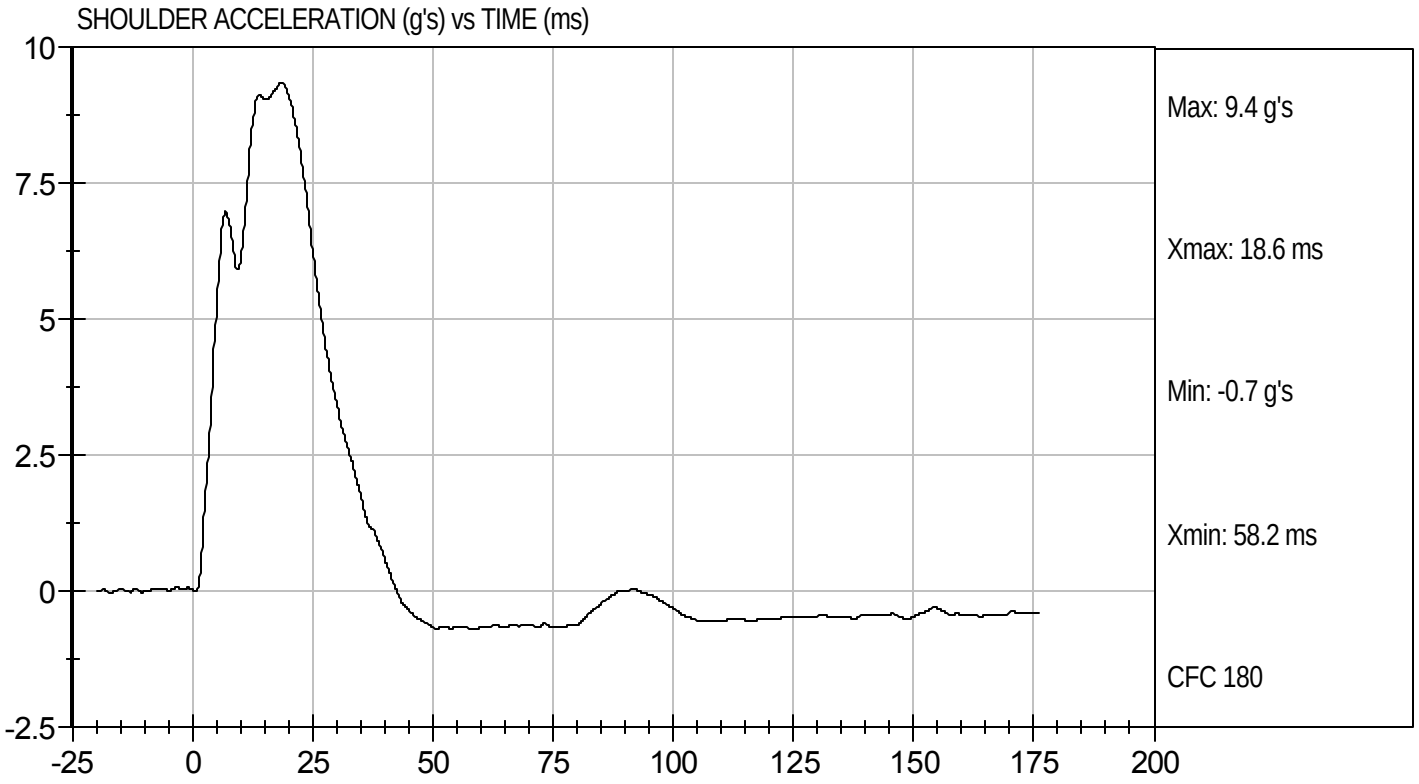
Jessica Hall
Laboratory Technician

5/3/11
Test Date

David Winkelbauer
Approved By

Test Desc: Shoulder Impact
Component ID: D111643

Test Date: 5/3/11
Velocity: 14.25 ft/s, 4.3 m/s



MGA RESEARCH CORPORATION

UPPER RIB TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111644

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	26	Pass
Displacement at 3 m/s	mm	36.0 to 40.0	39.2	Pass
Displacement at 4 m/s	mm	46.0 to 51.0	49.0	Pass
		Overall Test Results		Pass

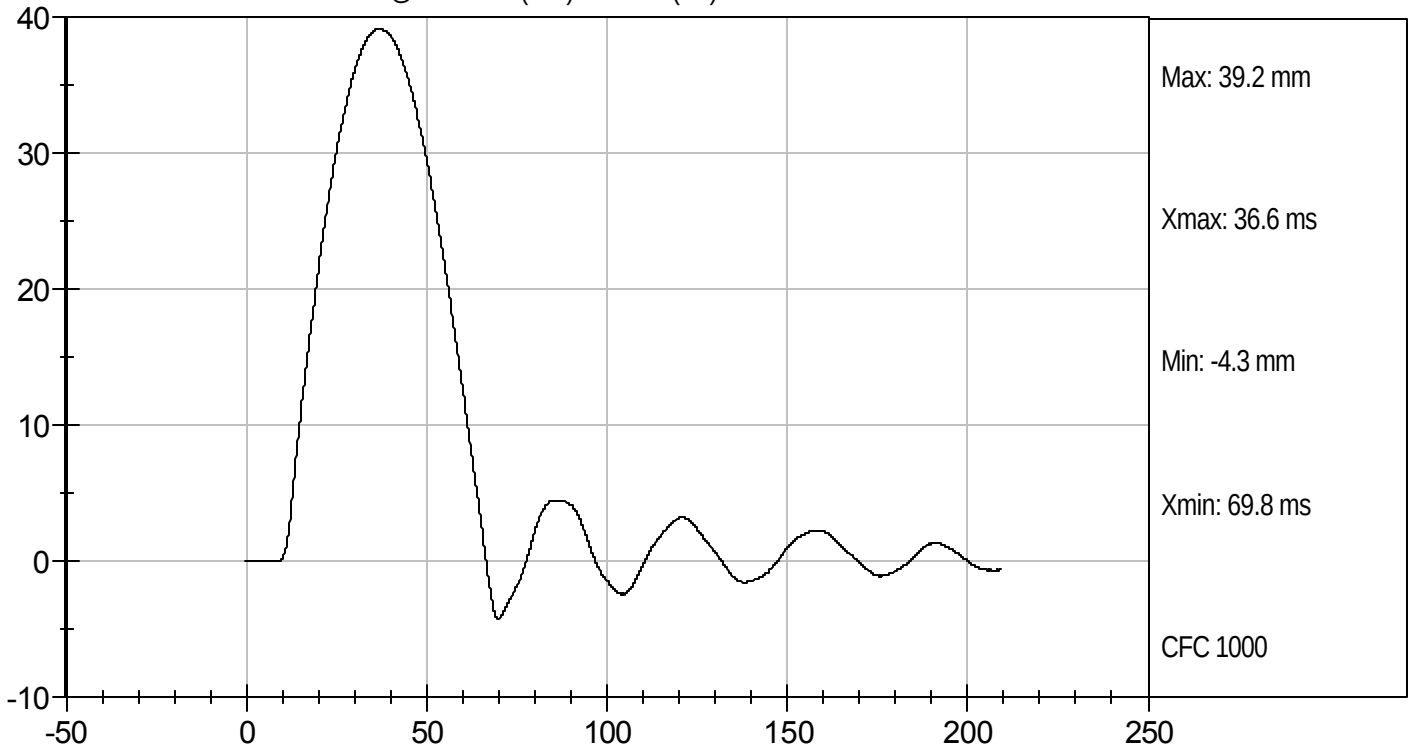
Jessica Gall
Laboratory Technician

5/3/11
Test Date

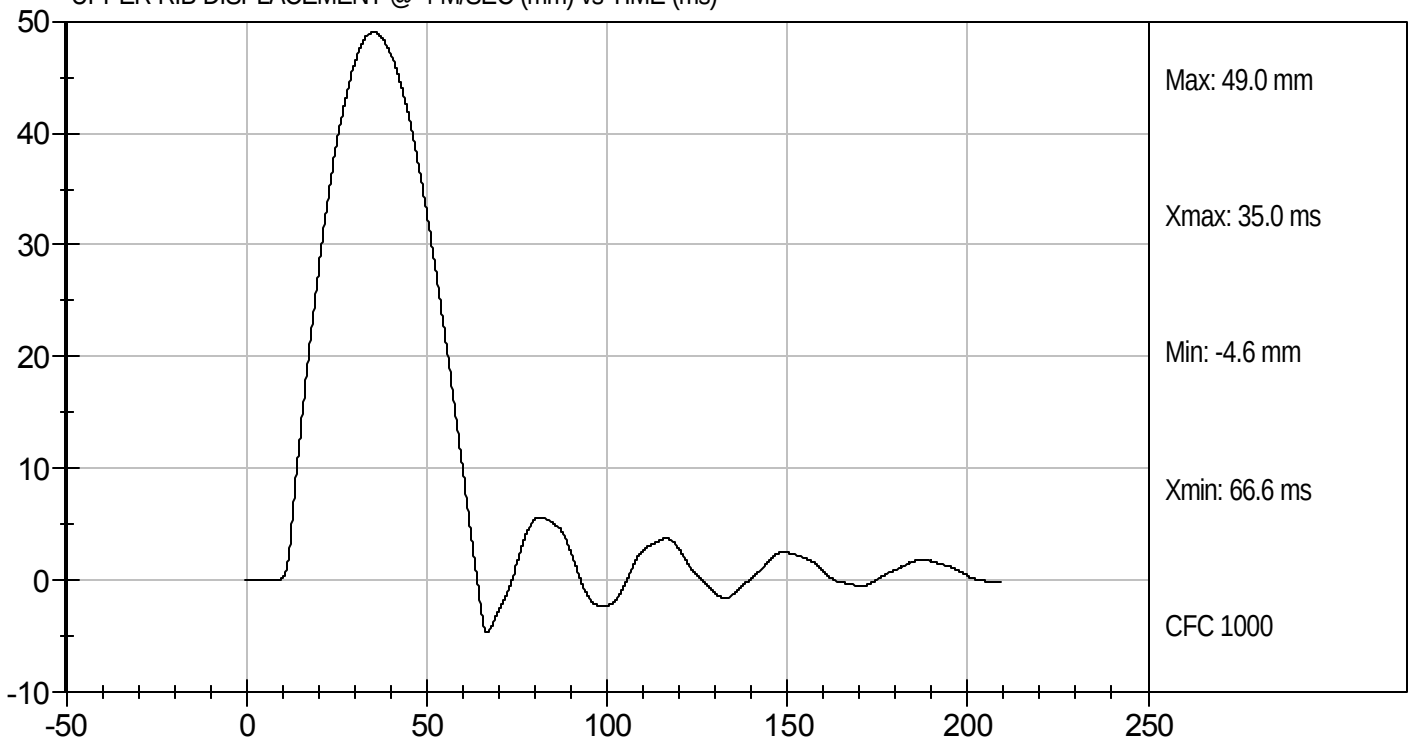
David Winkelbauer
Approved By

Test Desc: Rib Impact - Upper
Component ID: D111644
Test Date: 5/3/11

UPPER RIB DISPLACEMENT @ 3 M/SEC (mm) vs TIME (ms)



UPPER RIB DISPLACEMENT @ 4 M/SEC (mm) vs TIME (ms)



MGA RESEARCH CORPORATION

MID RIB TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111645

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	26	Pass
Displacement at 3 m/s	mm	36.0 to 40.0	38.1	Pass
Displacement at 4 m/s	mm	46.0 to 51.0	49.2	Pass
		Overall Test Results		Pass

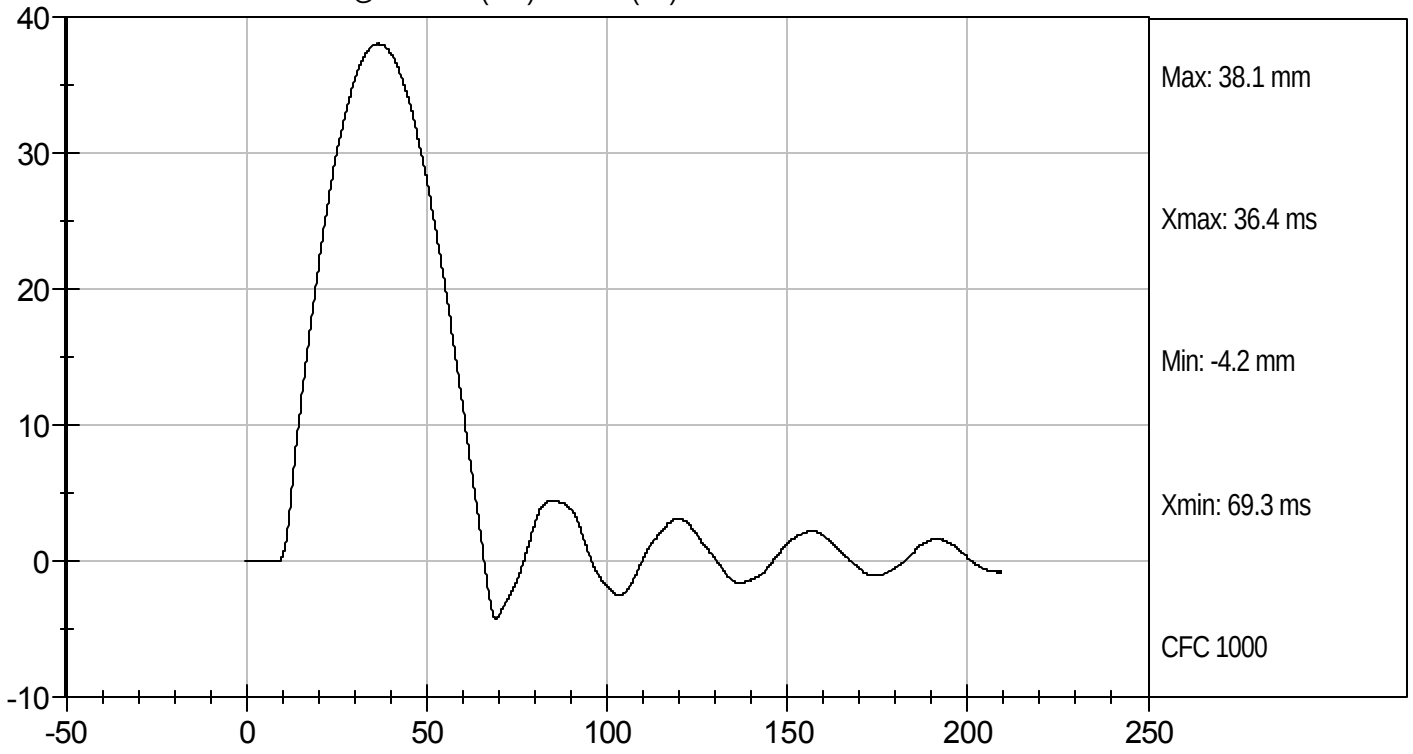
Jessica Hall
Laboratory Technician

5/3/11
Test Date

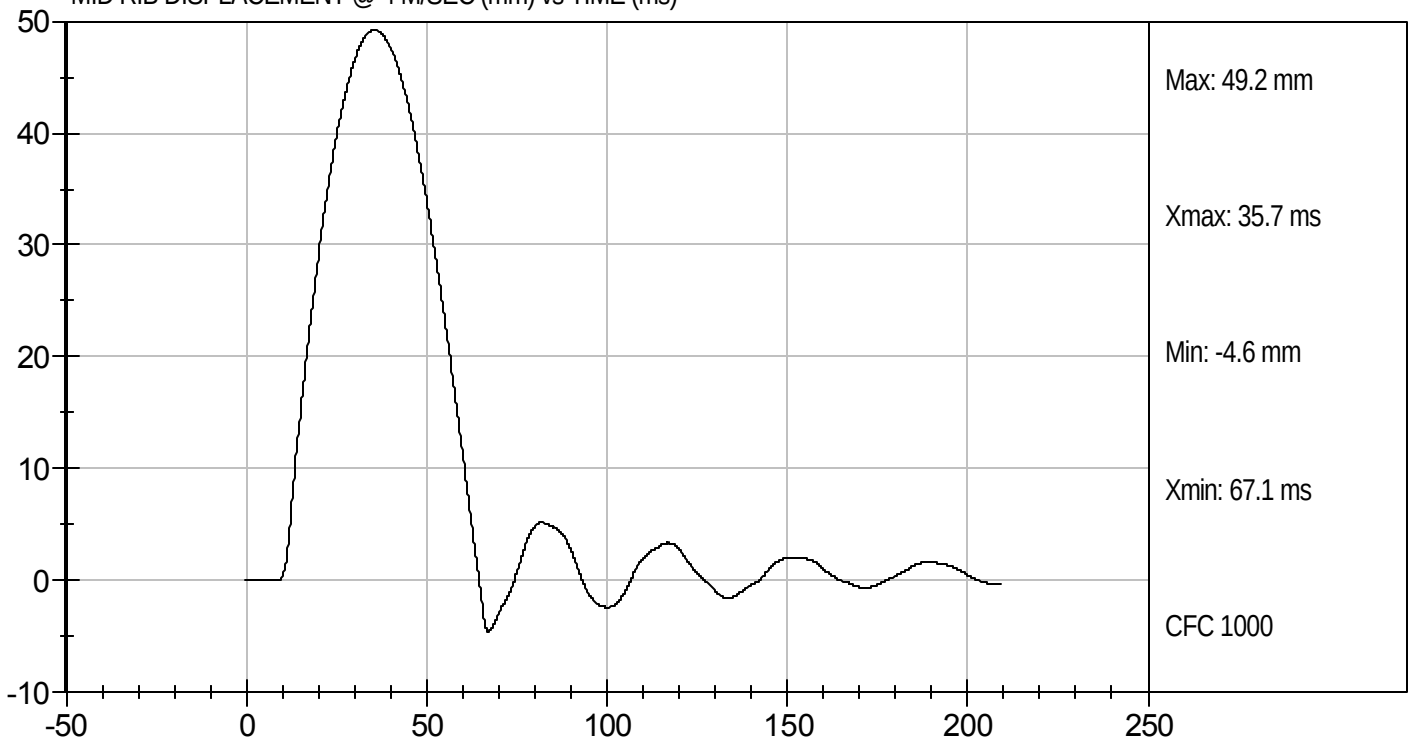
David Winkelbauer
Approved By

Test Desc: Rib Impact - Mid
Component ID: D111645
Test Date: 5/3/11

MID RIB DISPLACEMENT @ 3 M/SEC (mm) vs TIME (ms)



MID RIB DISPLACEMENT @ 4 M/SEC (mm) vs TIME (ms)



MGA RESEARCH CORPORATION

LOWER RIB TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111646

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	26	Pass
Displacement at 3 m/s	mm	36.0 to 40.0	39.0	Pass
Displacement at 4 m/s	mm	46.0 to 51.0	49.6	Pass
		Overall Test Results		Pass

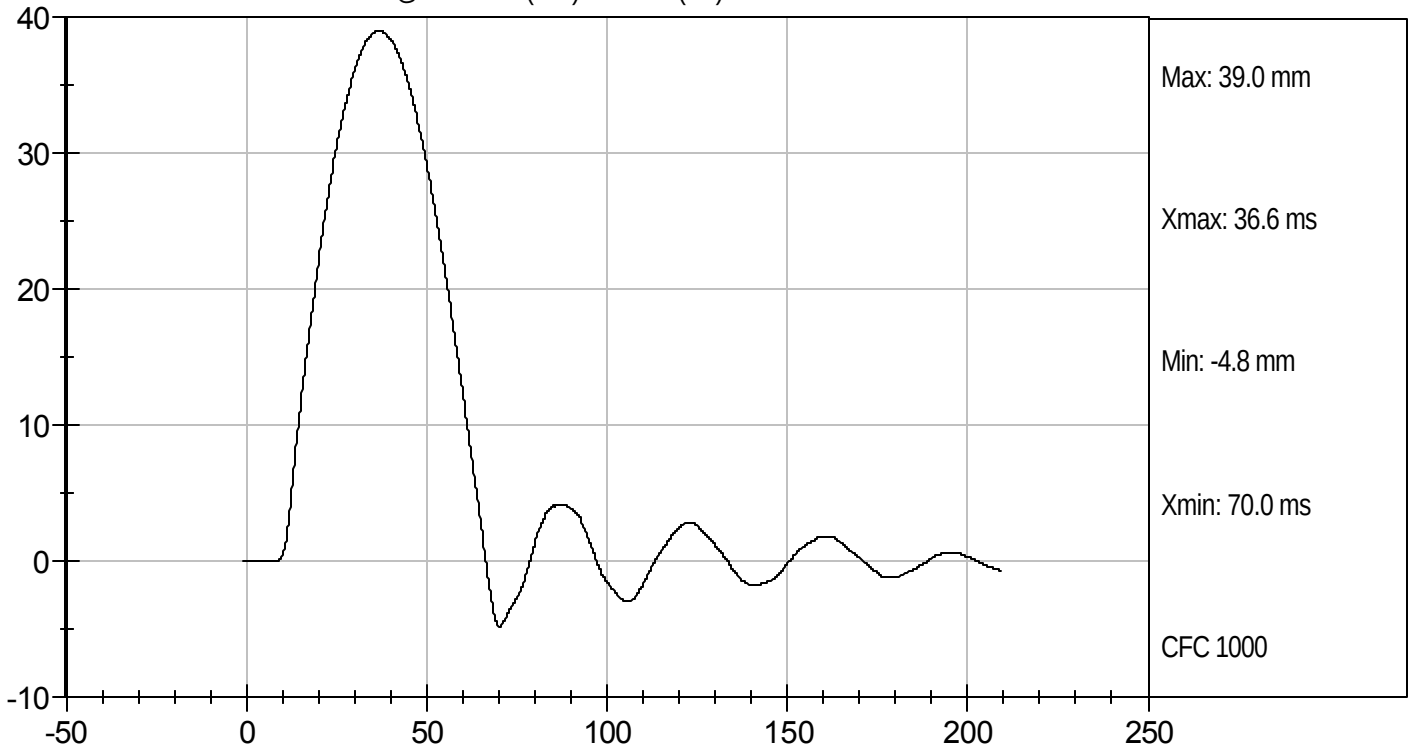
Jessica Hall
Laboratory Technician

5/3/11
Test Date

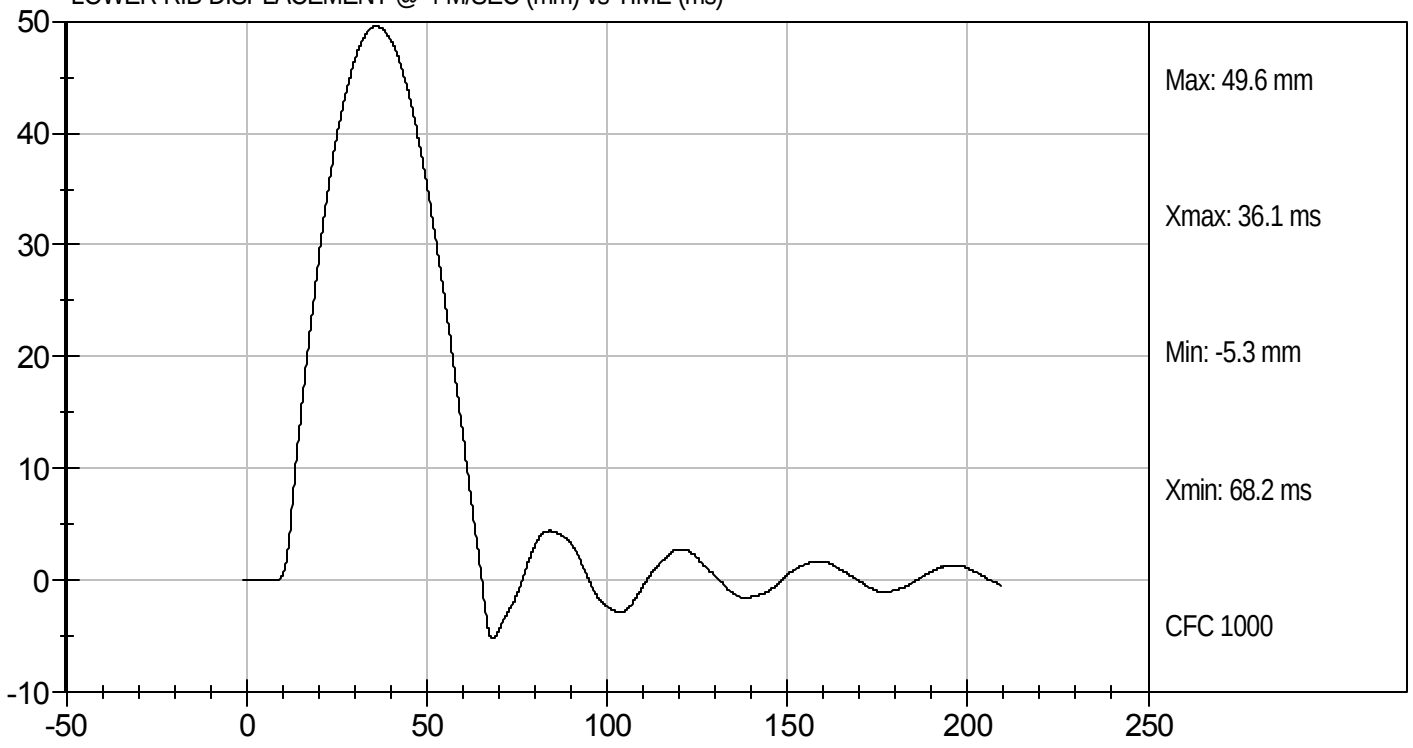
David Winkelbauer
Approved By

Test Desc: Rib Impact - Lower
Component ID: D111646
Test Date: 5/3/11

LOWER RIB DISPLACEMENT @ 3 M/SEC (mm) vs TIME (ms)



LOWER RIB DISPLACEMENT @ 4 M/SEC (mm) vs TIME (ms)



MGA RESEARCH CORPORATION

ABDOMEN TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111647

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	25	Pass
Probe Speed	m/s	3.90 to 4.10	4.06	Pass
Maximum Impact Force	kN	4.00 to 4.80	4.33	Pass
Time of Maximum Impactor Force	ms	10.60 to 13.00	11.30	Pass
Maximum Total Abdomen Force	kN	2.20 to 2.70	2.64	Pass
Time of Maximum Abdomen Force	ms	10.00 to 12.30	10.90	Pass
		Overall Test Results		Pass

Jessica Hall
Laboratory Technician

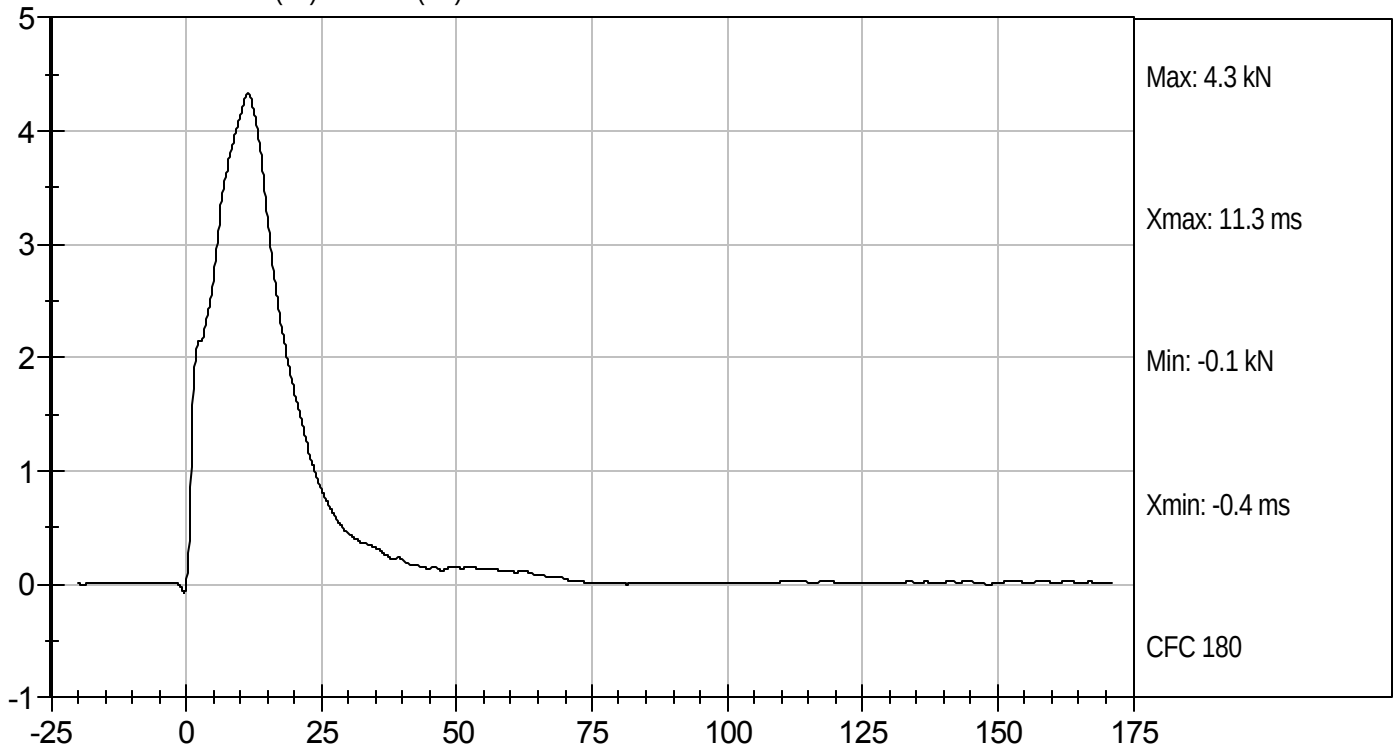
5/3/11
Test Date

David Winkelbauer
Approved By

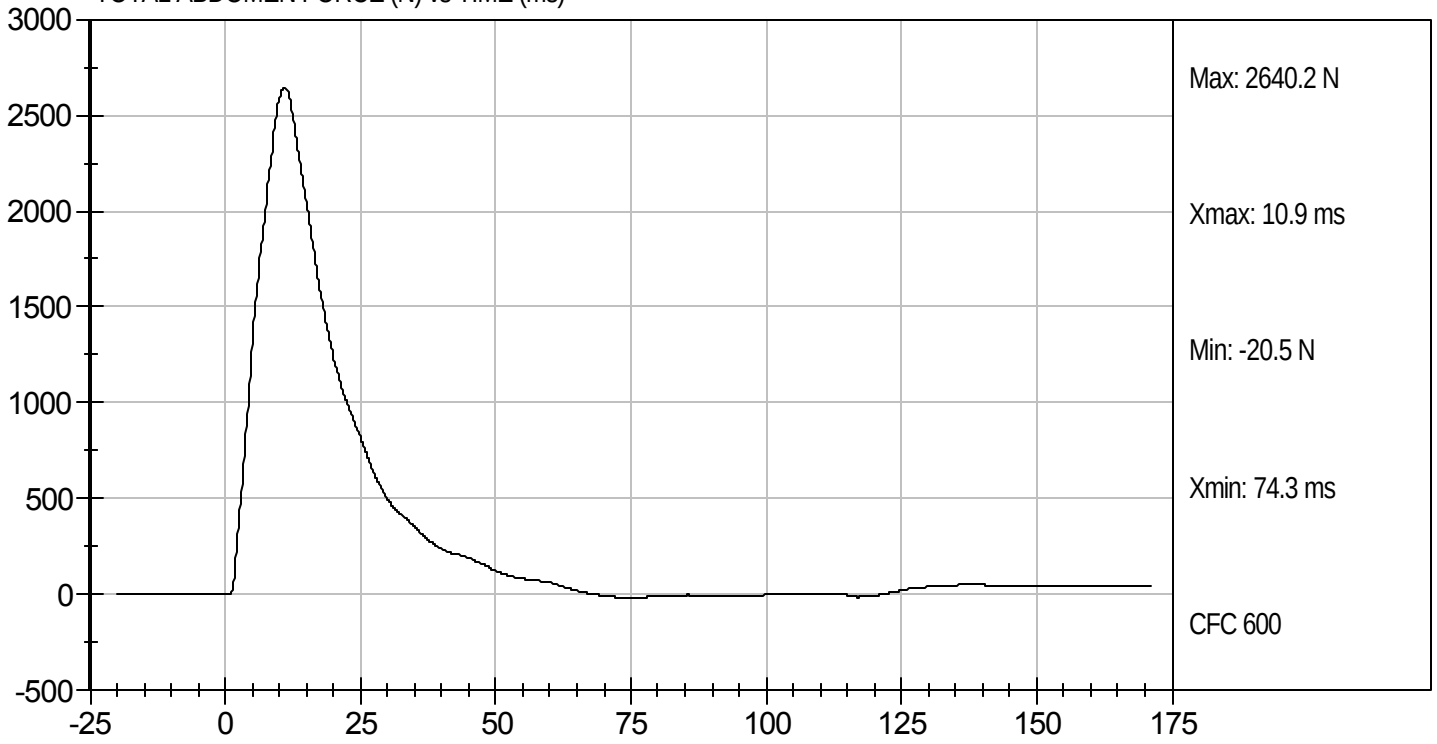
Test Desc: Abdomen Impact
Component ID: D111647

Test Date: 5/3/11
Velocity: 13.33 ft/s, 4.06 m/s

IMPACTOR FORCE (kN) vs TIME (ms)



TOTAL ABDOMEN FORCE (N) vs TIME (ms)



MGA RESEARCH CORPORATION

LUMBAR SPINE TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111648

Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	20.6 to 22.2	21.7	Pass
Laboratory Relative Humidity		%	10 to 70	25	Pass
Pendulum Speed		m/s	5.95 to 6.15	6.12	Pass
Pendulum Deceleration	1 ms	m/s	-0.05 to 0.00	-0.01	Pass
	3.7 ms	m/s	-0.425 to -0.24	-0.41	Pass
	27 ms	m/s	-6.50 to -5.80	-6.08	Pass
	30 ms	m/s	>= -6.5	-6.05	Pass
Maximum Flexion Angle		deg	45.0 to 55.0	45.4	Pass
Time of Maximum Flexion Angle		ms	39.0 to 53.0	45.4	Pass
Headform Rotation Decay to Initial Position		ms	37 to 57	43	Pass
			Overall Results		Pass

Jessica Hall
Laboratory Technician

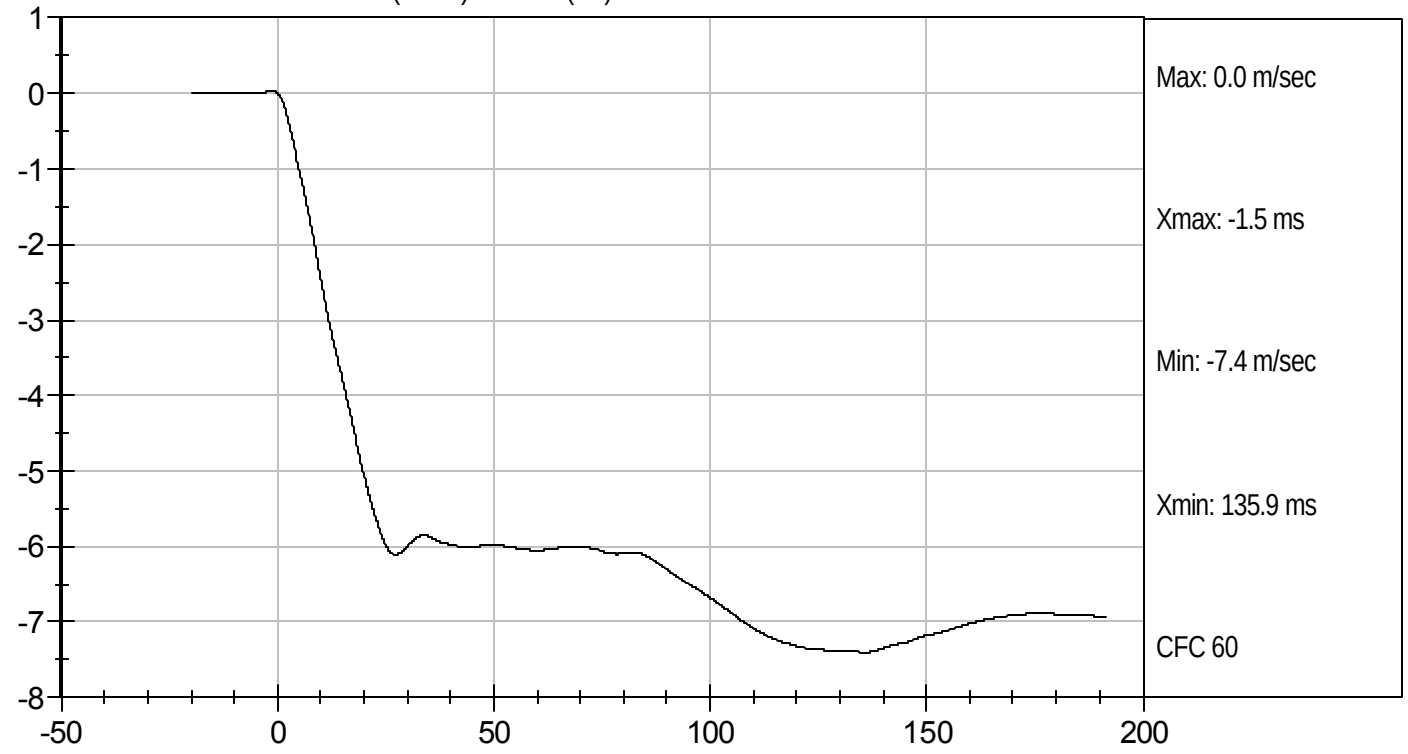
5/3/11
Test Date

David Winkelbauer
Approved By

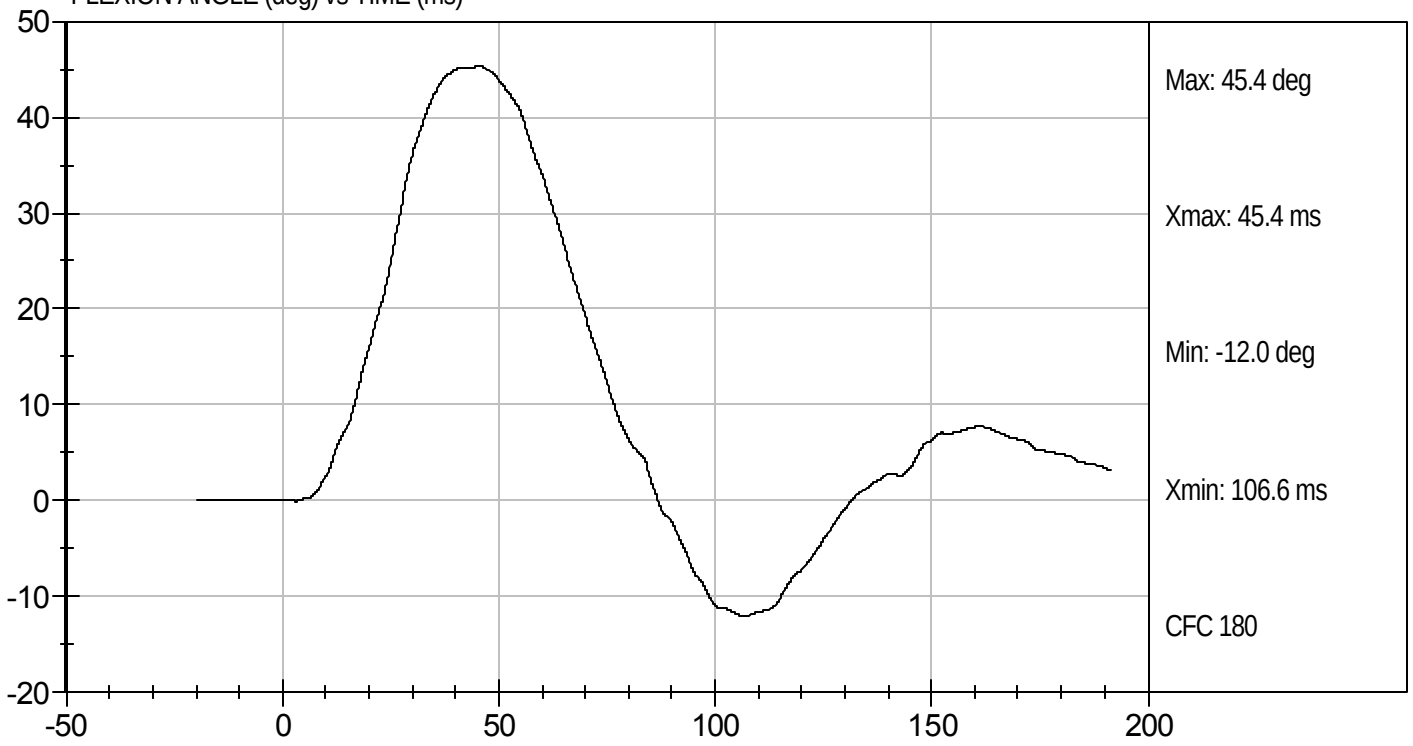
Test Desc: Lumbar Bending
Component ID: D111648

Test Date: 5/3/11
Velocity: 20.08 ft/s, 6.12 m/s

PENDULUM DECELERATION (m/sec) vs TIME (ms)

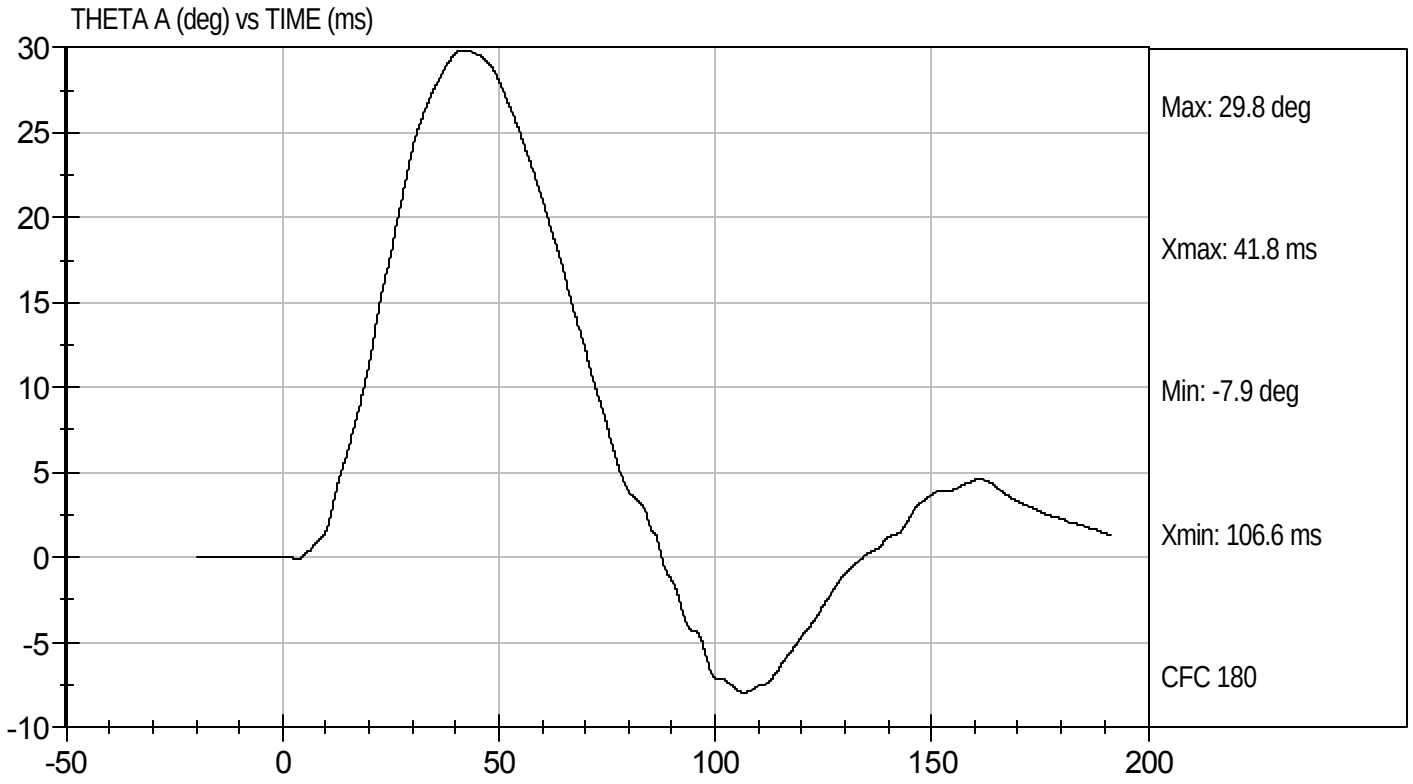


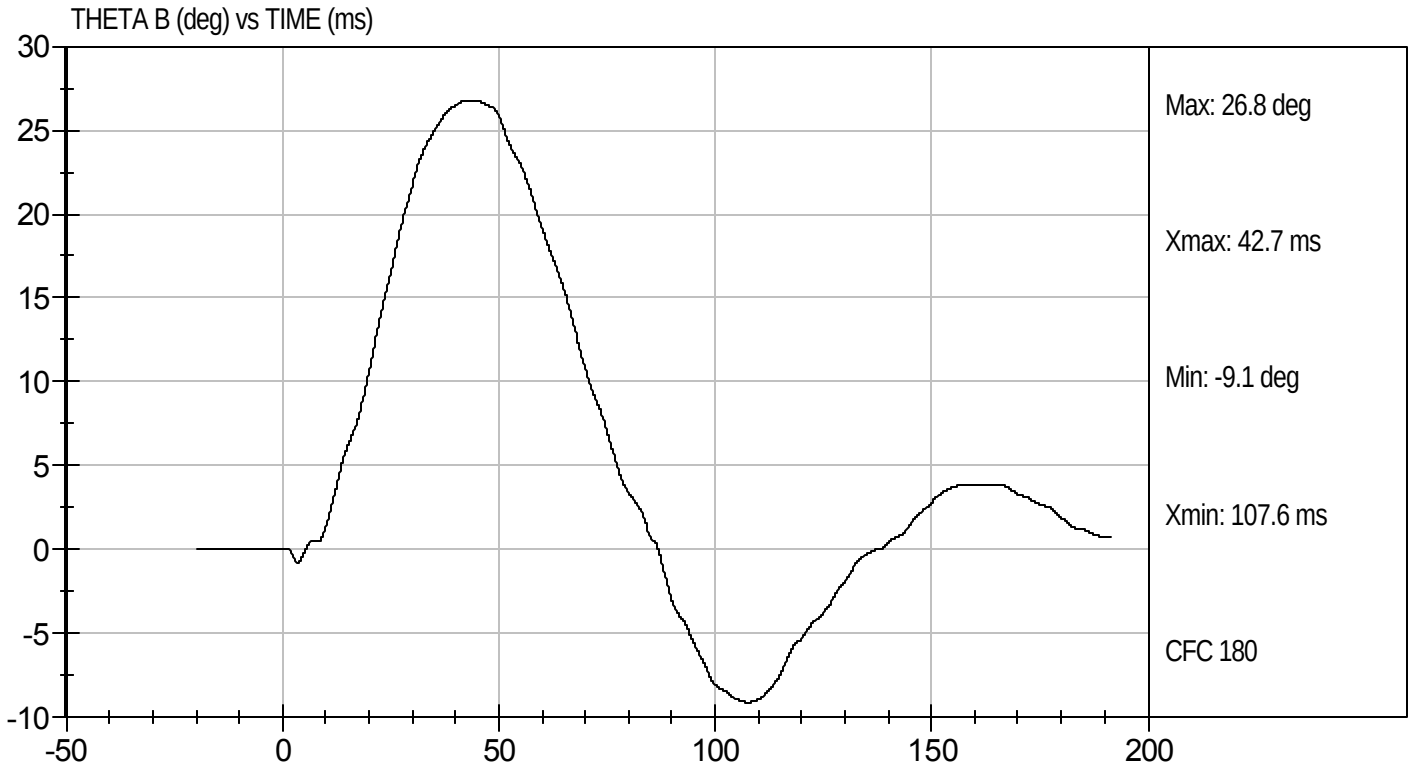
FLEXION ANGLE (deg) vs TIME (ms)



Test Desc: Lumbar Bending
Component ID: D111648

Test Date: 5/3/11
Velocity: 20.08 ft/s, 6.12 m/s





MGA RESEARCH CORPORATION

PELVIS TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111649

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	21.5	Pass
Laboratory Relative Humidity	%	10 to 70	25	Pass
Probe Speed	m/s	4.20 to 4.40	4.34	Pass
Maximum Impactor Force	kN	4.70 to 5.40	4.79	Pass
Time of Maximum Impactor Force	ms	11.80 to 16.10	13.90	Pass
Maximum Pubic Force	kN	1.23 to 1.59	1.39	Pass
Time of Maximum Pubic Force	ms	12.20 to 17.00	15.90	Pass
		Overall Test Results		Pass

Jessica Hall
Laboratory Technician

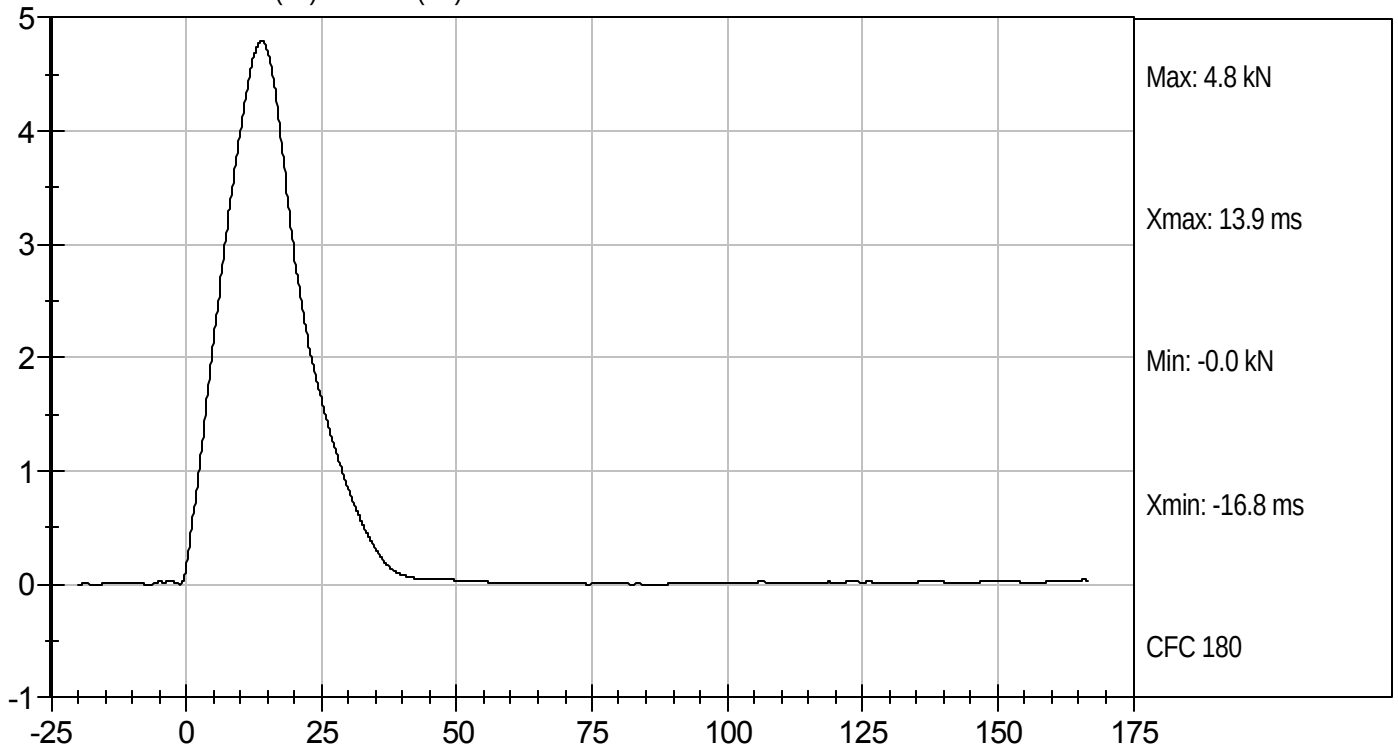
5/3/11
Test Date

David Winkelbauer
Approved By

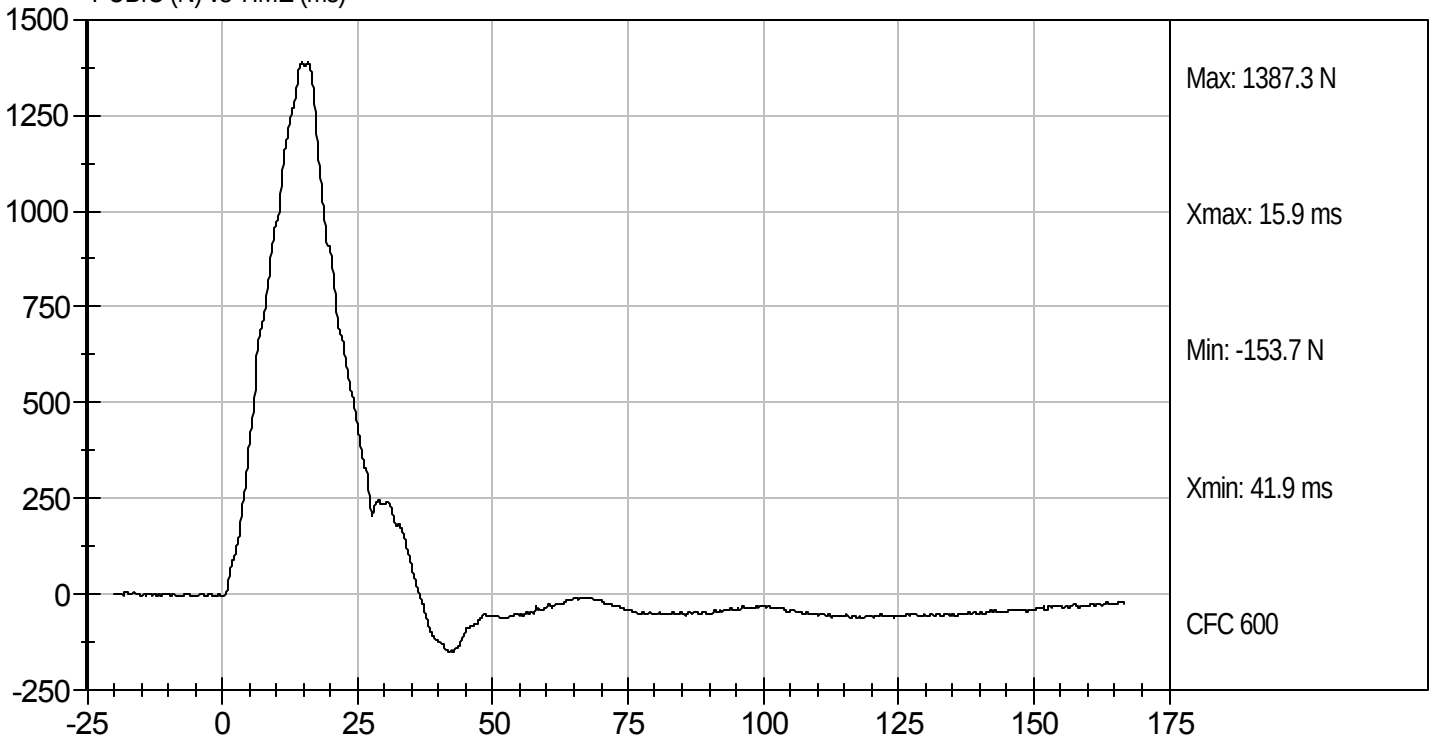
Test Desc: Pelvis Impact
Component ID: D111649

Test Date: 5/3/11
Velocity: 14.25 ft/s, 4.34 m/s

IMPACTOR FORCE (kN) vs TIME (ms)



PUBIC (N) vs TIME (ms)



MGA RESEARCH CORPORATION

FULL BODY THORAX IMPACT TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111640

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.6	Pass
Humidity	%	10 to 70	25	Pass
Probe Speed	m/s	5.40 to 5.60	5.58	Pass
Maximum Impactor Force (after 6 ms)	kN	5.10 to 6.20	5.10	Pass
Upper Rib Displacement	mm	34.0 to 41.0	38.7	Pass
Middle Rib Displacement	mm	37.0 to 45.0	41.2	Pass
Lower Rib Displacement	mm	37.0 to 44.0	40.9	Pass
		Overall Test Results		Pass

Jessica Gall
Laboratory Technician

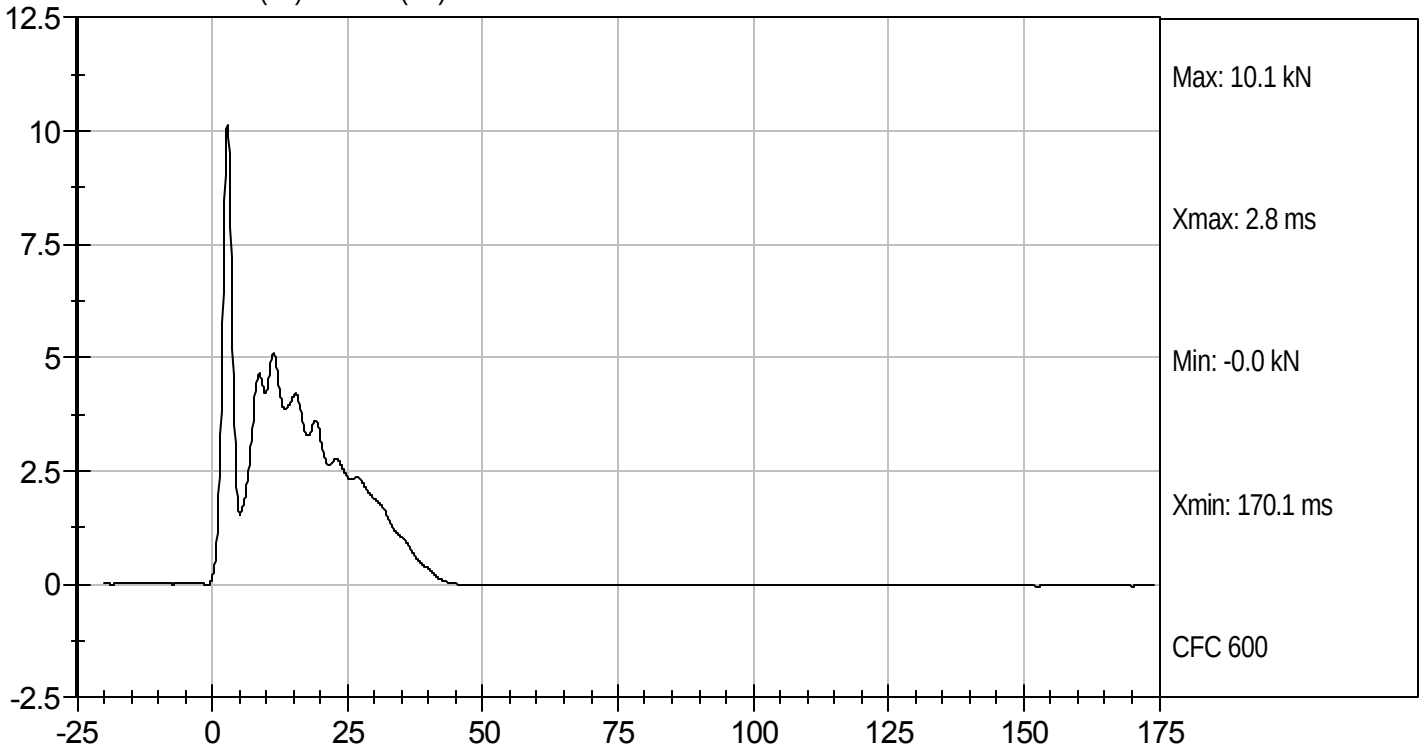
5/3/11
Test Date

David Winkelbauer
Approved By

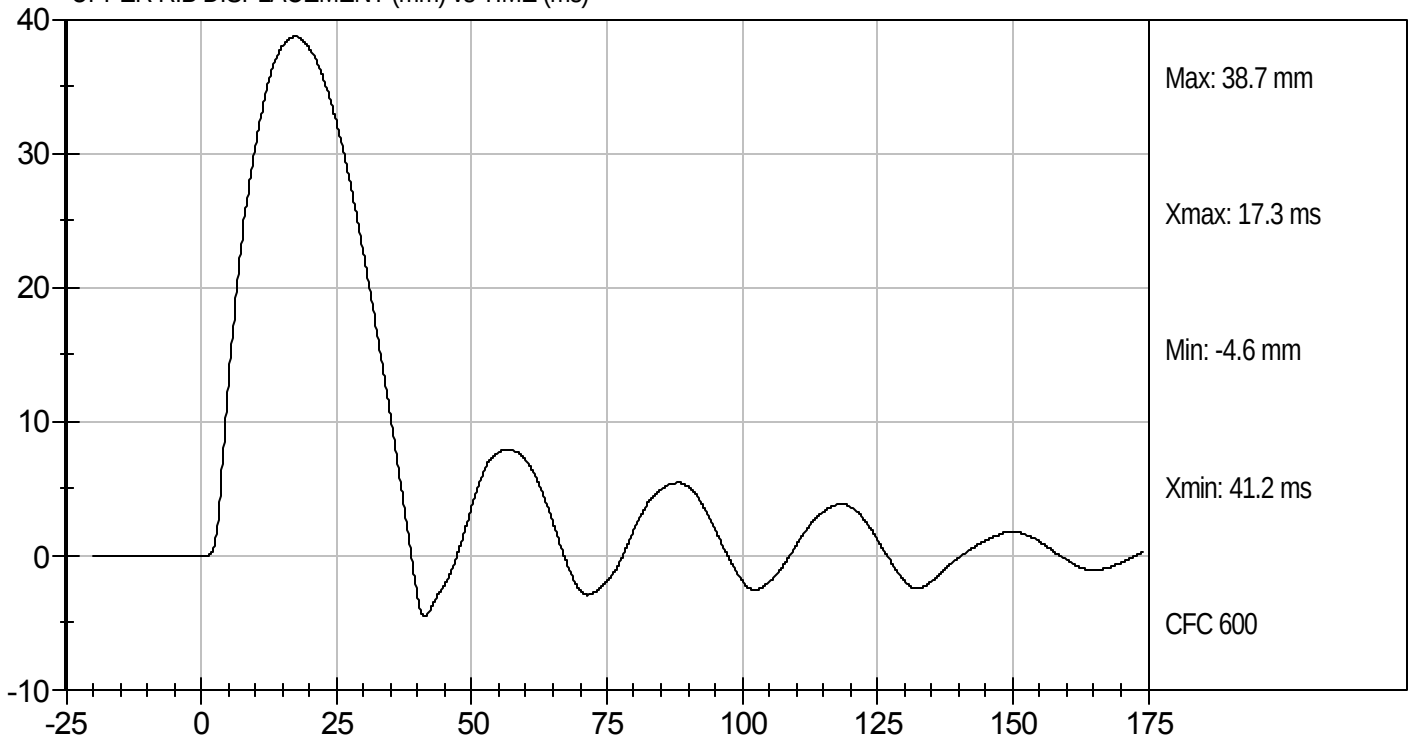
Test Desc: Thorax Impact
Component ID: D111640

Test Date: 5/3/11
Velocity: 18.32 ft/s, 5.58 m/s

PROBE FORCE (kN) vs TIME (ms)



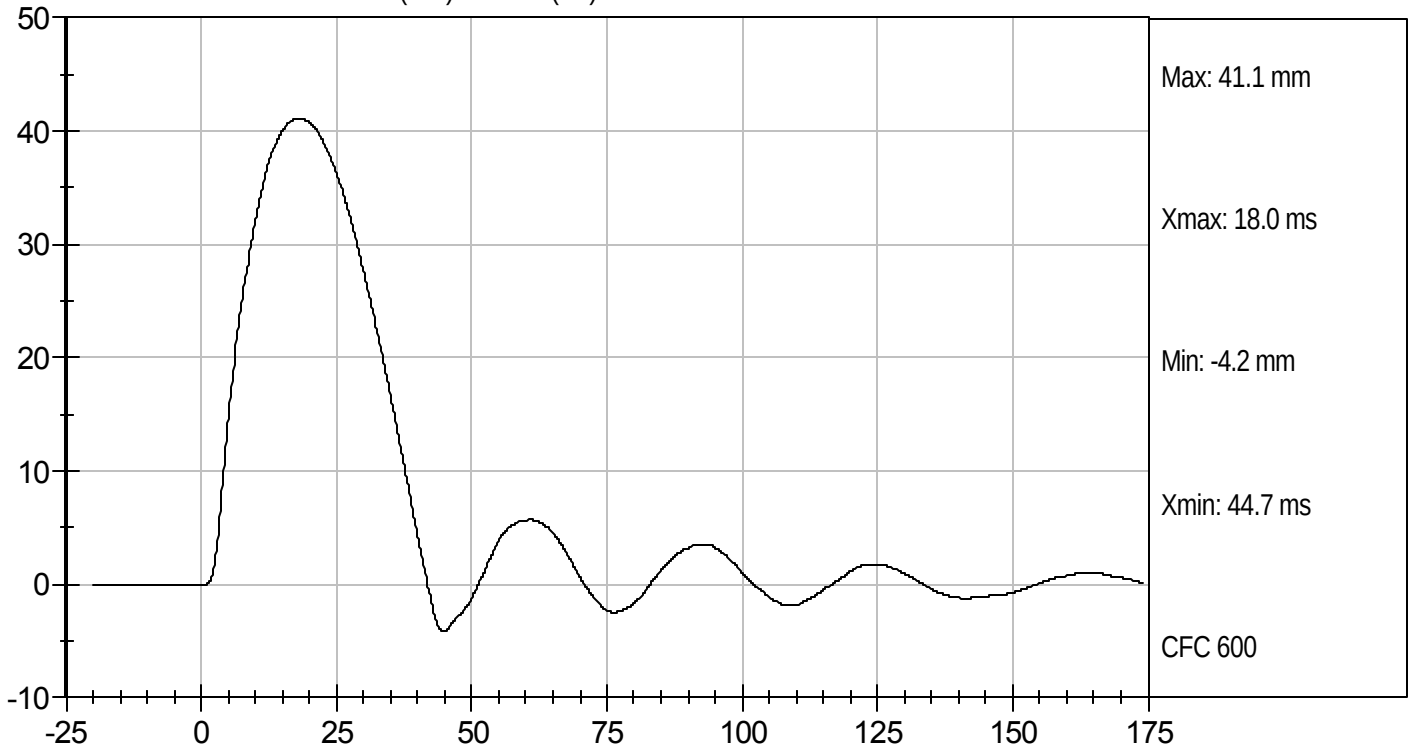
UPPER RIB DISPLACEMENT (mm) vs TIME (ms)



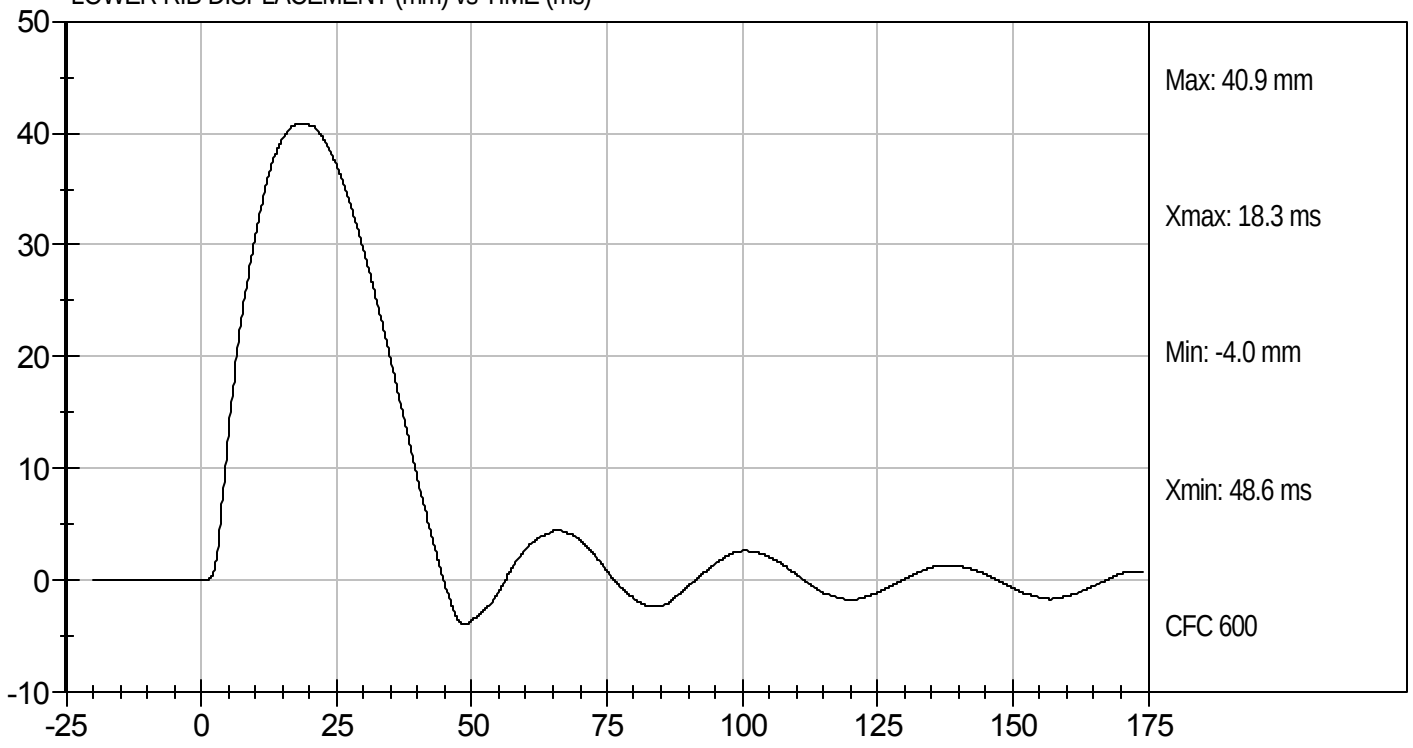
Test Desc: Thorax Impact
Component ID: D111640

Test Date: 5/3/11
Velocity: 18.32 ft/s, 5.58 m/s

MIDDLE RIB DISPLACEMENT (mm) vs TIME (ms)



LOWER RIB DISPLACEMENT (mm) vs TIME (ms)



MGA RESEARCH CORPORATION

HEAD DROP TEST

ES-2re DUMMY

ATD Serial No: 016 **Test ID:** D111671

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	18.9 to 25.6	22.1	Pass
Laboratory Relative Humidity	%	10 to 70	32	Pass
Peak Resultant Acceleration	G's	125 to 155	146	Pass
Peak Lateral Acceleration	G's	+/- 15	-10.7	Pass
Unimodal	N/A	Yes	Yes	Pass
Oscillations	N/A	within 15% of peak	Yes	Pass
		Overall Test Results		Pass

Jessica Hall
Laboratory Technician

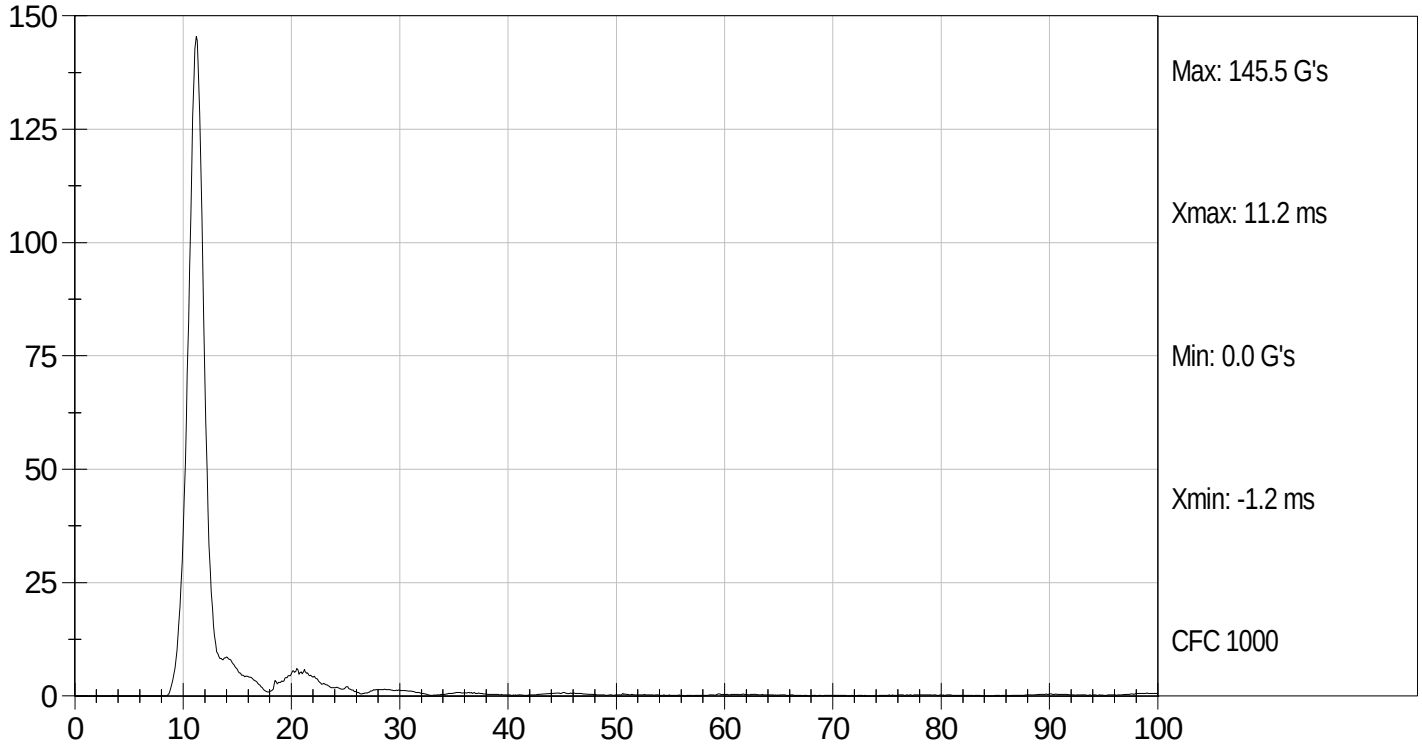
5/5/11
Test Date

David Winkelbauer
Approved By

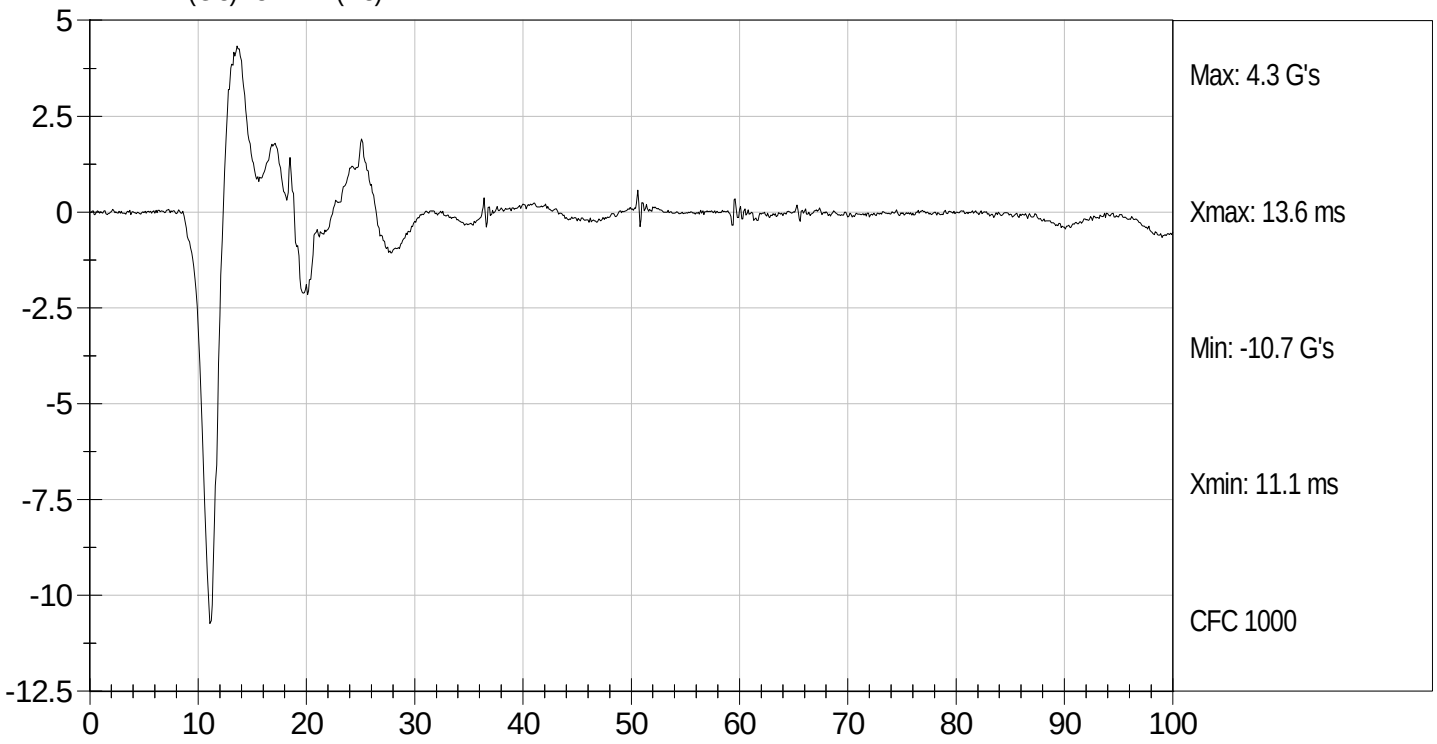
Test Desc: Head Drop
Component ID: D111671

Test Date: 5/5/11
Velocity: 0 ft/s, 0 m/s

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



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



MGA RESEARCH CORPORATION

NECK PENDULUM TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111672

Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	18.0 to 22.0	22.0	Pass
Laboratory Relative Humidity		%	10 to 70	31	Pass
Pendulum Speed		m/s	3.3 to 3.5	3.5	Pass
Pendulum Deceleration	1 ms	m/s	0.00 to -0.05	-0.03	Pass
	3 ms	m/s	-0.25 to -0.375	-0.34	Pass
	14 ms	m/s	-3.20 to -3.70	-3.32	Pass
Maximum Flexion Angle		deg	49.0 to 59.0	51.4	Pass
Time of Maximum Flexion Angle		ms	54.0 to 66.0	60.6	Pass
Head Rotation Decay Time to 0 degree		ms	53.0 to 88.0	59.8	Pass
			Overall Test Results		Pass

Jessica Hall
Laboratory Technician

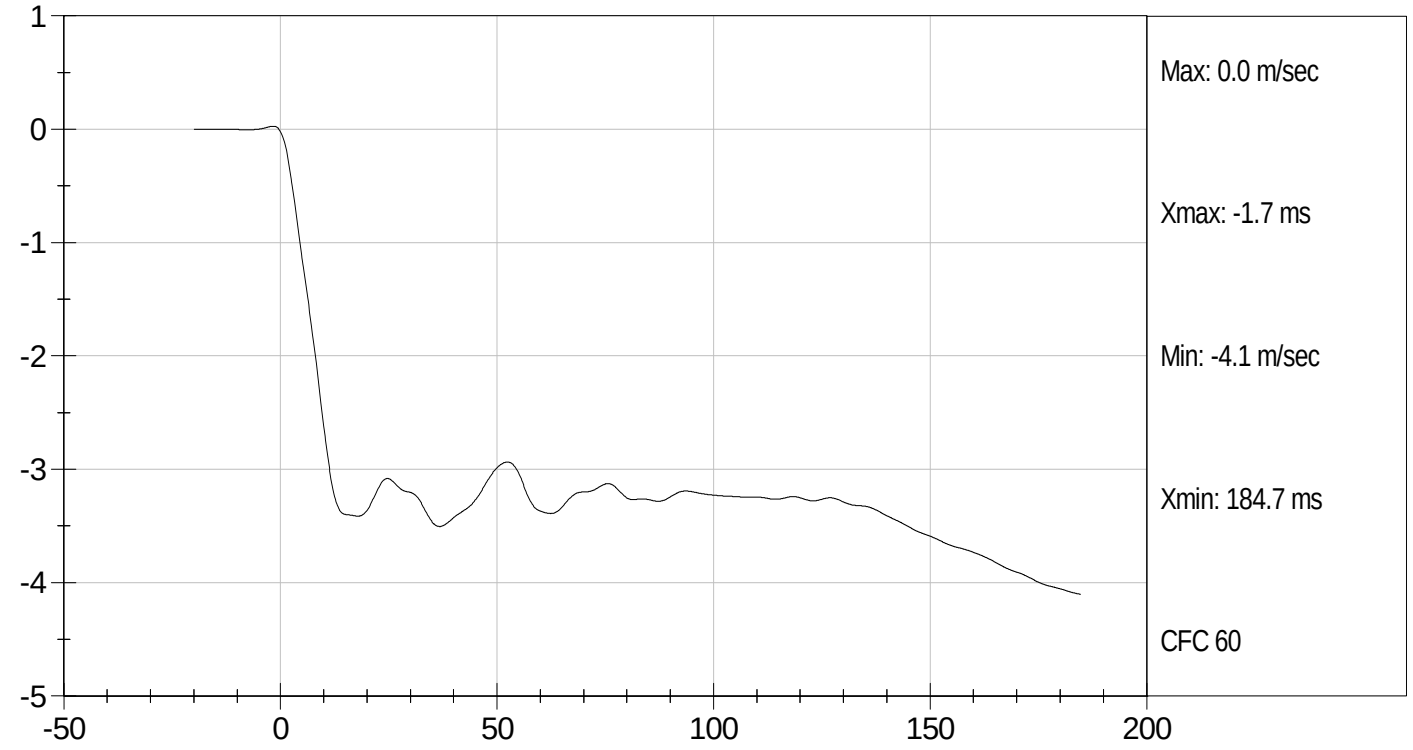
5/5/11
Test Date

David Winkelbauer
Approved By

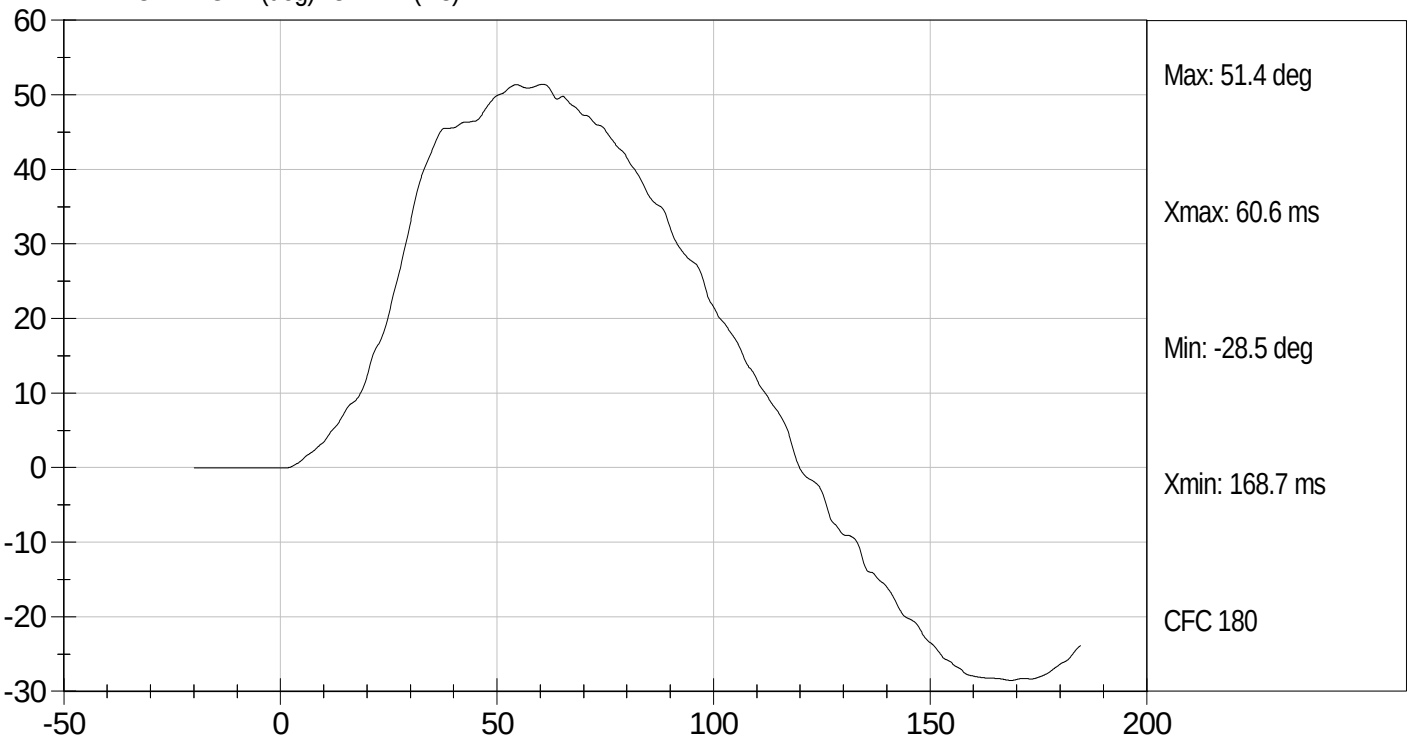
Test Desc: Neck Bending
Component ID: D111672

Test Date: 5/5/11
Velocity: 11.42 ft/s, 3.5 m/s

PENDULUM DECELERATION (m/sec) vs TIME (ms)



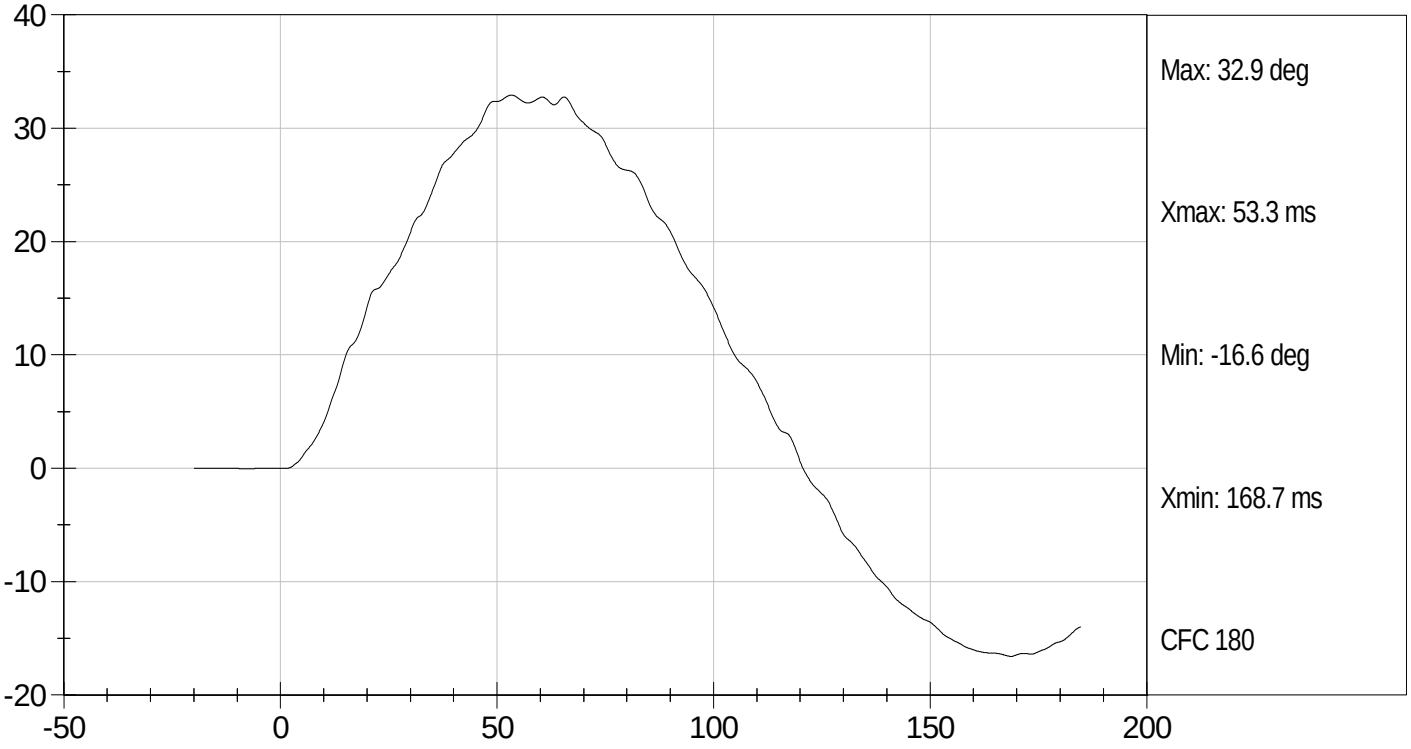
FLEXION ANGLE (deg) vs TIME (ms)



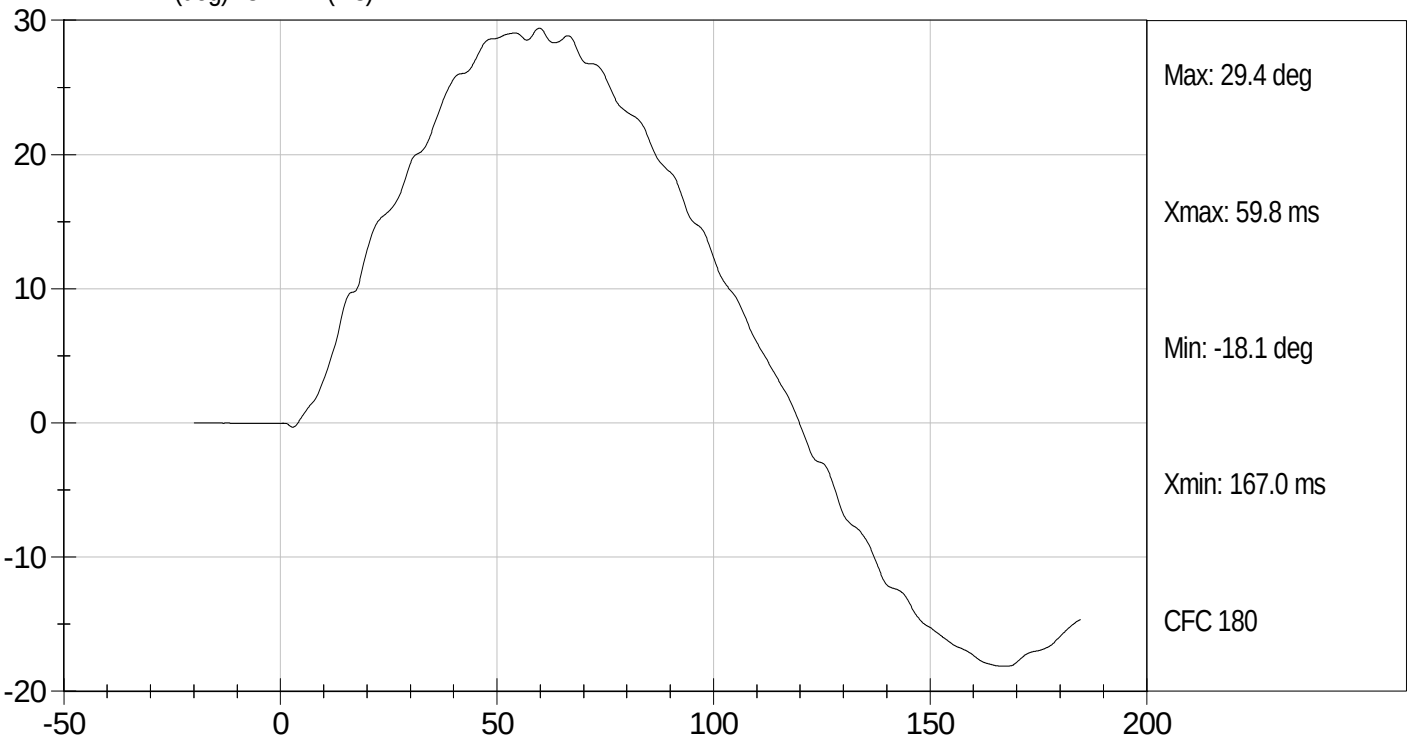
Test Desc: Neck Bending
Component ID: D111672

Test Date: 5/5/11
Velocity: 11.42 ft/s, 3.5 m/s

THETA A (deg) vs TIME (ms)



THETA B (deg) vs TIME (ms)



MGA RESEARCH CORPORATION

SHOULDER IMPACT TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111673

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	21.9	Pass
Laboratory Relative Humidity	%	10 to 70	37	Pass
Pendulum Speed	m/s	4.2 to 4.4	4.3	Pass
Peak Shoulder Acceleration	G's	7.5 to 10.5	8.7	Pass
Time of Peak Shoulder Acceleration	ms	NA	18.4	Pass
		Overall Test Results		Pass

Jessica Gall
Laboratory Technician

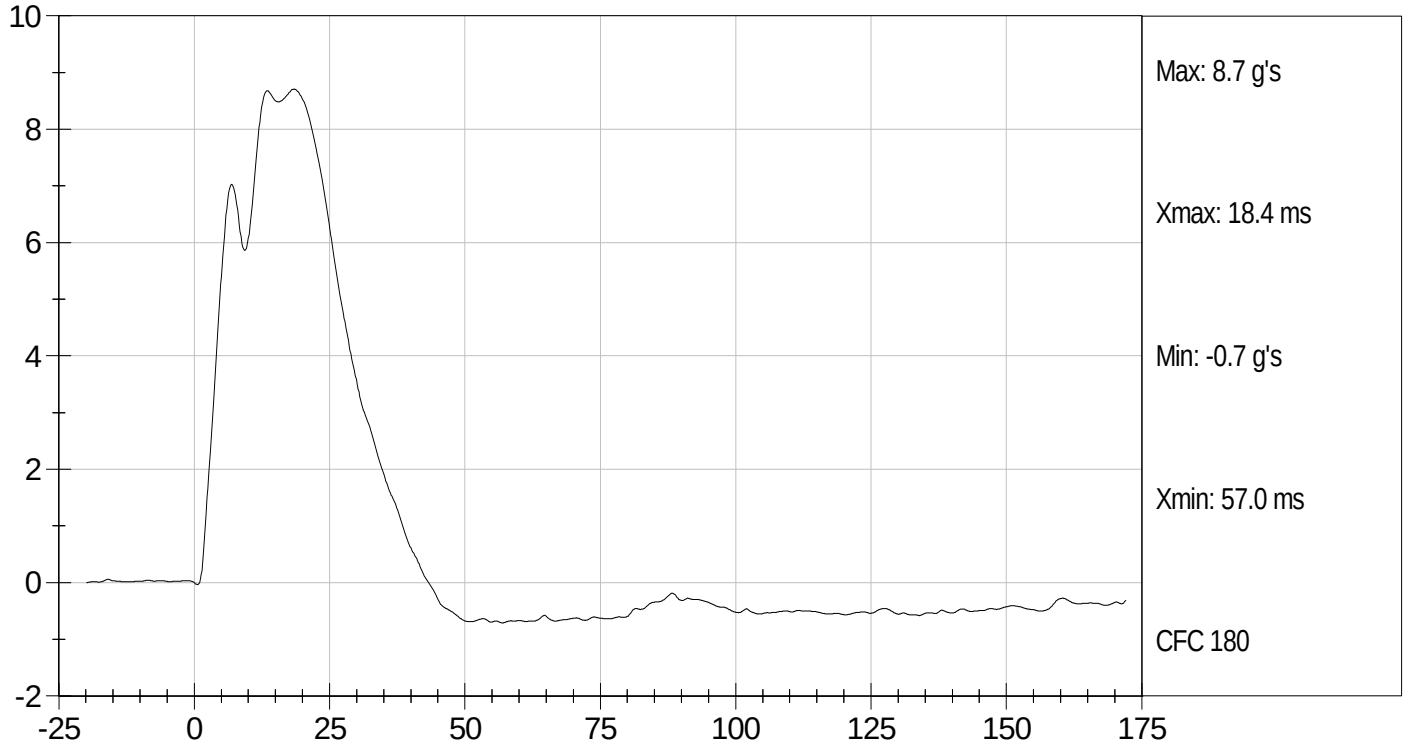
5/5/11
Test Date

David Winkelbauer
Approved By

Test Desc: Shoulder Impact
Component ID: D111673

Test Date: 5/5/11
Velocity: 14.24 ft/s, 4.3 m/s

SHOULDER ACCELERATION (g's) vs TIME (ms)



MGA RESEARCH CORPORATION

UPPER RIB TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111674

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	22.0	Pass
Laboratory Relative Humidity	%	10 to 70	30	Pass
Displacement at 3 m/s	mm	36.0 to 40.0	38.9	Pass
Displacement at 4 m/s	mm	46.0 to 51.0	48.8	Pass
		Overall Test Results		Pass

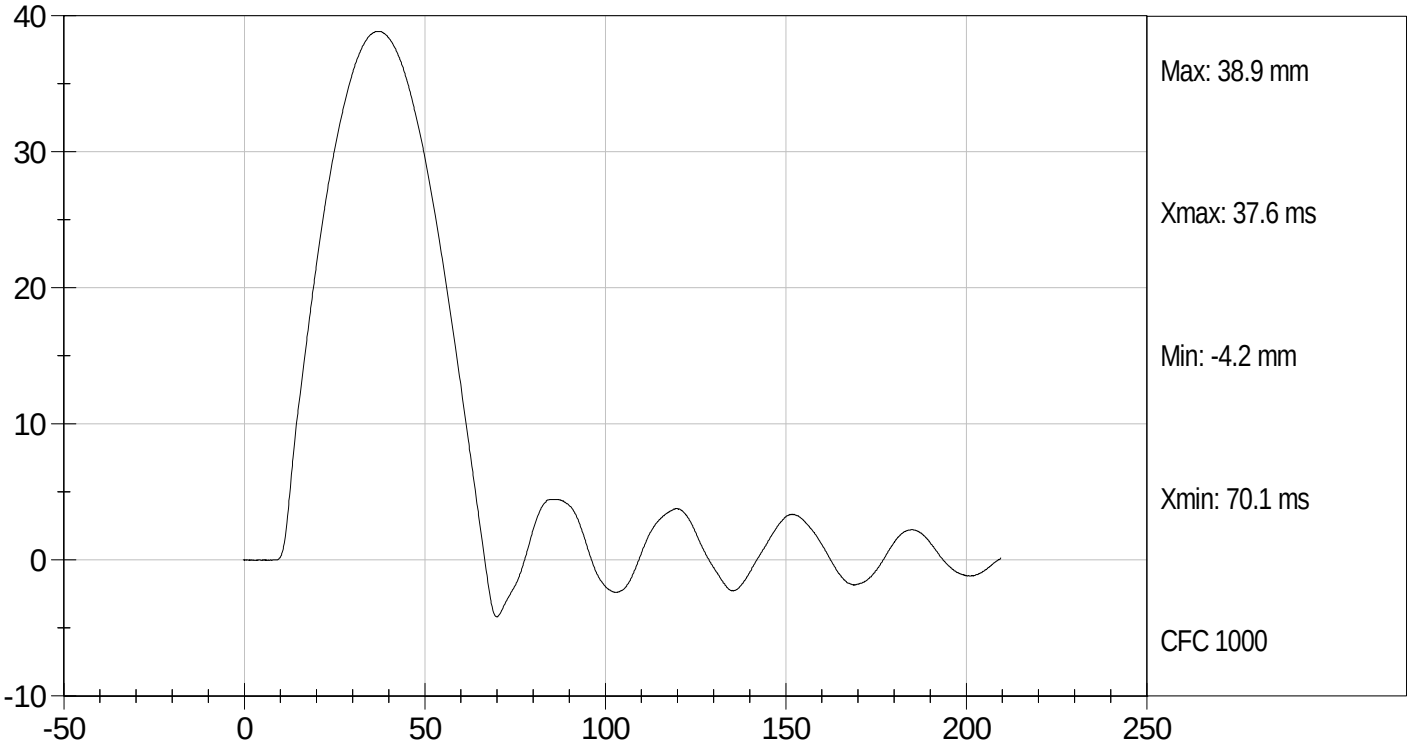
Jessica Hall
Laboratory Technician

5/5/11
Test Date

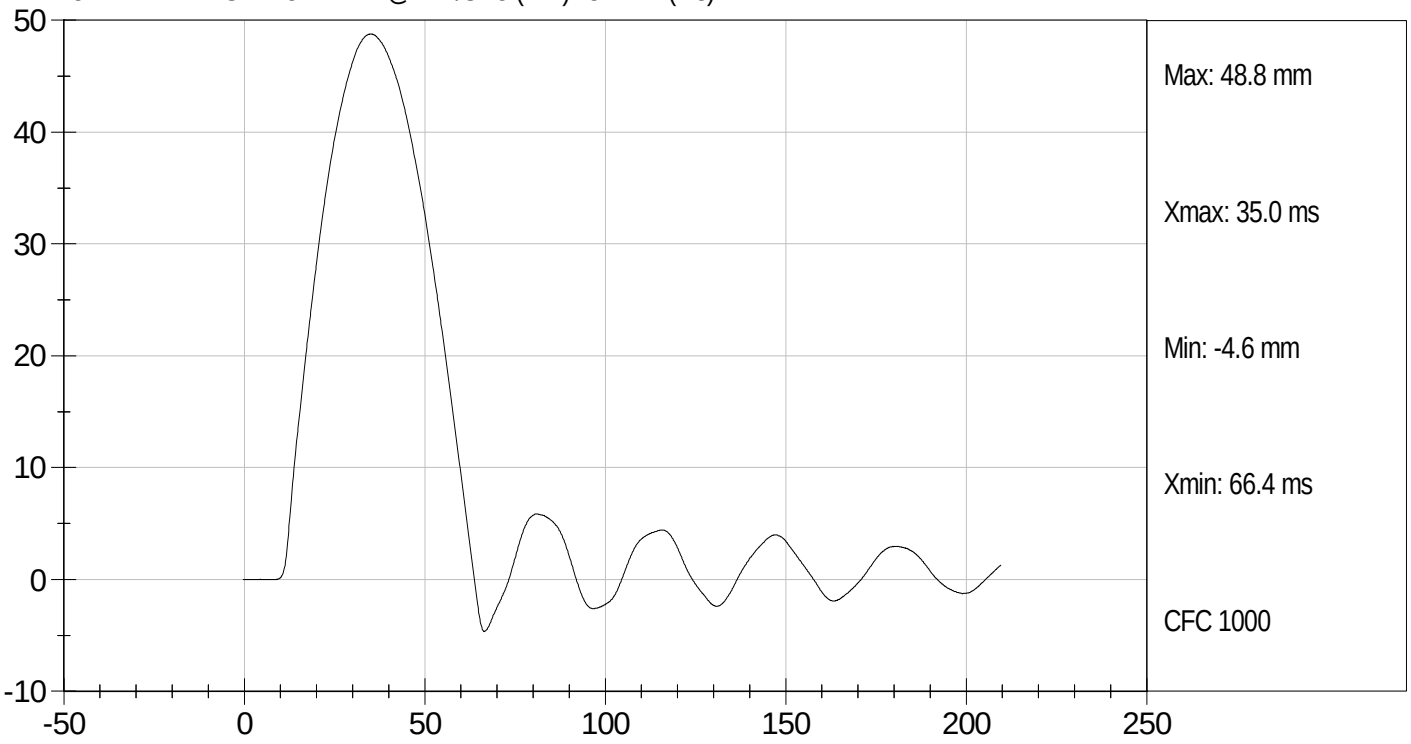
David Winkelbauer
Approved By

Test Desc: Rib Impact - Upper
Component ID: D111674
Test Date: 5/5/11

UPPER RIB DISPLACEMENT @ 3 M/SEC (mm) vs TIME (ms)



UPPER RIB DISPLACEMENT @ 4 M/SEC (mm) vs TIME (ms)



MGA RESEARCH CORPORATION

MID RIB TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111675

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	22.0	Pass
Laboratory Relative Humidity	%	10 to 70	30	Pass
Displacement at 3 m/s	mm	36.0 to 40.0	38.1	Pass
Displacement at 4 m/s	mm	46.0 to 51.0	47.1	Pass
		Overall Test Results		Pass

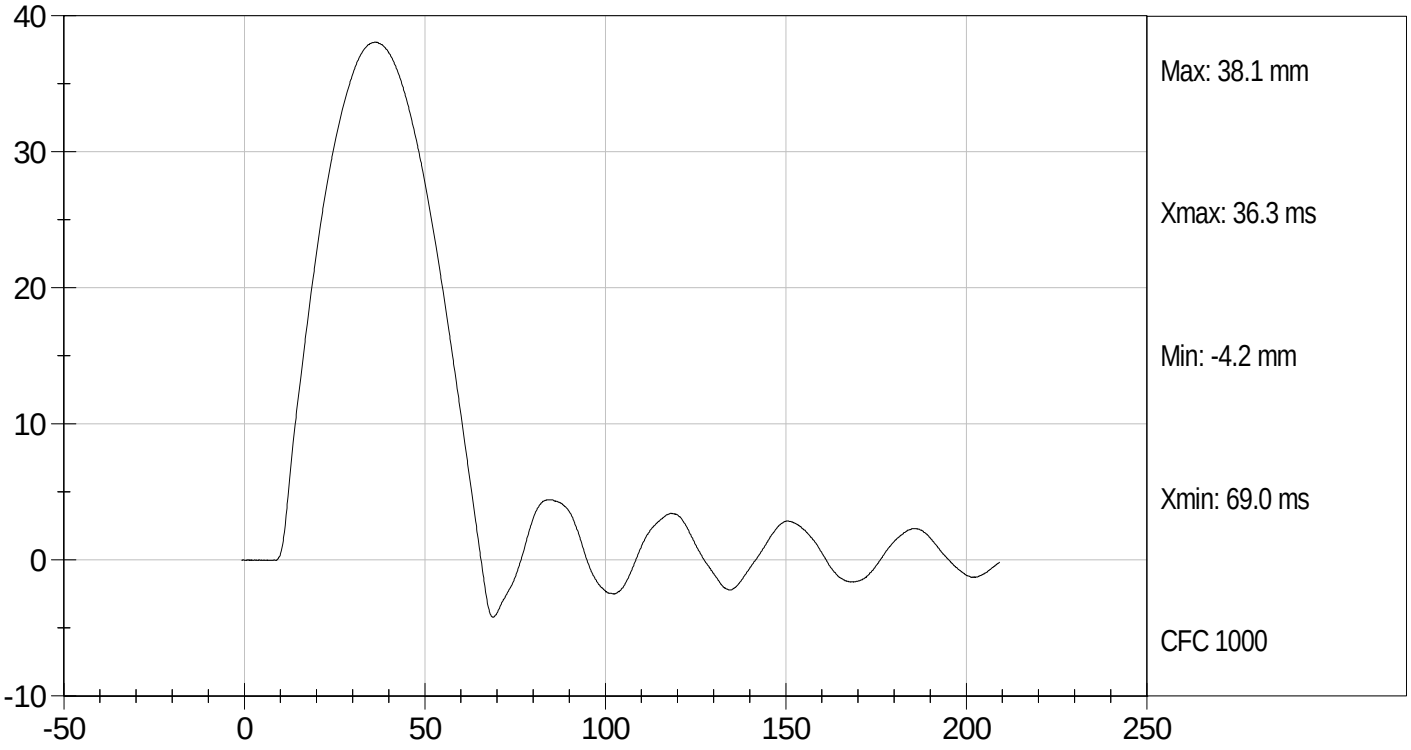
Jessica Gall
Laboratory Technician

5/5/11
Test Date

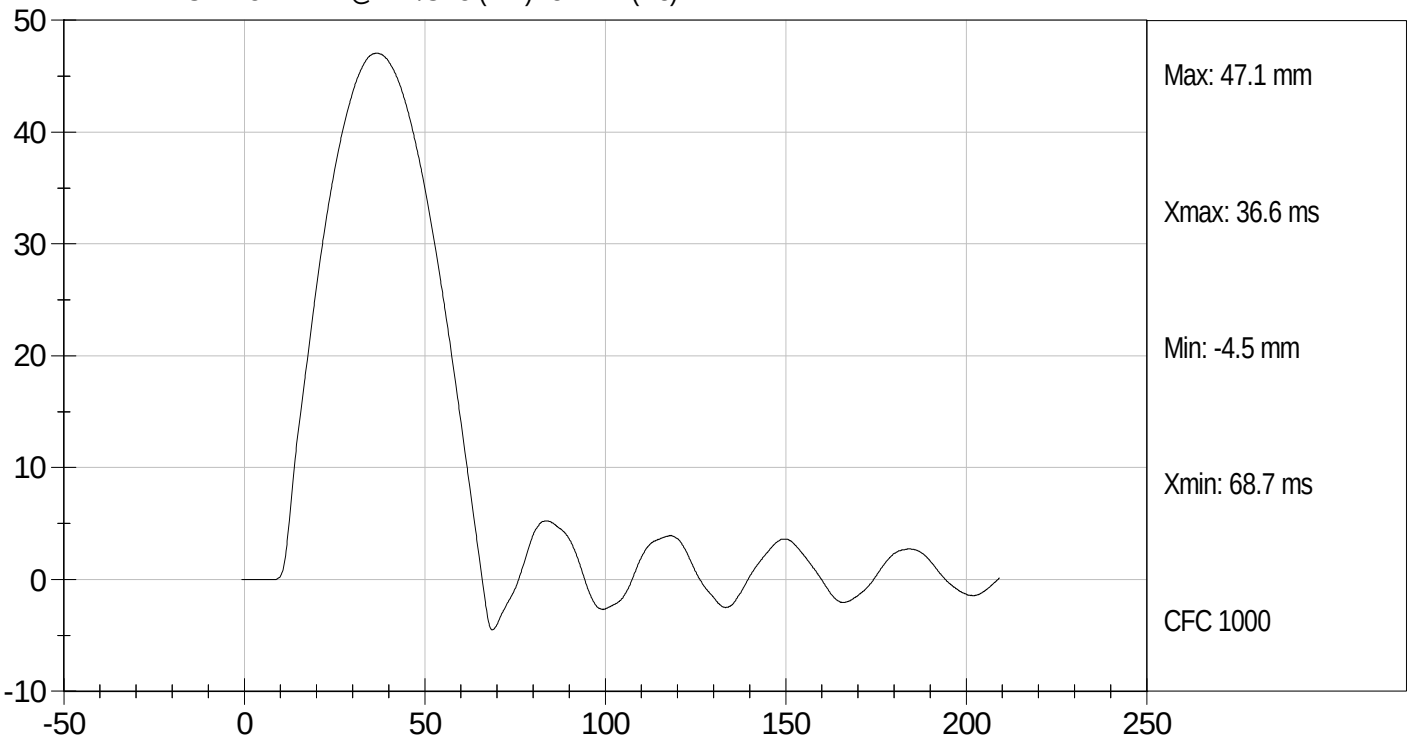
David Winkelbauer
Approved By

Test Desc: Rib Impact - Mid
Component ID: D111675
Test Date: 5/5/11

MID RIB DISPLACEMENT @ 3 M/SEC (mm) vs TIME (ms)



MID RIB DISPLACEMENT @ 4 M/SEC (mm) vs TIME (ms)



MGA RESEARCH CORPORATION

LOWER RIB TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111676

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	22.0	Pass
Laboratory Relative Humidity	%	10 to 70	30	Pass
Displacement at 3 m/s	mm	36.0 to 40.0	39.3	Pass
Displacement at 4 m/s	mm	46.0 to 51.0	49.6	Pass
		Overall Test Results		Pass

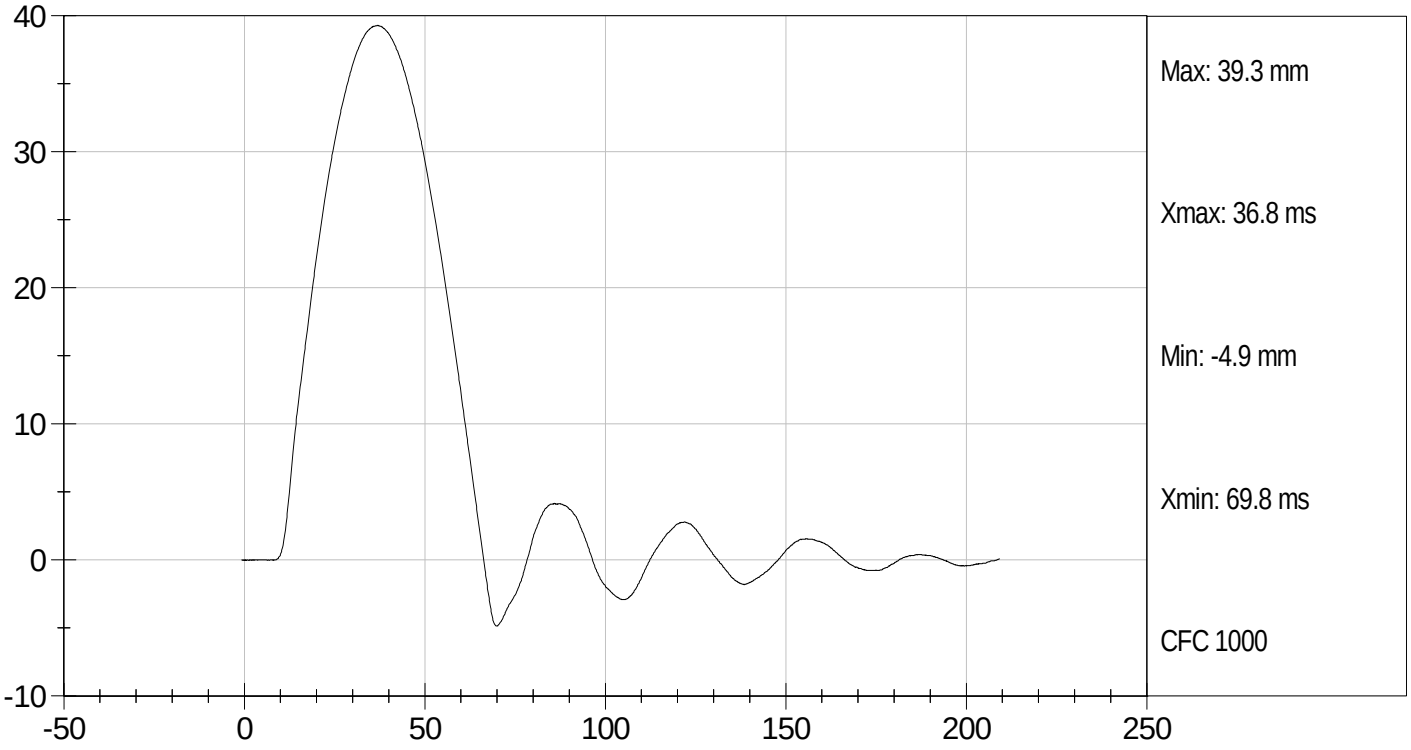
Jessica Hall
Laboratory Technician

5/5/11
Test Date

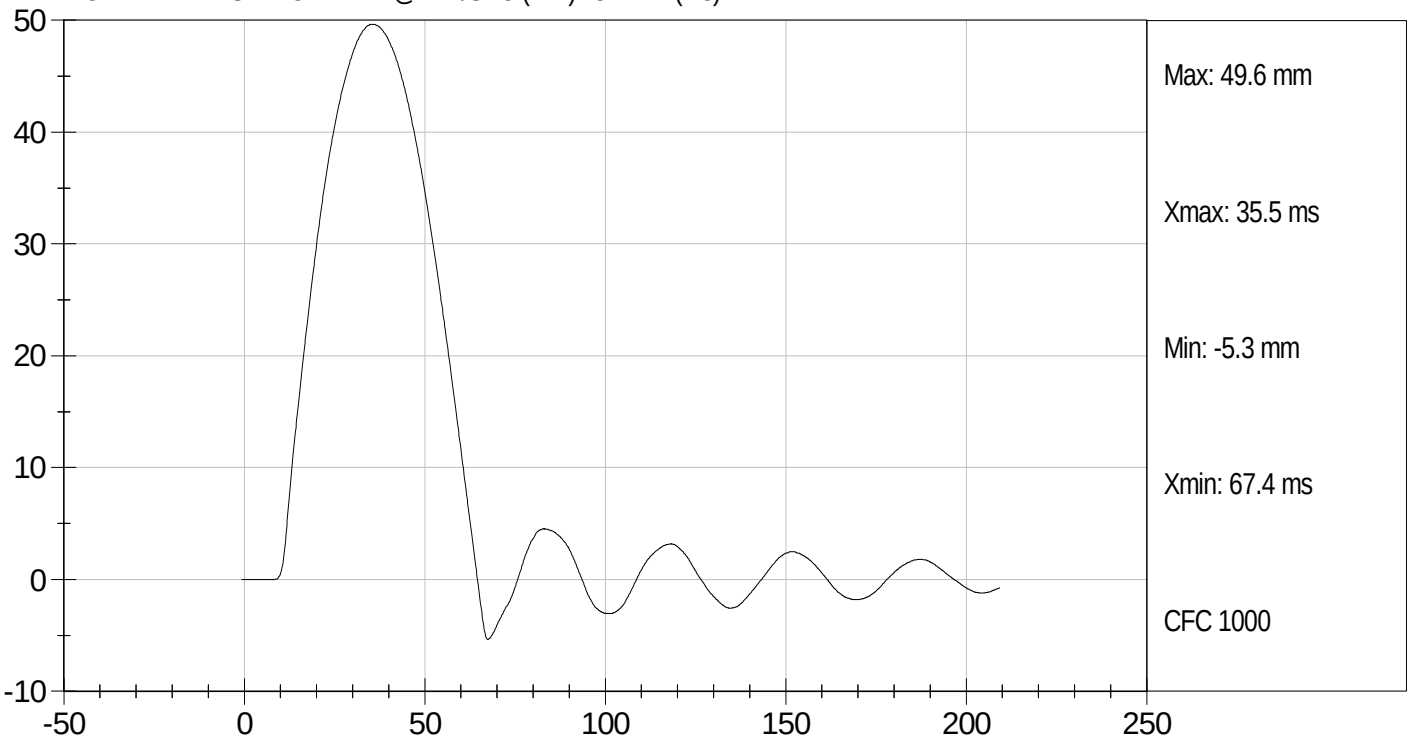
David Winkelbauer
Approved By

Test Desc: Rib Impact - Lower
Component ID: D111676
Test Date: 5/5/11

LOWER RIB DISPLACEMENT @ 3 M/SEC (mm) vs TIME (ms)



LOWER RIB DISPLACEMENT @ 4 M/SEC (mm) vs TIME (ms)



MGA RESEARCH CORPORATION

ABDOMEN TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111677

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	21.9	Pass
Laboratory Relative Humidity	%	10 to 70	37	Pass
Probe Speed	m/s	3.90 to 4.10	4.06	Pass
Maximum Impact Force	kN	4.00 to 4.80	4.24	Pass
Time of Maximum Impactor Force	ms	10.60 to 13.00	11.10	Pass
Maximum Total Abdomen Force	kN	2.20 to 2.70	2.62	Pass
Time of Maximum Abdomen Force	ms	10.00 to 12.30	10.90	Pass
		Overall Test Results		Pass

Jessica Hall
Laboratory Technician

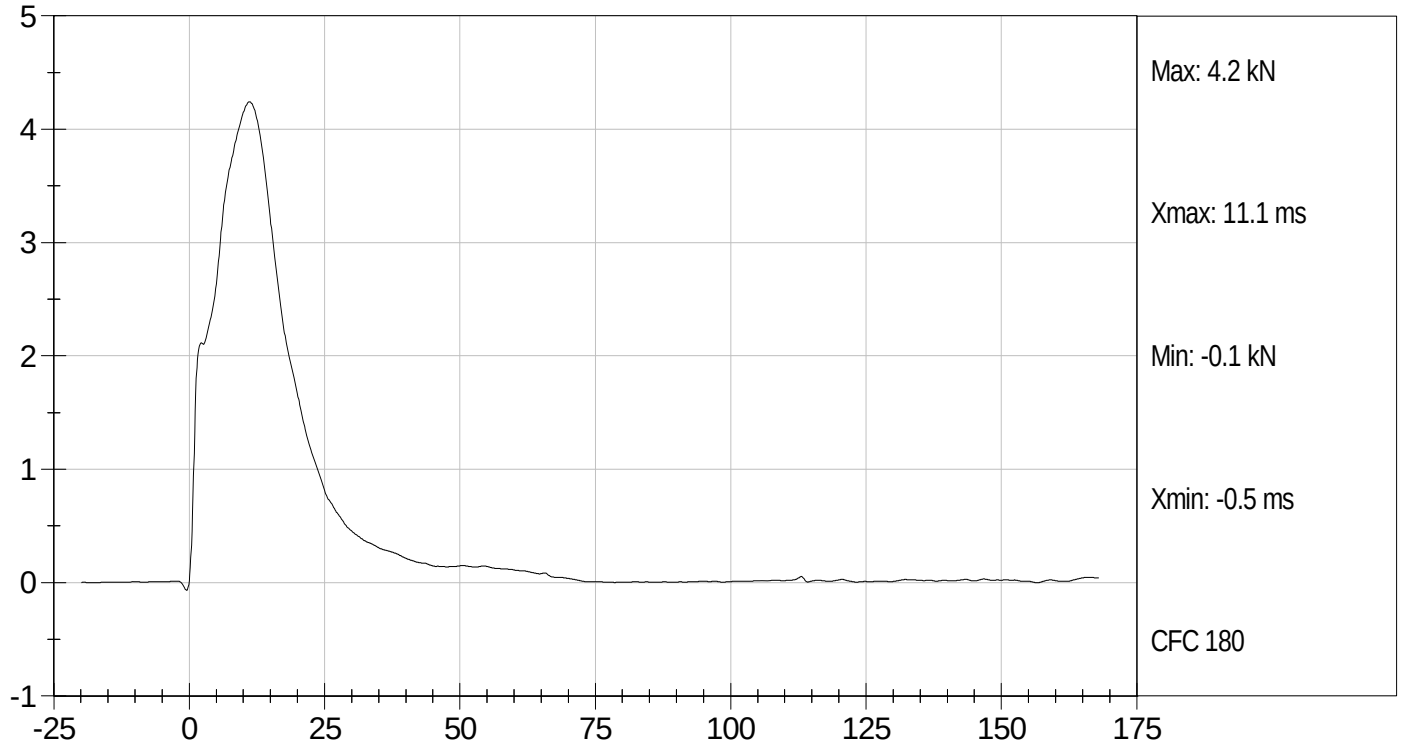
5/5/11
Test Date

David Winkelbauer
Approved By

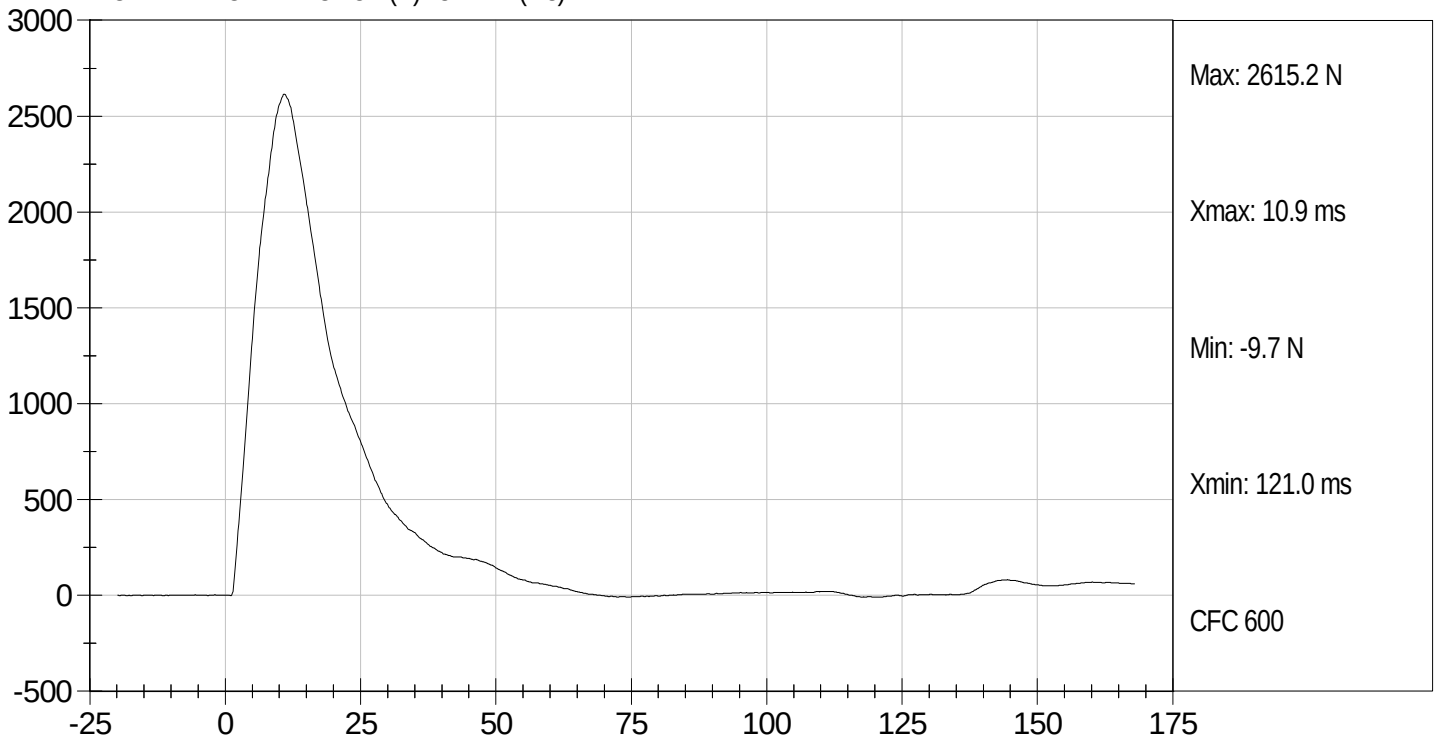
Test Desc: Abdomen Impact
Component ID: D111677

Test Date: 5/5/11
Velocity: 13.33 ft/s, 4.06 m/s

IMPACTOR FORCE (kN) vs TIME (ms)



TOTAL ABDOMEN FORCE (N) vs TIME (ms)



MGA RESEARCH CORPORATION

LUMBAR SPINE TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111678

Tested Parameter		Units	Specification	Result	Pass/Fail
Laboratory Temperature		deg C	20.6 to 22.2	22.1	Pass
Laboratory Relative Humidity		%	10 to 70	32	Pass
Pendulum Speed		m/s	5.95 to 6.15	6.05	Pass
Pendulum Deceleration	1 ms	m/s	-0.05 to 0.00	-0.01	Pass
	3.7 ms	m/s	-0.425 to -0.24	-0.42	Pass
	27 ms	m/s	-6.50 to -5.80	-5.81	Pass
	30 ms	m/s	>= -6.5	-6.03	Pass
Maximum Flexion Angle		deg	45.0 to 55.0	46.4	Pass
Time of Maximum Flexion Angle		ms	39.0 to 53.0	49.0	Pass
Headform Rotation Decay to Initial Position		ms	37 to 57	46	Pass
			Overall Results		Pass

Jessica Hall
Laboratory Technician

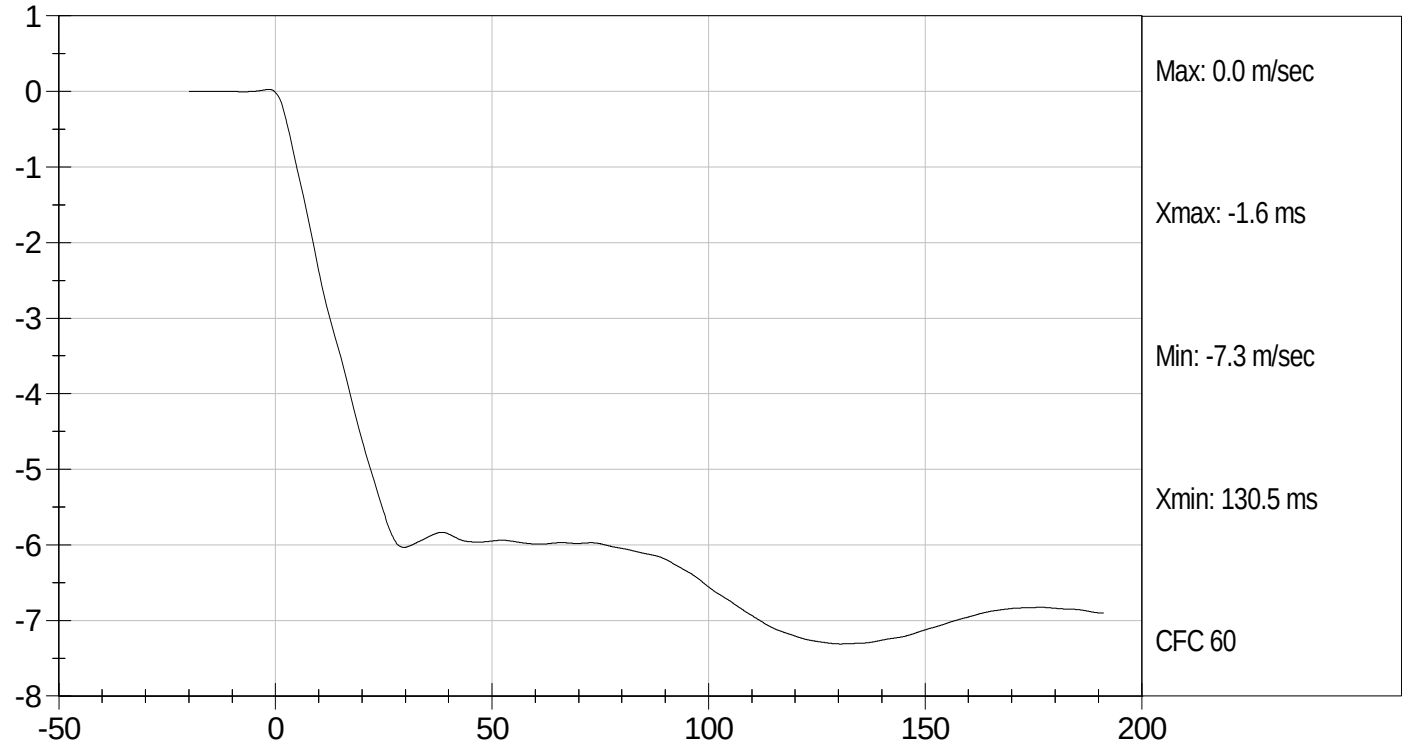
5/5/11
Test Date

David Winkelbauer
Approved By

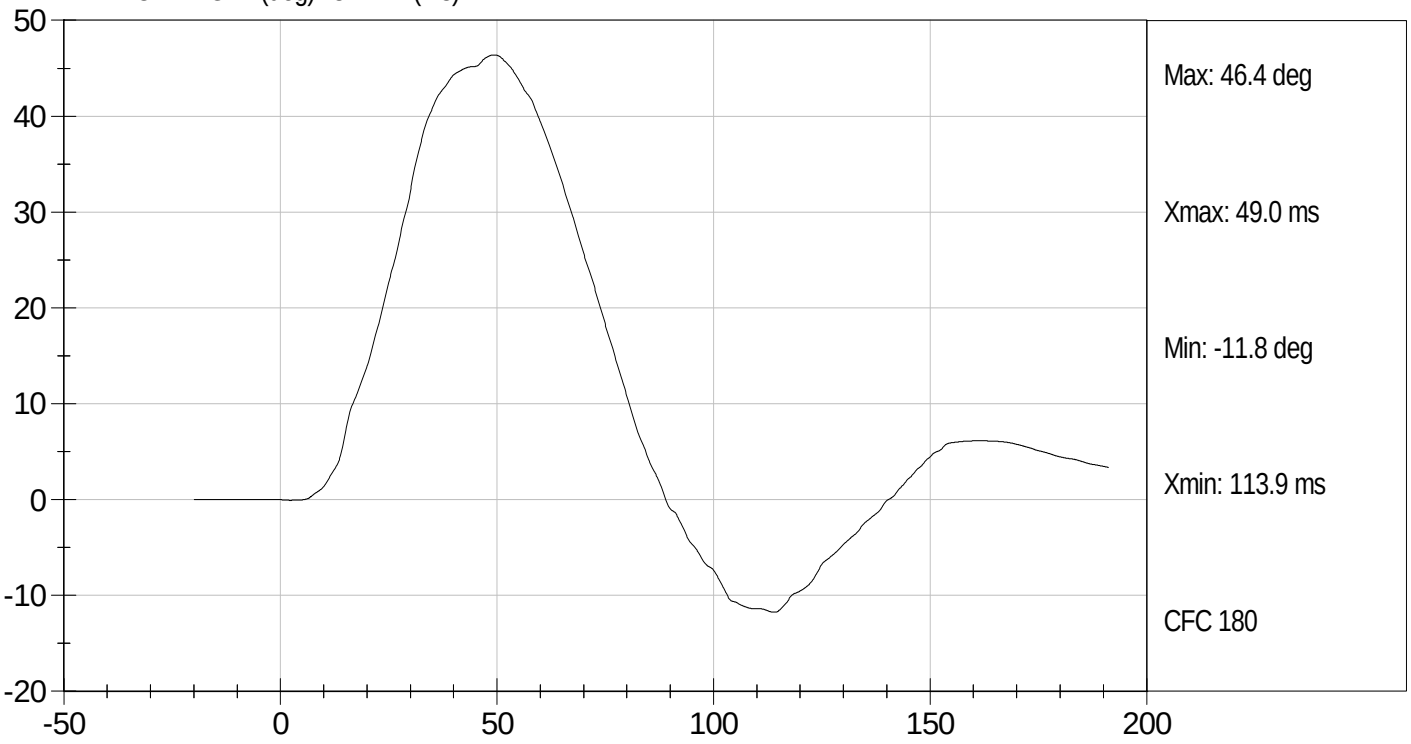
Test Desc: Lumbar Bending
Component ID: D111678

Test Date: 5/5/11
Velocity: 19.84 ft/s, 6.05 m/s

PENDULUM DECELERATION (m/sec) vs TIME (ms)



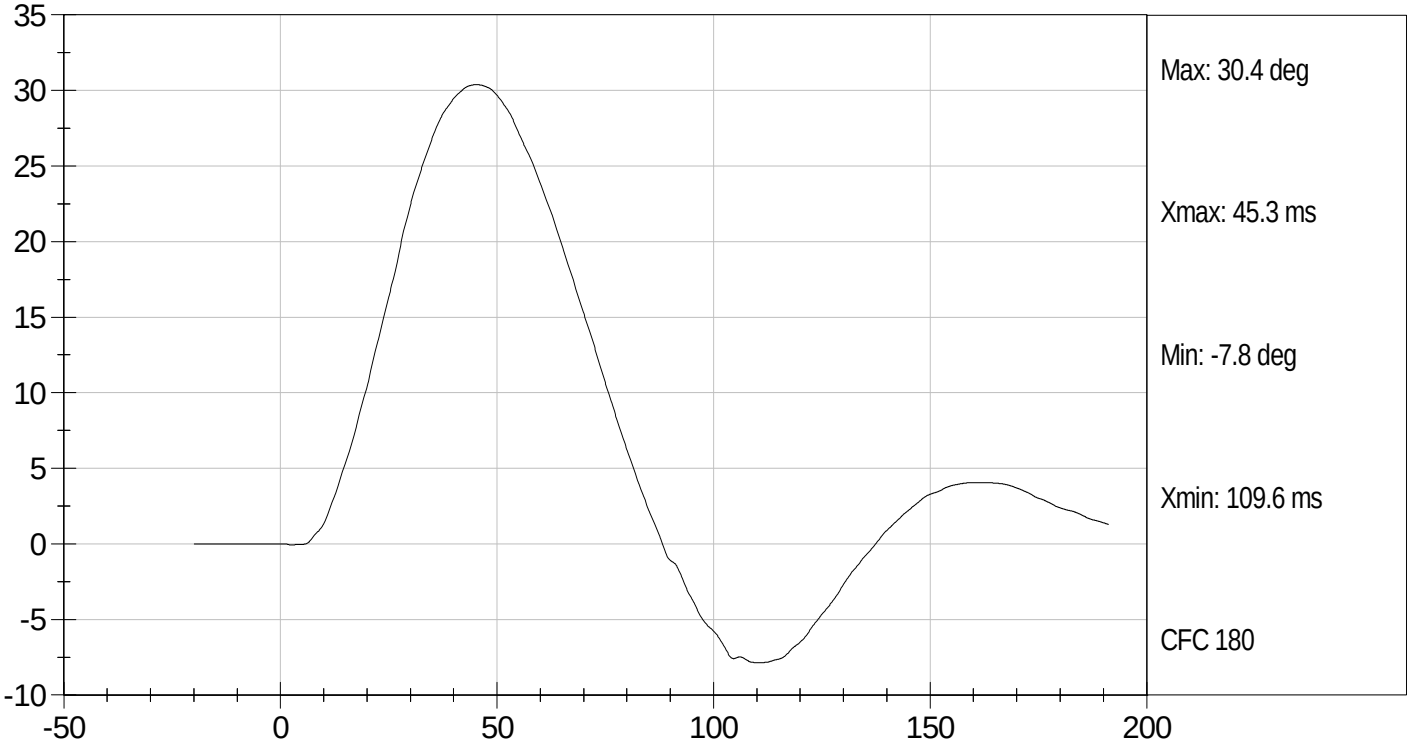
FLEXION ANGLE (deg) vs TIME (ms)



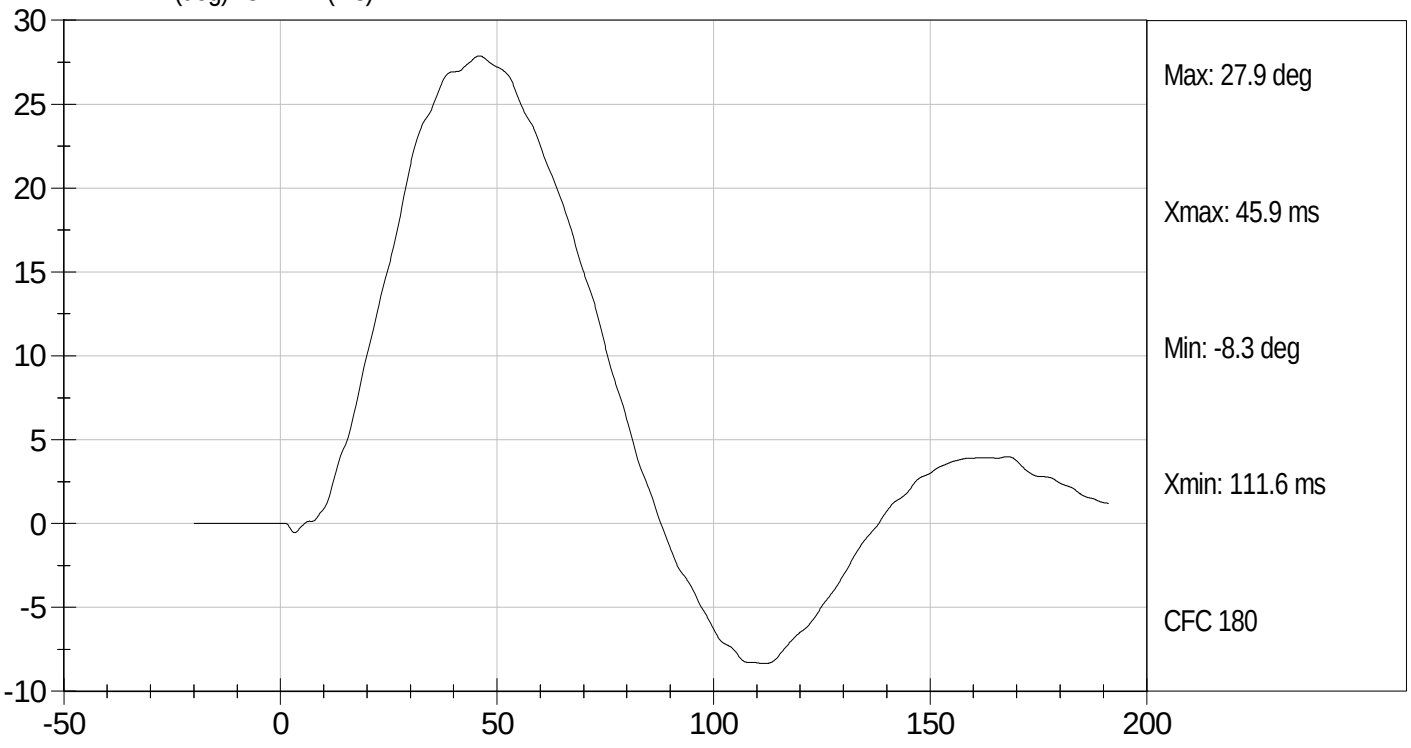
Test Desc: Lumbar Bending
Component ID: D111678

Test Date: 5/5/11
Velocity: 19.84 ft/s, 6.05 m/s

THETA A (deg) vs TIME (ms)



THETA B (deg) vs TIME (ms)



MGA RESEARCH CORPORATION

PELVIS TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111679

Tested Parameter	Units	Specification	Result	Pass/Fail
Laboratory Temperature	deg C	20.6 to 22.2	21.9	Pass
Laboratory Relative Humidity	%	10 to 70	37	Pass
Probe Speed	m/s	4.20 to 4.40	4.30	Pass
Maximum Impactor Force	kN	4.70 to 5.40	4.80	Pass
Time of Maximum Impactor Force	ms	11.80 to 16.10	13.80	Pass
Maximum Pubic Force	kN	1.23 to 1.59	1.37	Pass
Time of Maximum Pubic Force	ms	12.20 to 17.00	14.60	Pass
		Overall Test Results		Pass

Jessica Hall
Laboratory Technician

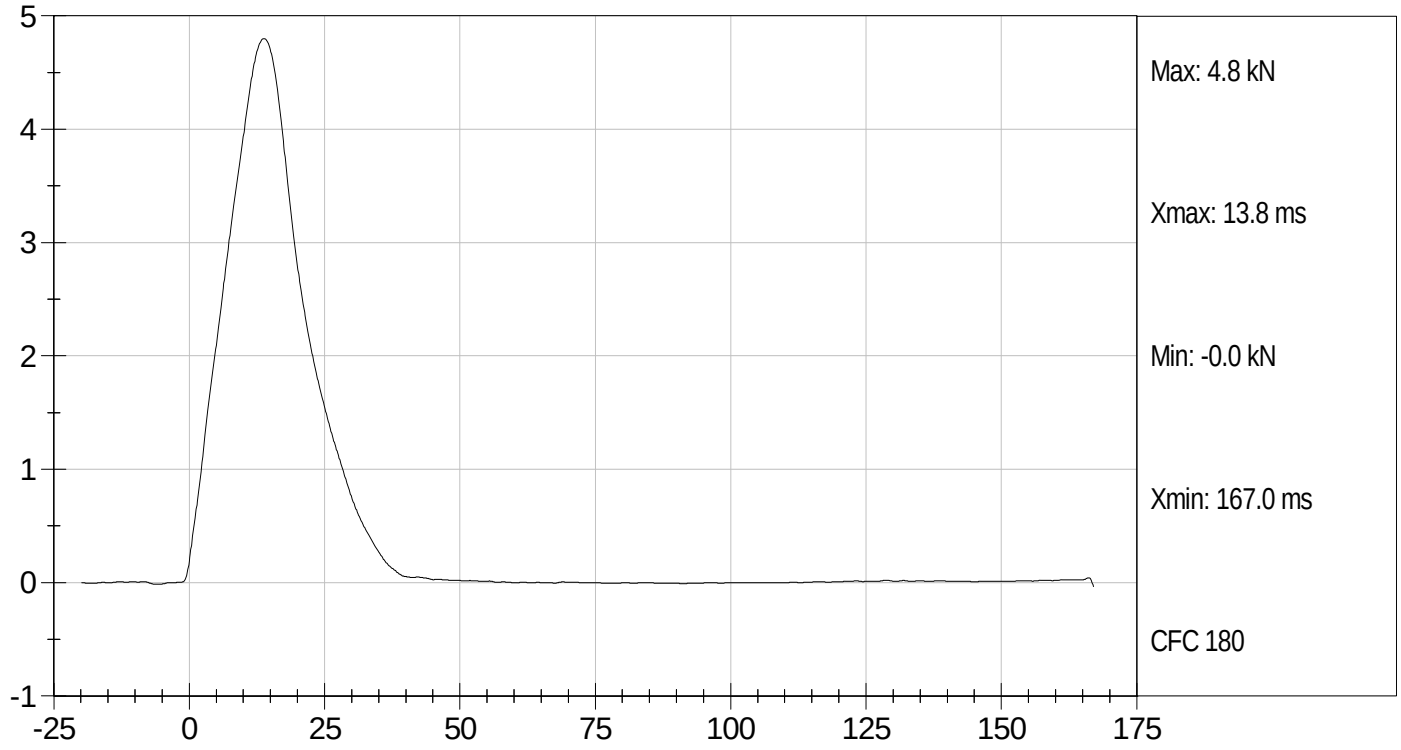
5/5/11
Test Date

David Winkelbauer
Approved By

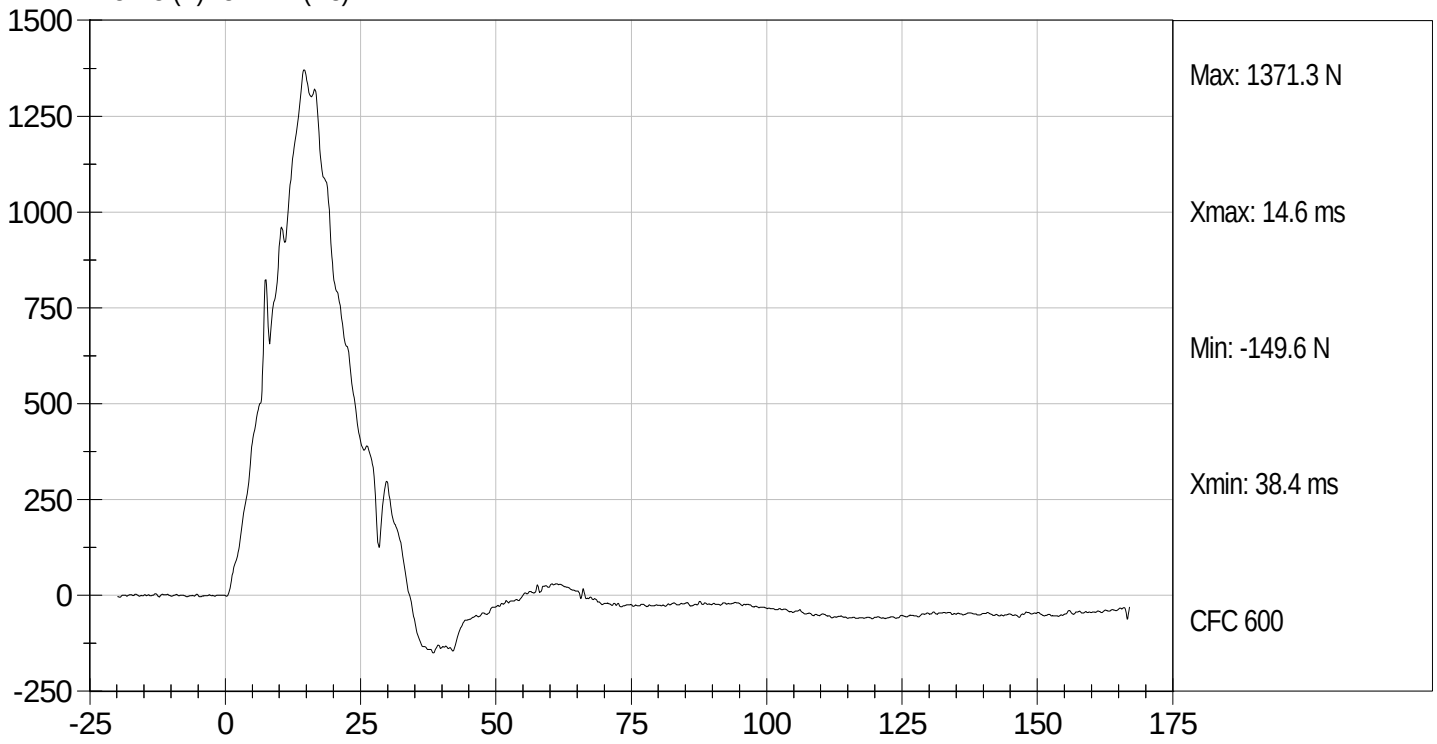
Test Desc: Pelvis Impact
Component ID: D111679

Test Date: 5/5/11
Velocity: 14.12 ft/s, 4.30 m/s

IMPACTOR FORCE (kN) vs TIME (ms)



PUBIC (N) vs TIME (ms)



MGA RESEARCH CORPORATION

FULL BODY THORAX IMPACT TEST

ES-2re DUMMY

ATD Serial No: 016 **Test I.D:** D111670

Tested Parameter	Units	Specification	Result	Pass/Fail
Temperature	deg C	20.6 to 22.2	21.9	Pass
Humidity	%	10 to 70	37	Pass
Probe Speed	m/s	5.40 to 5.60	5.58	Pass
Maximum Impactor Force (after 6 ms)	kN	5.10 to 6.20	5.19	Pass
Upper Rib Displacement	mm	34.0 to 41.0	38.7	Pass
Middle Rib Displacement	mm	37.0 to 45.0	41.2	Pass
Lower Rib Displacement	mm	37.0 to 44.0	40.9	Pass
		Overall Test Results		Pass

Jessica Gall
Laboratory Technician

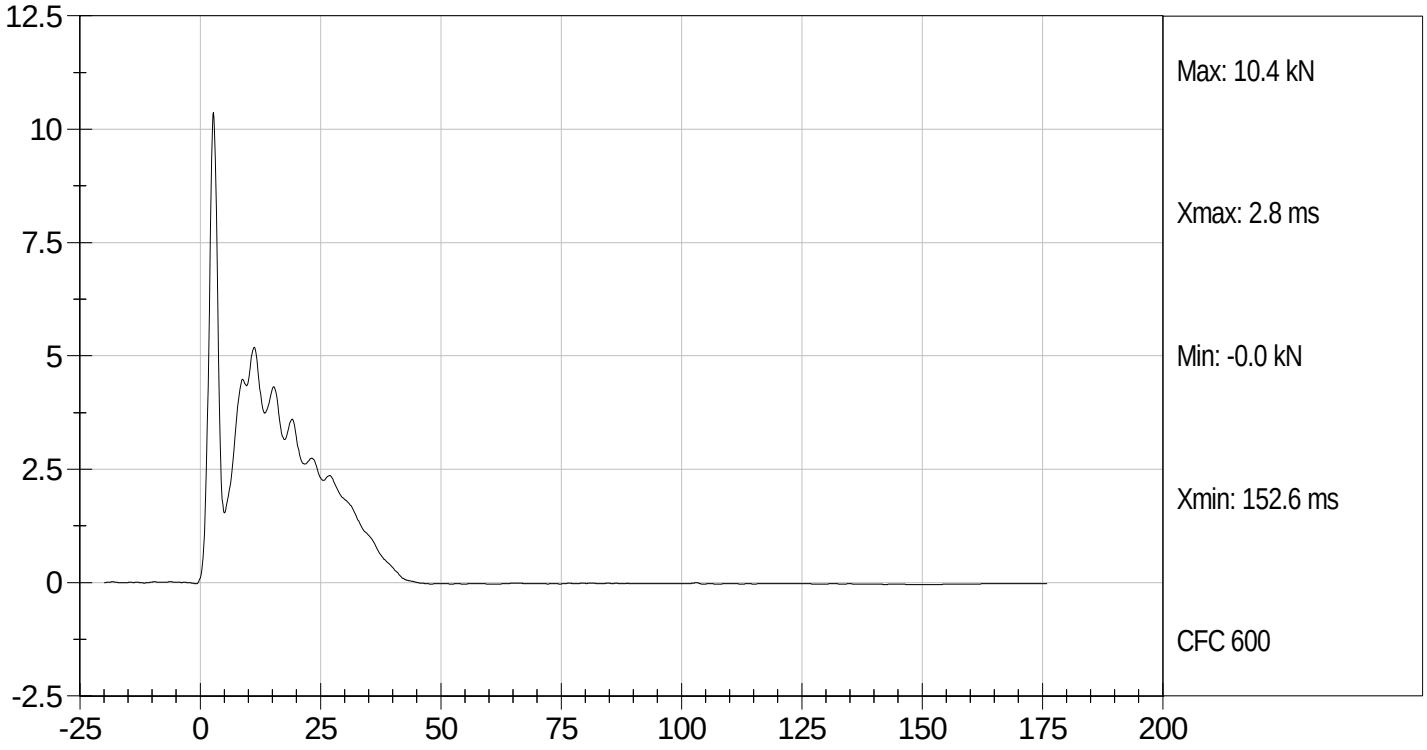
5/5/11
Test Date

David Winkelbauer
Approved By

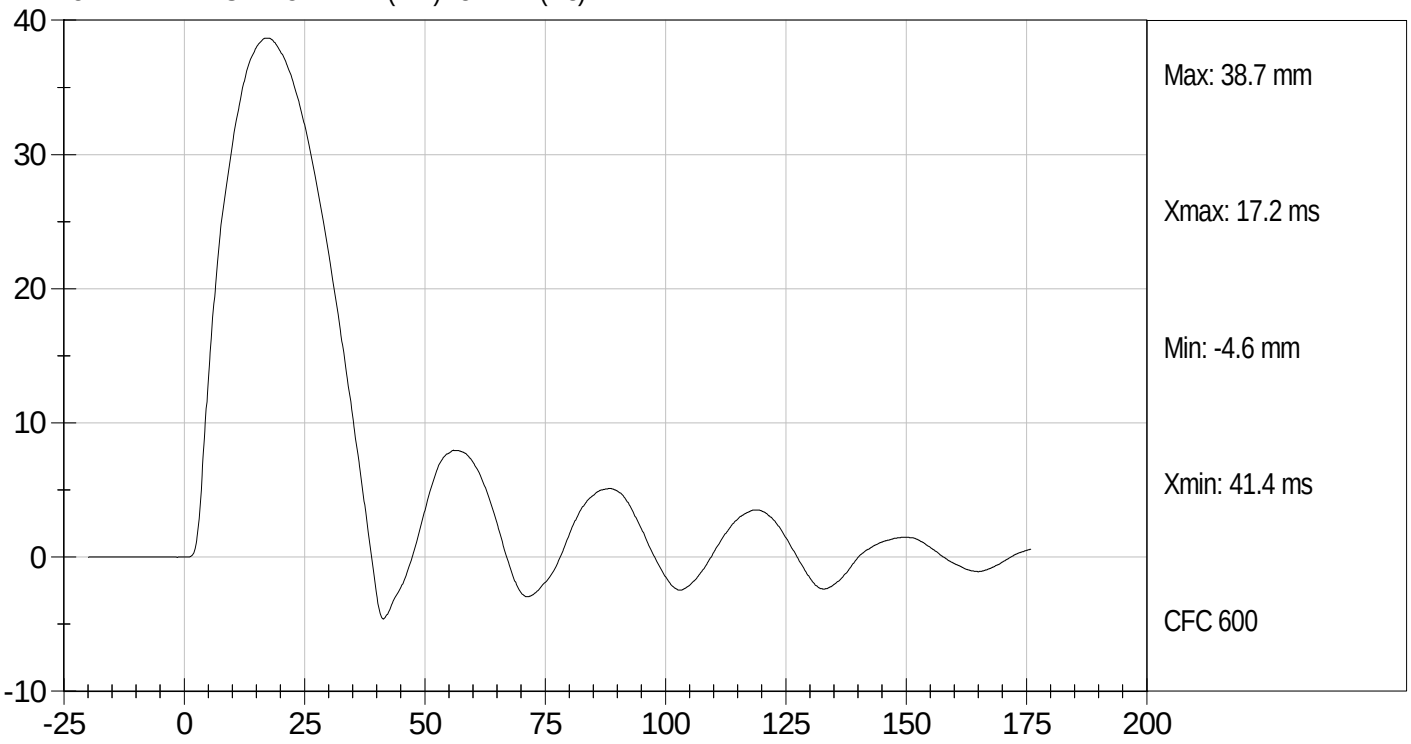
Test Desc: Thorax Impact
Component ID: D111670

Test Date: 5/5/11
Velocity: 18.31 ft/s, 5.58 m/s

PROBE FORCE (kN) vs TIME (ms)



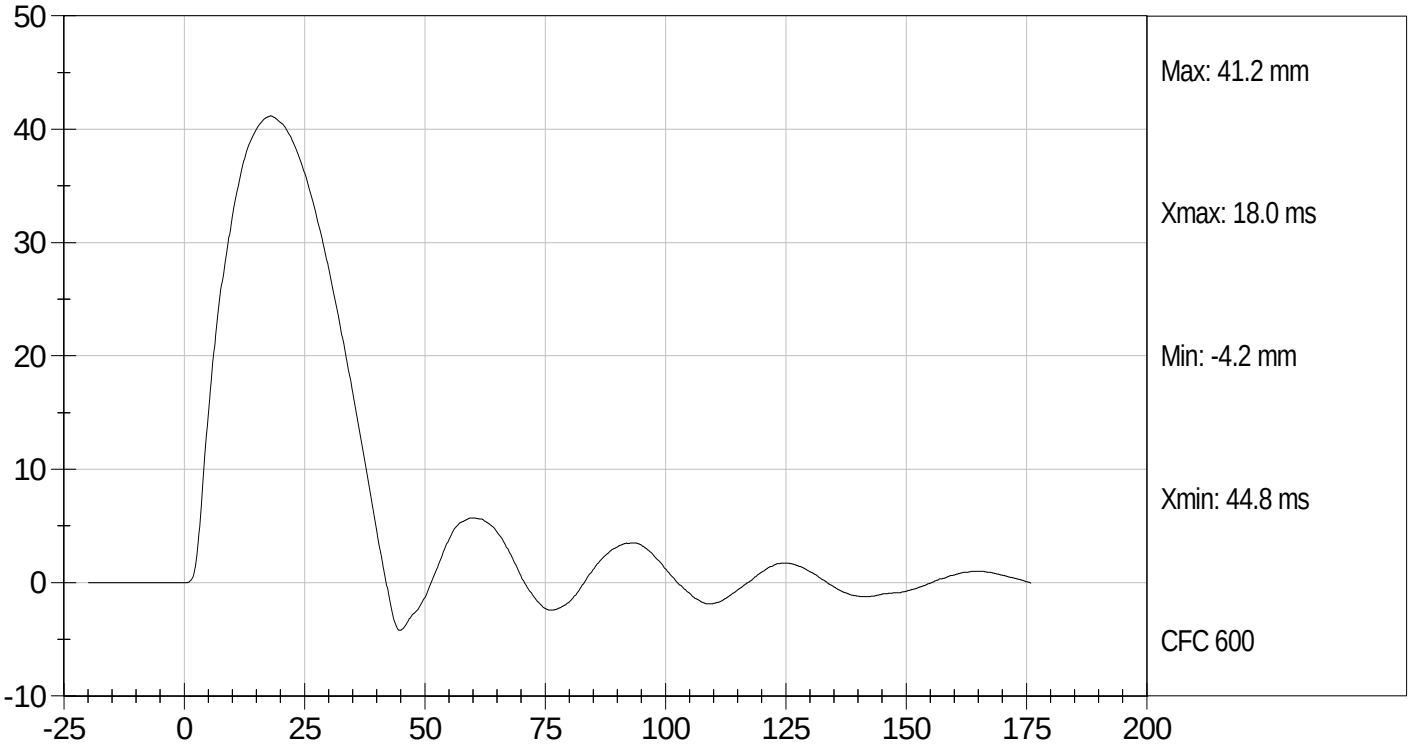
UPPER RIB DISPLACEMENT (mm) vs TIME (ms)



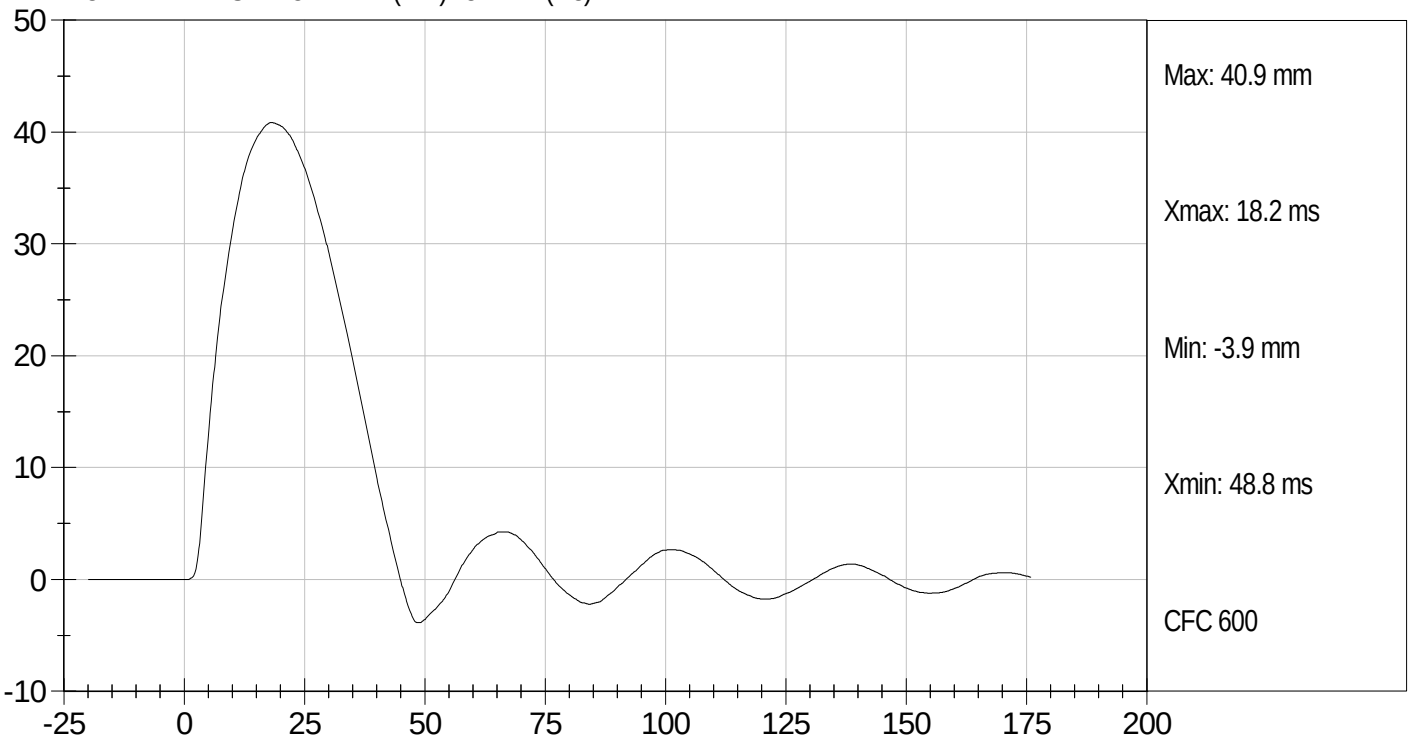
Test Desc: Thorax Impact
Component ID: D111670

Test Date: 5/5/11
Velocity: 18.31 ft/s, 5.58 m/s

MIDDLE RIB DISPLACEMENT (mm) vs TIME (ms)



LOWER RIB DISPLACEMENT (mm) vs TIME (ms)



APPENDIX E

TEST EQUIPMENT AND INSTRUMENTATION CALIBRATION

Table 1 – Dummy Instrumentation

		ES-2re S/N: 016		
		Serial Number	Manufacturer	Calibration Date
Head Accelerometers	X	P66854	Endevco	2/14/2011
	Y	P66855	Endevco	2/14/2011
	Z	P66856	Endevco	2/14/2011
Thorax Potentiometers	Upper Rib (Y)	G144	Honeywell	2/17/2011
	Middle Rib (Y)	G143	Honeywell	2/17/2011
	Lower Rib (Y)	G142	Honeywell	2/17/2011
Abdomen Load Cells	Forward (Y)	ABG1667	Denton	3/31/2011
	Middle (Y)	ABG1668	Denton	3/31/2011
	Rear (Y)	ABG1669	Denton	3/31/2011
Pubic Symphysis Load Cell (Y)		PG431	Denton	11/01/2010

Table 2 – Vehicle Instrumentation

	Serial Number	Manufacturer	Calibration Date
Vehicle CG (X)	P59316	Endevco	4/28/2011
Vehicle CG (Y)	P59315	Endevco	4/28/2011
Vehicle CG (Z)	P59317	Endevco	4/28/2011
Left Floor Sill (Y)	P59230	Endevco	4/27/2011
A Pillar Sill (Y)	P59662	Endevco	3/15/2011
A Pillar Low (Y)	P52212	Endevco	2/19/2011
A Pillar Mid (Y)	P59352	Endevco	1/13/2011
B Pillar Sill (Y)	P59397	Endevco	3/15/2011
B Pillar Low (Y)	P55712	Endevco	12/29/2010
B Pillar Mid (Y)	P59360	Endevco	1/13/2011
Seat (Y)	P47834	Endevco	2/19/2011
Engine (X)	P59669	Endevco	4/28/2011
Engine (Y)	P59670	Endevco	4/28/2011
Firewall (Y)	P59235	Endevco	4/27/2011
Roof (Y)	P50050	Endevco	12/13/2010
Floor Sill (Y)	P49475	Endevco	12/03/2010
Rear Deck (X)	P52268	Endevco	12/13/2010
Rear Deck (Y)	P52269	Endevco	12/13/2010