

REPORT NUMBER TR-P29018-06-NC

**SIDE AIRBAG OCCUPANT RISK PROGRAM
OCCUPANT OUT-OF-POSITION TESTS**

**HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC
2009 HYUNDAI SONATA
4-DOOR SEDAN**

NHTSA NUMBER: M90500TWG2

**PREPARED BY:
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9270 HOLLY ROAD
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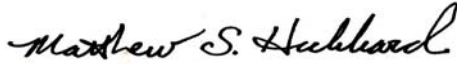
OCTOBER 19, 2009

FINAL REPORT

**PREPARED FOR:
ALPHA TECHNOLOGY ASSOCIATE, INC.
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This final test report was prepared for the U.S. Department of Transportation, Alpha Technology Associate, Inc., in response to Contract Number DTNH22-03-D-32005.

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Date: 10/19/09



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Date: 10/19/09

FINAL REPORT ACCEPTED BY:

Manager, New Car Assessment Program

Date of Acceptance

COTR, NCAP Frontal Impact Program

Date of Acceptance

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SECTION 1

PURPOSE AND SUMMARY OF TEST M90500TWG2

1.1 PURPOSE

This occupant out-of-position static side airbag deployment test is part of the Technical Working Group Occupant Injury Risk from Deploying Side Airbags Testing Program sponsored by Alpha Technology Associate, Inc. under Contract No. DTNH22-03-D-32005. The purpose of this test was to obtain occupant injury data for a side airbag deployment.

The occupant out-of-position side airbag test was conducted in accordance with the Technical Working Group Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags.

1.2 SUMMARY

The effects of a roof mounted curtain airbag and a torso airbag deployment in a 2009 Hyundai Sonata 4-Door Sedan with an out-of-position SID IIs 5th percentile adult female dummy were evaluated. The test was performed at Karco Engineering, LLC on October 19, 2009. Pre- and post-test photographs of the vehicle and dummy can be found in Appendix A.

Three high-speed digital cameras and one real time camera were used to document the curtain airbag deployment. Camera locations and other pertinent camera information can be found on Data Sheet No.1 and Data Sheet No.6.

SID IIs 5th percentile adult female anthropomorphic test device (ATD) was placed in the right front passenger seating position facing inboard according to the dummy placement instructions (3.3.5.3) in the July 2003 Revision of the Technical Working Group's 'Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags'.

The SID IIs 5th percentile adult female ATD was instrumented with head tri-axial accelerometers, and upper and lower neck transducers.

Fifteen (15) channels of data were recorded using an on-board data acquisition system. Appendix A contains Photographs. Appendix B contains dummy response data traces. Appendix C contains the Instrumentation Data Channel assignments.

The front passenger side door remained closed during the deployment and was operable after the deployment.

The SID IIs 5th percentile adult female dummy's visible contact points were as follows: The curtain airbag contacted the ATD's head and the torso airbag contacted the ATD's back.

OUT OF POSITION OCCUPANT DATA SUMMARY

ATD Position	HIC ₁₅
Passenger	16.4

Orientation of the SID IIs 5th percentile adult female dummy was in the inboard facing position leaning against the front passenger door. The dummy's spine was aligned with the deploying trajectory of the curtain airbag. The lower legs were extended. This orientation complies with section 3.3.5.3 of the Technical Working Group (TWG) recommendation in the Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags.

SECTION 2

OCCUPANT AND VEHICLE INFORMATION/DATA SHEETS

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan NHTSA No.: M90500TWG2
Test Program: TWG 3.3.5.3. Test Date: 10/19/09

CONVERSION FACTORS USED IN THIS REPORT*

Quantity	Typical Application	Std Units	Metric Unit	Multiply By
Mass	Vehicle Weight	lb	kg	0.4536
Linear Velocity	Impact Velocity	mile/h	km/h	1.609
Length or Distance	Measurements	in	mm	25.4
Volume	Fuel Systems	gal	liter	3.785
Volume	Small Fluids	oz	mL	29.573
Pressure	Tire Pressures	lbf/in ²	kPa	7.0
Volume	Liquid	gal	liter	3.785
Temperature	General Use	°F	°C	$=(tf - 32)/1.8$
Force	Dynamic Forces	lbf	N	4.448
Moment	Torque	lbf/ft	Nm	1.355

* Based on the Recommended Practice in SAE J916, May 85

DATA SHEET NO. 1

TEST SUMMARY

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan NHTSA No.: M90500TWG2

Test Program: TWG 3.3.5.3. Test Date: 10/19/09

TEST DUMMY INFORMATION

Description	Passenger Seat Forward Facing
Dummy Type / Serial No.	SID IIs / 299
Head Contact	Yes
Chest Contact	None
Abdomen Contact	None
Pelvis	None
Left Knee Contact	None
Right Knee Contact	None

MOVIE COVERAGE

High Speed Digital	3
Real Time	1
Total	4

DATA CHANNELS

SID IIs ATD Sensors	15
Belt Assessment Sensors	0
Vehicle Structure Accelerometers	0
Total	15

DATA SHEET NO. 2

GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan NHTSA No.: M90500TWG2

Test Program: TWG 3.3.5.3. Test Date: 10/19/09

TEST VEHICLE INFORMATION

Make	Hyundai
Model	Sonata
Body Style	4-Door Sedan
NHTSA No.	M90500TWG2
VIN	5NPET46C19H408058
Color	Slate Blue
Delivery Date	April 2, 2008
Odometer Reading (mile)	20
Dealer	Victorville Hyundai
Transmission	Automatic
Final Drive	Front
Type/Number Cylinders	Inline 4
Engine Displacement (L)	2.4
Engine Placement	Transverse

TEST VEHICLE OPTIONS

Driver Front Airbag	Yes
Driver Side Airbag	Yes
Driver Side Curtain Airbag	Yes
Pass. Front Airbag	Yes
Pass.Side Airbag	Yes
Pass. Curtain Airbag	Yes
Power Brakes	Yes
Power Steering	Yes
Disc Brakes, Front	Yes
Disc Brakes, Rear	Yes
Anti-lock Brakes	Yes
Tilt Steering Wheel	Yes
Power Windows	Yes
Power Seats	No

DATA FROM CERTIFICATION LABEL

Manufactured By	Hyundai Motor Manufacturing Alabama, LLC	GVWR (kg)	1950
Date of Manufacture	January-08	GAWR Front (kg)	1140
		GAWR Rear (kg)	970

DATA FROM TIRE PLACARD

Measured Parameter	Front	Rear
Maximum Tire Pressure (kPa)	308	308
Cold Pressure (kPa)	220	220
Recommend Tire Size	P215/60R16	P215/60R16
Tire Size on Vehicle	P215/60R16	P215/60R16
Tire Manufacturer	Michelin	Michelin

Measured Parameter	Front	Rear	Third	Total
Type of Seats	Bucket	Bench	Bench	
Number of Occupants	2	3	0	5
Capacity Wt. (VCW) (kg)				390

* Vehicle had undergone New Car Assessment Program Frontal Impact Testing on July 16, 2008

DATA SHEET NO. 3

TEST VEHICLE INFORMATION

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan NHTSA No.: M90500TWG2
Test Program: TWG 3.3.5.3. Test Date: 10/19/09

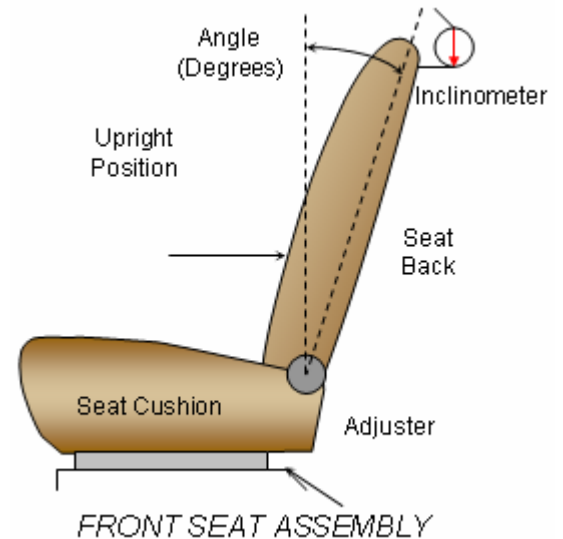
NOMINAL DESIGN RIDING POSITION

The passenger seat back is positioned to section 3.3.5.3. of the Technical Working Group (TWG) recommendation in the Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags.

SEAT BACK ANGLES

Position	Deg.
Passenger w/ Dummy	10.8

Seat upright is 0 degrees.



SEAT FORE/AFT POSITIONS

The first or forward most position is counted as number one (1). The fore/aft position is set aft of the middle position for the passenger seat.

SEAT FORE/AFT POSITIONING

	Total Fore/Aft Travel	Placed in Position #
Passenger Seat	25 detnets	13th detent

DATA SHEET NO. 4

DUMMY POSITIONING INFORMATION

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan NHTSA No.: M90500TWG2
 Test Program: TWG 3.3.5.3. Test Date: 10/19/09

TEST DUMMY POSITION MEASUREMENTS

Code	Measurement Description	SID IIs 5th percentile female	
		Length (mm)	Angle (°)
SA	Seat Back Angle		11
AMW	Side Airbag Module Width (Torso / Curtain)	35 / 25	
ABW	Side Airbag Width (Torso / Curtain)	420 / 353	
AML	Side Airbag Module Length (Torso / Curtain)	325 / 165	
ABL	Side Airbag Length (Torso / Curtain)	1435 / 375	
AN	Top of Airbag Module to Head/Neck Junction	274	
HD	Head CG to Door Panel/ Window	76	
HSC	Head to Seat Back Centerline	205	
HB	Head to B-Pillar (first contact)	245	
HZ	Head to Roof (Z)	132	
HHD	Head to Header	215	
ND	Nose to Dash	602	
NS	Nose to Seat Back	222	
NR	Nose to Header	330	
CD	Chest to Dash	540	
CS	Chest to Seat Back	224	
RACL	Right Arm to Seat Back Centerline	N/A	
LACL	Left Arm to Seat Back Centerline	01	
RA	Right Arm to Door Panel	N/A	
LA	Left Arm to Door Panel	150	
KK	Knee to Knee	124	
TT	Toe to Toe	110	
KSCR	Right Knee to Seat Cushion Centerline	220	
KSCL	Left Knee to Seat Cushion Centerline	228	
TSCR	Right Toe to Seat Cushion Centerline	704	
TSCL	Left Toe to Seat Cushion Centerline	700	

DATA SHEET NO. 5
HYBRID III ATD INJURY CRITERIA AND SENSOR DATA

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan

NHTSA No.: M90200TWG2

Test Program: TWG 3.3.5.3

Test Date: 10/19/09

HEAD PEAK ACCELERATIONS

Location	Axis	Units	Pass. SID-IIs			
			Max	Time	Min	Time
Head CG	X	G's	35.2	11.0	-1.9	204.3
Head CG	Y	G's	6.0	13.6	-12.4	11.7
Head CG	Z	G's	69.1	10.8	-11.0	12.2
Head CG Resultant	N/A	G's	73.0	10.8		

UPPER NECK PEAK FORCES AND MOMENTS

Location	Axis	Units	Pass. SID-IIs			
			Max	Time	Min	Time
Neck Force	X	Newtons	224.9	16.0	-95.6	26.2
Neck Force	Y	Newtons	165.4	26.1	-48.7	97.8
Neck Force	Z	Newtons	248.9	22.7	-829.8	11.1
Neck Force Resultant	N/A	Newtons	841.6	11.1		
Neck Moment	X	Nm	20.3	19.2	-11.9	10.8
Neck Moment	Y	Nm	25.9	16.1	-12.8	26.9
Neck Moment	Z	Nm	4.9	15.3	-3.8	73.6
Neck Moment Resultant	N/A	Nm	28.6	16.3		

LOWER NECK PEAK FORCES AND MOMENTS

Location	Axis	Units	Pass. SID-IIs			
			Max	Time	Min	Time
Neck Force	X	Newtons	171.1	11.4	-29.6	224.8
Neck Force	Y	Newtons	106.2	9.3	-65.9	17.9
Neck Force	Z	Newtons	124.1	22.7	-399.9	12.1
Neck Force Resultant	N/A	Newtons	422.0	15.0		
Neck Moment	X	Nm	31.6	28.2	-9.1	98.4
Neck Moment	Y	Nm	16.7	12.1	-13.2	22.6
Neck Moment	Z	Nm	11.1	12.3	-4.3	79.0
Neck Moment Resultant	N/A	Nm	33.8	29.0		

DATA SHEET NO. 5...(CONTINUED)Test Vehicle: 2009 Hyundai Sonata 4-Door SedanNHTSA No.: M90200TWG2Test Program: TWG 3.3.5.3Test Date: 10/19/09**HEAD INJURY CRITERIA (HIC 15)**

Location	Pass. SID-IIs			
	HIC15	T ¹	T ²	Avg G
Head CG	16.4	10.6	15.9	24.8

UPPER NECK NIJ VALUES

Location	Pass. SID-IIs			
	Ntf	Nte	Ncf	Nce
Upper Neck	0.03	0.21	0.32	0.05

DATA SHEET NO. 6**CAMERA LOCATIONS**Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan NHTSA No.: M90500TWG2Test Program: TWG 3.3.5.3. Test Date: 10/19/09

No.	Camera View	Location (mm)			Angle (Deg.)	Lens (mm)	Speed (fps)
		X	Y	Z			
1	Real Time	0	2342	-1138	-1.0	N/A	30
2	High Speed Side View	0	2105	-925	0.0	24	1000
3	High Speed 3/4 View	-1430	1570	-1220	-6.0	35	1000
4	High Speed Front View	-1770	45	-1250	-10.0	35	1000

* All measurements are taken relative to CG of dummy's head.

APPENDIX A

PHOTOGRAPHS



Figure A-1: Right Front $\frac{3}{4}$ View, As Received



MANUFACTURED BY
HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC

Jan/14/08

GVWR 4299 lbs

PAINT BF

GAWR 2513 lbs
FRONT

GAWR 2138 lbs
REAR

TRIM U7

THIS VEHICLE CONFORMS TO ALL APPLICABLE U.S.A. FEDERAL
MOTOR VEHICLE SAFETY, BUMPER, AND THEFT PREVENTION STANDARDS
IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE

V.I.N. 5NPET46C19H408058

PASSENGER CAR



Figure A-2: Vehicle Certification Label



Figure A-3: Post-Test Right Front $\frac{3}{4}$ View of Frontal NCAP Test



Figure A-4: Post-Test Right Side View of Frontal NCAP Test



Figure A-5: Pre-Test Dummy Position, Left Side View



Figure A-6: Pre-Test Dummy Position, $\frac{3}{4}$ View



Figure A-7: Pre-Test Dummy Position, Front View



Figure A-8: Post-Test Dummy Position and Airbags, Left Side View



Figure A-9: Post-Test Airbags, Left Side View



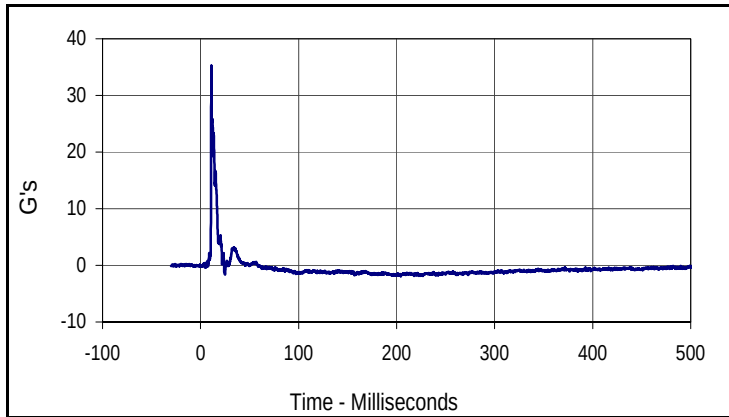
Figure A-10: Post-Test Airbags, Close-up View

APPENDIX B

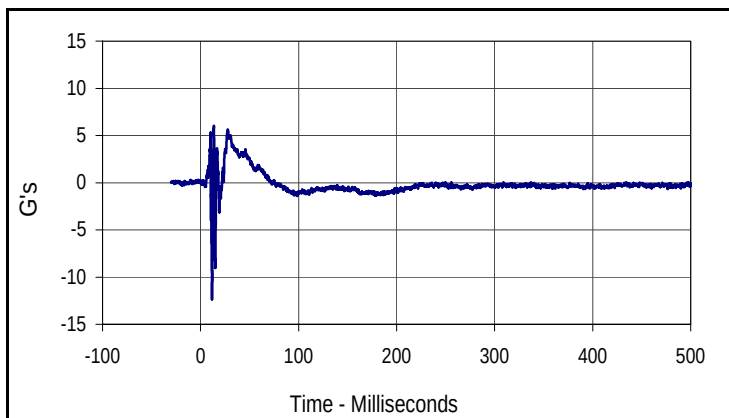
DATA PLOTS

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan
 Test Program: TWG 3.3.5.3

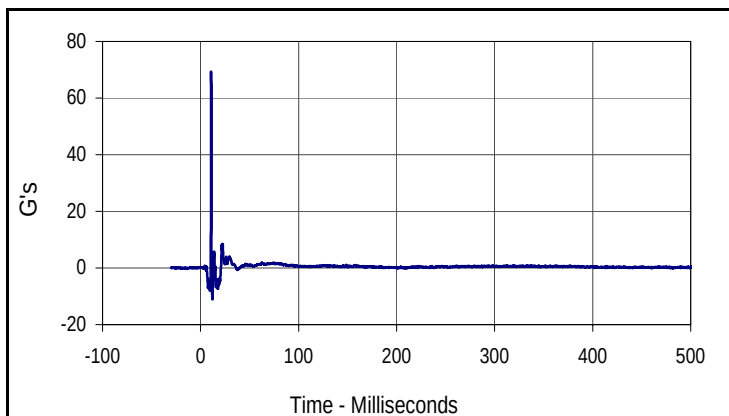
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 NHTSA No.: M90200TWG2



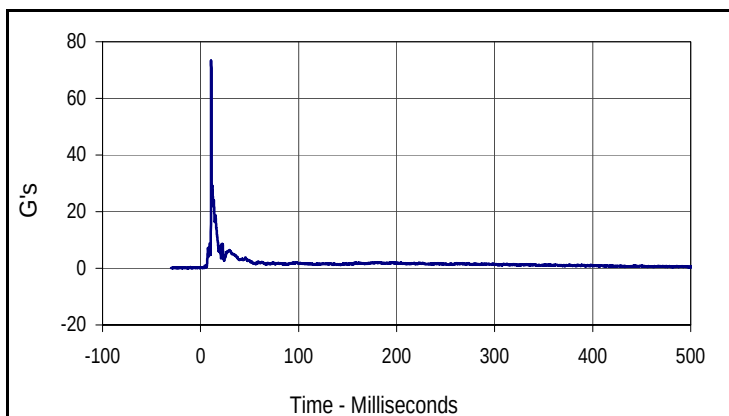
Curve Description			
Pass. SID-IIs Head X Primary			
CURNO	Type	SAE Class	Units
001	FIL	1000	G's
Max	Time	Min	Time
35.2	11.0	-1.9	204.3



Curve Description			
Pass. SID-IIs Head Y Primary			
CURNO	Type	SAE Class	Units
002	FIL	1000	G's
Max	Time	Min	Time
6.0	13.6	-12.4	11.7



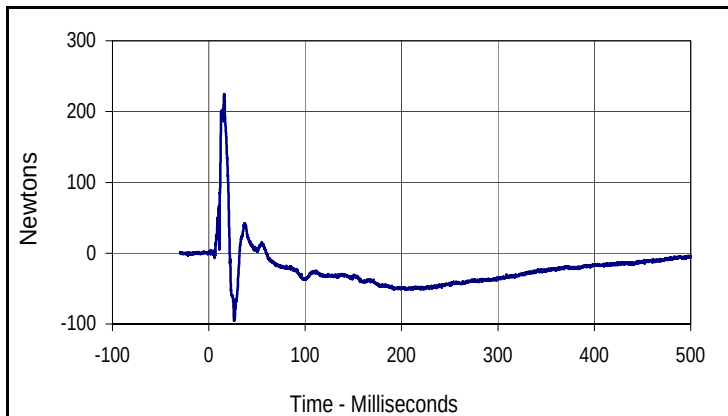
Curve Description			
Pass. SID-IIs Head Z Primary			
CURNO	Type	SAE Class	Units
003	FIL	1000	G's
Max	Time	Min	Time
69.1	10.8	-11.0	12.2



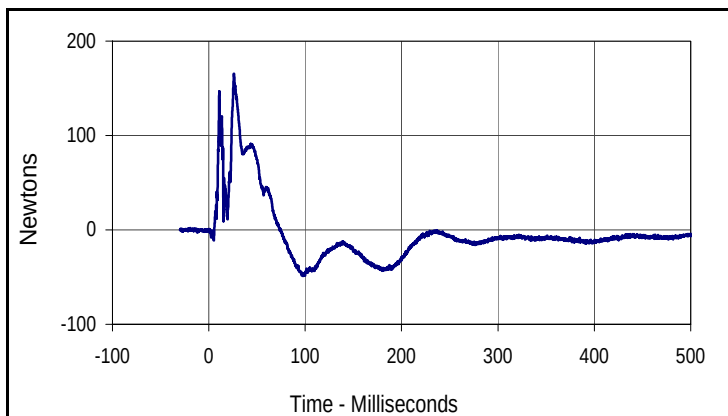
Curve Description			
Pass. SID-IIs Head Primary Resultant			
CURNO	Type	SAE Class	Units
001	RES	1000	G's
Max	Time	Min	Time
73.0	10.8	0.0	731.7

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan
 Test Program: TWG 3.3.5.3

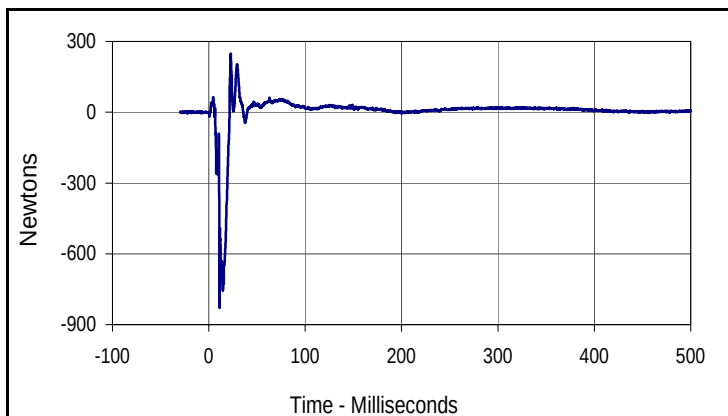
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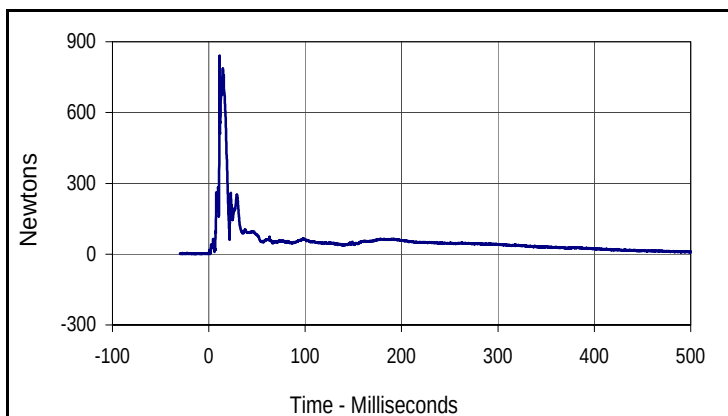
Curve Description			
Pass. SID-IIs Upper Neck Force X			
CURNO	Type	SAE Class	Units
004	FIL	1000	Newtons
Max	Time	Min	Time
224.9	16.0	-95.6	26.2



Curve Description			
Pass. SID-IIs Upper Neck Force Y			
CURNO	Type	SAE Class	Units
005	FIL	1000	Newtons
Max	Time	Min	Time
165.4	26.1	-48.7	97.8



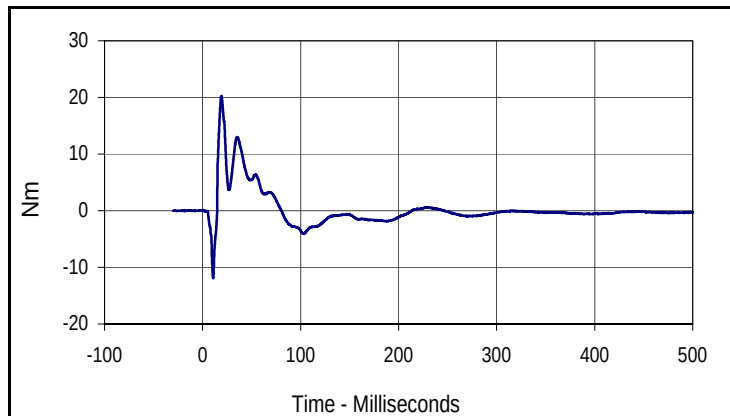
Curve Description			
Pass. SID-IIs Upper Neck Force Z			
CURNO	Type	SAE Class	Units
006	FIL	1000	Newtons
Max	Time	Min	Time
248.9	22.7	-829.8	11.1



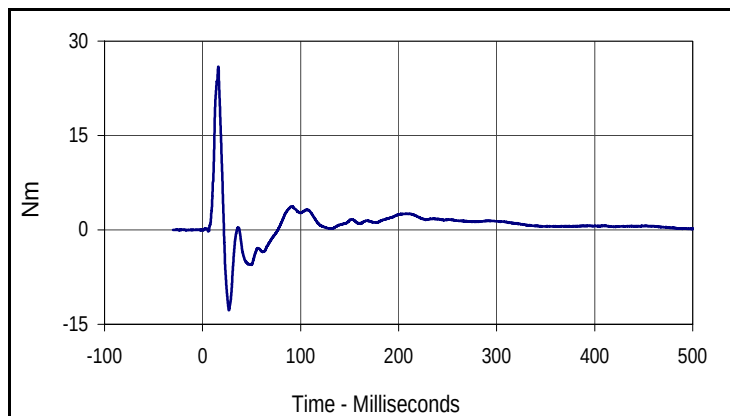
Curve Description			
Pass. SID-IIs Upper Neck Force Resultant			
CURNO	Type	SAE Class	Units
004	RES	1000	Newtons
Max	Time	Min	Time
841.6	11.1	0.7	0.0

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan
 Test Program: TWG 3.3.5.3

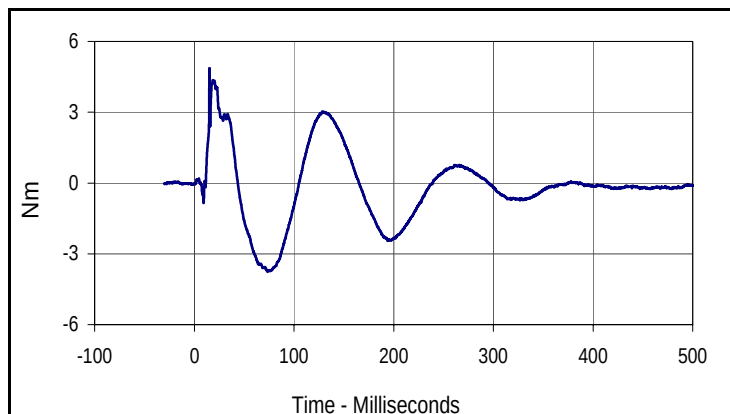
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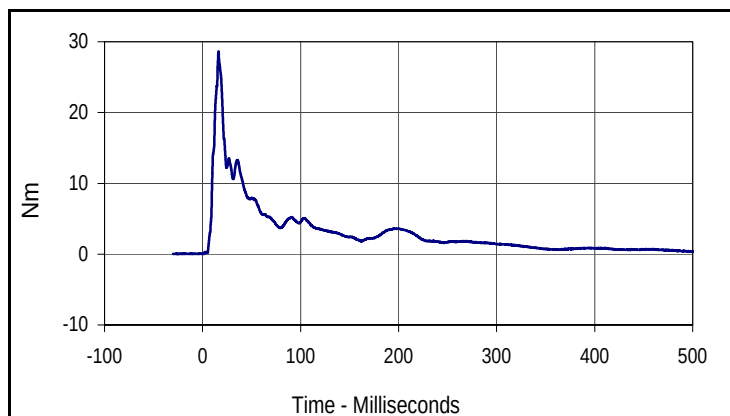
Curve Description			
Pass. SID-IIs Upper Neck Moment X			
CURNO	Type	SAE Class	Units
007	FIL	600	Nm
Max	Time	Min	Time
20.3	19.2	-11.9	10.8



Curve Description			
Pass. SID-IIs Upper Neck Moment Y			
CURNO	Type	SAE Class	Units
008	FIL	600	Nm
Max	Time	Min	Time
25.9	16.1	-12.8	26.9



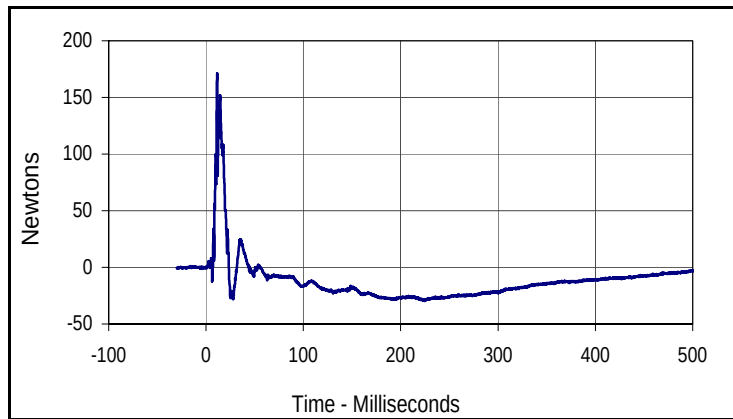
Curve Description			
Pass. SID-IIs Upper Neck Moment Z			
CURNO	Type	SAE Class	Units
009	FIL	600	Nm
Max	Time	Min	Time
4.9	15.3	-3.8	73.6



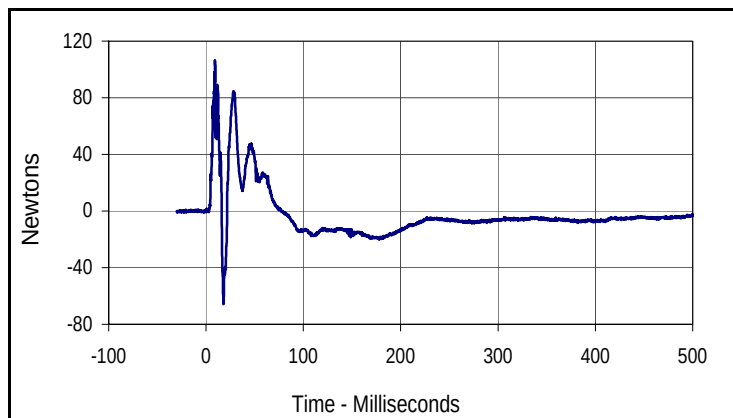
Curve Description			
Pass. SID-IIs Upper Neck Moment Resultant			
CURNO	Type	SAE Class	Units
007	RES	600	Nm
Max	Time	Min	Time
28.6	16.3	0.0	0.3

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan
 Test Program: TWG 3.3.5.3

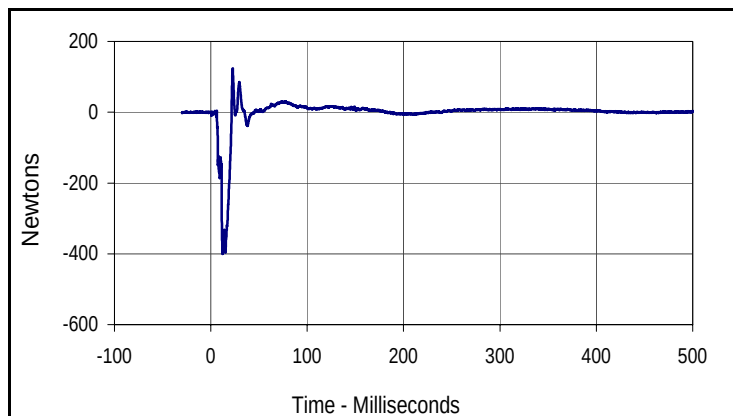
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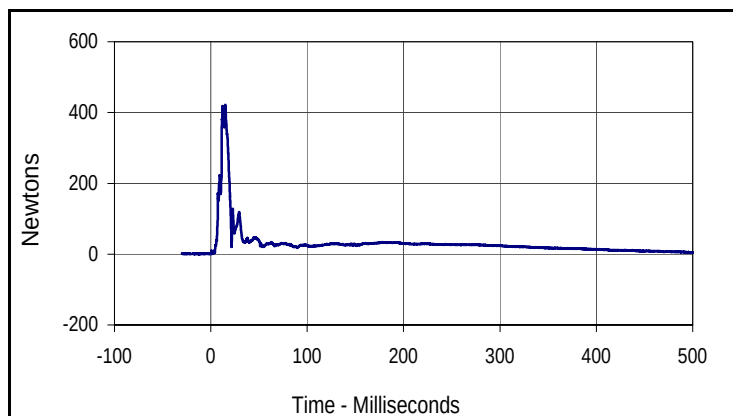
Curve Description			
Pass. SID-IIs Lower Neck Force X			
CURNO	Type	SAE Class	Units
010	FIL	1000	Newtons
Max	Time	Min	Time
171.1	11.4	-29.6	224.8



Curve Description			
Pass. SID-IIs Lower Neck Force Y			
CURNO	Type	SAE Class	Units
011	FIL	1000	Newtons
Max	Time	Min	Time
106.2	9.3	-65.9	17.9



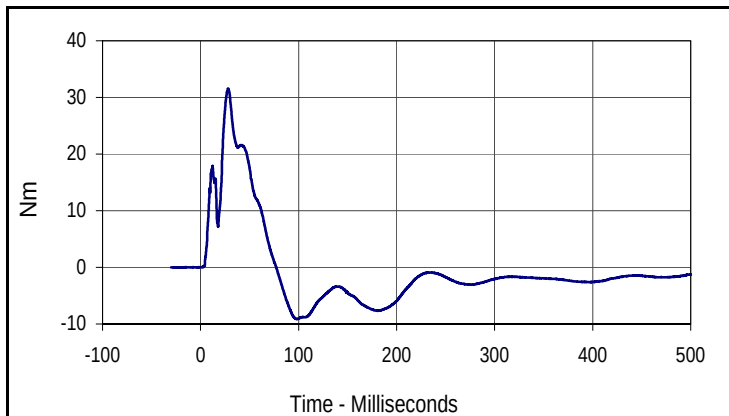
Curve Description			
Pass. SID-IIs Lower Neck Force Z			
CURNO	Type	SAE Class	Units
012	FIL	1000	Newtons
Max	Time	Min	Time
124.1	22.7	-399.9	12.1



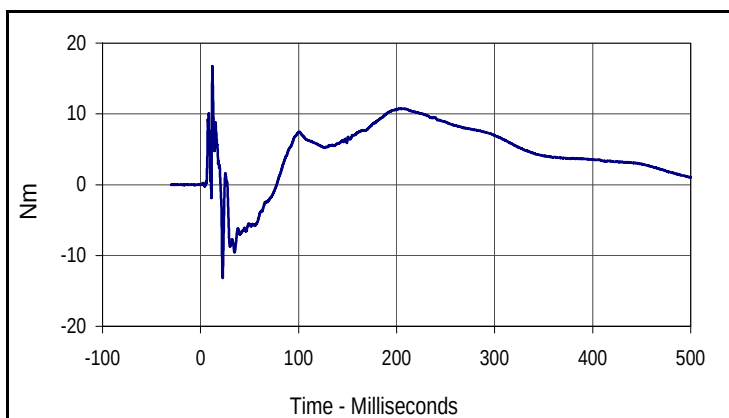
Curve Description			
Pass. SID-IIs Lower Neck Force Resultant			
CURNO	Type	SAE Class	Units
010	RES	1000	Newtons
Max	Time	Min	Time
422.0	15.0	0.3	1.3

Test Vehicle: 2009 Hyundai Sonata 4-Door Sedan
 Test Program: TWG 3.3.5.3

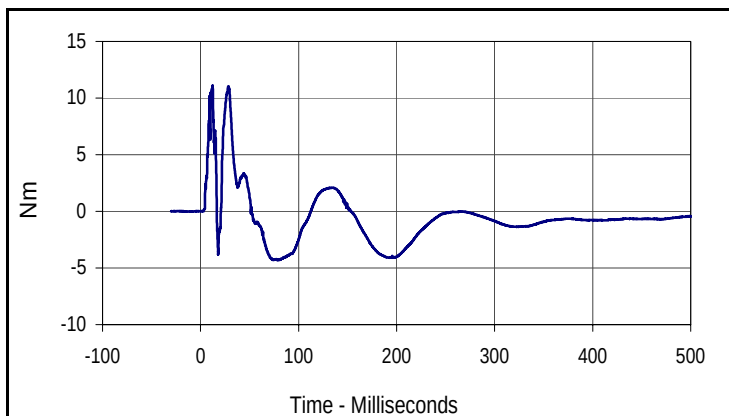
Test Date: 10/19/09
 NHTSA No.: M90200TWG2



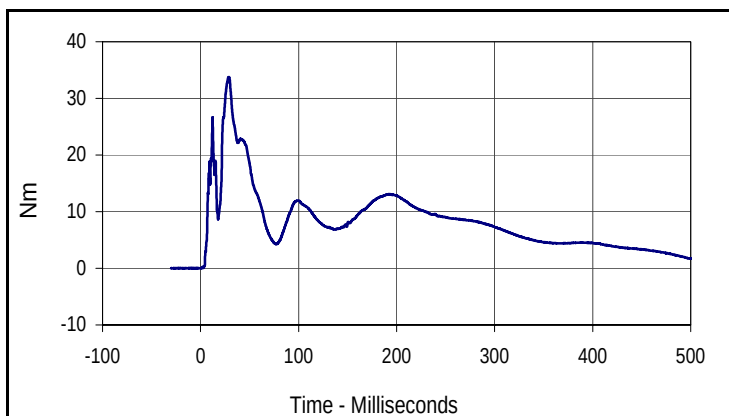
Curve Description			
Pass. SID-IIs Lower Neck Moment X			
CURNO	Type	SAE Class	Units
013	FIL	600	Nm
Max	Time	Min	Time
31.6	28.2	-9.1	98.4



Curve Description			
Pass. SID-IIs Lower Neck Moment Y			
CURNO	Type	SAE Class	Units
014	FIL	600	Nm
Max	Time	Min	Time
16.7	12.1	-13.2	22.6



Curve Description			
Pass. SID-IIs Lower Neck Moment Z			
CURNO	Type	SAE Class	Units
015	FIL	600	Nm
Max	Time	Min	Time
11.1	12.3	-4.3	79.0



Curve Description			
Pass. SID-IIs Lower Neck Moment Resultant			
CURNO	Type	SAE Class	Units
013	RES	600	Nm
Max	Time	Min	Time
33.8	29.0	0.0	1.0

APPENDIX C

INSTRUMENTATION DATA CHANNEL ASSIGNMENTS

TWG 3.3.5.3
Instrumentation Data Channel Assignments
A.T.D. Serial Number 299
10/19/09
2009 Hyundai Sonata 4-Door Sedan

CH.	LOCATION	AXIS	IDENT. NO.	DESCRIPTION	MFR	MODEL	UNITS
1	HEAD	X	P51926	Accel.,full bridge	ENDEVCO	7264-2000	G
2	HEAD	Y	P51929	Accel.,full bridge	ENDEVCO	7264-2000	G
3	HEAD	Z	P51934	Accel.,full bridge	ENDEVCO	7264-2000	G
4	UPPER NECK FORCE	X	1624 FX	Load cell, six axis neck	R. A. Denton	IF-205	N
5	UPPER NECK FORCE	Y	1624 FY	Load cell, six axis neck	R. A. Denton	IF-205	N
6	UPPER NECK FORCE	Z	1624 FZ	Load cell, six axis neck	R. A. Denton	IF-205	N
7	UPPER NECK MOMENT	X	1624 MX	Load cell, six axis neck	R. A. Denton	IF-205	Nm
8	UPPER NECK MOMENT	Y	1624 MY	Load cell, six axis neck	R. A. Denton	IF-205	Nm
9	UPPER NECK MOMENT	Z	1624 MZ	Load cell, six axis neck	R. A. Denton	IF-205	Nm
10	LOWER NECK FORCE	X	180 FX	Load cell, six axis neck	R. A. Denton	2430	N
11	LOWER NECK FORCE	Y	180 FY	Load cell, six axis neck	R. A. Denton	2430	N
12	LOWER NECK FORCE	Z	180 FZ	Load cell, six axis neck	R. A. Denton	2430	N
13	LOWER NECK MOMENT	X	180 MX	Load cell, six axis neck	R. A. Denton	2430	Nm
14	LOWER NECK MOMENT	Y	180 MY	Load cell, six axis neck	R. A. Denton	2430	Nm
15	LOWER NECK MOMENT	Z	180 MZ	Load cell, six axis neck	R. A. Denton	2430	Nm