REPORT NUMBER: R&D-KAR-16-006

OBLIQUE MOVING BARRIER INTO ANGLED STATIONARY VEHICLE CRASH TESTING IN SUPPORT OF NHTSA'S FRONTAL OBLIQUE PROGRAM

OBLIQUE MOVING DEFORMABLE BARRIER INTO LEFT FRONT OF A MOVING CONTOURED BARRIER

60 KM/H, 15 DEGREE ANGLE, 35% OVERLAP

TEST DATE: 05/25/2016

PREPARED BY:
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FINAL REPORT SUBMITTED
July 18, 2016

PREPARED FOR
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NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
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Prepared by:  Date: July 18, 2016

[Mr. Robert S. Ramos, Project Engineer]
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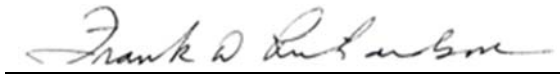
Approved by:  Date: July 18, 2016

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FINAL REPORT ACCEPTANCE BY VEHICLE SAFETY RESEARCH, OFFICE OF STRUCTURAL AND RESTRAINTS RESEARCH DIVISION:

Approved by: _____ Date: _____

[Name, Title]

TECHNICAL REPORT DOCUMENTATION PAGE

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16

Report No. R&D-KAR-16-006	**Government Accession No.**	**Recipient's Catalog No.**
Title and Subtitle Report for Frontal Oblique Offset Program Testing of a OMDB to MCB		**Report Date** July 18, 2016 **Performing Organization Code** KAR
Author(s) Mr. Robert S. Ramos, Project Engineer, KARCO Mr. Frank Richardson, Program Manager, KARCO		**Performing Organization Report No.** TR-P36072-03-NC
Performing Organization Name and Address KARCO Engineering, LLC. 9270 Holly Rd. Adelanto, CA 92301		**Work Unit No.** **Contract or Grant No.** DTNH22-14-D-00360
Sponsoring Agency Name and Address DOT / National Highway Traffic Safety Administration Office of Vehicle Safety Research 1200 New Jersey Ave., SE, Room W46-446 Washington, D.C. 20590		**Type of Report and Period Covered** Final Test Report, May 25 – July 18, 2016 **Sponsoring Agency Code** NSR210

Supplementary Notes

Abstract

A test was conducted in accordance with Contract DTNH22-14-D-00360, Task Order #0002. The Test consisted of an Oblique Moving Deformable Barrier (OMDB) traveling at a target speed of 60 km/h into a stationary FMVSS 301 Moving Contoured Barrier (MCB). The struck vehicle was positioned 15 degrees clockwise relative to the moving barrier which impacted 35% of the left side of the vehicle. The test was conducted to obtain performance of the full-barrier face in an oblique test. The test was conducted at KARCO Engineering, LLC. facility in Adelanto, California on May 25, 2016. The OMDB impact velocity was 59.71 km/h and the ambient temperature at the test vehicle at the time of impact was 24.0°C. The OMDB maximum static crush was 249.2 mm.

Key Words Oblique Offset Contoured OMDB MCB	**Distribution Statement.** Copies of this report are available from: National Highway Traffic Safety Administration Technical Reference Division 1200 New Jersey Ave., SE. Washington, D.C. 20590

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Form DOT F1700.7 (8-72)

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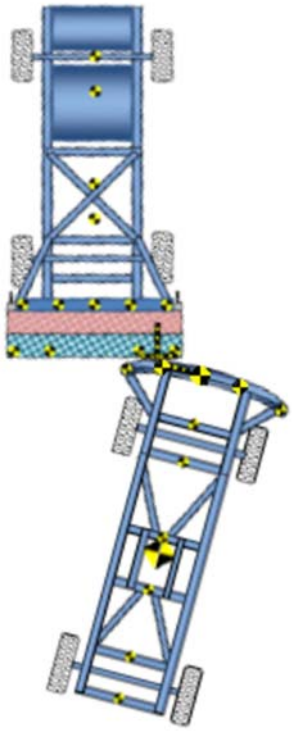
SECTION 1
TEST PURPOSE

This 60.0 km/h (37.3 mph) Oblique Moving Deformable Barrier (OMDB) into a Moving Contoured Barrier (MCB) test is part of Frontal Oblique Offset Program sponsored by the National Highway Traffic Safety Administration (NHTSA) under Contract No. DTNH22-14-D-00360, Task Order #0002. The purpose of this test was to evaluate half-barrier face utilization.

This test was conducted in accordance with the instructions set forth by NHTSA for a 15°, 35% offset moving barrier to vehicle impact, outlined in Task Order (TO) #0002. Data was obtained to the requirements of TO #0002.

SECTION 2
SUMMARY OF TEST RESULTS

A Moving Contoured Barrier (MCB) was impacted on the left front corner by an Oblique Moving Deformable Barrier. The MCB was stationary and positioned at a target angle of 15° and a target offset of 35% to the line of forward motion of the OMDB. The OMDB was towed down the test track in a full forward direction, without any crabbing, and the targeted impact velocity of 60.0 km/h (37.3 mph) into the MCB.



The MCB mass was 1,898.5 kg (4185.4 lbs), and the OMDB mass was 2508.5 kg (5,530.2 lbs). A full face honeycomb barrier was mounted on the OMDB. The test was conducted by KARCO Engineering, LLC. on May 25, 2016.

The OMDB impacted the MCB at a speed of 59.71 km/h. After impact the OMDB rotated 165.2°, coming to rest 4.40 m forward and 4.95 m left of its initial position. As a result of the impact, three M10x1.5 x 90 mm SHCS bolts on the left rear axle mount sheared causing the wheel assembly to rotate about the axle adapter. After the impact the MCB rotated 60.4° and traveled 14.43 m rearward and 8.15 m left of its initial position.

The test was documented by two (2) real time and seven (7) high-speed video cameras. Pre- and post-test photographs of the MCB, the OMDB and the test setup were taken using a digital still camera. Photographic documentation of the test is presented in Appendix A of this report.

Twenty four (24) channels of data from the OMDB and MCB were collected using a Diversified Technical Systems, Inc. data acquisition system. Appendix B contains MCB and OMDB response data plots.

PRIMARY IMPACT DATA

Measured Parameter	Units	Value
OMDB Velocity at Impact	km/h	59.71
OMDB Test Weight	kg	2508.5
OMDB Maximum Static Crush	mm	249.2
MCB Test Weight	kg	1898.5
Actual MCB Angle	°	15.2
Vertical Offset from Target Point (+ down / - up)*	mm	6
Lateral Offset from Target Point (+ left / - right)*	mm	2
Number of Data Channels		24
Number of Real-Time Cameras		2
Number of High-Speed Cameras		7

*Offsets are in relation to the vehicle coordinate system.

SECTION 3

VEHICLE INFORMATION/DATA SHEETS

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16

CONVERSION FACTORS

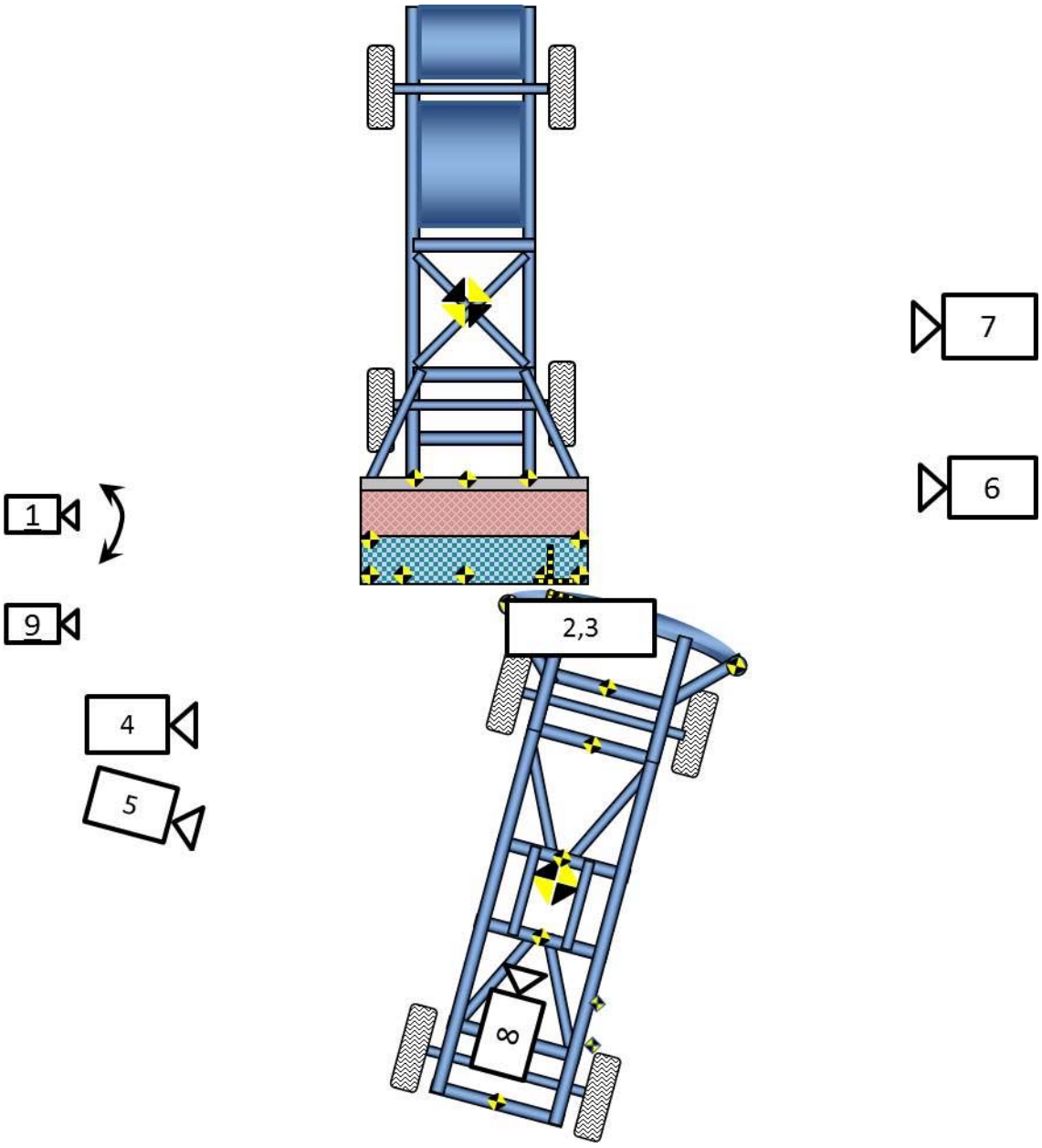
Quantity	Typical Application	Std Units	Metric Unit	Multiply By
Mass	Vehicle Weight	lb	kg	0.4536
Linear Velocity	Impact Velocity	miles/hr	km/hr	1.609344
Length or Distance	Measurements	in	mm	25.4
Volume	Fuel Systems	gal	liter	3.785
Volume	Small Fluids	oz	mL	29.574
Pressure	Tire Pressures	lbf/in^2	kPa	6.895
Temperature	General Use	^oF	^oC	=(Tf -32)/1.8
Force	Dynamic Forces	lbf	N	4.448
Moment	Torque	lbf-ft	N•m	1.355

DATA SHEET NO. 1

HIGH SPEED CAMERA LOCATIONS AND DATA

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16



DATA SHEET NO. 1 … (CONTINUED)

HIGH SPEED CAMERA LOCATIONS AND DATA

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16

CAMERA LOCATIONS

No.	Camera View	Location (mm)			Lens (mm)	Speed (fps)
		X	Y	Z		
1	Real-Time Left Side Panning View	N/A	N/A	N/A	N/A	29.97
2	Overall Top View	3974	-561	11918	20	1000
3	Zoomed Top View	4081	-558	11966	50	1000
4	Overall Left Side	5011	11691	549	35	1000
5	MCB Left Side	901	16056	365	50	1000
6	Overall Right Side	3122	-9775	115	50	1000
7	OMDB Right Side	875	-14062	985	85	1000
8	Onboard MCB	N/A	N/A	N/A	12	1000
9	Real-Time Left Side View	2389	15374	725	N/A	29.97

Reference point: center most rearward point of the OMDB when in contact with the MCB:

+X = from back of OMDB to front of OMDB

+Y = right of monorail center

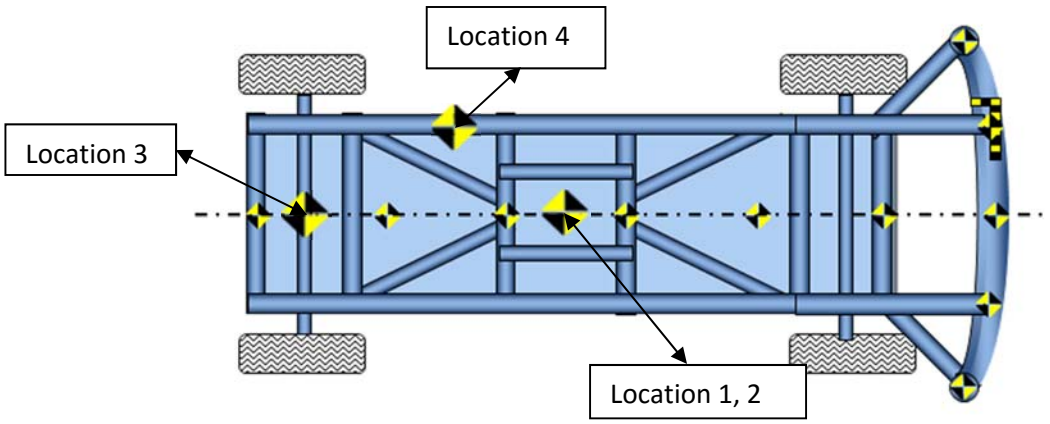
+Z = up from ground

DATA SHEET NO. 2

MCB ACCELEROMETER LOCATIONS

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16



MCB ACCELEROMETER PRE-TEST LOCATIONS

No.	Accelerometer Location	Axes	Units	Location (mm)		
				X	Y	Z
1	Vehicle CG Accelerometers	X, Y, Z	g's	1965	0	324
2	Vehicle CG ARS	X, Y, Z	deg/s	1965	0	324
3	Rear C/L Axle	X, Y, Z	g's	267	0	419
4	Left Rear Frame	X, Y, Z	g's	1437	-498	522

Reference point: center most rearward point of the MCB:

+X = from back of MCB to front of MCB

+Y = from left side of MCB to right side of MCB

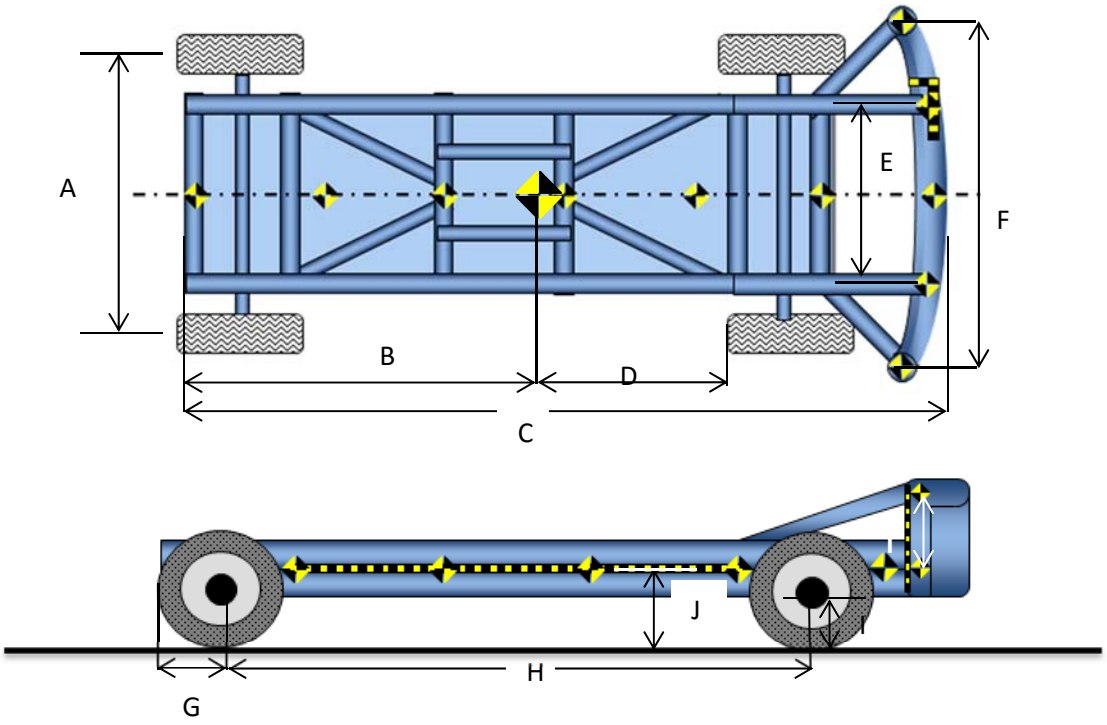
+Z = up from ground

DATA SHEET NO. 3

MCB PHOTOGRAPHIC REFERENCE TARGET LOCATIONS

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16



Item	Value	Item	Value
A	1495	F	1965
B	1970	G	312
C	4135	H	3048
D	1072	I	207
E	1040	J	355

All units in millimeters

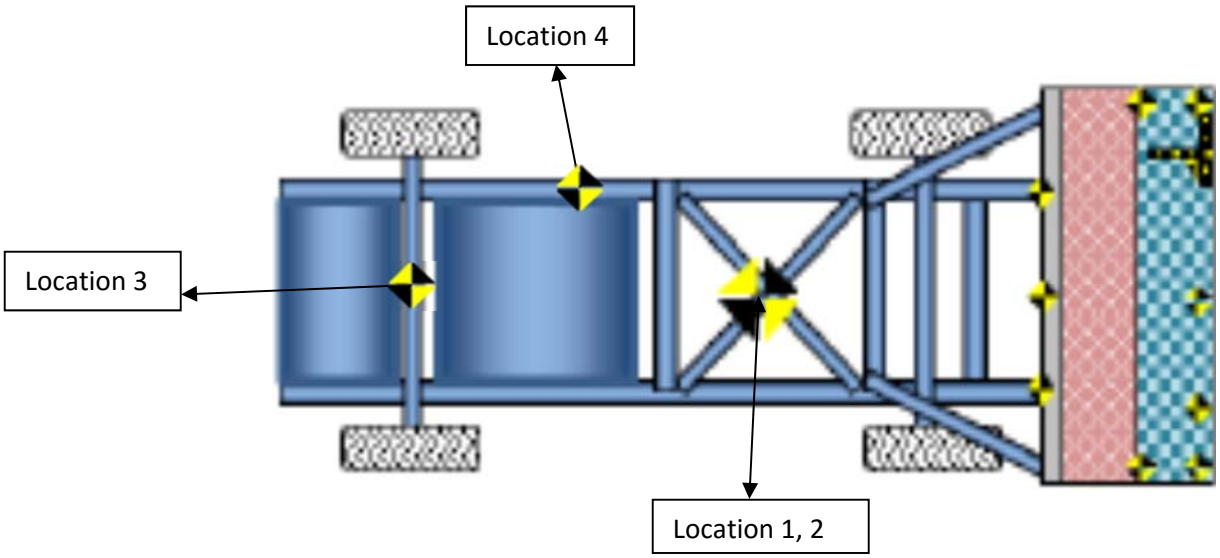
	Units	Front Axle	Rear Axle	Total
Left	kg	522.5	427.0	949.5
Right	kg	525.0	424.0	949.0
Ratio	kg	55.1%	44.8%	100%
Total	kg	1047.5	851.0	1898.5
CG Aft of Front Axle	mm			1366

DATA SHEET NO. 4

OMDB INSTRUMENTATION DATA

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16



OMDB ACCELEROMETER PRE-TEST LOCATIONS

No.	Accelerometer Location	Axes	Units	Location (mm)		
				X	Y	Z
1	Vehicle CG Accelerometers	X, Y, Z	g's	1675	0	6
2	Vehicle CG ARS	X, Y, Z	deg/s	1675	0	6
3	Rear C/L Axle	X, Y, Z	g's	-4	0	-11
4	Left Rear Frame	X, Y, Z	g's	1187	-622	-97

Reference point: Center point, right above the rear axle of the OMDB:

+X = from back of OMDB to front of OMDB

+Y = from left side of OMDB to right side of OMDB

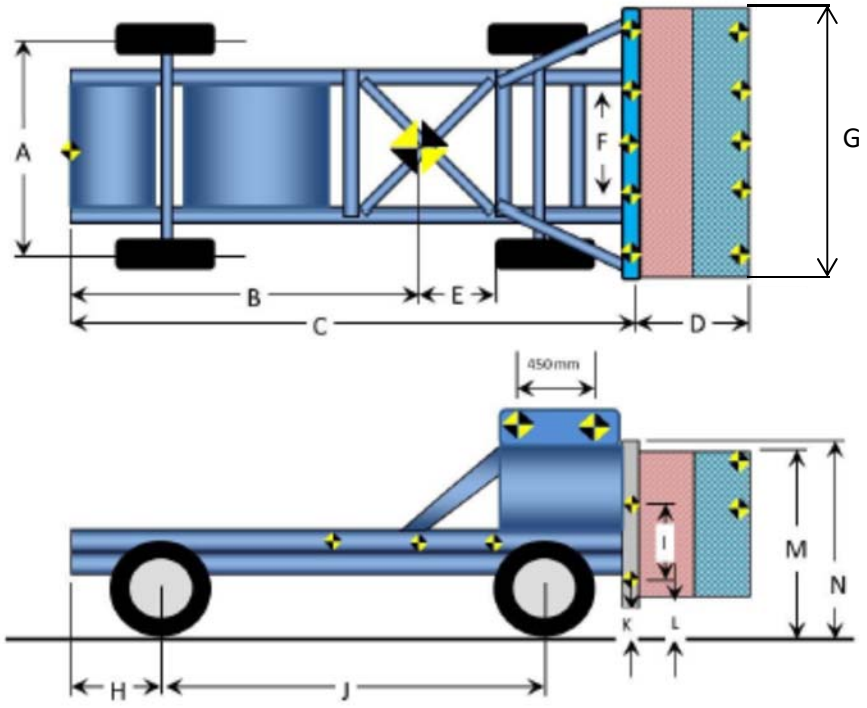
+Z = up from ground

DATA SHEET NO. 5

OMDB PHOTOGRAPHIC REFERENCE TARGET LOCATIONS

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16



Note: All targets on the OMDB honeycomb are 450mm apart unless otherwise noted.

Item	Value	Item	Value
A	1914	H	796
B	2397	I	450
C	3988	J	2590
D	602	K	83
E	986	L	79
F	1202	M	1083
G	2200	N	1183

All units in millimeters

	Units	Front Axle	Rear Axle	Total
Left	kg	764.0	474.0	1238.0
Right	kg	789.0	481.5	1270.5
Ratio	kg	61.9%	38.1%	100.0%
Total	kg	1553.0	955.5	2508.5
CG Aft of Front Axle	mm			987

DATA SHEET NO. 6

TEST VEHICLE SUMMARY OF RESULTS

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16

INSTRUMENTATION

Instrumentation	Number of Channels Collected
MCB Vehicle Accelerometers	12
OMDB Vehicle Accelerometers	12
Total	24

CAMERA COVERAGE

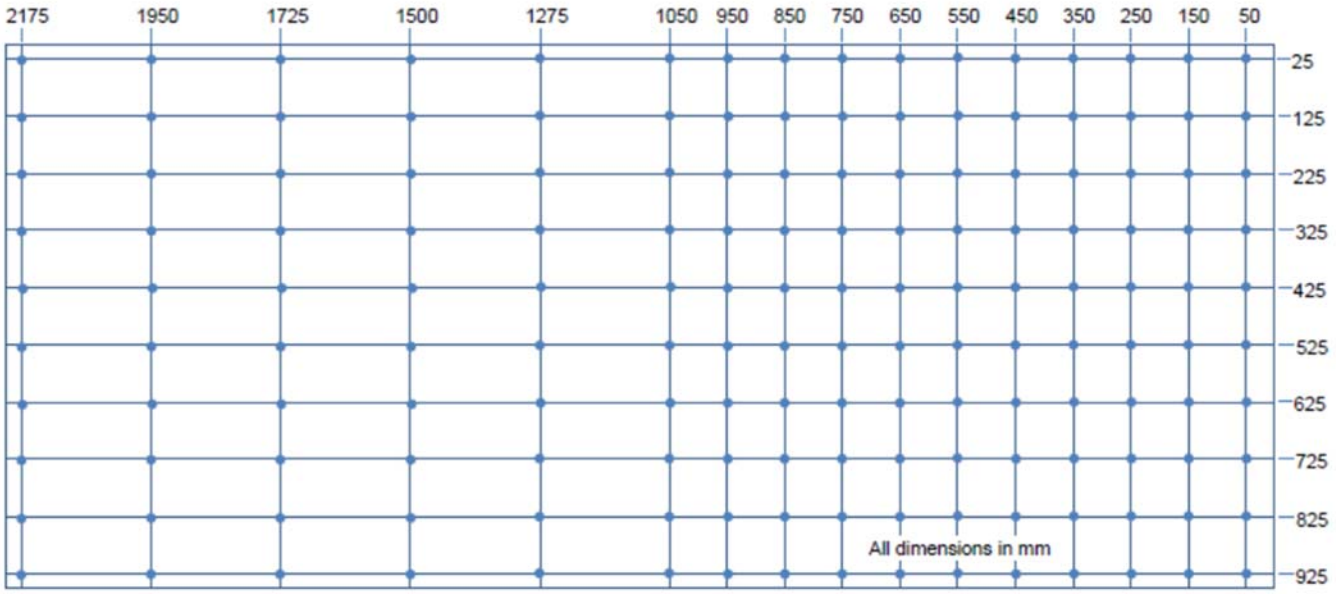
Type of Camera	Number Used in this Test
High-Speed Vehicle Onboard	1
High-Speed Off-Board	6
Real-Time Panning	2
Total	9

DATA SHEET NO. 7

OMDB CRUSH MEASUREMENTS

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16

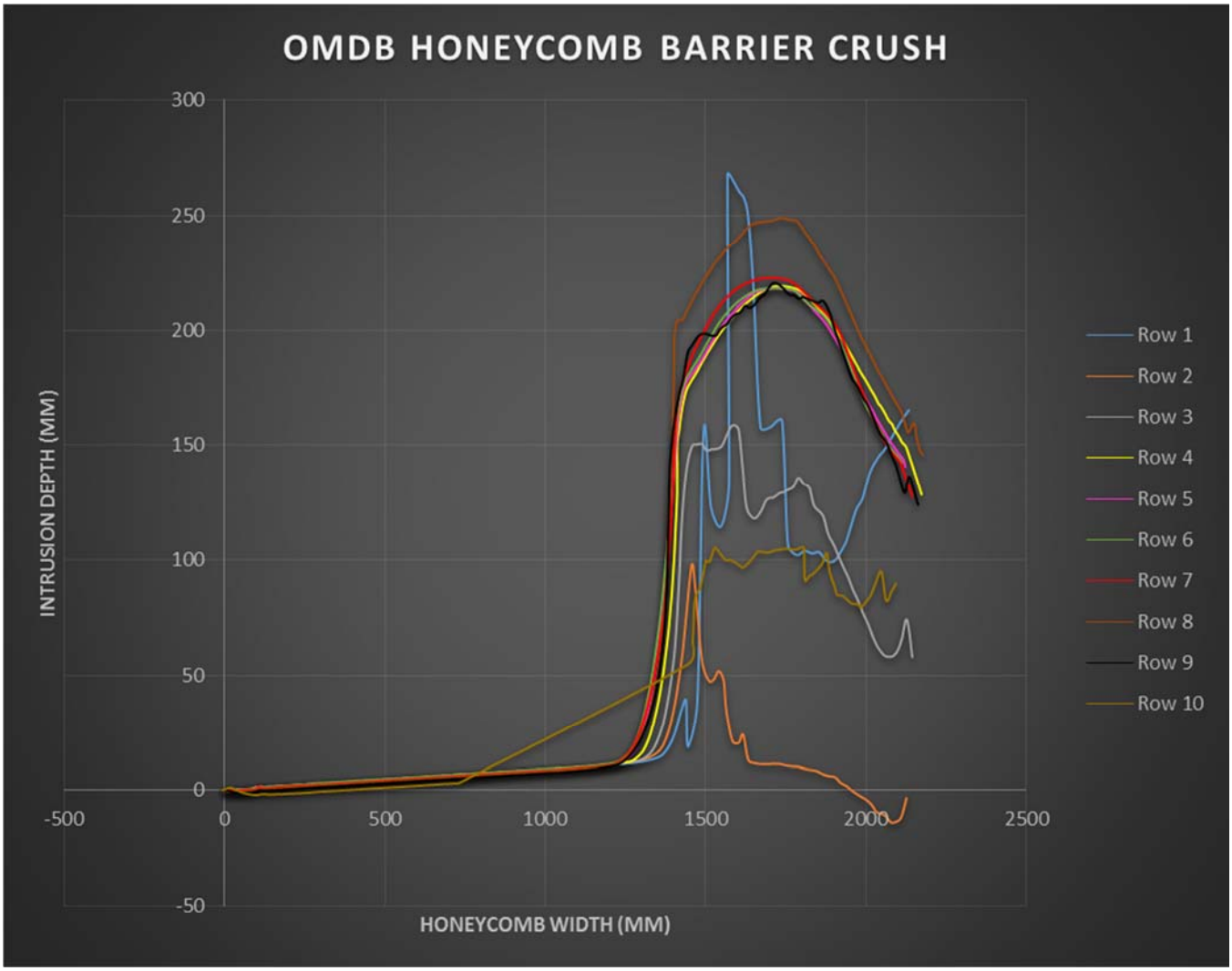


DATA SHEET NO. 7 … (CONTINUED)

OMDB CRUSH MEASUREMENTS

Test Vehicle: OMDB (Full Face) to MCB NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35% Test Date: 05/25/16



APPENDIX A

PHOTOGRAPHS

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FIGURE 1. Pre-Test Right View of OMDB and MCB

FIGURE 2. Pre-Test Left View of OMDB and MCB

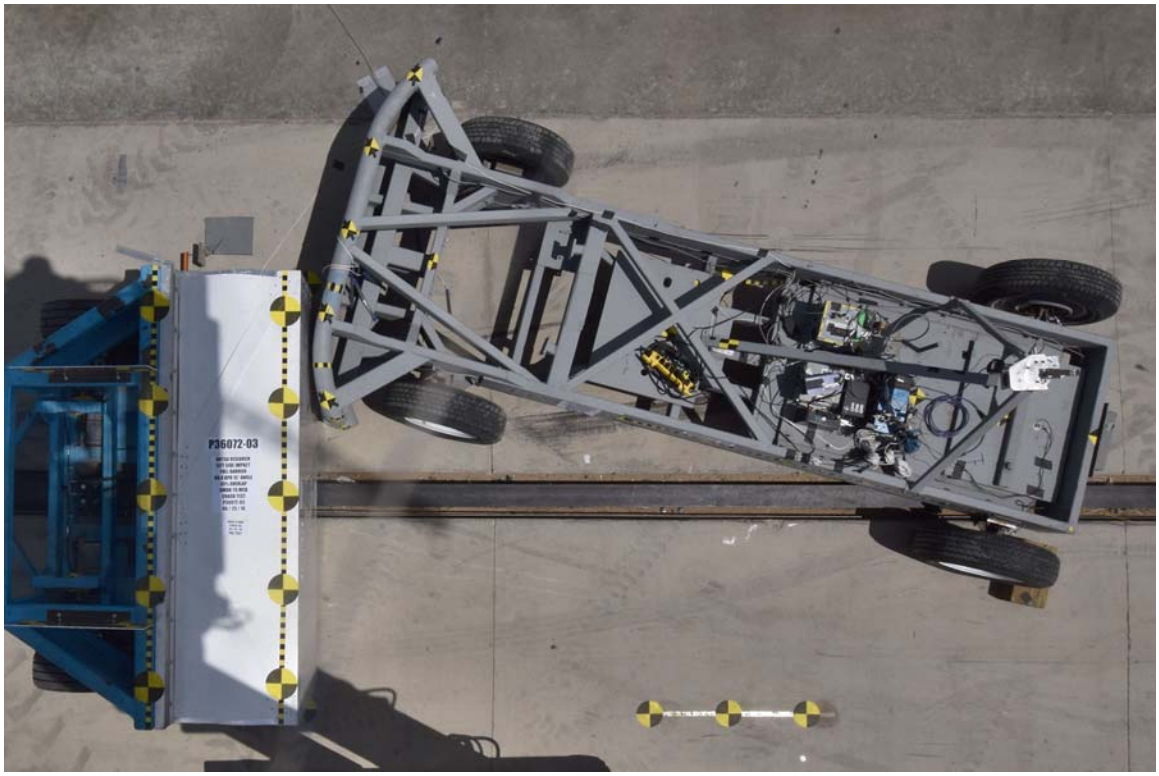


FIGURE 3. Pre-Test Top View of OMDB and MCB

FIGURE 4. Post-Test Top View of OMDB and MCB

FIGURE 5. Pre-Test Close-up View Of Impact Point

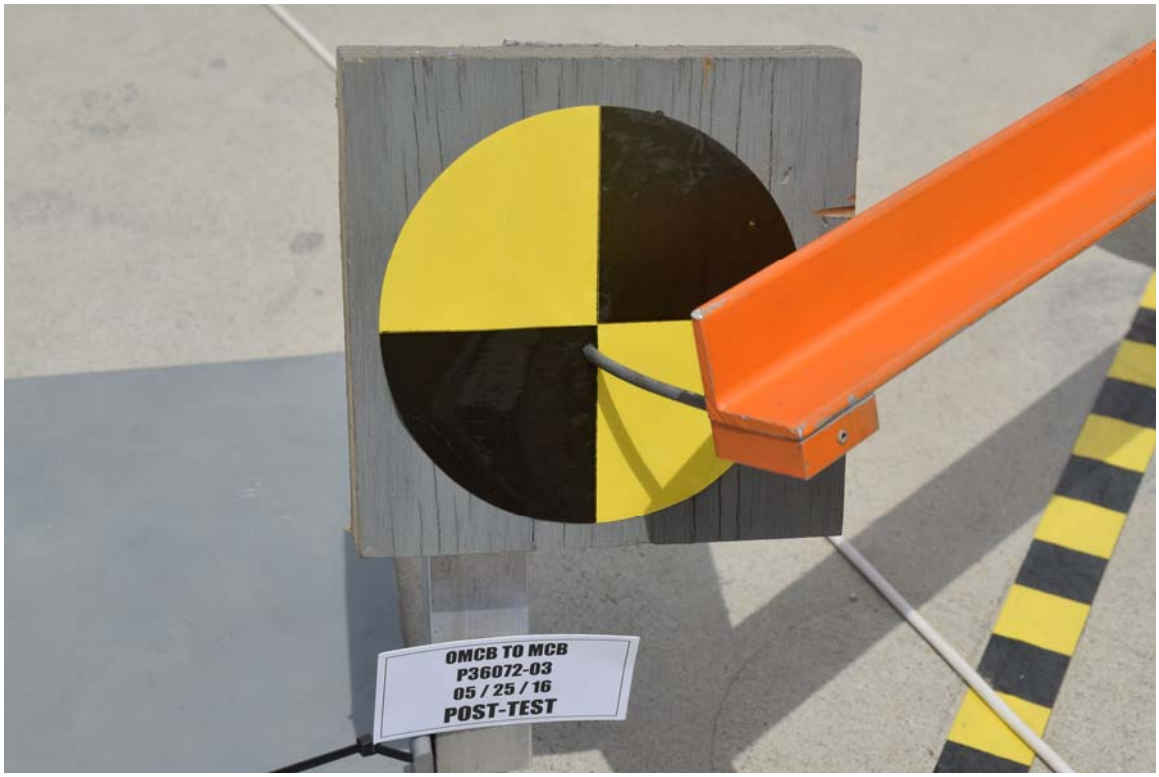


FIGURE 6. Post-Test Close-up View Of Impact Point

FIGURE 7. Pre-Test Right View of MCB

FIGURE 8. Post-Test Right View of MCB

FIGURE 9. Pre-Test Right Front ¾ View of MCB

FIGURE 10. Post-Test Right Front ¾ View of MCB

FIGURE 11. Pre-Test Front View of MCB

FIGURE 12. Post-Test Front View of MCB

FIGURE 13. Pre-Test Left Front ¾ View of MCB

FIGURE 14.Post-Test Left Front ¾ View of MCB

FIGURE 15. Pre-Test Left View of MCB

FIGURE 16. Post-Test Left View of MCB

FIGURE 17. Pre-Test Left View of OMDB Impactor Face

FIGURE 18. Post-Test Left View of OMDB Impactor Face

FIGURE 19. Pre-Test Right View of OMDB Impactor Face

FIGURE 20. Post-Test Right View of OMDB Impactor Face

FIGURE 21. Pre-Test Top View of OMDB Impactor Face

FIGURE 22. Post-Test Top View of OMDB Impactor Face

FIGURE 23. Pre-Test Front View of OMDB Impactor Face

FIGURE 24. Post-Test Front View of OMDB Impactor Face

FIGURE 25. Pre-Test Right View of OMDB

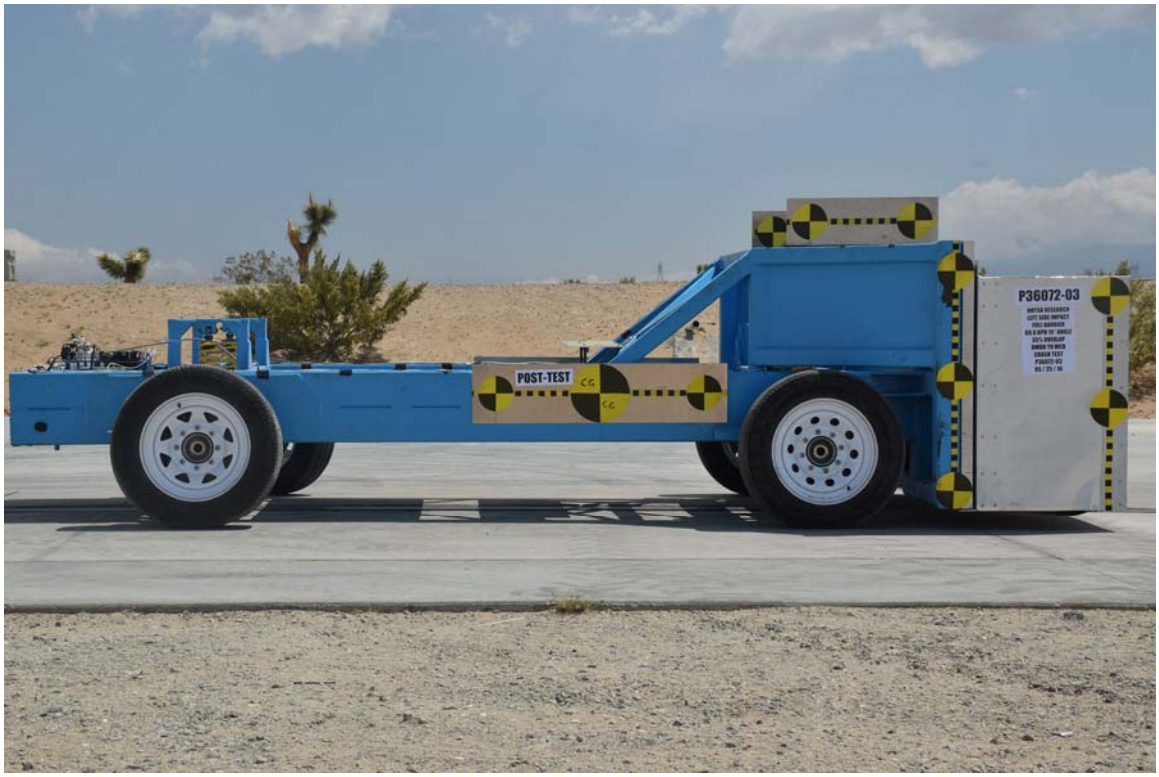


FIGURE 26. Post-Test Right View of OMDB

FIGURE 27. Pre-Test Left View of OMDB

FIGURE 28. Post-Test Left View of OMDB

FIGURE 29. Pre-Test OMDB and MCB Alignment

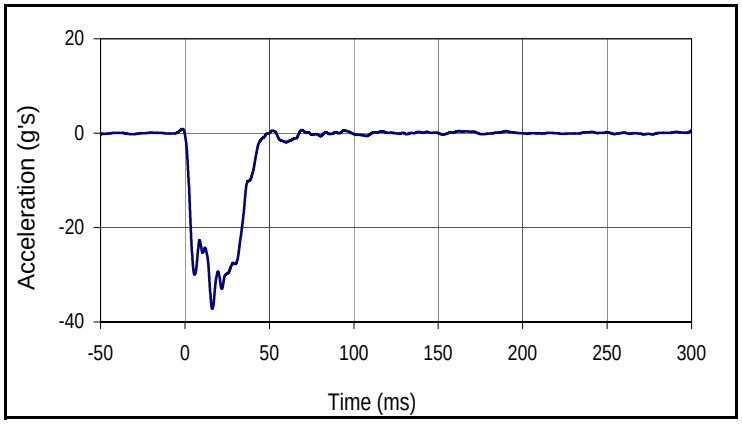
FIGURE 30. Impact Event

APPENDIX B

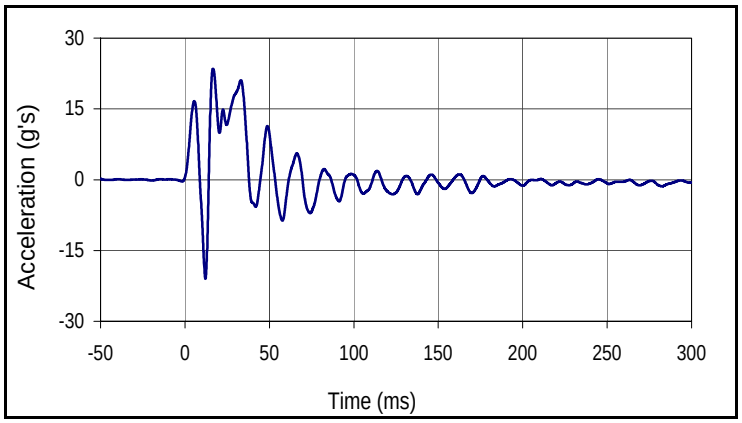
DATA PLOTS

TABLE OF DATA PLOTS

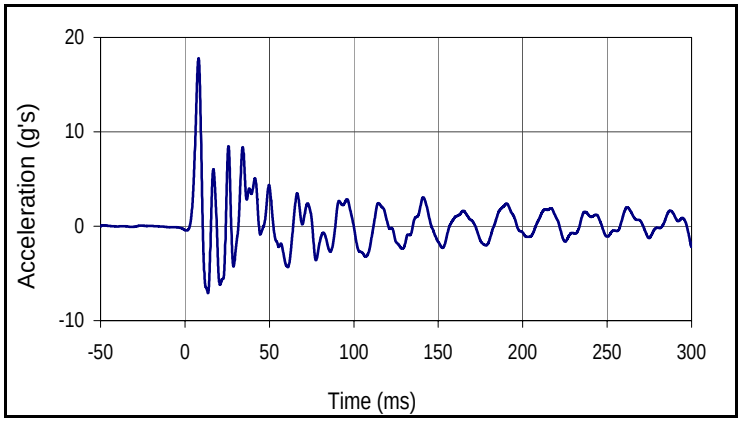
Test Vehicle:	OMDB (Full Face) to MCB	NHTSA No.:	N/A
Test Program:	NHTSA R&D Left Oblique Offset 15deg/35%	Test Date:	5/25/16



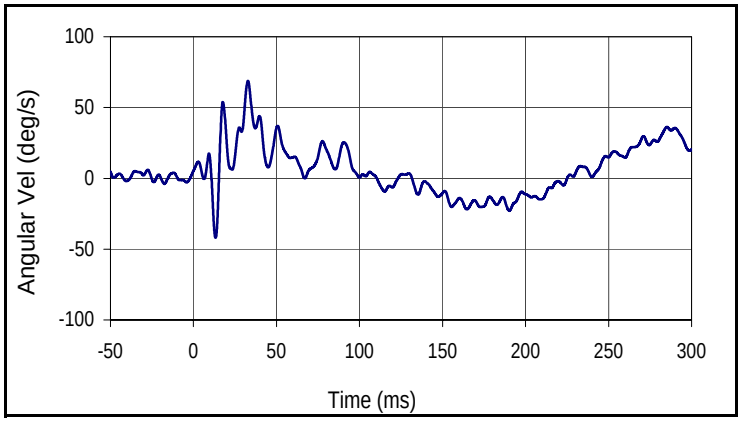
Curve Description			
V2 MCB CG X Acceleration			
Plot No.		SAE Class	Units
001		60	g's
Max	Time	Min	Time
0.9	-1.5	-37.2	16.2



Curve Description			
V2 MCB CG Y Acceleration			
Plot No.		SAE Class	Units
002		60	g's
Max	Time	Min	Time
23.5	16.6	-21.0	12.1

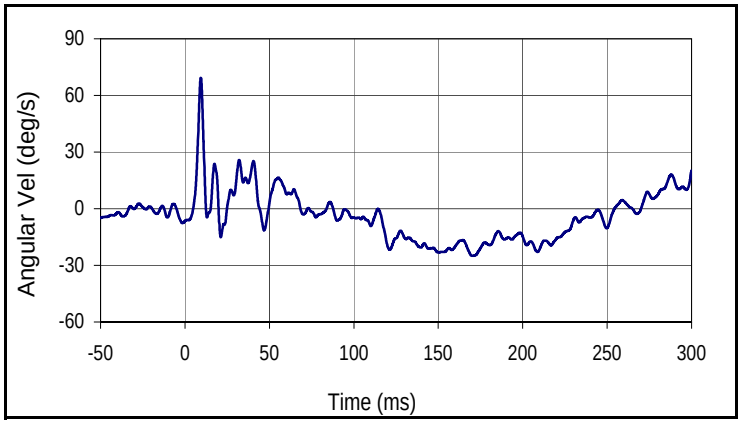


Curve Description			
V2 MCB CG Z Acceleration			
Plot No.		SAE Class	Units
003		60	g's
Max	Time	Min	Time
17.8	8.1	-7.1	13.7

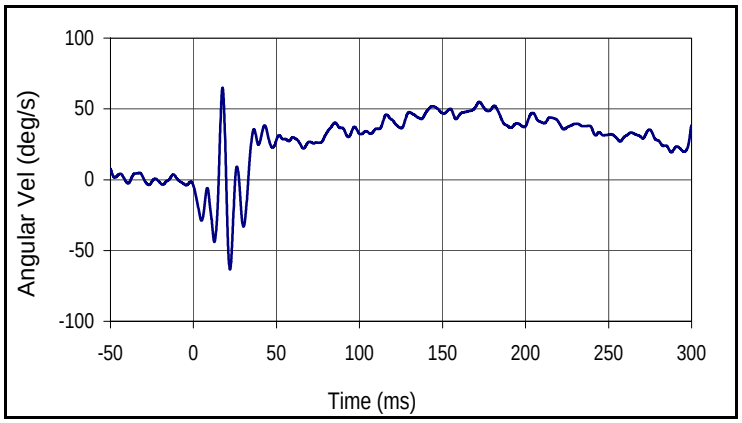


Curve Description			
V2 MCB CG Angular Rate X			
Plot No.		SAE Class	Units
004		60	deg/s
Max	Time	Min	Time
68.9	32.8	-42.0	13.3

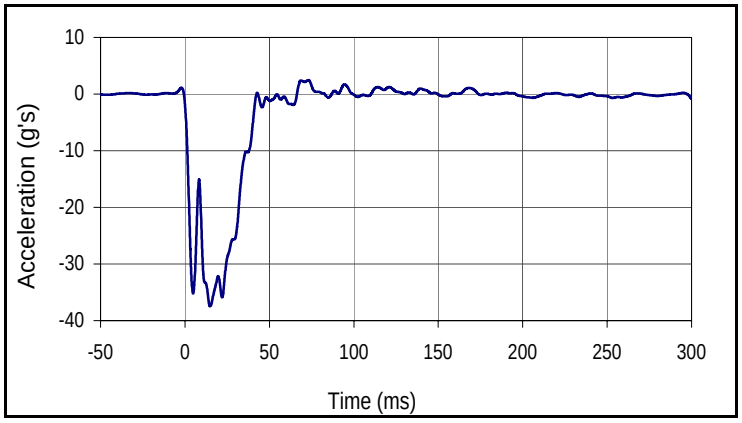
Test Vehicle:	OMDB (Full Face) to MCB	NHTSA No.:	N/A
Test Program:	NHTSA R&D Left Oblique Offset 15deg/35%	Test Date:	5/25/16



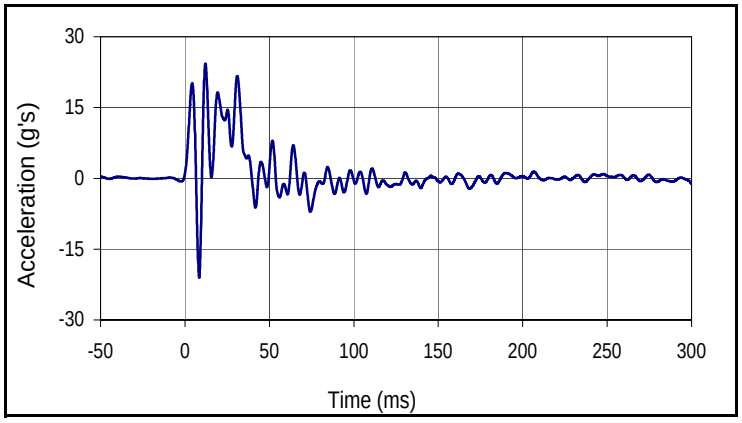
Curve Description			
V2 MCB CG Angular Rate Y			
Plot No.		SAE Class	Units
005		60	deg/s
Max	Time	Min	Time
69.4	9.4	-25.0	170.1



Curve Description			
V2 MCB CG Angular Rate Z			
Plot No.		SAE Class	Units
006		60	deg/s
Max	Time	Min	Time
65.1	17.5	-63.4	22.0

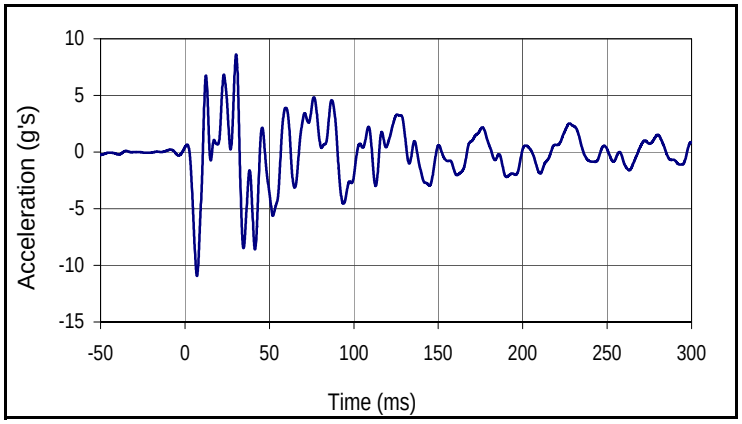


Curve Description			
V2 MCB Rear C/L X Acceleration			
Plot No.		SAE Class	Units
007		60	g's
Max	Time	Min	Time
2.5	73.2	-37.5	14.9

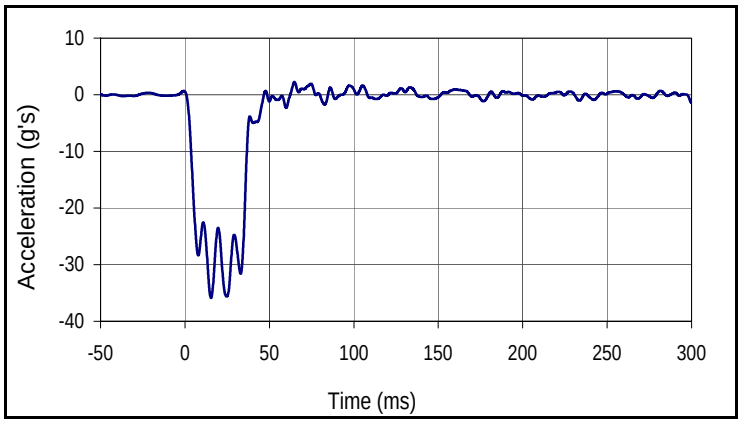


Curve Description			
V2 MCB Rear C/L Y Acceleration			
Plot No.		SAE Class	Units
008		60	g's
Max	Time	Min	Time
24.3	12.1	-21.1	8.4

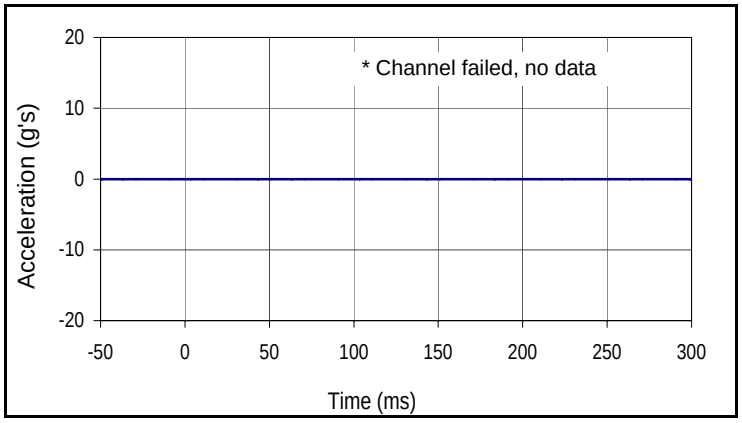
Test Vehicle:	OMDB (Full Face) to MCB	NHTSA No.:	N/A
Test Program:	NHTSA R&D Left Oblique Offset 15deg/35%	Test Date:	5/25/16



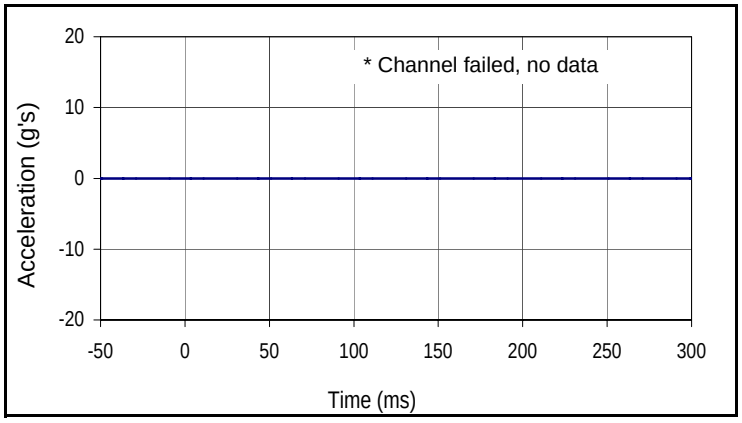
Curve Description			
V2 MCB Rear C/L Z Acceleration			
Plot No.		SAE Class	Units
009		60	g's
Max	Time	Min	Time
8.6	30.3	-10.9	7.1



Curve Description			
V1 MCB Left Frame X Acceleration			
Plot No.		SAE Class	Units
010		60	g's
Max	Time	Min	Time
2.3	64.8	-35.9	15.4

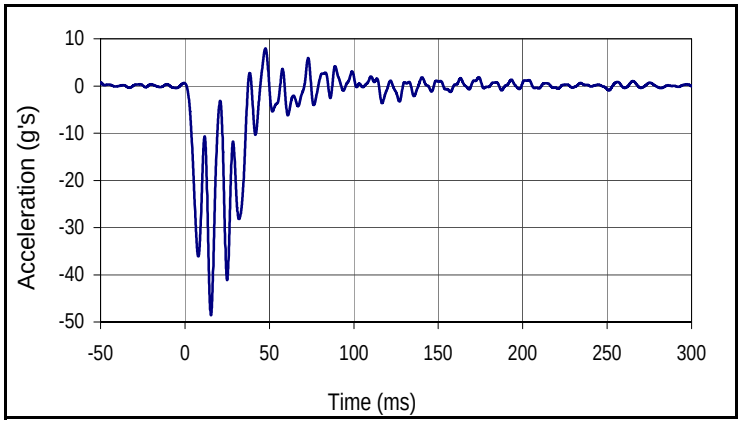


Curve Description			
V1 MCB Left Frame Y Acceleration			
Plot No.		SAE Class	Units
011		60	g's
Max	Time	Min	Time
0.0	-20.0	0.0	-20.0

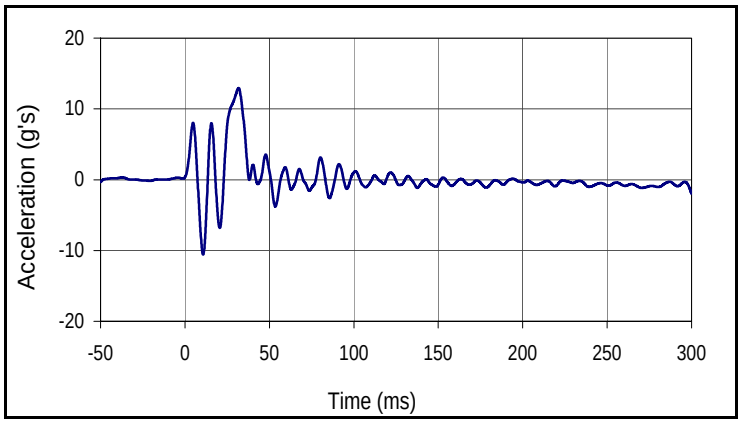


Curve Description			
V1 MCB Left Frame Z Acceleration			
Plot No.		SAE Class	Units
012		60	g's
Max	Time	Min	Time
0.0	-20.0	0.0	-20.0

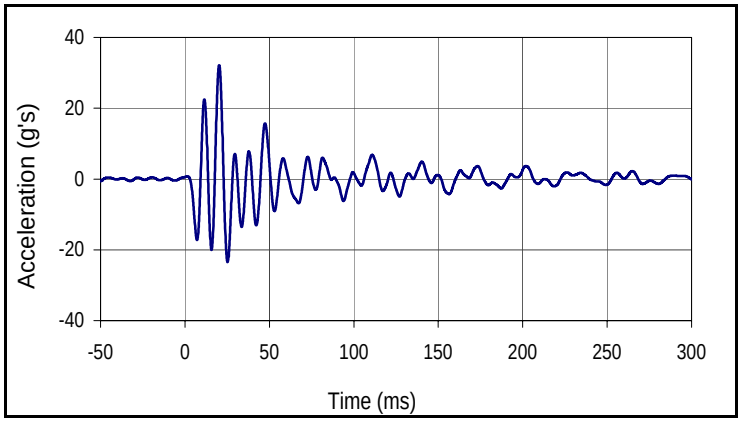
Test Vehicle:	OMDB (Full Face) to MCB	NHTSA No.:	N/A
Test Program:	NHTSA R&D Left Oblique Offset 15deg/35%	Test Date:	5/25/16



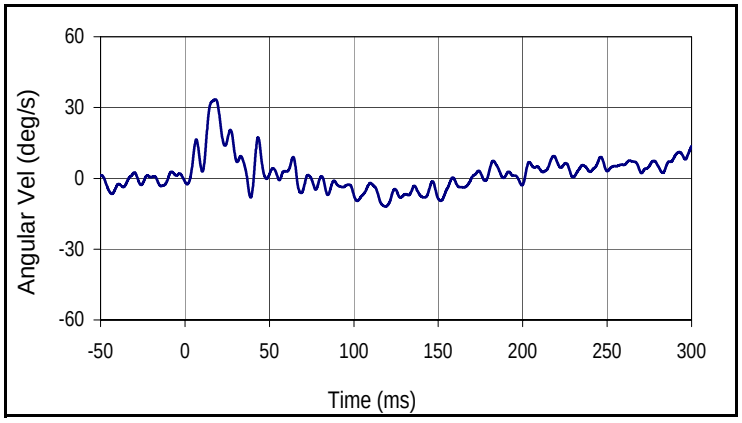
Curve Description			
V1 OMDB CG X Acceleration			
Plot No.		SAE Class	Units
013		60	g's
Max	Time	Min	Time
7.9	47.6	-48.6	15.4



Curve Description			
V1 OMDB CG Y Acceleration			
Plot No.		SAE Class	Units
014		60	g's
Max	Time	Min	Time
12.9	31.8	-10.6	10.7

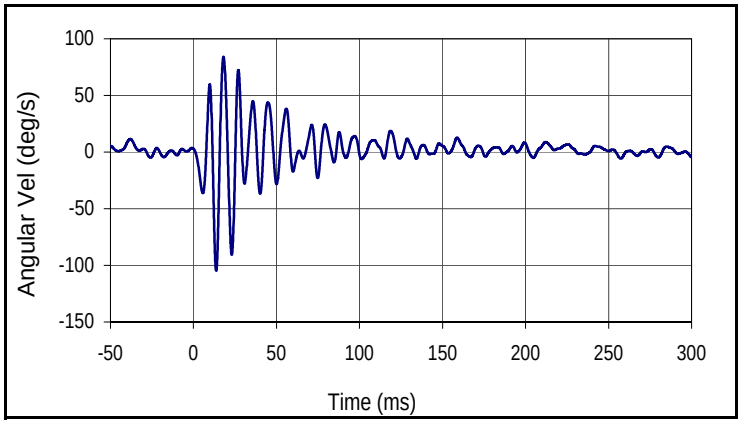


Curve Description			
V1 OMDB CG Z Acceleration			
Plot No.		SAE Class	Units
015		60	g's
Max	Time	Min	Time
32.1	20.3	-23.4	25.2

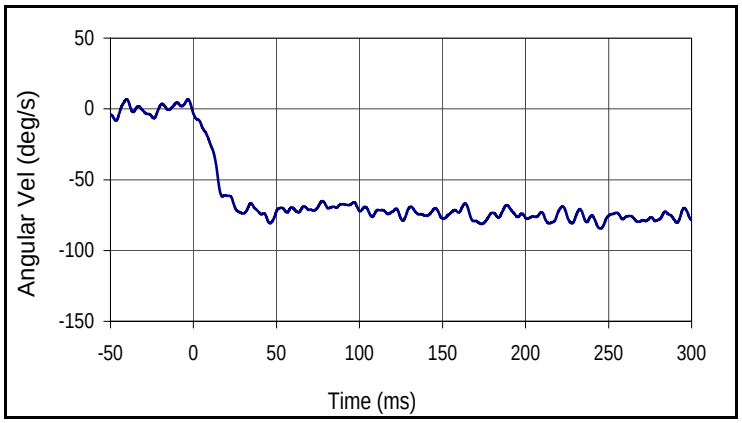


Curve Description			
V1 OMDB Angular Rate X			
Plot No.		SAE Class	Units
016		60	deg/s
Max	Time	Min	Time
33.5	18.0	-12.0	118.7

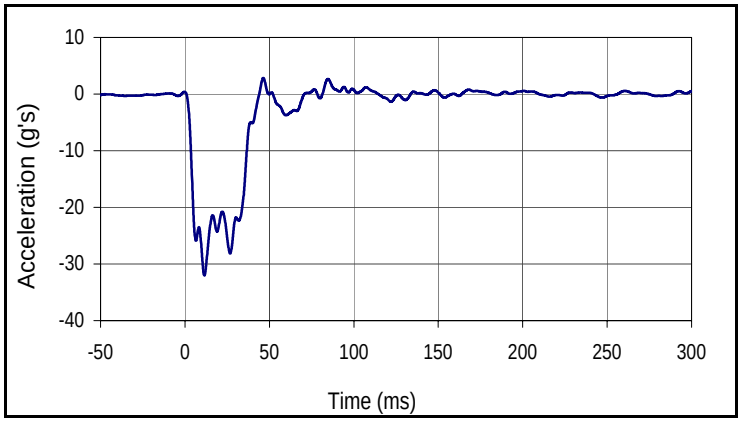
Test Vehicle:	OMDB (Full Face) to MCB	NHTSA No.:	N/A
Test Program:	NHTSA R&D Left Oblique Offset 15deg/35%	Test Date:	5/25/16



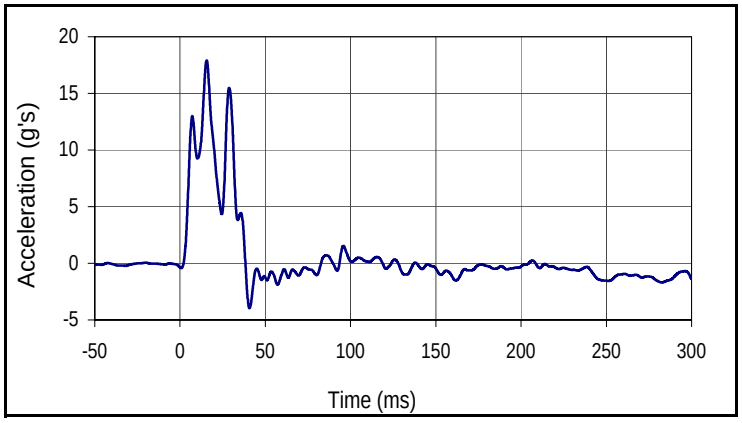
Curve Description			
V1 OMDB Angular Rate Y			
Plot No.		SAE Class	Units
017		60	deg/s
Max	Time	Min	Time
84.1	18.1	-104.9	13.7



Curve Description			
V1 OMDB Angular Rate Z			
Plot No.		SAE Class	Units
018		60	deg/s
Max	Time	Min	Time
6.9	-3.3	-84.6	245.2

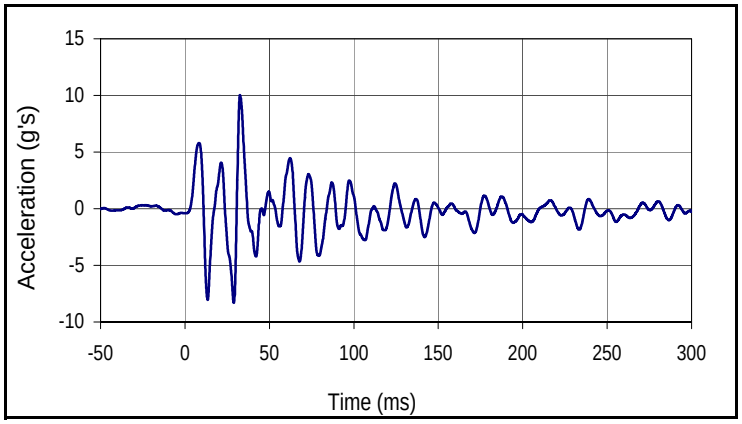


Curve Description			
V1 OMDB Rear C/L X Acceleration			
Plot No.		SAE Class	Units
019		60	g's
Max	Time	Min	Time
2.8	46.4	-32.0	11.5

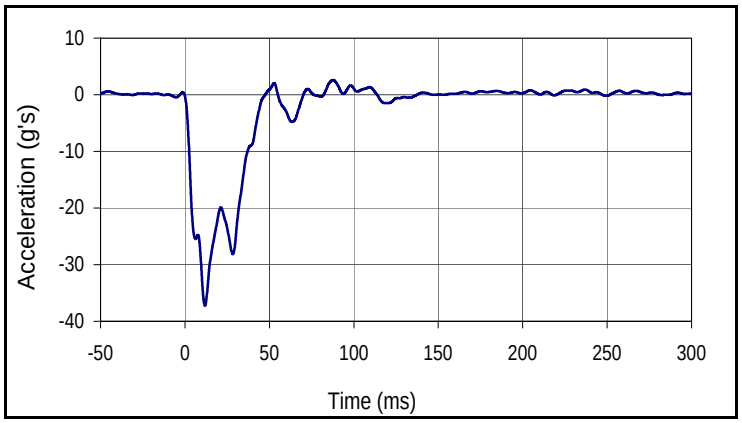


Curve Description			
V1 OMDB Rear C/L Y Acceleration			
Plot No.		SAE Class	Units
020		60	g's
Max	Time	Min	Time
17.9	15.6	-4.0	40.7

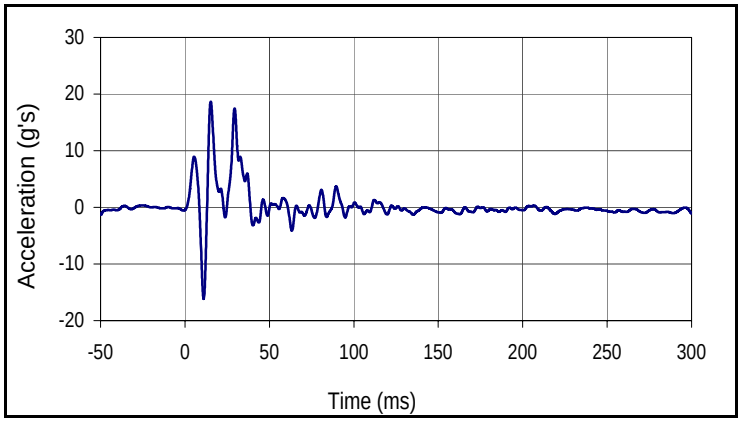
Test Vehicle:	OMDB (Full Face) to MCB	NHTSA No.:	N/A
Test Program:	NHTSA R&D Left Oblique Offset 15deg/35%	Test Date:	5/25/16



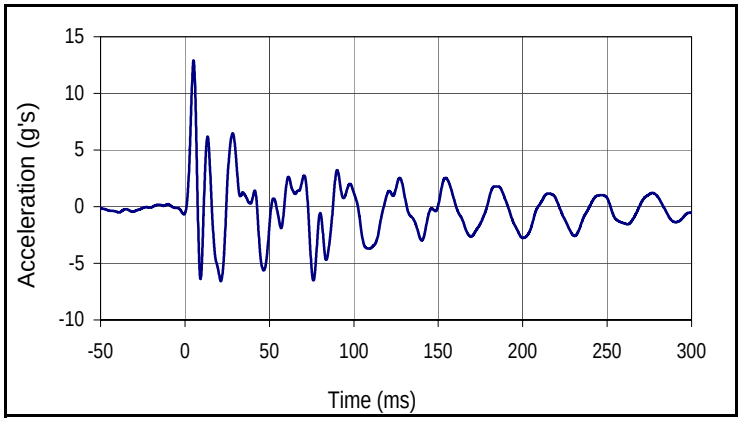
Curve Description			
V1 OMDB Rear C/L Z Acceleration			
Plot No.		SAE Class	Units
021		60	g's
Max	Time	Min	Time
10.0	32.6	-8.3	28.9



Curve Description			
V1 OMDB Left Frame X Acceleration			
Plot No.		SAE Class	Units
022		60	g's
Max	Time	Min	Time
2.6	87.8	-37.2	11.8



Curve Description			
V1 OMDB Left Frame Y Acceleration			
Plot No.		SAE Class	Units
023		60	g's
Max	Time	Min	Time
18.7	15.3	-16.1	11.1



Curve Description			
V1 OMDB Left Frame Z Acceleration			
Plot No.		SAE Class	Units
024		60	g's
Max	Time	Min	Time
12.9	5.1	-6.6	21.3