

**REPORT NUMBER: R&D-KAR-16-008**

**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: 05/27/2016**


**PREPARED BY:  
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**FINAL REPORT SUBMITTED  
July 18, 2016**

**PREPARED FOR  
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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: 05/27/16

<b>Report No.</b> R&D-KAR-16-008	<b>Government Accession No.</b>	<b>Recipient's Catalog No.</b>	
<b>Title and Subtitle</b> Report for Frontal Oblique Offset Program Testing of a OMDB to MCB		<b>Report Date</b> July 18, 2016	
		<b>Performing Organization Code</b> KAR	
<b>Author(s)</b> Mr. Robert S. Ramos, Project Engineer, KARCO Mr. Frank Richardson, Program Manager, KARCO		<b>Performing Organization Report No.</b>  TR-P36072-05-NC	
		<b>Work Unit No.</b>	
<b>Performing Organization Name and Address</b> KARCO Engineering, LLC. 9270 Holly Rd. Adelanto, CA 92301		<b>Contract or Grant No.</b> DTNH22-14-D-00360	
		<b>Type of Report and Period Covered</b>  Final Test Report, May 27 – July 18, 2016	
<b>Sponsoring Agency Name and Address</b> DOT / National Highway Traffic Safety Administration Office of Vehicle Safety Research 1200 New Jersey Ave., SE, Room W46-446 Washington, D.C. 20590		<b>Sponsoring Agency Code</b> NSR210	
<b>Supplementary Notes</b>			
<b>Abstract</b> 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 27, 2016. The OMDB impact velocity was 59.83 km/h and the ambient temperature at the test vehicle at the time of impact was 28.0°C. The OMDB maximum static crush was 247.1 mm.			
<b>Key Words</b> Oblique Offset Contoured OMDB MCB		<b>Distribution Statement.</b> Copies of this report are available from:	
		National Highway Traffic Safety Administration Technical Reference Division 1200 New Jersey Ave., SE. Washington, D.C. 20590	
<b>Security Classif. (of this report)</b> UNCLASSIFIED	<b>Security Classif. (of this Page)</b> UNCLASSIFIED	<b>No. of Pages</b> 42	<b>Price</b>

Form DOT F1700.7 (8-72)

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**SECTION 1**  
**TEST PURPOSE**

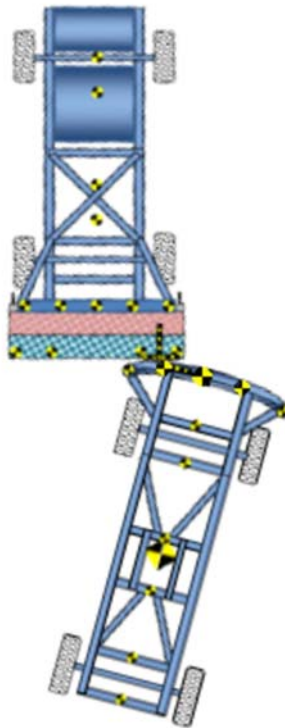
This 60.0 km/h (37.3 mph) Oblique Moving Deformable Barrier (OMDB) into a Moving Contoured Barrier (MCB) test is part of Frontal Oblique Offset Program sponsored by the National Highway Traffic Safety Administration (NHTSA) under Contract No. DTNH22-14-D-00360, Task Order #0002. The purpose of this test 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 27, 2016.

The OMDB impacted the MCB at a speed of 59.83 km/h. After impact the OMDB turned 118.2° coming to rest 6.55 m forward and 1.00 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 impact the MCB rotated 84.0° and traveled 13.28 m rearward and 5.94 m left of its initial position.

The test was documented by three (3) 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	59.83
OMDB Test Weight	kg	2508.5
OMDB Maximum Static Crush	mm	247.1
MCB Test Weight	kg	1898.5
Actual MCB Angle	°	15.0
Vertical Offset from Target Point (+ down / - up)*	mm	12
Lateral Offset from Target Point (+ left / - right)*	mm	-4
Number of Data Channels		24
Number of Real-Time Cameras		3
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: 05/27/16

#### 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 <sup>2</sup>	kPa	6.895
Temperature	General Use	°F	°C	$=(T_f - 32)/1.8$
Force	Dynamic Forces	lbf	N	4.448
Moment	Torque	lbf-ft	N•m	1.355

**DATA SHEET NO. 1**

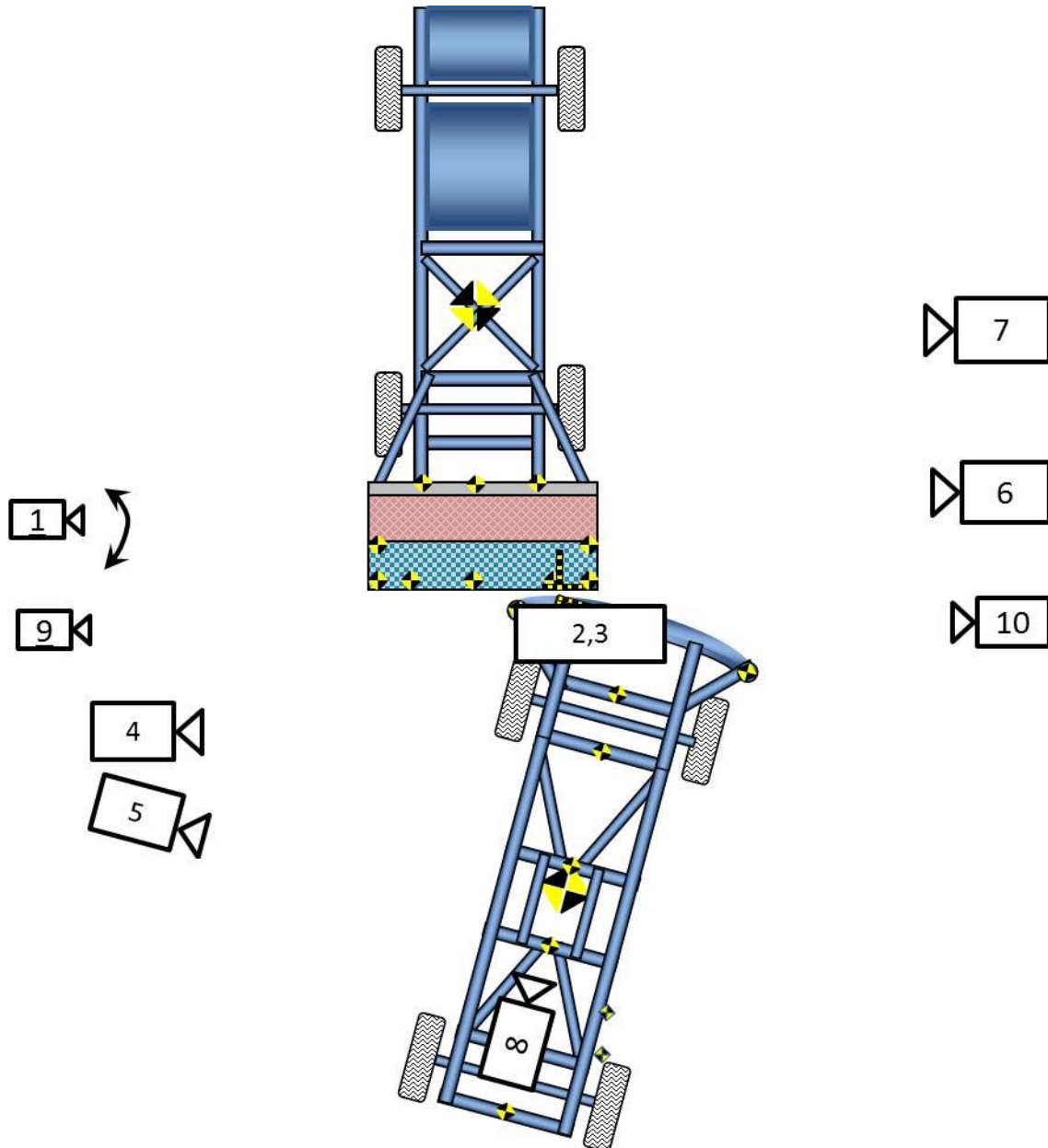
**HIGH SPEED CAMERA LOCATIONS AND DATA**

Test Vehicle: OMDB (Full Face) to MCB

NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35%

Test Date: 05/27/16



**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: 05/27/16

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	3736	-291	12697	20	1000
3	Zoomed Top View	N/A	N/A	N/A	50	1000
4	Overall Left Side	5054	11698	131	35	1000
5	MCB Left Side	940	16037	970	50	1000
6	Overall Right Side	2328	-8534	625	50	1000
7	OMDB Right Side	907	-14046	401	85	1000
8	Onboard MCB	N/A	N/A	N/A	12	1000
9	Real-Time Left Side View	N/A	N/A	N/A	N/A	29.97
10	Real-Time Right Side View	N/A	N/A	N/A	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

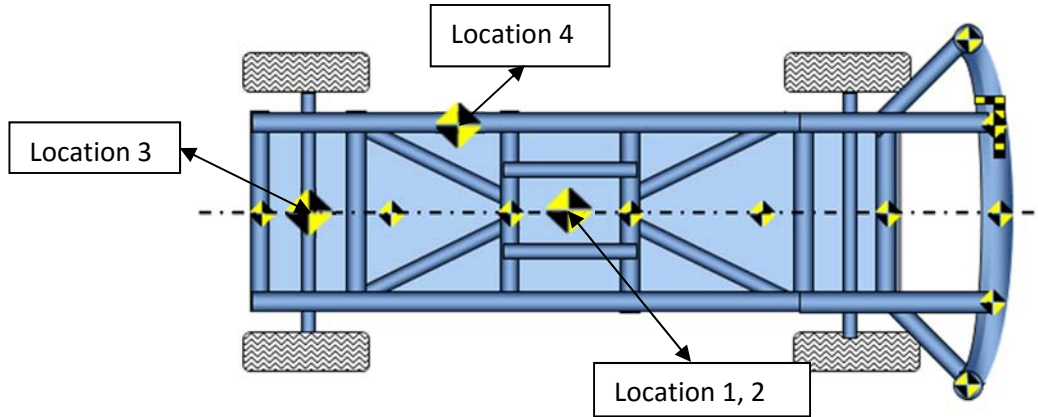
+Z = up from ground

**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: 05/27/16



**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

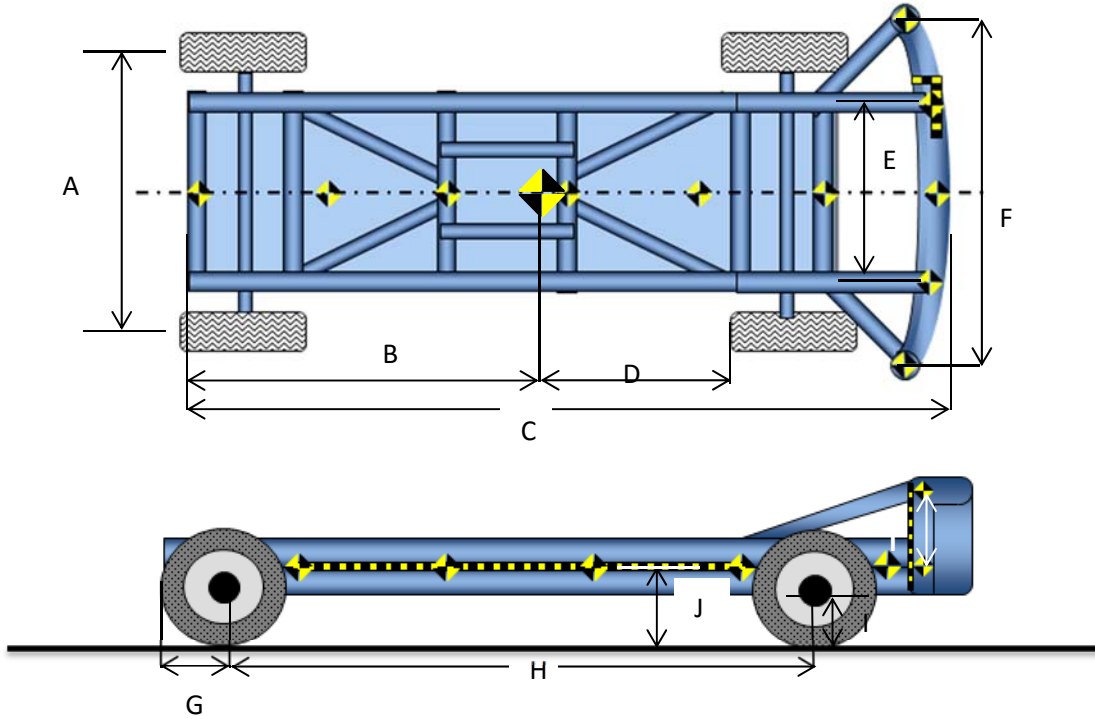
+Z = up from ground

**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: 05/27/16



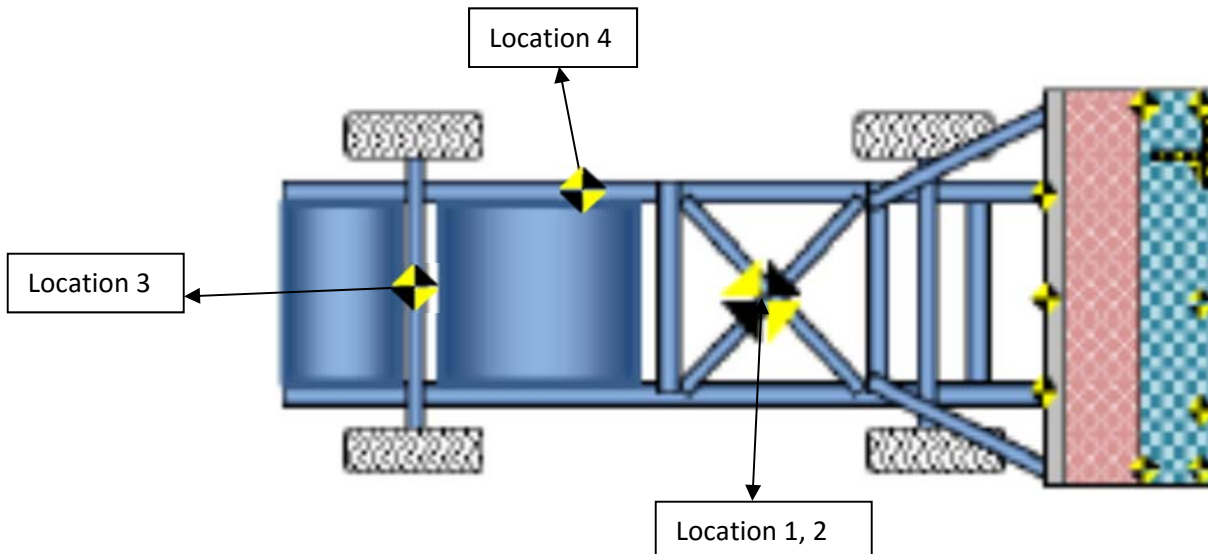
Item	Value	Item	Value
A	1495	F	1965
B	1970	G	312
C	4135	H	3048
D	1072	I	207
E	1040	J	355

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: 05/27/16



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:

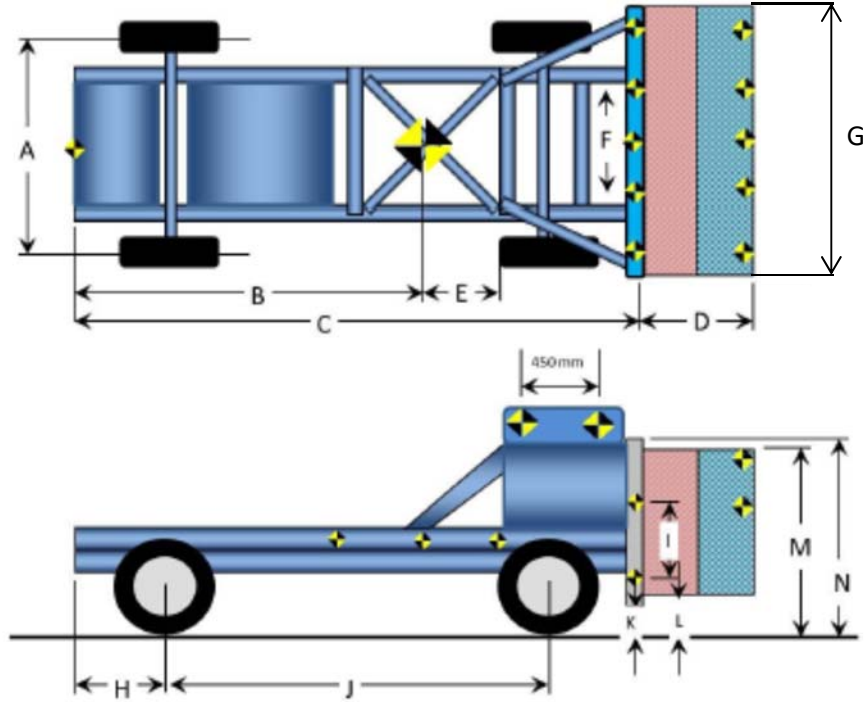
- +X = from back of OMDB to front of OMDB
- +Y = from left side of OMDB to right side of OMDB
- +Z = up from ground

**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: 05/27/16



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	89
E	986	L	79
F	1202	M	1089
G	2200	N	1189

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: 05/27/16

**INSTRUMENTATION**

<b>Instrumentation</b>	<b>Number of Channels Collected</b>
MCB Vehicle Accelerometers	12
OMDB Vehicle Accelerometers	12
<b>Total</b>	<b>24</b>

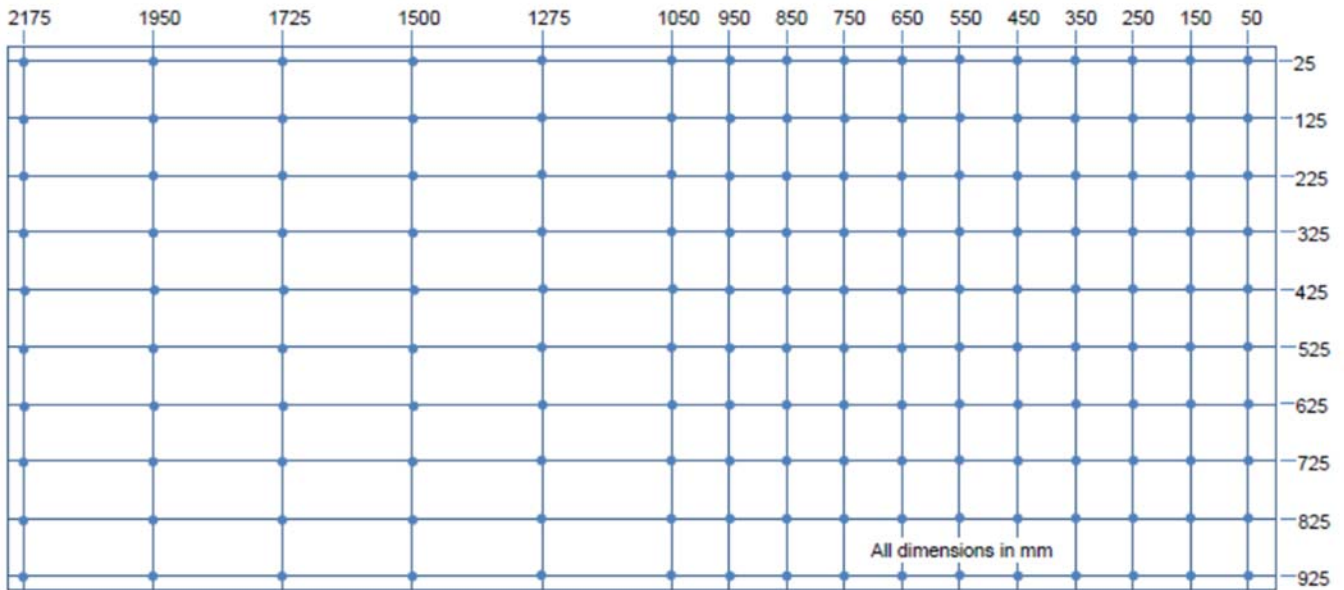
**CAMERA COVERAGE**

<b>Type of Camera</b>	<b>Number Used in this Test</b>
High-Speed Vehicle Onboard	1
High-Speed Off-Board	6
Real-Time Panning	3
<b>Total</b>	<b>10</b>

**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: 05/27/16



**DATA SHEET NO. 7 ... (CONTINUED)**

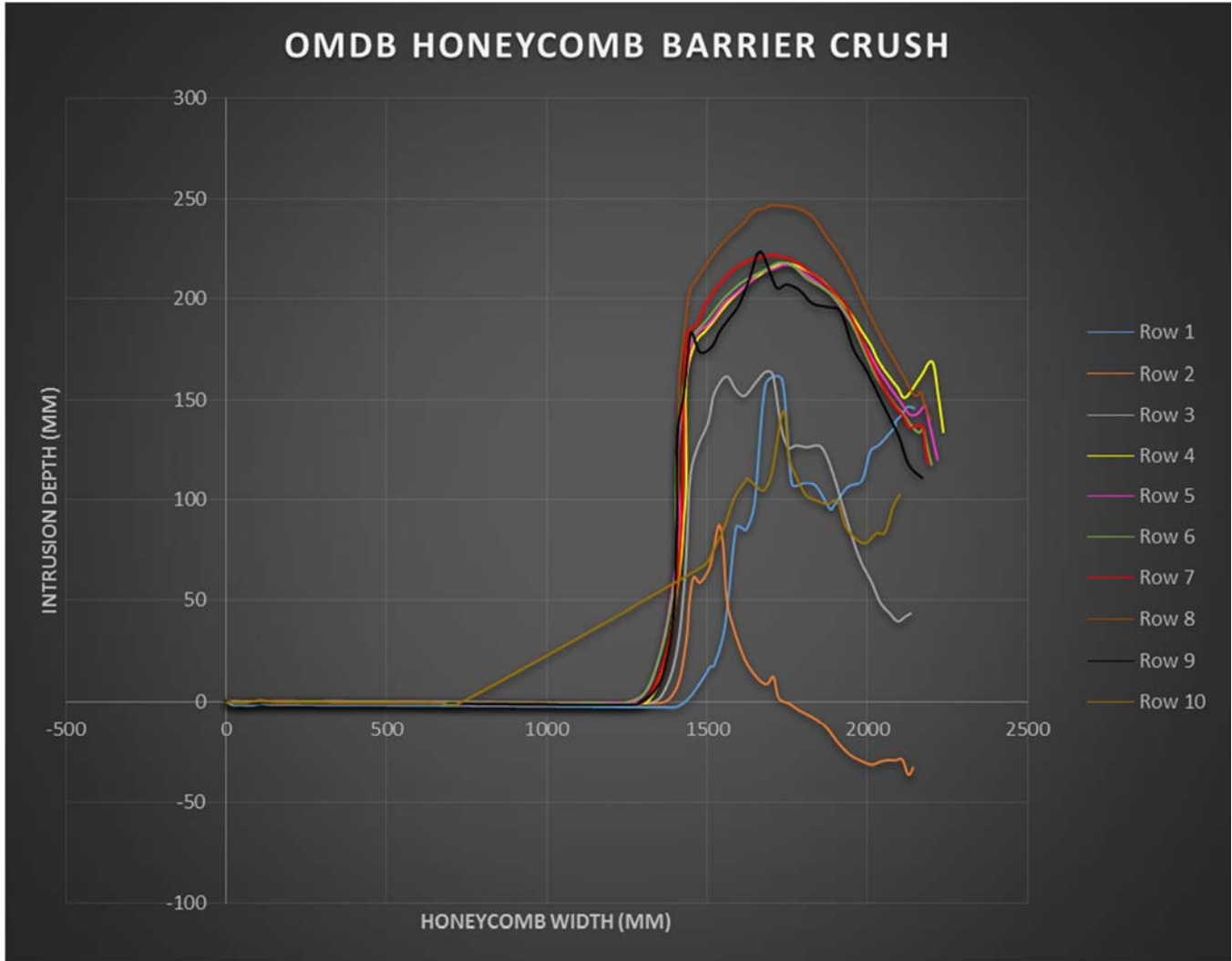
**OMDB CRUSH MEASUREMENTS**

Test Vehicle: OMDB (Full Face) to MCB

NHTSA No. N/A

Test Program: NHTSA R&D Left Oblique Offset 15deg/35%

Test Date: 05/27/16



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



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

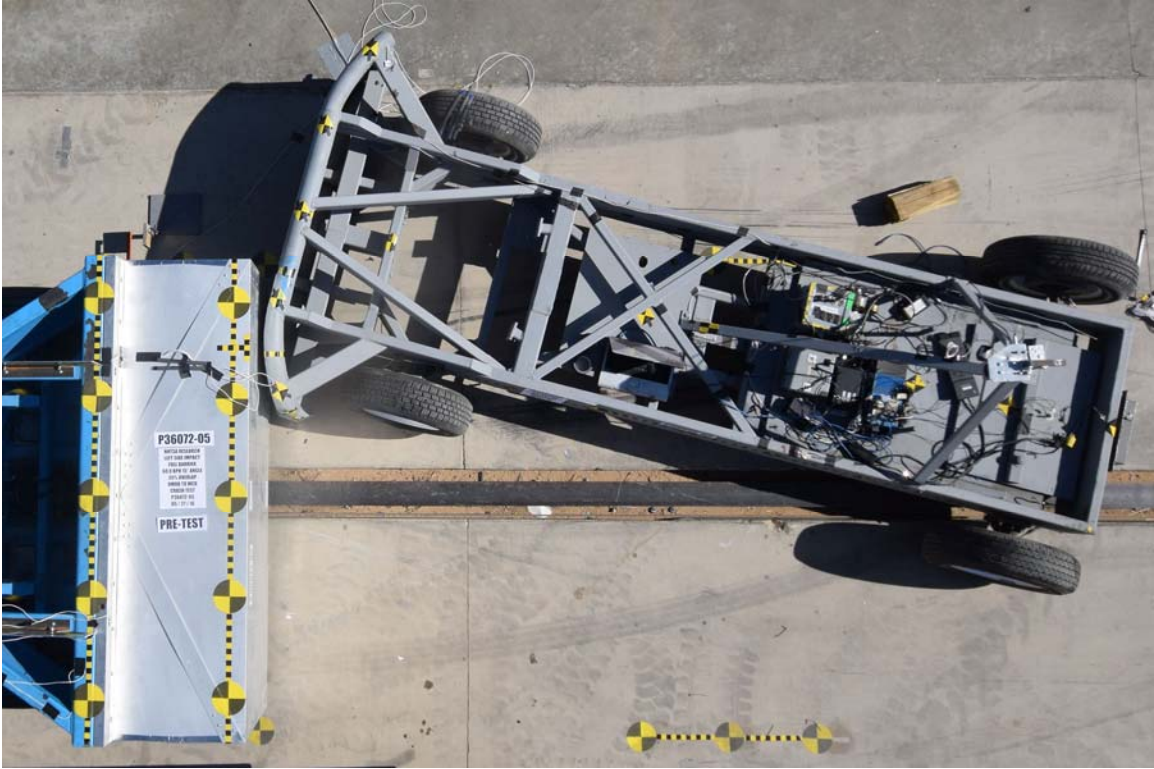


FIGURE 3. Pre-Test Top View of OMDB and MCB



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  $\frac{3}{4}$  View of MCB



FIGURE 10. Post-Test Right Front  $\frac{3}{4}$  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  $\frac{3}{4}$  View of MCB



FIGURE 14. Post-Test Left Front  $\frac{3}{4}$  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

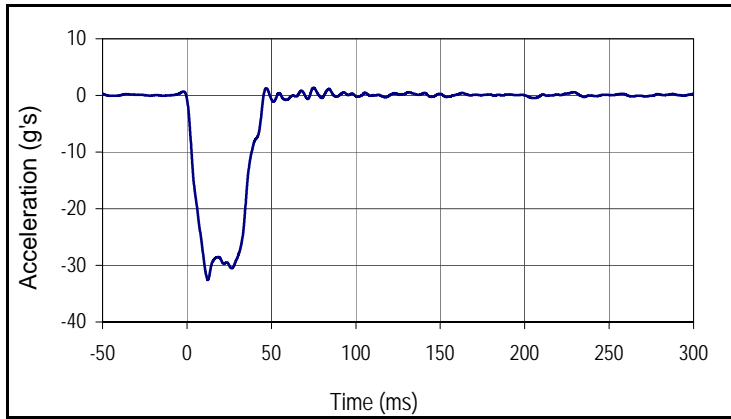
**APPENDIX B  
DATA PLOTS**

## TABLE OF DATA PLOTS

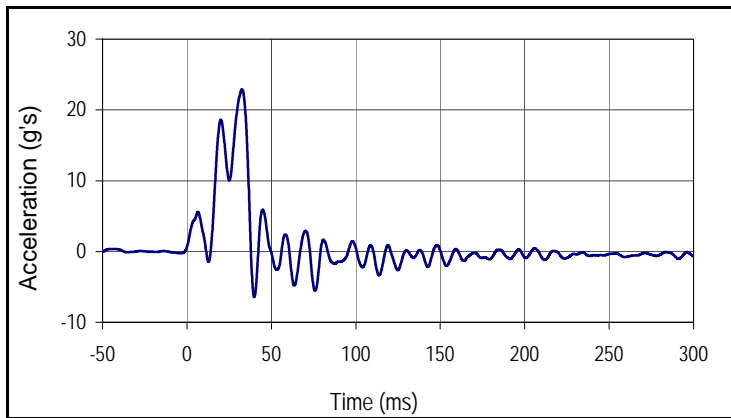
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20	V1 OMDB Rear C/L Y Acceleration	B-5
21	V1 OMDB Rear C/L Z Acceleration	B-6
22	V1 OMDB Left Rear Frame X Acceleration	B-6
23	V1 OMDB Left Rear Frame Y Acceleration	B-6
24	V1 OMDB Left Rear Frame Z Acceleration	B-6

Test Vehicle: OMDB (Full Face) to MCB  
 Test Program: NHTSA R&D Left Oblique Offset 15deg/35%

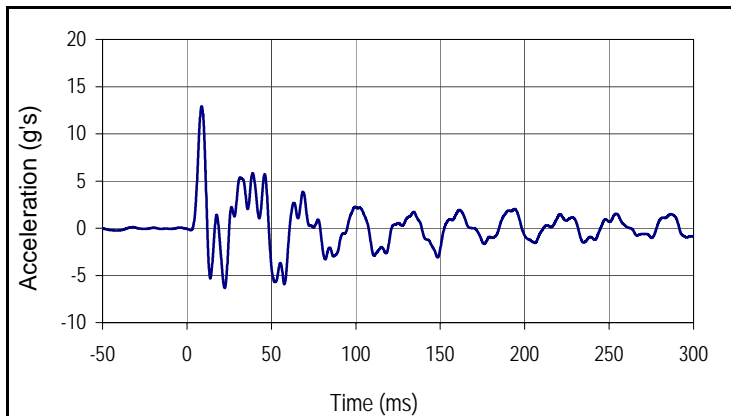
NHTSA No.: N/A  
 Test Date: 5/27/16



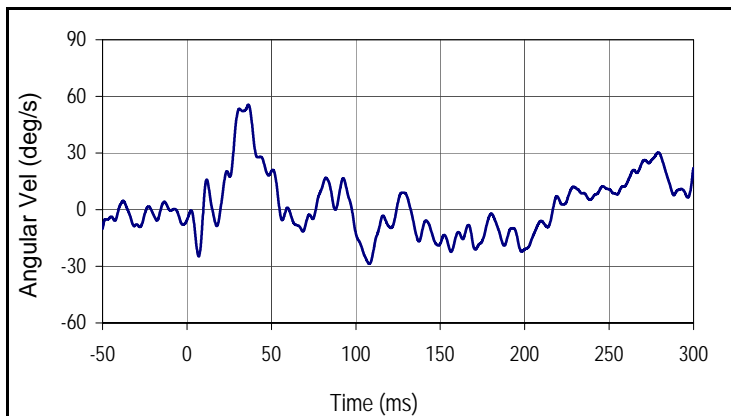
Curve Description			
V2 MCB CG X Acceleration			
Plot No.		SAE Class	Units
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Max	Time	Min	Time
1.4	74.9	-32.6	12.4



Curve Description			
V2 MCB CG Y Acceleration			
Plot No.		SAE Class	Units
002		60	g's
Max	Time	Min	Time
22.9	32.6	-6.4	39.8



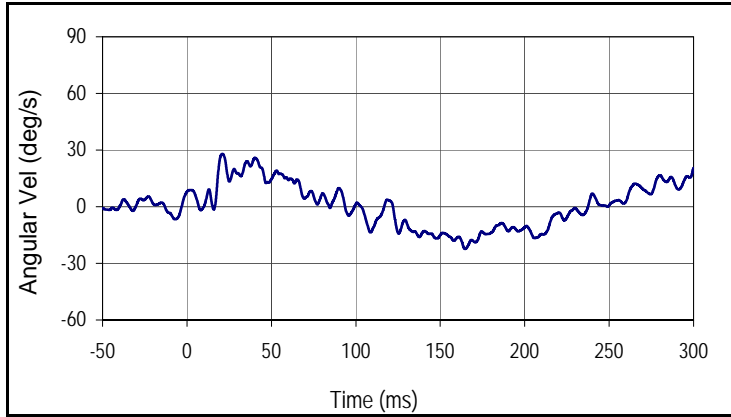
Curve Description			
V2 MCB CG Z Acceleration			
Plot No.		SAE Class	Units
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Max	Time	Min	Time
12.9	8.7	-6.3	22.4



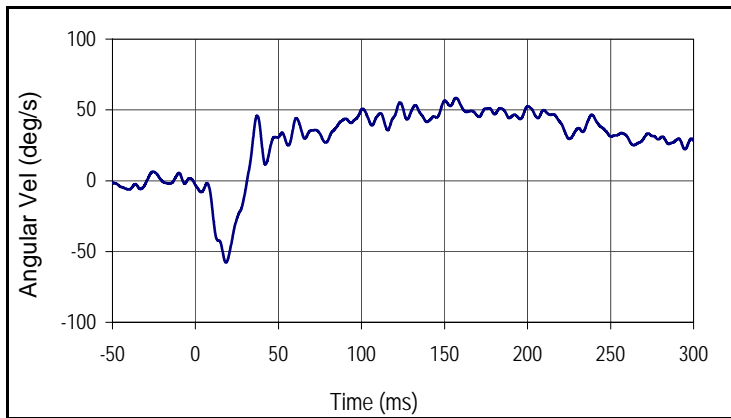
Curve Description			
V2 MCB CG Angular Rate X			
Plot No.		SAE Class	Units
004		60	deg/s
Max	Time	Min	Time
55.5	36.4	-28.7	108.0

Test Vehicle: OMDB (Full Face) to MCB  
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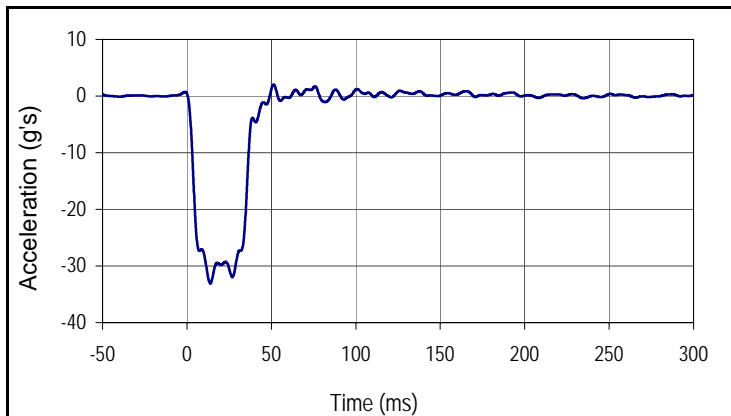
NHTSA No.: N/A  
 Test Date: 5/27/16



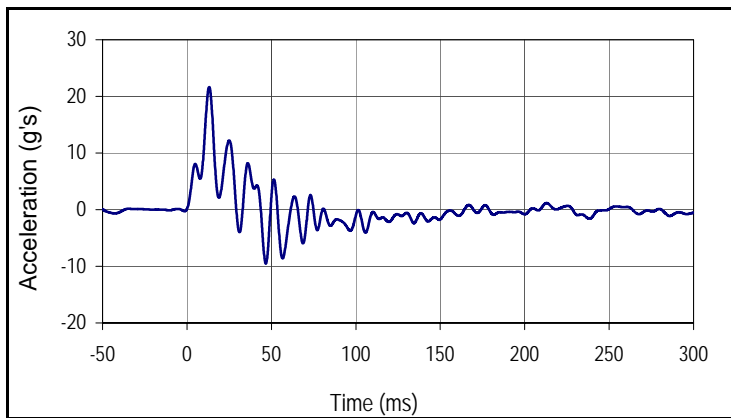
Curve Description			
V2 MCB CG Angular Rate Y			
Plot No.		SAE Class	Units
005		60	deg/s
Max	Time	Min	Time
28.0	21.0	-22.3	164.7



Curve Description			
V2 MCB CG Angular Rate Z			
Plot No.		SAE Class	Units
006		60	deg/s
Max	Time	Min	Time
58.5	157.0	-57.8	18.4



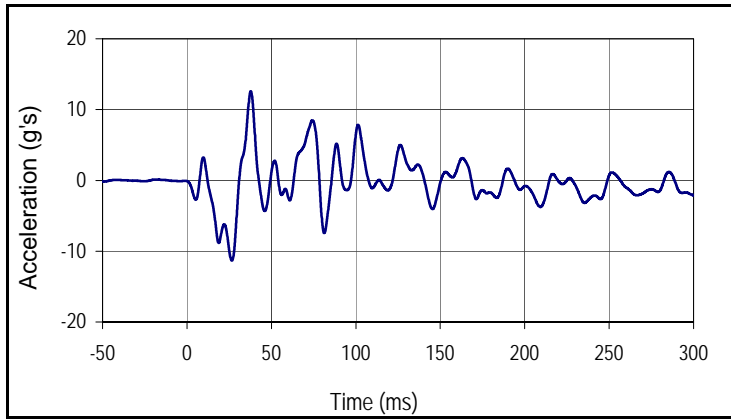
Curve Description			
V2 MCB Rear C/L X Acceleration			
Plot No.		SAE Class	Units
007		60	g's
Max	Time	Min	Time
2.0	51.3	-33.1	13.8



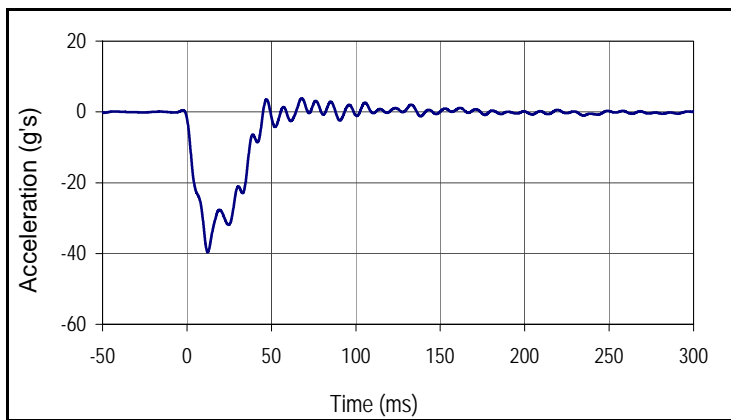
Curve Description			
V2 MCB Rear C/L Y Acceleration			
Plot No.		SAE Class	Units
008		60	g's
Max	Time	Min	Time
21.6	13.2	-9.5	46.7

Test Vehicle: OMDB (Full Face) to MCB  
 Test Program: NHTSA R&D Left Oblique Offset 15deg/35%

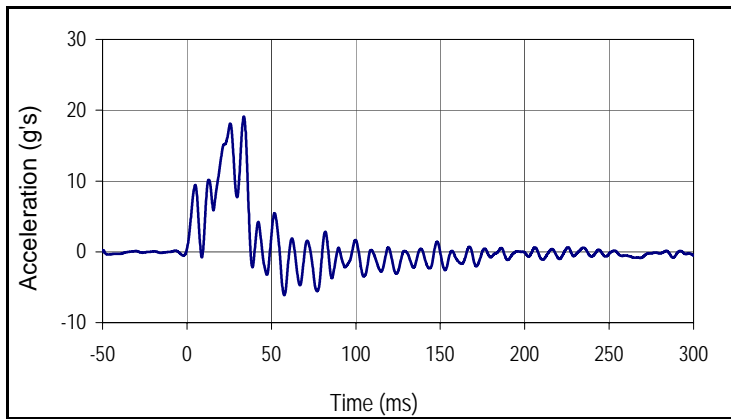
NHTSA No.: N/A  
 Test Date: 5/27/16



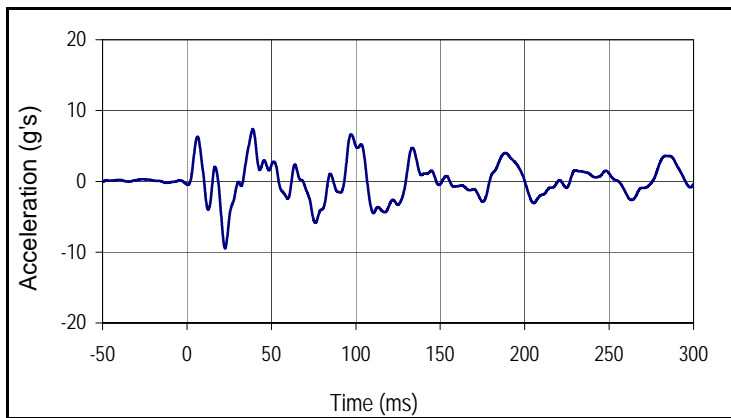
Curve Description			
V2 MCB Rear C/L Z Acceleration			
Plot No.		SAE Class	Units
009		60	g's
Max	Time	Min	Time
12.6	37.8	-11.3	26.6



Curve Description			
V1 MCB Left Frame X Acceleration			
Plot No.		SAE Class	Units
010		60	g's
Max	Time	Min	Time
3.8	68.0	-39.7	12.3



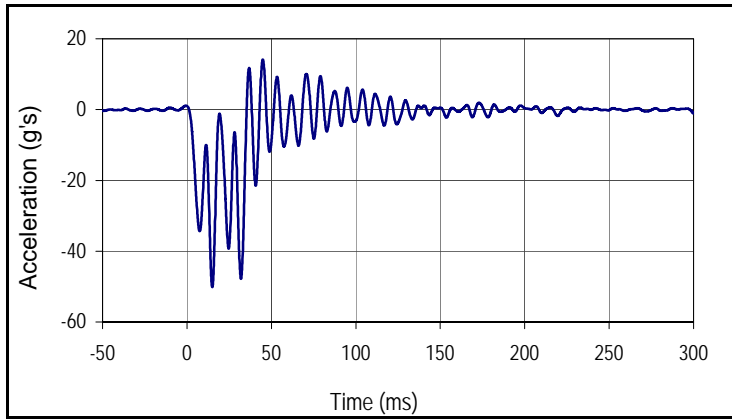
Curve Description			
V1 MCB Left Frame Y Acceleration			
Plot No.		SAE Class	Units
011		60	g's
Max	Time	Min	Time
19.1	33.7	-6.1	57.7



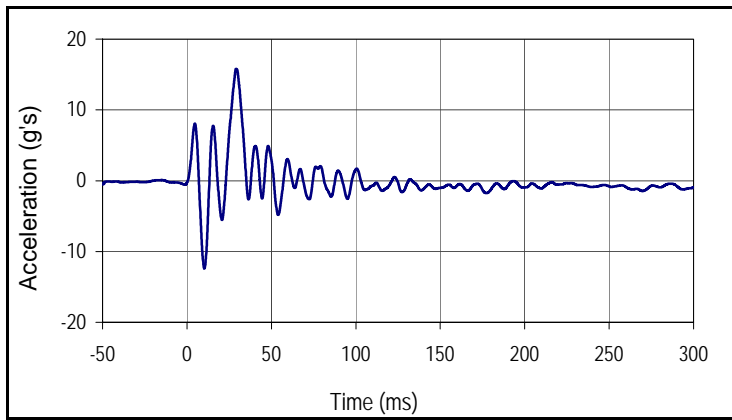
Curve Description			
V1 MCB Left Frame Z Acceleration			
Plot No.		SAE Class	Units
012		60	g's
Max	Time	Min	Time
7.4	39.0	-9.5	22.6

Test Vehicle: OMDB (Full Face) to MCB  
 Test Program: NHTSA R&D Left Oblique Offset 15deg/35%

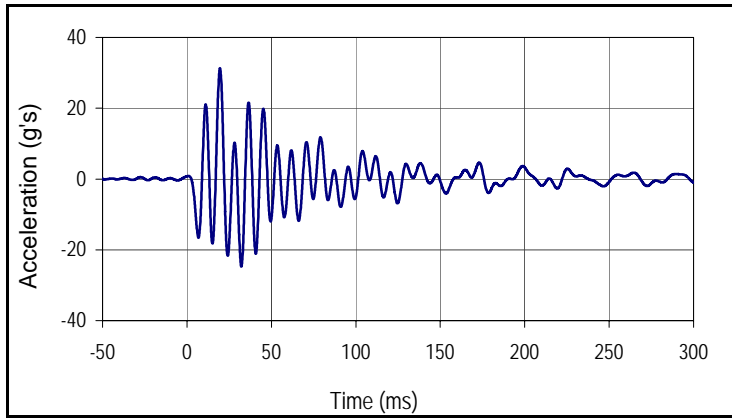
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 Test Date: 5/27/16



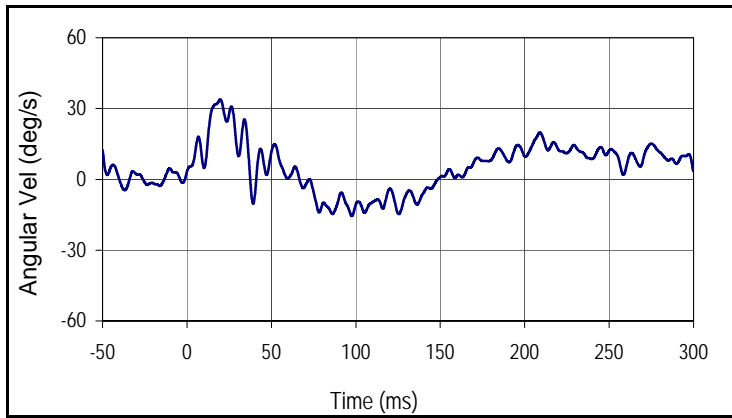
Curve Description			
V1 OMDB CG X Acceleration			
Plot No.		SAE Class	Units
013		60	g's
Max	Time	Min	Time
14.2	44.9	-50.2	15.0



Curve Description			
V1 OMDB CG Y Acceleration			
Plot No.		SAE Class	Units
014		60	g's
Max	Time	Min	Time
15.8	29.3	-12.4	10.3



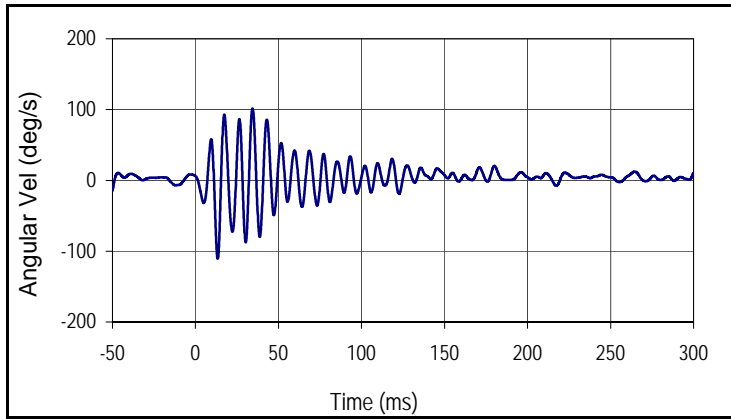
Curve Description			
V1 OMDB CG Z Acceleration			
Plot No.		SAE Class	Units
015		60	g's
Max	Time	Min	Time
31.3	19.5	-24.7	32.2



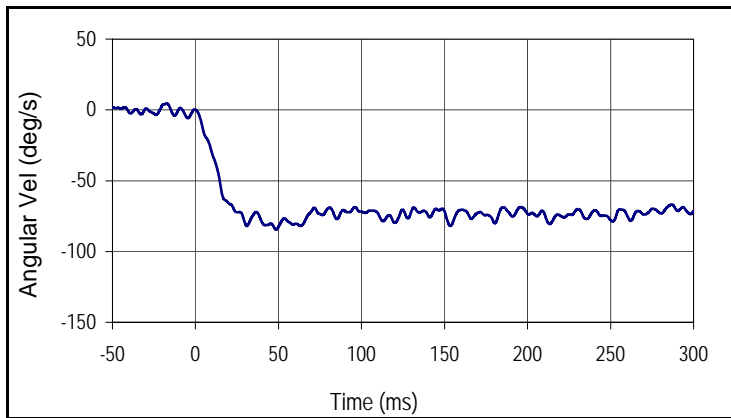
Curve Description			
V1 OMDB Angular Rate X			
Plot No.		SAE Class	Units
016		60	deg/s
Max	Time	Min	Time
33.8	19.7	-15.5	97.6

Test Vehicle: OMDB (Full Face) to MCB  
 Test Program: NHTSA R&D Left Oblique Offset 15deg/35%

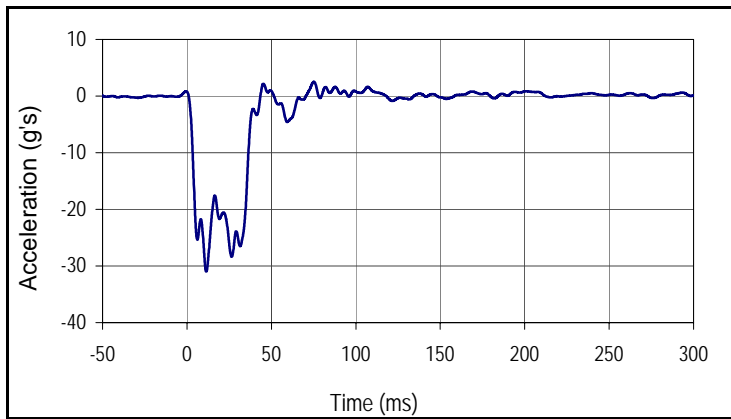
NHTSA No.: N/A  
 Test Date: 5/27/16



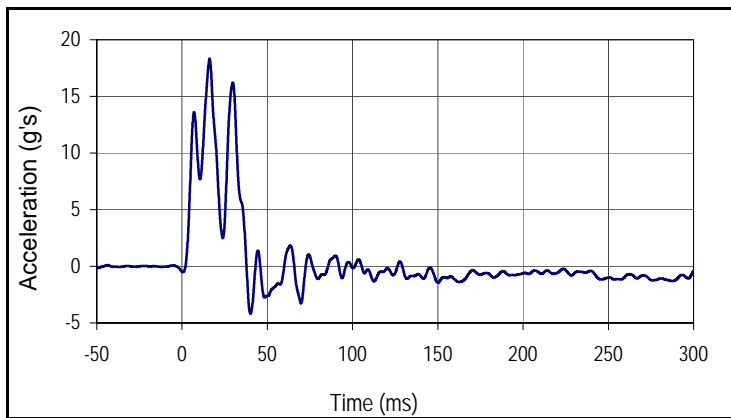
Curve Description			
V1 OMDB Angular Rate Y			
Plot No.		SAE Class	Units
017		60	deg/s
Max	Time	Min	Time
101.5	34.4	-110.5	13.4



Curve Description			
V1 OMDB Angular Rate Z			
Plot No.		SAE Class	Units
018		60	deg/s
Max	Time	Min	Time
4.5	-17.2	-84.5	48.5



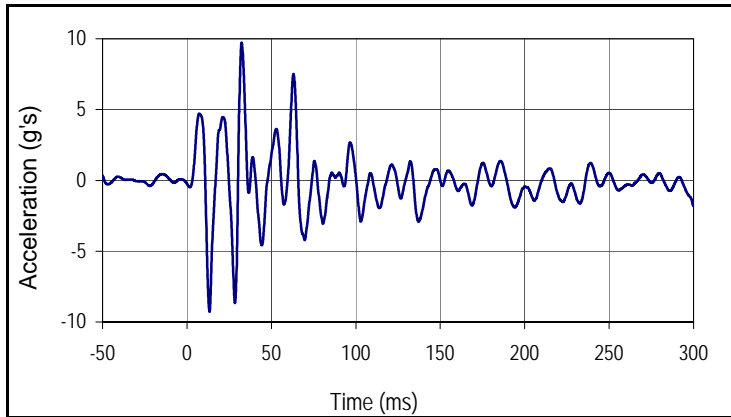
Curve Description			
V1 OMDB Rear C/L X Acceleration			
Plot No.		SAE Class	Units
019		60	g's
Max	Time	Min	Time
2.5	75.2	-31.0	11.4



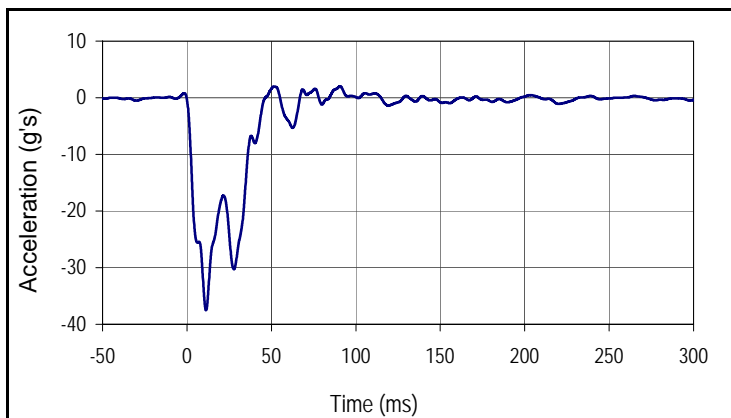
Curve Description			
V1 OMDB Rear C/L Y Acceleration			
Plot No.		SAE Class	Units
020		60	g's
Max	Time	Min	Time
18.3	16.2	-4.2	40.1

Test Vehicle: OMDB (Full Face) to MCB  
 Test Program: NHTSA R&D Left Oblique Offset 15deg/35%

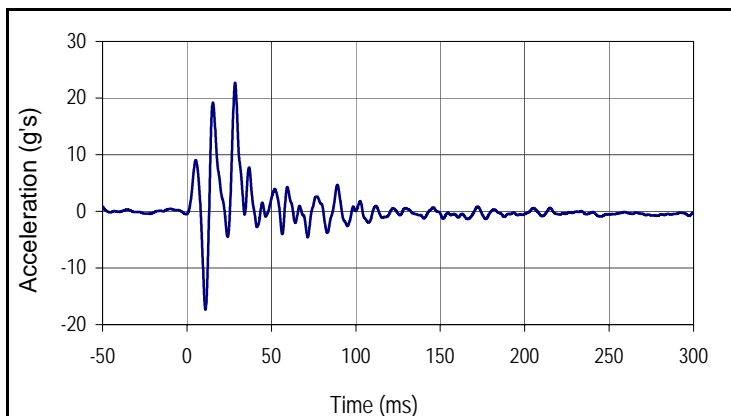
NHTSA No.: N/A  
 Test Date: 5/27/16



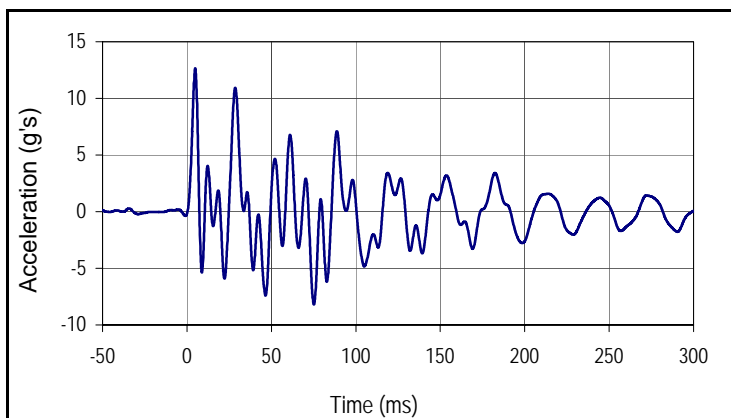
Curve Description			
V1 OMDB Rear C/L Z Acceleration			
Plot No.		SAE Class	Units
021		60	g's
Max	Time	Min	Time
9.7	32.4	-9.3	13.4



Curve Description			
V1 OMDB Left Frame X Acceleration			
Plot No.		SAE Class	Units
022		60	g's
Max	Time	Min	Time
2.0	90.6	-37.5	11.3



Curve Description			
V1 OMDB Left Frame Y Acceleration			
Plot No.		SAE Class	Units
023		60	g's
Max	Time	Min	Time
22.7	28.5	-17.3	11.0



Curve Description			
V1 OMDB Left Frame Z Acceleration			
Plot No.		SAE Class	Units
024		60	g's
Max	Time	Min	Time
12.7	4.9	-8.2	75.2