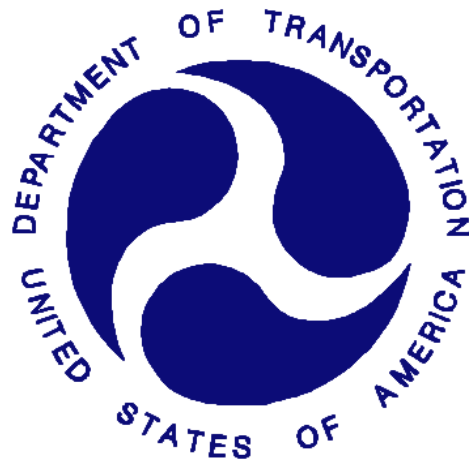


REPORT NUMBER: NCAP305I-MGA-2013-008

**NEW CAR ASSESSMENT PROGRAM (NCAP)
FMVSS No. 305 Indicant Test**

**FORD MOTOR COMPANY
2013 Ford C-MAX Energi SEL 5-Dr Hatchback
NHTSA NUMBER: MD0210**

**MGA RESEARCH CORPORATION
5000 Warren Road
Burlington, WI 53105**



Test Date: February 21, 2013


Report Date: March 21, 2013

FINAL REPORT

**U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crashworthiness Standards
Mail Code: NVS-111
1200 New Jersey Ave, SE
Room W43-410
Washington, DC 20590**

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If trade or manufacturers' names or products are mentioned it is only because they are considered essential to the object of the publication and should not be construed as an endorsement.

Prepared by: 
Donna Janovicz, Project Manager

Approved by: 
Joe Fleck, Project Engineer

Approval Date: March 21, 2013

FINAL REPORT ACCEPTANCE BY OVSC:

Division Chief, New Car Assessment Program
NHTSA, Office of Crashworthiness Standards

Date: _____

COTR, New Car Assessment Program
NHTSA, Office of Crashworthiness Standards

Date: _____

Technical Report Documentation Page

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		<p>14. <i>Sponsoring Agency Code</i> NVS-111</p>	
<p>15. <i>Supplementary Notes</i></p>			
<p>16. <i>Abstract</i></p> <p>An FMVSS No. 305 Indicant test, in conjunction with an NCAP side moving deformable barrier (MDB) impact test was conducted on the subject 2013 Ford C-MAX Energi SEL 5-Dr Hatchback hybrid vehicle in accordance with the specifications of the applicable Office of Crashworthiness Standards Test Procedures for the generation of consumer information for the New Car Assessment Program (NCAP). No test failures were reported.</p>			
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TABLE OF CONTENTS

<u>Section</u>		<u>Page No.</u>
1	Purpose of Test	1
2	Summary of Test Results	2
3	Data Sheets	3
 <u>Data Sheet</u>		 <u>Page No.</u>
1	Test Vehicle Specifications	4
2	Pre-Impact Data	6
3	Pre-Impact Electric Isolation Measurements and Calculations	7
4	Post-Impact Data	9
5	Static Rollover Test Data	11
 <u>Appendix</u>		
A	Photographs	A-1

SECTION 1
PURPOSE OF TEST

An FMVSS No. 305 Indicant test, in conjunction with an NCAP side moving deformable barrier (MDB) impact test was conducted on the subject 2013 Ford C-MAX Energi SEL 5-Dr Hatchback hybrid vehicle.

The Indicant test was conducted in accordance with the Office of Crashworthiness Standards Laboratory Test Procedure, dated March 11, 2012 to determine compliance to the requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 305, "Electric-Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection" for the purpose of providing consumer information.

This FMVSS No. 305 Indicant test is part of the FY13 New Car Assessment Program Test Program, sponsored by the National Highway Traffic Safety Administration (NHTSA), under contract DTNH22-09-D-00124.

SECTION 2 SUMMARY OF TEST RESULTS

A side moving deformable barrier (MDB) impact test was performed by MGA Research Corporation on a 2013 Ford C-MAX Energi SEL 5-Dr Hatchback hybrid vehicle on February 21, 2013. Electrical isolation measurements were taken immediately post-impact and observations were made related to electrolyte spillage and battery retention. A static rollover was subsequently performed on the subject vehicle and electrical isolation measurements were taken at each stage of the rollover.

Based on the test results, the 2013 Ford C-MAX Energi SEL 5-Dr Hatchback hybrid vehicle appears to meet the requirements for electrolyte spillage, electrical isolation, and battery retention during FMVSS No. 305 Indicant testing.

Data sheets, along with pre-test and post-test photographs of the test vehicle, are included in this report to document the test.

TEST NOTES

None.

MGA does not endorse or certify products. The manufacturer's name appears solely for identification purposes.

**SECTION 3
DATA SHEETS**

**DATA SHEET 1
TEST VEHICLE SPECIFICATIONS**

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210

TEST VEHICLE INFORMATION

Year/Make/Model/Body Style	2013 Ford C-MAX Energi SEL 5-Dr Hatchback
NHTSA No.	MD0210
Color	Ingot Silver Metallic
Odometer Reading	8 miles

DATA FROM CERTIFICATION LABEL

Manufactured By	FORD MOTOR COMPANY	GVWR (kg)	2250
Date of Manufacture	01/13	GAWR Front (kg)	1119
VIN:	1FADP5CU1DL520579	GAWR Rear (kg)	1131

ELECTRIC VEHICLE PROPULSION SYSTEM

Type of Electric Vehicle (Electric/Hybrid):	Gas-Plug-In Electric Hybrid
Electric Energy Storage/Device:	Lithium-Ion
Nominal Voltage (V):	300 V
Is this vehicle equipped with an Automatic Propulsion Battery Disconnect?	Yes
Physical Location of the Automatic Propulsion Battery Disconnect:	Two Contactors are located inside the battery pack in the electronics side (that is the passenger side of the pack).
Auxiliary Battery Type:	12 V Lead Acid Battery

**DATA SHEET 1 (CONTINUED)
TEST VEHICLE SPECIFICATIONS**

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210

ELECTRIC ENERGY STORAGE CONVERSION/DEVICE SYSTEM DATA (COTR SUPPLIED)

Electrolyte Fluid Type:	Flammable Liquid	
Electrolyte Fluid Specific Gravity:	1.23 (g/cc)	
Electrolyte Kinematic Viscosity (centistokes):	3.4 (mPa·s) 25° C	
Electrolyte Fluid Color:	Clear Liquid (APHA _≤ 80)	
Electric Energy Storage/Conversion System Coolant Type, Color, Specific Gravity (if applicable):	None; Air Cooled Battery	
Location of Battery Modules:	X	Inside Passenger Compartment
		Outside Passenger Compartment
	The high voltage battery is mounted behind the rear seat back.	

ELECTRIC ENERGY STORAGE CONVERSION/DEVICE STATE OF CHARGE

<i>For all battery types:</i>	
Voltage range corresponding to useable energy of the battery:	
Minimum State of Charge:	
Maximum State of Charge:	345.0 V
95% of Maximum State of Charge:	327.8 V
Test Voltage - No less than 95% of maximum State of Charge:	337.4 V
<i>For batteries that are rechargeable ONLY by an energy source on the vehicle:</i>	
Voltage range corresponding to useable energy of the battery:	
Minimum State of Charge:	
Maximum State of Charge:	
Test Voltage – Maximum practicable State of Charge within Normal Operating Range:	

**DATA SHEET 2
PRE-IMPACT DATA**

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210

VEHICLE CHASSIS GROUND POINT(S) LOCATION(S)

Details of Vehicle Chassis Ground Point(s) & Location(s)	Attached to Auxiliary 12V Lead (-) to Chassis
--	---

ELECTRIC ENERGY STORAGE/CONVERSION TEST POINTS

Details of Electric Energy Storage/Conversion System Test Points:	+ and - Terminal of the BEC Box
---	---------------------------------

**DATA SHEET 3
PRE-IMPACT ELECTRIC ISOLATION MEASUREMENTS & CALCULATIONS**

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210

VOLTMETER INFORMATION

Make:	Fluke
Model:	11
Serial Number:	68541895
Internal Impedance Value (MΩ):	> 10 MΩ < 100 pF
Resolution (V):	.001 Volts
Last Calibration Date:	12/17/2012

ELECTRIC ENERGY STORAGE/CONVERSION SYSTEM VOLTAGE

Measurement shall be made with Energy Storage/Conversion System connected to the vehicle propulsion system, and the vehicle in the “ready-to-drive” (propulsion system energized) position.

If voltage measurement is not at the voltage or within the normal operating voltage range specified by the manufacturer, the battery must be charged.

Vb (V):	337.4
---------	-------

ELECTRIC ENERGY STORAGE/CONVERSION SYSTEM TO VEHICLE CHASSIS

Vehicle chassis point(s) determined and supplied to contractor by COTR.

V1 (V):	37.6
V2 (V):	40.3

**ELECTRIC ENERGY STORAGE/CONVERSION SYSTEM TO
VEHICLE CHASSIS ACROSS RESISTOR**

The known resistance R_o (in ohms) should be approximately 500 times the normal operating voltage of the vehicle (in volts) per SAE J1766.

R_o (Ω):	179500
------------	--------

V1' (V) Pre-Impact:	6.6
V2' (V) Pre-Impact:	6.7

DATA SHEET 3 (CONTINUED)
PRE-IMPACT ELECTRICAL ISOLATION MEASUREMENTS & CALCULATIONS

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210

ELECTRICAL ISOLATION MEASUREMENT

Note: If measured voltage is zero and results in a division by zero, record "Zero Volts". This "zero voltage" condition is considered as being compliant.

V1' (V):	6.6
$R_{i1} = R_o (1 + V_2/V_1) [(V_1 - V_1')/V_1']$	
Ri1 (Ω):	1746754
V2' (V):	6.6
$R_{i2} = R_o (1 + V_1/V_2) [(V_2 - V_2')/V_2']$	
Ri2 (Ω):	1740048
Ri = The lesser of Ri1 and Ri2	
Ri Pre-Test (Ω):	1740048
Ri/Vb (Ω/V):	5157
Minimum Electrical Isolation Value is 500 Ω/V	

Is the measured Electrical Isolation Value:	Yes, Pass	No, Fail
≥500 Ω/V without electrical isolation monitoring	X	
≥100 Ω/V with electrical isolation monitoring		

**DATA SHEET 4
POST-IMPACT DATA**

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210

VOLTMETER INFORMATION

Make:	Fluke
Model:	11
Serial Number:	68541895
Internal Impedance Value (MΩ):	> 10 MΩ < 100 pF
Nominal Propulsion Battery Voltage (Vb) (V):	337.4

**ELECTRIC ENERGY STORAGE/CONVERSION SYSTEM
VOLTAGE LOCATION OF MEASUREMENT**

Measurement is made from the side of the automatic disconnect connected to the electric powertrain.

Vb (V):	2.1
---------	-----

ELECTRIC ENERGY STORAGE/CONVERSION SYSTEM VOLTAGE

V1 =	6.5	V	Impact Time:	1	Minutes	26	s
V2 =	4.4	V	Impact Time:	1	Minutes	33	s
V1' =	0.2	V	Impact Time:	1	Minutes	40	s
V2' =	0.2	V	Impact Time:	1	Minutes	47	s

ELECTRICAL ISOLATION MEASUREMENT

Note: If measured voltage is zero and results in a division by zero, record "Zero Volts". This "zero voltage" condition is considered as being compliant.

$Ri1 = Ro (1 + V2/V1) [(V1-V1')/V1']$							
Ri1 =	9481742	Ω	Impact Time:	1	Minutes	26	s
$Ri2 = Ro (1 + V1/V2) [(V2-V2')/V2']$							
Ri2 =	9338080	Ω	Impact Time:	1	Minutes	33	s
Ri = The lesser of Ri1 and Ri2							
Ri =	9338080	Ω	Impact Time:	1	Minutes	33	s
Ri/Vb = electrical Isolation Value/Nominal Battery Voltage							
Minimum Electrical Value is 500 Ω/V							
Ri/Vb =	27677	Ω/V	Impact Time:	1	Minutes	33	s

Is the measured Electrical Isolation Value:	Yes, Pass	No, Fail
≥500 Ω/V without electrical isolation monitoring	X	
≥100 Ω/V with electrical isolation monitoring		

**DATA SHEET 4 (CONTINUED)
POST-IMPACT DATA**

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210

ELECTRIC ENERGY STORAGE/CONVERSION DEVICE

	Inside Passenger Compartment	Outside Passenger Compartment
Location of Electric Energy Storage/Conversion Device:	X	

	Yes, Pass	No, Fail
All Components of Electrical Energy Storage/Conversion Device remained attached to the vehicle with at least one mounting location.	X	

Describe Electric Energy Storage/Conversion Device movement within the passenger compartment [Supply photographs as appropriate]:
Not Applicable

	Yes, Fail	No, Pass
Has the Electric Energy Storage/Conversion Device moved within the passenger compartment?		X

Describe intrusion of an outside Electric Energy Storage/Conversion Device into the passenger compartment [Supply photographs as appropriate]:
No Intrusion

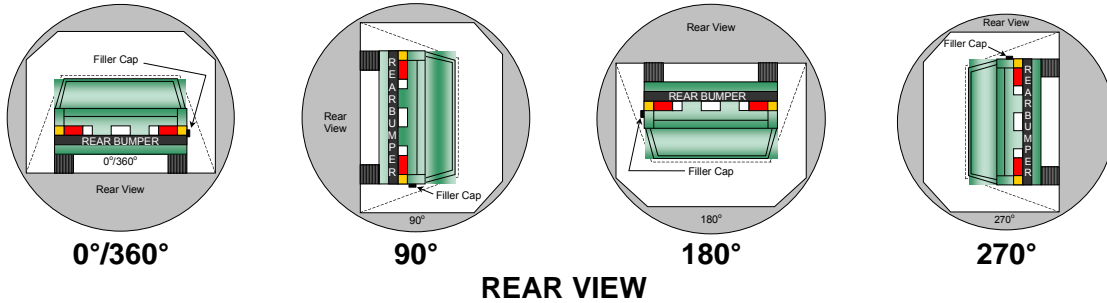
	Yes, Fail	No, Pass
Has an outside Electric Energy Storage/Conversion Device intruded into the passenger compartment?		X

	Yes, Fail	No, Pass
Is Electric Energy Storage/Conversion Device electrolyte spillage visible in the passenger compartment?		X

**DATA SHEET 5
STATIC ROLLOVER TEST DATA**

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210



**DETERMINATION OF ELECTRIC ENERGY STORAGE/CONVERSION DEVICE
ELECTROLYTE COLLECTION TIME PERIOD**

Rollover Stage	Rotation Time (spec. 1-3 min)				FMVSS 301 Hold Time		Total Time				Next Whole Minute Interval	
0° - 90°	1	minutes	47	seconds	5	minutes	6	Minutes	47	seconds	7	minutes
90° - 180°	1	minutes	50	seconds	5	minutes	6	minutes	50	seconds	7	minutes
180° - 270°	1	Minutes	50	seconds	5	minutes	6	minutes	50	seconds	7	minutes
270° - 360°	1	minutes	53	seconds	5	minutes	6	minutes	53	seconds	7	minutes

**ACTUAL TEST VEHICLE ELECTRIC ENERGY STORAGE/CONVERSION DEVICE
ELECTROLYTE SPILLAGE**

Rollover Stage	Electric Energy Storage/Conversion Device Electrolyte Spillage (L)	Spillage Location
0° to 90°	0	Not Applicable
90° to 180°	0	Not Applicable
180° to 270°	0	Not Applicable
270° to 360°	0	Not Applicable

Total Spillage: 0 L

	Yes, Fail	No, Pass
Is the total spillage of Electric Energy Storage/Conversion Device electrolyte greater than 5.0 Liters?		X
Is Electric Energy Storage/Conversion Device electrolyte spillage visible in the passenger compartment?		X

**DATA SHEET 5 (CONTINUED)
STATIC ROLLOVER TEST DATA**

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210

VOLTMETER INFORMATION

Make:	Fluke
Model:	11
Serial Number:	68541895
Internal Impedance Value (MΩ):	> 10 MΩ < 100 pF
Nominal Electric Energy Storage/Conversion Device Voltage (Vb) (V):	337.4
Record V1, V2, V1', V2' voltage measurements at the start of each successive increment of 90°, 180°, 270°, and 360° of the static rollover test.	

ELECTRICAL ISOLATION MEASUREMENT

V1 =	0.0	V	0°	Time:		Minutes		s
V1 =	0.0	V	90°	Time:	2	Minutes	0	s
V1 =	0.0	V	180°	Time:	2	Minutes	2	s
V1 =	0.0	V	270°	Time:	1	Minutes	59	s
V1 =	0.0	V	360°	Time:	2	Minutes	4	s
V2 =	0.0	V	0°	Time:		Minutes		s
V2 =	0.0	V	90°	Time:	2	Minutes	4	s
V2 =	0.0	V	180°	Time:	2	Minutes	8	s
V2 =	0.0	V	270°	Time:	2	Minutes	4	s
V2 =	0.0	V	360°	Time:	2	Minutes	8	s
V1' =	0.0	V	0°	Time:		Minutes		s
V1' =	0.0	V	90°	Time:	2	Minutes	11	s
V1' =	0.0	V	180°	Time:	2	Minutes	13	s
V1' =	0.0	V	270°	Time:	2	Minutes	11	s
V1' =	0.0	V	360°	Time:	2	Minutes	12	s
V2' =	0.0	V	0°	Time:		Minutes		s
V2' =	0.0	V	90°	Time:	2	Minutes	17	s
V2' =	0.0	V	180°	Time:	2	Minutes	18	s
V2' =	0.0	V	270°	Time:	2	Minutes	16	s
V2' =	0.0	V	360°	Time:	2	Minutes	19	s
Vb =	0.0	V	0°	Time:		Minutes		s
Vb =	0.0	V	90°	Time:	1	Minutes	53	s
Vb =	0.0	V	180°	Time:	1	Minutes	54	s
Vb =	0.0	V	270°	Time:	1	Minutes	54	s
Vb =	0.0	V	360°	Time:	1	Minutes	58	s

**DATA SHEET 5 (CONTINUED)
STATIC ROLLOVER TEST DATA**

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback

NHTSA No. MD0210

ELECTRICAL ISOLATION CALCULATION

Note: If measured voltage is zero and results in a division by zero, record "Zero Volts". This "zero voltage" condition is considered as being compliant.

$R_{i1} = R_o (1 + V_2/V_1) [(V_1 - V_1')/V_1']$								
R _{i1} =	Zero Voltage	Ω	0°	Time:		Minutes		s
R _{i1} =	Zero Voltage	Ω	90°	Time:	2	Minutes	0	s
R _{i1} =	Zero Voltage	Ω	180°	Time:	2	Minutes	2	s
R _{i1} =	Zero Voltage	Ω	270°	Time:	1	Minutes	59	s
R _{i1} =	Zero Voltage	Ω	360°	Time:	2	Minutes	4	s
$R_{i2} = R_o (1 + V_1/V_2) [(V_2 - V_2')/V_2']$								
R _{i2} =	Zero Voltage	Ω	0°	Time:		Minutes		s
R _{i2} =	Zero Voltage	Ω	90°	Time:	2	Minutes	4	s
R _{i2} =	Zero Voltage	Ω	180°	Time:	2	Minutes	8	s
R _{i2} =	Zero Voltage	Ω	270°	Time:	2	Minutes	4	s
R _{i2} =	Zero Voltage	Ω	360°	Time:	2	Minutes	8	s
R _i = The lesser of R _{i1} and R _{i2}								
R _i =	Zero Voltage	Ω	0°	Time:		Minutes		s
R _i =	Zero Voltage	Ω	90°	Time:	2	Minutes	0	s
R _i =	Zero Voltage	Ω	180°	Time:	2	Minutes	2	s
R _i =	Zero Voltage	Ω	270°	Time:	1	Minutes	59	s
R _i =	Zero Voltage	Ω	360°	Time:	2	Minutes	4	s
R _i /V _b = Electrical Isolation Value/Nominal Battery Voltage Minimum Electrical Isolation Value is 500 Ω /V								
R _i /V _b =	Zero Voltage	Ω/V	0°	Time:		Minutes		s
R _i /V _b =	Zero Voltage	Ω/V	90°	Time:	2	Minutes	0	s
R _i /V _b =	Zero Voltage	Ω/V	180°	Time:	2	Minutes	2	s
R _i /V _b =	Zero Voltage	Ω/V	270°	Time:	1	Minutes	59	s
R _i /V _b =	Zero Voltage	Ω/V	360°	Time:	2	Minutes	4	s

Is the measured Electrical Isolation Value:	Yes, Pass	No, Fail
≥500 Ω/V without electrical isolation monitoring	X	
≥100 Ω/V with electrical isolation monitoring		

**APPENDIX A
PHOTOGRAPHS**

TABLE OF PHOTOGRAPHS

	<u>Page No.</u>
Auxiliary Power Module Warning Label	A-1
Power Inverter Warning Label	A-1
First Responder Warning Label	A-2
First Responder Warning Location	A-2
Other Vehicle Label(s) Related to Electrical Propulsion System	A-3
Other Vehicle Label(s) Related to Electrical Propulsion System	A-3
Manual High Voltage Service Disconnect in Place	A-4
Manual High Voltage Service Disconnect Removed	A-4
Manual High Voltage Service Disconnect Removed	A-5
Pre-Impact View of Propulsion Battery	A-5
Post-Impact Front View of Propulsion Battery	A-6
Post-Impact Rear View of Propulsion Battery	A-6
Pre-Impact View of Battery Box(s) or Container(s) Which Holds Individual Battery Modules	A-7
Post-Impact View of Battery Box(s) or Container(s) Which Holds Individual Battery Modules	A-7
Pre-Impact View of Propulsion Battery Module(s)	A-8
Post-Impact View of Propulsion Battery Module(s)	A-8
Pre-Impact View of Electric Propulsion Drive	A-9
Pre-Impact View of Electric Propulsion Drive	A-9
Post-Impact View of Electric Propulsion Drive	A-10
Post-Impact View of Electric Propulsion Drive	A-10
Pre-Impact View of High Voltage Interconnect(s)	A-11
Pre-Impact View Propulsion Battery Venting System(s)	A-11
Pre-Impact View of Other Visible Electric Propulsion Components	A-12
Pre-Impact View of Ground Lead Attached	A-12
Pre-Impact View of High Voltage Leads Attached	A-13
Pre-Impact Close-Up View of High Voltage Leads Attached	A-13
Pre-Impact View of Installed Impact Interface Port	A-14
Post-Impact View of Installed Impact Interface Port	A-14
Pre-Impact View of Other Test Devices	A-15
Post-Impact View of Other Test Devices	A-15
FMVSS No. 305 Static Rollover at 90°	A-16
FMVSS No. 305 Static Rollover at 180°	A-16
FMVSS No. 305 Static Rollover at 270°	A-17

	<u>Page No.</u>
FMVSS No. 305 Static Rollover at 360°	A-17
Pre-Impact View of the Vehicle Passenger Compartment Adjacent to Propulsion Battery	A-18
Post-Impact View of the Vehicle Passenger Compartment Adjacent to Propulsion Battery	A-18
Post-Impact Propulsion Battery System Mounting and/or Intrusion Failure(s)	A-19
Post-Impact View of Battery Component Intrusion	A-19
Post-Impact View of Battery Module Movement or Retention Loss	A-20
Post-Impact View of Propulsion Battery Electrolyte Spillage Location	A-20
Post-Test View of Propulsion Battery Electrolyte Spillage Location	A-21
As Delivered Right Front $\frac{3}{4}$ View of Impact Vehicle	A-21
As Delivered Left Rear $\frac{3}{4}$ View of Impact Vehicle	A-22
Vehicle's Certification Label	A-22
Vehicle's Tire Information Placard or Label	A-23

PHOTOGRAPH NOT APPLICABLE

No. 001 Auxiliary Power Module Warning Label



No. 002 Power Inverter Warning Label

PHOTOGRAPH NOT APPLICABLE

No. 003 First Responder Warning Label

PHOTOGRAPH NOT APPLICABLE

No. 004 First Responder Warning Location



No. 005 Other Vehicle Label(s) Related to Electrical Propulsion System



No. 005a Other Vehicle Label(s) Related to Electrical Propulsion System



No. 006 Manual High Voltage Service Disconnect in Place



No. 007 Manual High Voltage Service Disconnect Removed



No. 008 Manual High Voltage Service Disconnect Removed



No. 009 Pre-Impact View of Propulsion Battery



No. 010 Post-Impact Front View of Propulsion Battery



No. 011 Post-Impact Rear View of Propulsion Battery



No. 012 Pre-Impact View of Battery Box(s) or Container(s) Which Holds Individual Battery Modules



No. 013 Post-Impact View of Battery Box(s) or Container(s) Which Holds Individual Battery Modules

PHOTOGRAPH NOT APPLICABLE

No. 014 Pre-Impact View of Propulsion Battery Module(s)

PHOTOGRAPH NOT APPLICABLE

No. 015 Post-Impact View of Propulsion Battery Module(s)



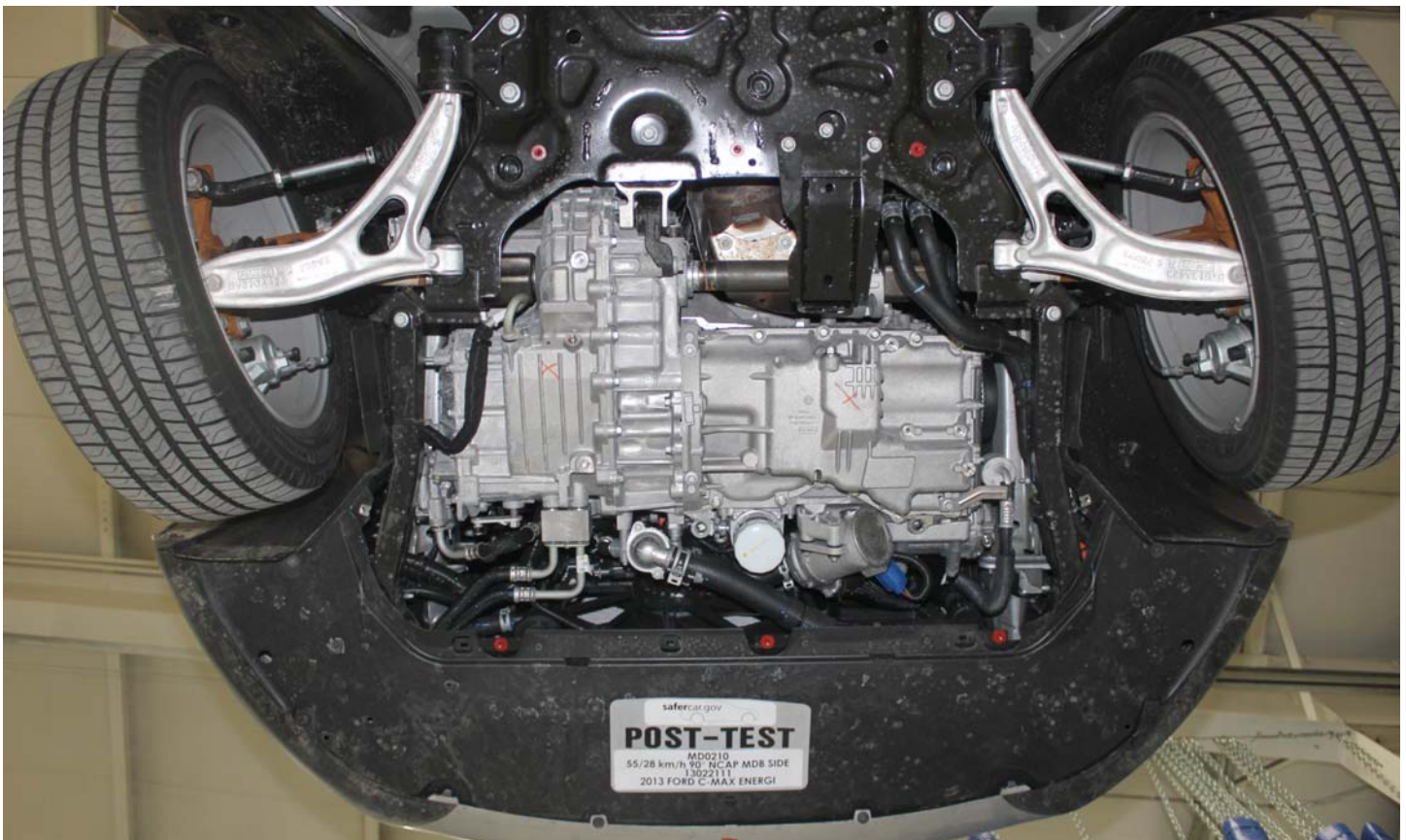
No. 016 Pre-Impact View of Electric Propulsion Drive



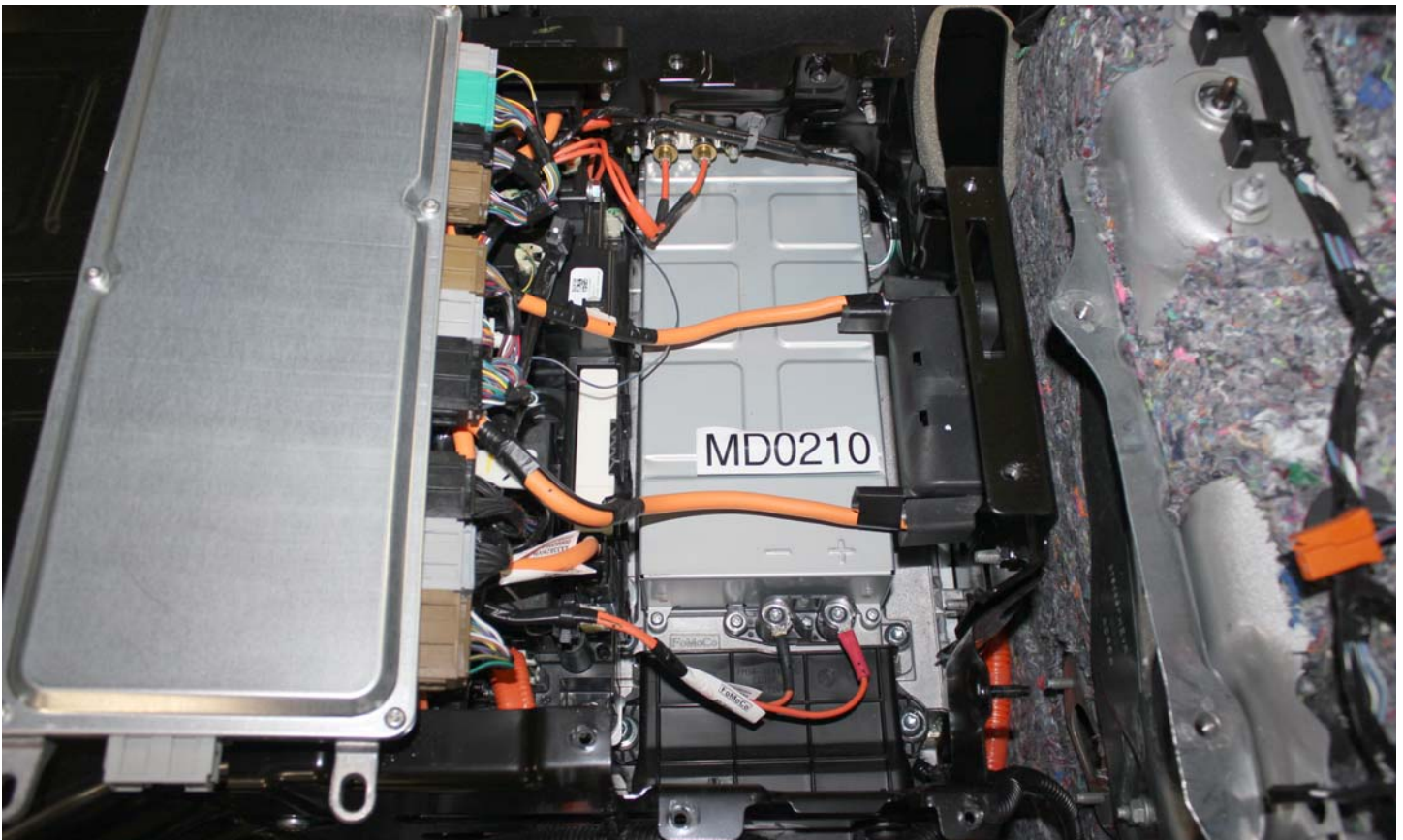
No. 016a Pre-Impact View of Electric Propulsion Drive



No. 017 Post-Impact View of Electric Propulsion Drive



No. 017a Post-Impact View of Electric Propulsion Drive



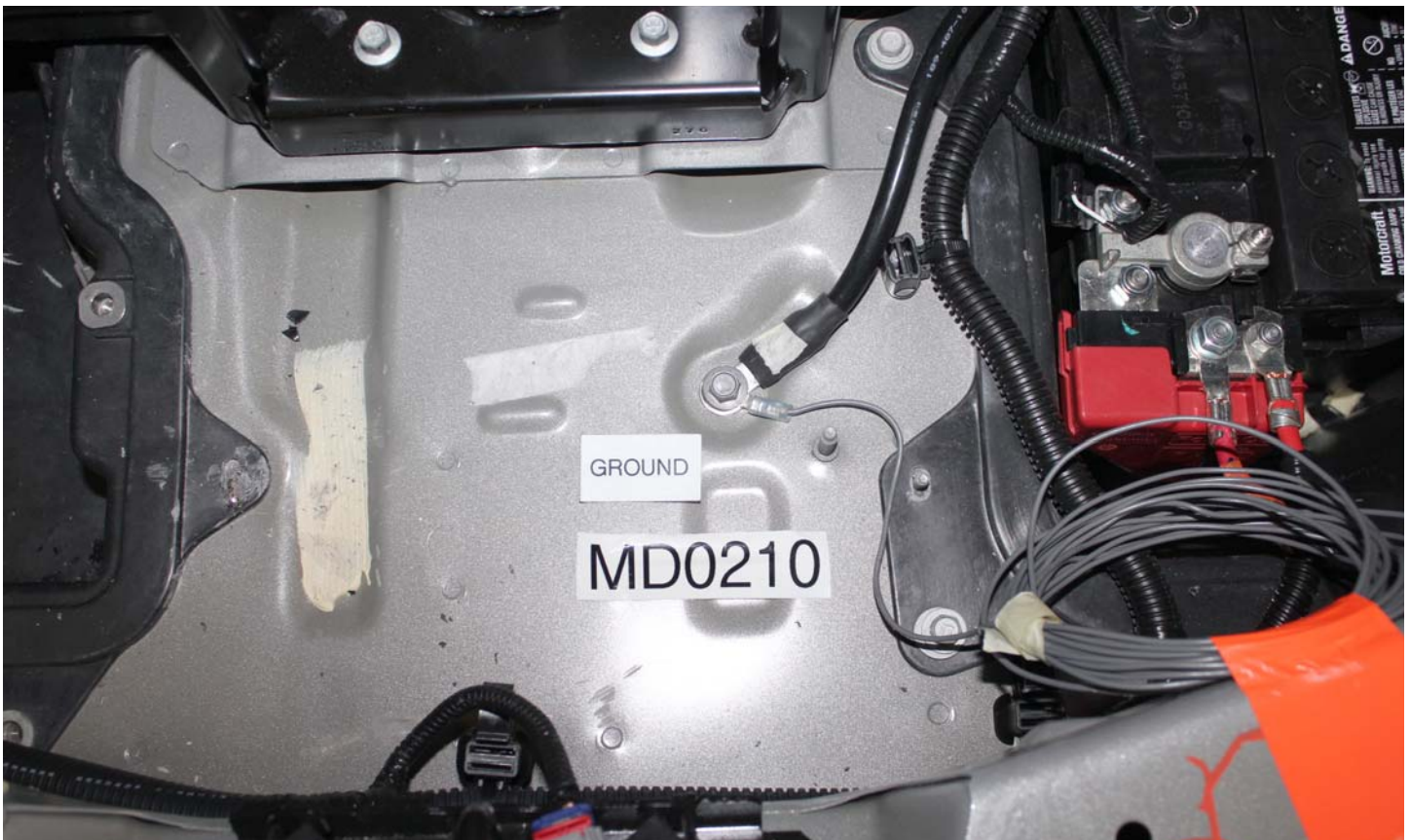
No. 018 Pre-Impact View of High Voltage Interconnect(s)



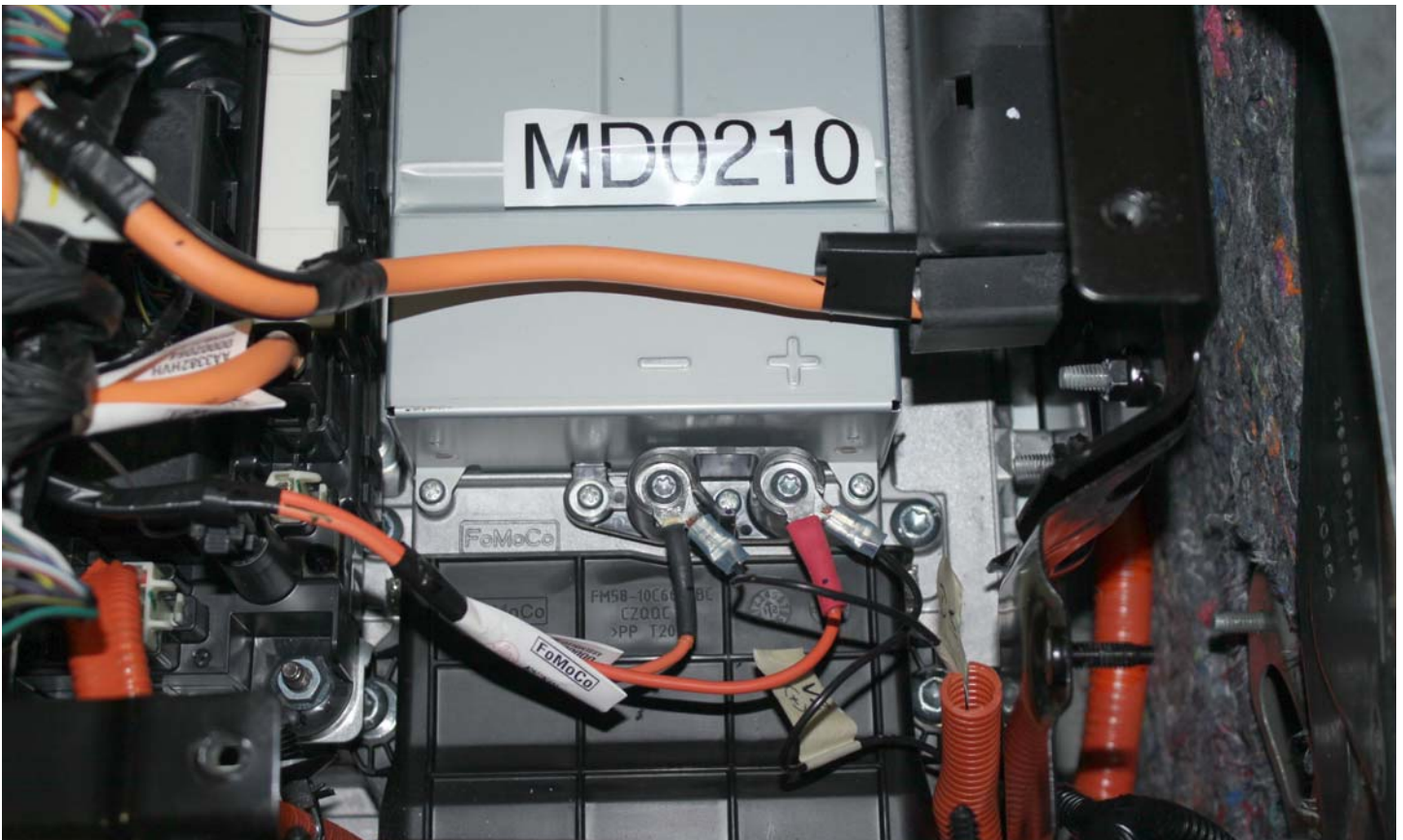
No. 019 Pre-Impact View Propulsion Battery Venting System(s)

PHOTOGRAPH NOT APPLICABLE

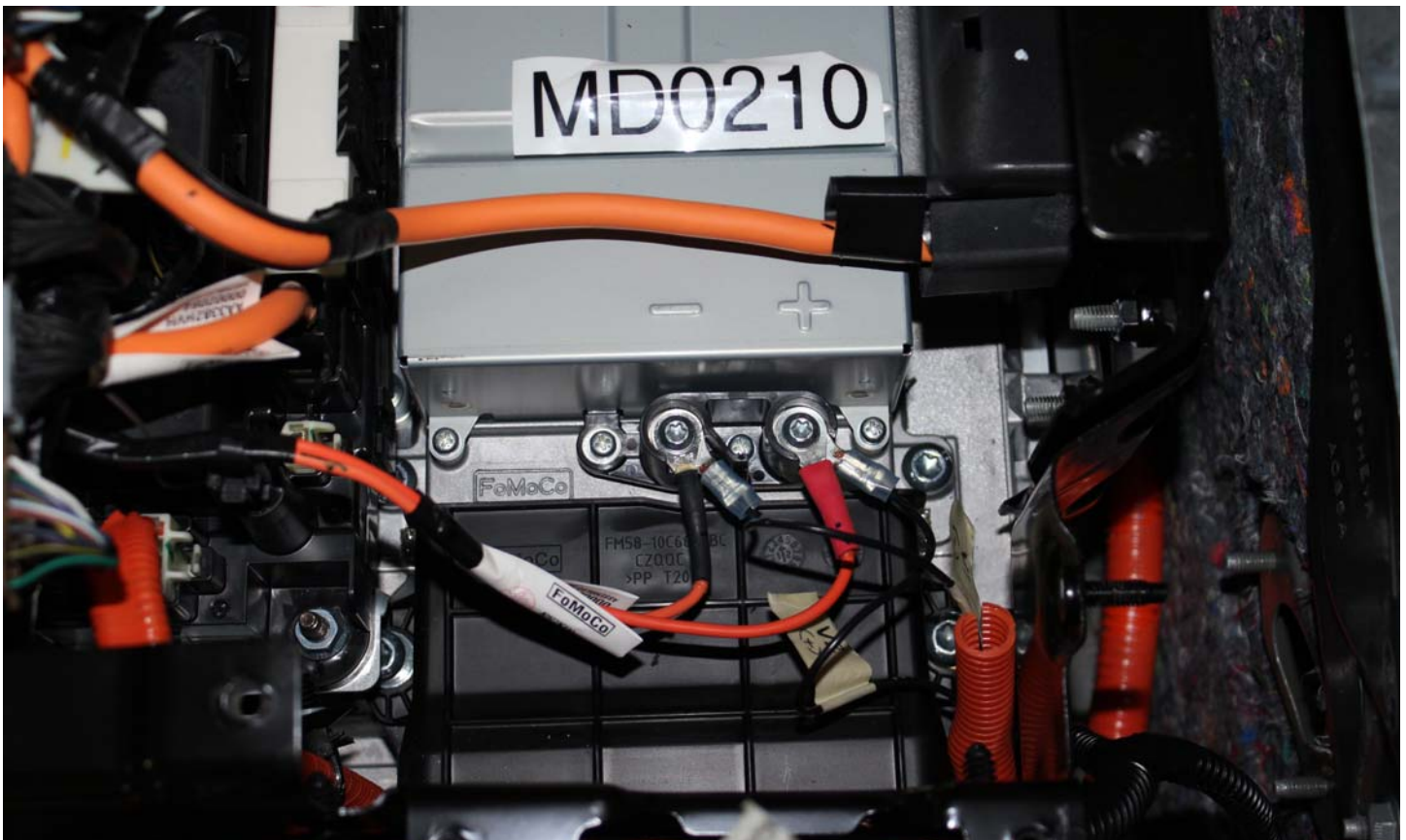
No. 020 Pre-Impact View of Other Visible Electric Propulsion Components



No. 021 Pre-Impact View of Ground Lead Attached



No. 022 Pre-Impact View of High Voltage Leads Attached



No. 023 Pre-Impact Close-Up View of High Voltage Leads Attached



No. 024 Pre-Impact View of Installed Impact Interface Port



No. 025 Post-Impact View of Installed Impact Interface Port

PHOTOGRAPH NOT APPLICABLE

No. 026 Pre-Impact View of Other Test Devices

PHOTOGRAPH NOT APPLICABLE

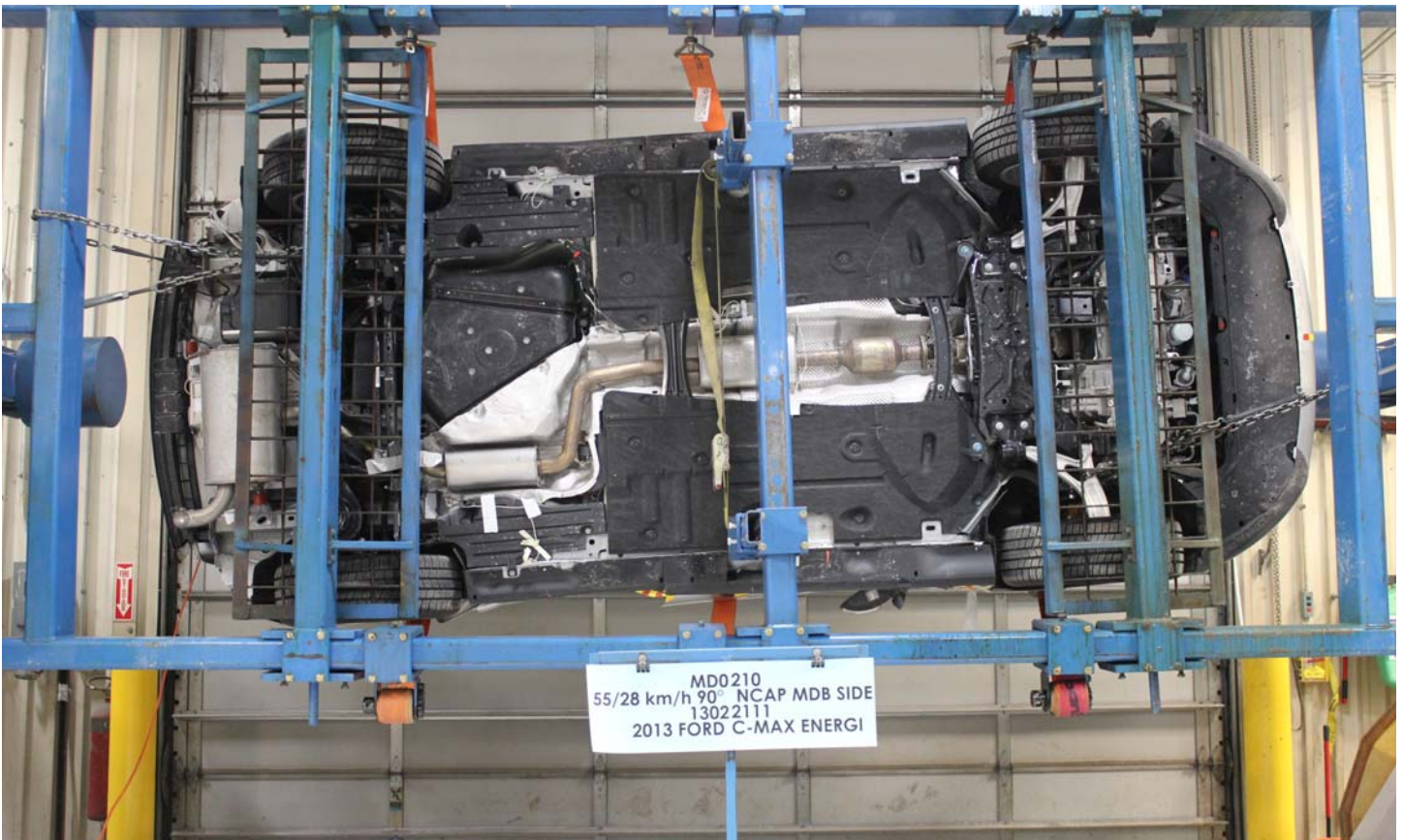
No. 027 Post-Impact View of Other Test Devices



No. 028 FMVSS No. 305 Static Rollover at 90°



No. 029 FMVSS No. 305 Static Rollover at 180°



No. 030 FMVSS No. 305 Static Rollover at 270°



No. 031 FMVSS No. 305 Static Rollover at 360°



No. 032 Pre-Impact View of the Vehicle Passenger Compartment Adjacent to Propulsion Battery



No. 033 Post-Impact View of the Vehicle Passenger Compartment Adjacent to Propulsion Battery

PHOTOGRAPH NOT APPLICABLE

No. 034 Post-Impact Propulsion Battery System Mounting and-or Intrusion Failure(s)

PHOTOGRAPH NOT APPLICABLE

No. 035 Post-Impact View of Battery Component Intrusion

PHOTOGRAPH NOT APPLICABLE

No. 036 Post-Impact View of Battery Module Movement or Retention Loss

PHOTOGRAPH NOT APPLICABLE

No. 037 Post-Impact View of Propulsion Battery Electrolyte Spillage Location

PHOTOGRAPH NOT APPLICABLE

No. 038 Post-Test View of Propulsion Battery Electrolyte Spillage Location



No. 039 As Delivered Right Front $\frac{3}{4}$ View of Impact Vehicle



No. 040 As Delivered Left Rear ¼ View of Impact Vehicle



No. 041 Vehicle's Certification Label



No. 042 Vehicle's Tire Information Placard