

REPORT NUMBER: NCAP305I-MGA-2013-009

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

**FORD MOTOR COMPANY
2013 Ford C-MAX Energi SEL 5-Dr Hatchback
NHTSA No.: MD0208**

**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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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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16. Abstract An FMVSS No. 305 Indicant test, in conjunction with an NCAP frontal barrier 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.					
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SECTION 1

PURPOSE OF TEST

An FMVSS No. 305 Indicant test, in conjunction with an NCAP frontal barrier 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 January 31, 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 DTNH22-06-D-00028.

SECTION 2

SUMMARY OF TEST RESULTS

A frontal barrier 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. MD0208

TEST VEHICLE INFORMATION

Year/Make/Model/Body Style	2013 Ford C-MAX Energi SEL 5-Dr Hatchback
NHTSA No.	MD0208
Color	Ruby Red Metallic
Odometer Reading	12 miles

DATA FROM CERTIFICATION LABEL

Manufactured By	FORD MOTOR COMPANY	GVWR (kg)	2250
Date of Manufacture	01/13	GAWR Front (kg)	1119
VIN:	1FADP5CU8DL520580	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. MD0208

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:	☒ 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:	340.7 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. MD0208

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. MD0208

VOLTMETER INFORMATION

Make:	Fluke
Model:	11
Serial Number:	68541895
Internal Impedance Value (M Ω):	> 10 M Ω < 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):	340.7
---------	-------

ELECTRIC ENERGY STORAGE/CONVERSION SYSTEM TO VEHICLE CHASSIS

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

V1 (V):	41.8
V2 (V):	37.8

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

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

Ro (Ω):	179500
------------------	--------

V1' (V) Pre-Impact:	6.7
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. MD0208

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):	6.7
$R_{i1} = R_o (1 + V_2/V_1) [(V_1 - V_1')/V_1']$	
Ri1 (Ω):	1790744
V2' (V):	6.7
$R_{i2} = R_o (1 + V_1/V_2) [(V_2 - V_2')/V_2']$	
Ri2 (Ω):	1754572
Ri = The lesser of Ri1 and Ri2	
Ri Pre-Test (Ω):	1754572
Ri/Vb (Ω/V):	5150
Minimum Electrical Isolation Value is 500 Ω/V	

Is the measured Electrical Isolation Value:	Yes, Pass	No, Fail
$\geq 500 \Omega/V$ without electrical isolation monitoring	X	
$\geq 100 \Omega/V$ with electrical isolation monitoring		

**DATA SHEET 4
POST-IMPACT DATA**

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

NHTSA No. MD0208

VOLTMETER INFORMATION

Make:	Fluke
Model:	11
Serial Number:	68541895
Internal Impedance Value (MΩ):	> 10 MΩ < 100 pF
Nominal Propulsion Battery Voltage (Vb) (V):	340.7

**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):	0.0
---------	-----

ELECTRIC ENERGY STORAGE/CONVERSION SYSTEM VOLTAGE

V1 =	0.0	V	Impact Time:	1	Minutes	33	s
V2 =	0.0	V	Impact Time:	1	Minutes	37	s
V1' =	0.0	V	Impact Time:	1	Minutes	42	s
V2' =	0.0	V	Impact Time:	1	Minutes	50	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.

$R_{i1} = R_o (1 + V_2/V_1) [(V_1 - V_1')/V_1']$							
Ri1 =	Zero Voltage	Ω	Impact Time:	1	Minutes	33	s
$R_{i2} = R_o (1 + V_1/V_2) [(V_2 - V_2')/V_2']$							
Ri2 =	Zero Voltage	Ω	Impact Time:	1	Minutes	37	s
Ri = The lesser of Ri1 and Ri2							
Ri =	Zero Voltage	Ω	Impact Time:	1	Minutes	33	s
Ri/Vb = electrical Isolation Value/Nominal Battery Voltage							
Minimum Electrical Value is 500 Ω/V							
Ri/Vb =	Zero Voltage	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. MD0208

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

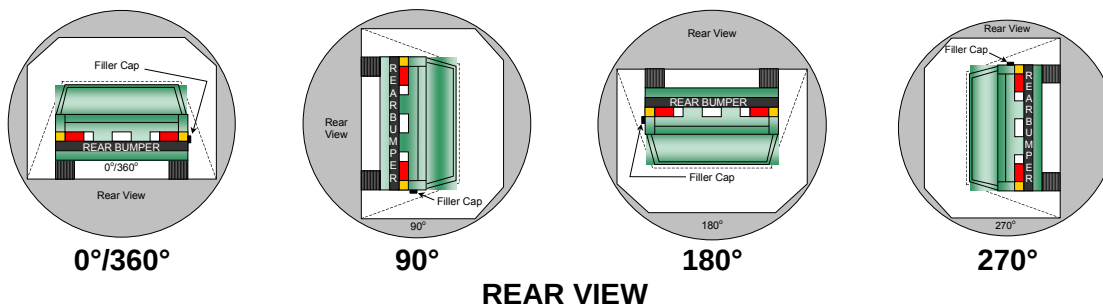
	Yes, Fail	No, Pass
Has an outside Electric Energy Storage/Conversion Device intruded into the passenger compartment?		X

	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. MD0208



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	52	seconds	5	minutes	6	Minutes	52	seconds	7	minutes
90° - 180°	1	minutes	50	seconds	5	minutes	6	minutes	50	seconds	7	minutes
180° - 270°	1	Minutes	48	seconds	5	minutes	6	minutes	48	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. MD0208

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):	340.7
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	25	s
V1 =	0.0	V	180°	Time:	4	Minutes	15	s
V1 =	0.0	V	270°	Time:	2	Minutes	17	s
V1 =	0.0	V	360°	Time:	2	Minutes	41	s
V2 =	0.0	V	0°	Time:		Minutes		s
V2 =	0.0	V	90°	Time:	2	Minutes	29	s
V2 =	0.0	V	180°	Time:	4	Minutes	20	s
V2 =	0.0	V	270°	Time:	2	Minutes	20	s
V2 =	0.0	V	360°	Time:	2	Minutes	44	s
V1' =	0.0	V	0°	Time:		Minutes		s
V1' =	0.0	V	90°	Time:	2	Minutes	36	s
V1' =	0.0	V	180°	Time:	4	Minutes	27	s
V1' =	0.0	V	270°	Time:	2	Minutes	27	s
V1' =	0.0	V	360°	Time:	2	Minutes	52	s
V2' =	0.0	V	0°	Time:		Minutes		s
V2' =	0.0	V	90°	Time:	2	Minutes	40	s
V2' =	0.0	V	180°	Time:	4	Minutes	38	s
V2' =	0.0	V	270°	Time:	2	Minutes	34	s
V2' =	0.0	V	360°	Time:	2	Minutes	59	s
Vb =	0.0	V	0°	Time:		Minutes		s
Vb =	0.0	V	90°	Time:	2	Minutes	51	s
Vb =	0.0	V	180°	Time:	4	Minutes	11	s
Vb =	0.0	V	270°	Time:	2	Minutes	13	s
Vb =	0.0	V	360°	Time:	2	Minutes	37	s

DATA SHEET 5 (CONTINUED)
STATIC ROLLOVER TEST DATA

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

NHTSA No. MD0208

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	25	s
R _{i1} =	Zero Voltage	Ω	180°	Time:	4	Minutes	15	s
R _{i1} =	Zero Voltage	Ω	270°	Time:	2	Minutes	17	s
R _{i1} =	Zero Voltage	Ω	360°	Time:	2	Minutes	41	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	29	s
R _{i2} =	Zero Voltage	Ω	180°	Time:	4	Minutes	20	s
R _{i2} =	Zero Voltage	Ω	270°	Time:	2	Minutes	20	s
R _{i2} =	Zero Voltage	Ω	360°	Time:	2	Minutes	44	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	25	s
R _i =	Zero Voltage	Ω	180°	Time:	4	Minutes	15	s
R _i =	Zero Voltage	Ω	270°	Time:	2	Minutes	17	s
R _i =	Zero Voltage	Ω	360°	Time:	2	Minutes	41	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	25	s
R _i /V _b =	Zero Voltage	Ω/V	180°	Time:	4	Minutes	15	s
R _i /V _b =	Zero Voltage	Ω/V	270°	Time:	2	Minutes	17	s
R _i /V _b =	Zero Voltage	Ω/V	360°	Time:	2	Minutes	41	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

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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

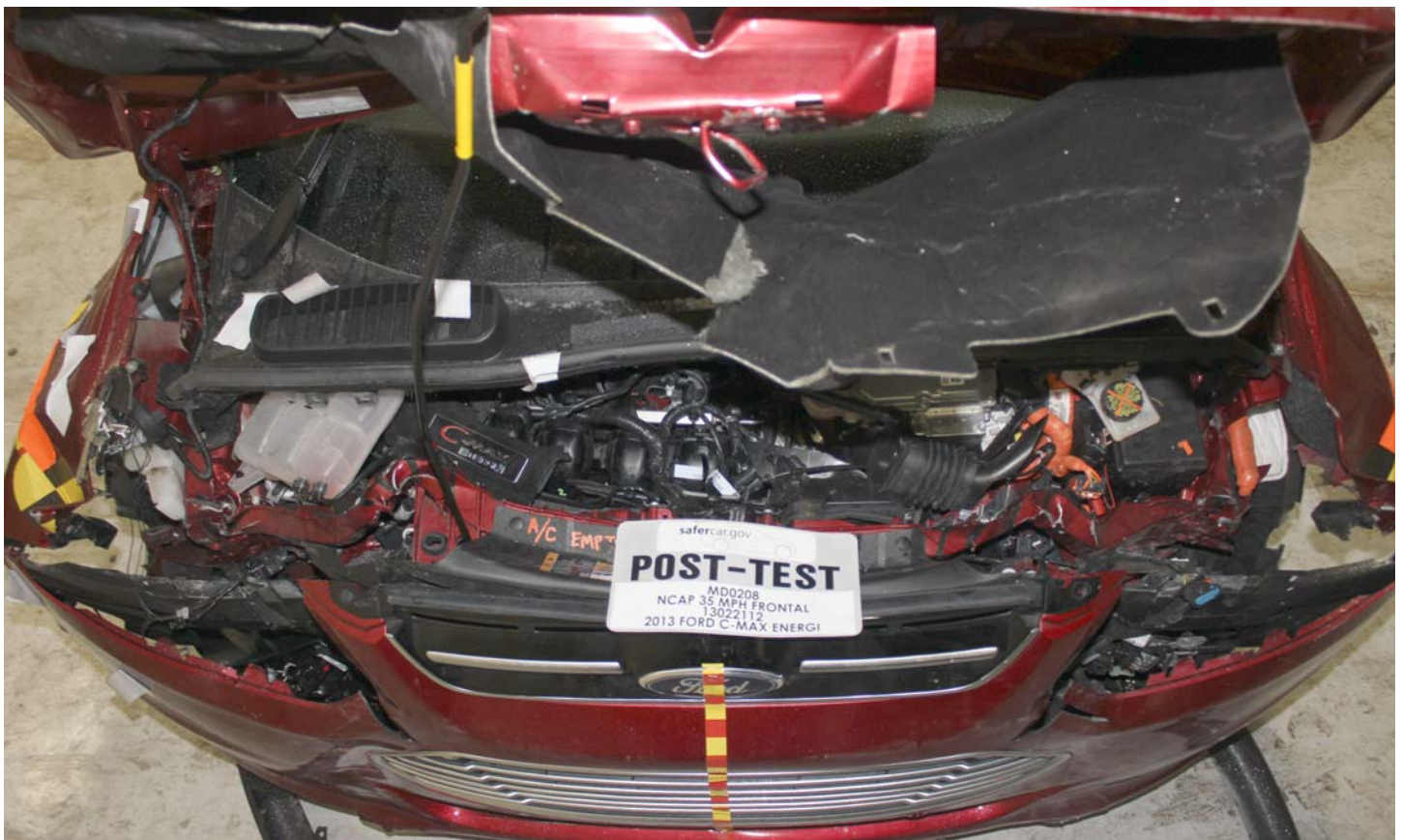
No. 015 Post-Impact View of Propulsion Battery Module(s)



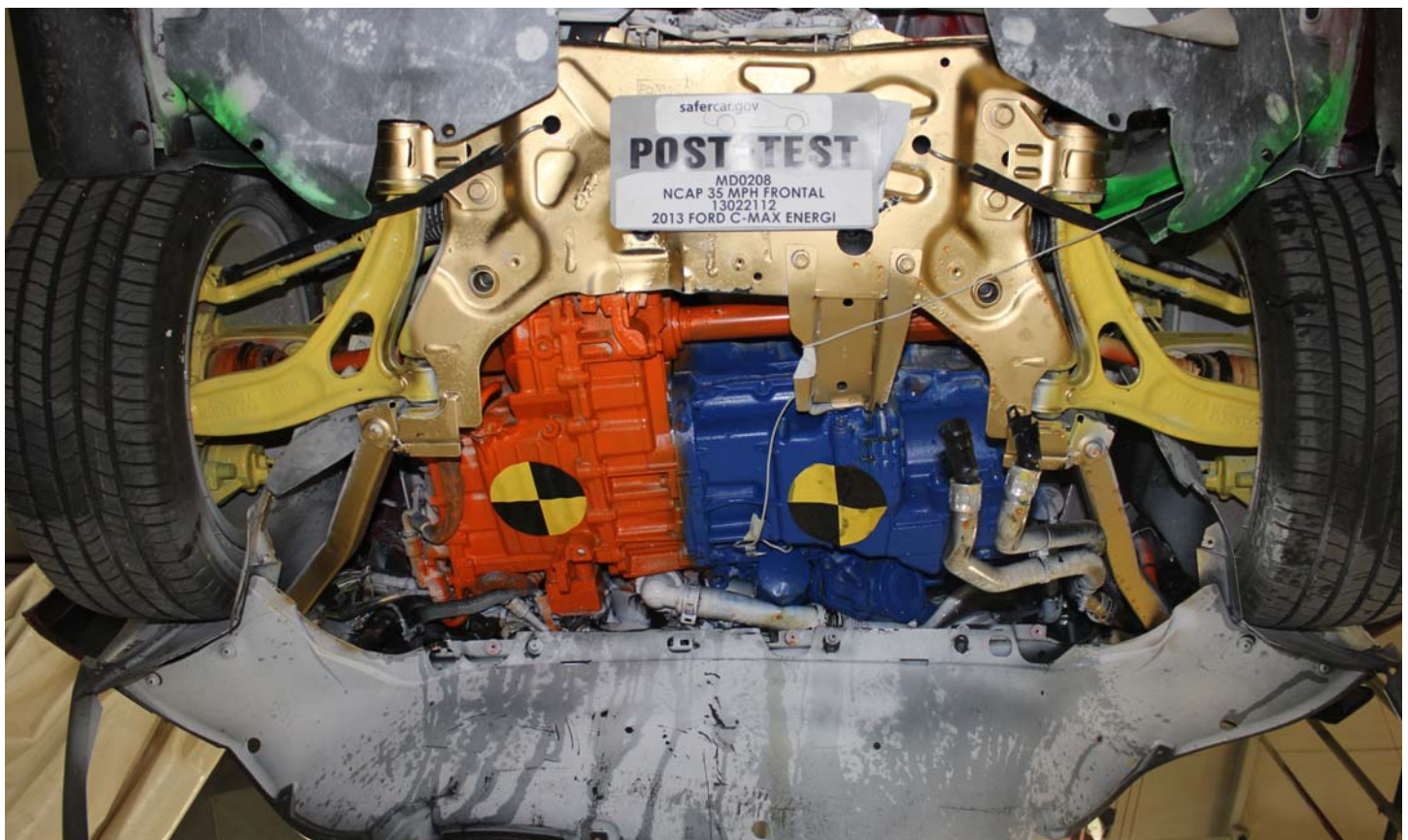
No. 016 Pre-Impact View of Electric Propulsion Drive



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



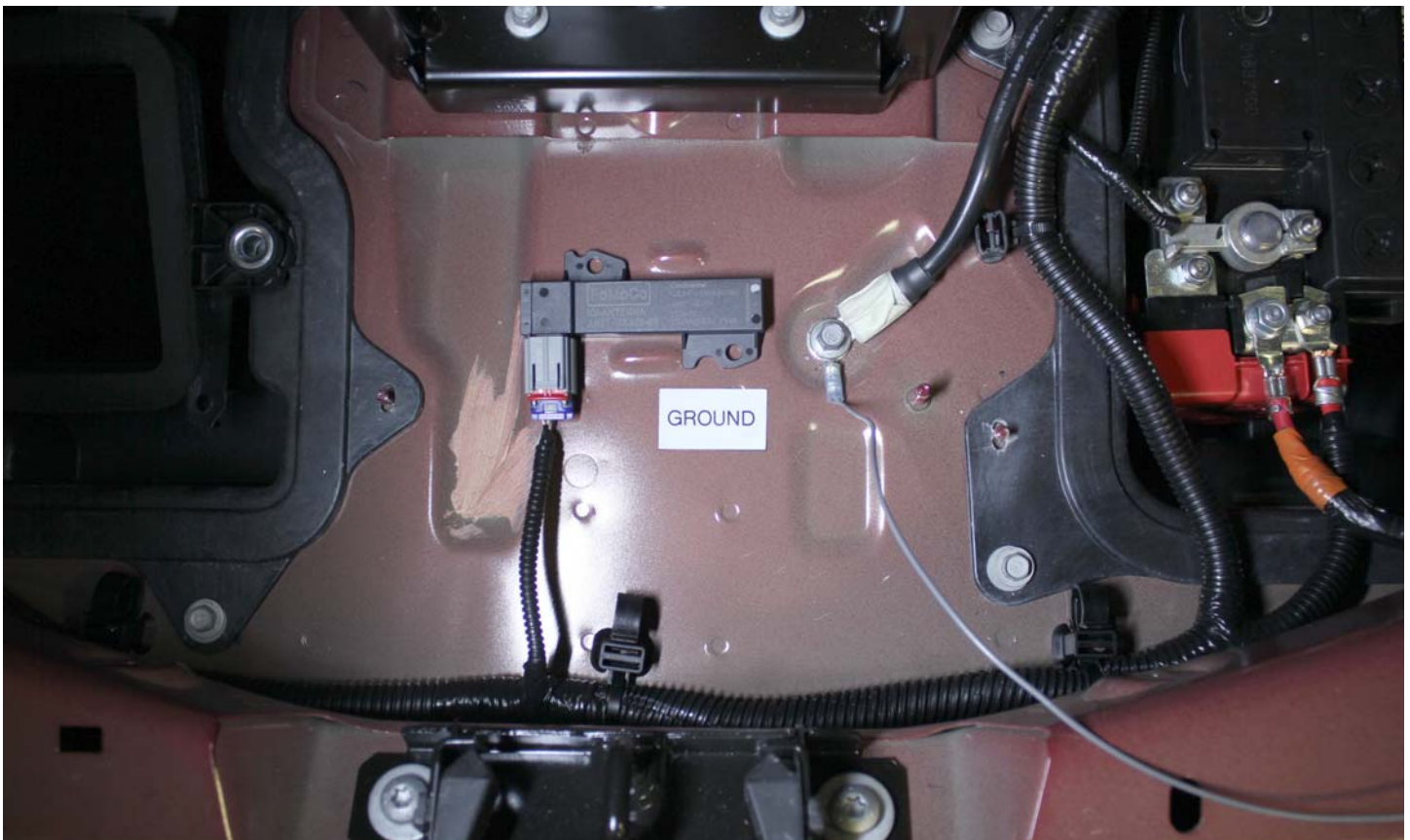
No. 018 Pre-Impact View of High Voltage Interconnect(s)



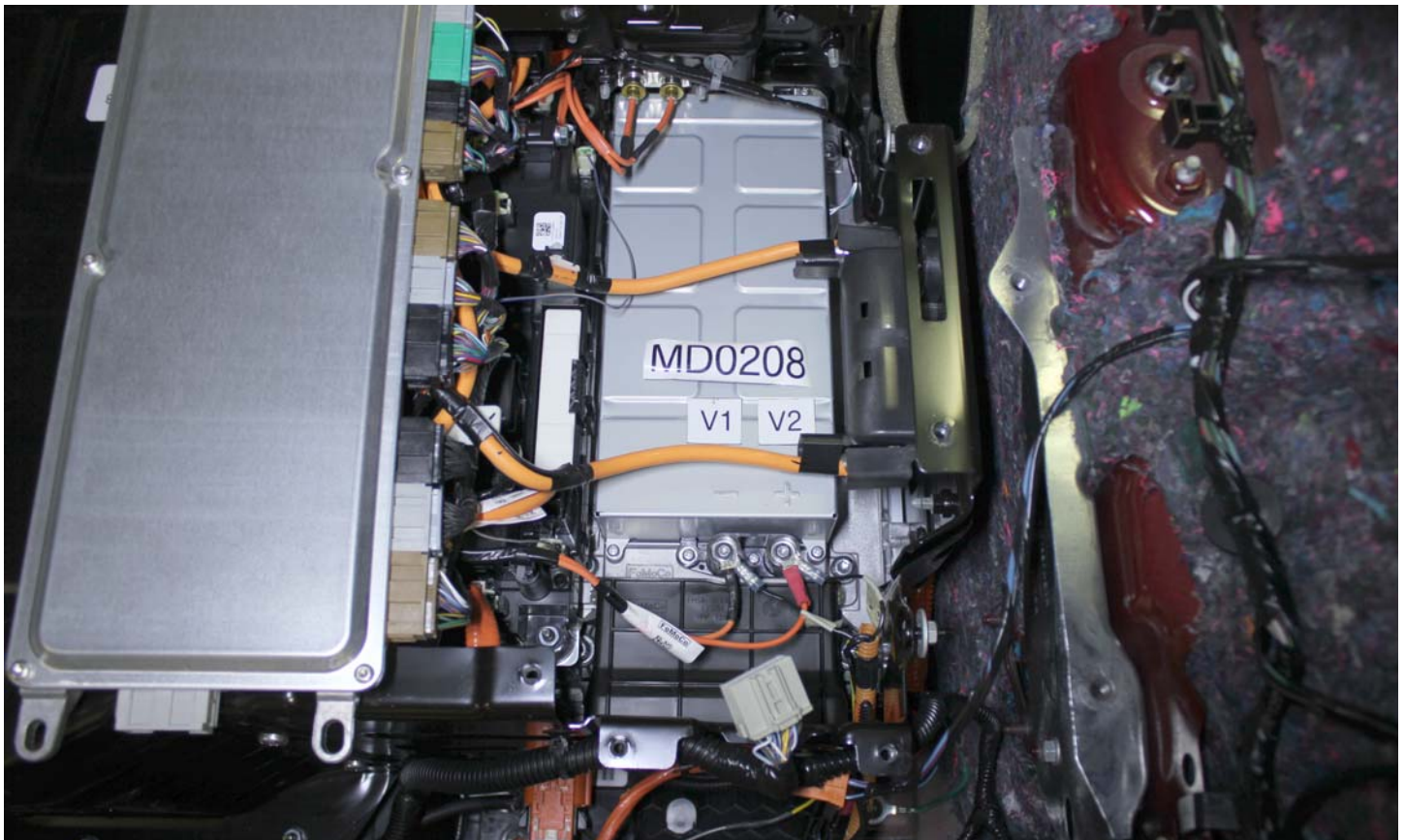
No. 019 Pre-Impact View Propulsion Battery Venting System(s)

PHOTOGRAPH NOT APPLICABLE

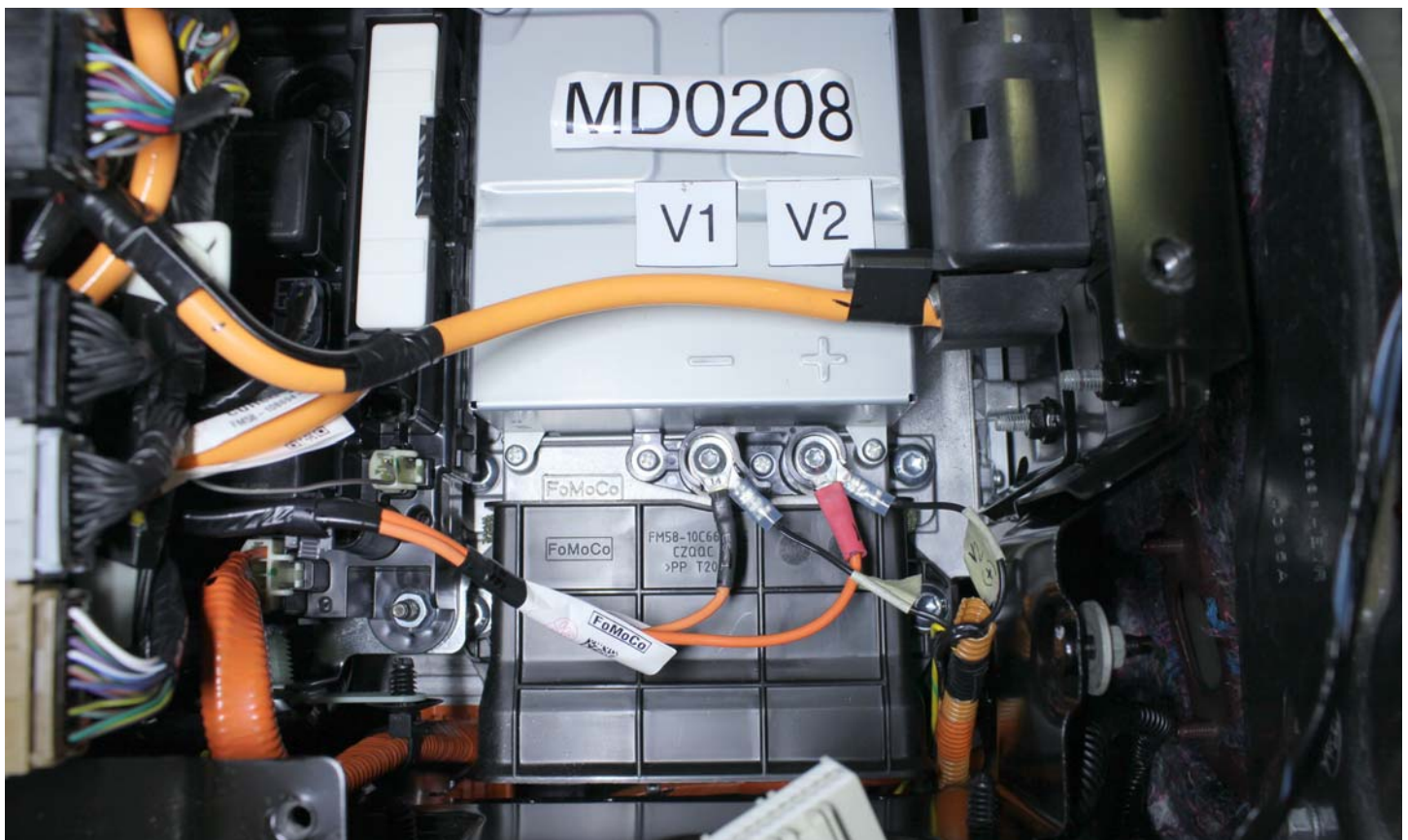
No. 020 Pre-Impact View of Other Visible Electric Propulsion Components



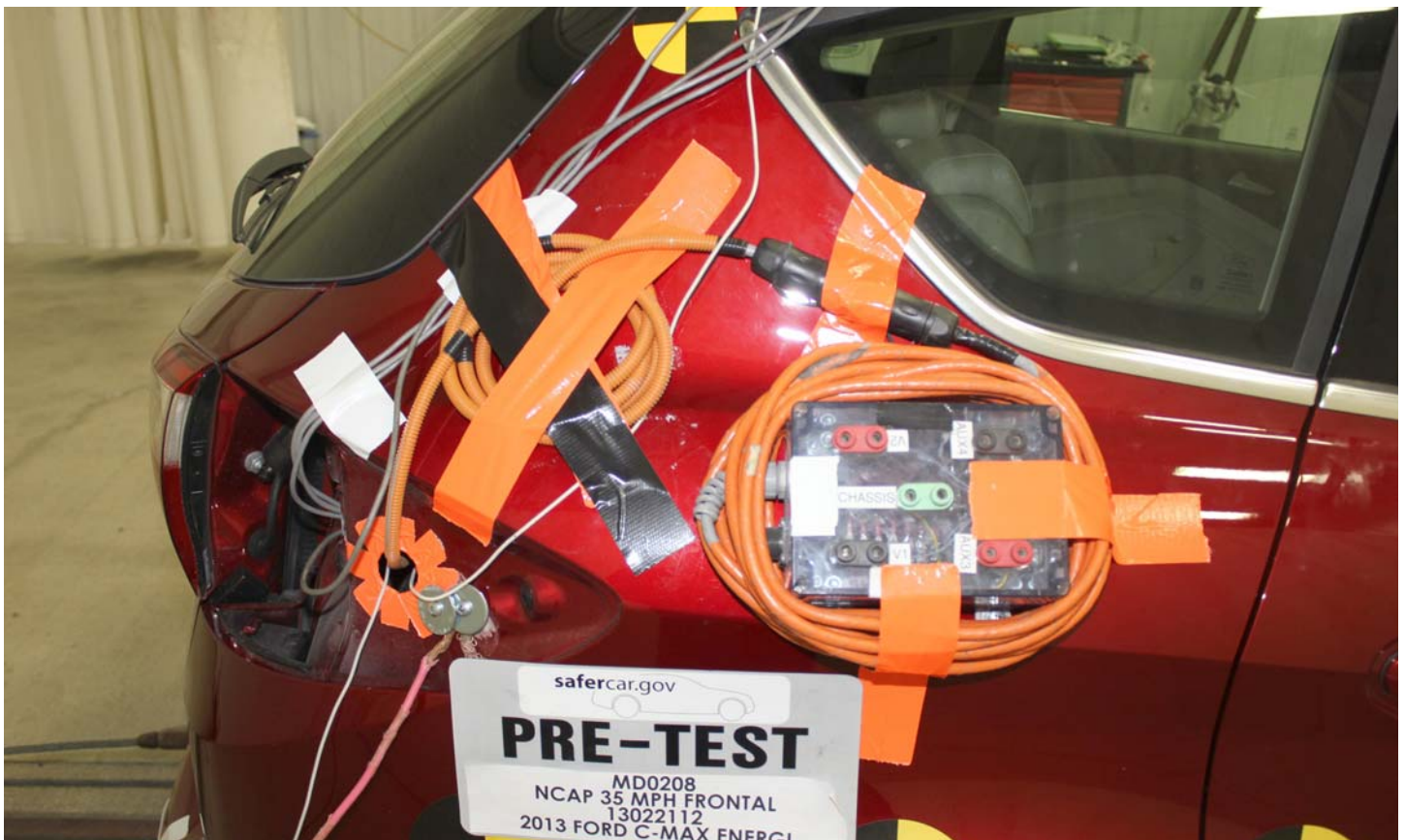
No. 021 Pre-Impact View of Ground Lead Attached



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

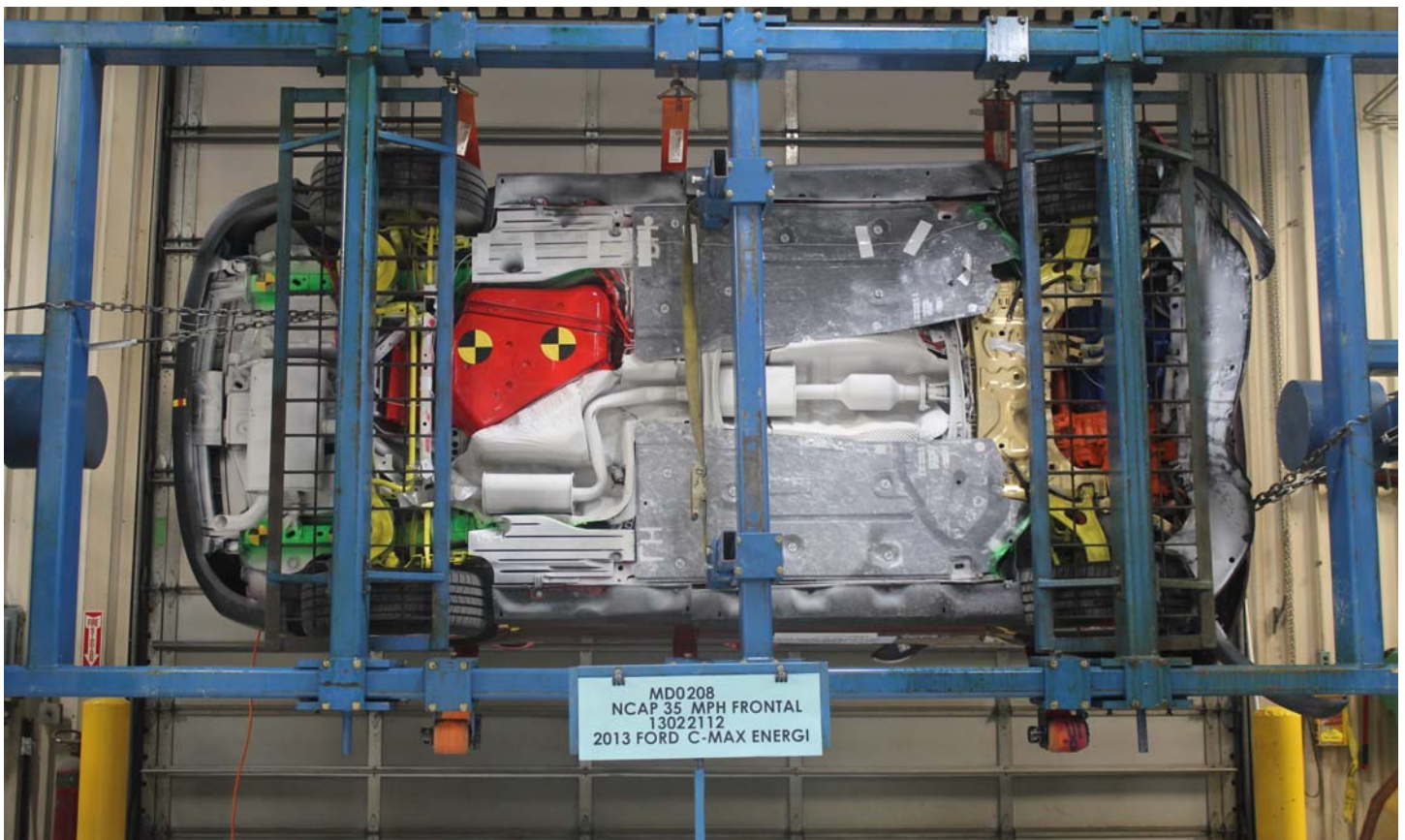
No. 027 Post-Impact View of Other Test Devices



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

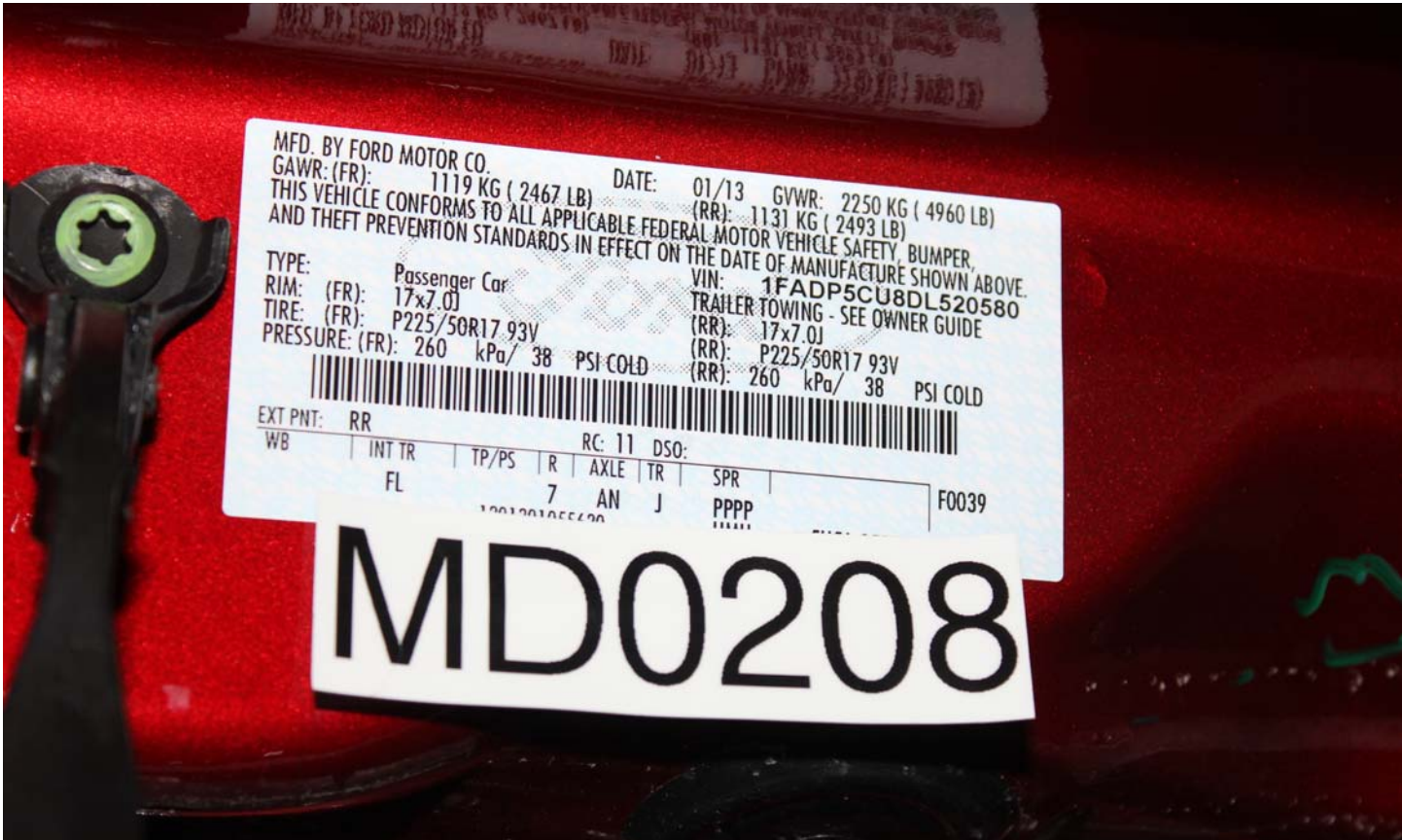
No. 038 Post-Test View of Propulsion Battery Electrolyte Spillage Location



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



No. 040 As Delivered Left Rear ¾ View of Impact Vehicle



No. 041 Vehicle's Certification Label



No. 042 Vehicle's Tire Information Placard