REPORT NUMBER: NCAP305I-MGA-2013-010

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

FORD MOTOR COMPANY
2013 Ford C-MAX Energi SEL 5-Dr Hatchback
NHTSA NUMBER: MD0209

MGA RESEARCH CORPORATION
5000 Warren Road
Burlington, WI 53105

Test Date: February 22, 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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Approved by: 
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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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4. Title and Subtitle Final Report of FMVSS 305 Compliance Testing of 2013 Ford C-MAX Energi SEL 5-Dr Hatchback, NHTSA No.: MD0209		*5. Report Date* March 21, 2013 *6. Performing Organization Code* MGA
7. Author(s) Donna Janovicz, Project Manager Joe Fleck, Project Engineer		*8. Performing Organization Report No.* NCAP305I-MGA-2013-010
9. Performing Organization Name and Address MGA Research Corporation 5000 Warren Road Burlington, WI 53105		*10. Work Unit No.* *11. Contract or Grant No.* DTNH22-09-D-00124
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Office of Crashworthiness Standards (NVS-111) 1200 New Jersey Ave, SE, Room W43-410 Washington, D.C. 20590		*13. Type of Report and Period Covered* Final Test Report February 22, 2013 to March 21, 2013 *14. Sponsoring Agency Code* NVS-111
15. Supplementary Notes		

16. Abstract

An FMVSS No. 305 Indicant test, in conjunction with an NCAP side pole 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.

17. Key Words New Car Assessment Program (NCAP) FMVSS 305 Indicant		*18. Distribution Statement* Copies of this report are available from: National Highway Traffic Safety Administration Technical Information Services Division, NPO-411 1200 New Jersey Ave, SE, Room E12-100 Washington, DC 20590 Email: tis@nhtsa.dot.gov FAX: 202-493-2833	
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SECTION 1
PURPOSE OF TEST

An FMVSS No. 305 Indicant test, in conjunction with an NCAP side pole 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 DTNH22-09-D-00124.

SECTION 2
SUMMARY OF TEST RESULTS

A NCAP side pole barrier impact test was performed by MGA Research Corporation on a 2013 Ford C-MAX Energi SEL 5-Dr Hatchback hybrid vehicle on February 22, 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. MD0209

TEST VEHICLE INFORMATION

Year/Make/Model/Body Style	2013 Ford C-MAX Energi SEL 5-Dr Hatchback
NHTSA No.	MD0209
Color	Sterling Gray Metallic
Odometer Reading	7 miles

DATA FROM CERTIFICATION LABEL

Manufactured By	FORD MOTOR COMPANY
Date of Manufacture	12/12
VIN:	1FADP5CU1DL519349

GVWR (kg)	2250
GAWR Front (kg)	1119
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. MD0209

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

For all battery types:	
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:	334.7 V
For batteries that are rechargeable ONLY by an energy source on the vehicle:	
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. MD0209

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. MD0209

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):	334.7

ELECTRIC ENERGY STORAGE/CONVERSION SYSTEM TO VEHICLE CHASSIS

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

V1 (V):	42.4
V2 (V):	42.6

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

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

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback NHTSA No. MD0209

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
Ri1 = Ro (1 + V2/V1) [(V1-V1’)/V1’]	
Ri1 (Ω):	1951896
V2’ (V):	6.6
Ri2 = Ro (1 + V1/V2) [(V2-V2’)/V2’]	
Ri2 (Ω):	1953585
Ri = The lesser of Ri1 and Ri2	
Ri Pre-Test (Ω):	1951896
Ri/Vb (Ω/V):	5832
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. MD0209

VOLTMETER INFORMATION

Make:	Fluke
Model:	11
Serial Number:	68541895
Internal Impedance Value (MΩ):	> 10 MΩ < 100 pF
Nominal Propulsion Battery Voltage (Vb) (V):	334.7

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):	2.1

ELECTRIC ENERGY STORAGE/CONVERSION SYSTEM VOLTAGE

V1 =	8.5	V	Impact Time:	1	Minutes	24	s
V2 =	5.5	V	Impact Time:	1	Minutes	30	s
V1' =	0.3	V	Impact Time:	1	Minutes	39	s
V2' =	0.2	V	Impact Time:	1	Minutes	45	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 =	8081020	Ω	Impact Time:	1	Minutes	24	s
Ri2 = Ro (1 + V1/V2) [(V2-V2')/V2']							
Ri2 =	12108091	Ω	Impact Time:	1	Minutes	30	s
Ri = The lesser of Ri1 and Ri2							
Ri =	8081020	Ω	Impact Time:	1	Minutes	24	s
Ri/Vb = electrical Isolation Value/Nominal Battery Voltage							
Minimum Electrical Value is 500 Ω/V							
Ri/Vb =	24144	Ω/V	Impact Time:	1	Minutes	24	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. MD0209

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

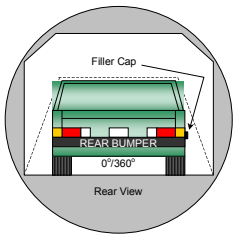
Describe intrusion of an outside Electric Energy Storage/Conversion Device into the passenger compartment [Supply photographs as appropriate]:
No Intrusion

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

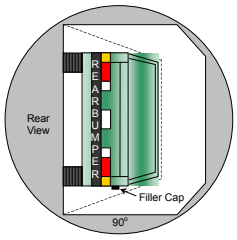
	Yes, Fail	No, Pass
Is Electric Energy Storage/Conversion Device electrolyte spillage visible in the passenger compartment?		X

DATA SHEET 5
STATIC ROLLOVER TEST DATA

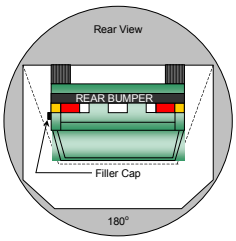
Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback NHTSA No. MD0209



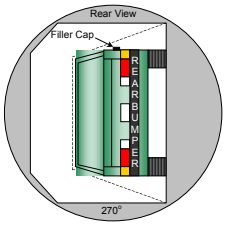
0°/360°



90°



180°



270°

REAR VIEW

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	54	seconds	5	minutes	6	Minutes	54	seconds	7	minutes
90° - 180°	1	minutes	51	seconds	5	minutes	6	minutes	51	seconds	7	minutes
180° - 270°	1	Minutes	47	seconds	5	minutes	6	minutes	47	seconds	7	minutes
270° - 360°	1	minutes	51	seconds	5	minutes	6	minutes	51	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. MD0209

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):	334.7
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	28	s
V1 =	0.0	V	180°	Time:	3	Minutes	49	s
V1 =	0.0	V	270°	Time:	2	Minutes	13	s
V1 =	0.0	V	360°	Time:	2	Minutes	46	s
V2 =	0.0	V	0°	Time:		Minutes		s
V2 =	0.0	V	90°	Time:	2	Minutes	32	s
V2 =	0.0	V	180°	Time:	3	Minutes	52	s
V2 =	0.0	V	270°	Time:	2	Minutes	18	s
V2 =	0.0	V	360°	Time:	2	Minutes	52	s
V1' =	0.0	V	0°	Time:		Minutes		s
V1' =	0.0	V	90°	Time:	2	Minutes	39	s
V1' =	0.0	V	180°	Time:	3	Minutes	58	s
V1' =	0.0	V	270°	Time:	2	Minutes	25	s
V1' =	0.0	V	360°	Time:	2	Minutes	58	s
V2' =	0.0	V	0°	Time:		Minutes		s
V2' =	0.0	V	90°	Time:	2	Minutes	47	s
V2' =	0.0	V	180°	Time:	4	Minutes	7	s
V2' =	0.0	V	270°	Time:	2	Minutes	30	s
V2' =	0.0	V	360°	Time:	2	Minutes	5	s
Vb =	0.0	V	0°	Time:		Minutes		s
Vb =	0.0	V	90°	Time:	2	Minutes	26	s
Vb =	0.0	V	180°	Time:	3	Minutes	46	s
Vb =	0.0	V	270°	Time:	2	Minutes	8	s
Vb =	0.0	V	360°	Time:	2	Minutes	43	s

DATA SHEET 5 (CONTINUED)
STATIC ROLLOVER TEST DATA

Test Vehicle: 2013 Ford C-MAX Energi SEL 5-Dr Hatchback NHTSA No. MD0209

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.

Ri1 = Ro (1 + V2/V1) [(V1-V1')/V1']								
Ri1 =	Zero Voltage	Ω	0°	Time:		Minutes		s
Ri1 =	Zero Voltage	Ω	90°	Time:	2	Minutes	28	s
Ri1 =	Zero Voltage	Ω	180°	Time:	3	Minutes	49	s
Ri1 =	Zero Voltage	Ω	270°	Time:	2	Minutes	13	s
Ri1 =	Zero Voltage	Ω	360°	Time:	2	Minutes	46	s
Ri2 = Ro (1 + V1/V2) [(V2-V2')/V2']								
Ri2 =	Zero Voltage	Ω	0°	Time:		Minutes		s
Ri2 =	Zero Voltage	Ω	90°	Time:	2	Minutes	32	s
Ri2 =	Zero Voltage	Ω	180°	Time:	3	Minutes	52	s
Ri2 =	Zero Voltage	Ω	270°	Time:	2	Minutes	18	s
Ri2 =	Zero Voltage	Ω	360°	Time:	2	Minutes	52	s
Ri = The lesser of Ri1 and Ri2								
Ri =	Zero Voltage	Ω	0°	Time:		Minutes		s
Ri =	Zero Voltage	Ω	90°	Time:	2	Minutes	28	s
Ri =	Zero Voltage	Ω	180°	Time:	3	Minutes	49	s
Ri =	Zero Voltage	Ω	270°	Time:	2	Minutes	13	s
Ri =	Zero Voltage	Ω	360°	Time:	2	Minutes	46	s
Ri/Vb = Electrical Isolation Value/Nominal Battery Voltage Minimum Electrical Isolation Value is 500 Ω /V								
Ri/Vb =	Zero Voltage	Ω/V	0°	Time:		Minutes		s
Ri/Vb =	Zero Voltage	Ω/V	90°	Time:	2	Minutes	28	s
Ri/Vb =	Zero Voltage	Ω/V	180°	Time:	3	Minutes	49	s
Ri/Vb =	Zero Voltage	Ω/V	270°	Time:	2	Minutes	13	s
Ri/Vb =	Zero Voltage	Ω/V	360°	Time:	2	Minutes	46	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		

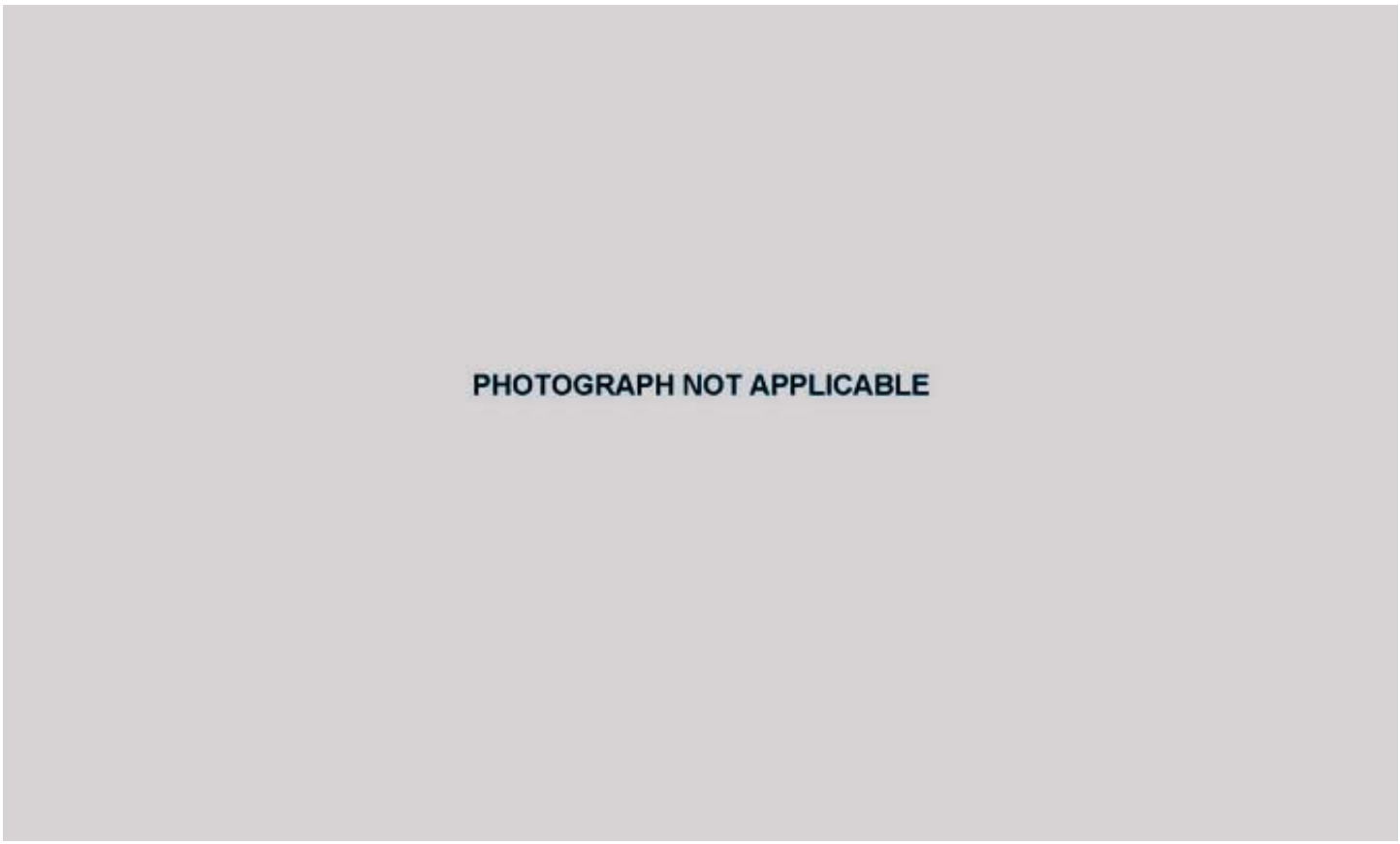
APPENDIX A
PHOTOGRAPHS

TABLE OF PHOTOGRAPHS

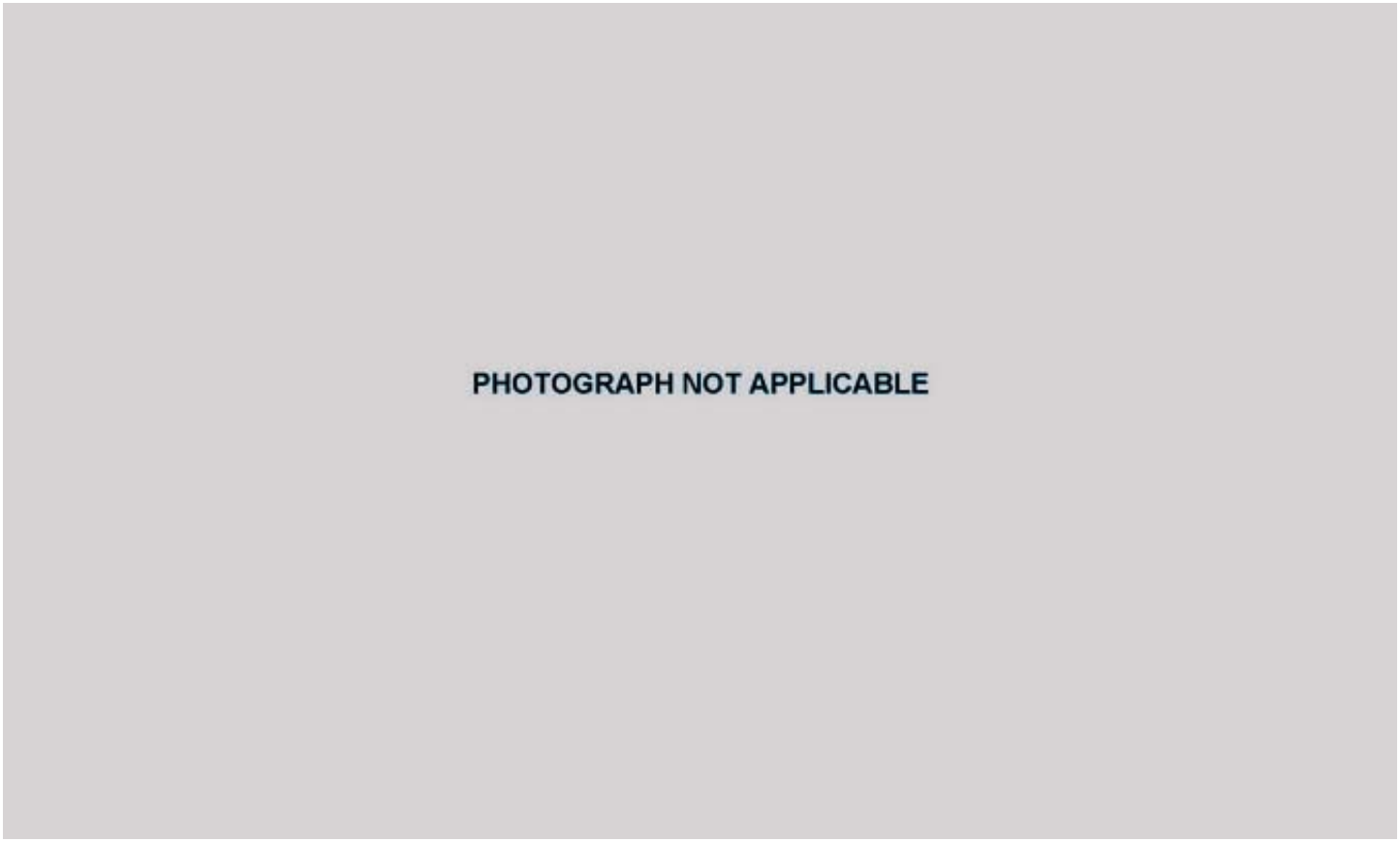
PHOTOGRAPH NOT APPLICABLE

No. 001 Auxiliary Power Module Warning Label

No. 002 Power Inverter Warning Label



No. 003 First Responder Warning Label



No. 004 First Responder Warning Location

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

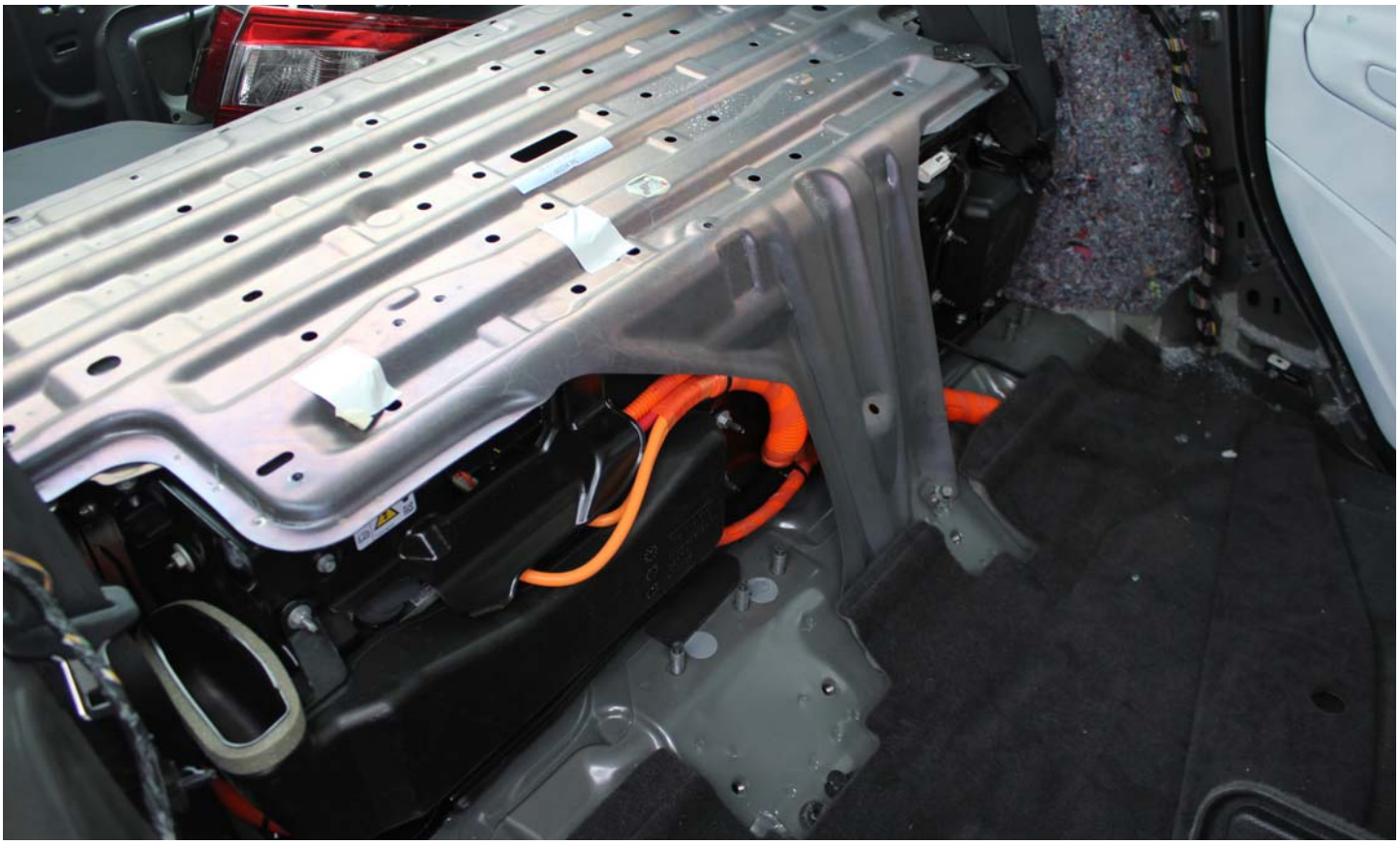
No. 005a Other Vehicle Label(s) Related to Electrical Propulsion System

No. 006 Manual High Voltage Service Disconnect in Place

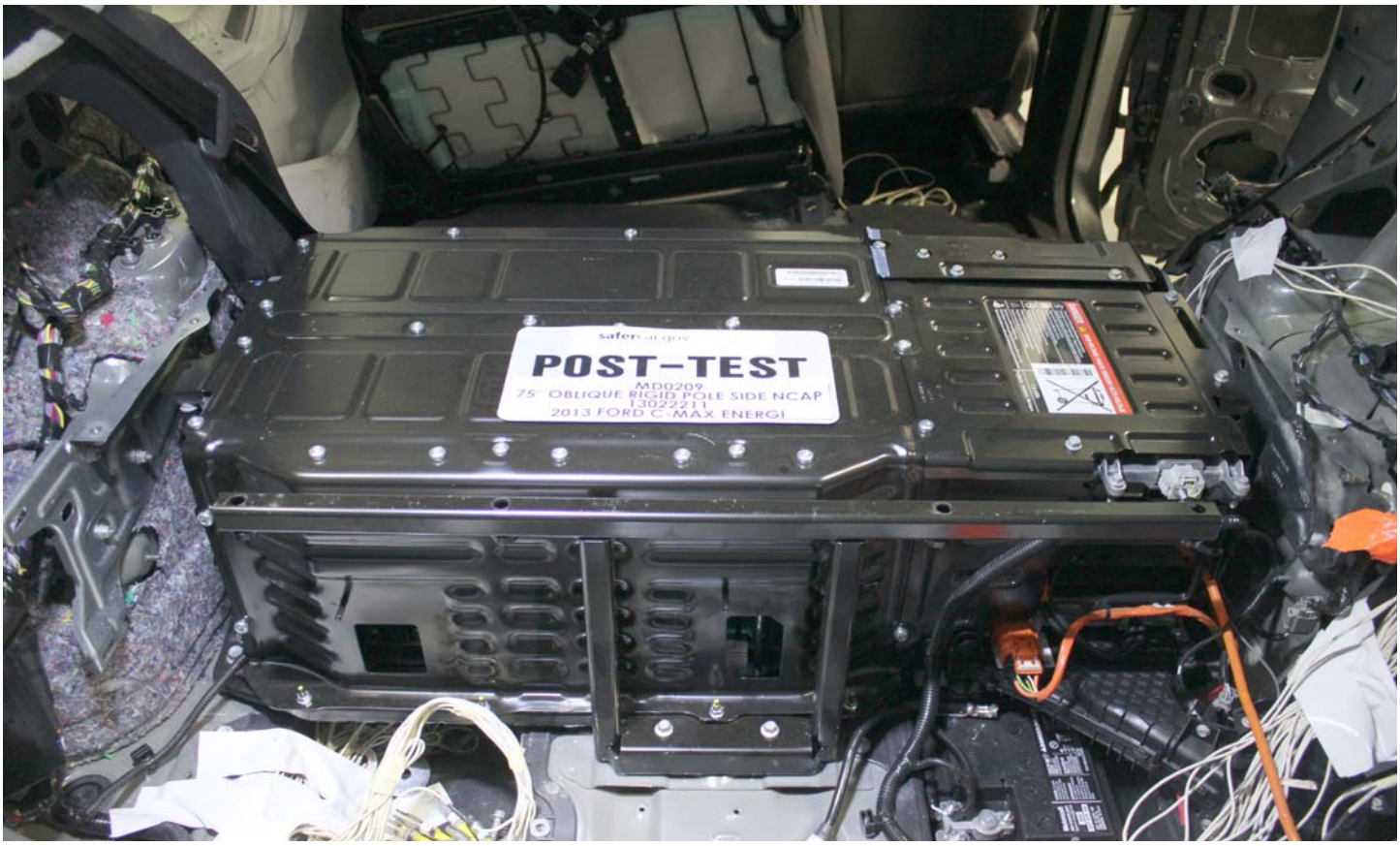
No. 007 Manual High Voltage Service Disconnect Removed

No. 008 Manual High Voltage Service Disconnect Removed

No. 009 Pre-Impact View of Propulsion Battery



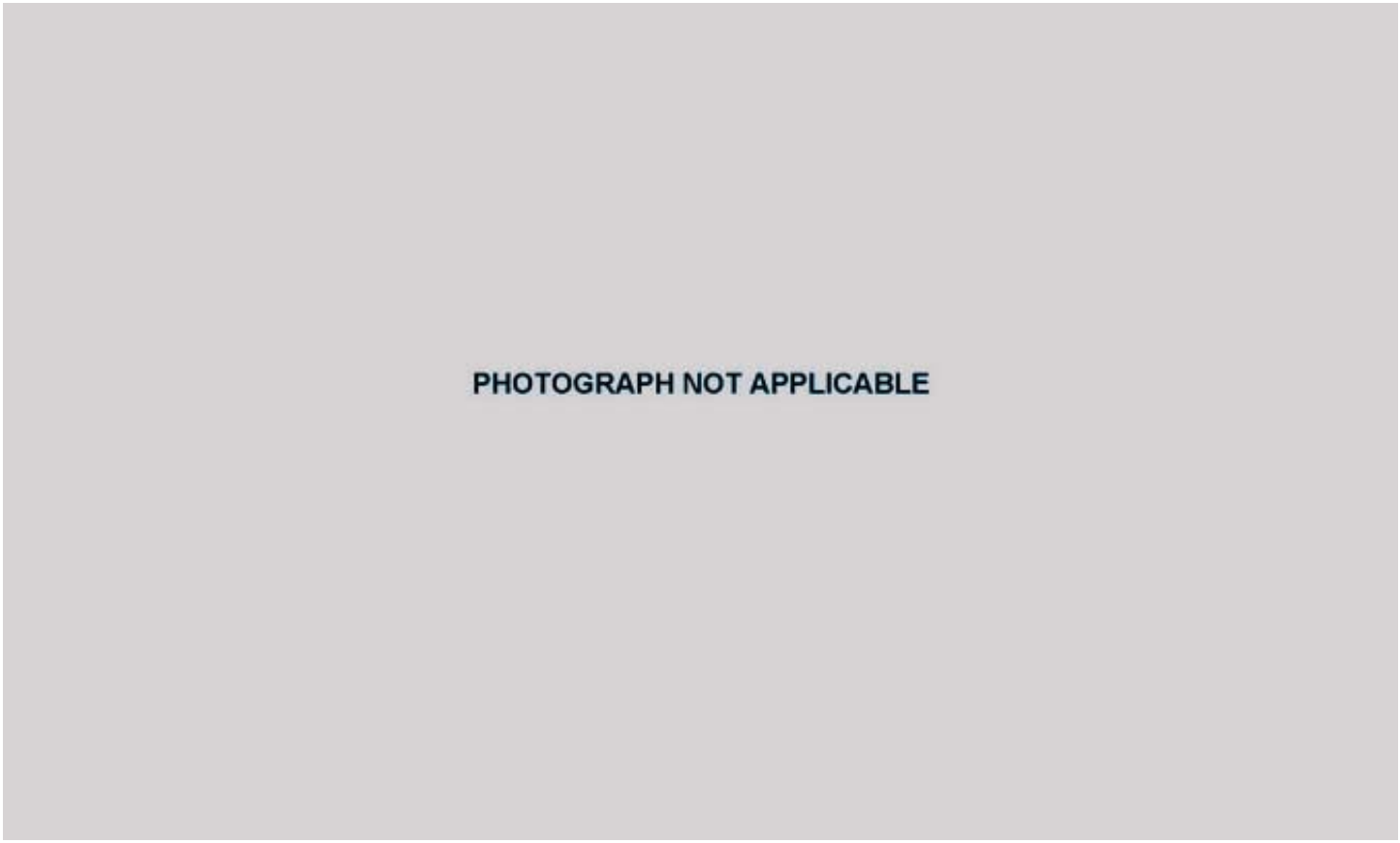
No. 010 Post-Impact Front View of Propulsion Battery



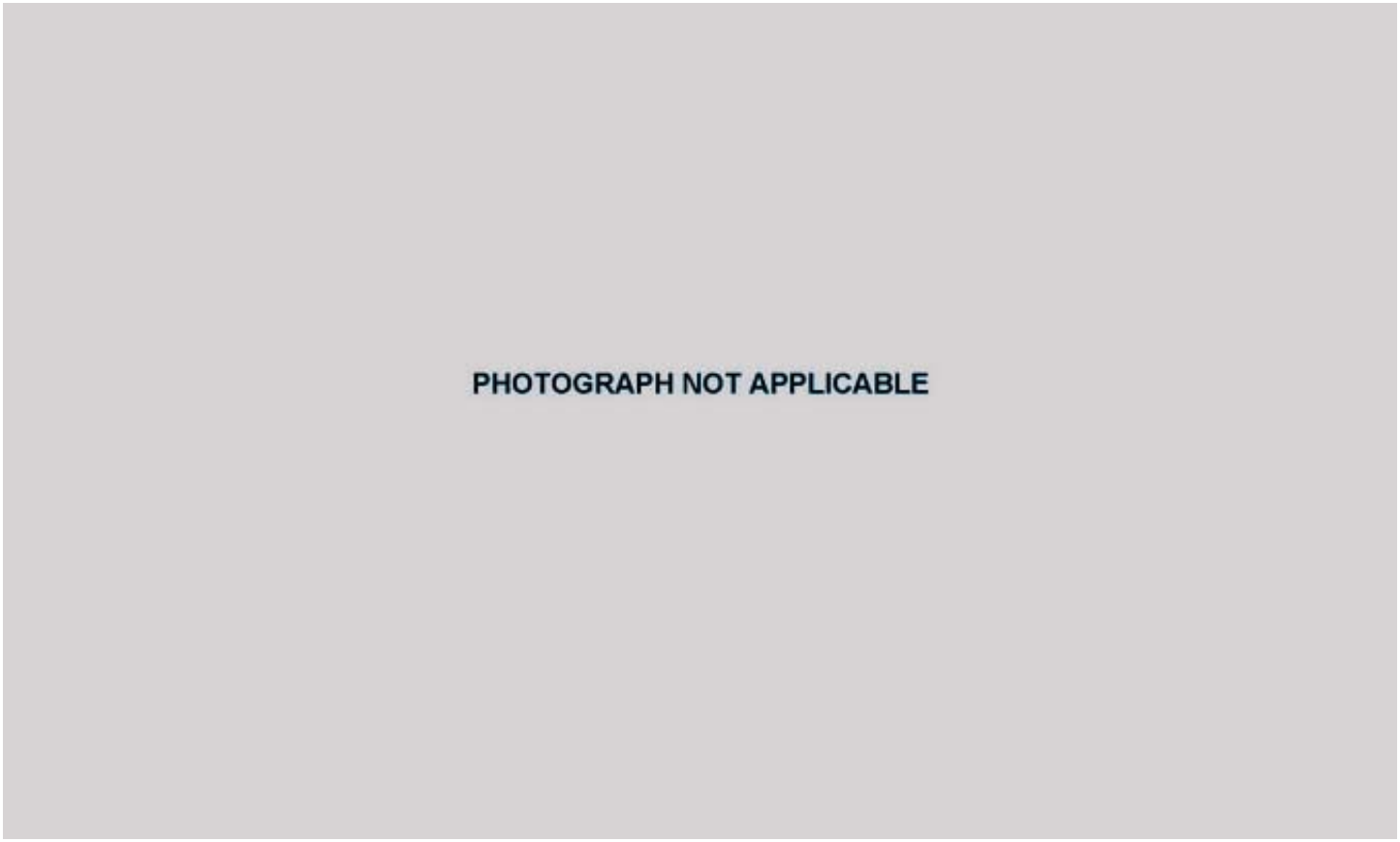
No. 011 Post-Impact Rear View of Propulsion Battery

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

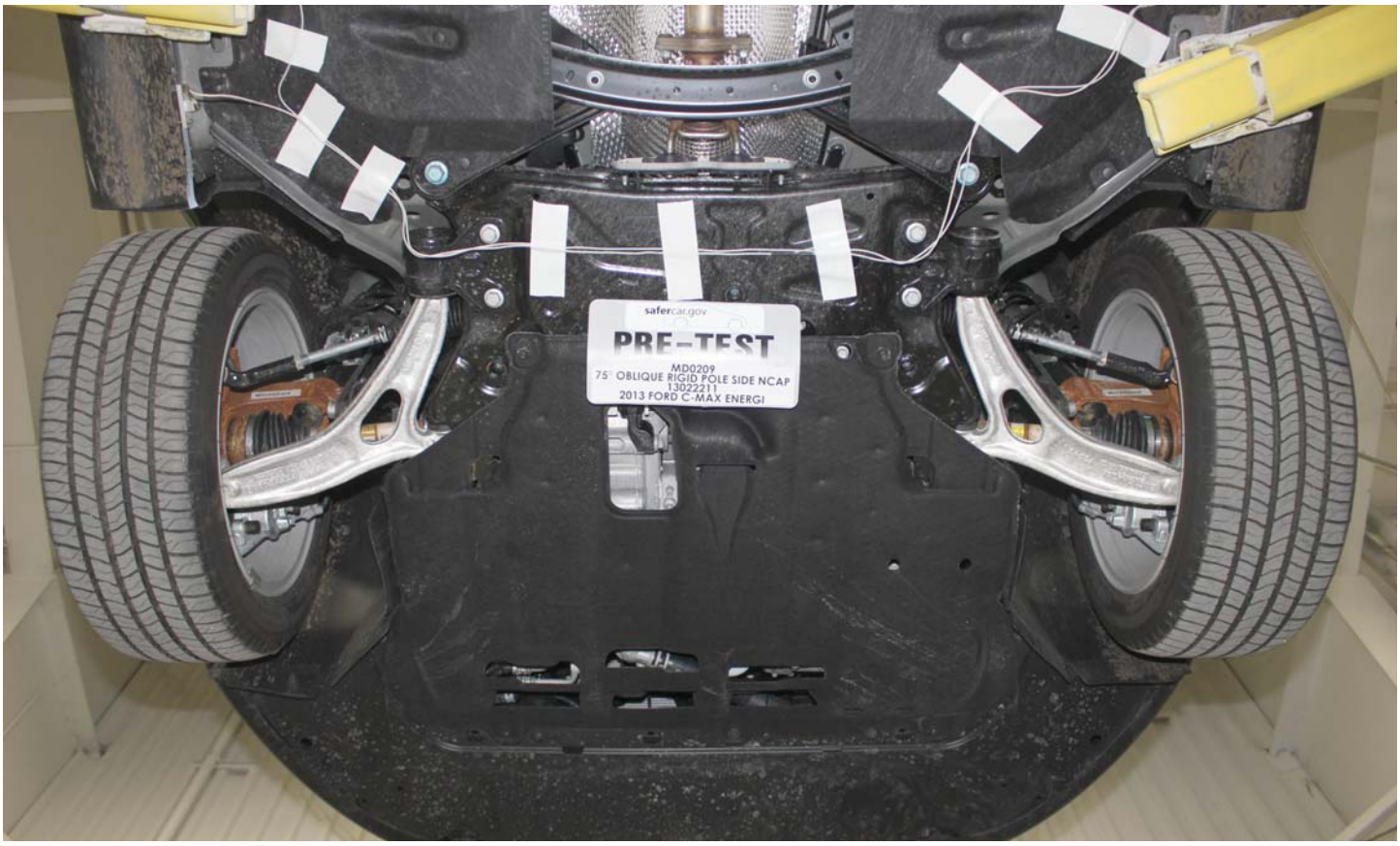


No. 014 Pre-Impact View of Propulsion Battery Module(s)



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

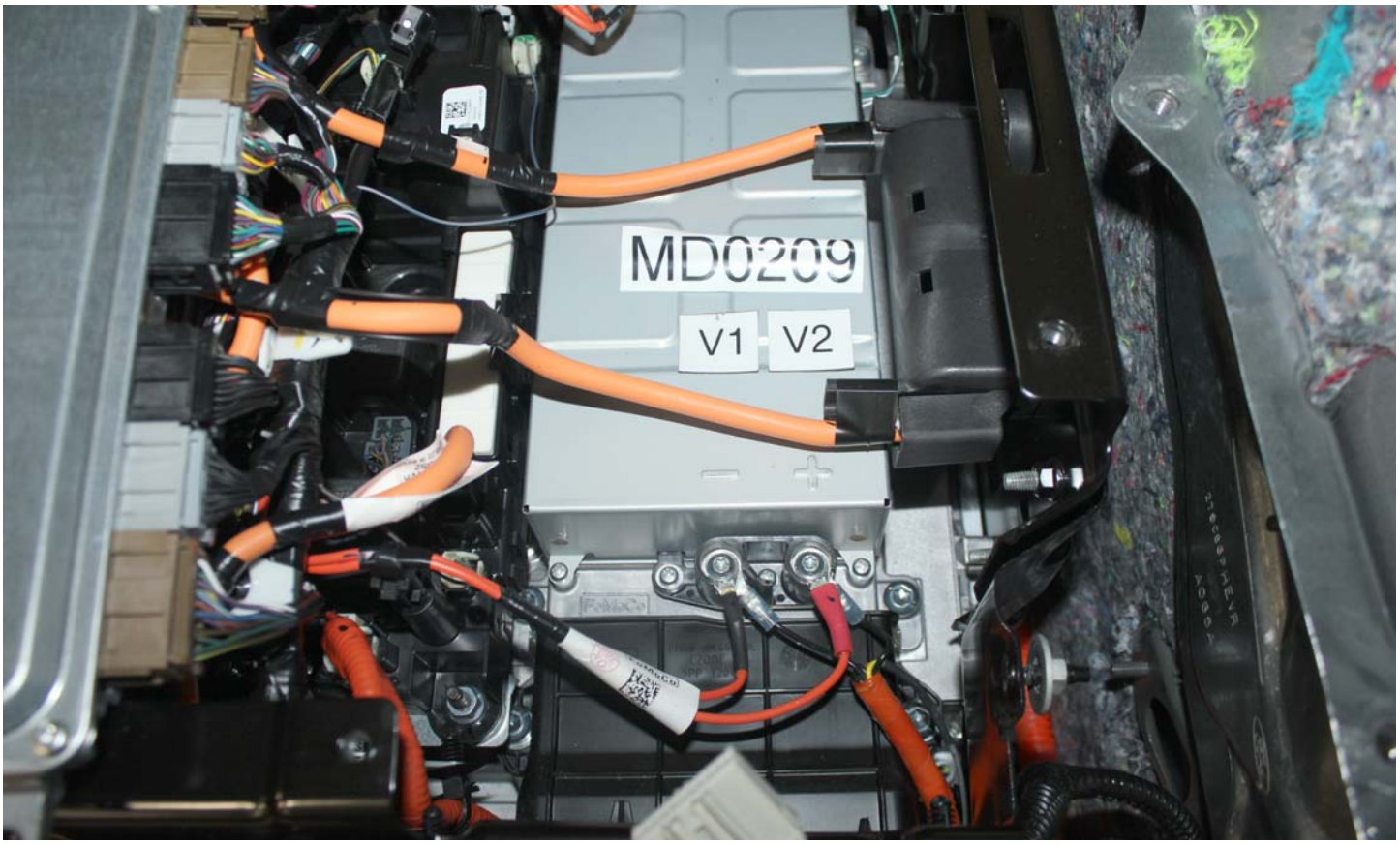
No. 018 Pre-Impact View of High Voltage Interconnect(s)

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

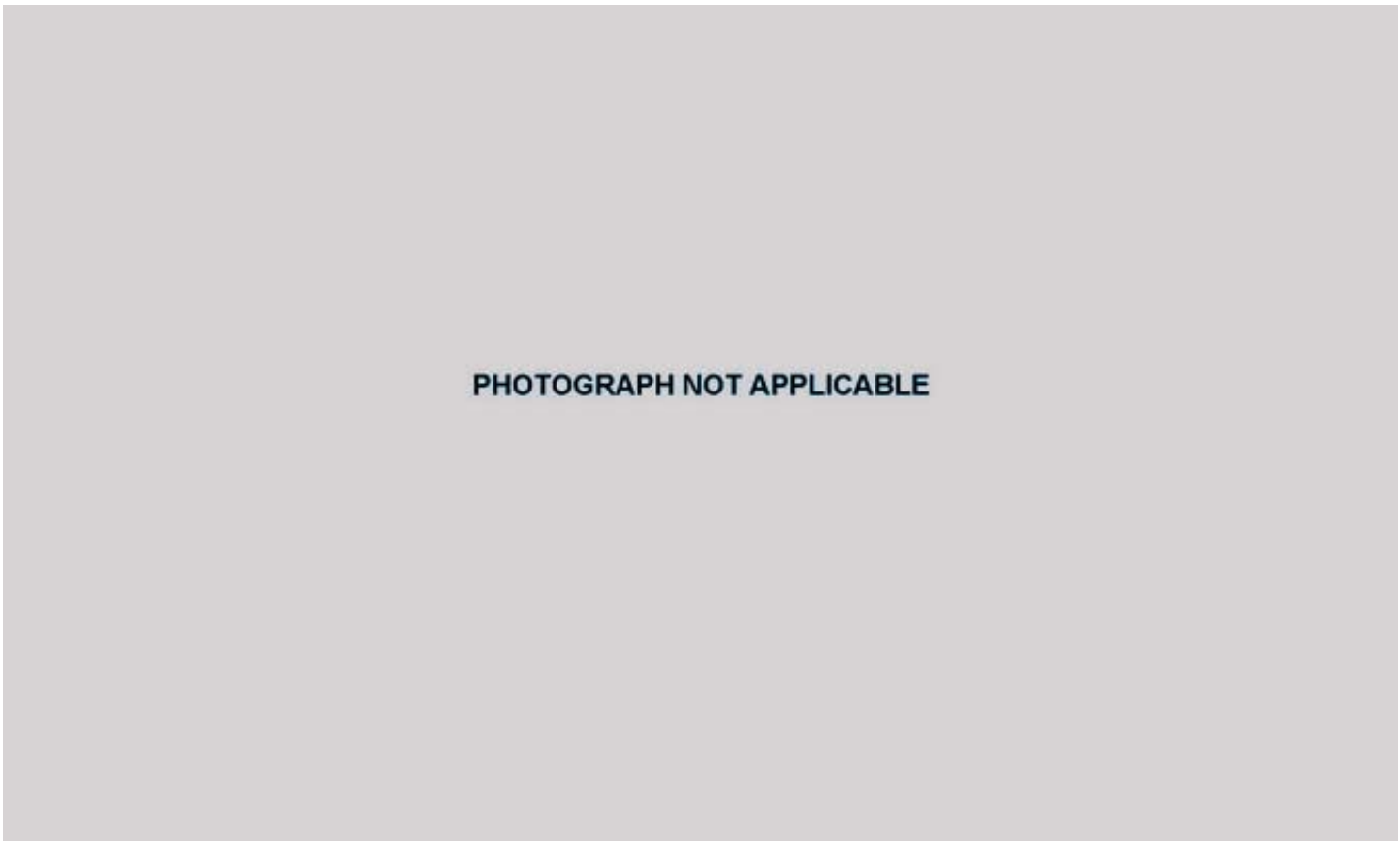


No. 022 Pre-Impact View of High Voltage Leads Attached

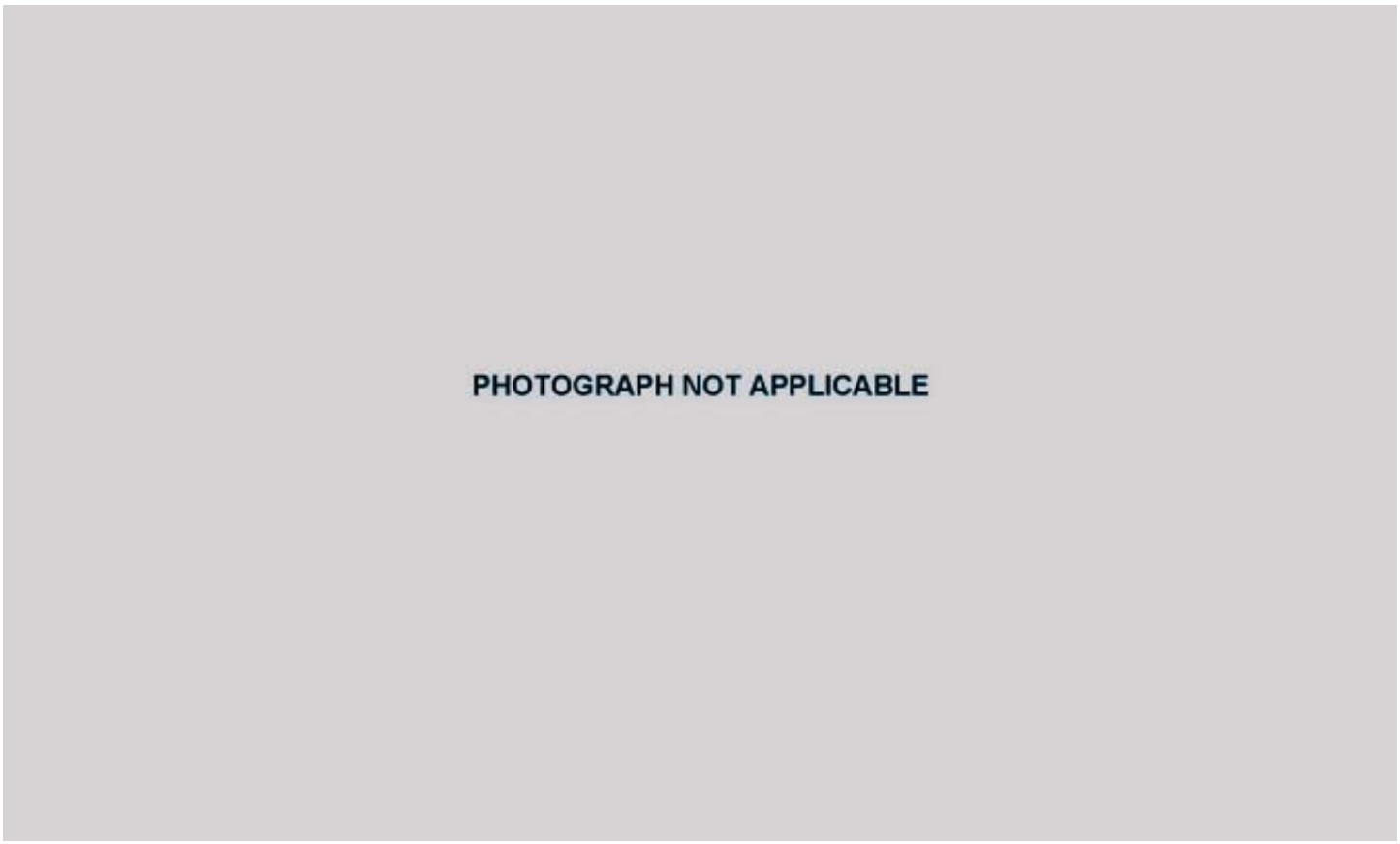
No. 023 Pre-Impact Close-Up View of High Voltage Leads Attached

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

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



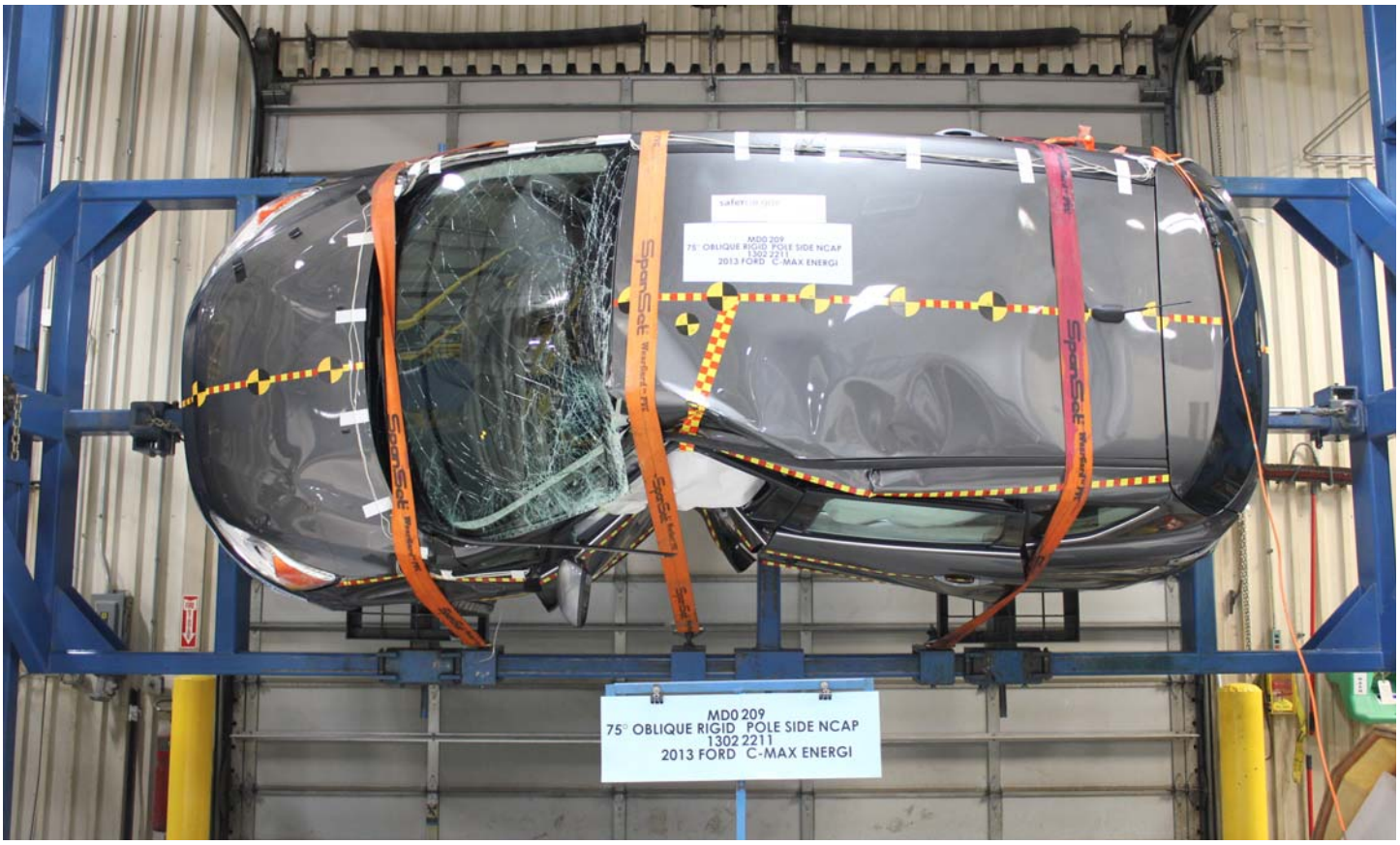
No. 026 Pre-Impact View of Other Test Devices



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°

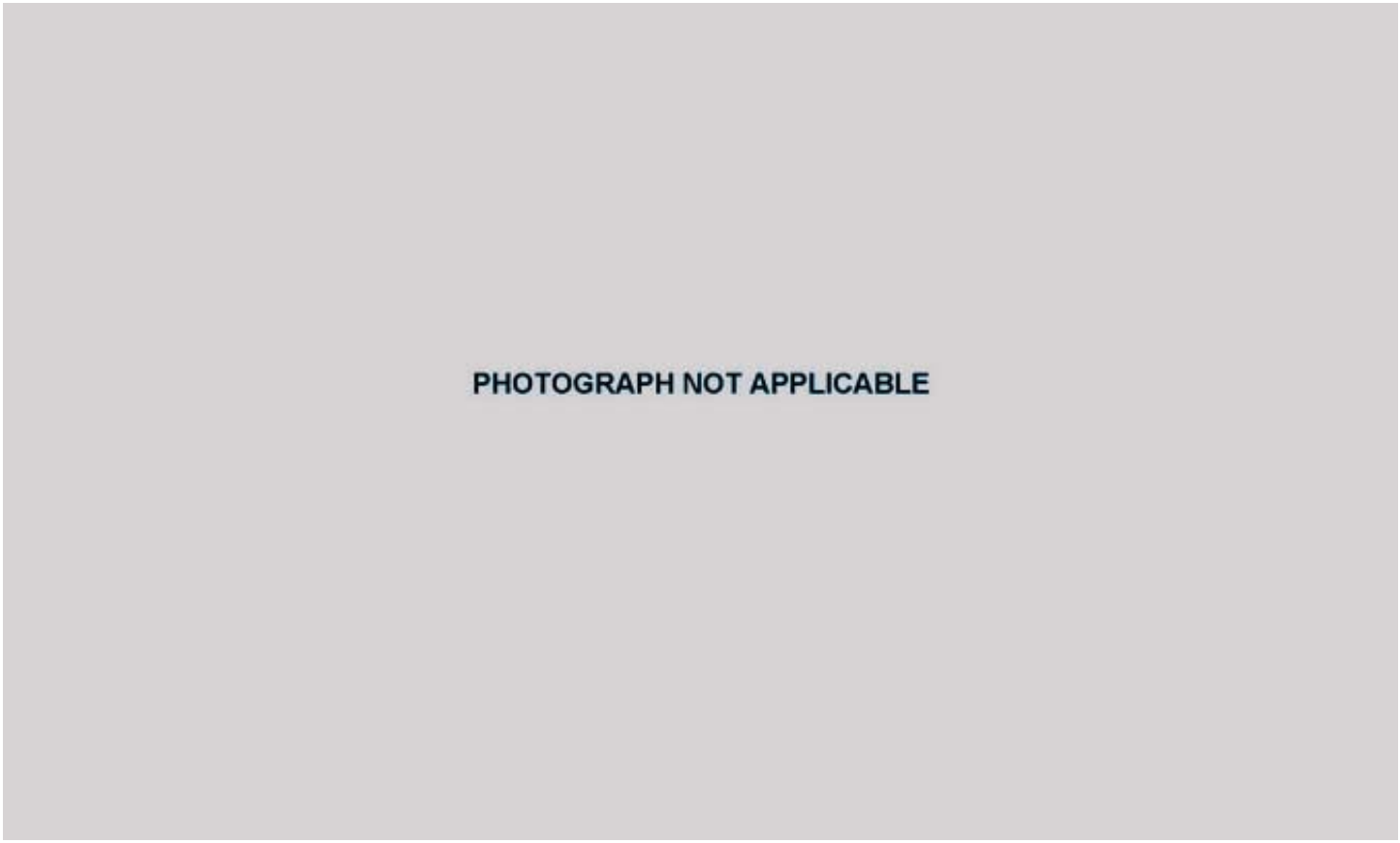


No. 030 FMVSS No. 305 Static Rollover at 270°

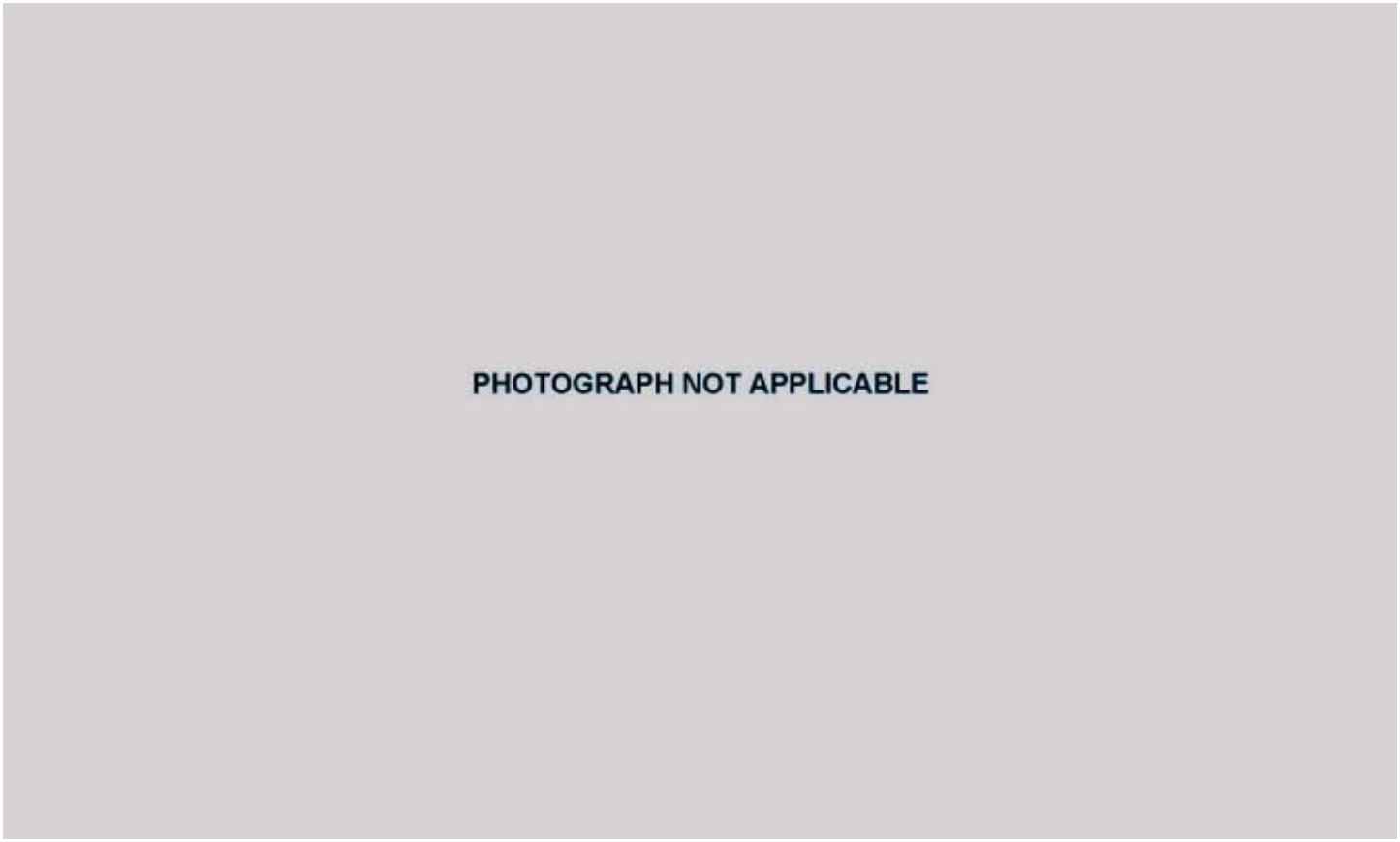
No. 031 FMVSS No. 305 Static Rollover at 360°

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

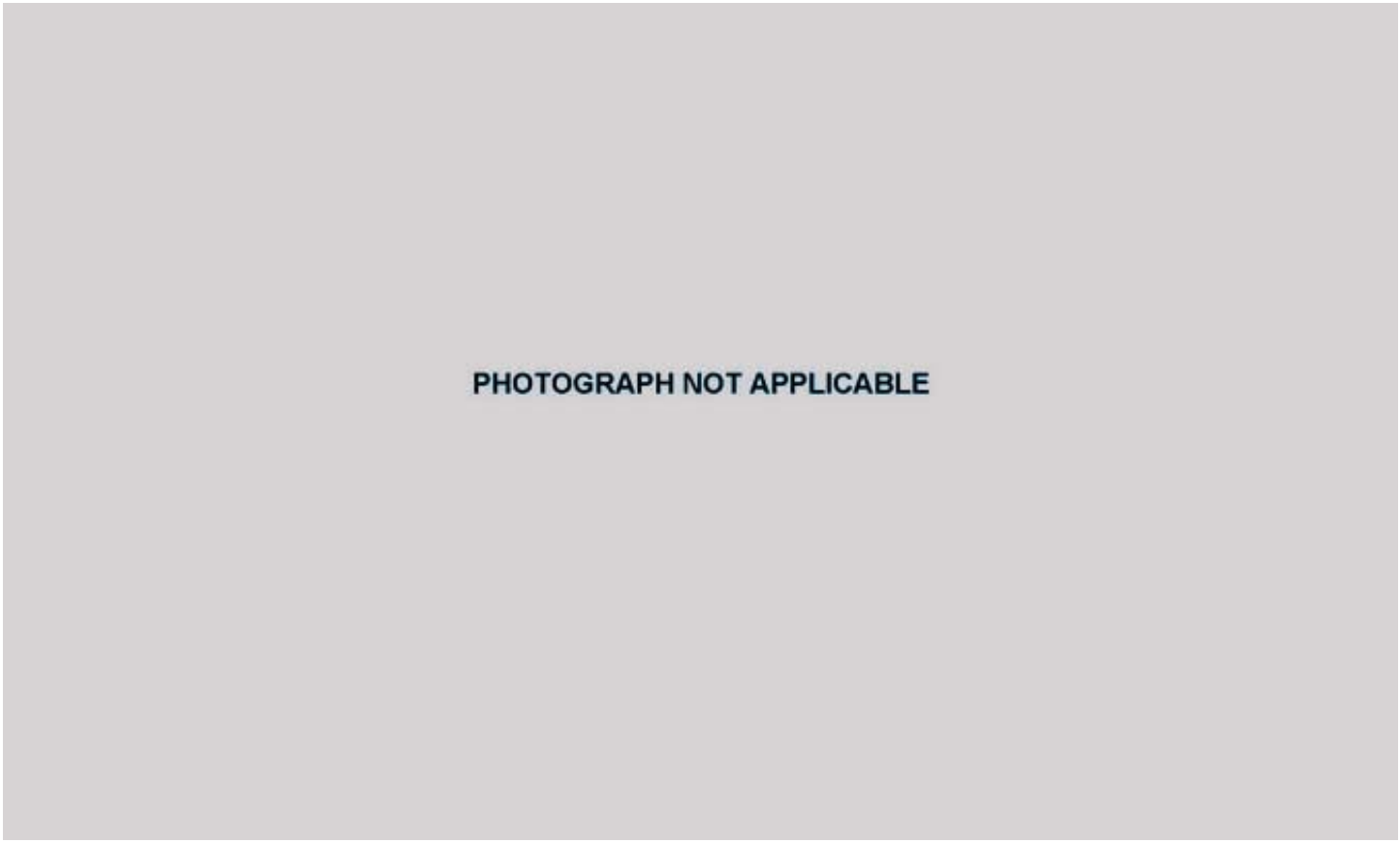
No. 033 Post-Impact View of the Vehicle Passenger Compartment Adjacent to Propulsion Battery



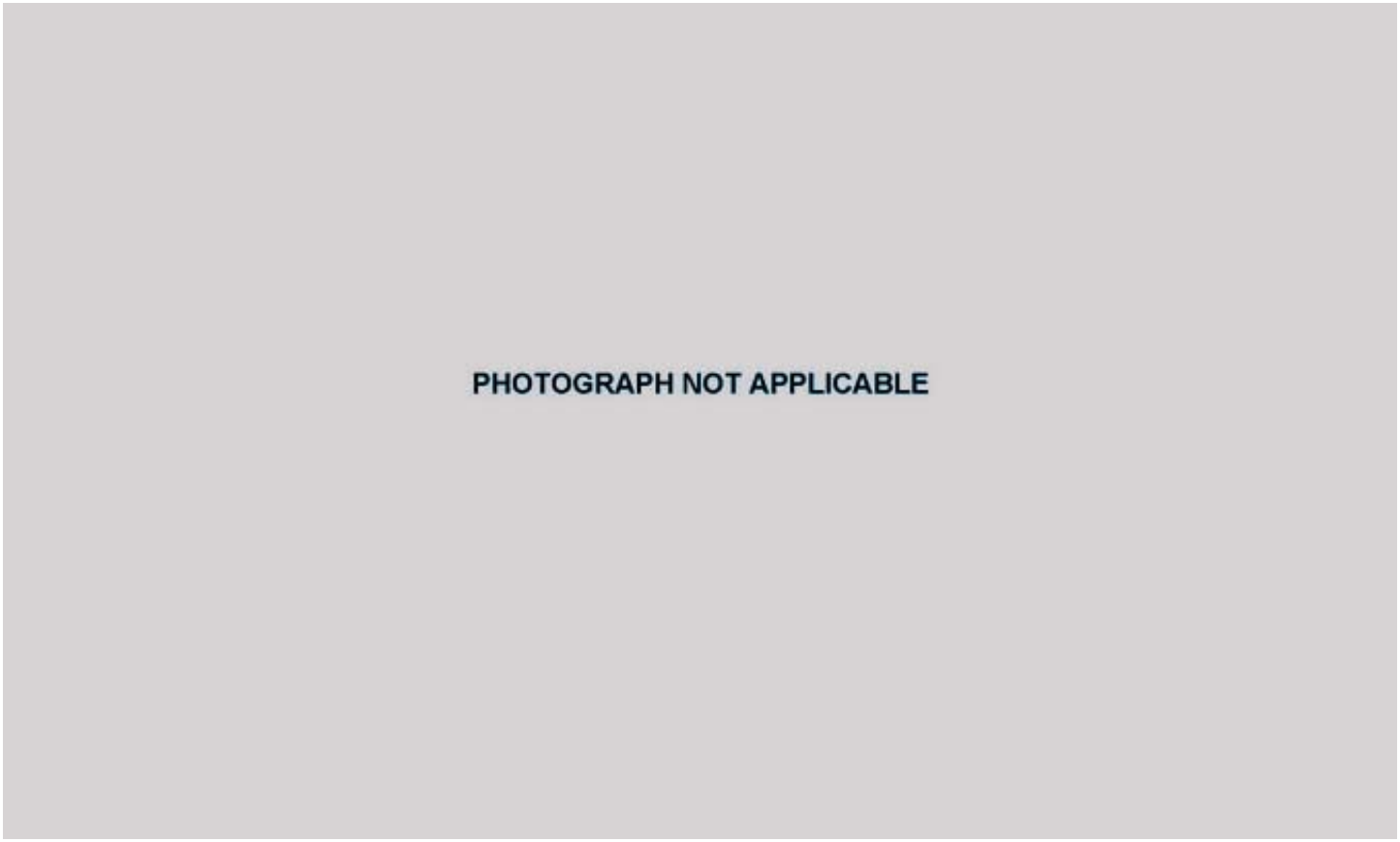
No. 034 Post-Impact Propulsion Battery System Mounting and-or Intrusion Failure(s)



No. 035 Post-Impact View of Battery Component Intrusion



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



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 ¾ 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