

REPORT NUMBER: 214D-CAL-23-003

**SAFETY COMPLIANCE TESTING FOR FMVSS 305
SIDE IMPACT MDB TEST INDICANT**

**Volvo Car Corporation
2023 Volvo XC40 Recharge Twin
SUV**

NHTSA No: C20235901

**PREPARED BY:
CALSPAN CORPORATION
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January 19, 2023

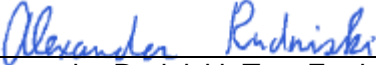
FINAL REPORT

**PREPARED FOR:
U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
ENFORCEMENT
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16. Abstract An FMVSS No. 305 Indicant test, in conjunction with Side MDB Impact Test was conducted on the subject 2023 Volvo XC40 Recharge Twin four door SUV in accordance with the specifications of the applicable Office of Vehicle Safety Compliance Test Procedures. No test failures were reported.			
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SECTION 1

TEST PURPOSE AND PROCEDURE

An FMVSS No. 305 Indicant test, in conjunction with a FMVSS 214 Side MDB test was conducted on the subject 2023 Volvo XC40 Recharge Twin four door SUV.

The Indicant test was conducted in accordance with the Office of Vehicle Safety Compliance Standards Laboratory Test Procedure, dated May 24, 2022 to determine compliance to the requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 305, "Electric Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection" (TP-305-2) for the purpose of providing consumer information.

SECTION 2

SUMMARY OF TEST RESULTS

A moving deformable barrier side impact test was conducted on a 2023 Volvo XC40 Recharge Twin four door SUV. The subject vehicle was impacted on the left side by a Moving Deformable Barrier (MDB) which was moving forward in a 27° crabbed position to the tow road guidance system at a velocity of 52.76 kph (32.78 mph). 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 2023 Volvo XC40 Recharge Twin four door SUV 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.

SECTION 3
OCCUPANT AND VEHICLE INFORMATION

This section contains information reporting for the following Data Sheets:

Data Sheet No. 1 - General Test and Vehicle Parameter Data

Data Sheet No. 2 – Pre-Impact Electric Isolation Measurements and Calculations

Data Sheet No. 3 – Post-Impact Electric Isolation Measurements and Calculations

Data Sheet No. 4 – FMVSS No. 305 Static Rollover Results for Electric Vehicles

**DATA SHEET NO. 1
GENERAL TEST AND VEHICLE PARAMETER DATA**

Test Vehicle: 2023 Volvo XC40 Recharge Twin four door SUV
 Test Program: FMVSS 214 MDB Side Impact Test - FMVSS No. 305

NHTSA No.: C20235901
 Test Date: 12/20/2022

TEST VEHICLE INFORMATION AND OPTIONS

Make	Volvo	Anti-Lock Brakes (ABS)	Yes
Model	XC40 Recharge Twin	All-Wheel Drive (AWD)	No
Body Style	SUV	Traction Control System (TCS)	Yes
VIN	YV4ED3UM1P2963963	Electric Stability Control (ECS)	Yes
Body Color	Silver	Side Curtain Airbags	Yes
Engine Displacement (L)	N/A	Torso Airbags – Front Seats	Yes
Type/No. Cylinders	N/A	Torso Airbags – Rear Seats	No
Engine Placement	Transverse	Combination/Head Torso Bag	No
Transmission Type	Automatic	Pelvic Airbag – Front Seats	No
Transmission Speeds	Direct Drive	Pelvis Airbag – Rear Seats	No
Overdrive	No	Knee Airbag – Driver	Yes
Final Drive	All Wheel Drive	Knee Airbag – Front Passenger	No
Odometer Reading (km/mi)	7 mi	Seat Belt Pretensioners – Front Seats	Yes
		Seat Belt Pretensioners – Rear Seats	Yes
		Seat Belt Load Limiter – Front Seats	Yes
		Seat Belt Load Limiter – Rear Seats	Yes
		Tire Pressure Monitoring System (TPMS)	Yes
		Tilt Steering Wheel	Yes
		Automatic Door Locks (ADL)	Yes
		Power Window Auto-reverse	Yes
		Power Seats	Yes

DATA FROM CERTIFICATION LABEL

Manufactured By	Volvo Car Corporation	GVWR (kg)	2649
Date of Manufacture	09/22	GAWR Front (kg)	1309
Vehicle Type	MPV	GAWR Rear (kg)	1451

VEHICLE SEATING AND CAPACITY WEIGHT DATA

Measured Parameter	Front	Rear	Third	Total
Type of Seats (Bench or Bucket)	Bucket	Bench	N/A	
Designated Seating Capacity (DSC)	2	3	N/A	5
Capacity Weight (VCW) (kg)				435

DATA SHEET NO. 1 (Continued)
ELECTRIC VEHICLE PARAMETER DATA

Test Vehicle: 2023 Volvo XC40 Recharge Twin four door SUV
 Test Program: FMVSS 214 MDB Side Impact Test - FMVSS No. 305

NHTSA No.: C20235901
 Test Date: 12/20/2022

ELECTRIC VEHICLE PROPULSION SYSTEM

Measured Parameter	Value
Type of Electric Vehicle (Electric/Gas-Electric Hybrid/Fuel Cell-Electric Hybrid)	Electric
Propulsion Battery Type	Not Specified
Nominal Voltage (Volts)	397
Is this Vehicle equipped with an Automatic Propulsion Battery Disconnect?	Yes
Physical Location of Automatic Propulsion Battery Disconnect, if applicable	Right Rear Toepan
Auxiliary Battery Type	Lead 70Ah

PROPULSION BATTERY SYSTEM DATA (COTR SUPPLIED)

Measured Parameter	Value
Electrolyte Fluid Type	Dry
Electrolyte Fluid Specific Gravity	N/A
Electrolyte Fluid Kinematic Viscosity (centistokes)	N/A
Electrolyte Fluid Color	Clear
Propulsion Battery Coolant Type, Color and Specific Gravity (if applicable)	Glycol, Green
Location of Battery Modules (Inside or Outside of Passenger Compartment?)	Outside

PROPULSION BATTERY STATE OF CHARGE

Measured Parameter	Units	Value
<i>For all battery types:</i>		
Voltage Range corresponding to useable energy of the battery:		
Minimum State of Charge	V	397
Maximum State of Charge	V	459
95% of Maximum	V	436.05
Test Voltage *	V	408.7
<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	V	
Maximum State of Charge	V	
95% of Maximum	V	
Test Voltage *	V	

* For all battery types-No less than 95% of Maximum Operating Voltage; for batteries that are rechargeable ONLY by an energy source on the vehicle-maximum practicable state of charge within normal operating range.

VEHICLE CHASSIS GROUND PT(S) LOCATION(S) & PROPULSION BATTERY SYSTEM

Measured Parameter	Value
Details of Vehicle Chassis Ground Points & Locations	The provided 305 adaptor is internally grounded to the vehicle. There was also an additional ground attached to instrumentation plate
Details of Propulsion Battery Components	HV battery is mounted under the vehicle body and there is one electric motor and inverter in the front and rear axle of the vehicle.

**DATA SHEET NO. 2
PRE-IMPACT ISOLATION MEASUREMENTS AND CALCULATIONS**

Test Vehicle: 2023 Volvo XC40 Recharge Twin four door SUV
 Test Program: FMVSS 214 MDB Side Impact Test - FMVSS No. 305

NHTSA No.: C20235901
 Test Date: 12/20/2022

VOLTMETER INFORMATION

Measured Parameter	Units	Value
Make & Model		Fluke 1587
Serial No.		581
Internal Impedance Value	MΩ	10
Resolution	V	0.0001
Last Calibration Date		4/28/2022

NOTES:

- The voltmeter used in this test shall measure DC values and have an internal impedance of at least 10 MΩ
- An oscilloscope meeting the above requirements may need to be used to adequately measure voltage in some vehicles.

**PROPULSION BATTERY VOLTAGE, RESISTANCE &
ELECTRICAL ISOLATION MEASUREMENTS & CALCULATIONS**

Measured Parameter	Symbol	Units	Value
Normal operating voltage range specified by the manufacturer	V _b	V	397 - 459
Propulsion Battery Voltage : (ready to drive position)	V _b	V	450.8
Propulsion Battery to Vehicle Chassis	V ₁	V	427.0
Propulsion Battery to Vehicle Chassis	V ₂	V	433.8
Propulsion Battery to Vehicle Chassis Across Known Resistor	R _o	Ω	200,000
Propulsion Battery to Vehicle Chassis with R _o installed	V ₁ '	V	163.0
Propulsion Battery to Vehicle Chassis with R _o installed	V ₂ '	V	165.3
$R_{i1} = R_o * (1 + V_2/V_1) * [(V_1 - V_1')/V_1']$	R _{i1}	Ω	653,011
$R_{i2} = R_o * (1 + V_1/V_2) * [(V_2 - V_2')/V_2']$	R _{i2}	Ω	644,635
Lesser value of R _{i1} and R _{i2}	R _i	Ω	644,635
Electrical Isolation Value (Minimum E.I. Value is 500 Ω/V)	R _i /V _b	Ω/V	1,430

Is the Electrical Isolation Value ≥ 500 Ω/V (Yes/No)? X Yes No (Fail)

NOTES:

- The measurement shall be made with the propulsion battery connected to the vehicle propulsion system, and the vehicle in the "ready-to-drive" (propulsion motor(s) activated) position.
- If the voltage measurement is not at the voltage or within the normal operating voltage range specified by the manufacturer, the battery must be charged.
- The known resistance R_o (in Ohms) should be approximately 500 times the nominal operating voltage of the vehicle (in volts) per SAE J1766
- If measured voltage is zero and results in a division by zero, record "Zero Volts." This "zero voltage" condition is considered as being compliant

COMMENTS: None

DATA SHEET NO. 3
POST-IMPACT ISOLATION MEASUREMENTS AND CALCULATIONS

Test Vehicle: 2023 Volvo XC40 Recharge Twin four door SUV
 Test Program: FMVSS 214 MDB Side Impact Test - FMVSS No. 305

NHTSA No.: C20235901
 Test Date: 12/20/2022

VOLTMETER INFORMATION

Measured Parameter	Units	Value
Make & Model		Fluke 1587
Serial No.		581
Internal Impedance Value	MΩ	10
Nominal Propulsion Battery Voltage (V _b)	V	0.09

NOTES:

- The voltmeter used in this test shall measure DC values and have an internal impedance of at least 10 MΩ
- An oscilloscope meeting the above requirements may need to be used to adequately measure voltage in some vehicles.

ELECTRICAL ISOLATION MEASUREMENTS & IMPACT CALCULATIONS

Parameter	Value	Units		Value		Value	
V ₁ =	43.000	V	Impact Time:	0	Minutes	35	Seconds
V ₂ =	16.200	V	Impact Time:	0	Minutes	42	Seconds
R _o =	200,000	Ω	Impact Time:		Minutes		Seconds
V ₁ ' =	0.800	V	Impact Time:	0	Minutes	49	Seconds
V ₂ ' =	0.280	V	Impact Time:	0	Minutes	55	Seconds
R _{i1} =	14,524,651	Ω	Impact Time:	0	Minutes	49	Seconds
R _{i2} =	41,554,850	Ω	Impact Time:	0	Minutes	55	Seconds
R _i =	14,524,651	Ω	Impact Time:	0	Minutes	49	Seconds
R _i /V _b =	161,385,011	Ω/V	Impact Time:	0	Minutes	49	Seconds

Is the Electrical Isolation Value ≥ 500 Ω/V (Yes/No)? X Yes No (Fail)

NOTES:

- $R_{i1} = R_o * (1 + V_2/V_1) * [(V_1 - V_1')/V_1']$, $R_{i2} = R_o * (1 + V_1/V_2) * [(V_2 - V_2')/V_2']$, $R_i =$ Lesser value of R_{i1} and R_{i2}
- If measured voltage is zero and results in a division by zero, record "Zero Volts." This "zero voltage" condition is considered as being compliant
- Minimum Electrical Isolation Value is 500 Ω/V

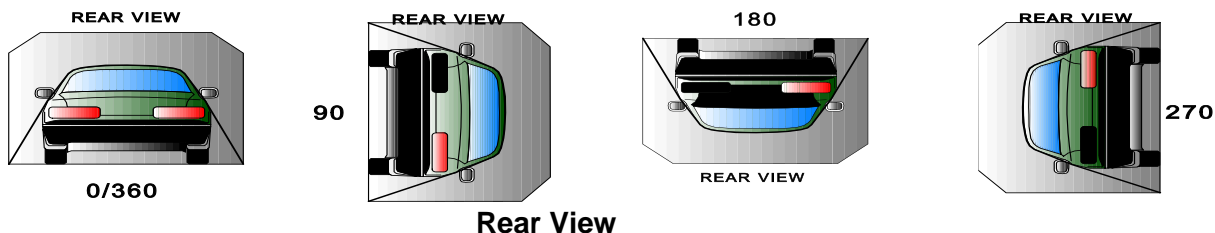
PROPULSION BATTERY SYSTEM COMPONENTS

Measured Parameter	Comments	Passed	Failed
Propulsion Battery Module movement within the passenger compartment	None	X	
Intrusion of an outside Propulsion Battery Component into the passenger compartment	None	X	
Is propulsion battery electrolyte spillage visible in the passenger compartment?	None	X	

DATA SHEET NO. 4
FMVSS NO. 305 STATIC ROLLOVER RESULTS FOR ELECTRIC POWERED VEHICLES

Test Vehicle: 2023 Volvo XC40 Recharge Twin four door SUV
 Test Program: FMVSS 214 MDB Side Impact Test - FMVSS No. 305

NHTSA No.: C20235901
 Test Date: 12/20/2022



DETERMINATION OF PROPULSION BATTERY ELECTROLYTE COLLECTION TIME PERIOD

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

ACTUAL TEST VEHICLE PROPULSION BATTERY ELECTROLYTE SPILLAGE

Rollover Stage	Propulsion Battery Electrolyte Spillage	Units	Spillage Location
0° to 90°	0.0	Liters	None
90° to 180°	0.0	Liters	None
180° to 270°	0.0	Liters	None
270° to 360°	0.0	Liters	None
Total Spillage	0.0	Liters	None

* FMVSS 305 Requirements: Maximum allowable propulsion battery electrolyte spillage is **5.0 Liters**

Is the total spillage of propulsion battery electrolyte greater than 5.0 Liters? Yes (Fail) No
 Is propulsion battery electrolyte spillage visible in the passenger compartment? Yes (Fail) No

VOLTMETER INFORMATION

Measured Parameter	Units	Value
Make & Model		Fluke 1587
Serial No.		581
Internal Impedance Value	MΩ	10
Nominal Propulsion Battery Voltage (V _b)	V	0.09

NOTES:

- The voltmeter used in this test shall measure DC values and have an internal impedance of at least 10 MΩ
- An oscilloscope meeting the above requirements may need to be used to adequately measure voltage in some vehicles.

DATA SHEET NO. 4 (Continued)
FMVSS NO. 305 STATIC ROLLOVER RESULTS FOR ELECTRIC POWERED VEHICLES

Test Vehicle: 2023 Volvo XC40 Recharge Twin four door SUV
 Test Program: FMVSS 214 MDB Side Impact Test - FMVSS No. 305

NHTSA No.: C20235901
 Test Date: 12/20/2022

ELECTRICAL ISOLATION MEASUREMENTS & CALCULATIONS

Parameter	Rollover Stage	Value	Units		Minutes	Seconds
$V_1 =$	90°	11.57	V	Time:	1	18
	180°	3.16	V		10	41
	270°	10.07	V		16	46
	360°	10.70	V		23	15
$V_2 =$	90°	8.30	V	Time:	1	21
	180°	3.12	V		10	45
	270°	6.96	V		16	50
	360°	6.78	V		23	20
$V_1' =$	90°	0.25	V	Time:	1	25
	180°	0.11	V		10	50
	270°	0.14	V		16	54
	360°	0.65	V		23	23
$V_2' =$	90°	0.12	V	Time:	1	29
	180°	0.06	V		10	53
	270°	0.08	V		16	59
	360°	0.09	V		23	27
$R_{i1} =$	90°	15,552,525	Ω	Time:	1	25
	180°	11,020,713	Ω		10	50
	270°	23,990,339	Ω		16	54
	360°	5,051,733	Ω		23	23
$R_{i2} =$	90°	32,637,871	Ω	Time:	1	29
	180°	20,530,769	Ω		10	53
	270°	42,085,632	Ω		16	59
	360°	38,328,810	Ω		23	27
$R_i =$	90°	15,552,525	Ω	Time:	1	25
	180°	11,020,713	Ω		10	50
	270°	23,990,339	Ω		16	54
	360°	5,051,733	Ω		23	23
$R_i/V_b =$	90°	172,805,833	Ω/V	Time:	1	25
	180°	122,452,367	Ω/V		10	50
	270°	266,559,322	Ω/V		16	54
	360°	56,130,367	Ω/V		23	23

Is the Electrical Isolation Value $\geq 500 \Omega/V$ (Yes/No)?



Yes



No (Fail)

DATA SHEET NO. 4 (Continued)
FMVSS NO. 305 STATIC ROLLOVER RESULTS FOR ELECTRIC POWERED VEHICLES

Test Vehicle: 2023 Volvo XC40 Recharge Twin four door SUV
Test Program: FMVSS 214 MDB Side Impact Test - FMVSS No. 305

NHTSA No.: C20235901
Test Date: 12/20/2022

NOTES:

- $R_{i1} = R_o * (1 + V_2/V_1) * [(V_1 - V_1')/V_1']$, $R_{i2} = R_o * (1 + V_1/V_2) * [(V_2 - V_2')/V_2']$, $R_i =$ Lesser value of R_{i1} and R_{i2} ,
 $R_i/V_b =$ Electrical Isolation Value/ Nominal Battery Voltage
- V_1 , V_2 , V_1' , & V_2' voltage measurements were recorded at the start of each successive increment of **90°**, **180°**, **270°**, and **360°** of the static rollover test. The increment of rotation for each turn was completed within a maximum of 3 minutes.
- If measured voltage is zero and results in a division by zero, record "Zero Volts." This "zero voltage" condition is considered as being compliant
- Minimum Electrical Isolation Value is 500 Ω / V

COMMENTS: None

APPENDIX A
PHOTOGRAPHS

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Figure 305-1: Auxiliary Power Module Warning Label

Photo Not Applicable

Figure 305-2: Power Inverter Warning Label

Photo Not Applicable

Figure 305-3 First Responder Warning Label

Photo Not Applicable

Figure 305-4: First Responder Warning Label Location

Photo Not Applicable

Figure 305-5: Other Vehicle Label Related to Electric Propulsion System



Figure 305-6: Manual High Voltage Service Disconnect in Place



Figure 305-7: Manual High Voltage Service Disconnect Removed (Show Plug)



Figure 305-8: Manual High Voltage Service Disconnect Removed Location



Figure 305-9: Pre-Impact View of Propulsion Battery



Figure 305-10: Post-Impact Front View of Propulsion Battery

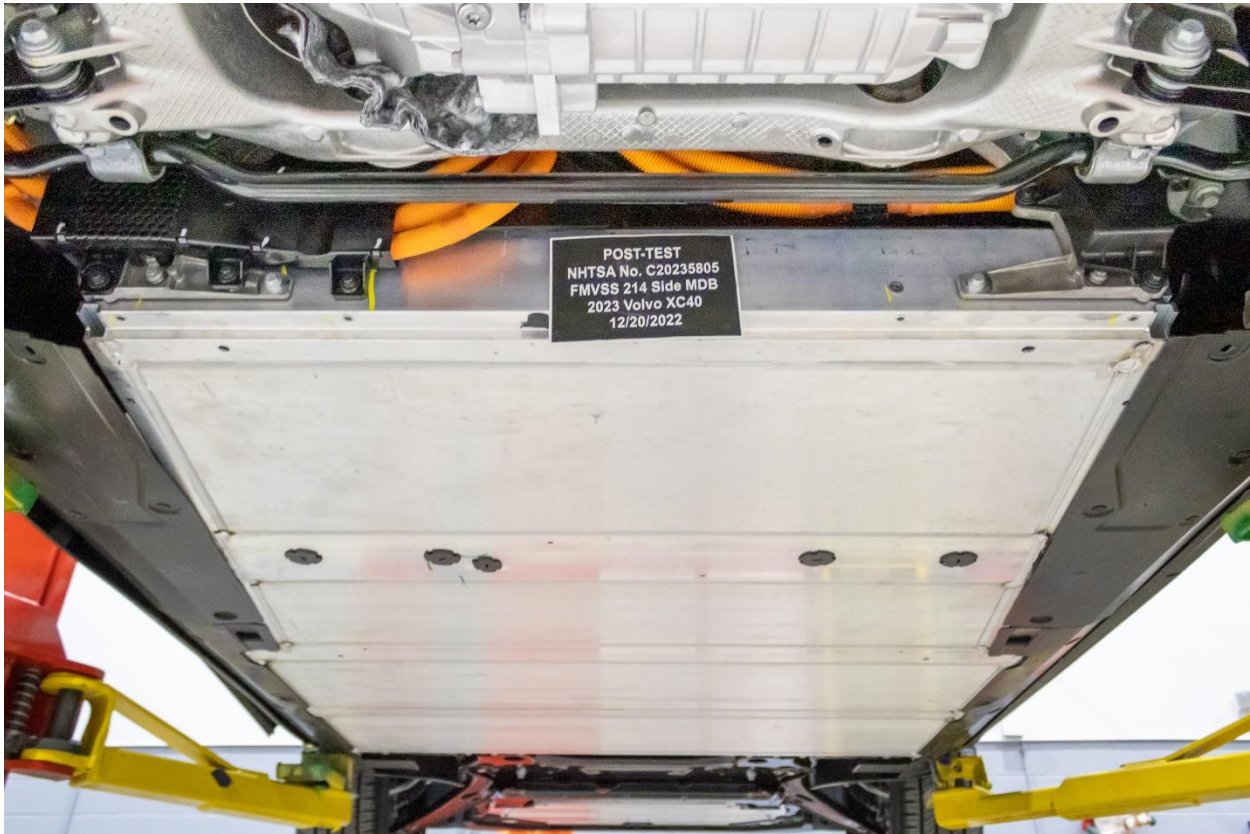


Figure 305-11: Post-Impact Rear View of Propulsion Battery (if any part of it is visible)

Photo Not Applicable

Figure 305-12: Pre-Impact View of Battery Box(s) or Container(s) Which Holds Individual Battery Modules

Photo Not Applicable

Figure 305-13: Post-Impact View of Battery Box(s) or Container(s) Which Holds Individual Battery Modules



Figure 305-14: Pre-Impact View of Propulsion Battery Module(s)



Figure 305-15: Post-Impact View of Propulsion Battery Module(s)

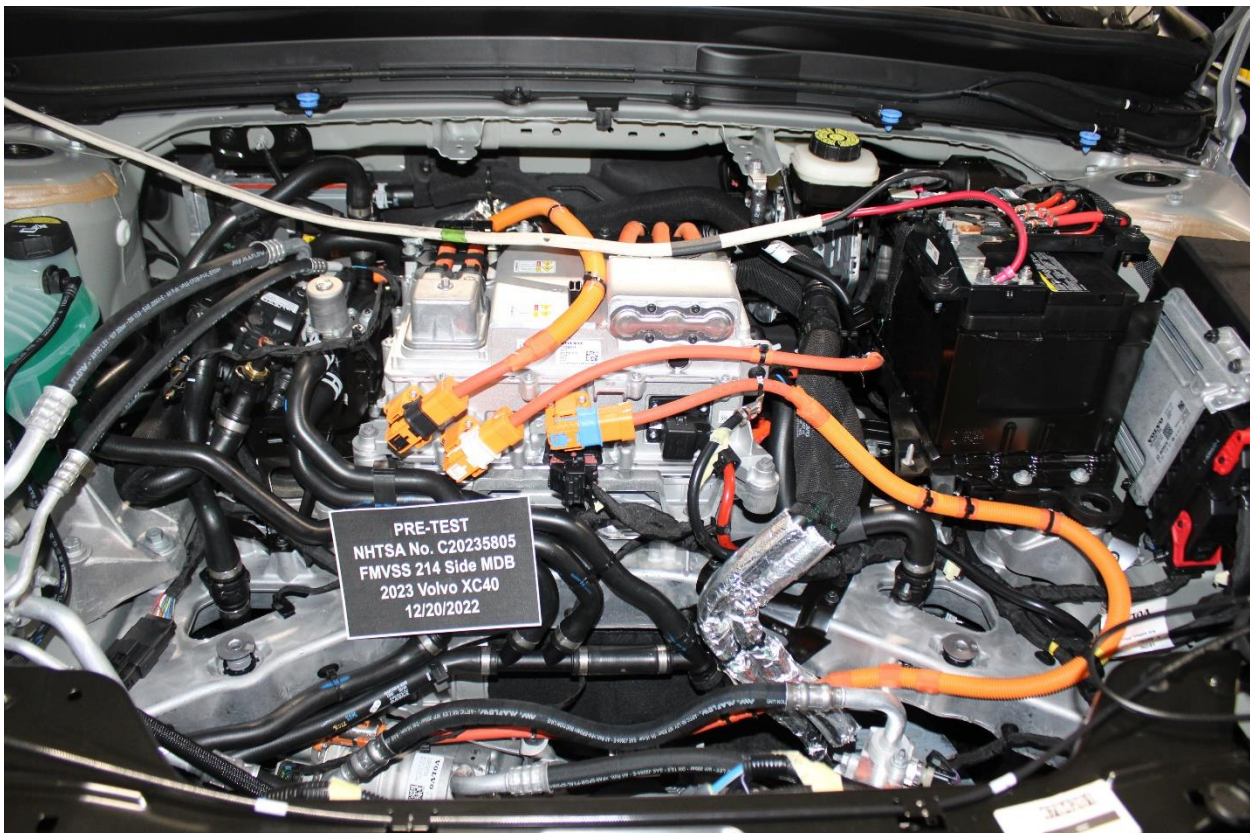


Figure 305-16: Pre-Impact View of Electric Propulsion Drive



Figure 305-17: Post-Impact View of Electric Propulsion Drive



Figure 305-18: Pre-Impact View of High Voltage Interconnects

Photo Not Applicable

Figure 305-19: Pre-Impact View of Propulsion Battery Venting System

Photo Not Applicable

Figure 305-20: Pre-Impact View of Other Visible Electric Propulsion Components



Figure 305-21: Pre-Impact View of Ground Lead Attached



Figure 305-22: Pre-Impact View of High Voltage Leads Attached



Figure 305-23: Pre-Impact Close Up View of High Voltage Leads Attached



Figure 305-24: Pre-Impact View of Installed Test Interface Port



Figure 305-25: Post-Impact View of Installed Test Interface Port

Photo Not Applicable

Figure 305-26: Pre-Impact View of Other Test Devices

Photo Not Applicable

Figure 305-27: Post-Impact View of Other Test Devices



Figure 305-28: FMVSS No. 305 Static Rollover 90 Degrees

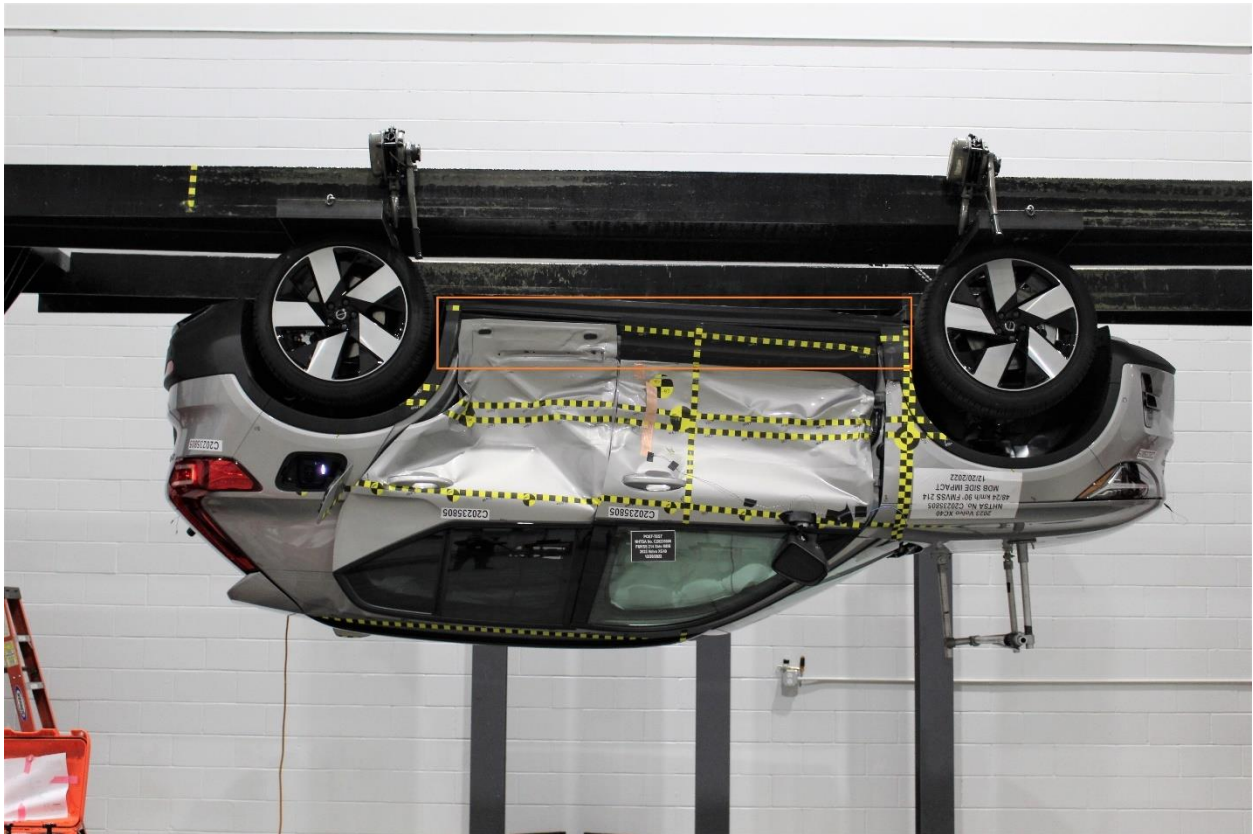


Figure 305-29: FMVSS No. 305 Static Rollover 180 Degrees

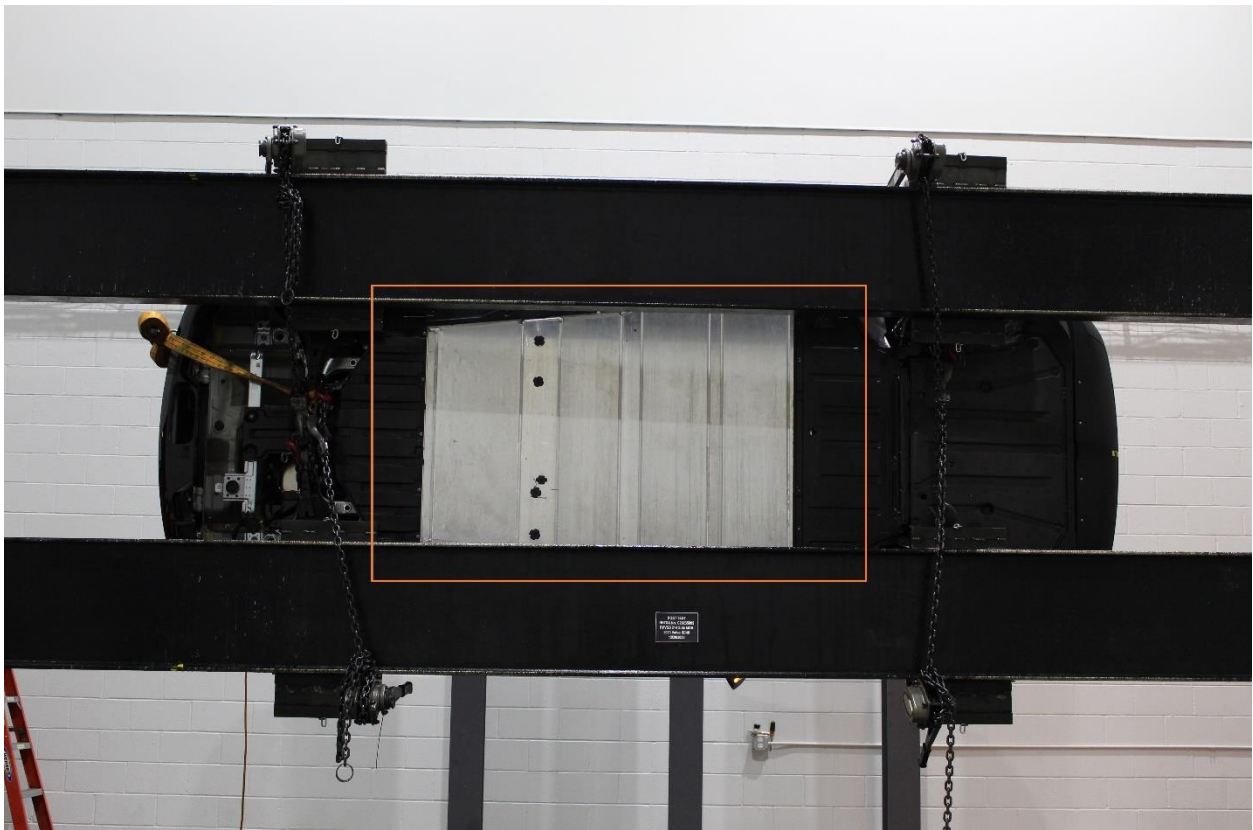


Figure 305-30: FMVSS No. 305 Static Rollover 270 Degrees



Figure 305-31: FMVSS No. 305 Static Rollover 360 Degrees



Figure 305-32: Pre-Impact View of the Vehicle Passenger Compartment Adjacent to Propulsion Battery



Figure 305-33: Post-Impact View of the Vehicle Passenger Compartment Adjacent to Propulsion Battery

Photo Not Applicable

Figure 305-34: Post-Impact Propulsion Battery System Mounting and-or Intrusion Failure(s)

Photo Not Applicable

Figure 305-35: Post-Impact View of Battery Component Intrusion (if applicable)

Photo Not Applicable

Figure 305-36: Post-Impact View of Battery Module Movement or Retention Loss (if applicable)

Photo Not Applicable

**Figure 305-37: Post-Impact View of Propulsion Battery Electrolyte Spillage Location
(if applicable)**

Photo Not Applicable

**Figure 305-38: Post-Impact View of Propulsion Battery Electrolyte Spillage Location
(after rollover)**