



INSTRUCTION TO SERVICE

ITS: 59220		DATE April 15, 2021
SECTION:	260	Battery Compartment
WRITTEN BY:	Joe Nordlie	
SUBJECT:	XHE Inspection	
ISSUE:	Validate and Inspect High Voltage Systems	
SUMMARY:	XHE High Voltage Inspection Procedure	

ITS59220

THIS ITS DOCUMENT SHOULD BE RETAINED AND REFERRED TO FOR FUTURE MAINTENANCE UNTIL THE NEW FLYER PARTS AND/OR SERVICE MANUAL IS UPDATED TO REFLECT WORK DONE AS A RESULT OF THIS DOCUMENT. ENSURE THAT THIS DOCUMENT IS AVAILABLE FOR PARTS AND MAINTENANCE STAFF GOING FORWARD.



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XHE High Voltage Inspection Procedure

Thoroughly read through this document in its entirety before starting your first inspection. Install all panels/covers removed during the inspection at the end of each section using the existing hardware if not already detailed. After verifying the torque on each connection, apply torque marks using the supplied black paint marker. If any bolt is found with insufficient torque, remove the existing torque marks and apply a black torque mark. Ensure the XHE High Voltage Inspection Check Sheet is filled out as you carry out the inspection for **each bus**. Ensure to be as descriptive as possible when describing the issues found during the inspection. Take pictures when required to grasp the severity of an issue and provide to the RPSM to submit with the check sheets. The XE High Voltage Inspection Check Sheet can be found in appendix B. The Isolation Detection Process can also be performed as you carry out the inspection for **each bus**. Ensure to be as descriptive as possible when describing the issues found during the Isolation Detection Process. The Isolation Detection Process can be found on pages 24-27.

PLC and Siemens Programming

1. Contact your local RPSM for the latest Siemens software package, A123 and PLC programs.
2. Update the bus with the latest Siemens software, A123 and PLC programs.

Lock Out Tag Out

3. Turn the MRS to the off position and wait 5 minutes before proceeding to the next step.
4. Turn the main battery disconnect and HV Interlock switch to the “OFF” position.
5. Follow the High Voltage Safety Guidelines & Procedures as referenced in appendix A and perform a proper Lock Out Tag Out procedure.
6. Wearing proper PPE and using an appropriate voltmeter as per appendix A, confirm that no voltage is present between HVPOS_VEH_FB & HVNEG_VEH_FB before proceeding. These connections are located inside the HV Fuse box inside the inverter rack as seen in Figure 1. Please see Figure 1 below for an example of a High Voltage Fuse Box Layout with HVPOS_VEH_FB & HVNEG_VEH_FB highlighted.

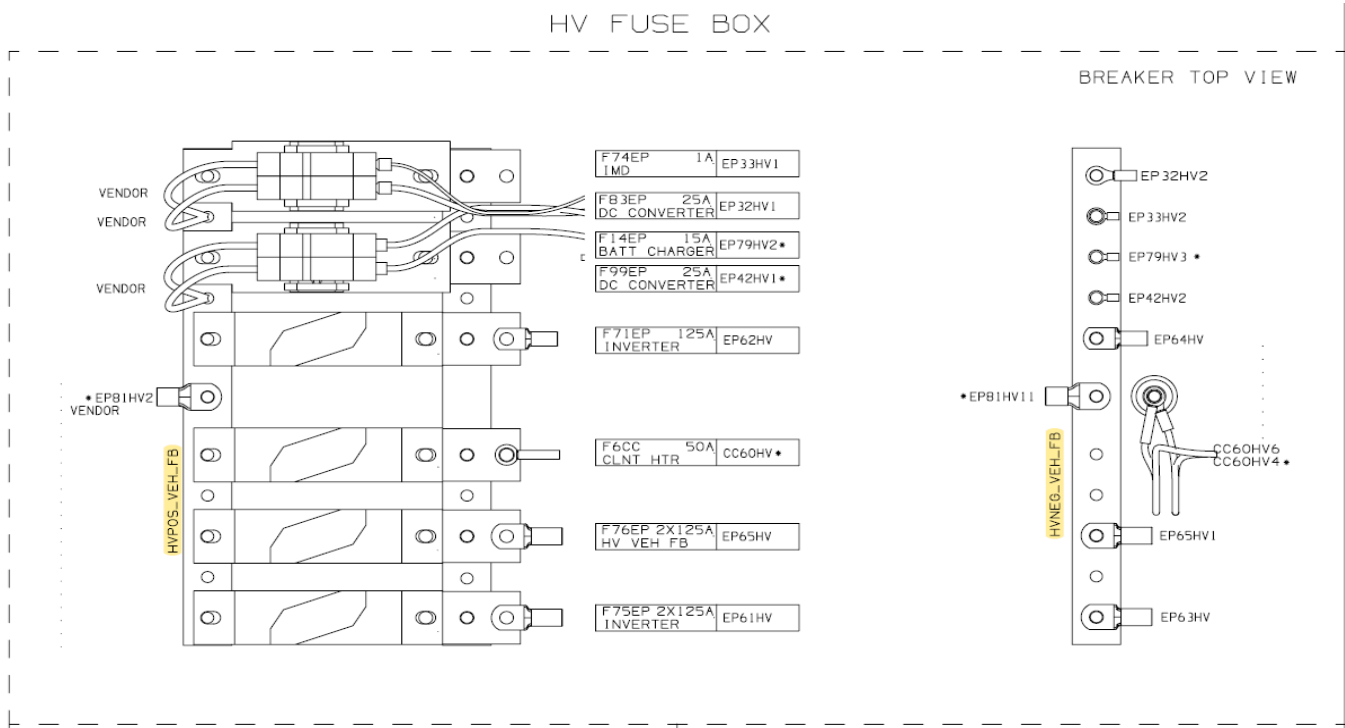


Figure 1: High Voltage Fuse Box Layout

☞ **NOTE:** Layout of Fuse Box may vary.

⚠ WARNING: Using appropriate PPE, confirm that there is no voltage present on any connection point.

⚠ WARNING: The work detailed in the following steps involves working closely to HV connections. It is required that the service personnel be trained in NFI HV safety practices such as Appendix A – NFIL Spec 532295 - High Voltage Safety Guidelines & Procedures for New Flyer Battery Bus.

Air Compressor

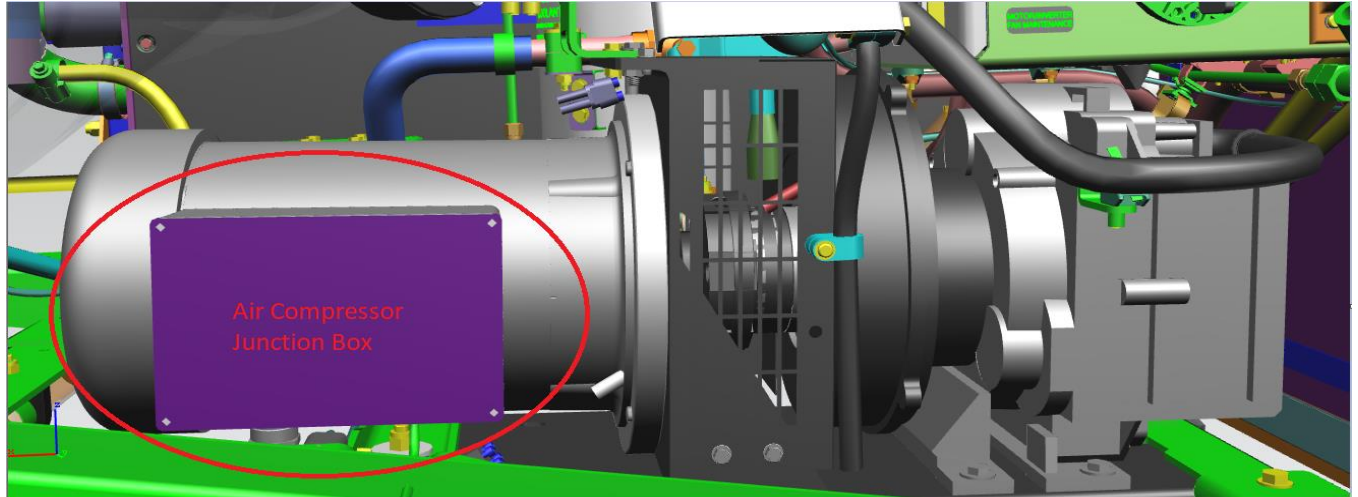


Figure 2: Air Compressor Junction Box Location

⚠ WARNING: Using appropriate PPE, confirm that there is no voltage present on any connection point.

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7. Ensure proper securement of the junction box to the air compressor motor.
8. Remove the front face plate of the air compressor junction box circled in Figure 2 above.
9. Lightly pull on the orange high voltage supply cable to confirm the cable gland is properly secured to the junction box.
10. Ensure the black distribution block is properly secured to the junction box.
11. Ensure grommets are present on all holes used to route cables to the junction box.
12. Thoroughly inspect all wires for chafing/kinking. Ensure to check where the cables route through the junction box through the grommets.
13. Thoroughly inspect all connections for corrosion.
14. Ensure terminal block connections are torqued to 16 in-lbs.

15. Locate the air compressor grounding connection highlighted and circled below in Figure 3.
16. Verify that the air compressor grounding connection has contact to bare metal and is torqued to 17 FT-LBS dry.

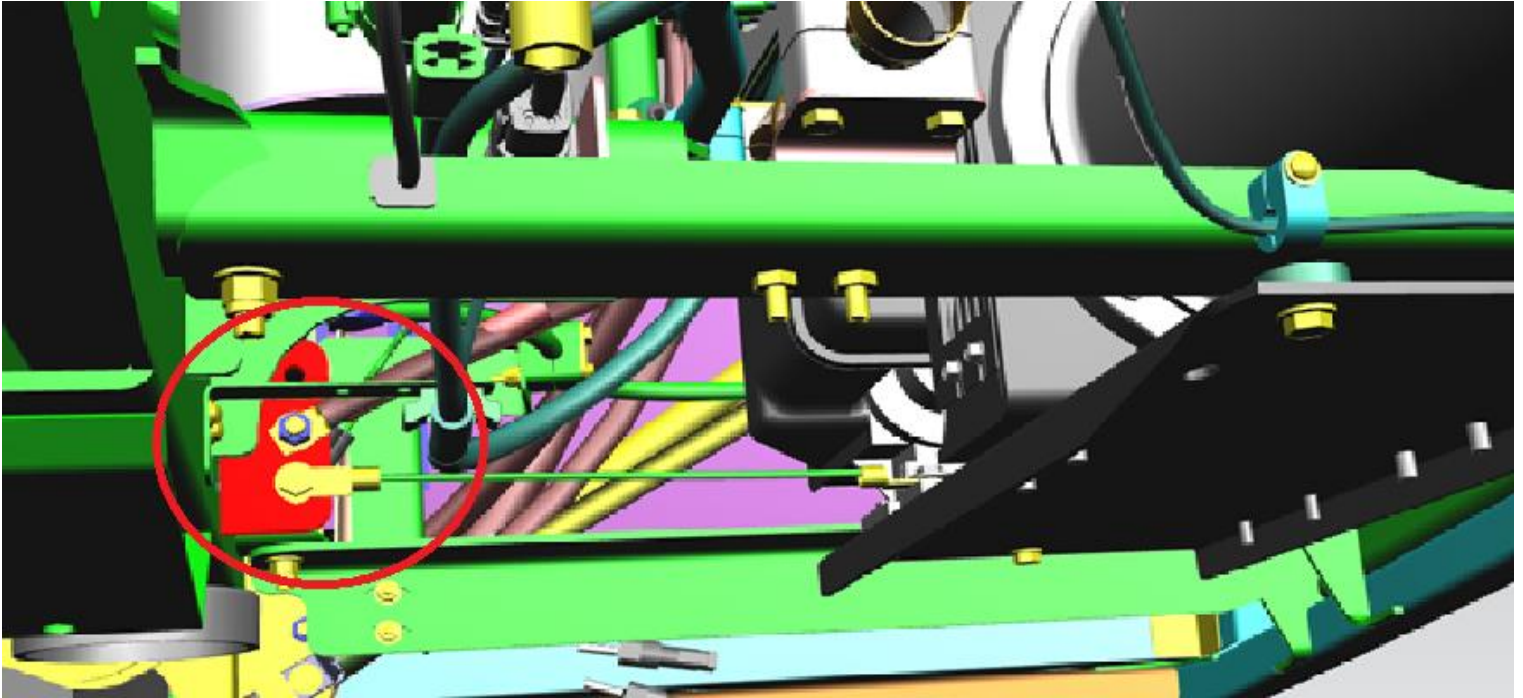


Figure 3: Bottom View of Air Compressor

PEM Motor Junction Box

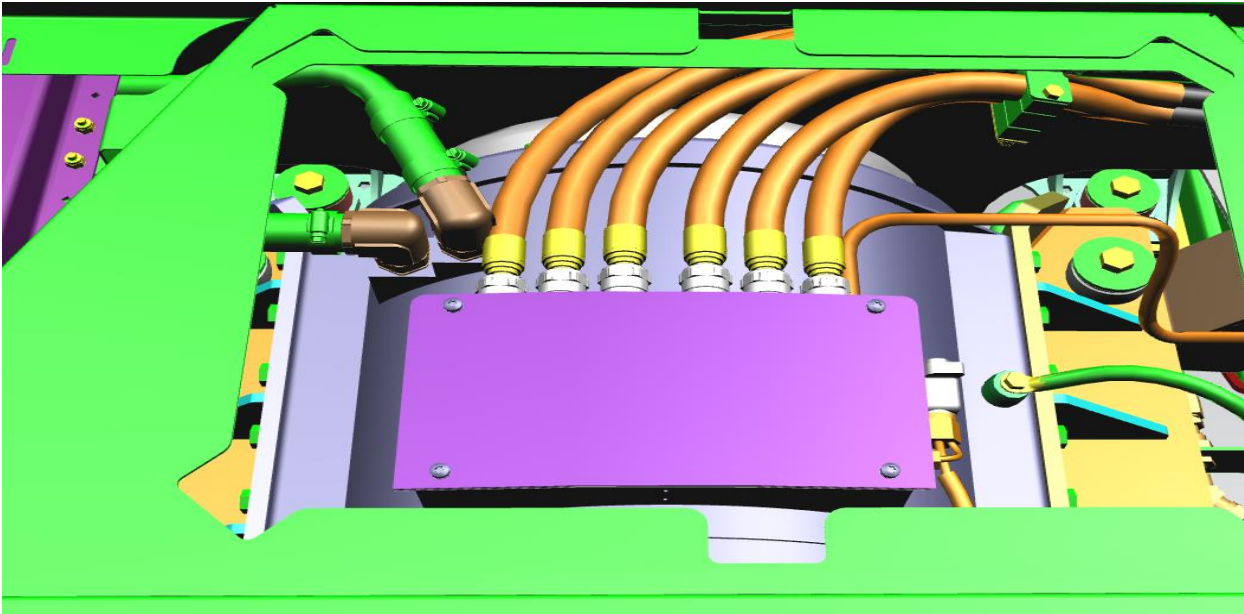


Figure 4: PEM Motor Junction Box Location

⚠ WARNING: Using appropriate PPE, confirm that there is no voltage present on any connection point.

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17. Locate and remove the access panel to the PEM Motor. The access panel is located on the interior floor at the rear of the bus shown in Figure 4.
18. Remove the PEM Motor Junction Box Cover.
19. Thoroughly inspect all cables and wires for chafing/kinking.
20. Thoroughly inspect all connections for corrosion.
21. Ensure all forked lugs are fully inserted into the terminal bolt.
22. Ensure proper torque on motor terminal connections.
 - A, Standard grade (3 Cables) - 20 Nm
 - B. High grade motor (6 Cables) – 20 Nm
23. Ensure all M25 cable glands are torqued to the terminal box with 10 Nm.
24. Re-install the terminal box cover using an X pattern and to 8 Nm.

Service Charge Receptacle

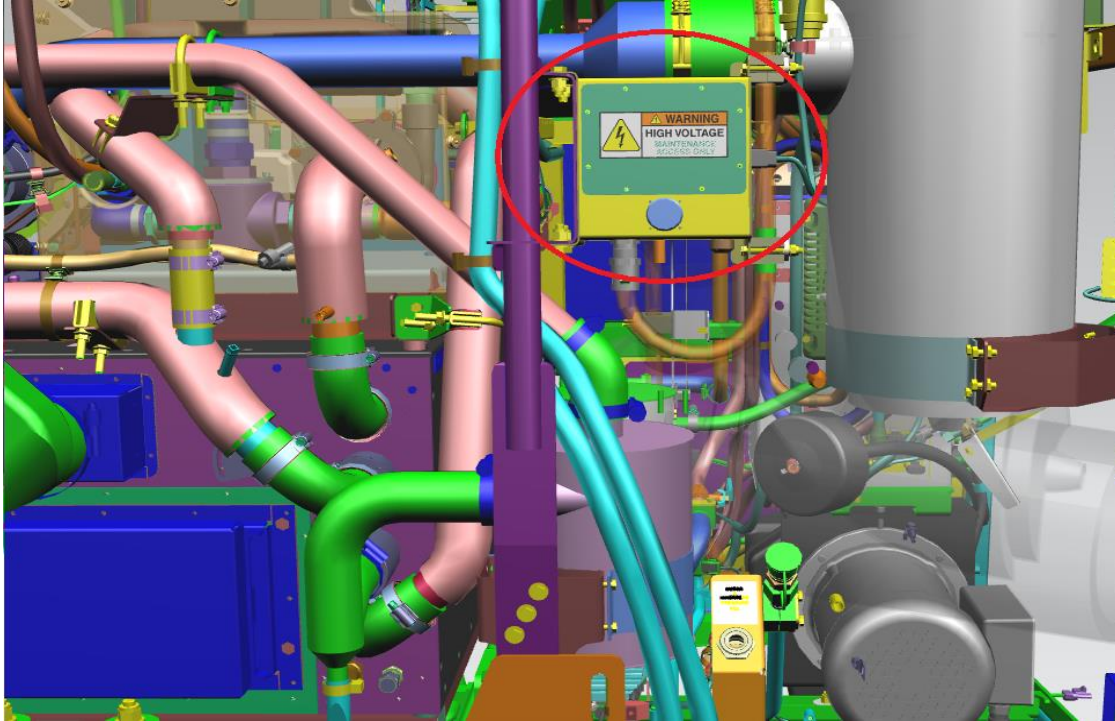


Figure 5: Service Charge Receptacle Location

⚠ WARNING: Using appropriate PPE, confirm that there is no voltage present on any connection point.

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25. Remove the Service Receptacle face plate as shown below.

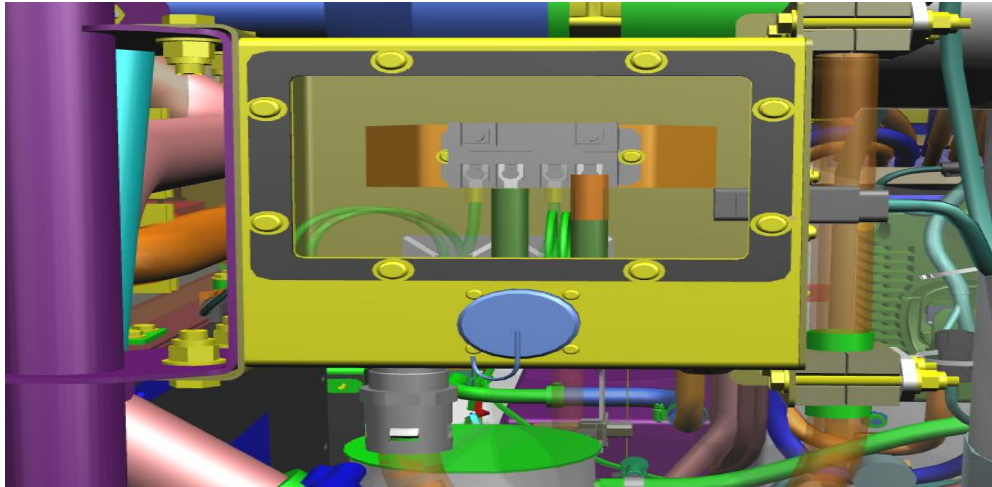


Figure 6: Service Charge Receptacle Face Plate Removed

- 26. Inspect for water/moisture/debris and dry if needed.
- 27. If any water, moisture or debris is found, replace failed or missing gasket.
- 28. Lightly pull all cables to ensure proper cable securement to the junction box.
- 29. Thoroughly inspect all cables and wires for chafing/kinking.
- 30. Thoroughly inspect all connections for corrosion.
- 31. Ensure all power connections are torqued to 36 IN-LBS.

ESS HVAC

32. Locate the ESS HVAC assembly located on the roof of the bus as shown in Figure 7

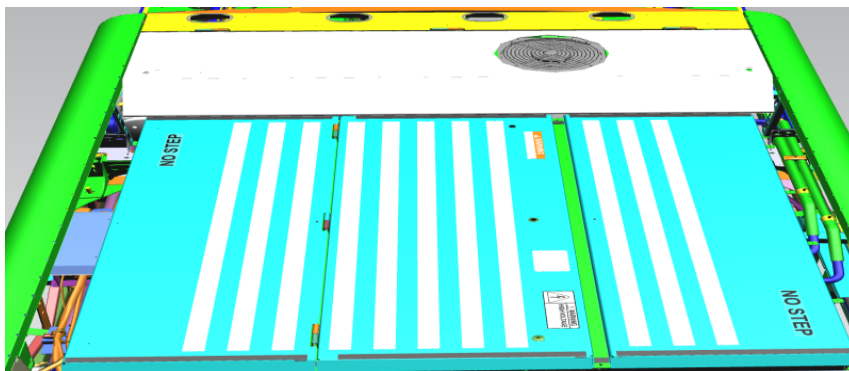


Figure 7: ESS HVAC Location

NOTE: Layout of roof components may be vary.

⚠ WARNING: Using appropriate PPE, confirm that there is no voltage present on any connection point.

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33. Remove access cover to gain entree to HV cables as shown in Figure 8.

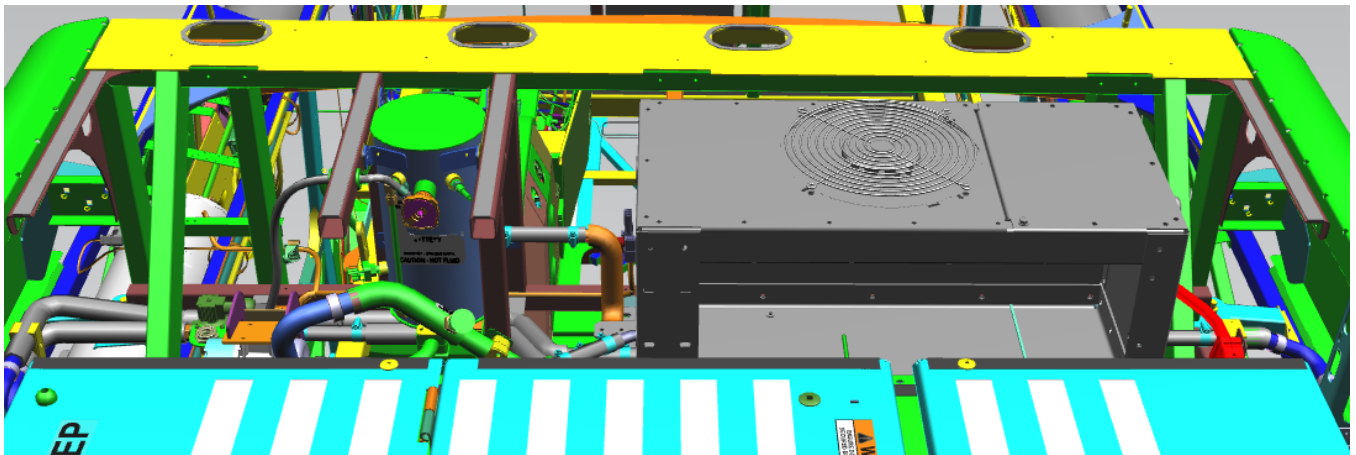


Figure 8: ESS HVAC Access Cover Removed

34. Lightly pull all cables to ensure proper cable securement to the ESS unit.

35. Thoroughly inspect all cables and wires for chafing/kinking.

36. Thoroughly inspect all connections for corrosion.

37. Ensure ESS Exchanger connections are torqued to 12.5 +/- 1.5 IN-LBS shown in Figure 9.

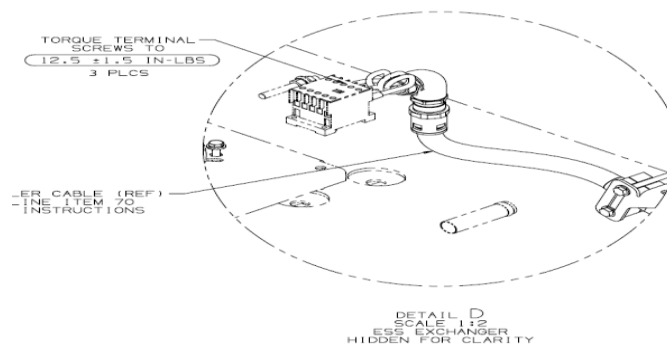


Figure 9: ESS Exchanger Connection Detail

Inverter Rack

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ADDITIONAL INFORMATION CAN BE OBTAINED BY REFERENCING THREE DIMENSIONAL DESIGN DATA. CONTACT YOUR NEW FLYER REPRESENTATIVE AS REQUIRED.

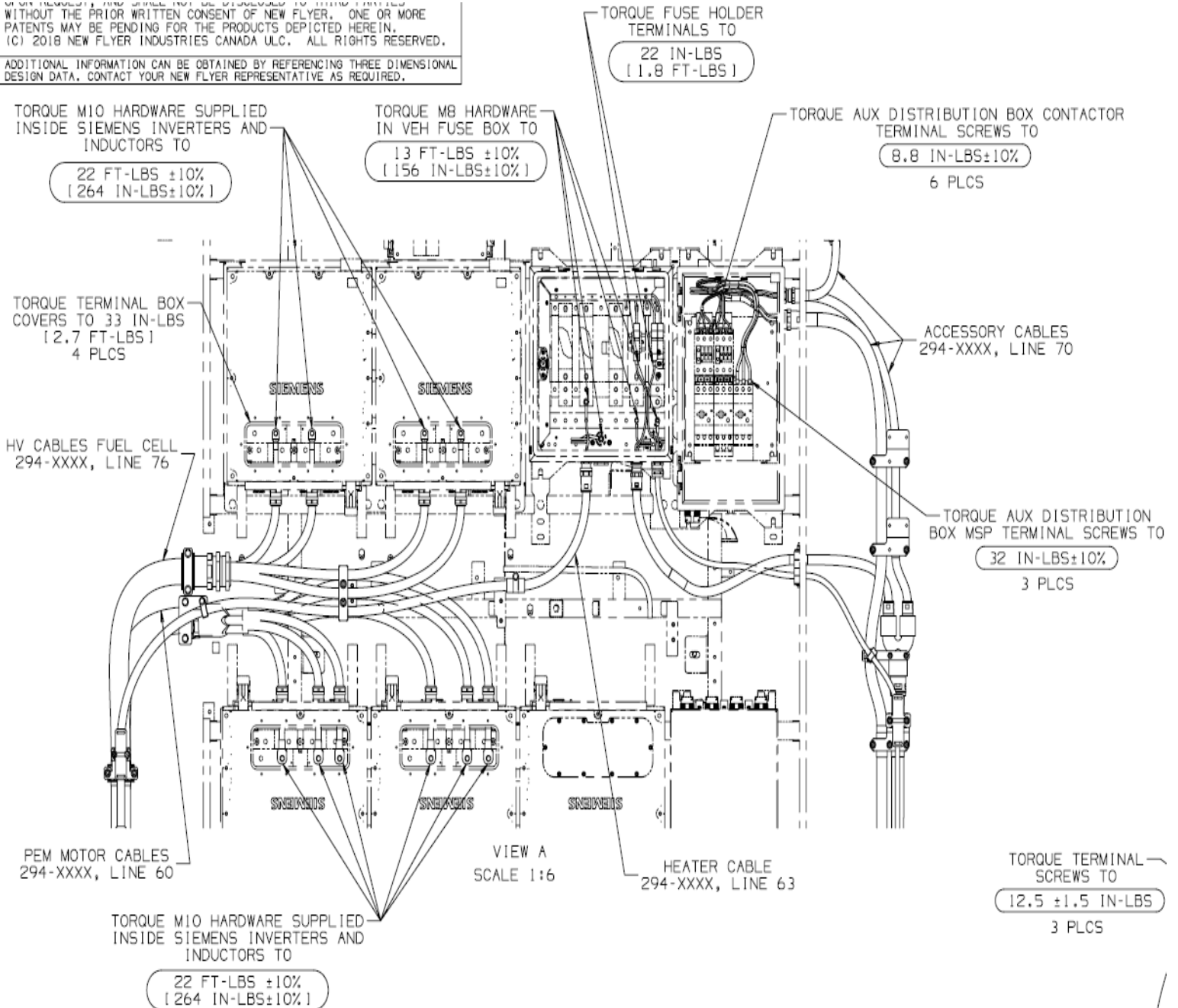


Figure 10: Inverter Rack HV Cable Torque Layout

NOTE:Layout may vary slightly depending on build.

⚠ WARNING: Using appropriate PPE, confirm that there is no voltage present on any connection point.

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38. Remove the Inverter Rack cover to gain access to HV cabling.
39. Lightly pull all cables to ensure proper cable securement in Fuse Boxes and Inverters.
40. Thoroughly inspect all cables and wires for chafing/kinking.
41. Thoroughly inspect all connections for corrosion.
42. Ensure HV cables are torque to specification detailed in Figure 10.

Inverter Rack Ground Connections

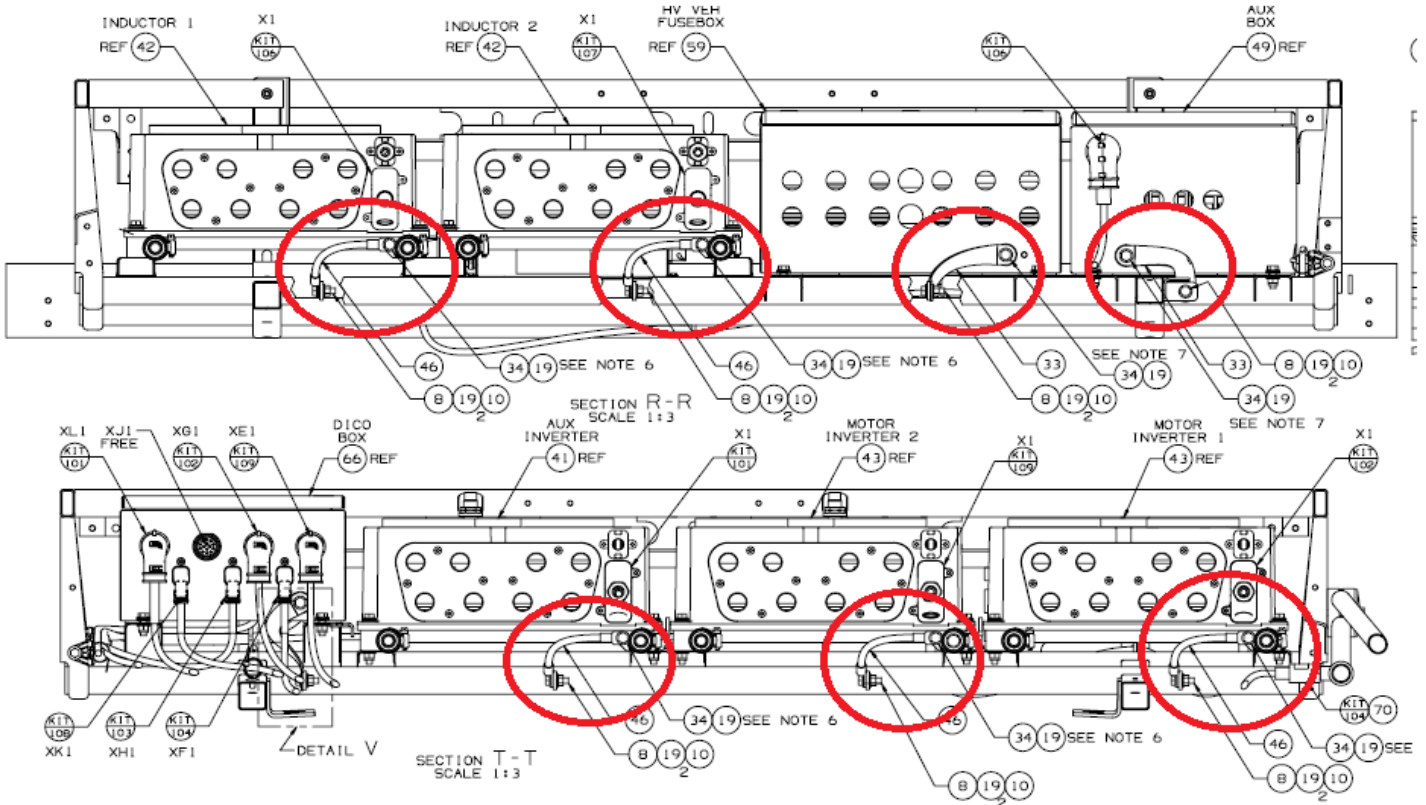


Figure 11: Inverter Rack Ground Location layout

43. Ensure M8 hardware at Ground Straps at inverters are torqued to 11 FT-LBS dry +/- 10% shown in figure 11.
44. Ensure M8 hardware at Ground Straps at Chassis connections has contact to bare metal and are torqued to are torqued to 13 FT-LBS dry +/- 10% shown in Figure 11.

HV Isolation IMD Box

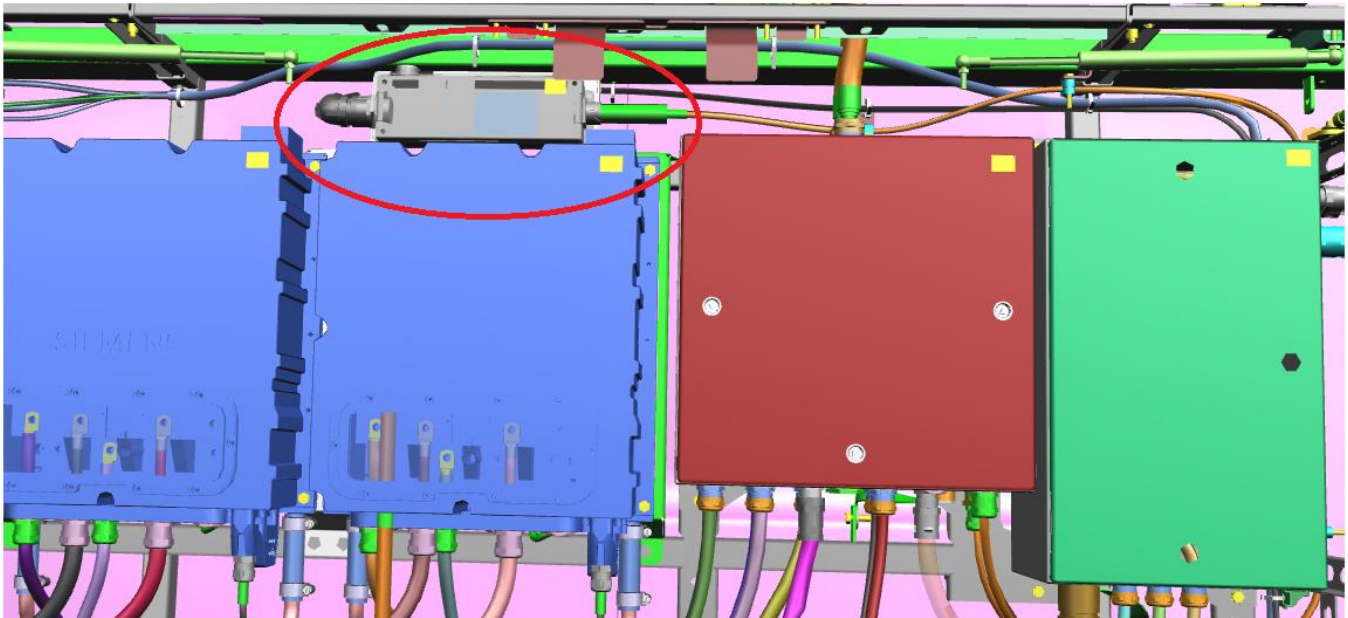


Figure 12: HV Isolation IMD Box Location

NOTE: Location may vary Slightly depending on build.

WARNING: Using appropriate PPE, confirm that there is no voltage present on any connection point.

WARNING: The work detailed in the following steps involves working closely to HV connections. It is required that the service personnel be trained in NFI HV safety practices such as Appendix A – NFIL Spec 532295 - High Voltage Safety Guidelines & Procedures for New Flyer Battery Bus.

45. Locate HV Isolation IMD Box inside the Inverter Rack shown in Figure 12.
46. Remove HV and LV cables and thoroughly inspect all cables and wires for chafing/kinking.
47. Thoroughly inspect all connections for corrosion.
48. Reinstall HV and LV cables securely.
49. Open HV Isolation IMD Box Cover and measure the fuse using an appropriate multimeter.
50. Restore HV Isolation IMD Box Cover.
51. Locate the HV Isolation IMD Box Ground Strap shown in Figure 13.
52. Ensure M8 Hardware at HV Isolation IMD Box is torqued to 13 FT-LBS dry +/- 10%.
53. Ground Strap at Chassis connection has contact to bare metal and are torqued to are torqued to 13 FT-LBS dry +/- 10%.

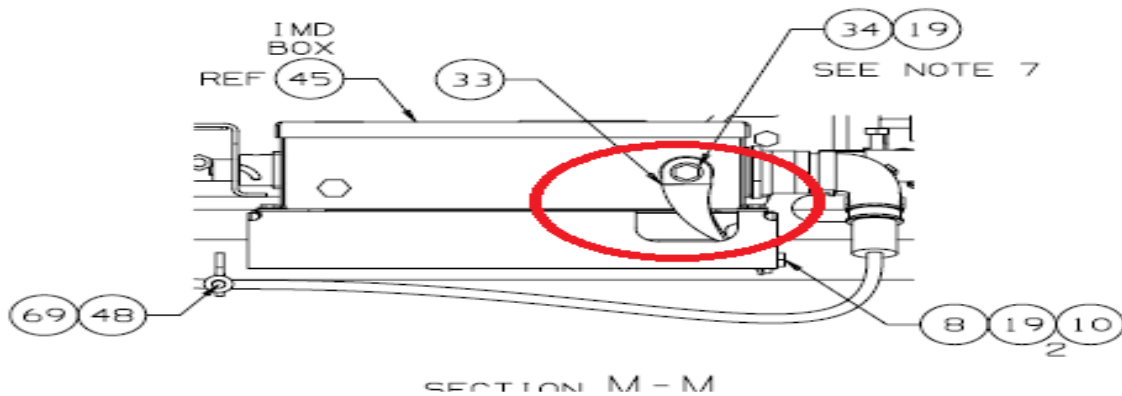


Figure 13: HV Isolation IMD Box Ground Strap Location

DC/DC Converter Rack

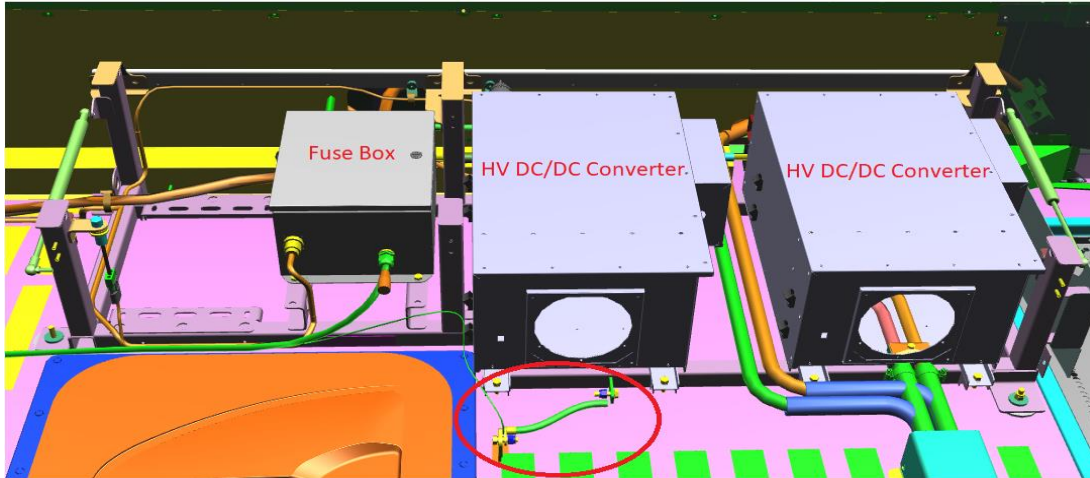


Figure 14: DC/DC Converter Rack Roof Location. Cover removed for clarity.

⚠ WARNING: Using appropriate PPE, confirm that there is no voltage present on any connection point.

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54. Verify the chassis connection circled in Figure 14 is clean to bare metal and torqued to 17 FT-LBS.
55. Remove the DC/DC Converter Rack cover to gain access to HV cabling.
56. Lightly pull all cables on the back side of the DC/DC converters to ensure proper cable securement to the DC/DC converters.
57. Thoroughly inspect all cables and wires for chafing/kinking.
58. Thoroughly inspect all connections for corrosion.

59. Remove Fuse Box cover shown in Figure 15.

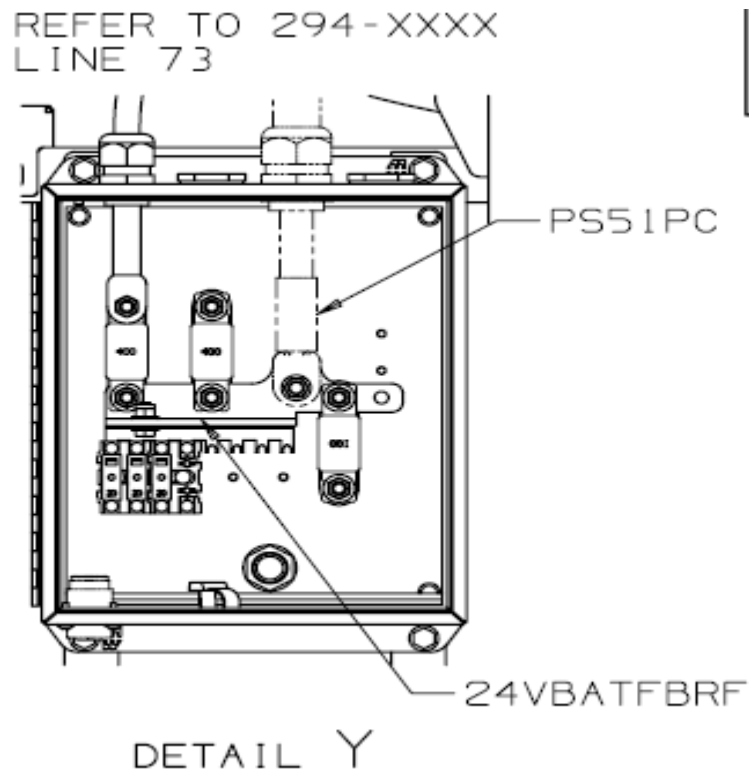


Figure 15: DC/DC Converter Rack Fuse Box

☞ **NOTE:** Additional cables may be routed in the fuse box then shown in Figure 18

60. Although unlikely inspect box for any residual water damage.
61. Lightly pull all cables to ensure proper cable securement.
62. Thoroughly inspect all cables and wires for damage/chaffing/kinking.
63. Thoroughly inspect all connections for corrosion.
64. Referring 24v output cables on backside of DC/DC Converters ensure hardware is torqued to 100 IN-LBS
65. Referring to all Fuse Box cable securement Ensure torque nuts on carriage bolt are torqued to 13 FT-LBS.
66. Locate HV Fuse Box to DC/DC converter cables circled in Figure 16 and detailed in Figure 17.

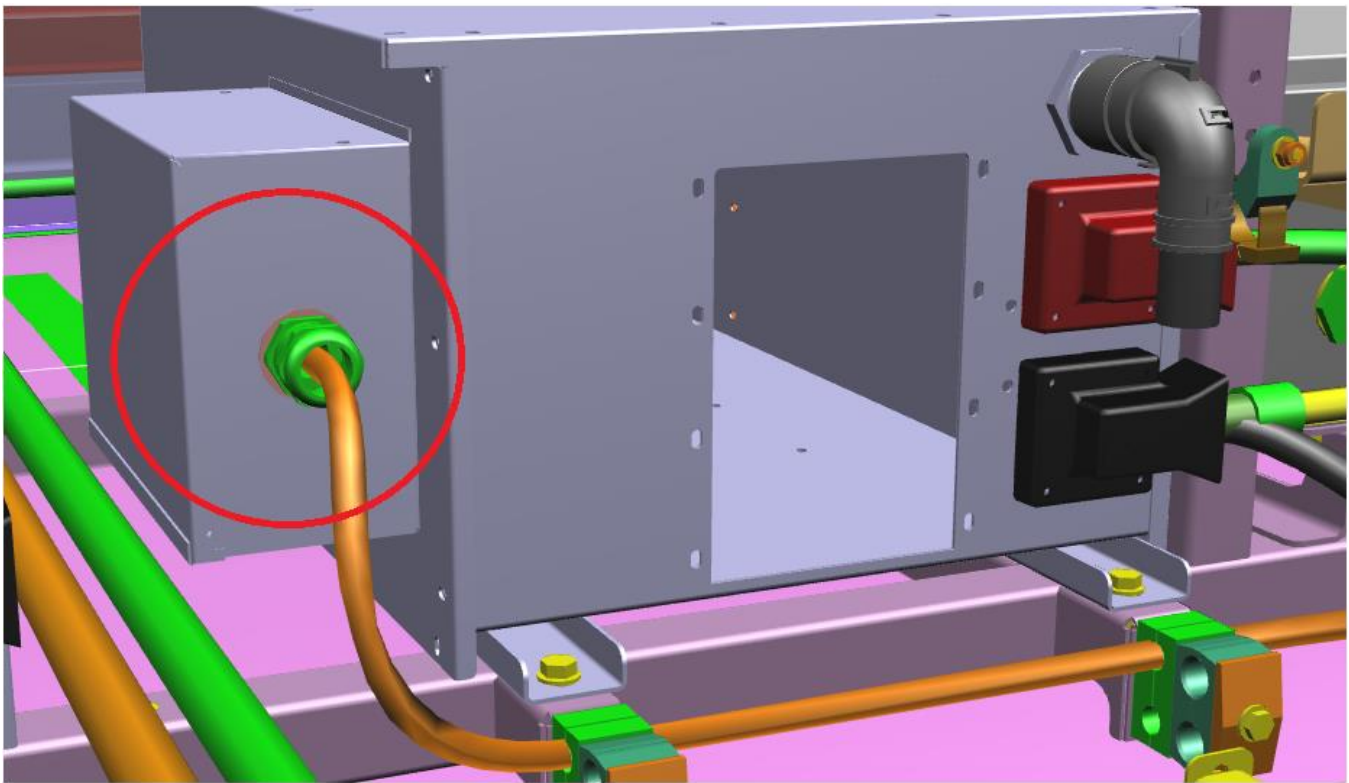


Figure 16: HV Fuse Box DC/DC converter cables Converter side

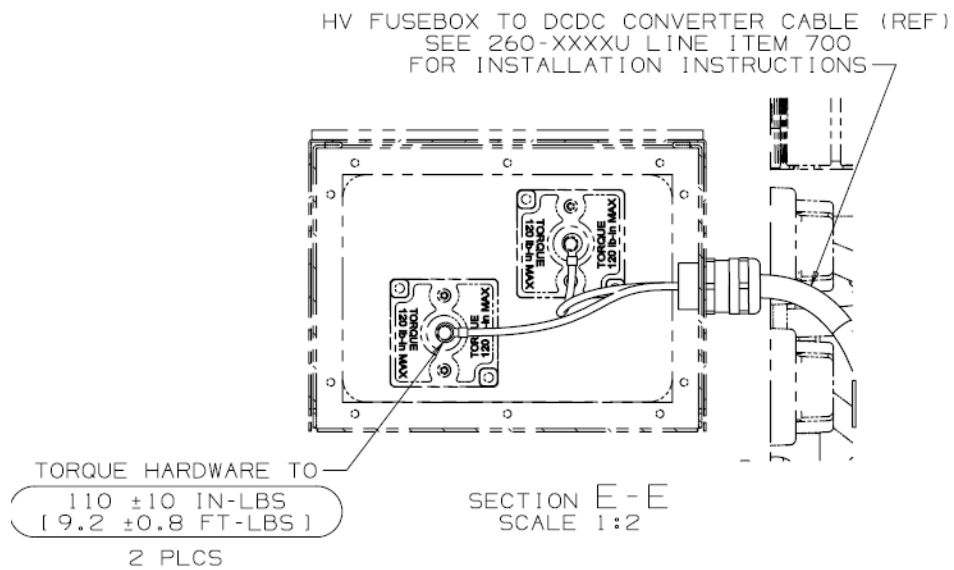


Figure 17: HV Fuse Box DC/DC Converter Cable Converter Side

- 67. Ensure connections are torqued to 110 +/- 10 IN-LBS.
- 68. Ensure all M25 retaining nuts are torqued 7 FT-LBS +/- 10% and M32 retaining nuts to 11 FT-LBS on all fuse box and DC/DC converter locations.

Rear Mount HVAC Unit

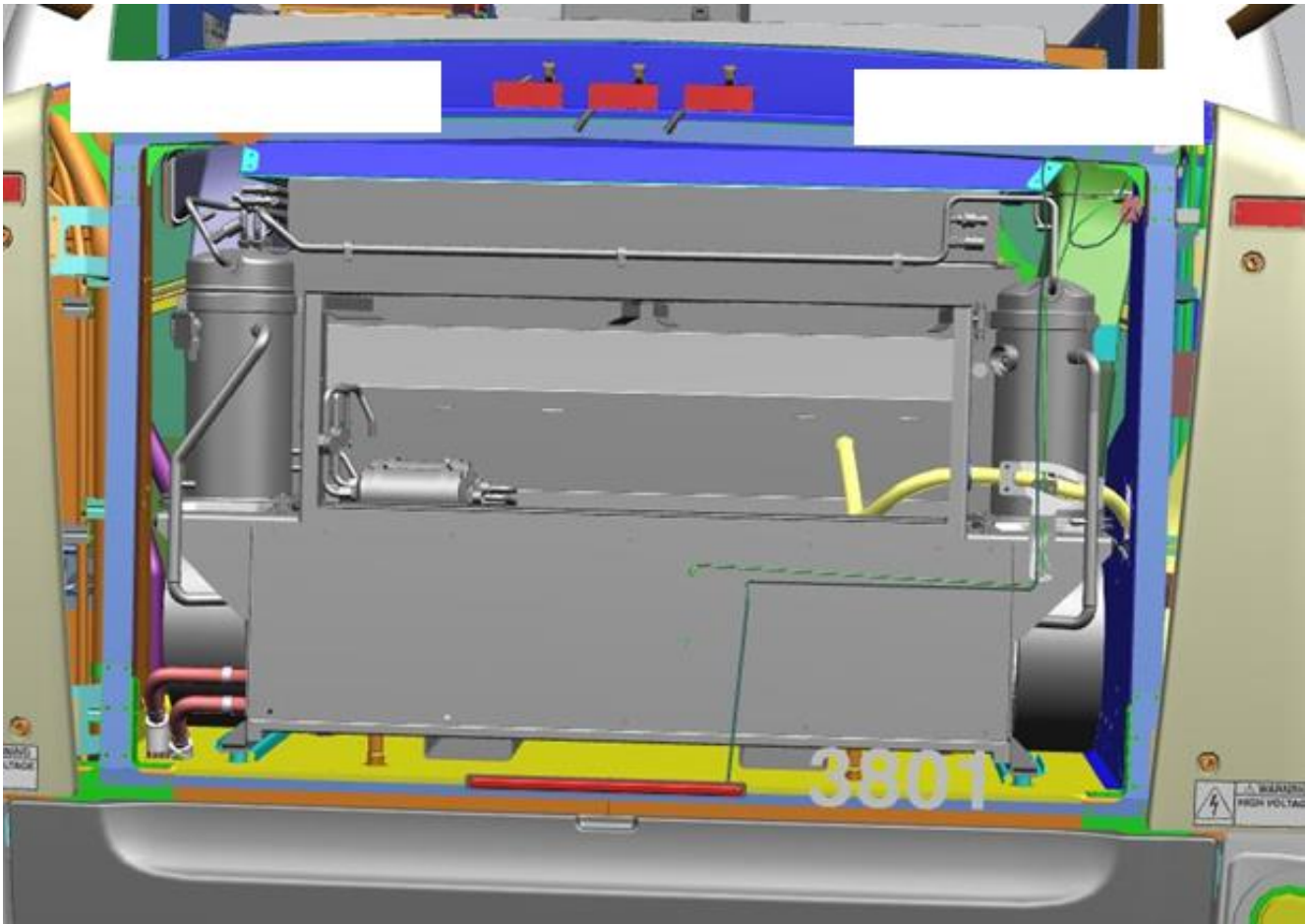


Figure 18: Rear Mount HVAC Location

69. Although unlikely inspect box for any residual water damage.
70. Lightly pull all cables to ensure proper cable securement.
71. Thoroughly inspect all cables and wires for damage/chaffing/kinking.
72. Thoroughly inspect all connections for corrosion.

Electric Auxiliary Heater

73. Locate the electric auxiliary heater on the rear of the bus beside the rear mount HVAC.
74. Remove the heater head cover to access the high voltage connections.

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75. Verify the orange high voltage cable secured to the contactor and circled in yellow below in figure 19 is torqued to 5.9 FT-LBS.



Figure 19: High Voltage Positive Auxiliary Heater Connection

76. Lightly pull on the orange high voltage cable circled below in figure 20 and connected to the terminal block to ensure proper cable securement.

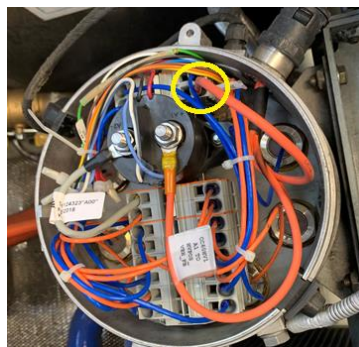


Figure 20: High Voltage Negative Auxiliary Heater Connection

Battery Roof Pack (ESS)

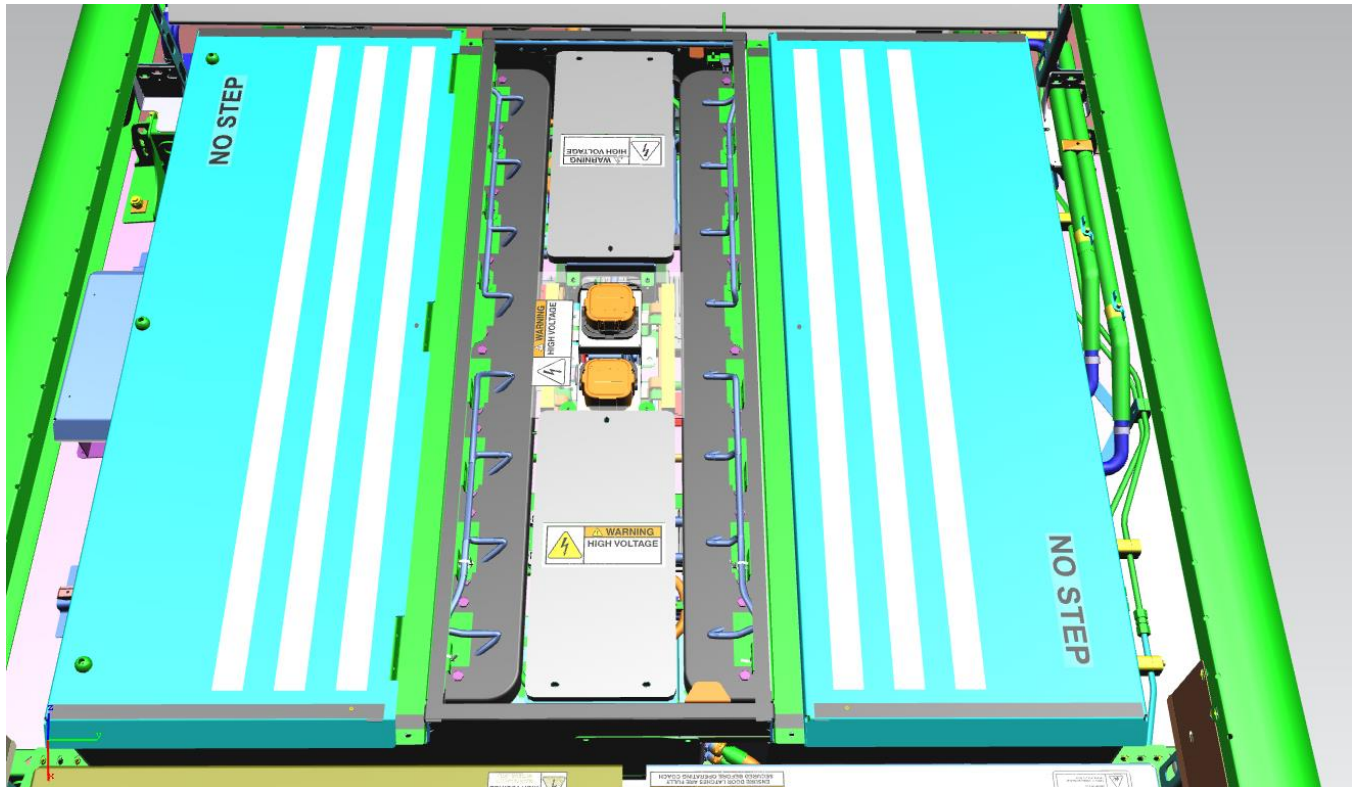


Figure 21: Battery Roof Pack (ESS). Covered removed for clarity

⚠ WARNING: Using appropriate PPE, confirm that there is no voltage present on any connection point.

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77. Ensure EAD-016631 implemented to improve robustness and reliability of the ESS is complete.
Refer to your local RPSM for EAD detail.
78. Although unlikely inspect the compartment area for any water damage throughout next steps.
79. Remove Panels to gain access to bus bars.

80. Using an appropriate voltmeter and before removing any MSD(s), confirm voltage is present between the positive in terminal on the CMS/EDM and negative in terminal on the CMS/EDM. See Figure 22.
81. Using an appropriate voltmeter confirm that **NO** voltage is present between the positive out terminal on the BDU contactor and negative out terminal on the BDU contactor. See Figure 22.
82. Remove MSD's and inspect for damage.

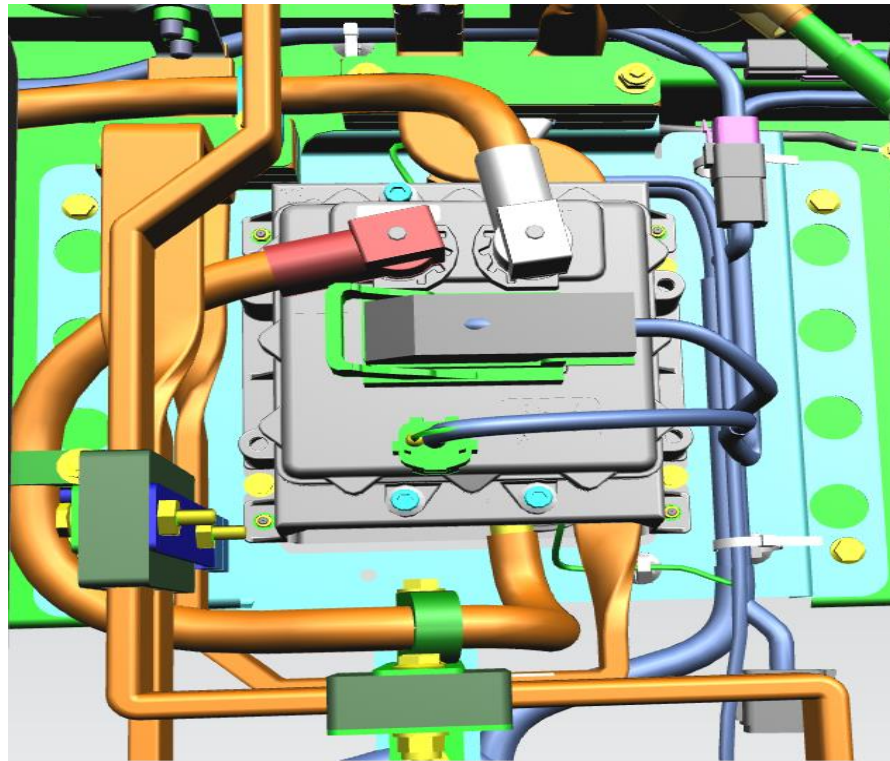


Figure 22: CMS/EDM located in ESS

83. Ensure ITS 59024 is implemented for replacement of MSD's to NFIL P/N 806450 and P/N 805480 is complete. Refer to your local RPSM for ITS detail.
84. Lightly pull all cables to ensure proper cable securement.
85. Thoroughly inspect all cables and wires for damage/chaffing/kinking.
86. Thoroughly inspect all connections for corrosion.
87. Inspect all Bus Bars for damage or break in the insulation
88. Inspect all Battery Modules for damage to the Ribbon and Circuit Board
89. Inspect entire compartment of any residual water damage

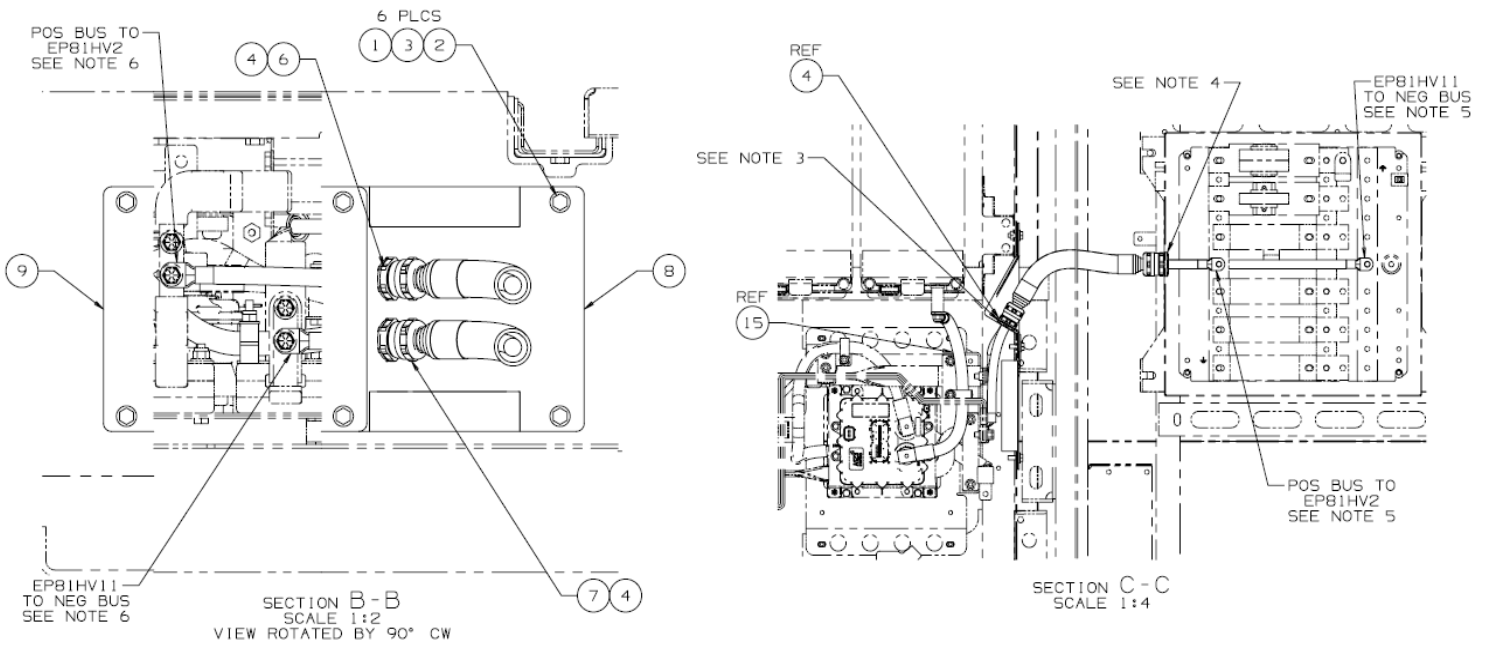


Figure 23: HV cables into ESS Routing

- 90. Ensure HV power cables coming into rack to CSM/EDM are routed correctly. See Figure 23.
- 91. Ensure 5/16 hardware in CSM/EDM is torqued to 13 FT-LBS +/- 10%. See Figure 23.
- 92. Ensure M8 hardware in HV Fuse Box is torqued to 13 FT-LBS +/- 10%. See Figure 23.
- 93. Ensure the Bus Bars between each module are torqued to 97-114 IN-LBS. See Figure 24.

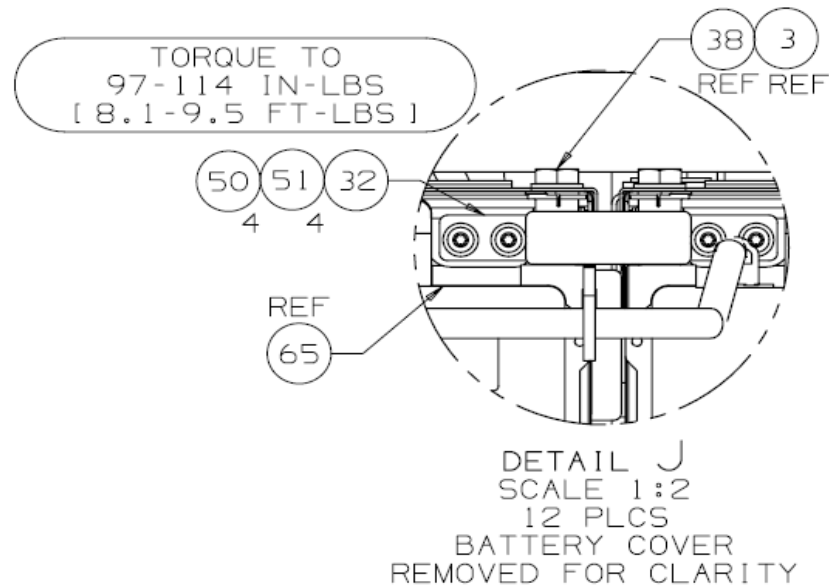


Figure 24: Module to Module bus bar connection location



94. Unless otherwise specified in previous steps of this ITS, torque HV bus bars, cables and clamps per the chart detailed in Figure 25.

NOMINAL SIZE	BOLT P/N	BOLT DESCRIPTION	NUT P/N	NUT DESCRIPTION	TORQUE
1/4"	460160	SST SERRATED FLANGE	626195	STEEL CLINCH NUT	72 IN-LBS [6 FT-LBS]
5/16"	626206	GR. 8 SER. FLANGE	626188	STEEL CLINCH NUT	135 IN-LBS [11.3 FT-LBS]
5/16"	10B05###	GRADE 8 STEEL	626188	STEEL CLINCH NUT	135 IN-LBS [11.3 FT-LBS]
5/16"	10B05###	GRADE 8 STEEL	40N05000	GRADE 8 NYLOCK	135 IN-LBS [11.3 FT-LBS]
M3	73BM03###	A2-70 SST FLANGE	SEE ENG NOTE 1		7.1 IN-LBS [0.6 FT-LBS]
M4	73BM04###	A2-70 SST FLANGE	SEE ENG NOTE 1		16.8 IN-LBS [1.4 FT-LBS]
M5	73BM05###	A2-70 SST FLANGE	SEE ENG NOTE 1		32 IN-LBS [2.7 FT-LBS]
M6	73BM06###	A2-70 SST FLANGE	SEE ENG NOTE 1		58 IN-LBS [4.8 FT-LBS]
M8	73BM08###	A2-70 SST FLANGE	SEE ENG NOTE 1		133 IN-LBS [11.1 FT-LBS]
M10*	73BM10###	A2-70 SST FLANGE	SEE ENG NOTES 1 & 2		22.9 FT-LBS
M12*	73BM12###	A2-70 SST FLANGE	SEE ENG NOTES 1 & 2		36.9 FT-LBS

ENGINEERING NOTES:

1. NUT SPECIFICATIONS MUST BE MINIMUM GRADE CLASS 5.8 OR A_x-70 WITH CONSIDERATIONS FOR GALLING PREVENTION AND CORROSION PROTECTION (EXAMPLE: 75NM##### FLANGE NUTS OR SPEC P/N 827749 CLINCH NUTS).
- *2. HV CONNECTIONS ARE NOT RECOMMENDED USING SHORT BOLTS IN SIZES M10 AND LARGER DUE TO LIMITED BOLT STRETCH AND CORRESPONDING LIMITED CLAMP LOAD RETENTION.

MATERIAL SEE NOTES	UNSPEC'D TOLS.	DEC. IN.	TITLE
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Figure 25: Torque Specification Chart

95. Reinstall panels from step 79 and ensure hardware is torqued to 50 IN-LBS.

Fuel Cell

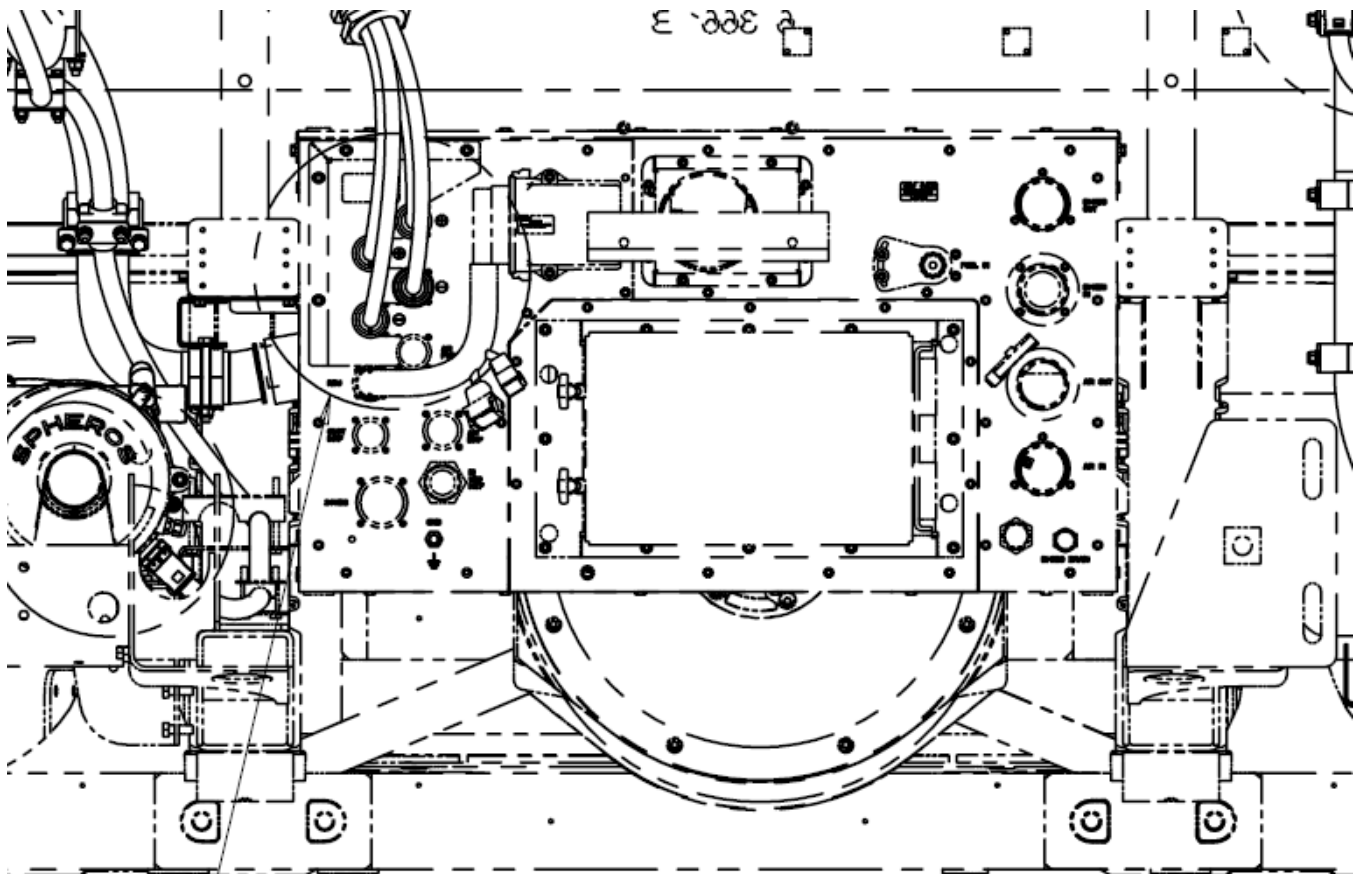


Figure 26: Fuel Cell Engine Compartment location

96. Lightly pull all cables to ensure proper cable securement.
97. Thoroughly inspect all cables and wires for damage/chaffing/kinking.
98. Thoroughly inspect all connections for corrosion.
99. Remove cable connection detailed in Figures 26 and inspect pins for damage and loose connections.
100. Reinsert cables connections in the same locations by inserting Fuel cell cable receptacle and rotating 120 degrees, once fully rotated, an audible click can be heard and the red arrow on the receptacle should align with the red dot on the coupling nut.
101. Verify that the Fuel Cell grounding connection detailed in Figure 27 has contact to bare metal and is torqued to 17 FT-LBS dry on Chassis side and 8.85 FT-LBS on Fuel Cell side.

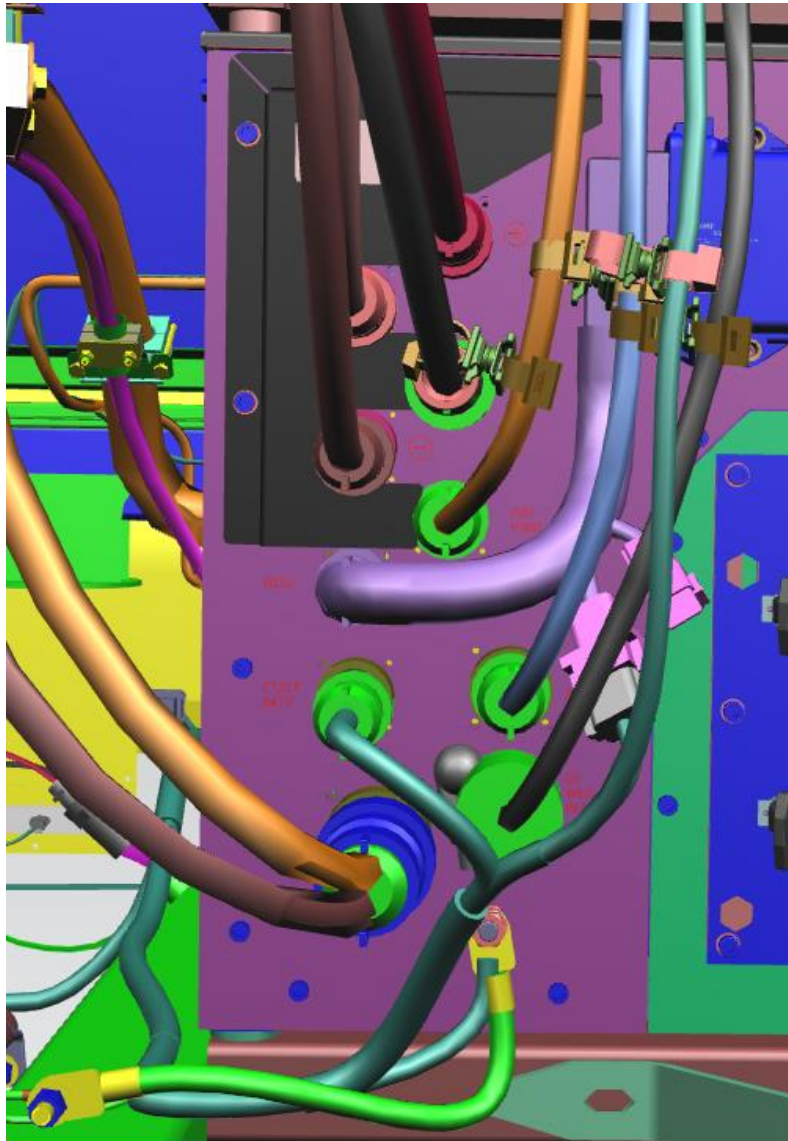


Figure 27: Fuel cell cable connection location

Loss of Isolation – Detection Process for A123 Systems

⚠ WARNING: The work detailed in the following steps involves working closely to HV connections. It is required that the service personnel be trained in NFI HV safety practices such as Appendix A – NFIL Spec 532295 - High Voltage Safety Guidelines & Procedures for New Flyer Battery Bus.

The Follow process is meant to verify any loss of isolation in the A123 system. This procedure can be performed in unison throughout this ITS. Any HV power cables, panels, and parts removed throughout this isolation procedure should be reinstalled using the torque specifications detailed throughout the ITS. Be sure to document isolation values throughout the procedure and notify your RPSM if any irregular values are noted. Ensure the XHE Isolation procedure is filled out as you carry out the inspection for **each bus**. Ensure to be as descriptive as possible when describing the issues found during the inspection. Take pictures when required to grasp the severity of an issue and provide to the RPSM to submit with the check sheets.

PACK NUMBER:

Insulation Meter Manufacturer, Module Number, and Serial Number: _____

Digital Multi-Meter Manufacturer, Module Number, and Serial Number: _____

Do not remove the pack cover until after the initial isolation measurements are complete.

- 1) _____ Install the Manual Service Disconnect (MSD) into the battery pack.
- 2) _____ Configure the test setup and make all connections to the battery pack low voltage and high voltage systems.
- 3) _____ Use CANalyzer to verify that the isolation issue is still present in the battery pack:
 - Close the battery pack contactors
 - Record the Current Sense Module (CSM) isolation measurement: _____ Ω
 - Record the batter pack voltage: _____ Vdc
 - Record any Diagnostic Trouble Codes (DTCs): _____
- 4) _____ Use CANalyzer to disable the CSM isolation measurements.
 - Use a digital volt meter (DVM) to measure and record the DC voltages between the following points:
 - Traction Battery (-) to Chassis Ground: _____ Vdc
 - Traction Battery (+) to Chassis Ground: _____ Vdc
 - Use an insulation meter set to 500V to measure and record the resistance between the following points:
 - Traction Battery (-) to Chassis Ground: _____ Ω
 - Traction Battery (+) to Chassis Ground: _____ Ω



- 5) _____ Open the battery pack contactors, disable the 12V wakeup signal, and stop CANalyzer. Remove the LV connector and the chassis ground connection from the pack.

- 6) _____ Remove the MSD.

- 7) _____ Drain the coolant from the pack and purge the cooling system using house air (5 minutes at 15PSI).

- 8) _____ Perform a pressure test on the coolant system. The pack should maintain 30 PSI of pressure for 10 minutes. Leave the pressure test fixture attached to the pack during the remainder of the test. Periodically monitor the pressure reading on the pressure gauge.

- 9) _____ Remove the battery pack cover.

- 10) _____ Perform a visual inspection of the battery pack (bus bars/wires, fluid in pack, etc.). Record any issues:

- 11) _____ Label the battery modules with location tags per Figure 1.

- 12) _____ Re-install the MSD.

- 13) _____ Reconnect the LV connector and chassis ground connection to the battery pack, start CANalyzer, and re-enable the 12V wakeup signal. Verify that the isolation issue is still present in the pack:
 - Close the battery pack contactors
 - Record the Current Sense Module (CSM) isolation measurement: _____ Ω
 - Record the batter pack voltage: _____ Vdc
 - Record any Diagnostic Trouble Codes (DTCs): _____

- 14) _____ Use CANalyzer to disable the CSM isolation measurements.
 - Use a DVM to measure the DC voltages between the following points:
 - Traction Battery (-) to Chassis Ground: _____ Vdc
 - Traction Battery (+) to Chassis Ground: _____ Vdc
 - Use an insulation meter set to 500V to measure the resistance between the following points:
 - Traction Battery (-) to Chassis Ground: _____ Ω
 - Traction Battery (+) to Chassis Ground: _____ Ω

- 15) _____ Open the pack contactors, disable the 12V wakeup signal, and stop CANalyzer. Remove the LV connector and the chassis ground connection from the pack.

- 16) _____ Disconnect the CSM HVBATT_NEG connection (RADSOK) and remove the high voltage sense connector from the CSM. Perform the following measurements:
 - Use an insulation meter set to 500V to measure the resistance between the following points:



- Traction Battery (-) to Chassis Ground: _____ Ω
- Traction Battery (+) to Chassis Ground: _____ Ω

Note: This step confirms the isolation fault is not due to the CSM

- 17) _____ Use a DVM to measure and record the DC voltages between the pack chassis ground connection point and the test points in Table A.

<u>Table A</u>	
Measurement Points	Voltage
Module 1 Negative Terminal	
Module 2 Negative Terminal	
Module 3 Negative Terminal	
Module 4 Negative Terminal	
Module 5 Negative Terminal	
Module 6 Negative Terminal	
Module 7 Negative Terminal	
Module 8 Negative Terminal	

Note: The point at which the polarity of the voltage changes indicates which area of the pack is likely contributing to the isolation fault.

- 18) _____ Remove the MSD
- Connect the insulation meter from Chassis Ground to Traction Battery (-) if the isolation fault is between Battery Negative Terminal and the MSD **OR** Connect the insulation meter from Chassis Ground to Traction Battery (+) if the isolation fault is between Battery positive and the MSD
 - The Traction Battery terminal established above will be referred to as “TB ISOLATION POINT (TIP)”
 - Starting at the Module closest to the MSD (Module 7 if the isolation fault is between the MSD and Negative Terminal of the battery, Module 8 if the isolation fault is between the MSD and Positive battery). Measure the impedance from “TIP” to Chassis using “Table B”
- 19) _____ With all Module interconnects intact perform an isolation measurement between the “TIP” and Chassis Ground. Record results in “Table B”
- 20) _____ Starting with the interconnect cable between the two Modules furthest from the “TIP”, remove the interconnect cable and perform an isolation measurement. Record the results in the table below. Repeat this process for each of the interconnect cable working towards the “TIP”.

<u>Table B</u>		
Fluke Insulation tester @ 500V setting, MSD removed	Interconnect Location	Resistance M Ω
<u>Negative Terminative Side of MSD if <550MΩ</u>		
No interconnects disconnected	Module 4P	
Removed connection from:		

Removed connection from:		
Removed connection from:		
Removed connection from:		
Removed connection from:		
Removed connection from:		
Removed connection from:		
Positive Side of MSD if <550MΩ		
No interconnects disconnected	Module 5N	
Removed connection from:		
Removed connection from:		
Removed connection from:		
Removed connection from:		
Removed connection from:		
Removed connection from:		
Removed connection from:		
Removed connection from:		
Removed connection from:		

21) _____ With the faulty Module(s) electrically isolated from the neighboring Module use an insulation meter and DVM to perform and record the following measurements.

Table C				
Measurement Points	Resistance MΩ	Voltage	Module Location	Module S/N
Module Negative Terminal to Chassis Ground				
Module Pos to Chassis Ground				
Module Negative Terminal to Chassis Ground				
Module Pos to Chassis Ground				

Note: This step confirms the location of the isolation fault with this Module

22) _____ Remove the Module (s) for further analysis

23) _____ Store all the CANalyzer data and test notes

LABOUR ESTIMATE				
	Operation	Number of Technician(s)	Hours	Labor Time T X HR
1	Inspect various systems in XHE buses to ensure long term reliability	2	8.0	16

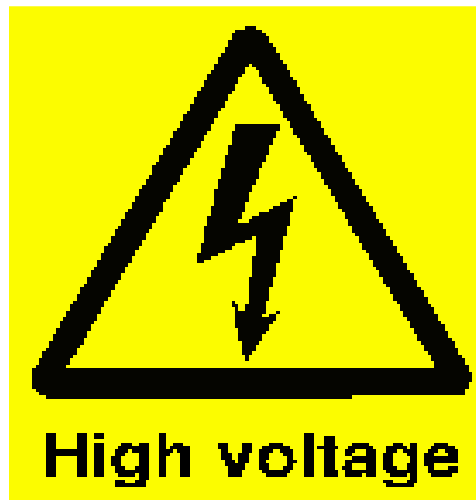
PARTS REQUIRED					
Item	Part Number	Description	Qty. per Coach	Units	Notes
1	121202	Paint Marker Black	1	EA	

SPECIAL TOOLS REQUIRED					
Item	Part Number	Description	Qty.	Units	Notes
1	N/A	Digital Multimeter with long test leads	1	EA	

Appendix A – NFIL Spec 532295 - High Voltage Safety Guidelines & Procedures for New Flyer Battery Bus

The following provides general guidelines in relation to safety and best practices when completing installation or servicing work on any New Flyer battery bus vehicle platform.

This document is not meant to supersede the actual released installation and assembly drawings and where conflicts arise, the released engineering drawings take precedence.



Introduction

The utmost concern, while working with High Voltage (HV) systems, is the safety of yourself, other personnel and the potential of damage to property. To minimize these risks, it is crucial to be properly trained and always maintain a very alert, questioning and disciplined attitude without fail. As soon as your guard is lowered, then the potential of an accident is probable that can hurt or kill yourself or someone else and possibly damage property.

What is High Voltage (HV)?

Any form of voltage that is greater than 50 volts if the person's skin at the electrical contact points is not compromised and not wet.

Equipment Required

The following equipment shall be required:

Digital Multimeter (DMM), 1000-volt Category III, 600 volt Category IV,

10Megohm impedance or greater with insulated case or rubber holster

Clamp-on current probe, 1000-volt Category III, 600 volt Category IV
High Pot Tester (Hi-Pot)
Phase rotation meter
Personal Protection Equipment (PPE) appropriate for 700volt DC & 230 volt AC with Class 00 or higher HV gloves with compatible leather over gloves. Appropriate safety glasses as well as the face shield. The PPE shall also meet the required Arc Flash & Arc Blast requirements. Before use, inspect the PPE in accordance with this guideline.
Adequate lighting
HV insulated mat
Two fused HV clip leads 10 inches long
Safety barricade with warning lights & "Danger High Voltage" signs
Belt tool pouch (use only to carry small components up/down a ladder)
Torque Screwdriver set
Imperial torque nut driver set
Metric torque nut driver set

Equipment Calibration

All test equipment must be within their calibration interval and recorded such with the respective serial numbers. These records must be available to the Checker.

Personnel Requirement

Only trained personnel shall supervise and perform High Voltage system testing, checkout and troubleshooting. Two personnel (one called the Checker & the other called Monitor/Recorder) shall perform Checkout Procedures, together, to ensure safety of themselves, others nearby & for the protection of vehicle & property. Refresher training shall be provided to these personnel on a regular basis and when new systems are to be checked by them. The training of the personnel shall consist of:

HV & low voltage basics, intermediate & advanced electricity
HV & low voltage electrical systems of the vehicle
Shop safety practices & procedures
First aide including CPR & the use of the shop defibrillator
How to release a victim that can't let go HV
Quickest method of shutting down HV
Firefighting and emergency procedures
HV & arc flash safety
Organized & tidy placement of equipment & tools allowing for unrestricted movement
Operation of Hi-pot

To ensure effectiveness of training, exams of the trained material shall be required with a high passing mark of at least 80% and a retraining of the missed 20 % on a one to one basis.

Checker Function



(Caution: The Checker must not have any health conditions that can be exacerbated when startled and must not have any electronic implants.)

Directed by the Monitor/Recorder
Performs all preparations & checks
Wears PPE as specified by the Checkout Procedure
Performs all restorations

Vehicle Inspection

It is necessary that the vehicle to be checked out, first be visually inspected of all systems, workmanship and with special attention to ensuring there is no HV cable or equipment damage or chafing.

High Voltage Checkout Preparation

(1) The scope of the work must be accurately defined such as a Checkout Procedure that requires systematic steps with sign offs. Before a Checkout is performed, the Supervisor, Checker and Monitor/Recorder must conduct a briefing of what shall transpire, identify potential hazards, resist pressures of “is it done yet?”, anticipate problems and question possible events. If an unexpected electrical hazard or fault occurs, during any time of the Checkout, it must be immediately reported to the supervisor. After the Checkout is completed the same group should review the results and processes and make proposed modifications to the procedures if required.

(2) Install Safety barricade with warning lights & signs indicating "Danger High Voltage" around the vehicle perimeter and ensure no personnel are within the fenced perimeter during the checkout procedure.

(3) It shall always be the goal to check the systems as much as possible with all HV power OFF and Locked Out/Tagged Out and proven as de-energized by voltage measurement using the DMM. The functionality of the DMM must be proved before and after the verification of no HV present. Then, if possible, the HV systems should be challenged by trying to energize them while checking that no HV appears.

(4) When it is necessary to perform tests of HV systems with the power ON, then the Working Live procedure must be followed.

(5) The test personnel shall always rehearse the actions required in case of any possible accident scenarios.

(6) Before beginning the Checkout Procedure, the test personnel shall remove all their jewelry (including pierced ones), watches and any electrically conductive objects on them.

PPE Requirements

The PPE voltage class, Arc Flash and Arc Blast rating shall be compatible with the voltage and Arc Flash capability of the systems being tested. Appropriate leather glove protectors shall be worn over the HV rubber gloves.

PPE Care & Testing

Rubber insulated PPE shall be periodically cleaned and tested in accordance with 29 CFR 1910.137 and the appropriate ANSI/ASTM standards. HV gloves, sleeves and mats shall be tested every 6 months. PPE apparel shall be cleaned and maintained in accordance with the manufacturer’s instructions. A record of the PPE testing shall be maintained and available to the users.

PPE Inspection

Inspect PPE equipment, before use, for any degradation or damage and ensure that the HV gloves have been tested every 6 months. Also perform an air pressure test on the HV gloves before and after each use. If during PPE use a potential damaging incident occurred to the PPE, stop further testing and inspect the PPE. If at any time the PPE is defective, reject it, and obtain an accepted one.

PPE Storage

PPE apparel should be stored lying flat, undistorted, right-side out and not folded in protective containers. The HV mats can be rolled with an inside diameter greater than 2 inches. Rubber HV gloves should be stored in cool, dark, dry, and free from damaging chemicals or vapors. The glove cuffs should face downwards, without folding, in the appropriate glove bag and hung vertically.

Insulated Tools

Insulated tools should be visually inspected for insulation damage before and after each session of use.

Lockout/Tagout Procedure

The Lockout/Tagout procedure should be followed that is specified in the respective checkout procedure. When removing the lock and tag:

- (1) The locks and tags shall be removed by the installer of them or under her/his supervision.
- (2) If the installer of the locks and tags is not available, then her/his supervisor:
 - (a) Ensures that the installer of the locks and tags is not in the facility
 - (b) Contacts the installer to inform her/him that the locks and tags will be removed
 - (c) Reminds the installer of the lock and tag removal when she/he resumes work

Stored Energy

Personnel must always remember the characteristics of stored energy devices such as capacitors and batteries and when energy is available from.

Working Live

To maximize safety, it is always important to perform the maximum amount of HV checkout in the de-energized state.

When it is necessary to work with HV equipment while energized or to verify whether HV is present, the utmost care and safety procedures must be utilized including:

- (1) Wearing appropriate PPE with protector gloves over top of the HV rubber gloves
- (2) Ensure all personnel, except the Checker and Monitor/Recorder, are clear of the vehicle
- (3) Kneeling or standing on HV insulated mat

Energizing & De-energizing Procedure

It is critical that before any HV system is energized that a visual check be performed to ensure that all possible HV compartments are closed and there is no debris, tools or test equipment lying on HV terminations. If there is a certain sequence of energizing and de-energizing the HV system, then all personnel involved must be trained in this sequence. **(CAUTION: Never try to connect or disconnect circuit components such as cables, fuses, connectors, etc. while there is current flowing in the circuit.)**

Electrical Injuries

Electrical injuries should be immediately reported to the first aide personnel and the supervisor. Other than electrostatic shocks, even non-injurious electrical shocks should be reported to the supervisor. These should be immediately investigated and documented to determine the cause and prevent the occurrence in the future.

Appendix B – XHE High Voltage Inspection Check Sheet

Section	Step #	Page #	Inspection	Issue (Yes/No)	Issue Description (List quantity if Applicable)	Signature of Approval
Air Compressor	7	5	Securement of Junction box to the Air Compressor			
	9	5	Securement of HV cables to Junction Box			
	10	5	Distribution block securement			
	11	5	Grommet present			
	12	5	Wire damage inspection and routing			
	13	5	Corrosion inspection			
	14	5	Terminal Block securement - 16 IN-LBS			
	16	6	Air Compressor Ground connection - 17 FT-LBS			
PEM Motor Junction Box	19	7	Cable damage inspection to Junction Box			
	20	7	Corrosion inspection			
	21	7	Terminal Seating inspection			
	22	7	Cable to Junction Box securement - 20 NM			
	23	8	Gland Nut securement - 10 NM			

	24	8	Junction box - 8 NM			
Service Charge Receptable	26	9	Water Damage Inspection			
	28	9	Cable securement to junction box			
	29	9	Cable damage inspection to Junction Box			
	30	9	Cable corrosion inspection			
	31	9	Connection securement - 36 IN-LBS			
ESS HVAC	34	10	Cable securement to ESS Unit			
	35	10	Cable damage inspection to Junction Box			
	36	10	Cable corrosion inspection			
	37	10	Connection securement - 12.5 +/- 1.5 IN-LBS			
Inverter Rack	39	12	Cable securement to Fuse Box and Inverters			
	40	12	Cable damage inspections			
	41	12	Cable corrosion inspection			
	42	12	Torque verification – refer to table			
Inverter Rack Ground Connections	43	13	Ground connection securement - 11 FT-LBS +/- 10%			
	44	13	Ground connection securement - 13 FT-LBS +/- 10%			

HV Isolation IMD Box	46	14	Cable inspection			
	47	14	Corrosion inspection			
	49	14	Fuse validation			
	52	14	Ground connection at IMD - 13 FT-LBS			
	53	14	Ground connection at Chassis - 13 FT-LBS +/- 10%			
DC/DC Converter Rack	54	15	Ground Chassis connection - 17 FT-LBS			
	56	15	Cable securement inspection			
	57	15	Cable damage inspection to Junction Box			
	58	15	Cable corrosion inspection			
	60	16	Water Damage Inspection			
	61	16	Cable securement inspection			
	62	16	Cable damage inspection to Junction Box			
	63	16	Cable corrosion inspection			
	64	16	24V cable torque validation - 100 IN-LBS			
	65	16	Fuse Box torque validation - 13 FT-LBS			
	67	17	HV cable torque validation - 110 +/- 10 IN-LBS			
	68	17	Retaining nut securements - 7 FT-LBS and 11 FT-LBS			
Rear Mount HVAC Unit	69	18	Water Damage Inspection			
	70	18	Cable securement inspection			

	71	18	Cable damage inspection to Junction Box			
	72	18	Cable corrosion inspection			
Electric Auxiliary Heater	75	19	Cable inspection and torque validation - 5.9 FT-LBS			
	76	19	Cable securement validation to terminal block			
Battery Roof Pack (ESS)	77	20	EAD-016631 Validation			
	78	20	Water Damage Inspection			
	80	21	Voltage verification			
	81	21	Voltage verification			
	82	21	MSD inspection			
	83	21	ITS 59024 validation			
	84	21	Cable securement validation to terminal block			
	85	21	Cable damage inspection to Junction Box			
	86	21	Cable corrosion inspection			
	87	21	Bus Bar inspection			
	88	21	Battery Module inspection			
	89	21	Water Damage Inspection			
	90	22	Cable routing validation			
	91	22	5/16 hardware torque validation - 13 FT-LBS +/- 10%			
	92	22	M8 hardware torque validation - 13 FT-LBS +/- 10%			

	93	22	Bus Bar between Battery Modules torque validation - 97-114 IN-LBS			
	94	23	ESS Rack torque validation			
	95	23	Reinstall panels - 50 IN-LBS			
Fuel Cell	96	24	Cable securement inspection			
	97	24	Cable damage inspection to Junction Box			
	98	24	Cable corrosion inspection			
	99	24	Cable pin inspection			
	101	24	Ground torque validation - 17 FT-LBS to Chassis and 8.85 FT-LBS to Fuel Cell			
Isolation Validation		26	Procedure Performed through inspection			