Battery & Electrical Systems  
Scrutineering Checklist

Version 0.1 – 05-07-2024

Team Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

LV Battery Voltage: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

HV Battery Voltage: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
  
Inspection by: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Inspection Verdict: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Introduction

This document serves as a detailed scrutineering checklist for the battery and electrical systems of teams wanting to demonstrate and/or operate their electrical systems at EHW 2024.

It provides an addition to the existing scrutineering checklist and in no way replaces the existing requirements / compliance checks performed therein.

Teams are not allowed to operate their electrical and / or high-voltage systems without having passed these compliance checks.

Preparations

To be as prepared as possible we kindly ask teams to prepare the following prior to arriving at scrutineering (have it readily available):

• General availability of all required safety equipment as stated in the scrutineering checklist.

• Schematic of the complete high-voltage system and components.

• Datasheets of the following components (if applicable):

•

• LV battery (cells)

• HV battery (cells)

• Battery fuse

• Battery isolation relays

• Pre-charge relay

• Manual Isolation Disconnect (MID)

•   
Pre-charge resistor

• Dis-charge resistor

• Insulation Monitoring Device (IMD)

• BMS

• A way to safely measure the following points in their electrical circuit:

•

• HV+ (outside battery)

• HV- (outside battery)

•   
LV+ (outside battery)

• LV GND (e.g. chassis frame)

• Prepare their demonstrator in a finished state – changes or modifications after the scrutineering checks may lead to re-evaluation.

• Be familiar with the contents of this document.

VISUAL INSPECTIONS

► All the inspections in this section will be performed with **all systems turned off**.

Safety Equipment & Tools

HV insulating gloves (two pairs) with the appropriate voltage rating for the electrical system.

Insulated tools with the appropriate voltage rating for the electrical system.

Fire extinguishers are nearby.

Multimeter with the appropriate ratings for the electrical system.

Comments: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Low-voltage battery

The maximum voltage of the batteries is below 50 VDC.

The positive and negative terminals of the batteries can easily be identified.

The positive and negative terminals can not be plugged in incorrectly.

The overall battery assembly is of high build quality and the components in the battery are properly fixed. Any mechanical connections are connected properly.

There is a battery management system (BMS) incorporated into the low-voltage battery.

There is no visual damage or risk of shorting present within (or around) the battery.

The low-voltage battery is properly fixed onto the demonstrator.

Comments: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Inverters (if applicable)

► For the inspection of the inverters the inside of the inverters is required to be accessible, unless a fully off-the-shelf unit is used without any modifications.

The positive and negative terminals of the inverters can easily be identified.

The positive and negative terminals can not be plugged in incorrectly.

The overall inverter assembly is of high build quality and the components in the inverter are properly fixed. Any mechanical connections are connected properly.

There is no visual damage or risk of shorting present within (or around) the inverter.

The inverter is properly fixed onto the demonstrator.

Comments: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

High-voltage battery & Charger

► For the inspection of the high-voltage battery the inside of the battery is required to be accessible.

The positive and negative terminals of the batteries can easily be identified.

The positive and negative terminals can not be plugged in incorrectly.

The overall battery assembly is of high build quality and the components in the battery are properly fixed. Any mechanical connections are connected properly.

There is a battery management system (BMS) incorporated into the high-voltage battery.

There is no visual damage or risk of shorting present within (or around) the battery.

The main fuse is installed directly after the battery + side.

The main fuse installed has the correct current and voltage rating and matches the provided datasheet.

The isolation relays are installed properly and have the correct rating and matches the provided datasheet.

*If in battery / applicable*: The pre-charge circuit has been installed correctly and the pre-charge resistor and relay are adequately sized and match the datasheet.

*If in battery / applicable*: The dis-charge circuit has been installed and by default discharges the high-voltage system. Its components are adequately sized and match the datasheet.

*If in battery*: Each high-voltage battery features a separate Insulation Monitoring Device (IMD) measuring high-to-chassis and low-to-chassis insulation.

The high-voltage battery is properly fixed onto the demonstrator.

The battery charger is of high build quality and there is no visual damage to any of the wiring or risk of shorting present.

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Manual Isolation Disconnect (MID)

The Manual Isolation Disconnects (MIDs) is placed in the high-current line and operates independently of the low-voltage system. It isolated at least one pole of the battery pack when switches / removed.

The MID is switchable / removable without any tools.

The MID is accessible if the demonstrator is stuck on the track and is accessible without removing any parts of the demonstrator.

The MID is connected using a positive locking mechanisms preventing disconnection through external forces.

There are no conducting surfaces on the MID apart from the electrical connection.

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Low-Voltage Wiring and Components

There are no loose connections within the low-voltage (wiring) circuit.

All low-voltage wiring is separated from high-voltage wiring by at least 25 mm.

There is no visual damage to any wiring or components.

Wiring going to moving components have enough slack to allow for the movement and no wiring is under tension.

Orange coloured wiring is not used for low-voltage wiring.

Comments: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

HIgh-Voltage wiring and components

There are no loose connections within the high-voltage (wiring) circuit.

All high-voltage wiring is separated from low-voltage wiring by at least 25 mm.

There is no visual damage to any wiring or components.

Wiring going to moving components have enough slack to allow for the movement and no wiring is under tension.

All wiring carrying >120 V is coloured orange.

All high-voltage wiring has the correct voltage and power ratings.

Visual indicators (e.g. LEDs) are present on the demonstrator signalling presence of high-voltage outside the battery and proper insulation.

The visual indicators are visible without removing components.

The visual indicators are not controlled through software and come directly from hardware/circuitry connected to the system.

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Measurements & Testing

Grounding Checks

► All grounding checks will be performed with **all systems turned off**.

All conductive parts that are near high-voltage wires and components are properly grounded with a resistance of <300 mΩ @ 1A.

All conductive parts that are at risk of being touched by people are properly grounded with a resistance of <300 mΩ @ 1A. E.g. near switches, MID, and parts of the vehicle that might be pushed.

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Insulation Measurement test

► All insulation measurement tests will be performed with **all systems turned off**.

► Determine the test voltage: 100V / 250V / 500V / 1000V (based on battery voltage).

Measure the resistance at the test voltage between HV+ and LV GND, the resistance is much higher than 300 kΩ.

Measure the resistance at the test voltage between HV- and LV GND, the resistance is much higher than 300 kΩ.

Comments: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Battery Management System (BMS)

► If required to access the BMS data, teams are allowed to power-up their low-voltage system.

The team can show it is receiving the following data from the BMS of the high-voltage battery:

•

• State of charge

• Pack voltage

• Pack current

• Cell temperature of >25% of all cells

• Minimum and maximum cell voltages

• Voltage of every cell connected in series

The team can show it is receiving the following data from the BMS of the low-voltage battery:

•

• State of charge

• Pack voltage

• Pack current

• Cell temperature of >25% of all cells

• Minimum and maximum cell voltages

• Voltage of every cell connected in series

Comments: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

High-voltage System Power-up

► Connect multimeter between HV+ and HV-, measuring the voltage.

► Remove Manual Isolation Disconnect (MID).

► Team tries to power-up their high-voltage system.

Battery does not turn on / second relay does not close, there is no voltage measured.

► Reconnect the Manual Isolation Disconnect (MID).

► If applicable: engage any (emergency) switch (including software switches) on the demonstrator (one by one).

► Team tries to power-up their high-voltage system.

Battery does not turn on, no relay is switched, there is no voltage measured.  
(repeat for all switches)

► The team can now power-up their high-voltage system as normal.

The system is pre-charged sufficiently (>90%) prior to second relay closing.

The visual indicator (e.g. LED) switches on when the voltage goes above 50V.

The visual indicator is clearly visible under different light conditions (e.g. sun).

► The team can now power-down their high-voltage system as normal.

The measured voltage decreases in adequate time (5-10 seconds) below 50V (discharging).

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high-voltage system shutdown

► Connect multimeter between HV+ and HV-, measuring the voltage.

► The team can now power-up their high-voltage system as normal.

Engaging any (emergency) switches powers off the high-voltage system (relays) and system discharges to <50V in approx. 5-10 seconds (including software switches).   
(repeat for all switches)

► The team can now power-up their high-voltage system as normal.

Check if Manual Isolation Disconnect (MID) can be switched off under load.

Removing the Manual Isolation Disconnect (MID) powers off the high-voltage system (relays) and system discharges to <50V in approx. 5-10 seconds.

Comments: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Insulation Monitoring Device (IMD)

► Test Resistance: ~110 kΩ.

► The team can now power-up their high-voltage system as normal.

► The test resistance is connected between HV+ and LV GND.

The IMD triggers and the relays open within 30 seconds.

A visual indicator shows that there is no proper insulation (DM.47).

The system discharges to <50V in approx. 5-10 seconds.

Removing the test resistance does not result in reactivation of the high-voltage system.

► The team can now power-up their high-voltage system as normal.

► The test resistance is connected between HV- and LV GND.

The IMD triggers and the relays open within 30 seconds.

A visual indicator shows that there is no proper insulation (DM.47).

The system discharges to <50V in approx. 5 seconds.

Removing the test resistance does not result in reactivation of the high-voltage system.

Comments: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_