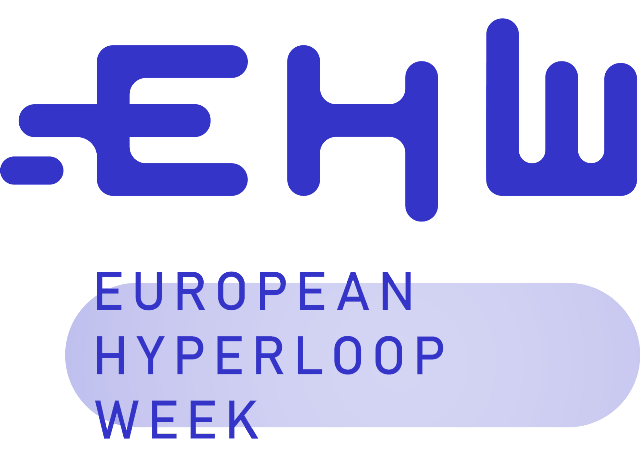


Battery & Electrical Systems  
Scrutineering Checklist

Version 0.1 – 05-07-2024

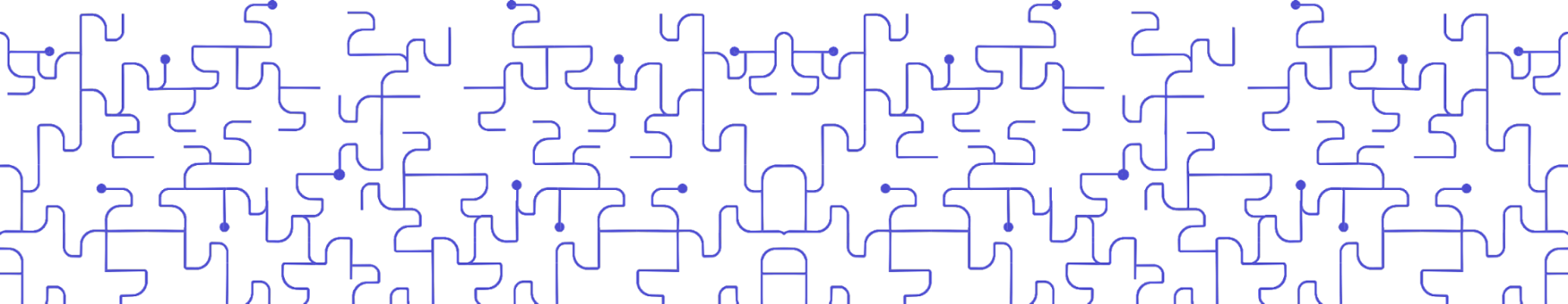


Team Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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.

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

### 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.

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

### 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.

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

# 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.

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

### 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).

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

### 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: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_