| | |
|---|---|
| University: | Lorem University |
| Vehicle number: | 420 |
| ESF Passed: | - |
| TS Voltage: | 600 V |

Present the vehicle for inspection in the following order
1. Pre-Inspection
2. Egress Test
3. Done simultaneously
    - 3.1 Accumulator Inspection
    - 3.2 Mechanical Inspection
4. Electrical Inspection (TS OFF)
5. High Voltage Inspection (TS ON)
6. Tilt Test
7. Rain Test
8. Brake Test

### INFORMATION

**USED SYMBOLS**
- ● Information
- ▲ Action
- △ Check is the responsibility of the team
- ○ Check

**NOTES**
- This sheet must always stay with the push bar. (Can be temporarily split for Accumulator inspection)
- Technical inspection approval voids if the inspection sheet is lost.
- If there is a conflict between this sheet and the rules, the rules prevail.

# PART I: PRE-INSPECTION

### APPROVAL

| Inspector Names | Date and Time | Signatures when passed |
|---|---|---|
| | | |
| | | |

### ○ TIRES

1 ○ **DRY TIRES** - Make

2 ○ **DRY TIRES** - Size

3 ○ **DRY TIRES** - Compound

4 ○ **WET TIRES** - Make

5 ○ **WET TIRES** - Size

6 ○ **WET TIRES** - Compound

7 ○ **WET TIRES** - 2.4 mm min. tread depth molded by tire manufacturer

### ○ DRIVER GEAR AND SAFETY

● Fire-resistant clothing must not be older than 10 years, recognizable since no FIA hologram label present.

8 ○ **FACE SHIELDS** - Made of impact resistant material.

9 ○ **UNDERWEAR** - Must be made from acceptable fire-resistant material as listed in T 13.3.13 and must cover the driver's body completely from neck down to ankles and wrists.

10 ○ **SOCKS** - Nomex or equivalent, fire-resistant socks (no cotton, no polyester, no bare skin).

11 ○ **GLOVES** - Fire resistant material. No holes. Leather is allowed only over fire-resistant material.

12 ○ **ARM RESTRAINTS** - SFI Standard 3.3 or equivalent.

13 ○ **HELMETS** - Snell K2015, K2020, M2015, M2020, SA2020, EA2016 or newer, SFI 31.1/2015, 31.1/2020, 41.1/2015, 41.1/2020 or newer, FIA 8860-2010, FIA 8860-2018, FIA 8859-2015 or newer. Closed Face, no Open Face, must have integrated shield (no dirt bike helmets). No camera mounts.

14 ○ **FRONTAL HEAD RESTRAINT** - If FHR/HANS is used, it must be certified to one of the following standards and be labelled as such - FIA 8858-2010, FIA 8860-2004, SFI 38.1.

15 ○ **DRIVER SUITS** - SFI 3.2A/5 (or higher), SFI 3.4/5 (or higher), FIA Standard 8856-2000 or FIA Standard 8856-2018.

16 ○ **HAIR COVER** - Fire resistant (Nomex or equiv.) balaclava of full helmet skirt REQUIRED FOR ALL DRIVERS.

17 ○ **SHOES** - SFI 3.3 or FIA 8856-2000/2018.

**NON-COMPLIANCE/COMMENTS**

# PART II: EGRESS TEST

## APPROVAL

| Inspector Names | Date and Time | Signatures when passed |
|---|---|---|
| | | |
| | | |

## ○ DRIVER POSITION

18 ○ **ARM RESTRAINTS** - Must be installed, so the driver can release them and exit unassisted regardless of the vehicle's position.

19 ○ **HEAD RESTRAINT** - Near vertical. Max. 25 mm from helmet. Helmet contact point 50 mm min. from any edge.

20 ○ **MAIN HOOP AND FRONT HOOP HEIGHTS** - Helmet of driver to be 50 mm below the line between the top of the front and main roll hoop AND between the top of the main hoop to rear attachment point of main hoop bracing.

21 ○ **LAP BELT MOUNTING** - Must pass over pelvic area between 45° and 65° to horizontal for upright driver, 60° to 80° for reclined. The lap belts must not be routed over the sides of the seat.

22 ○ **SHOULDER HARNESS MOUNTING** - Angle from shoulder between 10° up and 20° down to horizontal.

## ○ DRIVER EGRESS TEST

● All drivers must be able to exit the vehicle in less than 5 s.

● Driver must be seated in ready-to-race condition.

## ○ EGRESS PROCEDURE

▲ Both hands on the steering wheel - in all possible steering positions.

▲ Pressing cockpit-mounted shutdown button.

▲ The egress time will stop when the driver has both feet on the ground.

## DRIVER APPROVAL AND RUN DOCUMENTATION

| Driver Name | Driver ID | Approved by | Acc | SkidPad | AutoX | Endurance |
|---|---|---|---|---|---|---|
| | | | ○○ | ○○ | ○○ | ○○ |
| | | | ○○ | ○○ | ○○ | ○○ |
| | | | ○○ | ○○ | ○○ | ○○ |
| | | | ○○ | ○○ | ○○ | ○○ |
| | | | ○○ | ○○ | ○○ | ○○ |
| | | | ○○ | ○○ | ○○ | ○○ |

## NON-COMPLIANCE/COMMENTS

# PART III: ACCUMULATOR INSPECTION

## APPROVAL

| Inspector Names | Date and Time | Signatures when passed |
|---|---|---|
| | | |
| | | |

## INSPECTION RULES

- The time limit for each attempt at this technical inspection is 120 min. Continuation of the inspection is possible after requeuing.
- During technical inspection all work carried out on the vehicle must be approved by a technical inspector.
- The time limit for repair works is 15 min cumulative per one inspection attempt.

## ○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Present ▲ Atach/place the timer ▲ Start the timer

## ○ REQUIRED RESOURCES

23 ○ An ESO must attend.
- All accumulator containers to be used during the event.
- Accumulator Container Hand Cart.
- Charger.
- Tools needed for (dis)assembly of the Accumulator Container.
- PDF or printout of rule questions, if necessary.
- Pictures of accumulator internals, if necessary.
- Datasheets for used wiring, insulation materials, and TS components. Printed or properly sorted on one laptop, not on a cell phone.
- Samples of all wire types used inside the accumulator container.
- Samples of all used accumulator container material.
- Fully assembled spare boards of all inaccessible TS boards inside the accumulator.
- Laptop and cables to display data of the AMS.

## ○ SAFETY BRIEFING

- All accumulator containers to be used during the event.
- No jewelry, no rings.
- No cell phone.
- No badge / no necklace.
- No other sources of distraction.
- Wear safety glasses.
- Wear safety gloves.

## ○ BASIC SET OF HV-PROOF TOOLS

24 ○ Insulated cable shears.
25 ○ Insulated screwdriver.
26 ○ Insulated spanners (n/a if no screwed connections in TS).
27 ○ Multimeter with protected probe tips.
28 ○ Two 4 mm banana plug test leads (1000 V CAT III).

## ○ SAFETY EQUIPMENT

29 ○ Face shield.
30 ○ Safety glasses (minimum three).
31 ○ HV insulating gloves (minimum two pairs).
32 ○ HV insulating blankets (two) (min 1 $m^2$) with label or serial number and datasheet.

## ○ SELF DEVELOPED PCBS

▲ Ask for fully assembled PCB spares of self-developed PCBs inside the TSAC and the charger.
33 ○ Sufficient TS to LVS spacing and resistance regarding system voltage and implementation.
34 ○ The 1 min AC RMS isolation voltage (TS to LVS) is $\geq 1800\,V_{DC}$ [1].
35 ○ The working voltage of the isolation barrier (TS to LVS), if specified in the datasheet, is higher than the $U_{TSmax}$.
36 ○ Sufficient insulation and temperature rating of coating if used, datasheet available.
37 ○ Coating process according to datasheet.

## ○ CHARGER ASSEMBLY

38 ○ Completely closed. Check openings in HV/TS enclosures, try to reach HV/TS potentials with an insulated test probe (100 mm length, 6 mm diameter).
39 ○ Interlock integrated.
40 ○ TSMP integrated.
41 ○ Emergency shutdown button integrated.
42 △ Emergency shutdown button $\geq 24$ mm diameter.
43 ○ TS wiring is orange, ask team to prove temperature rating 85 °C and voltage rating.
44 ○ Conductive parts of charging equipment and accumulator are connected to protective earth (PE) while charging.

## ○ DISCHARGE CIRCUIT AND BODY PROTECTION RESISTORS

▲ Switch off Charger. Measure resistance between TS+ and TS measuring points.
45 ○ Resistance is $30\,k\Omega$[2]$+R_{discharge}$. If not measurable, ask for an explanation and alternative measurement procedure.
46 ○ Body protection resistor power rating is sufficient.[3]
47 ○ Discharge power rating is sufficient for continuous discharge.

## ○ INSULATION MEASUREMENT TEST

▲ Check low resistance connection between LVS ground MP and PE/casing.
▲ Choose test voltage according to IN 4.1.1.[4]
▲ Connect insulation tester to charger TS+ and LVS GND measuring point.
▲ Connect charger (do not activate charger) to accumulator, keep AIRs opened.
▲ Measure resistance: $R_{iso+} =$ kΩ
48 ○ Resistance is much higher than $315\,k\Omega$[5].
▲ Connect insulation tester to charger TS- and LVS ground.
▲ Measure resistance: $R_{iso-} =$ kΩ
49 ○ Resistance is much higher than $315\,k\Omega$[5].
50 ○ Resistances are nearly equal.

## ○ ASSEMBLY

▲ Open container housing, remove maintenance plugs.
▲ Check if no voltage is present.
51 ○ All components and parts of the accumulator container are properly fixed.
52 ○ TS potentials are insulated against the inner wall of the accumulator container if the container is made from conductive materials.
53 ○ All used fasteners must be secured by the use of positive locking except they are non-conductive and non-structural.
54 ○ Tabs of pouch cells do not carry mechanical loads. Pouch cells carry mechanical loads only on large surface areas.

[1] $3 \times U_{TSmax}$
[2] 2 x Body Protection Resistor (BPR). It is one of following:

$U_{TSmax} \leq 200\,V_{dc} : BPR = 5\,k\Omega$
$200\,V_{dc} \leq U_{TSmax} \leq 400\,V_{dc} : BPR = 10\,k\Omega$
$400\,V_{dc} \leq U_{TSmax} \leq 600\,V_{dc} : BPR = 15\,k\Omega$

[3] Sufficient to short circuit TS+ and TS-
[4]
$U_{TSmax} \leq 250\,V_{DC} : U_{Test} = 250\,V_{DC}$
$U_{TSmax} > 250\,V_{DC} : U_{Test} = 500\,V_{DC}$
[5] Minimal Resistance $= 500\,\Omega/V \times U_{TSmax} + R_{BPR}$

55 ○ No soldering in the high current path.
56 ○ Every container contains at least one appropriately sized and rated fuse.
▲ Check the datasheet of fuse, main wire and cells and compare them to ESF.
57 ○ Every container contains at least two appropriately sized and rated isolation relays (current and voltage).
58 ○ Isolation relays and fuses are separated from cells by a barrier according to UL94-V0 or equivalent.
▲ Check the datasheet of the pre-charge relay and compare it to ESF.
59 ○ Pre-charge relay is of mechanical type with appropriate voltage rating.
60 ○ Maintenance plugs are located at both poles of each stack (including the first and last stack). Removable from both poles.
61 ○ Maintenance plugs are removable without tools.
62 ○ Maintenance plugs have a positive locking mechanism.
63 ○ Maintenance plugs must not be able to unintentionally create circuits or short circuits.
64 ○ Stacks separated by Maintenance plugs $\leq$ 120 $V_{DC}$.
65 ○ Stacks separated by Maintenance plugs 6 MJ.
66 ○ Stacks are insulated and separated by a fire-resistant barrier according to UL94-V0 for min. used thickness or equivalent.
67 ○ Holes in the container only for the wiring harness, ventilation, cooling or fasteners, mechanical properties are not influenced.
68 ○ External openings for cooling or mounted connected cooling ducts are not pointing towards the driver, or if the accumulator is out of the car, towards the operator of the accumulator hand cart.
69 ○ Check openings in TS enclosures, try to reach TS potentials with an insulated test probe (100 mm length, 6 mm diameter).
70 ○ If fully closed, an equalizing valve is implemented.
71 ○ Spare accumulators of the same size, weight, and type.

## ○ WIRING

72 ○ All TS wires have proper overcurrent protection.
73 ○ No other wires than TS wires are orange.
74 ○ Securely anchored to withstand at least 200 N, if outside of enclosure.
75 ○ Located out of the way of possible snagging or damage.
76 ○ TS and LVS wires separated (n/a for Interlock).
77 ○ Every wire used in the Accumulator container (TS and LVS) is rated for $U_{TSmax}$.
78 ○ Ask team to prove that TS wires fulfill temperature rating $>$ 85 °C and voltage rating.
79 ○ Positive locking mechanism or automotive certified components if no positive locking is possible.
80 ○ Connectors outside TS enclosures are physically impossible to electrically connect in other than the design intended configuration.
▲ Check if insulated tools needed for the assembly of certified components are available.
81 ○ Insulation is not only insulating tape or rubber-like paint.

## ○ INDICATOR LIGHT OR VOLTMETER

82 ○ Indicator light or voltmeter installed.
83 ○ Marked with "Voltage Indicator".
84 ○ Visible while opening the battery connector.
85 ○ Hard-wired electronics, supplied by TS.
▲ Connect power supply with 60 $V_{DC}$[6] to accumulator TS connector.
86 ○ Indicator light on or voltmeter showing present TS voltage.
87 ○ Red (in case of indicator light) and visible in bright sunlight.

## ○ ACCUMULATOR MANAGEMENT SYSTEM

88 ○ A minimum of 30 % of cells equally distributed within TSAC(s) are monitored with temperature sensors.
89 ○ Every temperature sensor is placed on the negative terminal of the monitored cell or in $\leq$ 10 mm distance on the busbar.
90 ○ If multiple TSACs are used, each one has its own, full AMS and includes exclusive SDC.
▲ Connect charger to battery/batteries, start charging process.
▲ Do the following procedure for all TSACs, if applicable.
▲ Disconnect AMS current sensor connector.
91 ○ AMS must open the shutdown circuit within 0.5 s.
▲ Disconnect one SINGLE voltage sense wire, if any wires are used.
92 ○ AMS must open the shutdown circuit within 0.5 s.

[6] 60 V or half the nominal tractive system voltage, whichever is lower

▲ Ask the team to connect their laptop to the AMS.
93 ○ Cell voltages can be displayed.
94 ○ Cell temperatures can be displayed.
▲ Disconnect AMS internal connector used for cell temperature measurement.
95 ○ Respective failed cell temperature measurement is displayed.
96 ○ Plausible accumulator current can be displayed.

## ○ CHARGER SHUTDOWN CIRCUIT

97 ○ IMD is integrated into the charging system 5 s.
▲ Connect the charger to the battery/batteries, and start the charging process.
98 ○ Voltage indicator shows that HV is present.
▲ Press the shutdown button.
99 ○ AIRs open.
100 ○ Voltage indicator shows voltage $< 60\,\text{V}$.
▲ Start charging, unplug TS accumulator connector.
101 ○ AIRs open.
102 ○ Charger disabled, no voltage at charger connector.

## ○ INSULATION MONITORING DEVICE

103 ○ One IMD ground line is connected to the accumulator container and one ground line is connected to the charger casing by a separate wired connection.
▲ $R_{Test} = 135\,\text{k}\Omega$[7]
▲ Activate charger output, connect $R_{Test}$ between TS+ and LVS GND.
104 ○ Shutdown circuits opens within 30 s.
105 ○ TS voltage decreases below $60\,\text{V}_{\text{DC}}$ within 5 s after shutdown circuit opens.
106 ○ Reactivation of charger output is not possible.
▲ Push the reset button, if any.
107 ○ Reactivation of charger output is not possible.
▲ Remove $R_{Test}$. Wait 40 s until IMD resets status output.
108 ○ Reactivation of charger output is not possible.
▲ Ask the team to perform power cycle to unlatch all faults.
▲ Activate TS, connect $R_{Test}$ between TS- and LVS GND.
109 ○ Shutdown circuits opens within 30 s.

## ○ ACCUMULATOR CONTAINER

▲ Invite mechanical scrutineer for assistance with point 110.
▲ Team must show approved SES for the accumulator container.
▲ Team must show SES test samples for the accumulator container if alternative materials are used.
110 ○ Accumulator container manufactured according to SES.
111 ○ Internal vertical walls have to be rigidly fastened to the container. Minimum 75 % of the height of the external walls. Divide the accumulator into sections of max. 12 kg.
112 ○ Barriers do not divide any accumulator segment.
113 ○ Cells securely fastened towards all 3 directions.
114 ○ Vehicle number, university name and ESO phone number(s) written on a high contrast background.
115 △ Roman Sans-Serif characters of at least 20 mm high are used.
116 ○ Warning stickers with a side length of $\geq 100\,\text{mm}$ and text "Always Energized" and "High Voltage" (if TS$> 60\,\text{V}$) installed. (Triangle with black lightning bolt on yellow background).
117 ○ Check if all parts and the cover/lid of the housing are rigidly fastened.

## ○ HAND CART

118 ○ Hand cart present with four wheels. Max. dimensions $1200 \times 800\,\text{mm}$.
119 ○ Hand cart has an always-on type brake system.
120 ○ Hand cart provides a firewall with the same width as the hand cart to protect the person while moving it, starting at the lowest point of the hand cart (excluding wheels) and is $> 30\,\text{cm}$ higher than the handle and the TSAC.
121 ○ The firewall must be made from a rigid, fire retardant material (UL94-V0 or equivalent) and be transparent from 1.3 m above the ground.
122 ○ The accumulator must be mechanically fixed to the hand cart while on the hand cart.
123 ○ The accumulator must be protected from vibrations and shocks.
124 ○ The accumulator must not protrude the hand cart.
125 ○ The hand cart itself must have a label according to EV5.3.8 on its firewall below the hand cart handle (The vehicle number, the university name, and the ESO phone number(s) must be displayed

[7] $R_{Test} = (U_{TSmax} \times 250\,\Omega/\text{V}) - R_{BPR}$

and written in Roman Sans-Serif characters of at least 20 mm high, clearly visible and placed on a high-contrast background).

## ○ SEALING OF COMPONENTS

▲ After all tests have been passed successfully seal the inspected TS housings:

126 ○ Accumulator container(s) including spares.

127 ○ Charger.

128 ○ Additional Part:

129 ○ Additional Part:

## ○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Passed or Failed

▲ Stop the timer

▲ Collect the timer

## NON-COMPLIANCE/COMMENTS

# PART IV: ELECTRICAL INSPECTION (TS OFF)

## APPROVAL

| Inspector Names | Date and Time | Signatures when passed |
|---|---|---|
| | | |
| | | |

## INSPECTION RULES

- The time limit for each attempt at this technical inspection is 120 min. Continuation of the inspection is possible after requeuing.
- During technical inspection all work carried out on the vehicle must be approved by a technical inspector.
- The time limit for repair works is 15 min cumulative per one inspection attempt.

## ○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Present ▲ Atach/place the timer ▲ Start the timer

## ○ REQUIRED RESOURCES

130 ○ An ESO must attend.
- TSAC mounted into the vehicle.
- LV battery or cell datasheet.
- For self-developed LV battery packs: an opened LV battery pack, laptop, and cables to display data of the LV battery AMS.
- Datasheets for used wiring, insulation materials, and TS components. Printed or properly sorted on one laptop, not on a cell phone.
- At least all non-passed parts of the ESF. Printed or properly sorted on one laptop, not on a cell phone.
- Samples of all wire types used for the tractive system.
- Photographs of all inaccessible TS connections.
- "TSAL green" sign.

## ○ LV BATTERY

131 ○ Voltage $\leq 60\,V_{DC}$.
132 ○ Rigid and sturdy casing.
133 ○ Only for wet-cell batteries: IPX7 rated and acid resistant casing if inside the cockpit.
134 ○ Behind Firewall.
135 ○ Short circuit protection (e.g., fused).
136 ○ Proper insulation of internal electrical connections.
137 ○ Proper mounting of cells.
138 ○ Complete battery pack inside rollover protection envelope.
139 ○ Has overpressure relief, gas vent behind a firewall (only applies to fully enclosed battery case).
▲ Following checks only for Li-Ion batteries other than LiFePO4:
140 ○ UL94-V0 for min. used thickness or equivalent casing.
141 ○ Overcurrent protection that trips below max. discharge current.
142 ○ Overtemperature protection of at least 30 % of the cells (max. 60 °C or datasheet, whichever is lower).
143 ○ Voltage protection of all cells.
144 ○ Signal failures electrically disconnect the LV battery (SCS) (check the schematics of LV battery AMS).
▲ Ask the team to connect their laptop to the AMS.
145 ○ Cell voltages can be displayed.
146 ○ Cell temperatures can be displayed.

## ○ SELF DEVELOPED PCBS

▲ Ask for fully assembled PCB spares of self-developed boards where both TS and LVS parts are present (outside the TSAC) - i.e. discharge, TSMP, motor controller...
147 ○ Sufficient TS to LVS spacing and resistance regarding system voltage and implementation.
148 ○ The 1 min AC RMS isolation voltage (TS to LVS) is $\geq 1800\,V_{DC}$ [8].

[8] $3 \times U_{TSmax}$

149 ○ The working voltage of the isolation barrier (TS to LVS), if specified in the datasheet, is higher than the $U_{TSmax}$.
150 ○ Sufficient insulation and temperature rating of coating if used, datasheet available.
151 ○ Coating process done properly and according to the datasheet.

▲ Ask for fully assembled PCB spare(s) and schematic of BSPD board(s).
152 ○ BSPD PCB(s) is standalone with only minimum interface.
153 △ BSPD PCB(s) are directly supplied from the LVMS.

## ○ MASTER SWITCHES

154 ○ TSMS and LVMS installed easily accessible on the right side of the vehicle and located next to each other.
155 △ All master switches are located above 80 % of shoulder height of Percy.
156 ○ Rigidly mounted and no need to be removed during maintenance.
157 ○ Rotary type with removable handle.
158 △ Handle length $\geq$ 50 mm.
159 ○ "ON" position in horizontal.
160 ○ "ON" and "OFF" positions marked.
161 ○ TSMS with a locking mechanism for "OFF" position.
162 ○ LVMS marked with "LV" and a symbol showing a red spark in a white-edged blue triangle.
163 ○ LVMS mounted on a red circular area on a high contrast background.
164 △ Circular area diameter $\geq$ 50 mm.
165 ○ TSMS marked with "TS" and triangle with a black lightning bolt on a yellow background.
166 ○ TSMS mounted on an orange circular area on a high contrast background.
167 △ Circular area diameter $\geq$ 50 mm.

## ○ MEASURING POINTS

168 ○ Two TS measuring points on exclusive orange background.
169 ○ A black LV ground measuring point installed.
170 ○ Next to the master switches.
171 ○ 4 mm shrouded banana jacks.
172 ○ Non-conductive cover.
173 ○ Cover removable without tools.
174 ○ Correctly marked ("TS+", "TS-", "GND").

## ○ TS SHUTDOWN DEVICES

175 ○ Two shutdown buttons installed next to the main hoop, right and left on the vehicle at approx. height of the driver's head. Push Pull or Push-Rotate-Pull functionality.
176 ○ Marked with red sparked sticker.
177 △ Diameter > 39 mm.
178 ○ One cockpit shutdown button installed. Push-Pull or Push Rotate-Pull functionality.
179 ○ Marked with red sparked sticker.
180 ○ Easy actuation by the driver.
181 △ Diameter $\geq$ 24 mm.
182 ○ Inertia switch rigidly mounted to the chassis with correct orientation (according to datasheet) and can be unmounted for functionality test.

● Check interlocks on ...
183 ○ TS accumulator container(s).
184 ○ Inverters.
185 ○ HVD.
186 ○ Power distribution boxes.
187 ○ Data Logger box.

● If outboard wheel motors are used:
188 ○ Outboard wheel motors - interlocks must act before a TS wiring failure.
189 ○ Suspension member - interlock must act in case of suspension failure.

## ○ TS VOLTAGE

▲ Measure voltage at TS measuring points.
190 ○ Equal or less than 60 $V_{DC}$.

## ○ DISCHARGE CIRCUIT AND BODY PROTECTION RESISTORS

▲ Switch off LVMS. Measure resistance between TS+ and TS- measuring points.

191 ○ Resistance is 30 kΩ[9]+$R_{discharge}$. If not measurable, ask for an explanation and alternative measurement procedure.

192 ○ Body protection resistor power rating is sufficient.[10]

193 ○ Discharge power rating is sufficient for continuous discharge.

## ○ TS WIRING

194 ○ All TS wiring and components have to be in the envelope and behind the impact structures.

195 ○ TS wires of outboard wheel motors must not be able to reach the cockpit opening in case of a wire break. Any wiring outside the impact structure is the shortest possible distance.

196 ○ All TS wires and connectors have proper overcurrent protection.

197 ○ TS wiring channels are orange.

198 ○ No other wires than TS wires are orange.

199 ○ TS wiring outside electrical enclosures in a separate non-conductive enclosure or orange shielded cable.

200 ○ Securely anchored to withstand at least 200 N, if outside of enclosure.

201 ○ Located out of the way of possible snagging or damage.

202 ○ Shielded against rotating/moving parts.

203 ○ No wire lower than the chassis.

204 ○ TS and LVS wires separated (n/a for Interlock).

205 ○ Ask team to prove that TS wires fulfill temperature rating $> 85\,°C$ and voltage rating.

206 ○ Suitable temperature rating for the used position.

207 ○ Positive locking mechanism on every screwed connection, photographs for all inaccessible TS connections.

208 ○ Positive locking mechanism on every TSMP connection, photographs for all inaccessible connections.

209 ○ Insulation is not only insulating tape or rubber-like paint.

## ○ HV WARNING STICKERS

▲ Check for warning stickers on TS containing enclosures - triangle with a black lightning bolt on yellow background.

210 ○ Inverter(s).

211 ○ Motor(s).

212 ○ Power Distribution box(es).

213 ○ Energy meter box.

214 ○ Other TS containing enclosures.

## ○ TRACTIVE SYSTEM PROTECTIONS

▲ Check opening in TS enclosures, try to reach TS potentials with insulated test probe (100 mm length, 6 mm diameter).

215 ○ Not possible to reach any TS potentials.

216 ○ TS components and containers protected from moisture.

## ○ HIGH VOLTAGE DISCONNECT

217 ○ Clearly marked with "HVD".

218 △ Distance to ground greater than 350 mm.

219 ○ Inside roll-over protected envelope.

220 ○ No remote actuation (e.g., through wires).

221 ○ Integrated interlock.

▲ Ask ESO to remove HVD and document the process (video).

222 ○ Removed within 10 s without tools.

223 ○ TS protection still given (insulated test probe). If a dummy connector is used, it must be stored at the push bar.

[9] 2 x Body Protection Resistor (BPR). It is one of following:

$$U_{TSmax} \leq 200\,V_{dc} : BPR = 5\,k\Omega$$
$$200\,V_{dc} \leq U_{TSmax} \leq 400\,V_{dc} : BPR = 10\,k\Omega$$
$$400\,V_{dc} \leq U_{TSmax} \leq 600\,V_{dc} : BPR = 15\,k\Omega$$

[10] Sufficient to short circuit TS+ and TS-

## ○ TRACTIVE SYSTEM ACTIVE LIGHT

224 ○ Mounted below the highest point of the main roll hoop (no lower than 75 mm) and within the roll-over protected envelope (including mounting).

● Cockpit indicator light...
225 ○ ... is inside the cockpit and marked with "TS off",
226 ○ ... is visible for the driver.

## ○ DATA LOGGER

227 ○ Data logger is fully enclosed in a housing.
228 ○ Data logger is properly mounted.
229 ○ All TS current flowing from/to accumulator flows through the data logger.

## ○ ACCUMULATOR MANAGEMENT SYSTEM

▲ Disconnect AMS signal(s) from the TS accumulator.
● AMS indicator light...
230 ○ ... is inside the cockpit and marked with "AMS",
231 ○ ... is illuminated red and visible in bright sunlight, even from outside,
232 ○ ... is visible for the driver.

## ○ FIREWALLS

● Separates any point of the driver (less than 100 mm above the bottom of the helmet of the tallest driver) from any TS component (including TS wiring)...
233 ○ ... behind the driver's back,
234 ○ ... at the sides of the driver,
235 ○ ... at the front of the vehicle.
236 ○ First layer, facing TS must be made of Aluminum with a thickness of at least 0.5 mm.
237 ○ Second layer, facing driver must be made of electrically insulated material (no CFRP).
238 ○ Material meets UL94-V0 for min. used thickness or equivalent.

## ○ ACCELERATOR PEDAL POSITION SENSOR (APPS)

239 ○ Returns to the original position if not actuated.
240 ○ At least two sensors with different transfer functions, each having a positive slope sense with either different gradients and/or offsets to the other(s) are installed. For digital sensors, a checksum is necessary.
241 ○ Sensors do not share supply or signal lines.
242 ○ Sensors are protected from being mechanically overstressed (positive stop of the pedal).
243 ○ Minimum two springs installed to return pedal.
244 ○ Each spring still returns the pedal with the second one disconnected (springs in the torque encoders not counted).

## ○ BRAKE LIGHT

245 ○ Only one brake light.
246 ○ Located on vehicle centerline, height between wheel center line and driver's shoulder.
247 ○ Round, triangle, or rectangular on black background.
248 △ 15 $cm^2$ minimum illuminated area, or LED strips with a total length greater than 150 mm with elements <20 mm apart.

## ○ INSULATION MEASUREMENT TEST

▲ Choose test voltage according to IN 4.1.1.[11]
▲ Connect insulation tester to TS+ and LVS GND measuring point.
▲ Measure resistance: $R_{iso+}$ = kΩ
249 ○ Resistance is much higher than 315 kΩ[12].
▲ Connect insulation tester to TS- and LVS ground.
▲ Measure resistance: $R_{iso-}$ = kΩ
250 ○ Resistance is much higher than 315 kΩ[12].
251 ○ Resistances are nearly equal.

[11] $U_{TSmax} \leq 250\,V_{DC}$ : $U_{Test} = 250\,V_{DC}$
$U_{TSmax} > 250\,V_{DC}$ : $U_{Test} = 500\,V_{DC}$
[12] Minimal Resistance = $500\,\Omega/V \times U_{TSmax} + R_{BPR}$

## GROUNDING CHECKS

- EV 3.1 has been fully revised. Each TS enclosure must either contain a $\geq$ 0.5 mm properly grounded conductive layer or all materials must be electrically isolating for each own. Conductive seat, driver harness, and firewall mountings, as well as TS firewalls and conductive parts protruding through TS enclosures, must be properly grounded. A conductive part having $\leq$ 300 mΩ measured at 1 A and being able to continuously carry $\geq$ 10 % of the TS main fuse to LVS ground is properly grounded. Other conductive parts within 100 mm of any TS component must be $\leq$ 100 Ω to LVS ground.
- It is possible to join two TS enclosures one following EV 3.1.1 point 1 and the other one following EV 3.1.1 point 2 if each individual TS enclosure is fully closed.

▲ Check for each TS enclosure...

252 ○ ... all materials used to build a TS enclosure separately have a resistance $\geq$ 2 MΩ @ 500 V $\rightarrow$ fully isolated TS enclose, no grounded layer needed.

253 ○ ... except e.g. screws, (shielded) connectors, backing plates isolating materials used $\rightarrow$ fully isolated TS enclose, no grounded layer needed but protruding elements must be properly grounded.

254 ○ ... at least one material has $<$ 2 MΩ $\rightarrow$ $\geq$ 0.5 mm thick solid grounded layer made of aluminium or better required and properly grounded.

255 ○ ... $\geq$ 0.9 mm thick steel layer might be used for TSAC as the grounded layer.

- Each $\leq$ 300 mΩ grounding is able to carry $\geq$ 10 % of TS main fuse - measure if needed/in doubts.
- N/A: Not applicable - not conductive or not closer to TS components than 100 mm.

▲ Measure resistance between LVS GND measuring point and...

| Part | N/A | $<$ 300 mΩ@1 A | $<$ 100 Ω |
|---|---|---|---|
| Main Roll Hoop | | ☐ | |
| Driver harness mounting points | | ☐ | |
| Seat and seat mounting points (N/A if not conductive) | ☐ | ☐ | |
| Firewall(s) mounting points and aluminium layer | | ☐ | |
| Accumulator container and/or protruding parts (fasteners, connectors) | ☐ | ☐ | |
| TS enclosures and/or protruding parts (fasteners, connectors) | ☐ | ☐ | |
| TS connectors (shells) (N/A if not conductive) | ☐ | ☐ | |
| TS motor(s) startionary part (N/A if fully enclosed/unreachable) | ☐ | ☐ | |
| Suspension Front left (N/A e.g. if RWD) | ☐ | | ☐ |
| Suspension Front right (N/A e.g. if RWD) | ☐ | | ☐ |
| Suspension Rear left (N/A e.g. if FWD) | ☐ | | ☐ |
| Suspension Rear right (N/A e.g. if FWD) | ☐ | | ☐ |
| | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ |

## ○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Passed or Failed

▲ Stop the timer

▲ Collect the timer

## NON-COMPLIANCE/COMMENTS

# PART V: MECHANICAL INSPECTION

## APPROVAL

| Inspector Names | Date and Time | Signatures when passed |
|---|---|---|
| | | |
| | | |

## INSPECTION RULES

- The time limit for each attempt at this technical inspection is 75 min. Continuation of the inspection is possible after requeuing.
- During technical inspection all work carried out on the vehicle must be approved by a technical inspector.
- Only tools needed for the (dis)assembly of parts for mechanical inspection.

## ○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Present ▲ Atach/place the timer ▲ Start the timer

## ○ VEHICLE WITH TALLEST DRIVER READY TO RACE

256 ○ **FIRE EXTINGUISHERS** - Two 2 hand-held, 0.9 kg (2 lb) minimum, dry chemical (10BC, 1A10BC, 34B, 5A 34B, 20BE or 1A 10BE), with pressure/charge gauge, Aqueous Film Forming Foam (AFFF) fire extinguishers are prohibited, 1 WITH VEHICLE securely installed on push bar, 1 in paddock. (Must see BOTH at Tech.). On-board fire system possible.

257 ○ **PUSH BAR (red color)** - With vehicle, securely attached to the vehicle, detachable, push and pull function for 2 people. University name on it.

258 △ **CAMERAS** - Must be secured by two points on different sides of the camera body, see T 11.11. No cameras mounted to helmet.

259 ○ **VISIBILITY** - Minimum of 100° field either side. Head rotation allowed or mirrors. If mirrors, must be firmly installed and adjusted.

260 △ **VEHICLE CONTROLS** - All controls, including the shifter, must be inside the cockpit. No arms or elbows outside the SIS plane.

261 ○ **DRIVER FLUID PROTECTION** - A firewall (rigidly mounted cover plate for cooling systems using plain water) must extend sufficiently far upwards and/or rearwards such that any point, less than 100 mm above the bottom of the helmet of the tallest driver, is not in a straight line of sight with any of the following parts: fuel supply system, hydraulic fluid (except brake system and dampers), flammable liquids and low voltage battery.

262 ○ **ROLL BAR PADDING** - Roll bar or bracing that could be hit by the driver's helmet must be covered with 12 mm thick, SFI spec 45.1 or FIA 8857-2001 padding.

263 △ **OTHER SIDE TUBES** - Design prevents driver's neck hitting bracing or other side tubes

264 ○ **HEAD RESTRAINT** - Near vertical. Must take 890 N load. 40 mm thick, SFI 45.2 standard or FIA technical list n°17 type B. Max. 25 mm from helmet. Helmet contact point 50 mm min. from any edge. May be changed for different drivers. Minimum 150x150 mm.

265 ○ **DRIVER RESTRAINT HARNESS** - SFI 16.1, SFI 16.5, SFI 16.6, or FIA 8853/2016. 6- or 7-point system – Two-piece lap belt (min. width 50 mm), two shoulder straps (min. width 75 mm) and two leg or anti-submarine straps (min. width 50 mm). (7-point system must have three anti-submarine straps). Must be securely attached to prim. structure (25.4 × 2.4 mm or equal.)

266 ○ **LAP BELT MOUNTING** - Pivoting mounting with eye bolts or shoulder bolts attached securely to Primary Structure. Min. tab thickness 1.6 mm. Attachment brackets to the monocoque must be steel, see T 5.3.2.

267 ○ **SHOULDER HARNESS MOUNTING** - Mounting points 180 mm to 230 mm apart (measured center to center). Angle from shoulder between 10° up and 20° down to horizontal. Attach to Primary Structure - 25.4 × 2.4 mm or 25.0 × 2.5 mm steel tube min. NOT to put bending loads into the Main Hoop Bracing without extra bracing. Additional braces if not straight to the main hoop. Cannot pass through a firewall. Attachment brackets to the monocoque must be steel.

268 ○ **SUSPENSION** - Fully operational with dampers front and rear; 50 mm minimum wheel travel (minimum jounce of 25 mm) with driver in vehicle.

## ○ VEHICLE WITHOUT DRIVER

269 △ **TECH STICKER SPACE** - 45 × 175 mm on the centerline of front of the vehicle in front of the cockpit opening

270 △ **SCHOOL NAME AND OTHER DECALS** - School Name, or recognized initials - min. 50 mm tall (all letters). on both sides in Roman letters. Must be clearly visible.

271 △ **VEHICLE NUMBERS** - On front and both sides of vehicle, minimum 150 mm tall, 20 mm stroke and spacing, 25 mm min. between number and background edge, Black on White, White on Black only, and specified background shapes. Must be clearly visible, font: Roman Sans-Serif characters.

272 △ **BODYWORK/AERODYNAMIC DEVICES EDGES** - Edges that could contact with any standing pedestrian without reaching to the vehicle must have a minimum radius of 3.0 mm for all forward-facing edges and 1.0 mm for all other edges (safety requirement).

273 △ **BODY AND STYLING** - Open wheeled, open cockpit, formula style body. Vertical keep-out zones 75 mm in front and behind tires (no aero exceptions), tires unobstructed from sides.

274 ○ **BODYWORK** - Min. 38 mm radius on nose. No large openings in bodywork into the driver compartment in front of or alongside the driver, (except cockpit opening). Any gaps between bodywork and other parts must be reduced to a minimum. No external concave radii of curvatures in front of the cockpit opening and T 8.2 (in side view).

275 ○ **AERODYNAMIC DEVICES** - Securely mounted. The deflection may not exceed 10 mm when a force of 200 N is applied over a surface of 225 $cm^2$ and not more than 25 mm when a point force of 50 N is applied.

276 △ **AERODYNAMICS** - ALL aerodynamic devices maximum 250 mm rearward of rear tires, maximum 700 mm forward of front tires. Devices lower than 500 mm from the ground rearward of the front axle must be no wider than vertical plane from the outside of the front and rear tires. Devices higher than 500 mm behind the front axle must not be wider than the inside of the rear tires.

277 △ **AERO VERTICAL HEIGHT** - Devices forward of a vertical plane through the rearmost portion of the front face of the driver head restraint support, excluding any padding, set to its most rearward position, must be lower than 500 mm from the ground. Rear device max 1.2 m above ground (incl. end plates); Front device max 250 mm above ground outside of the inside plane of the front tires inside this plane max 500 mm.

278 △ **SEAT** - Insulated against heat conduction, convection and radiation. The lowest point no lower than the top of the upper surface of the lowest SIS member OR must have a longitudinal, 25.4 × 1.65 mm steel tube underneath.

279 ○ **COCKPIT OPENING** - Fig. 12 (left) template passes down from above the cockpit to below the upper side impact member. The steering wheel, seat and padding can be removed. No removing of firewall.

280 ○ **COCKPIT INTERNAL CROSS SECTION** - Fig. 11 (right) template passes from the cockpit opening to 100 mm rear of the rearmost pedal contact area (in most forward position). The steering wheel and paddings can be removed (without tools).

281 △ **STEERING WHEEL** - Continuous perimeter, near round (no concave sections) with driver-operable quick disconnect. 250 mm max from the front hoop.

282 △ **ROTATING PARTS** - Finger guards are requiered to cover any parts (e.g. fans) that spin while the vehicle is stationary. No holes > 12 mm dia.

## ○ REMOVE BODY PANELS

283 ○ **DRIVER'S LEG PROTECTION** - Covers inside of cockpit over any sharp edges or moving suspension / steering components.

284 ○ **DRIVER'S FOOT PROTECTION** - Feet must be rearward of the Front Bulkhead and no part of shoes or legs above or outside the Major Structure (25x1.2 or equivalent) in side or front views when touching the pedals.

285 ○ **PERCY** - Helmet of 95th percentile male (PERCY) to be 50 mm below the lines between the top of the front and main roll hoops and between the top of the main hoop to rear attachment point of main hoop bracing. Center of bottom circle placed minimum 915 mm from pedals.

286 ○ **BRAKES** - Dual hydraulic system and reservoirs, operating on all four wheels, (one brake on limited slip differential is OK). System must be protected by structure or shields from drivetrain failure or minor collisions. No plastic brake lines. No brake-by-wire. Any part of the brake system must be within the surface envelope. Brake pedal capable of 2000 N, no failures if official exerts max force (seated normally in the vehicle).

287 △ **BRAKE OVER TRAVEL SWITCH** - In the

event of a failure in one or both brake circuits the brake pedal over travel will result in the shutdown circuit being opened.

288 △ **LOW VOLTAGE MASTER SWITCH** - Must be located on the right side of the vehicle, in proximity to the main hoop, at the 95th percentile male driver's shoulder height, in the middle of a completely red circular area of $\geq 50$ mm diameter. Marked with LV and international symbol. Level horizontal when in ON position.

289 ○ **TUBING AND MATERIALS** - Team must show an APPROVED SES. No Magnesium tubes in the primary structure.

290 ○ **MONOCOQUE** - Must see laminate test specimen. All samples must be marked with the following non-removable (e.g.: permanent marker or engraving, but no sticker) information: laminated structure acronym and date of testing. Steel backing plates ($\geq$ 2 mm thick) used at attachment points (must be fully supported).

291 ○ **BOLTED JOINTS** - In primary structure - distance hole centerline to the nearest free edge > 1.5 x hole diameter.

292 ○ **MAIN HOOP** - MUST BE STEEL. Check dimensions as shown in the approved SES. Must be made of one piece and extend to the lowest frame member. Above Major Structure, must be within 10° of vertical plane. Smooth bends without wrinkles.

293 ○ **MAIN HOOP BRACING** - MUST BE STEEL. One straight brace on each side. Dimension as shown in the approved SES. Attached within 160 mm from the top. Min. 30° Included angle with hoop. If the main hoop is not vertical, bracing must not be on the same side of the vertical plane as the main hoop. No bends. No rod-ends. Proper design for removable braces (capping etc.) on BOTH ENDS. Must take the load back to the bottom of the main hoop and node of the upper side impact tube through proper triangulated structure. ($25.4 \times 1.2$ mm or equivalent)

294 ○ **FRONT HOOP** - Must be closed section metal tube. Can be multi-piece with gussets or additional attachments to the monocoque. Must extend down to lowest frame member. No lower than the top of the steering wheel. Max. 20° to vertical. Check dimensions as shown in the approved SES. Requires 6 attachment points – 2 on each side connecting to front bulkhead support structures and two connecting to front hoop bracing.

295 ○ **FRONT HOOP BRACING** - Two straight forward-facing braces, 25.4 mm1.65 or $25.0 \times 1.75$ mm or $25.4 \times 1.6$ mm wall steel or equivalent, attached within 50 mm of top and must have a minimum distance of 100 mm between each other at the front hoop. Extra rearward bracing is required if the Front Hoop leans backwards more than 10°.

296 ○ **SIDE IMPACT PROTECTION** - Min. of 2 tubes + diagonal must connect the main and front hoops in a straight line. The upper tube between 240 - 320 mm above the lowest inside chassis point between FH and MH. Dimension as shown in approved SES.

297 ○ **FRONT IMPACT PROTECTION** - No non-crushable objects forward of bulkhead. IMPACT ATTENUATOR forward of the bulkhead, 200 mm long x 200 mm wide x 100 mm high. No portion of the required $100 \times 200 \times 200$ mm volume of the IA can be positioned more than 350 mm above the ground. No wing supports through the IA. IA must be securely fastened directly to AIP capable of taking transverse and vertical loads (no tape, etc.) Test piece presented and same as IA on vehicle. Standard IA: Requires diagonal brace if bulkhead >25.4 mm from IA on any side, adhesive used to mount standard IA to AIP must have a shear strength of at least 24 MPa.

298 ○ **ANTI INTRUSION PLATE** - A 1.5 mm solid steel or 4.0 mm solid aluminum sheet. Must be welded (size: min. to centerlines) or min. 8 screws M8 Grade 8.8 critical fasteners T10 (size: min. outside dimensions). CFRP plate is accepted if SES is approved. Attachment(s) using adhesive must be able to carry a load of 60kN in any direction.

299 ○ **FRONT BULKHEAD SUPPORT** - Support back to front roll hoop; 3 tubes per side, all $25 \times 1.5$ mm wall steel tube or equiv. 1 bottom; 1 top within 50 mm of top of bulk-head and connecting within 100 mm above and 50 mm below upper SIS tube; 1 or more node-to-node diagonal to completely triangulate connections to upper and lower SIS tubes.

300 ○ **INSPECTION HOLES** - 4.5 mm inspection holes required in non-critical areas of front and main hoops. Inspectors may ask for holes in other tube(s).

301 ○ **JACKS** - One or two devices that must be available to safely lift and hold all driven wheels min. 100 mm above the ground. In lifted position the jack (s) must be locked/secured and function without the support of a person or additional weights. It must be safe for the driver to enter and exit the vehicle. The device must not extend out of the vehicle's projected surface area. Device pick-up points must be indicated by orange triangles on both sides. University name on it.

302 ○ **WHEELS** - 203.2 mm (8") min. diam. No Aluminum or hollow wheel bolts. Single retaining nut must incorporate a device to retain the nut. Aluminum wheel nuts must be hard anodized.

303 ○ **FIREWALL** - Fire resistant material; must separate driver compartment from cooling, oil system and LV battery. Passthroughs are OK with grommets. Multiple panels are OK if gaps are sealed. No gaps at the sides or bottom. Must be rigidly mounted to the chassis. Material must meet UL94-V0, FAR 25.853(a)(1)(i) or equivalent(THICKNESS NEEDED IN DATA SHEET).

## ○ VEHICLE LIFTED AND WHEELS REMOVED

304 ○ **SUSPENSION PICK-UP POINTS** - Inspected thoroughly for integrity.

305 ○ **FASTENERS** - Steering, braking, harness and suspension systems must use SAE Grade 5 or Metric Grade M8.8 or higher specs (AN/MS) with visible positive locking mechanisms, no Loctite or lock washers. Minimum of 2 exposed threads with locking nuts. Rod ends in single shear are captured by a washer larger than the ball diameter. Adjustable tie-rod ends must have jam nuts to prevent loosening. No Nylon lock nuts for Brake calipers or Brake discs. No button head cap, pan head or round head screws in critical locations, e.g. cage structure or harness mount. Primary structure e/D $> 1.5$. Alternative fasteners allowed for steering and suspension if equivalency can be shown.

306 ○ **STEERING** - All steerable wheels must have positive stops placed on the rack to prevent linkage lock up or tires from contacting any part of the vehicle. 7° max. free play at the steering wheel. NO STEER-BY-WIRE on front wheels. Rear wheel steering, max. 6° and mechanical stops installed. No bonded joints in the steering column.

307 △ **FLOOR CLOSEOUT PANEL** - Required from foot area to firewall; solid, non-brittle material; multiple panels are OK if gaps less than 3 mm.

308 ○ **GAS CYLINDERS** - Proprietary manufacture and labeled, Nonflammable gas, regulator on tank, securely mounted, axis not pointed at driver, within the rollover protection envelope, or in structural side pod, insulated from the exhaust, appropriate lines and fittings. Positively retained, i.e., no tie-wraps. Gas cylinders/tanks and their pressure regulators must be shielded from the driver. The shields must be steel or aluminum with a minimum thickness of 1 mm.

309 ○ **SCATTERSHIELDS INCL. MOUNTING** - Required for clutches, chains, belts, etc. No holes. 6 mm diam. Grade 8.8 minimum. End parallel to the lowest part of the sprocket/pulley in front and rear.

310 △ **SCATTERSHIELD MATERIALS** - For chains, 2 mm min. thick solid STEEL, 3 x chain width. For belts, 3 mm min. thick Al 6061-T6, 3 x belt width. Finger guards: cover all drivetrain parts that spin while the vehicle is stationary. No holes $> 12$ mm dia.

311 ○ **LV BATTERY** - Rigid and sturdy casing and attached securely to frame or chassis. Battery behind a firewall; wet cells in IPX7 rated and acid resistant casing if inside cockpit. Must be contained within the rollover protection envelope, see T 1.1.16. Grounded to chassis; hot terminal insulated; protected for short circuits (fused). No circuits $> 60\,V_{DC}$. Completely closed LV battery cases must have an overpressure relief. Venting gases must be separated from the driver by a firewall.

312 ○ **STUDENT BUILD LV BATTERY** - Proper Insulation of internal connections; proper mounting of cells.

313 ○ **LI-ION LV BATTERY** - BATTERY (only applicable if other than LiFePO4)- Has a fire-retardant casing according to UL94-V0. Battery pack includes: an overcurrent protection that trips below maximum discharge current; overtemperature protection of 30 percent of the cells; voltage protection of all cells; it must be possible to display all cell voltages and measured temperatures on a team laptop.

314 ○ **HIGH PRESS HYDRAULICS** - Pumps and lines must have 1 mm steel or aluminum shields protecting driver and workers.

315 ○ Including all autonomous system high pressure hydraulics like the ASB.

316 △ **COOLANT** - 100 percent water. NO ADDITIVES WHATSOEVER.

317 ○ **CATCH TANKS** - Any coolant overflow or combustion engine lubrication system vents must have separate catch tanks. 0.9 L or 10 percent of the fluid being contained minimum volume each, whichever is greater. 100 °C material, behind firewall, below shoulder level. 3 mm min. dia. vent away from the driver down to the bottom level of the frame. Trans or diff., cooling systems using plain water, unless sealed, require 100 mL catch tanks.

318 △ **FLUID LEAKS** - Oil, grease, coolant, Brake fluid → none permitted

319 ○ **BELLYPANS** - In a total minimum of two venting holes of at least 25 mm diameter in the lowest part of the structure to prevent accumulation of liquids. One in each enclosed chassis structure. Additional holes are required when multiple local lowest parts exist in the structure.

## ○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Passed or Failed

▲ Stop the timer

▲ Collect the timer

## NON-COMPLIANCE/COMMENTS

# PART VI: HIGH VOLTAGE INSPECTION (TS ON)

## APPROVAL

| Inspector Names | Date and Time | Signatures when passed |
|---|---|---|
| | | |
| | | |

## INSPECTION RULES

- The time limit for each attempt at this technical inspection is 120 min. Continuation of the inspection is possible after requeuing.
- During technical inspection all work carried out on the vehicle must be approved by a technical inspector.
- The time limit for repair works is 15 min cumulative per one inspection attempt.

## ○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Present ▲ Atach/place the timer ▲ Start the timer

## ○ SAFETY BRIEFING

- No badge / no necklace.
- No cell phone nor radio - do your calls outside.
- No other sources of distraction.
- One team member at SDC button when TS ON.
- Wear safety gloves when touching TS components.

## ○ TRACTIVE SYSTEM POWER-UP

▲ Recommend the team to lower the maximum motor speed for the upcoming inspection.
▲ All driven wheels are off the ground, driven wheels are removed.
▲ Connect multimeter between TS+ and TS- measuring points.
▲ Switch on TSMS with LVMS deactivated.
320 ○ Voltage at TS measurement points less or equal 60 $V_{DC}$.
▲ Switch on LVMS with TSMS deactivated.
321 ○ IMD and AMS cockpit indicator lights illuminate for 1 s to 3 s for visible check.
322 ○ IMD and AMS cockpit indicator lights are clearly visible in very bright sunlight.
323 ○ Voltage at TS measurement points less or equal 60 $V_{DC}$.
▲ Switch on TSMS and all shutdown buttons.
▲ Reset any IMD or AMS errors.
324 ○ TS still deactivated.
▲ Activate TS, measure TS voltage during TS power-up.
325 ○ System is pre-charged before the second AIR closes.
▲ Switch off TSMS.
326 ○ TS voltage decreases below 60 $V_{DC}$ within 5 s.
▲ Try to power up TS with switched off TSMS.
327 ○ TS still deactivated.
▲ Switch on TSMS.
328 ○ TS still deactivated.

## ○ TRACTIVE SYSTEM SHUTDOWN

▲ Connect multimeter between TS+ and TS- measuring point.
▲ For each of the following switches, deactivation leads to TS shutdown, voltage decreases below 60 $V_{DC}$ within 5 s.
329 ○ LVMS.
330 ○ Shutdown button left.
331 ○ Shutdown button right.
332 ○ Cockpit shutdown button.
333 ○ Inertia switch.
334 ○ Break-over-travel-switch.
▲ Show schematic of TS with all interlocks (ESF).
335 ○ Interlocks.

## ○ TRACTIVE SYSTEM ACTIVE LIGHT

▲ Activate LVS.

336 ○ TSAL and "TS Off" Cockpit Indicator (CI) is green only, visible in bright sunlight.

▲ Activate TS.

337 ○ TSAL flashes red with a frequency of 2 Hz to 5 Hz, and CI is off.

338 ○ Entire illuminated surface of the TSAL is visible in bright sunlight.

339 ○ TSAL has a fully illuminated surface visible by a person standing 3 m away from TSAL (1.6 m eye height) - use a dedicated tool.

340 ○ Less than 10° is blocked by the main hoop.

▲ Deactivate TS, disconnect TSAC state detection circuitry connector if applicable[13], activate LVS and TS.

341 ○ TSAL flashes red and CI is off.

▲ Deactivate TS, reconnect TSAC state detection, connect power supply $> 60\,V_{DC}$ to TS[14], activate LVS.

342 ○ TSAL is green and simultaneously is flashing red, CI is on.

▲ Disconnect power supply, remove HVD, override HVD interlock (!! cover TS potentials !!), activate LVS and TS.

343 ○ TSAL and CI is completely off (no red nor green light).

▲ Deactivate TS, reconnect HVD, activate LVS. Ask the team to demonstrate the safe state of TSAL by disconnecting any signal influencing the green light.

344 ○ TSAL and CI is completely off (no red nor green light).

## ○ INSULATION MONITORING DEVICE

345 ○ One IMD ground line is connected to the accumulator container and one ground line is connected to the main hoop by a separate wired connection.

▲ $R_{Test} = 135\,k\Omega$[15]

● IMD indicator light...

346 ○ ...is inside the cockpit and marked with "IMD",

347 ○ ...is red and visible in bright sunlight, even from outside (check during power-on self-test),

348 ○ ...is visible for the driver.

▲ Activate TS, connect $R_{Test}$ between TS+ and LVS GND.

349 ○ Shutdown circuits opens within 30 s.

350 ○ IMD indicator light illuminates.

351 ○ TS voltage decreases below $60\,V_{DC}$ within 5 s after shutdown circuit opens.

352 ○ Reactivation of TS is not possible.

▲ Push the reset button which is not accessible to the driver, if any and/or restart LVMS.

353 ○ Reactivation of TS is not possible.

▲ Remove $R_{Test}$. Wait 40 s until IMD resets the status output.

354 ○ Reactivation of TS is not possible.

▲ Push all reset buttons in the cockpit if any.

355 ○ Reactivation of TS is not possible.

▲ Push the IMD reset button, which is not accessible to the driver, if any.

356 ○ Reactivation of TS is possible.

▲ Push and hold the reset button, which is not accessible to the driver, if any. Connect $R_{Test}$ between TS- and LVS GND measuring points.

357 ○ Shutdown circuits opens within 30 s.

358 ○ IMD indicator light illuminates.

## ○ MOTOR(S) SPINNING SAFETY RULES

● Clean up unnecessary equipment from car surroundings.

● All team members in inspection slot are aware of upcoming actions.

● Don't stand in spinning parts scatter areas (even the SDC button responsible team member if possible).

[13] Skip test if disconnecting the connector also opens the interlock or stops LVS supply

[14] Do not use measuring points

[15] $R_{Test} = (U_{TSmax} \times 250\,\Omega/V) - R_{BPR}$

## ○ READY-TO-DRIVE ACTIVATION SEQUENCE

▲ Activate TS, press the torque pedal.
359 ○ Motors are not spinning.
▲ Let the team set the vehicle to ready-to-drive mode.
360 ○ Pressing brake pedal WHILE activating is necessary.
361 ○ Brake light in red color.
362 ○ Verify that motors respond to the torque pedal and spin.
▲ Repeat the activation sequence, but push the brake pedal only once before finally pushing the activation button.
363 ○ No ready-to-drive mode possible.
▲ Disconnect the brake sensor.
364 ○ No ready-to-drive mode possible.
▲ Set vehicle to ready-to-drive state.
365 ○ Ready-to-drive sound duration is 1 s to 3 s continuously.
366 △ Ready-to-drive sound is min 80 dBA (2 m around the vehicle).
367 ○ Ready-to-drive sound is easily recognizable and no animal sound or song part.

## ○ APPS AND BSPD

▲ Set vehicle to ready-to-drive state.
368 ○ Verify that motors respond to the torque pedal and spin.
▲ Disconnect $\geq 50\,\%$ of APPS.
▲ Move the accelerator pedal over the entire pedal travel range.
369 ○ Motors do not spin.
▲ Disconnect all APPS.
▲ Move the accelerator pedal over the entire pedal travel range.
370 ○ Motors do not spin.
▲ Team simulates 5 kW power (complete BSPD circuitry must be used), press brake representing hard braking ($> 0.5\,$s).
371 ○ TS shuts down.
▲ Reactivate TS. Disconnect the current sensor, and press the brake representing hard braking ($> 0.5\,$s).
372 ○ TS shuts down.
373 ○ Reactivation of TS is only possible after 10 s without implausibility.

## ○ SEALING OF COMPONENTS

▲ After all tests have been passed successfully seal the inspected TS housings:
374 ○ Motor Controller housing,
375 ○ Energy Meter housing
376 ○ IMD housing,
377 ○ TSAL circuitry housing,
378 ○ BSPD casing /BSPD calibration.
379 ○ Additional Part:
380 ○ Additional Part:

## ○ DATA LOGGER

▲ Check data logger functionality and connectivity.

## ○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Passed or Failed
▲ Stop the timer
▲ Collect the timer

## NON-COMPLIANCE/COMMENTS

# PART VII: TILT TEST

## APPROVAL

| Inspector Names | Date and Time | Signatures when passed |
|---|---|---|
| | | |
| | | |

## ○ TILT TEST

381 ○ **FLUID LEAKAGE** - No fluid spill permitted when the vehicle is tilted to 60° in the direction most likely to create spillage. Tanks must be filled to the scribe line with non-moveable fuel level line 12-25 mm below the top of the sight tube.

382 ○ **VEHICLE STABILITY** - All wheels in contact with tilt table when tilted to 60° to the horizontal.

383 △ **GROUND CLEARANCE** - At least 30 mm with driver. If an active suspension is installed, the static ground clearance is measured in the lowest adjustable position

## NON-COMPLIANCE/COMMENTS

# PART VIII: RAIN TEST

## APPROVAL

| Inspector Names | Date and Time | Signatures when passed |
|---|---|---|
| | | |
| | | |

## ○ RAIN TEST

▲ The vehicle is lifted off the ground.

▲ Turn on Tractive System - TSAL is flashing red.

384 ○ Tractive system voltage is present at TSMPs.

▲ No driver is allowed to sit in the vehicle during the test. Rain-like water will be sprayed at the vehicle for 120 s. Then wait another 120 s without spraying.

385 ○ The Insulation Monitoring Device does not react and does not shut down the tractive system.

▲ Connect $R_{Test}$ between any TSMP and LVS ground.

386 ○ Shutdown circuit opens within 30 s.

## NON-COMPLIANCE/COMMENTS

# PART IX: BRAKE TEST

## APPROVAL

| Inspector Names | Date and Time | Signatures when passed |
|---|---|---|
| | | |
| | | |

## ○ BRAKE TEST

387 ○ **BRAKING PERFORMANCE** - Must lock all four wheels and stop the vehicle in a straight line at the end of an acceleration run specified by the officials without stalling the engine.

388 ○ **BRAKE LIGHT** - Must be clearly visible even in bright sunlight.

## NON-COMPLIANCE/COMMENTS