

FORMULA STUDENT

NETHERLANDS

TECHNICAL INSPECTION SHEET
ACCUMULATOR INSPECTION

V1.0 / 2021

Formula Student Netherlands

2020 Inspection Sheet

Accumulator Inspection

Car Number

University

REQUIRED RESOURCES

No.

Checkpoint

- All accumulator containers to be used during the event
- Accumulator Container Hand Cart
- Tools needed for (dis-)assembly of Accumulator Container
- Laptop and cables to display data of the AMS
- Print-out of Rule Request (if applicable)
- Charger
- An ESO must attend
- Pictures of accumulator internals, if necessary
- Datasheets for used wiring, insulation materials, tractive system components and container material with needed values highlighted.
- Samples of all wire types used inside the accumulator container.
- Power Supply for ALL test
- Samples of all used accumulator container material.

SAFETY BRIEFING

No.

Checkpoint

- no jewellery, no rings
- no cell phone
- no watch / no necklace
- no sources of distraction
- do not wear synthetic clothes
- wear safety glasses
- wear safety gloves (if necessary)

BASIC SET OF HV-PROOF TOOLS

No.

Checkpoint

- 1 Insulated cable shear
- 2 Insulated screw drivers
- 3 Insulated spanners, if applicable
- 4 Multimeter with protected probe tips
- 5 two 4mm banana plug test leads (1000V CAT III)

SAFETY EQUIPMENT

No.

Checkpoint

- 6 Face shield
- 7 Safety glasses (minimum three)
- 8 HV Insulating gloves (minimum two pairs)
- 9 HV insulating blankets (two) (min 1m²) with label or serialnumber and datasheet.

SELF DEVELOPED PCBs

No.

Checkpoint

- ▶ Ask for fully assembled spare PCB of self developed PCBs inside accumulator container.
- 10 Sufficient spacing regarding system voltage and implementation.
- 11 Sufficient insulation and temperature rating of coating if used, datasheet available.
- 12 Coating process according to datasheet

CHARGER ASSEMBLY

No.

Checkpoint

- 13 Completely closed (no open TS connections).
- 14 Interlock integrated
- 15 TSMP integrated
- 16 Emergency shutdown button integrated ≥ 24 mm diameter
- 17 TS wiring is orange, marked with gauge, temperature rating $>85^{\circ}\text{C}$ and voltage rating.
- 18 Conductive parts of charging equipment and accumulator are connected to protective earth (PE) while charging.

DIS-CHARGE CIRCUIT AND BODY PROTECTION RESISTORS

No.

Checkpoint

	▶ Switch off Charger. Measure resistance between HV+ and HV- measuring points.
	19 Resistance is 30 kΩ + discharge resistor
	20 Body protection resistor power and voltage rating is sufficient
INSULATION MEASUREMENT TEST	
No.	Checkpoint
	▶ Check low resistance connection between LVMP and PE/casing
	▶ Choose test voltage to 500V.
	▶ Connect insulation tester to charger TS+ and LV ground.
	▶ Connect charger (do not activate charger) to accumulator, keep AIRs opened.
	▶ Measure resistance: Riso+ = MΩ
	21 Resistance is much higher than (min. 500Ω/V*Umax)
	▶ Connect insulation tester to TS- and GLV ground.
	▶ Measure resistance: Riso+ = MΩ
	22 Resistance is much higher than (min. 500Ω/V*Umax)
	23 Resistances are nearly equal.
HOUSING	
No.	Checkpoint
	24 The accumulator must be mechanically fixed to the handcart
	25 Vehicle number, university name and ESO phone number(s) written on a high contrast background.
	26 Roman Sans-Serif characters of at least 20mm high are used.
	27 Warning stickers with side length of 100mm and text "Always Energized" and "High Voltage" (if TS >60 V) installed. (triangle with black lightning bolt on yellow background)
	28 Check if all parts and the cover/lid of the housing are rigidly fastened.
	▶ Open container housing, remove maintenance plugs.
	▶ Check if no voltage is present.
Accumulator Container Materials and Cell Stack	
No.	Checkpoint
	▶ Remove a random stack from the accumulator
	▶ Compare the SES/ESF documentation with the stack on the table
	29 Stack and SES/ESF documentation are the same
	30 Stacks are robust and rigidly fastened to the container
	31 Stacks are separated by maintenance plugs <120VDC and <6MJ
	32 Stacks are insulated and separated by barrier according to UL94-V0, FAR25 or equivalent
	33 Cell tabs must not be mechanically loaded
	Every temperature sensor placed on negativ terminal of monitored cell or in <10mm distance on busbar.
	34 busbar.
	35 Galvanic Separation included inside the Accumulator Management System
	36 Maintenance plugs are located at both poles of each stack (including first and last stack). (including first and last stack).
	37 Maintenance plugs removable without tools.
	38 Maintenance plugs have positive locking mechanism.
	39 Maintenance plugs must not be able to unintentionally create circuits or short circuits
	40 Internal vertical walls have to be rigidly fastened to the container.
	▶ Present all Accumulator container materials
	▶ Compare samples with Accumulator container
	41 Samples and Accumulator container are of equal quality
	42 All Accumulator material samples are marked with the team number and a seal
	• The burning tests will be done in the welding area!
	▶ Try to burn the materials with a lighter(max 20 mm flame)
	43 Burning ceases within 10 seconds for all materials
	▶ Flame will be reapplied for 10 seconds
	44 Burning ceases within 10 seconds for all materials
ASSEMBLY	
No.	Checkpoint
	45 All components and parts of the AC need to be properly fixed
	46 All used fasteners must be secured by the use of positive locking except they are non-conductive and non-structural
	47 TS potentials are insulated against inner wall of accumulator container if container made from conductive material.

	48 No soldering in high current path
	49 Every container contains at least one appropriately sized and rated fuse
	▶ Check datasheet of fuse and compare to ESF
	50 If the fuse uses a bolt to disconnect there must be sufficient space for the bolt to move into.
	51 Every container contains at least two appropriately sized and rated isolation relays
	52 Isolation relays and fuses are separated from cells by barrier according UL94-V0, FAR25 or equivalent
	53 Holes in container only for wiring harness, ventilation, cooling or fasteners.
	54 Check opening in TS enclosures, try to reach TS potentials with insulated test probe (100mm length, 6mm diameter).
	55 If fully closed, an equalizing valve must be implemented
	56 Spare accumulators of same size, weight and type
	WIRING
No.	Checkpoint
	57 All TS wires have proper overcurrent protection.
	58 No other wires than HV wires are orange.
	59 Securely anchored to withstand at least 200N, if outside of enclosure.
	60 Located out of the way of possible snagging or damage.
	61 TS and LV wires separated (not valid for Interlock).
	62 Every wire used in the Accumulator container (TS and GLVS) is rated for maximum TS voltage
	63 TS wires are marked with gauge, temperature rating >85°C and voltage rating.
	64 Positive locking mechanism or if no positive locking possible, automotive certified components.
	▶ Check if insulated tools needed for the assembly of certified components are available
	65 Insulation is not only insulating tape or rubber-like paint.
	INDICATOR LIGHT OR VOLTMETER
No.	Checkpoint
	66 Red Indicator light or voltmeter installed
	67 Marked with "Voltage Indicator"
	68 Visible while opening the battery connector
	69 Hard wired electronics, supplied by TS
	▶ Connect power supply with 60VDC to accumulator HV connector.
	70 Indicator light on or voltmeter showing present TS voltage.
	71 Visible in bright sunlight.
	ACCUMULATOR MANAGEMENT SYSTEM
No.	Checkpoint
	72 A minimum of 30% of cells are monitored with temperature sensors
	▶ Disconnect any AMS internal connector
	73 The AMS must open the shutdown circuit within 1s.
	▶ disconnect AMS current sensor
	74 The AMS must open the shutdown circuit within 0.5s
	▶ Ask the team to connect their laptop to the AMS.
	▶ Connect charger to battery/batteries, start charging process
	75 Cell voltages can be displayed
	76 Cell temperatures can be displayed.
	77 Temperature and voltage limit according to ESF
	78 Plausible accumulator current can be displayed.
	CHARGER SHUTDOWN CIRCUIT
No.	Checkpoint
	79 IMD is integrated into the charging system.
	▶ Connect charger to battery/batteries, start charging process.
	80 Voltage indicator shows that HV is present.
	▶ Press shutdown button.
	81 AIRs open.
	82 Battery indicator shows voltage <60V.
	▶ Start charging, unplug HV battery connector.
	83 AIRs open.
	84 Charger disabled, no voltage at charger connector.
	INSULATION MONITORING DEVICE
No.	Checkpoint
	85 IMD connected to vehicle side of the AIRs

- ▶ Determine Rtest = (max TS voltage * 250 Ω/V) - BPR
- ▶ Activate charger output, connect RTest between TS+ and GLVS GND.
- 86 Shutdown circuits opens within 30 s.
- 87 TS voltage decreases below 60VDC within 5 s after shutdown circuit opens.
- 88 Reactivation of charger output is not possible
- 89 Push the reset button, if any.
- ▶ Reactivation of charger output is not possible.
- 90 Remove RTest. Wait 40 s until IMD resets status output.
- ▶ Reactivation of charger output is not possible.
- ▶ Activate TS, connect RTest between HV- and GLVS GND.
- 91 Shutdown circuits opens within 30 s.
- 92 chassis ground measurement line connected to charger housing?
- IMD indicator light . . .
- 93 . . . is available during charging
- 94 . . . is red and visible in bright sunlight.
- 95 . . . is visible for the ESO

SEALING OF COMPONENTS

No.

Checkpoint

- 96 Seal accumulator container(s)
- 97 Seal charger
- 98 Additional part:
- 99 Additional part:

OTHER COMMENTS

APPROVAL STATUS

Approval (Control box) (DON'T CHANGE MANUALLY)