

Formula Student Netherlands			
2024 Inspection Sheet			
Accumulator Inspection			
Car Number			
University			
Failed items		Comments	
ESF			
Progress	0.00%		
REQUIRED RESOURCES			
No.	Checkpoint	Checkbox	Comment
	- All accumulator containers to be used during the event		
	- Accumulator Container Hand Cart		
	- Charger		
	- Tools needed for (dis-)assembly of Accumulator Container		
	- Laptop and cables to display data of the AMS		
	- Print-out of Rule Request (if applicable)		
	- 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 <b>NOT ON A CELL PHONE</b>		
	- Samples of all wire types used inside the accumulator container		
	- Samples of all used accumulator container material		
	- Power Supply for ALL test		
SAFETY BRIEFING			
No.	Checkpoint	Checkbox	Comment
	- No jewelry, 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	Checkbox	Comment
	1 Insulated cable shear	<input type="checkbox"/>	
	2 Insulated screw drivers	<input type="checkbox"/>	
	3 Insulated spanners, if applicable	<input type="checkbox"/>	
	4 Multimeter with protected probe tips	<input type="checkbox"/>	
	5 Two 4mm banana plug test leads (1000V CAT III)	<input type="checkbox"/>	
SAFETY EQUIPMENT			
No.	Checkpoint	Checkbox	Comment
	6 Face shield	<input type="checkbox"/>	
	7 Safety glasses (minimum three)	<input type="checkbox"/>	
	8 HV Insulating gloves (minimum two pairs)	<input type="checkbox"/>	
	9 HV insulating blankets (two) (min 1m <sup>2</sup> ) with label or serial number and datasheet	<input type="checkbox"/>	
SELF DEVELOPED PCBs			
No.	Checkpoint	Checkbox	Comment
	► Ask for fully assembled spare PCB of self developed PCBs inside accumulator container		
	10 Sufficient spacing regarding system voltage and implementation	<input type="checkbox"/>	
	11 All components span the complete required isolation barrier	<input type="checkbox"/>	
	12 Sufficient insulation and temperature rating of coating if used, datasheet available	<input type="checkbox"/>	
	13 Coating process according to datasheet	<input type="checkbox"/>	
	14 The 1 min AC RMS isolation test voltage is $\geq 3x$ max. TS voltage	<input type="checkbox"/>	
	15 The working voltage of the isolation barrier, if specified in the datasheet, is higher than the maximum TS voltage	<input type="checkbox"/>	
CHARGER ASSEMBLY			
No.	Checkpoint	Checkbox	Comment
	16 Completely closed (no open TS connections), test with probe (100mm length, 6mm diameter)	<input type="checkbox"/>	
	17 Interlock integrated	<input type="checkbox"/>	
	18 TSMP integrated	<input type="checkbox"/>	
	19 Red emergency shutdown button integrated $\geq 24$ mm diameter	<input type="checkbox"/>	
	20 Switches, plugs and indicators must be labeled	<input type="checkbox"/>	
	21 TS wiring is orange, marked with gauge, temperature rating $>85^{\circ}\text{C}$ and voltage rating	<input type="checkbox"/>	
	22 Conductive parts of charging equipment and accumulator are connected to protective earth (PE) while charging	<input type="checkbox"/>	

23	Conductive parts are able to continuously carry current of 10% of main fuse	<input type="checkbox"/>	
24	Charger and accumulator casing made of at east 0.5 mm thick electrically conductive material or electrically insulated material	<input type="checkbox"/>	
25	Connect the accumulator to the charger and check the grounding according to EV 3.1	<input type="checkbox"/>	If the team has no current rating for used cables regarding rule EV 3.1.2, use following table as reference: <a href="https://www.engineeringtoolbox.com/wire-gauges-d_419.html">https://www.engineeringtoolbox.com/wire-gauges-d_419.html</a>
<b>DIS-CHARGE CIRCUIT AND BODY PROTECTION RESISTORS</b>			
No.	Checkpoint	Checkbox	Comment
	▶ Switch off Charger. Measure resistance between TS+ and TS- measuring points	<input type="checkbox"/>	
26	Resistance is 30 kΩ + discharge resistor	<input type="checkbox"/>	
27	Body protection resistor power and voltage rating is sufficient	<input type="checkbox"/>	
<b>INSULATION MEASUREMENT TEST</b>			
No.	Checkpoint	Checkbox	Comment
	▶ Check low resistance connection between LVMP and PE/casing	<input type="checkbox"/>	
	▶ Choose test voltage to 500V	<input type="checkbox"/>	
	▶ Connect insulation tester to charger TS+ and LV ground	<input type="checkbox"/>	
	▶ Connect charger (do not activate charger) to accumulator, keep AIRs opened	<input type="checkbox"/>	
	▶ Measure resistance: Riso+ = MΩ	<input type="checkbox"/>	
28	Resistance is much higher than ( min. 500Ω/V*Umax)	<input type="checkbox"/>	
	▶ Connect insulation tester to TS- and GLV ground	<input type="checkbox"/>	
	▶ Measure resistance: Riso+ = MΩ	<input type="checkbox"/>	
29	Resistance is much higher than ( min. 500Ω/V*Umax)	<input type="checkbox"/>	
30	Resistances are nearly equal.	<input type="checkbox"/>	
<b>ACCUMULATOR HOUSING</b>			
No.	Checkpoint	Checkbox	Comment
31	Vehicle number, university name and ESO phone number(s) written on a high contrast background	<input type="checkbox"/>	
32	Roman Sans-Serif characters of at least 20mm high are used	<input type="checkbox"/>	
33	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)	<input type="checkbox"/>	
34	Check if all parts and the cover/lid of the housing are rigidly fastened	<input type="checkbox"/>	
	▶ Open container housing, remove maintenance plugs	<input type="checkbox"/>	
	▶ Check if no voltage is present	<input type="checkbox"/>	
<b>ACCUMULATOR CONTAINER MATERIALS AND CELL STACK</b>			
No.	Checkpoint	Checkbox	Comment
	▶ Remove a random stack from the accumulator	<input type="checkbox"/>	
	▶ Compare SES/ESF documentation with the stack on the table	<input type="checkbox"/>	
35	Stack construction and SES/ESF documentation are the same	<input type="checkbox"/>	
36	Stacks are robust and rigidly fastened to the container	<input type="checkbox"/>	
37	Stacks are insulated and separated by barrier according to UL94-V0, FAR25 or equivalent	<input type="checkbox"/>	
38	Maintenance plugs are located at both poles of each stack (including first and last stack)	<input type="checkbox"/>	
39	Maintenance plugs removable without tools	<input type="checkbox"/>	
40	Maintenance plugs have positive locking mechanism	<input type="checkbox"/>	
41	Maintenance plugs must not be able to unintentionally create circuits or short circuits	<input type="checkbox"/>	
42	Stacks separated by maintenance plugs <120VDC and <6MJ	<input type="checkbox"/>	
43	Cell tabs must not be mechanically loaded	<input type="checkbox"/>	
	• If the cells are fixed using friction	<input type="checkbox"/>	
44	Fiction design is the same as in the SES and was approved	<input type="checkbox"/>	
45	Mockups for testing are representative with actual implementation	<input type="checkbox"/>	
	• If the cells are fixed otherwise	<input type="checkbox"/>	
46	At least 80% of the large surface area is used for fixing the cells	<input type="checkbox"/>	
47	No cells are damaged or can be damaged by the segment structures	<input type="checkbox"/>	
48	Cells securely fastened towards all 3 directions	<input type="checkbox"/>	
49	All parts carrying cells and loads are made of UL94-V0 or equivalent certified materials	<input type="checkbox"/>	
50	Every temperature sensor placed directly on negative terminal of monitored cell or in <10mm distance on busbar	<input type="checkbox"/>	
51	Galvanic Separation included inside the Accumulator Management System	<input type="checkbox"/>	
52	All connections from a TS component to external devices, such as laptops must include galvanic isolation	<input type="checkbox"/>	
53	Internal vertical walls have to be rigidly fastened to the container	<input type="checkbox"/>	
54	Internal vertical walls have a minimum height of 75% of the external walls	<input type="checkbox"/>	
55	Internal vertical walls divide the accumulator in sections of maximum 12 kg	<input type="checkbox"/>	
	▶ Present all Accumulator container materials	<input type="checkbox"/>	
	▶ Compare samples with Accumulator container	<input type="checkbox"/>	
56	Samples and Accumulator container are of equal quality	<input type="checkbox"/>	
<b>ASSEMBLY</b>			
No.	Checkpoint	Checkbox	Comment
57	All components and parts of the TSAC need to be properly fixed	<input type="checkbox"/>	
58	All used fasteners must be secured by the use of positive locking except they are non-conductive and non-structural	<input type="checkbox"/>	
59	TS potentials are insulated against inner wall of accumulator container if container made from conductive material	<input type="checkbox"/>	

60	No soldering in high current path	<input type="checkbox"/>	
61	Every container contains at least one appropriately sized and rated fuse	<input type="checkbox"/>	
	▶ Check datasheet of fuse, main wires and cells and compare to ESF		
62	Every container contains at least two appropriately sized and rated isolation relays	<input type="checkbox"/>	
63	Pre-charge relay is of mechanical type with appropriate voltage rating	<input type="checkbox"/>	
64	Isolation relays and fuses are separated from the cells by a barrier according UL94-V0, FAR25 or equivalent	<input type="checkbox"/>	
65	Holes in container only for wiring harness, ventilation, cooling or fasteners if mechanical properties are not influenced	<input type="checkbox"/>	
66	Holes in the accumulator must not cover more than 25% of the surface of the wall	<input type="checkbox"/>	
67	Any covers over the holes must be fire retardant	<input type="checkbox"/>	
68	External openings not pointing towards hand cart operator	<input type="checkbox"/>	
69	Check opening in TS enclosures, try to reach TS potentials with insulated test probe (100mm length, 6mm diameter)	<input type="checkbox"/>	
70	If fully closed, an equalizing valve must be implemented	<input type="checkbox"/>	
71	Spare accumulators of same size, weight and type	<input type="checkbox"/>	
<b>WIRING</b>			
No.	Checkpoint	Checkbox	Comment
72	All TS wires have proper overcurrent protection	<input type="checkbox"/>	
73	No other wires than TS wires are orange	<input type="checkbox"/>	
74	Securely anchored to withstand at least 200N, if outside of enclosure	<input type="checkbox"/>	
75	Located out of the way of possible snagging or damage	<input type="checkbox"/>	
76	TS and LV wires separated (not valid for Interlock)	<input type="checkbox"/>	
77	Every wire used in the Accumulator container (TS and LV) is rated for maximum TS voltage	<input type="checkbox"/>	
78	TS wires are marked with gauge, temperature rating >85°C and voltage rating	<input type="checkbox"/>	
79	Positive locking mechanism or if no positive locking possible, automotive certified components	<input type="checkbox"/>	
	▶ Check if insulated tools needed for the assembly of certified components are available		
80	Insulation is not only insulating tape or rubber-like paint	<input type="checkbox"/>	
81	One IMD GND line is connected to the TSAC and the other to the charger housing with a direct wire	<input type="checkbox"/>	
<b>INDICATOR LIGHT OR VOLTMETER</b>			
No.	Checkpoint	Checkbox	Comment
82	Red Indicator light or voltmeter installed	<input type="checkbox"/>	
83	Marked with "Voltage Indicator"	<input type="checkbox"/>	
84	Visible while disconnecting the battery connector	<input type="checkbox"/>	
85	Hard wired electronics, supplied by TS on the vehicle side of the AIRs	<input type="checkbox"/>	
	▶ Connect power supply with 60VDC to accumulator TS connector with proper plugs, <b>no measuring probes</b>		
86	Indicator light on or voltmeter showing present TS voltage	<input type="checkbox"/>	
87	Visible in bright sunlight	<input type="checkbox"/>	
<b>ACCUMULATOR MANAGEMENT SYSTEM</b>			
No.	Checkpoint	Checkbox	Comment
88	AMS is located in the TSAC	<input type="checkbox"/>	
89	A minimum of 30% of cells are monitored with temperature sensors	<input type="checkbox"/>	
	▶ Disconnect any AMS internal connector		
90	The AMS must open the shutdown circuit within 1s	<input type="checkbox"/>	
	▶ Disconnect AMS current sensor		
91	The AMS must open the shutdown circuit within 0.5s	<input type="checkbox"/>	
	▶ Ask the team to connect their laptop to the AMS		
	▶ Connect charger to battery/batteries, start charging process		
92	Cell voltages can be displayed in one overview	<input type="checkbox"/>	
93	Cell temperatures can be displayed	<input type="checkbox"/>	
94	Temperature and voltage limit according to ESF	<input type="checkbox"/>	
95	Plausible accumulator current can be displayed	<input type="checkbox"/>	
	▶ Disconnect one SINGLE voltage sense wire, if any wires used		
96	The AMS must open the shutdown circuit within 0.5 s	<input type="checkbox"/>	
	▶ Disconnect one SINGLE temperature sense wire, if any wires used		
97	The AMS must open the shutdown circuit within 1 s	<input type="checkbox"/>	
<b>CHARGER SHUTDOWN CIRCUIT</b>			
No.	Checkpoint	Checkbox	Comment
98	IMD is integrated into the charging system	<input type="checkbox"/>	
	▶ Connect charger to battery/batteries, start charging process		
99	Voltage indicator shows that HV is present	<input type="checkbox"/>	
	▶ Press shutdown button		
100	AIRs open	<input type="checkbox"/>	
101	Battery indicator shows voltage <60V	<input type="checkbox"/>	
	▶ Start charging, unplug TSAC connector		
102	AIRs open	<input type="checkbox"/>	
103	Charger disabled, no voltage at charger connector, measure on TSMP	<input type="checkbox"/>	
<b>INSULATION MONITORING DEVICE</b>			

No.	Checkpoint	Checkbox	Comment
103	IMD connected to vehicle side of the AIRs	<input type="checkbox"/>	
	▶ Determine Rtest = (max TS voltage * 250 Ω/V) - BPR		
	▶ Activate charger output, connect RTest between TS+ and LV GND		
104	Shutdown circuits opens within 30 s	<input type="checkbox"/>	
105	TS voltage decreases below 60VDC within 5 s after shutdown circuit opens	<input type="checkbox"/>	
106	Reactivation of charger output is not possible	<input type="checkbox"/>	
	▶ Push the reset button, if any		
107	Reactivation of charger output is not possible	<input type="checkbox"/>	
	▶ Remove RTest. Wait 40 s until IMD resets status output		
108	Reactivation of charger output is not possible	<input type="checkbox"/>	
	▶ Activate TS, connect RTest between TS- and LV GND		
109	Shutdown circuits opens within 30 s	<input type="checkbox"/>	
	▶ IMD indicator light . . .		
110	. . . is available during charging	<input type="checkbox"/>	
111	. . . is red and visible in bright sunlight	<input type="checkbox"/>	
<b>HAND CART</b>			
No.	Checkpoint	Checkbox	Comment
112	Hand cart has four wheels	<input type="checkbox"/>	
113	Hand cart has maximal dimensions of 1200mm x 800mm	<input type="checkbox"/>	
114	Hand cart has always on type brake system	<input type="checkbox"/>	
115	The accumulator must be mechanically fixed to the handcart while on the handcart	<input type="checkbox"/>	
116	The accumulator must be protected from vibrations and shocks	<input type="checkbox"/>	
117	Firewall made from rigid fire retardant material	<input type="checkbox"/>	
118	Firewall (same width as hand cart, from lowest point to 30 cm above TSAC/handle) must protect operator	<input type="checkbox"/>	
119	Firewall must be transparent from 1.3m above the ground	<input type="checkbox"/>	
120	Label according to EV5.3.8 on the firewall below the hand cart handle	<input type="checkbox"/>	
<b>SEALING OF COMPONENTS</b>			
No.	Checkpoint	Checkbox	Comment
121	Seal accumulator container(s)	<input type="checkbox"/>	
122	Seal charger	<input type="checkbox"/>	
123	Additional part:	<input type="checkbox"/>	
124	Additional part:	<input type="checkbox"/>	
<b>OTHER COMMENTS</b>			