EV Inspection Guide
-2018 Student Formula Japan (SFJ)-

JSAE
Student Formula Japan
EV WG
P12: updated July 17, 2018
2018 SFJ EV Inspection Guide

Contents

1. Revisions to 2017 rules for 2018
   • The only revision is to rule EV5.7.3 (rule about triggering of the inertia switch).
   • See the SFJ homepage for the local rules.

2. Key Points of Electrical Technical Inspection: Common mistakes will be explained in this document in the order that they appear on the Technical Inspection Sheets.
   • Technical inspection procedure
   • Technical Inspection Sheets 1 and 2 (Self-Check)
   • EV0: Basic electrical systems inspection
   • EV1: Inspections with high-voltage system OFF
   • EV2: Inspections with high-voltage system ON
   • EV3: Rain Test
1. Revisions to 2018 FSAE Rules

EV5.7.3 Inertia Switch

The requirements of this rule have been changed.

New:

EV5.7.3 The device must trigger due to an impact load which decelerates the vehicle at between 8g \((\text{previously } 6g)\) and 11g depending on the duration of the deceleration (see spec sheet of the Sensata device).

• Take care when entering the Electrical Systems Form (ESF).
1. 2018SFJ Local Rules (Revisions from 2017SFJ)

■ 2018-20 Charging (refer to rule EV8.2.2 of 2017-18 FSAE®)
   Accumulators do not need to be removed from the car for charging. However, the indicator in accordance with EV 3.3.9 must be visually confirmed when the charging connectors are plugged/unplugged. Structurally, rule EV 3.2.4 is still applicable. If the accumulator is not removed from the car, teams may have to wait for charging.
   From the 2019 Competition, charging may not take place with the accumulator installed in the car. The accumulator container must be removed from the car for charging.

■ J2018-22 Failure Modes and Effects Analysis (FMEA) (refer to rule EV9.2.1 of 2017-18 FSAE®)
   When carrying out the FMEA, it is acceptable to implement items FMEA Nos. 41 to 54 on the "FMEA" sheet of the 2018 Failure Modes and Effects Analysis Template (file name: 2018-FMEA-template1.xls). In addition, the FMEA template may be entered in Japanese.

■ J2018-27 Relaxation of Weight Rule in the Accumulator Container Section Requirements (refer to rule EV3.4.6 of 2017-18 FSAE®)
   Teams may comply with the design guidelines for the 2016 Formula SAE® Rules (EV3.4.6).
   Note that the 2016 rules will not be acceptable from the 2019 Competition.

■ J2018-28 Thickness of Accumulator Container Floor (refer to rule EV3.4.6 a. of 2017-18 FSAE®)
   An aluminum sheet thickness of 3.2 mm (0.125 inches) is acceptable up to a negative tolerance of 10%.

■ 2018-30 Seals after Rain Test (refer to rules EV7.3 and EV7.1.3 of 2017-18 FSAE®)
   As part of the rain test, seals will be applied to items attached to the car for waterproofing (tape or the like).
   Teams must re-take the rain test if any of these seals are broken.

* Refer to the local rules published on the SFJ homepage for the official details of these rules.
2. Key Points of Electrical Technical Inspection: Procedure

The EV1 and EV2 set, and Mechanical Technical Inspection and Tilt/Weight Test set may be carried out in any order.

EV0: • Basic systems Insulation state Requirement for Mechanical Technical Inspection

EV1: • Confirmation of circuit configuration (inactive, high voltage OFF) Make proper preparation to explain these items.

EV2: • Confirmation of circuit operation (active, high voltage ON)

EV3: • Confirmation of operation The grounded low voltage (GLV) battery must be sufficiently charged.

• Rain Test Teams should apply rain countermeasures assuming that the car will be driven in the rain, rather than simply to pass the test.

• Installation of energy meter Teams must prepare the high-voltage terminals (round terminals). Other connectors will be provided by the JSAE.

• The cowling and other parts of the bodywork that are removed for maintenance must be removed and brought to the Electrical Technical Inspection.

Note the order of priority (Technical Inspection sequence, etc.).
2. Key Points of Electrical Technical Inspection: Technical Inspection Sheet 1

Self-check of the overall system

• Fill out this sheet before the Electrical Technical Inspection.
  It may not be filled out at the Electrical Technical Inspection Area.

• The purpose of this sheet is to confirm whether the overall high-voltage system is consistent (voltages, currents, etc.).

• Most of this sheet can be copied from the ESF.
Self-check of accumulator container

- The accumulator container should be constructed to the standard configuration (following rule EV3.4.6).
- If a team is concerned that the accumulator container does not comply with rule EV3.4.6, confirm using the Q&A system.
- Please bring drawings and photographs if the configuration is difficult to see at the Technical Inspection Area.
  → If these are not prepared, teams may be asked to dismantle the container.
- If the standard configuration is not used, calculations must be performed following the Alternative Frame Rules process in rules EV3.4.5 and AF4.8.
## Review: Accumulator Container

### EV3.4.6: Configuration of accumulator container

<table>
<thead>
<tr>
<th>EV3.4.6</th>
<th>Item</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Floor or bottom</td>
<td>Steel: 1.25 mm (0.049 inch) / Aluminum: 3.2 mm (0.125 inch)</td>
</tr>
<tr>
<td>b</td>
<td>External vertical walls</td>
<td>Steel: 0.9 mm (0.035 inch) / Aluminum: 2.3 mm (0.09 inch)</td>
</tr>
</tbody>
</table>
| c       | Internal vertical walls | Steel: 0.9 mm (0.035 inch) / Aluminum: 2.3 mm (0.09 inch)  
Must be minimum of 75% of the height of the external vertical walls |
| d       | Covers and lids | Steel: 0.9 mm (0.035 inch) / Aluminum: 2.3 mm (0.09 inch) |
| e       | Joining method of floor and walls | Welds and/or fasteners: Fasteners must be 6 mm Metric Grade 8.8 or stronger. |
| f       | Weight in each section | The accumulator container must be divided into sections by vertical walls. A maximum of 12 kg is allowed in any section. |
| f-i     | Number of fasteners between floor and any vertical wall (internal or external) | At least 2 |
| f-ii    | Fasteners between internal and external vertical walls | Must be located in the top half of the internal vertical wall |
| f-iii   | Number of fasteners for each section | Sections containing 8 kg or less: minimum of 2 fasteners connecting any two vertical walls |
| f-iv    | Number of fasteners for each section | Sections containing between 8 and 12 kg: minimum of 3 fasteners connecting any two vertical walls |
| g       | Plate folding or bending | The folding or bending of plates to create flanges or eliminate joints between walls is acceptable. |
| h       | Location of cover or lid fasteners | Covers or lids must be fastened with a minimum of one fastener for each external vertical wall per section |
| i       | Alternate materials | Alternate materials are allowed with proof of equivalency following rule T3.31. Proof of equivalency must be documented in the Structural Equivalency Spreadsheet (SES) and test samples must be available at the Technical Inspection. |
| j       | Use of smaller bolts | One 6 mm bolt may be substituted with two 5 mm or three 4 mm bolts. |

### Assumptions of guidelines

**Longitudinal:** 40G  
**Lateral:** 40G  
**Vertical:** 20G  

In 2018, the weights listed above are still acceptable. These weights will not be acceptable from the 2019 Competition.
• EV3.4.7: Securing of cells/and or segments inside the container
  • The mounting system must be designed to withstand 40G in the longitudinal (front/rear) direction, 40G in the lateral (left/right) direction, and 20G in the vertical (up/down) direction.
  • Calculations and/or tests proving these requirements are met must be included in the SES or Structural Requirements Certification Form (SRCF).
  • Any fasteners must be 6 mm Metric Grade 8.8 or stronger.

• EV3.4.8: Attachment of container to major structure
  • Attachment must use 8 mm Metric Grade 8.8 fasteners or stronger.
  • If the accumulator weighs less than 20 kg, a minimum of 4 attachment points are required.
  • If the accumulator weighs between 20 and 29 kg, a minimum of 6 attachment points are required.
  • If the accumulator weighs between 30 and 39 kg, a minimum of 8 attachment points are required.
  • If the accumulator weighs 40 kg or more, a minimum of 10 attachment points are required.
2. Key Points of Electrical Technical Inspection: Sheet 2

Review: Terminology related to the accumulator

• Electrical capacity: cell(s) < segment(s) (< container)
• Physical size: section(s) < container

Between segments:
• Segments must be separated electrically.
• An electrically insulating barrier must be present.

Between sections:
• Sections must be separated physically by internal walls.

< 6 MJ < 120 V

< 12 kg (from 2019)
(In 2018, 15 kg is still acceptable.)
6. Shutdown buttons:
   • Two shutdown buttons must be located behind the driver's compartment at approximately head height, one at each side of the car. The diameter of the buttons must at least 40 mm.
   • One shutdown button must be mounted in the cockpit alongside the steering wheel. The diameter of this button must be at least 24 mm.
   • A label consisting of "a red spark on a white-edged blue triangle" must be affixed close to all shutdown buttons.

7. Resistance measurement using Tractive System Measuring Points (TSMP)
   • Before the Electrical Technical Inspection, teams must prepare to enable measurement using the TSMP (these measuring points are often set far back into the car).
   • Wiring leading to the TSMP must be orange because high voltage is applied! (Caution is required.)
8. Ground measuring point
   - This measuring point should be connected using a thick low-
     resistance wire since it is used for measuring the contact resistance
     in point 7 on the previous slide.

10. HV disconnect (HVD)
    - The "HVD" label should be attached to the back surface rather than
      the side to make it easier to see from the rear.
    - The HVD should be installed within the primary structure. It should
      not protrude.
    - The HVD should be installed within the envelope of any part of the
      frame… (EV4.2 Positioning of tractive system parts)
    - An untrained person must be able to remove the HVD within 10
      seconds. (Some teams even attach a diagram.)
      - It must be possible to disconnect the HVD without removing the
        cowling or any bodywork.
      - Opening a lid or cover is acceptable. However, if the process is
        not intuitive, it will be impossible to comply with the 10-second rule.
## Review: Lightning bolt/spark

### Review: Display of lightning bolt/spark for high voltage systems

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV3.4.14</td>
<td>Accumulator container</td>
<td>• A red or black lightning bolt on a yellow background or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• at least 750 mm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The text &quot;High Voltage&quot; or something similar</td>
</tr>
<tr>
<td>EV4.6</td>
<td>Tractive System Enclosures</td>
<td>• A red lightning bolt on a white background</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The text &quot;High Voltage&quot; or something similar</td>
</tr>
<tr>
<td>EV5.2.8</td>
<td>Tractive System Master Switch</td>
<td>• Clearly marked with &quot;LV&quot; and &quot;HV&quot;</td>
</tr>
<tr>
<td>EV5.3</td>
<td>Shutdown Buttons</td>
<td>The international electrical symbol consisting of a red spark on a white-edged blue triangle</td>
</tr>
</tbody>
</table>
11. Attachment condition of cables
   • All cables must be fastened securely to the body. Cables must not be fixed to each other.
   • Cables should be wrapped in corrugated sheaths: Cables will break if the cover is damaged. (This is a cause of grounding faults and electrical shocks.)
   • "Spaghetti" cabling is strictly forbidden. All cables should be appropriately gathered together and fixed to the body: This is a cause of incorrect connections and other faults.
   • Use different color wiring. If all the wires are the same color, it will be confusing when checking the wiring after an issue occurs.

14. Installation method of tractive system accumulators
   • It must be possible to remove the tractive system accumulator from the car without disassembling the accumulator container.
     → Although the local rules permit charging without removing the accumulator, it must be possible to remove the accumulator container from the car as-is. It is recommended to carry out maintenance of the container contents after removing the container from the car.
     (From 2019, charging must be carried out after removing the accumulator.)
15. Confirmation of electrical safety of tractive system accumulator
   • Teams must prepare photographs of the state inside the accumulator container. It is very difficult and time consuming to open the container during the Electrical Technical Inspection.
   • Segments must be separated electrically without requiring use of a tool. It is prohibited to use hand tightened nuts in the separation structure. Use connectors, service plugs, or the like.

16. Confirmation of wiring of the tractive system supply
   • All tractive system power must flow through the energy meter.
     → When accumulator containers are connected in parallel, the accumulator containers must be wired to a single point.
   • Teams are strongly recommended to install their own energy meter.
     → This meter can be used to collect data for analysis by each team. Data measured by the energy meter distributed at the event will not be provided to teams.
     → This energy meter is also useful as a backup in case an issue occurs.
Ref.: Details of energy meter connection.

Each team should prepare the round high-voltage terminals.

These connectors will be provided by the JSAE.
18. Firewall
   • There must be an electrically insulating layer surrounding the driver on the driver's side.
   • There must be no holes near the driver. Gaps of pass-throughs for wiring must be sealed.
   • If a battery is located at the side, the insulation must cover the side of the driver. The escape route must be secured.

19. Confirmation of contact safety of high-voltage system
   • All high-voltage terminals and the like must be isolated by covers and gaps filled with silicon or the like.
     The inspectors will confirm whether contact is possible using a 6 mm diameter probe or finger.

20. Accumulator Management System (AMS) (Battery Management System (BMS))
   • If a team purchases an accumulator (cells) that is integrated with an AMS or BMS, consider using it as-is (without making any changes).
     Consult in advance even if a slight divergence from the rules occurs.
   • AMS wiring should be collected together tidily and not left in an untidy state.
     Ensure a clean arrangement by placing a board in the container or adopting another measure.
21. Tractive system parts must be installed in locations protected from rear and side impacts by the truss structure described in rule T3.4.

Note: The main purpose of this is to protect high-voltage parts from direct damage if a collision occurs. If the car clearly deviates from that purpose (for example, if rigid components that accompany these parts protrude from the truss frame), this will be pointed out during the Technical Inspection.

E.g. 1: When the motor is inside the truss frame, but the transmission (i.e., a robust rigid component coupled with the motor) protrudes from the truss frame.

E.g. 2: When the accumulator container is within the prescribed range, but its cooling fan (i.e., a rigid component that directly accompanies the accumulator container) protrudes from the truss frame.
23. Confirmation of shutdown circuit

This will be confirmed using the ESF or the like.

Teams should print out and bring a large copy of the circuit diagram (A2 or A3 size) that is easy to read.

Many teams bring blurry or difficult to read print outs.

Bring two types of diagrams: one that shows the overall configuration, and one that shows individual areas.
EV5.2: Master Switches

Key points:

- No interlocks may be connected in the \textcolor{red}{\underline{TSMS}} area in the diagram on the left.
- Only pre-charge circuitry and hardwired interlocks may be located in the \textcolor{blue}{\underline{AIR\_P}} area.

EV5.2.4
24. Confirmation of Accelerator Pedal Position Sensors (APPS)
   • Two entirely separate sensors must be used as APPS. Both the current wires and output wires must be independent and cannot be shared.
   • Each APPS must have a separate detachable connector.
     From 2017, the dedicated Technical Inspection switch box may also be used.

25. Accelerator pedal return springs
   • Each return spring must be capable of returning the pedal to the fully released position when the other is not functional.
   • The weak springs inside the APPS are not acceptable. Either two springs must be used that are recognizable when viewed from the outside, or the teams must explain the internal structure.
28. Confirmation of contact state (electrical shock protection by potential equalization)

The inspectors will confirm whether the prescribed locations are connected to the chassis ground at or below the required resistance.

- Locations that teams often forget:
  - Steering wheel surface
  - Parts operated by the driver attached to plastic panels (switches, etc.)
- Smart teams directly connect ground wires and do not rely on bolt joints. Paint and the like often prevents conductance.

- When carbon parts are used within the prescribed areas (use of carbon parts has increased in recent years)
  Special measures are required to ensure a sufficiently low contact resistance with carbon parts.
  E.g.: Incorporating metal meshes into the carbon fiber, ensuring definite contact with the aluminum honeycomb (core) as the measurement point.
2. Key Points of Electrical Technical Inspection: Sheet 8

EV2: Finally, Technical Inspections when high voltage system is ON

1. Confirmation of start-up method
   • The easiest confirmation method is to use the "ready-to-drive mode" indicator. Teams have designed cars in the past in which even the driver could not confirm this state.

2. Tractive System Active Light (TSAL)
   • The TSAL must illuminate when high voltage is present between the AIR and inverter.

3. Confirmation of high-voltage system shutdown
   • When the GLV master switch is turned OFF, the voltage might not shut down for 5 seconds. Teams should examine the relationship between the GLV master switch and the discharge circuit.
4. Confirmation of tractive system accumulator pack operation indication
   • When high voltage is present on the outer side of the AIR, the indicator must operate even when the container is removed from the body.
   • An analog voltmeter is permitted.

6. Confirmation of safety when Brake System Encoder (BSE) error occurs
   • The brake sensor used for error detection must be used for the brake override (rule EV2.5).
   • It is strongly recommended that the same sensor as this be used for the brake sensor in the Brake System Plausibility Device (BSPD, rule EV5.6), which is the final measure against the car running out of control.
8. Confirmation of BSPD operation
   • Each team must consider how to prove BSPD operation (the method may be described on the ESF).
   • Confirmation by non-operation of the brake override is not the preferred method.
   • Teams should assume that it will not be possible to confirm at the Technical Inspection Area that power of 5 kW or more is actually delivered.
     A normal method is to use a pseudo signal that indicates 5 kW or more.

10. Confirmation of Insulation Monitoring Device (IMD)
    • Cautions when using the IMD manufactured by Bender (supplied by Protrad):
      • Connect the two ground wires separately.
      • Teams should thoroughly discuss the addition of a voltage detection function (when purchasing a new one).
        When this detection function activates, shutdown will take place before the high voltage builds up.

11. Confirmation of operation of IMD
    • Teams must prepare the resistance (of at least 250 $\Omega/V$) that triggers detection and operation during the Technical Inspection.
12. Confirmation of charger

Cautions regarding the Standard Charging Procedure and Charging Abnormality Procedure documents:

• Both should be expressed as flow charts.
• Use diagrams (photographs) to make them easier to understand.
• Clearly state the criteria for determining whether charging is complete or an error has occurred.
Review: Insulation Monitoring Device (IMD)

Key points:

• The two reference ground wires of the IMD must be connected to the chassis separately.

• During the Technical Inspection, one or two of the reference ground wires will be disconnected to check that a failure occurs.

Teams should test in advance whether a failure is detected under both of these conditions.
2. Key Points of Electrical Technical Inspection: Sheet 10

**EV3: Rain Test**

- Each team should prepare a stand that can hold the car with all four wheels approximately 50 to 150 mm above the ground.
- Seals will be attached to plastic covers and the like used as a countermeasure against rain. → These cannot be removed.
  → Use a structure that does not use tape or the like to seal against rain.
- In the event of an emergency, teams should bring enough insulated gloves for the people required to lift the car up.
- This test can be failed in circumstances other than an insulation failure (electrical leakage) (e.g., sensor signal disruption leading to shutdown).

**Reference: Brake Test**

- After accelerating, the system must be stopped by pressing the **shutdown button** before braking.
- Since it is more difficult to lock the tires with an EV than a gasoline-powered car, the same design may not work.
  This is caused by higher weight and the rotational inertia of the motor applied to the drive wheels.
Operational Safety in the Technical Inspections

- Dangerous operations
  - Jacking up the car
  - Rotating the motor
  - Measuring potential
  - Charging
  - Operations involving touching the accumulator container must be carried out in the Charging Area.

Although the following operations will not be carried out at the Technical Inspection Area, see the following slides for hints about how to carry them out.

- High-voltage wiring connection
- Wiring inside the accumulator container
Operational Safety in the Technical Inspections

Key point:
Short circuits caused by screws and the like can cause molten metal to jump out like fireworks.

Key point:
Only the connection operation area is uncovered.
Operational Safety in the Technical Inspections

Key point:
Cables move. Although troublesome to set up, covers can be beneficial.