2024 Formula Hybrid+Electric Electrical System Form 2 (ESF-2)

INTRODUCTION

The goal of the ESF is to ensure that vehicles are as safe as possible, and that they comply with the Formula Hybrid+Electric completion rules. The ESF is divided into fourteen main sections:

1. System Overview
2. Operating Voltage
3. Safety Circuit
4. TSMP
5. Cables & Fusing
6. Motors
7. Isolation & Insulation
8. IMD
9. AMS
10. Accumulator & Container
11. Pre-Charge & Discharge
12. Torque Control
13. GLV
14. Charger

A clear, concise ESF will help you to build a better car. It will also help you to pass tech testing as most common tech problems can be addressed before the car reaches the track.

IMPORTANT INSTRUCTIONS AND REQUIREMENTS
Read carefully!

1. Every part of this ESF must be filled with content. If a section is not relevant to your vehicle, mark it as “N/A” and describe briefly why not.
2. Please leave the written instructions in place and add your responses below them.
3. All figures and tables must be included. An ESF with incomplete tables or figures will be rejected.
4. The maximum length of a complete ESF is 100 pages.
5. Note that many fields ask for information that was submitted in your ESF-1. This information must be reentered – in some cases will be different than what was entered in ESF-1, which is OK.

6. Submit this document in Word format – *do not convert it to PDF!*
   Submit to: https://formulahybridupload.supportsystem.com/

ESF-2 REVIEW PROCESS

Feedback on your ESF occurs through both your team's Google Doc and the FH ticket system at: https://formulahybridelectric.supportsystem.com/

Your ESF will be reviewed by a team of "section reviewers" - experts in specific areas of the FH rules.

Reviewers will add comments in the Google doc:

Comments are coded as follows:
(!!!) – Important – we need a team response, e.g.,
!!! We have a concern regarding your accumulator protection - how did you calculate required fuse sizes?

(!!!) comments **require action** - either by responding to the comment in the Google doc, or opening a rules ticket (and adding a response, e.g., "See FH Ticket 1234 for resolution".

(!!! PLEASE OPEN A TICKET) – discussion needed via ticket system, e.g.,
!!! PLEASE OPEN A TICKET – your safety schematic is not rules compliant.
The inspector wants a ticket opened for response.

Comment Resolution
When your team has reviewed a non (!!!) comment, you can resolve the comment to indicate that it has been seen and acknowledged.

For !!! comments, please wait for an inspector to review your response. Then they will resolve the comment.

Our goal is to have your ESF-2 form completed with all comments resolved before the competition.

If you have not received a response to a critical Google doc question, please open a follow-up ticket at: https://formulahybridelectric.supportsystem.com/

The ESF2 is a tool which was created to improve the probability that your vehicle will pass the electrical inspections on its first try.

It is up to you and your team to follow up on all open items.

TITLE PAGE

Please include team logo, car picture, etc..

University Name: _____

Team Name: _____

Car Number: _____

Main Team Contact for ESF related questions:

Name: _____

e-mail: _____

Table of Contents

I List of Figures

Must be hyperlinked!

II List of Tables

Must be hyperlinked!

III List of Abbreviations

AIR	Accumulator Isolation Relay
AMS	Accumulator Management System
BRB	Big Red Button
FH Rules	Formula Hybrid Rule
GLV	Grounded Low-Voltage
GLVMS	Grounded Low Voltage Master Switch.
IMD	Insulation Monitoring Device
IMI	Insulation Monitoring Interrupter
RTDS	Ready To Drive Sound
SMD	Segment Maintenance Disconnect
ESOK	Safety Systems OK
TS	Tractive System
TSAL	Tractive System Active Light
TSMP	Tractive System Measurement Point
TSMS	Tractive System Master Switch.
TSV	Tractive System Voltage

(Add additional abbreviations or acronyms specific to your diagrams or schematics)

Section 1 **Vehicle Overview**

Person primarily responsible for this section:

Name: _____

e-mail: _____

Check the appropriate boxes:

Vehicle is

- ☐ New (built on an entirely new frame)
- ☐ New, but built on a pre-existing frame
- ☐ Updated from a previous year vehicle

Architecture

- ☐ Hybrid
  - ☐ Series
  - ☐ Parallel
- ☐ Hybrid in Progress (HIP[1])
- ☐ Electric-only

Drive

- ☐ Front wheel
- ☐ Rear wheel
- ☐ All-wheel

Regenerative braking

- ☐ Front wheels
- ☐ Rear wheels
- ☒ None

[1] HIP does not need to be declared prior to the competition. If unsure, check “Hybrid”

NARRATIVE OVERVIEW

Provide a brief, concise description of the vehicles main electrical systems including tractive system, accumulator, hybrid type (series or parallel) and method of mechanical coupling to wheels. Describe any innovative or unusual aspects of the design.

Include the following figures:

- **Figure 1** – an electrical system block diagram showing all major parts associated with the tractive-system. (Not detailed wiring).
- **Figure 2** – Drawings or photographs showing the vehicle from the front, top, and side
- **Figure 3** – A wiring diagram superimposed on a top view of the vehicle showing the locations of all major TS components and the routing of TS wiring.
- **Figure 4** -- A complete TSV wiring schematic per FH Rule **EV13.2.1** showing connections between all TS components.

  This should include:

  - Accumulator Cells
  - AIRs
  - SMDs
  - Fuses
  - Wire Gauges
  - Motor controller
  - Motor
  - Pre-charge and discharge circuits
  - AMD
  - IMD
  - Charging port
  - Any other TS connections.

IMPORTANT NOTICE

When pasting drawings and schematics into the provided boxes, be certain that the graphics in the files are at a high enough resolution that the smallest details can be examined by enlarging the files.

Figure 1 - Electrical System Block Diagram

Figure 2 - Drawings showing the vehicle from the front, top, and side

Figure 3 - Locations of all major TS components

Figure 4 - TSV Wiring Schematic

Section 2 **Operating Voltage**

Person primarily responsible for this section:

Name: _____

e-mail: _____

Fill in the following table:

Item	Data
Nominal Tractive System Voltage (TSV_{nom})	VDC
Maximum Tractive System Voltage (TSV_{max})	VDC
Control System Voltage / Grounded Low Voltage system (GLV) (Note: for 2024, Rule EV1.2, the GLV may be 48V max)	VDC

Table 1- General Electrical System Parameters

Section 3 **Safety Circuit**

Person primarily responsible for this section:

Name: _____

e-mail: _____

3.1 Shutdown Circuit

Include a schematic of the shutdown circuit for your vehicle including all major components in the loop

Figure 5 – Safety Shutdown Circuit Schematic

Describe the method of operation of your shutdown circuit, including the master switches, shut down buttons, brake over-travel switch, etc. Also complete the following table

Part	**Function (Momentary, Normally Open or Normally Closed)**
Main Switch (for control and tractive-system; CSMS, TSMS)	
Brake over-travel switch (BOTS)	
Shutdown buttons (BRB)	
Insulation Monitoring Device (IMD)	
Battery Management System (AMS)	
Interlocks (if used)	

Table 2 - Switches& devices in the shutdown circuit

Describe wiring and additional circuitry controlling AIRs. Write a functional description of operation

Total Number of AIRs:	
Coil holding current per AIR:	A
Current drawn by other components wired in parallel with the AIRs.	A
Total current in shutdown loop:	A

Table 3 - Shutdown circuit Current Draw

Provide CAD-renderings showing the shutdown circuit parts. Mark the parts in the renderings

Figure 6 – Location of Shutdown Circuit Components

If your shutdown state diagram differs from the one in the Formula Hybrid rules, provide a copy of your state diagram (commented as necessary).

Figure 7 - Shutdown State Diagram (if non-standard)

3.2 Shutdown System Interlocks

(If used) describe the functioning and circuitry of the Shutdown System Interlocks. Describe wiring, provide schematics.

Section 4 **Indicator Operation**

Person primarily responsible for this section:

Name: _____

e-mail: _____

4.1 Tractive System Active Lamp (TSAL)

*Describe the tractive system active lamp components and method of operation. Describe location and wiring, provide schematics. See **EV9.1.***

4.2 Safety Systems OK Lamp (ESOK)

*Describe the Safety Systems OK Lamp components and method of operation. Describe location and wiring, provide schematics. See **EV9.3***

4.3 Ready-To-Drive-Sound (RTDS)

*Describe your design for the RTDS system. See **EV9.2.***

Section 5 **TSMP**

Person primarily responsible for this section:

Name: _____

e-mail: _____

5.1 Tractive System Measurement Points (TSMP)

*The TSMP must comply with FH Rule **EV10.3**. Describe the TSMP housing and location. Describe TSMP electrical connection point.*

TSMP Output Protection Resistor Value	kΩ
Resistor Voltage Rating	V
Resistor Power Rating	W

Table 4 – TSMP Resistor Data

Section 6 **Cables & Fusing**

Person primarily responsible for this section:

Name: _____

e-mail: _____

6.1 Fusing & Overcurrent Protection

List data for Primary TS and GLV fuses (or circuit breakers) and cross-reference to schematic.

Mfg.	Fuse Part Number	Cont. Rating (A)	DC Voltage Rating	DC Interrupt Rating (A)	Schematic reference-designators (ref-des)

Table 5 - Fuse Table

6.2 Component Fusing

List data sheet max fuse rating for each <u>major</u> component (e.g., motor controller, dc-dc converter, etc.) Ensure that the rating of the fuse used is ≤ the maximum value for the component

Component	Max Fuse Rating per data sheet (A)	Conductor (Table 7 line number)	Installed Fuse Rating (A)	Fuse Part Number	Notes

Table 6 - Component Fuse Ratings

6.3 System Wire Tables

List wires and cables used in the Tractive System and the GLV system – (wires protected by a fuse of 1 A or less may be omitted.) Cable capacity is the value from FH Rules ***Appendix E*** *(Wire Current Capacity).*

	Mfg.	Part Number	Size AWG / mm2	Insulation Type	Voltage Rating	Temp. Rating (C)	Current capacity (A)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							

12							
13							
14							
15							
16							

Table 7 - System Wire Table

(Add additional lines as required)

Section 7 **Motors**

Person primarily responsible for this section:

Name: _____

e-mail: _____

7.1 Motor(s)

Describe the motor(s) used. Copy and Paste additional tables if multiple motor types are used

Manufacturer and Model:	
Motor type (PM, Induction, DC Brush)	
Number of motors of this type used	
Nominal motor voltage (V_{rms} l-l or V_{dc})	
Nominal / Peak motor current (A or A/phase)	Nom: / Peak:
Nominal / Peak motor power	Nom: / Peak:
Motor wiring – conductor	Table 7 Line Number:
Calculated max. road speed	MPH

Table 8 - Motor Data

Provide calculations for currents and voltages. State how this relates to the choice of cables and connectors used.

Provide a calculation of max. road speed based on motor voltage constant, nominal battery voltage, gear ratio and tire size.

7.2 Motor Controller

Describe the motor controller(s) used. Copy and Paste additional tables if multiple motor controller types are used.

Manufacturer	
Model Number	
Number of controllers of this type used:	
Maximum Input voltage:	
Nominal Input Current (A)	
Output voltage (Vac l-l or Vdc)	
Isolation voltage rating between GLV (power supply or control inputs) and TS connections	
Is the accelerator galvanically isolated from the Tractive System per **EV3.5.7 & EV5.1**?	☐Yes / ☐ No

Table 9 - Motor Controller Data

*If the answer to the last question is NO, how do you intend to comply with **EV3.5** (an external isolator is acceptable).*

Provide calculations for currents and voltages. State how this relates to the choice of cables and connectors used.

Section 8 **Isolation & Insulation**

Person primarily responsible for this section:

Name: _____

e-mail: _____

8.1 Separation of Tractive System and Grounded Low Voltage System

*Describe how the TS and GLV systems are physically separated (**EV5.3**). Add CAD drawings or photographs illustrating TS and GLV segregation in key areas of the electrical system.*

Figure 8 - TS and GLV separation

8.2 Grounding System

*Describe how you keep the resistances between accessible components below the required levels as defined in FH Rules **EV8.1**. If wire is used for ground bonding, state the AWG or mm^2 of the wire*

8.3 Conductive Panel Grounding

*If carbon fiber or coated conductive panels are used in your design, describe the fabrication methods used to ensure point to point resistances that comply with **EV8.1.2**. Describe results of*

Figure 9 - Team Designed PCB Layout

List all purchased components that have connections to both TS and GLV

Component	TS/GLV Isolation (V)	Link to Document Describing Isolation	Notes

Table 10 – Purchased Components

8.4 Isolation

Provide a list of containers that have TS and GLV wiring in them. If a barrier is used rather than spacing, identify barrier material used (reference Table 12- Insulating Materials).

Container Name	Segregation by Spacing (Y or N)	How is Spacing maintained	Actual Measured Spacing mm	Alt – Barrier Material P/N	Notes

Table 11 – List of Containers with TS and GLV wiring

*List all insulating barrier materials used to meet the requirements of **EV2.4.3** or **EV5.4***

Insulating Material / Part Number	UL Recognized(Y / N)	Rated Temperature ºC	Thickness mm	Notes

Table 12- Insulating Materials

8.5 Conduit

*List different types of conduit used in the design. Specify location and if manufacturer's standard fittings are used. Note Virtual Accumulator Housing FH Rules **EV2.12** requires METALLIC type LFMC.*

Describe how the conduit is anchored if standard fittings are not used.

Conduit Type	MFR	Part Number	Diameter Inch or mm	Standard Fittings (Y or N)	Location / Use

Table 13 - Conduit Data

*Is all conduit contained within the vehicle Surface Envelope per **EV3.1.6**? (**Y or N**).*
*Does all conduit comply with **EV3.2**? (**Y or N**).*

8.6 Shielded dual-insulated cable

*If Shielded, dual-insulated cable per **EV3.2.5(a)** used in the vehicle, provide specifications and where used:*

MFR	Part Number	Cross Section mm2	Shield grounded at	Location / Use

			both ends (Y or N)	

Table 14 - Shielded Dual Insulated Cable Data

8.7 Firewall(s)

Description/materials

*Describe the concept, layer structure and the materials used for the firewalls. Describe how all firewall requirements in FH Rules **T4.5** are satisfied. Show how the low resistance connection to chassis ground is achieved.*

***Position in car** Provide CAD-rendering or photographs showing the location of the firewall(s).*

Section 9 **Printed Circuit Boards**

Person primarily responsible for this section:

Name: _____

e-mail: _____

List all electrical circuit boards designed by team that contain TS and GLV voltage in the following table.

Device / PCB	TS Voltage Present (V)	Minimum Spacing mm	Thru Air of Over Surface	Notes

Table 15 - PCB Spacings

*Add a figure (board layout drawing) <u>for each</u> team-designed PCB showing that spacings comply with **EV5.5.***

REPLACE WITH YOUR OWN DIAGRAM OR FIGURE

Section 10 **IMD**

Person primarily responsible for this section:

Name: _____

e-mail: _____

10.1 IMD

Describe the IMD used and use a table for the common operation parameters, like supply voltage, temperature, etc. Describe how the IMD indicator light is wired. Complete the following table.

MFR / Model	
Set response value:	___ kΩ (___ Ω/Volt)

Table 16 - Parameters of the IMD

Describe IMD wiring with schematics.

10.2 Reset / Latching for IMD and AMS

Describe the functioning and circuitry of the latching/reset system for a tripped IMD or AMS. Describe wiring, provide schematics.

Section 11 **AMS**

Person primarily responsible for this section:

Name: _____

e-mail: _____

11.1 Accumulator Management System (AMS)

Manufacturer	
Model Number	
Number of AMSs	
Upper cell voltage trip	V
Lower cell voltage trip	V
Temperature trip	°C

Table 17 - AMS Data

- *Describe how the AMS meets the requirements of **EV2.11.***
- *Describe other relevant AMS operation parameters.*
- *Describe how many cells are monitored by each AMS board, the configuration of the cells, the configuration of the boards and how AMS communications wiring is protected and isolated.*
- *Describe how the AMS opens the AIRs if an error is detected*
- *Indicate in the AMS system the location of the isolation between TS and GLV*

Section 12 **Accumulator and Container**

Person primarily responsible for this section:

Name: _____

e-mail: _____

12.1 Accumulator Pack

Provide a narrative design of the accumulator system and complete the following table.

Maximum Voltage (during charging):	VDC
Nominal Voltage:	VDC
Total number of cells:	
Cell arrangement (x in series / y in parallel):	/
Are packs commercial or team constructed?	☐Commercial / ☐ Team
Total Capacity (per FH Rules **Appendix A**[2]):	kWh
Maximum Segment Capacity	MJ
Number of Accumulator Segments	

Table 18 - Main accumulator parameters

*Describe how pack capacity is calculated. Provide calculation at 2C (0.5 hour) rate. How is capacity derived from manufacturer's data? If so, include discharge data or graph here. Include Peukert calculation if used (See FH Rules **Appendix A**)*

Show your segment energy calculations. The segment energy is calculated as:

$$Vnom\ x\ Cell\ AH\ (2C\ rate)\ x\ Number\ of\ Cells\ x\ 3.6\ (kJ)$$

[2] This includes an 80% derating for available traction energy

(Note: The 80% factor is not applied for this calculation.)

12.2 Cell description

Describe the cell type used and the chemistry and complete the following table.

Cell Manufacturer	
Model Number	
Cell type (prismatic, cylindrical, pouch, etc.)	☐Yes / ☐ No
Are these pouch cells	☐Yes / ☐ No
Cell nominal capacity at 2C (0.5 hour) rate:	Ah
Data sheet nominal capacity	Ah at ___C rate
Maximum Voltage (during charging):	V
Nominal Voltage (data sheet value):	V
Minimum Voltage (AMS setting):	V
Maximum Cell Temperature (charging - AMS setting)	°C
Maximum Cell Temperature (discharging - AMS setting)	°C
Cell chemistry:	

Table 19 - Main cell specification

IMPORTANT: *Show your calculations here for 2C nominal AH capacity if the data sheet uses a different discharge rate. Refer to FH rules* ***Appendix A***

12.3 Cell configuration

Describe cell configuration, show schematics, cover additional parts like internal cell fuses etc. Describe configuration: e.g., N cells in parallel then M packs in series, or N cells in series then M strings in series.

Does the accumulator combine individual cells in parallel without cell fuses? ☐Yes / ☐ No
If Yes, explain how ***EV2.6.3*** *is satisfied.*

12.4 Segment Maintenance Disconnect

Describe segment maintenance disconnect (SMD) device, locations, ratings etc.

Is HVD used as an SMD?	☐Yes / ☐ No
Number of SMD Devices / Number of Segments	/
SMD MFR and Model	
SMD Rated Voltage (if applicable)	V
SMD Rated Current (if applicable)	A
Segment Energy (6 MJ max[3])	MJ
Segment Energy Discharge Rate (Ref FH Rules **Appendix A**)	C

Table 20 - SMD Data

12.5 Lithium-Ion Pouch Cells

The vehicle accumulator uses individual pouch cells. Yes ☐ No ☐

Note that designing an accumulator system utilizing pouch cells is a substantial engineering undertaking which may be avoided by using prismatic or cylindrical cells.

*If your team has designed your accumulator system using individual Lithium-Ion pouch cells, include drawings, photographs and calculations demonstrating compliance with all sections of rule **EV11.** If your system has been issued a variance to **EV11** by the Formula Hybrid rules committee, include the required documentation from the cell manufacturer along with a copy of the variance.*

12.6 Cell temperature monitoring

Describe how the temperature of the cells is monitored, where the temperature sensors are placed, how many cells are monitored, etc. Show a map of the physical layout. Provide schematics for team-built electronics.

Number of Cells with Temperature Monitoring	
Total Number of Cells	
Percentage Monitored $(monitored\ /\ total)$	

[3] Note *Segment energy = rated AH x nominal voltage*. The 80% derating is NOT applied for this calculation.

Percentage Required by FH Rules: **Table 11**	
If each sensor monitors multiple cells, state how many:	

Table 21 - Cell Temperature Monitoring

12.7 Accumulator Isolation Relays (AIR)

Describe the number of AIRs used and their locations. Also complete the following table.

Manufacturer	
Model Number	
Contact arraignment:	
Continuous DC current rating:	A
Overload DC current rating:	A for _____ sec
Maximum operation voltage:	VDC
Nominal coil voltage:	VDC
Normal Load switching:	Make and break up to _____ A

Table 22 - AIR data

12.8 Accumulator wiring, cables, current calculations

Describe internal wiring with schematics if appropriate. Provide calculations for currents and voltages and show data regarding the cables and connectors used. Discuss maximum expected current, whether DC or AC, and duration Compare the maximum values to nominal currents

12.9 Accumulator indicator

If accumulator container is removable, describe the voltage indicator, including indicating voltage range

12.10 Accumulator Container/Housing

Describe the design of the accumulator container. Include the housing material specifications and construction methods. Include data sheets for insulating materials. Include information documenting compliance with UL94-V0, FAR25 or equivalent.

If the housing is made of conductive material, include information on how the poles of the accumulators are insulated and/or separated from the housing, and describe where and how the container is grounded to the chassis.

*Include additional photographs if required, to illustrate compliance with rule **EV2.4.***

*Show how the cells are mounted, use CAD-Renderings, sketches or photographs showing compliance with FH Rule **EV2.4.7.***

12.11 HV Disconnect (HVD)

*Describe your design for the HVD and how it is operated, wiring, and location. Describe how your design meets all requirements for **EV2.9.***

Section 13 **Pre-charge / Discharge**

Person primarily responsible for this section:

Name: _____

e-mail: _____

13.1 Pre-Charge circuitry

Describe your design for the pre-charge circuitry. Describe wiring, connectors and cables used.

- *Include a schematic of the pre-charge circuit*
- *Include a plot of calculated TS Voltage vs. time*
- *Include a plot of calculated Current vs. time*
- *Include a plot of resistor power vs time.*

Provide the following information:

Resistor Type:	
Resistance:	Ω
Continuous power rating:	W
Overload power rating:	W for sec
Voltage rating:	V

Table 23 - Data for the pre-charge resistor

Relay MFR & Type:	
Contact arrangement: (e.g. SPDT)	
Continuous DC contact current:	A
Contact voltage rating:	Vdc

Table 24 - Data of the pre-charge relay

13.2 Discharge circuitry

Describe your concept for the discharge circuitry. Describe wiring, connectors and cables used.

- *Include a schematic of the discharge circuit*
- *Include a plot of calculated TS Voltage vs. time*
- *Include a plot of calculated "Discharge current" vs. time*
- *Include a plot of resistor power vs time.*

Provide the following information:

Resistor Type:	
Resistance:	Ω
Continuous power rating:	W
Overload power rating:	W for _____ sec
Voltage rating:	V
Maximum expected current:	A
Average current:	A

Table 25 - Discharge circuit data

Section 14 **Torque Control**

Person primarily responsible for this section:

Name: _____

e-mail: _____

14.1 Accelerator Actuator / Throttle Position Sensor

*Describe the accelerator actuator and throttle position sensor(s) used, describe additional circuitry used to check or condition the signal going to the motor controller. Describe wiring, cables and connectors used. Provide schematics and a description of the method of operation of any team-built signal conditioning electronics. Explain how your design meets all of the requirements of FH Rules **IC1.6** and **EV3.5.***

Actuator / Encoder manufacturer	
Model Number	
Encoder type (e.g.Potentiometer):	
Output:	
Is motor controller accelerator signal isolated from TSV?	☐Yes / ☐ No
If no, how will you satisfy rule **EV3.5**?	

Table 26 - Throttle Position encoder data

14.2 Accelerator / throttle position encoder error check

*Describe how the system reacts if an error (e.g. short circuit or open circuit or equivalent) is detected. Describe circuitry used to check or condition the signal going to the motor controller. Describe how failures (e.g. Implausibility, short circuit, open circuit etc.) are detected and how the system reacts if an error is detected. State how you comply with **EV3.5.4.***

Section 15 **GLV**

Person primarily responsible for this section:

Name: _____

e-mail: _____

15.1 GLV System Data

Provide a brief description of the GLV system and complete the following table

GLV System Voltage (Same as Table 1) (Note: for 2024, Rule EV1.2, the GLV may be 48V max)	V
GLV Main Fuse Rating	A
Is a Li-Ion GLV battery used?	☐Yes / ☐ No
If Yes, is a firewall provided per **T4.5.1**?	☐Yes / ☐ No
Is a dc-dc converter used from TSV?	☐Yes / ☐ No
Is the GLV system grounded to chassis?	☐Yes / ☐ No
Does the design comply with all requirements of **EV4**?	☐Yes / ☐ No

Table 27- GLV System Data

Section 16 **Charger**

Person primarily responsible for this section:

Name: _____

e-mail: _____

16.1 Charging

Describe how the accumulator will be charged. How will the charger be connected? How is the accumulator to be supervised during charging? Include a diagram showing how the charging circuit is fused.

Figure 10 – Charging Circuit with fusing

Complete the table

Charger Manufacturer	
Model Number	
Maximum charging power:	kW
Mains Isolation	☐Yes / ☐ No
Galvanically Isolated	☐Yes / ☐ No
Maximum charging voltage:	V
Maximum charging current:	A
Interface with accumulator (e.g. CAN, relay etc.)	
Input voltage:	VAC (single phase)

Input current:	A

Table 28 - Charger data

Hybrid Battery Control Methods

For hybrid vehicles, describe your on-board battery control methods including voltage and current limits. Describe method for dealing with a fully-charged pack (CV/CC algorithm etc.).

Section 17 **Appendices**

Include only highly-relevant data. A link to a web document in the ESF text is often more convenient for the reviewer.

The specification section of the accumulator data sheet, and sections used for determining accumulator capacity (FH Rules **Appendix A**) should be included here.