

Electric Vehicle Forum

- **Introduction with Hugh Chambers**
- **Technical Introduction with David Lapworth**
- **Future of Electric Karting Hugh Chambers & Rob Smedley**
- **Safety & Organisation of past, present & Future events with John Ryan**
- **Overview of the Proposed Technical Regulations with Roger Ratley & Ian Goodman**
- **Question & Answers session with a panel of experts, chaired by Garry Wilson**



Introduction

- This forum has been put together to discuss the future of Electric Vehicles (EVs) in Motorsport with key stakeholders in the sport
- We will be covering the current status of Electric Vehicles in Motorsport along with delving into the proposed Technical Regulations for Electric Vehicles in the UK

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Overview of the proposed Technical Regulations governing the use of Electric Vehicles in UK Motorsport

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1. Introduction

Introduction

- Motorsport UK have been working with representatives from the OEM's , entrants, organizing clubs, competition vehicle and component manufacturers and potential competitors to develop a policy and governance framework (incl Technical regulations) to enable EV's to compete safely in UK motorsport
- Motorsport UK is working with the clubs, promoters and venue owners to develop the requirements for the associated support infrastructure and personnel training to enable EV's to participate safely
- The Technical requirements summarized in this presentation relate to the electrified powertrain content of the vehicle only. The material contained in the “Blue Book” relating to other aspects of competition vehicles will apply: to gain an understanding of the complete Technical Requirements for an EV, both sources of information must be used
- These regulations are the “core” safety requirements for EV's. Individual category / discipline (Race, Rally, Hill Climb etc.) regulations are tbd as are the specific Sporting Regulations
- The EV Technical Regulations are work-in-progress and subject to Motorsport UK Board ratification

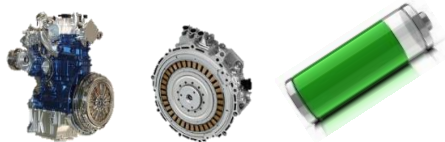
2. Permitted Vehicle Types

Electric Vehicle Types

- The term Electrified Vehicle (**EV**) covers all types of electrification as defined in FIA Appendix J – Art 251, including mild-hybrid, full hybrid, plug-in hybrid and battery electric vehicles. EV's contain high voltage (**HV**) or low voltage (**LV**) propulsion systems
- **HV systems operate at 350+v and are potentially fatal to life. Special precautions in the manufacture, operation, maintenance and handling following an incident are required**



Hybrid (HEV)



A **hybrid** vehicle uses **two** or more distinct power sources to move the vehicle. Usually an **internal combustion engine** and one or more **electric motors**. *All the energy to move and power the vehicle comes from the fuel tank*

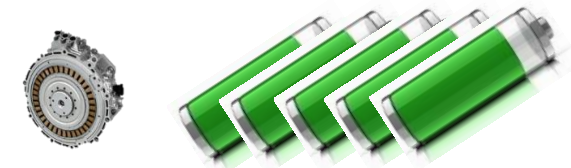


Plug-In Hybrid (PHEV)



A **plug-in hybrid electric vehicle** is a HEV with a battery that can be recharged by connecting to an external power source via a charge socket on the vehicle

Battery Electric Vehicle (BEV)



A **battery electric vehicle** uses the chemical energy stored in a rechargeable battery to power electric motor(s)

A **mild hybrid (mHEV)** is a hybrid with a smaller capacity battery which usually operates at lower voltage (**48v**)

Permitted Vehicle Types

- A **Standard** vehicle is as-built by the manufacturer in accordance with its homologation/type approval and discipline specific **safety** modifications **only** e.g. addition of ROPS and fitment of fire extinguisher and seats etc.
- A **Modified** vehicle is a standard vehicle with non powertrain modifications only
No modifications to the internal combustion engine (ICE) and/or EV powertrain are permitted
- A **Bespoke** vehicle is one designed and constructed from scratch. Only bespoke BEV's are permitted. Bespoke includes prototype or otherwise unique competition vehicles
- A vehicle with its ICE powertrain replaced by an electric one is classified as bespoke e.g. MK2 Escort with a battery electric powertrain
- The Technical Regulations cover all EV's, but not all regulations apply to all vehicles : none of the HV related requirements apply to an mHEV vehicle with a 48v battery system
- The discipline-specific Sporting Regulations will determine which category of EV's are allowed to compete in which discipline

	mild hybrid (mHEV)	hybrid ^{1/} (HEV)	plug-in hybrid ^{1/.2/} (PHEV)	electric (BEV)
Standard	Y	Y	Y	Y
Modified ^{3/}	Y	Y	Y	Y
Bespoke	N	N	N	Y
Voltage	LV	HV	HV	HV

Notes

1/. Hydrogen / fuel cell vehicles are prohibited

2/. PHEV includes range extended (REX) BEV's

3/. No modification of the Powertrain (ICE or EV) allowed.

3. Competition categories

Competition Categories

- The initial competition categories / disciplines that will permit EV's to compete are under discussion with championship organizers, venue owners and organizing clubs
- The final decision will be based on many factors including the level of risk, safety and facility readiness of the venues, level of training of all personnel involved and level of interest from competitors
- As the number of EV's on the road increases and people gain more experience of them, it is anticipated that the range of categories/disciplines open to EV's will widen
- Based on initial studies, it is anticipated that **single start speed events** (tbc hillclimbs, sprints and autotests) will be first to allow EV's followed by certain **multi start race events** followed by multi stage **rallying**. The final plan is tbc

4. Technical Regulations Overview

General

- Hydrogen powered fuel-cell hybrid vehicles are **prohibited**
- The regulations apply to any standard or modified National Type Approved or bespoke/prototype EV's intended for competition use
- Completely standard and unmodified production EV's are subject to the existing requirements of Motorsport UK and the FIA where applicable. (i.e. safety equipment (ROPS etc.)
- Additional requirements or restrictions from discipline and/or category specific regulations will apply

Definitions

- General definitions for Electric and Hybrid Vehicles shall be according to FIA Appendix J – Art 251 unless where stated otherwise
- All EV's must comply with **FIA Appendix J Art 253, Art 18**, or be fully compliant with **National Vehicle Type Approval** unless stated in the regulations.
- The formal term for a traction battery is a Rechargeable Energy Storage System (**RESS**)
- The RESS will comprise the housing, cells/cell modules, the battery management system, cooling, cabling, contactors and protection devices
- For the purposes of these EV regulations, **High Voltage (HV)** shall be as defined in FIA Appendix J Art 251 3.1.10 (from ISO 6469-1:2009) . Note: This is equivalent to the Voltage Class B definition.
 - > **30v AC** (and $\leq 1000\text{v AC}$) > **60v DC** (and $\leq 1500\text{v DC}$)

Motor and Inverter

- Only commercially available production motors and inverters are permitted. Repurposing of OEM motors and inverters is permitted. The inverter may be integrated with or separate from the motor
- Only a **single** motor controlled by a **single** inverter driving the wheels through a **single mechanical** gearbox and **single mechanical** differential is allowed (multiple motors on a common shaft are prohibited).
- Only a **single** driven axle is permitted i.e. FWD or RWD not AWD/4WD
- Hub / wheel motors are prohibited
- Any system that achieves torque vectoring across or between axles is prohibited.
- Brushed DC motors are discouraged – motors with exposed commutators must be fitted with a commutator shield
- If the motor or inverter is liquid cooled, >51% water based coolant must be used
- If the motor is air cooled, all ventilation holes must be small enough to prevent the passage of 12mm diameter spherical test object through the hole

Rechargeable Energy Storage System (RESS)

General

- Ultra (Super) capacitors and flywheel energy storage systems are prohibited
- Only a single RESS (battery pack) per vehicle
- The RESS must be installed within the survival cell, passenger compartment, engine compartment or boot
- The RESS must not be a structural or load bearing part of the vehicle
- For bespoke EV's the **maximum** total power going out of the RESS at any time is limited to **250 kW**
- For modified National Type Approved EV's the power out of the RESS may not exceed the homologated power
- For bespoke EV's, the maximum voltage on the Power Bus must never exceed **450v** at all time
- For modified National Type Approved EV's the maximum voltage must not exceed the homologated maximum voltage

RESS contd.

Enclosure

- The RESS must pass a crash test defined by Motorsport UK, or calculations must be submitted to Motorsport UK 3 months in advance of the vehicle inspection to confirm that mechanical and electrical safety is ensured in a crash. ***Test & calculation methodology defined by Motorsport UK or with Motorsport UK prior agreement***
- The RESS enclosure must be to a minimum rating of **IP65** and provide a fire barrier to **UL94-V0** standard
- Cells/modules must be mechanically secured inside a metallic or composite enclosure. Any covers or access panels must be secured with fasteners requiring tools to remove
- The RESS must be designed to prevent short circuit of the conductive parts. In the event of compartment or component deformation, the design must ensure that no fluids enter the cockpit/passenger compartment
- The RESS must prevent the build-up of an ignitable gas / dust mixture by means of a burst valve or vent tube. Any vent tube must discharge direct to atmosphere external to the survival cell/ passenger compartment
- All HV connections to the RESS must be made using either proprietary HV connectors or the cables must pass through HV approved and suitably sized and IP rated cable glands

RESS contd.

Cells

- Off-the-shelf commercially available cells / modules must may be used
- It is prohibited to modify individual cells or off-the-shelf/repurposed OEM battery modules
- The competitor must supply documents from the Cell/module producer specifying safety relevant data, including manufacturers datasheet: **UN38.3** report and **MSDS**. The certification must be forwarded to Motorsport UK 3 months in advance of the vehicle inspection
- Any type of commercially available cell chemistry is allowed subject to prior agreement from Motorsport UK. Full details of the chemistry and safety handling must be forwarded to Motorsport UK 3 months in advance of the vehicle inspection.

RESS contd.

Battery Management System

- A Battery Management System (BMS) from an approved supplier is mandatory. ***List of approved suppliers is wip***
- The enclosure containing the cells, must also contain the BMS for those cells, fuses and circuit breakers. For modified National Type Approved EV's the architecture of and functionality of the BMS must not be changed from standard.
- The BMS must ensure that all cells do not exceed the manufacturers' stated limitations for voltage or temperature under any circumstances
- The BMS must monitor every serial cell for voltage and a minimum of 25% of the cells (evenly distributed throughout the modules/pack) for temperature
- In the event that any cell exceeds the manufacturers stated limitations for voltage or temperature, the BMS must automatically isolate the battery from the traction circuit within 3 seconds.

RESS contd.

Cooling

- If the RESS is liquid cooled, >51% water based coolant must be used
- It is prohibited for the liquid to come into direct contact with any active components within the RESS

Protection

- The RESS must be capable of being isolated from the Power Circuit by at least two independent systems (e.g. contactor or a manually operated Service Switch). There must be at least one manually operated system and one automatic system (under control of the BMS)
- The RESS must include appropriately specified fuses and circuit breakers to prevent over-current in the event of short circuit. The fuses must be located inside the RESS as close as possible to the main power bus connector

Electrical Equipment and Safety

- Any EV with an electrical system, operating at a voltage exceeding 60V DC or 30V AC must display the sign detailed in **Blue Book Drawing 5.14** next to all competition numbers
- Where HV is present, symbols warning of "High Voltage" must be displayed on/ near the protective covers of all electrical equipment that can operate at high voltage.
- No HV potential should be exposed anywhere on the vehicle during normal operation. It must be ensured that a single point of failure of the electric system cannot cause an electric shock hazardous to life and the components cannot cause injury under any circumstances during normal operation or fault conditions.
- Electrical cables and electrical equipment must be protected against any risk of mechanical damage (stones, corrosion, mechanical failure, etc.) as well as any risk of fire and electrical shock.
- The HV components and wiring must comply with the applicable sections of **IEC 60664** on clearances, creepage distances (3.4.2) and solid insulation; or meet the withstand voltage capability according to the withstand voltage test given in **ISO/DIS 6469-3.2:2010**
- All parts of the HV electrical equipment must be protected using an appropriate IP class with **IP65** as a minimum



Electrical Equipment and Safety contd.

- The HV traction circuit must be isolated from the vehicle chassis
- All HV cabling must be **orange** and shielded, either internally or by conduit and must be securely fixed to the vehicle chassis using insulated fixings. Tie wraps are not acceptable
- A plug must physically only be able to mate with the correct socket of any sockets within reach. All HV Power Circuit connectors must not have live contacts on either the plug or the receptacle unless they are correctly mated
- An automatic HViL (High Voltage Interlock) system must be present in every HV connector and detect if a connector is de-mated. Remating of the connector must not re-energise the circuit
- Every part of the electrical equipment must have a minimum insulation resistance between all live components and earth of **500 Ohms per volt**
- If not part of the BMS, a proprietary isolation surveillance system must be used to continuously monitor the status of the isolation between the HV system and chassis whilst the HV system is energised. The surveillance system must be wired in series with the main battery contactors and shall open the contactors automatically if an isolation fault is detected. Details must be submitted to Motorsport UK 3 months in advance of the vehicle inspection

Electrical Equipment and Safety contd.

- At least one Emergency Stop button and one Stop Switch must be easily accessible to the driver.
- A second Emergency Stop button must be located so that it can be operated if the vehicle is on its side, or inverted. This button must latch mechanically once operated and require a manual operation to reset
- The Emergency Stop button & driver Stop Switch must act as a Circuit Breaker that interrupts **ALL** electrical transmission between the RESS and all other HV circuits by means of a spark-proof circuit breaker
- In the event that the Emergency Stop, Stop Switch or Normal Shutdown is activated, the HV potential, outside the RESS, must drop below **60V DC** with **2** seconds
- On vehicles without a 12v alternator, A DC/DC converter of suitable power rating must be provided to charge the auxiliary battery / supply the 12v electrical system
- The competitor must supply a detailed guide illustrating all aspects of the HV system including component locations and details of the standard and emergency HV isolation procedures. This document should be structured in a similar way as the OEM Emergency Services guides for production EV's. Details must be submitted to Motorsport UK 3 months in advance of the vehicle inspection.

Electrical Equipment and Safety contd.

Extinguisher switches

- There must be two exterior horizontal handles which are capable of being operated from a distance by a hook. These handles must be situated at the base of the main rollover structure on both sides of the vehicle for a single seater or at the base of the windscreen for a closed cockpit vehicle.
- A means of triggering from the outside must be combined with the general circuit breaker switches. They must be marked with a letter "E". See detailed regs for sizes

Neutral switch

- To enable the driver or other individual to isolate the RESS from the power bus in less than 2 seconds, a switch or button which operates the general circuit breaker must be provided
- In a crash, all energy sources of the Power Circuit must be switched off automatically by electric switches or contactors and the full RESS must be isolated. The arrangements must be validated by the failure mode analysis submitted 3 months ahead of the inspection and correct functionality must be demonstrated by simulation of a crash event during the inspection.
- An FIA approved Accident Data Recorder may be used to initiate the shutdown

Safety Indicators

All Bespoke/prototype vehicles with a **HV RESS** must be fitted with 2 safety indicators:

HV RESS status light

- Is in working order throughout the event even if other power systems on the vehicle have failed
- remains powered for at least 15 minutes after the general circuit breaker is activated
- For a single seater faces upwards and is recessed into the top of the survival cell
- For a saloon vehicle is fitted into the windscreen apron
- is marked with a “HIGH VOLTAGE” symbol.

Light Status	RESS Status
Green	Safe
Red	Danger (system defect)

Ready-to-Move-light

- Is a white light that illuminates to indicate that the vehicle can move if the throttle pedal is pressed
- For a single seater faces forward and is fitted to the top of the roll hoop
- For a saloon vehicle is fitted to the front roll over structure to be visible through the windscreen
- will flash “on” for 0.05 seconds and “off” for 2 seconds whilst the vehicle is charging
- will flash "on" for 0.5 seconds and "off" for 0.5 seconds if, when the system has been requested to energize and the bus voltage has not exceeded 50 V.

Light Status	Vehicle Status
Off	HV system de-energised
White always on	HV system energised – vehicle ready to move
White flashing	Charging

These requirements are aligned with the FIA for bespoke EV's including Formula E and Formula 1

Charging

- Off-board chargers must be commercially available and meet all UK Electrical safety requirements. Details must be supplied to Motorsport UK 3 months prior to the inspection
- Standard and modified vehicles must use the unmodified on-board charger, charge port and charging cable
- Charging of the battery must be done in-situ
- Bespoke vehicles must use a charging system compliant with a recognized charging standard and be able to use public chargers (**SAE J1772, IEC 62196, CHAdeMO or Combined Charging System (CCS)**) and must follow standard protocols for connecting/disconnecting the charge connector and initiating/stopping the charging process
- Bespoke vehicles must use a commercially available on-board charger (if fitted) and if liquid cooled, >51% water based coolant must be used
- **It is prohibited for any work to be carried out on the vehicle whilst the HV battery is charging**
- Any temporary charging installation must be installed and connected to the mains supply by a trained competent person following the **Code of practice for Electric Vehicle Charging Equipment Installation, 3rd edition** and meet all the requirements of **BS7671: 2018** (the 18th Edition wiring regulations), with particular attention paid to earthing
- The charging system must be automatic and must ensure that the battery cannot be overcharged or damaged if left permanently connected to the charger
- The use of diesel or petrol generators to provide the energy to charge EV's is ***strongly discouraged*** – Motorsport UK are working with circuit / venue owners to investigate provision of sustainable charging facilities

5. Electric Vehicle Passport

Electric Vehicle Passport

General

- EV's must undergo and pass an **Electric Vehicle Passport (EVP)** inspection and be in possession of a valid EVP to compete irrespective of discipline or category

	mild hybrid (mHEV)	hybrid (HEV)	plug-in hybrid (PHEV)	electric (BEV)
Standard	VP	EVP	EVP	EVP
Modified	VP	EVP	EVP	EVP
Bespoke	na	na	na	EVP
Voltage	LV	HV	HV	HV

VP Vehicle Passport
EVP Electric Vehicle Passport

- The inspection will determine if the vehicle satisfies the specific requirements relating to the safe design and construction of a competition EV
- Each vehicle must pass ALL aspects of inspection and testing before an EVP will be issued by the Motorsport UK Technical department
- The inspection will be performed by an HV qualified Motorsport UK Technical Commissioner
- All supporting data including a fully completed Technical Inspection Form must be provided to Motorsport UK 3 months prior to the inspection taking place. The inspection will not occur until all the information is submitted and deemed satisfactory
- EVP fee is **tbd** and will be borne by the entrant.

Electric Vehicle Passport

Inspection requirements

- The entrant is responsible for ensuring that the vehicle satisfies all the Motorsport UK EV requirements ***before*** presenting it for inspection: vehicles must be presented in a ***finished*** and competition-ready condition.
- Technical inspection will examine as a minimum all items included on the EV inspection Checklist.
- Inspection of Standard or Modified EV's will focus on ensuring that the installation of the ROPS and other safety systems has not compromised the EV system (HV battery damaged, HV cables must not be repositioned etc.)
- Inspection will include the off-board charging system used to charge the vehicle if required
- Demonstration of the correct function of all the indication and safety systems forms part of the inspection
- If any part of the EV system does not comply or is a concern, the entrant must correct the problem and re-present the vehicle for inspection. Minor faults may be rectified immediately, majors will require a new inspection to be arranged and paid for.
- Motorsport UK Technical Officials reserve the right to request any EV to be re-inspected at any time during an event

EV Inspection Checklist

- Photos required for Electric vehicle Passport: Battery pack (cover on and off), Inverter, motor, HV cabling, charge port and charger (if fitted), location of safety indicators, location of internal and external safety switches
- The full details of the inspection requirements and process and examples of the checklist, photos and presubmission information will be published in due course

6. Scrutineering

Scrutineering

Safety

- A valid EVP must be provided at scrutineering
- Safety scrutineering procedures will be widened to encompass visual inspection of the EV system and demonstration of correct function of the HV safety and indication systems
- The Team HV Safety Representative must be present at Safety scrutineering
- The vehicle specific Emergency Response Guide must be provided to the circuit/venue emergency services team before the vehicle is allowed to compete

Eligibility

- Motorsport UK Technical Officials reserve the right to request access to any set-up information or data from the vehicle ECU(s), Inverter, Battery Management System, Isolation Monitoring System (if separate from the BMS), and on-board charger (if fitted) at any time during an event
- It is the responsibility of the competitor to prove that the vehicle has not exceeded any control parameter limits during an event (e.g. maximum power, maximum voltage etc.)
- Motorsport UK Technical Officials reserve the right to request that the vehicle be fitted with a data logger (details tbc)
- The Team HV Safety Representative must be present at Eligibility scrutineering and be prepared to safely isolate the HV system and remove any HV components for more detailed inspection at the request of the Scrutineer
- Sealing requirements for HV system components will be developed and published in due course

7. Summary and Next Steps

Summary

- Draft Technical Regulations have been created as a framework to govern safe participation of EV's in UK Motorsport. The EV Technical regulations are subject to Motorsport UK Board ratification
- The regulations draw heavily from existing FIA regulations including the requirements in Appendix J Art 251 and 253
- All EV's will require a valid Electric Vehicle Passport(EVP) to compete, which will be issued once the vehicle passes a detailed technical inspection (focussing on but not limited to the EV system)
- EV's will be categorized into **Standard, Modified** and **Bespoke/Prototype** : Standard and modified HEV's, PHEV's and BEV's are permitted. Bespoke BEV's are permitted. Bespoke/prototype HEV's and PHEV's are prohibited
- Hydrogen powered/fuel cell vehicles and super capacitors and flywheel energy storage systems are prohibited
- Not all parts of the EV regulations apply to all categories. Discipline specific regulations will also apply
- Bespoke BEV's will be limited to 450v & 250kW with one motor/inverter driving one axle, powered by one battery
- Standard and Modified vehicles must have unmodified powertrain (ICE and EV system) as per Type Approval

Next Steps

- A copy of this presentation, the draft EV regulations, the draft EVP inspection process and checklist (with example photos etc.) will be published on the Motorsport UK website following Autosport.
- Confirmation of which categories / disciplines will allow EV's to compete will be published on the Motorsport UK website in due course and the associated Technical and Sporting regulations will then follow
- Pending ratification by the Motorsport UK board, it is planned to incorporate the full set of EV Technical and Sporting Regulations in the Blue Book from 2021 onwards
- Entrants interested in modifying a production vehicle or building a bespoke/prototype BEV to comply with the EV Technical Regulations are encouraged to familiarize themselves with the full contents of FIA Appendix J – Arts 251 and 253.
- As the Technical Regulations are subject to change, entrants are encouraged to remain in contact with the Motorsport UK technical department at all stages of an EV build project
- Comments are welcome and should be emailed to the Motorsport UK Technical Department at technical@motorsportuk.org

8. Q&A