**CAA Electric Vehicle Response Guidance**

**1. Introduction**

 1.1 With the growth in environmental awareness, the use of electric and hybrid vehicles (E&HVs) at aerodromes is increasing.

1.2 Voltages present in E&HVs are significantly higher (currently up to 650 Volts direct current (dc)) than those used in other vehicles (12/24 Volts dc).  In dry conditions, accidental contact with parts that are live at voltages above 110 Volts dc can be fatal.  For E&HVs dc voltages between 60 and 1500 Volts are referred to as 'high voltage'.  The term “high voltage” is defined differently in other industry sectors.

1.3 Battery systems may contain chemicals that can be harmful if released. They also store significant amounts of energy that can give rise to explosion if not dealt with correctly.

1.4 Manufacturers’ E&HV designs differ substantially, and the relevant technology is evolving. Aerodrome Operators should consider having information specific to the manufacturer of the E& HV vehicles used at their aerodrome e.g., the NFPA’s electric vehicle responder guides.

1.5 It is imperative that RFFS crews are aware of the risks and hazards posed by E&HVs when responding to incidents involving such vehicles.

## **2. Types of vehicles**

### 2.1 Electric vehicles

2.2 Electric vehicles use a large capacity battery and electric motor(s) to drive the vehicle.  The battery needs to be charged from the electricity supply network when the vehicle is not in use although some energy may be recovered during braking.

### 2.3 Hybrid vehicles

2.4 Hybrid vehicles typically have two sources of energy, an internal combustion engine using either diesel or petrol for fuel and a battery. Hybrid vehicles will use the two sources of power automatically and may use both simultaneously.  The internal combustion engine and energy recovered from the vehicle braking systems are used to charge the battery.

2.5 A plug-in hybrid vehicle can have its battery charged directly from the electrical supply network.

## **3. Risks Associated with Responding to E&HV Incidents**

3.1 Such risks include but are not limited to:

* Difficulty in initially identifying the vehicle as E&HV.
* The presence of high voltage components and cabling capable of delivering a fatal electric shock.
* The storage of electrical energy with the potential to cause explosion or fire.
* Components that may retain a dangerous voltage even when a vehicle is switched off.
* Electric motors or the vehicle itself that may move unexpectedly due to magnetic forces within the motors.
* The potential for the release of explosive vapours, and harmful liquids if batteries are damaged.
* When electrically driven, E&HVs are silent in operation. This could cause responders to be unaware that a vehicle is moving.

**4. E&HV vehicle incidents hazards:**

4.1 Hazards may include but are not limited to:

* Difficulty in accessing battery trays and therefore hampering the RFFS’s ability to extinguish or sufficiently cool affected batteries.
* Difficulty in identifying the individual batteries or battery groups that are involved.
* Overheating due to thermal runaway. (An accelerating increase in temperature caused by chemical reactions which may lead to fire, explosion, the pressurised release of highly flammable organic electrolyte and unpredictable fire behaviour).
* The reignition of batteries after prolonged periods.
* If thermal runaway is not stopped, the risk of explosion increases.
* Extinguishing a fire without continuing to remove heat will move the hazard from a fire to an explosion.
* There may be now warning that an explosion is about to happen. Long flame lengths will be experienced along with the hazards posed by shrapnel.
* Contaminated firefighting media run-off.
* The presence of reactive metals, such as lithium, can cause the release of explosive and toxic, explosive vapours and alkaline solution, caused by a chemical reaction with water, for example, lithium hydroxide (LiOH) and hydrogen (H2). (This can resemble steam).

**5. Operational Considerations:**

5.1 Operational considerations include but are not limited to:

* Deciding on an offensive or defensive firefighting mode.
* Identifying the type of E&HV- vehicle markings, vehicle responder information, discussion with driver, presence of orange cables (this colour is not standard however).
* Immobilise vehicle – chocks, place in neutral and apply parking brake.
* PPE & RPE– over 100 organic chemicals may be generated during an E&HV fire, including carbon monoxide and hydrogen cyanide. Li-On battery fires may produce between 500 -6000 L/kWh of vapour up to 60% of which will be hydrogen.
* RFFS crews may be faced with 2 options – extinguish the fire or let it burn out. The option chosen may depend on the type of vehicle involved and the need to protect the surrounding area.
* Establish a cordon. Current good practice suggests a minimum of 15 metres.
* Vapour release and noise from battery packs should be observed.
* The time required to extinguish E&HV fires.
* The quantity of extinguishing media and resources required to extinguish an E&HV fire.
* The possible need to contain fireground runoff.
* Use of Thermal Imaging Cameras (TIC). Results can be unpredictable however as a Li-On battery fire will absorb Infra-Red light.
* Careful use of piercing firefighting tools – piercing can make a situation worse. Direct injection of water into a battery pack has been shown to produce hydrogen and oxygen which may cause an explosion.
* Current research e.g., NFPA, has confirmed that E&HV fires do not require special equipment for fire suppression / extinguishment.
* Post incident management should be conducted in liaison with responding emergency service colleagues and vehicle recovery companies.

**6. Training**

6.1 RFFS training programmes should include but are not limited to:

* Awareness of the types of E&HVs operating at their aerodrome.
* How to recognise the types of E&HV operating at their aerodrome.
* Use of E&HV manufacturers’ emergency responder guides.
* Tactics and techniques required when responding to E&HV incidents.
* The use of suitable extinguishing agents, and equipment to deal with E&HV incidents.
* Awareness of the potential for battery re-ignition.
* Use of Thermal Imaging Cameras and their limits.
* Awareness of the quantity of firefighting media and additional resources that may be required and the time that may be needed to deal with EV incidents.
* Use of PPE & RPE.
* The use of cordons.
* Immobilising an E&HV where safe to do so.
* Awareness of high voltage cable systems and their routing within an E&HV.
* Containing firefighting runoff and liaison with environment agencies/on-site teams.
* Access to battery packs and applying extinguishing media to burning battery cells.
* Knowledge and understanding of the risks and hazards posed by thermal runway.
* Liaison/handover with Local Authority Fire & Rescue Service colleagues and use of specialist officers.
* Tactics and techniques for dealing with E&HV fires where the vehicle is plugged into a charging station.
* Liaison/handover with vehicle recovery specialists.
* Awareness of the risks posed by the extra weight of H&EVs when responding to incidents in multi-storey car parks and the possible impact on the structural integrity of such facilities.
* Awareness of the potential for rapid fire spread in all car parks.

**8. Bibliography**

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* **HSE** – [Electric and hybrid vehicles (hse.gov.uk)](https://www.hse.gov.uk/mvr/topics/electric-hybrid.htm)
* **IET** – Code of Practice for Electrical Vehicle Charging Equipment Installation, current edition. <https://electrical.theiet.org/>
* **NFCC** - [Emergency responders guide for alternatively fuelled vehicles (nationalfirechiefs.org.uk)](https://www.nationalfirechiefs.org.uk/Emergency-responders-guide-for-alternatively-fuelled-vehicles)
* **FAA** [Lithium Battery Incidents | Federal Aviation Administration (faa.gov)](https://www.faa.gov/hazmat/resources/lithium_batteries/incidents)
* **FRS National Operational Guidance** – <https://www.ukfrs.com/> Alternative Fuelled Vehicles & Environmental Agencies Response to Incidents.
* **NFPA** - [NFPA - Emergency Response Guides for Alternative Fuel Vehicles](https://www.nfpa.org/Training-and-Events/By-topic/Alternative-Fuel-Vehicle-Safety-Training/Emergency-Response-Guides)
* **EV Fire Safe** – [www.evfiresafe.com](http://www.evfiresafe.com) Paul Christensen