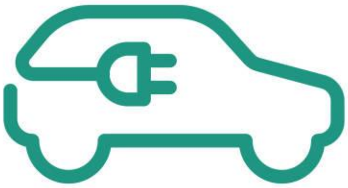
EUROPEAN MOBILITY GROUP

Safety Guidance for Installation of Mobility Aids into Electric Vehicles



FOREWORD

The European Mobility Group brings together over 50 Companies that adapt vehicles so that they can be used by people with reduced mobility.

The introduction of electric vehicles and adapting them are new challenges for the industry. For example, the large batteries in many electric vehicles make lowering the floor almost impossible. Indeed, there are technical, financial and safety challenges for the adaptation industry. First among these is safety and this guide is intended to help ensure that those who work on electric vehicles are aware of the risks and will be able to do so in a safe way.

Electric vehicles can be highly dangerous and it is essential that all those in the industry are aware of the risks and take all possible precautions to deal with them safely. This report sets out the risks, describes training requirements for those working with electric vehicles, and explains the procedures to deal with different kinds of incidents. It is recommended that all EMG companies ensure that this training is undertaken and that the safety precautions set out are rigorously observed. This publication is accompanied by a safety poster that can be hung in workshops and offices so that staff are reminded at all times of these procedures.

EMG would like to thank the MIRA consultancy and in particular Martin Brown for preparing the drafts of this report and also the members of EMG's technical committee for commenting and helping to improve the report.

We hope it will be useful to our members and also to any other companies or technical services having to deal directly with electric vehicles.

DR JACK SHORT
President EMG

EUROPEAN
MOBILITY
GROUP

Table of Contents

1 Introduction

The purpose of this document is to help provide guidance on the installation of aftermarket equipment into vehicles which have high voltage (HV) electrified traction powertrain systems.

WARNING – The electrical voltages that are used in the automotive high voltage systems on xEVs are hazardous and can cause a fatality if live components are touched.

It is unlikely that you will be required to break into or deactivate the HV systems on these vehicles to install the aftermarket equipment into these types of vehicles. The HV systems are designed to be completely isolated from the vehicle chassis and have several safety features in place to prevent you touching any live components. As such you will be able to fit the equipment using your current training and conventional tools, but it is important that you receive additional safety awareness training for EVs to understand if and when a hazard could present on these vehicles to ensure your safety.

Electric vehicles (EVs) do not pose a greater danger to you than conventional internal combustion engine (ICE) vehicles, but they are dangerous in a different way. This guidance will help you understand what these dangers are and when to recognise if a system is becoming unstable. By understanding these hazards, you will be able to plan, and risk assess your work to ensure that you can complete it in a safe manner and ensure the safety of others around you.

This document and the guidance herein, does not replace your current safety training for installations into ICE vehicles which is still valid. The information in this document provides an additional reference source to compliment your current training for professionals involved in installation of aftermarket equipment into vehicles. This document is not exhaustive and is not intended to be a training document and should not be used as an alternative for undertaking suitable training but will help you understand if additional training is required for you to safely perform your work. We do recommend that you should undertake a certified training course on EV Safety Awareness from a competent trainer before you begin working on vehicles with HV systems.

This document does not consider the hazards posed by conventional powertrains (petrol or diesel) which may also be present in the case of a Hybrid Electric Vehicle (HEV), nor does this document consider the hazards posed by the high-pressure hydrogen systems found in Fuel Cell Electric Vehicles (FCEVs).

In all circumstances, it is important to recognise the limits of your knowledge and experience. You should not attempt to work on a vehicle, especially if it could be in an unsafe condition, if you do not understand the hazards it may pose and how to effectively mitigate against them.

1.1 Definitions

AED – Automatic Emergency Defibrillator, first aid device to help those suffering cardiac arrest or heart rhythm problems.

Battery - two or more cells which are electrically connected together, fitted with devices necessary for use, for example, case, terminals, marking and protective devices.

Battery Electric Vehicle (BEV) – pure electric vehicle design using a rechargeable energy storage system (RESS) and motor. The RESS provides the only energy to power the vehicle.

Battery Module - single unit containing one cell or a set of cells electrically connected and mechanically assembled.

Battery Pack - energy storage device that includes cells or cell assemblies normally connected with cell electronics, power supply circuits and overcurrent shut-off device, including electrical interconnections, interfaces for external systems.

Battery System - energy storage device that includes cells or cell assemblies or battery pack(s) as well as electrical circuits and electronics.

Capacity - total number of ampere-hours (Ah) that can be withdrawn from a fully charged rechargeable energy storage system (RESS) under specified conditions.

Cell - collection of several aggregated components, which when assembled form an independent electrochemically active rechargeable energy storage device.

Competence - ability to apply knowledge and skills to achieve intended results.

Component - entity or system that forms a part of a larger system.

CPR – Cardiopulmonary Resuscitation, a first aid emergency procedure used to restart a person's heartbeat and breathing after one or both have stopped.

Dead - equipment that is not electrically live.

Dynamic Risk Assessment - The continuous process of identifying hazards, assessing risk, taking action to eliminate or reduce risk, monitoring and reviewing, in the rapidly changing circumstances of an operational incident.

Electric Drive - combination of an electric traction motor, power electronics and their associated controls for the conversion of electric to mechanical power and vice versa.

Electric Shock - physiological effect resulting from an electric current through a human body or animal body.

Electrocution – the consequence caused by electric shock from electric current passing through the body resulting in death or severe injury.

Electrical hazard - dangerous condition where a person might make electrical contact with energized equipment or a conductor, and from which the person might sustain an injury from shock; and/or, there is potential for the worker to receive an arc flash burn, thermal burn, or blast injury which could lead to a fatality.

Electric Vehicle (EV) – vehicle with one or more electric drive(s) for vehicle propulsion.

Emergency Response Guide (ERG) – document that provides first responders with essential safety information guidance for a vehicle in the event of an emergency situation.

Explosion - sudden release of energy sufficient to cause pressure waves and/or projectiles that might cause structural and/or physical damage to the surrounding area.

Fuel Cell Electric Vehicle (FCEV) – series hybrid vehicle design utilising a hydrogen fuel cell.

Full Hybrid Electric Vehicle (FHEV) – vehicle design were a vehicle can be powered by multiple power sources, one of which is a HV battery/motor system. Vehicle is capable of EV only mode, although this might be of a very limited range.

Fire - process in which substances combine chemically with oxygen from the air and typically give out bright light, heat, and smoke; combustion or burning.

Hazard - potential source of harm.

Hazardous live part/component - live part which, under certain conditions, can give a harmful electric shock.

HGV – Heavy Goods Vehicle (delivery vehicle, truck, lorry etc)

High (Hazardous) Voltage (HV) – means the classification of an electric component or circuit, if its working voltage is >60V and ≤ 1500V DC or >30V and ≤ 1000V AC root mean Square (rms). Lower limits are defined by UNECE Regulation 100, upper limits are defined by European Low Voltage Directive, 2014/35/EU. For Automotive purposes under ECER100 high voltage is defined as >60V DC and >30V AC.

Hybrid Electric Vehicle (HEV) - vehicle with both a rechargeable energy storage system (RESS) and a fuelled power source for propulsion. EXAMPLE: Internal combustion engine or fuel cell systems are typical types of fuelled power sources.

ICE – internal combustion engine.

Isolated – equipment which is disconnected and separated by a safe distance (the isolating gap) from all sources of electrical energy in such a way that the disconnection is secure, i.e. the equipment cannot be re-energized accidentally or inadvertently.

Leakage - escape of liquid or gas except for venting.

Li-Ion / Lithium-Ion – common term used to describe all types of rechargeable battery chemistries using the reversible reduction of lithium ions to store electricity.

Live – equipment that is at voltage by being connected to a source of electricity.

Live part - conductor or conductive part intended to be energized in normal use, but by convention not the electric chassis.

Low Voltage Directive (LVD) (2014/35/EU) – European directive on health and safety risks of electrical equipment operating with an input or output voltage of between 50-1000 VAC(rms) or 75- 1500 VDC.

Material Safety Data Sheet (MSDS) – a technical document obtained from the Supplier or Manufacture which provides detailed and comprehensive information on a controlled product. For HV systems this would be the battery cell used, this will allow staff to ascertain the chemistry being used and any potential hazards and operational limits that exist.

Medium Hybrid Electric Vehicle (MHEV) – vehicle design where a HV electric motor propulsion system is integrated into the vehicle powertrain. EV only mode is not available.

Micro Hybrid Vehicle - Vehicles with automatic Start/Stop engines which use an integrated alternator & starter motor design, these are also classed as a MHEVs.

Mild Hybrid Electric Vehicle (MHEV) – vehicle design where a 48V (or smaller voltage) electric motor propulsion system is integrated into the powertrain and is used to assist the internal combustion engine while driving. Normally EV only mode is not possible with this design.

MSD – Manual Service Disconnect, item that can be removed or operated to create an isolation gap is in the HV system to ensure the vehicle is isolated.

Ni-Mh / Nickel Metal Hydride – rechargeable battery chemistry used in many self-charging hybrid vehicles.

Parallel Hybrid – hybrid system design where multiple power sources, usually an internal combustion engine and an electrical machine, can be used to drive the vehicle either independently or in combination.

Plug-in Hybrid Electric Vehicle (PHEV) – full hybrid vehicle fitted with larger capacity traction battery that can be recharged by an external supply to provide an increased electric only vehicle range. Propulsion system - combination of power source and powertrain for vehicle propulsion.

PPE – Personal Protective Equipment, is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection

PSV – Public Service Vehicle (bus, coach etc)

RAG – safety status reporting system based on a traffic light. Red (R) – high risk, Amber (A) – medium risk and Green (G) – low risk.

Risk Assessment (RA) – a process of evaluating the potential risks that may be involved in a projected activity or undertaking. It is normally a legal requirement to do an RA for any work to comply with a country's health and safety regulations.

Range Extended Electric Vehicle (REEV or EREV) – electric vehicle of a series hybrid design which contains an additional auxiliary power supply (APU) to increase the range of the vehicle. The APU could be an ICE/generator, hydrogen fuel cell, gas turbine, cryogenic pressure etc.

Rechargeable Energy Storage System (RESS) or Rechargeable Electrical Energy Storage (REES) - rechargeable system that stores energy for delivery of electric energy for the electric drive [EXAMPLES: Battery, capacitor, flywheel].

Risk management - co-ordinated activities to direct and control an organisation regarding risk.

Safe System of Work (SSoW) – formal procedures which define the safe methods and procedures that need to be adopted during work activities to ensure that hazards are eliminated, and risks minimised. SSoWs can also be referred to as a Method Statement.

Safety - state of being protected from or unlikely to cause danger, risk, or injury.

SCBA – Self Contained Breathing Apparatus, a device worn to provide breathable air in an atmosphere that is immediately dangerous to life or health.

Series hybrid - hybrid system design where multiple power sources are installed but only the electrical machine can provide tractive effort to drive the vehicle. The additional power source, or auxiliary power unit (APU), only creates electrical energy to recharge the battery systems to extend the range of the vehicle. The APU may be a different energy vector or technology.

State Of Charge (SOC) - available capacity of a rechargeable energy storage system (RESS) or RESS subsystem expressed as a percentage of rated capacity.

State Of Health (SOH) - indication of how healthy a battery pack, module or cell is compared to its ideal conditions. *NOTE: SOH does not correspond to a particular physical quality as there is no consensus in the automotive industry on how SOH is to be determined.*

System - interacting or interdependent set of things working together and forming an integrated whole. Systems can be made up of smaller systems, or subsystems.

Traction battery - collection of all battery packs, which are electrically connected, for the supply of electric power to the electric drive and conductively connected auxiliary system, if any. A traction battery is primary RESS used in electric vehicle design.

Thermal event - condition when the temperature within the battery pack is significantly higher (as defined by the manufacturer) than the maximum operating temperature (even at reduced power). Often the term thermal event is used to describe the occasion when a battery is, or has been, on fire.

Thermal runaway - uncontrollable condition whereby a cell or battery shall overheat and reach very high temperatures in very short periods (seconds) through internal heat generation caused due to an internal short, other damage or due to an abusive condition.

VIN – Vehicle identification Number, unique code used by vehicle manufacturers to identify an individual vehicle.

xEV - a term used to describe all types and genres of hybrid and electric vehicles and all their associated sub-systems under a common definition, “x” designates a wildcard letter placement.

2 What is an xEV

There are many different types of vehicles incorporating electrified powertrains, including Battery Electric Vehicles (BEV), Hybrid Electric Vehicles (HEV), Mild/Medium Hybrid Electric vehicles (MHEV), Range Extended Electric Vehicles (REEV) and Fuel Cell Electric Vehicles (FCEV).

The term “xEV” may be used to describe any of these, with the “x” being a wild card designation for the electric vehicle variant. While there are many different types and systems used to power these types of vehicles, the hazards associated with all these electric vehicle designs are very similar. So, the term xEV is used within the guidance and documentation to incorporate all these types of vehicles. The different types of xEVs that you may come across during your work are described next.

2.1 Types of xEV

2.1.1 Micro Hybrid

Any vehicle that incorporates a start-stop system can be identified from the auto start symbol, see below, which may be visible on a dashboard indicator or initiated via a button. These cars may have a more robust starter motor system or are designed with an integral alternator/starter motor to enable the ICE to be stopped and then started again very quickly. These vehicles use an energy management system to recover energy and store it in a low voltage battery system, normally nominal 12V for passenger vehicles. These vehicles do not have any electric only power drive and the motor systems are only used to restart the ICE.

	
Start-Stop symbol	Start-Stop Button

2.1.2 Mild or Medium Hybrid (MHEV)

These vehicles are equipped with an electric motor that assists the powertrain to either improve efficiency or performance. The electric motor only works in conjunction with the ICE and never separately. Mild HEVs usually utilise low voltage (48V) systems that use either lead acid or Li-ion chemistry batteries; they generally have no EV-only drive mode although some models do have a very low speed EV creep capability. Medium HEVs usually have a high voltage (HV) system that uses a nickel metal hydride (Ni-MH) or Lithium-ion (Li-ion) chemistry battery; again they will normally have no EV only drive mode or have a restricted low speed EV capability. Mild and Medium HEVs do not have any external battery charger socket and the batteries are directly recharged from the ICE, commonly known as a self-charging hybrid.

2.1.3 Full Hybrid (FHEV or HEV)

Full hybrid vehicles incorporate an electric motor and a larger HV battery than an MHEV, that can not only assist the powertrain but can also drive the vehicle in an EV only mode. However, the batteries generally have a limited power capacity, as they are usually of the Ni-MH chemistry type. As such although they can drive in electric only mode the EV range is very limited. So, while FHEVs do have EV capability, most of the time the electric motors work in conjunction with the ICE to reduce fuel consumption and improve vehicle emissions. As with MHEVs, they do not have any external battery charger socket and the batteries are directly recharged from the ICE, commonly known as a self-charging hybrid.

2.1.4 Plug-In Hybrid (PHEV or PEV)

PHEVs are fitted with larger Li-ion batteries so that they can have an extended electric only drive range, which can range between 15 to 40 miles, dependant on the vehicle model. PHEVs Li-ion batteries can be externally charged and so there will be a charge socket on the vehicle. Although these batteries are larger than those found in FHEVs they are smaller than those found in pure electric vehicles (BEVs).

2.1.5 Battery Electric Vehicle or Pure Electric (BEV)

Battery electric vehicles (BEV) are also known as pure electric vehicles; these vehicles are only powered by electrical motors and the stored energy in their HV batteries. As such BEVs have the largest Li-ion batteries of all xEVs. As the batteries used in BEVs store the highest amount of energy and, due to their size, are more susceptible to being damaged in a severe incident and during maintenance and installation operations, then they also pose the highest risk to you.

2.1.6 Range Extend Electric Vehicle (REEV or E-REV)

An electric vehicle that also incorporates an auxiliary power unit to create additional electrical energy to extend the range of the vehicle, it is also known as a series hybrid vehicle. The auxiliary power unit electrical generator can come in various different types and technologies, e.g., petrol/diesel ICE, gas turbine, hydrogen fuel cell, etc.

2.1.7 Hydrogen Fuel Cell Electric Vehicle (FCEV, Fuel Cell or F-Cell)

The most common type of REEV is the hydrogen fuel cell vehicle (FCEV). FCEVs are effectively electric vehicles which use a hydrogen fuel cell to create the electrical energy to drive the vehicle. FCEVs use a smaller buffer HV battery as the hydrogen fuel cell will create most of the energy to propel the vehicle. Therefore, the HV battery used in these vehicles is usually of the NiMH chemistry, but Li-ion batteries can also be used. FCEVs only emissions are water vapour caused by hydrogen reacting with oxygen in the atmosphere when they create their electrical energy. FCEVs do not have external charge ports for the battery as the onboard smaller HV batteries are self-charged, but they do have hydrogen filling ports and the vehicle tanks can be refilled in about 5 to 10 minutes. This makes them ideal for larger vehicles which would require very heavy battery systems, or for vehicles that undertake longer driving distances to reduce downtime while recharging. While FCEVs are on sale in many countries, they are seldom seen as hydrogen filling stations are uncommon and so is can be difficult to refuel them. However due to the potential increase in the use of hydrogen fuel cells for delivery vans, HGVs and PSVs, the number of refuelling stations may grow which will accelerate the uptake of this technology.

3 Working SAFE (Study – Assess – Formulate – Execute)

When working on or around an xEVs we must ensure that we are working in a SAFE manner.

SAFE is an easy to remember acronym to help you remember the correct work process.

Study

It is important to initially gather information on the work you are going to undertake before you begin and understand if you are working on an xEV. Also consider the location where you will be working and the condition of the xEV to determine if this will impact the safety of your work.

Taking time to collect this information will allow any potential hazards to be identified. You should assess whether you have the necessary competence and training to deal with the situation in hand, or whether you will need additional assistance to complete the operation, especially if you believe the vehicle may be in a damaged or unsafe condition.

Assess

By using the information gathered during the Study phase, you can assess the risks and hazards for the work you will be undertaking, including those for any bystanders in the area you will be working in. Consider if these dangers can be removed or if they could cause an additional hazard to you work.

Formulate

After completing your risk assessment, you can now formulate a plan, or method statement, to ensure that you can complete your work in a safe manner. This will include consideration on how to mitigate the identified risks and reduce the likelihood of causing any additional dangers. Consideration should be given to how the plan will change if things do start to go wrong.

Execute

Execute and monitor the work plan to complete the installation process. Use a dynamic risk assessment to monitor the environment and if circumstances change, reassess the situation and modify the work plan. It will also help you to decide if further help may be needed from specialist staff or the emergency services to complete your task.

3.1 Study

The study phase is very important so that any vehicles equipped with an HV system are identified and any other hazards are recognised, as this will influence the actions needed to ensure safety. This is especially so as most xEVs outwardly may look like their petrol and diesel counterparts.

3.1.1 How to identify xEVs

There are many ways in which you can identify if you are going to be working on an xEV;

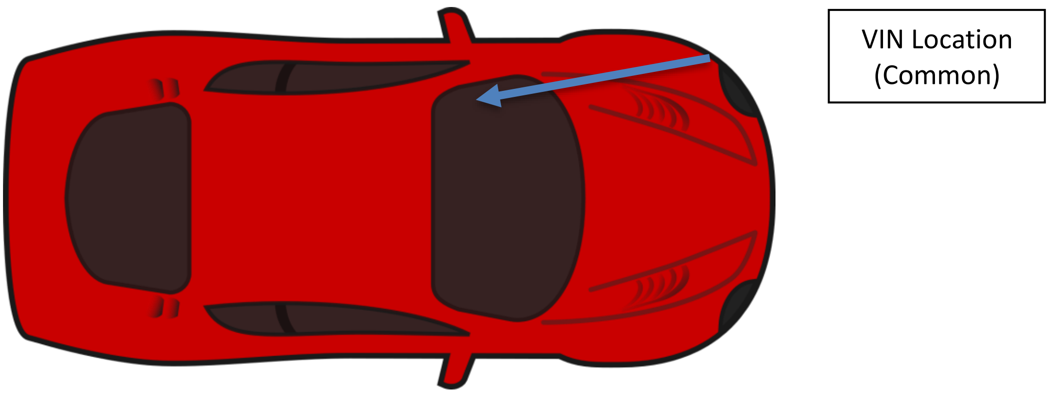
3.1.1.1 Vehicle Badging

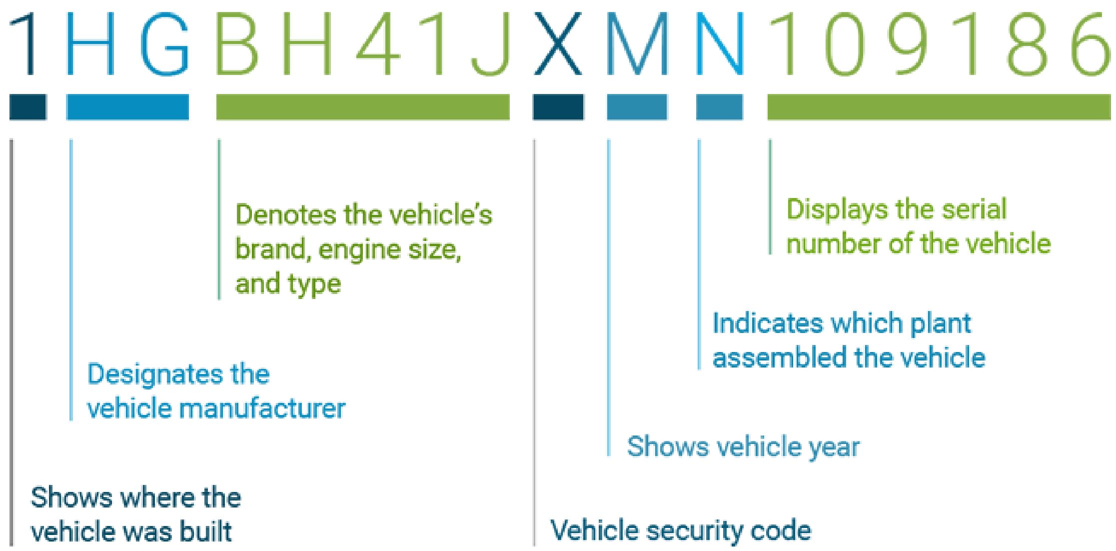
There may be vehicle labels such as "Hybrid", "PHEV", "EV" or other similar markings attached to the vehicle. Blue or blue tinged logos or body trim may also help to identify these types of vehicles, while older xEVs may have green badging or trim. Some manufacturers, such as Tesla, only produce vehicles with electric powertrains. See examples below:

However, modern vehicle marketing has now focused on selling xEVs as a direct replacement for the ICE vehicles and as such the styling of the xEVs has changed. Rather than trying to highlight an xEV and make it stand out from the others, marketing is now more subtle and tries to blend them with other vehicles on the road which can make them more difficult to identify.

3.1.1.2 Vehicle Identification Number (VIN)

All vehicles have a vehicle identification number (VIN); sometimes this is called a chassis number or frame number. The VIN is now commonly found in the bottom left of the windscreen attached to the dashboard, it is a unique 17-digit code assigned to each vehicle, if you decode the VIN one of the letters will identify what type of powertrain the vehicle has, usually this is the 8th digit.





3.1.1.3 Registration Plate

Many countries now have dedicated vehicle registration plates which will identify if the vehicle has a high voltage system installed. However, there is no standard design, and, in many countries, there is no legal requirement to display these types of plates and this is still a vehicle owner's decision. Indeed, many people may use their own personalised registration plates on their vehicles, so the absence of a dedicate EV registration plate does not indicate that a vehicle has no HV system.

In some countries, only vehicle classed as zero emissions vehicles (BEV and FCEV) are allowed to display these types of registration plates. As such other types of xEVs which still have high voltage systems installed, may not display these plates to help identification of an HV hazard.

Examples of countries vehicle registration plates are shown below:

UNITED KINGDOM (Green side stripe)

GERMANY (Blue disc and Letter "E")

POLAND (Green background)

Austria (Green letters & numbers)

Romania (Green letters & numbers)

Ukraine (Green letters & numbers)

3.1.1.4 Government website

In some countries information can be obtained from government websites when the vehicle's registration number is submitted. In the UK the vehicle enquiry service on the GOV.UK website will provide information on the vehicle fuel type to help you identify the type of powertrain.

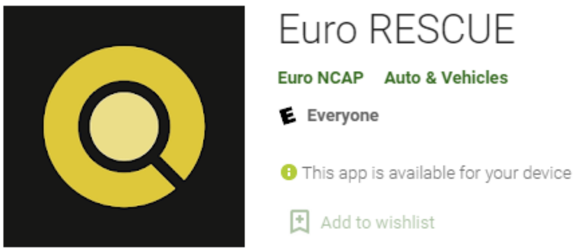
GOV.UK Website

Vehicle make	TOYOTA
Date of first registration	May 2010
Year of manufacture	2010
Cylinder capacity	1797 cc
CO_2 emissions	89 g/km
Fuel type	HYBRID ELECTRIC

3.1.1.5 Phone Apps, ERGs and Rescue Sheets

There are now several phone apps which will allow you rapid access to vehicle emergency response guide (ERG) information and rescue datasheets. These will help you to identify an xEV and provide information on the location of high voltage components and wiring and ensure that the equipment installation process will not impinge or damage the vehicle's high voltage systems.

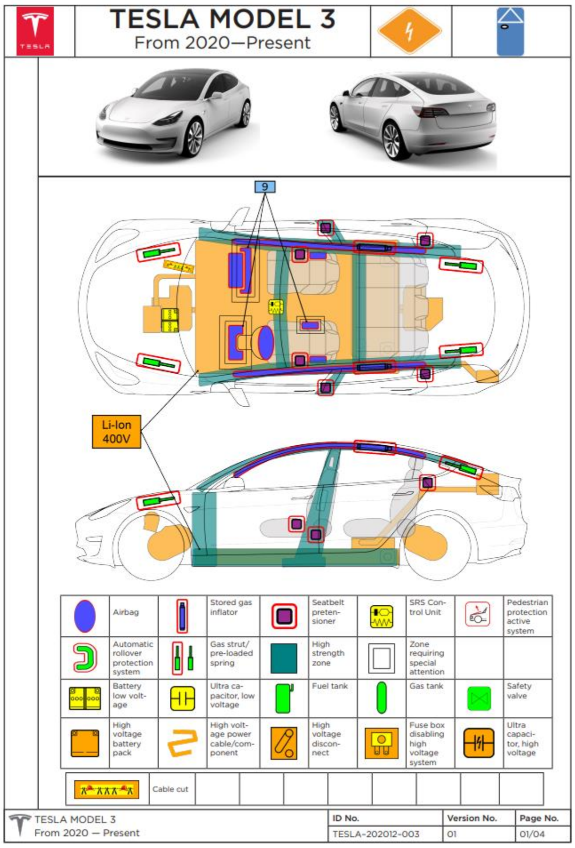
The recommended application is a free to use app called Euro RESCUE which was developed by the EuroNCAP vehicle safety group and is a comprehensive database providing safety critical information for most vehicles and models found on the public roads across Europe and is available for both iOS and Android.

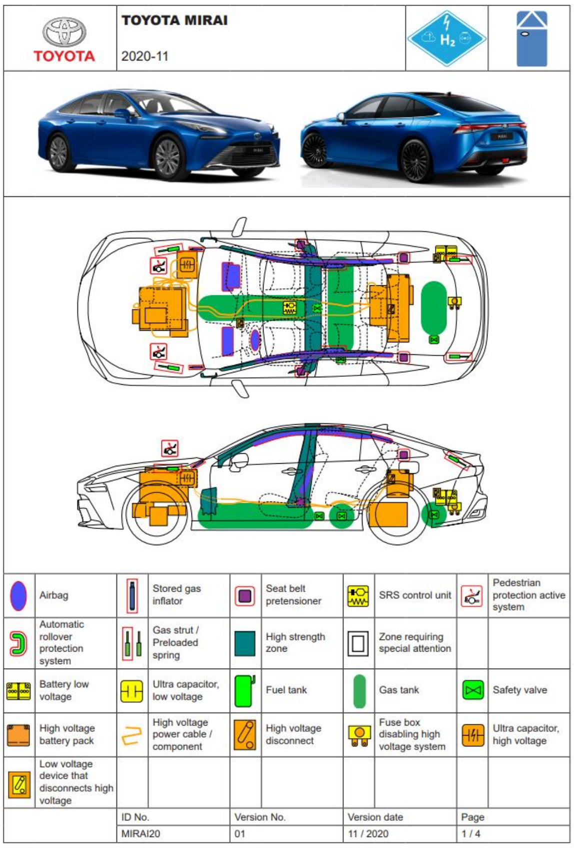


Other similar free apps are available, such as Rescuecode (French), Rescuesheet (German) and also regional variations of the Euro RESCUE app are also available, such as ANCAP RESCUE for Australia and New Zealand.

The Moditech Crash Recovery System (CRS) is also offered but, while it is a very good system, it does require an annual paid subscription to use.

The ERGs and Rescue Sheets will not only comprise a comprehensive visual image of the HV component locations but also provides safety critical emergency information; examples of a rescue sheets can be found below.





These datasheets can be accessed via the phone apps, although as these are a collected database some documents may be out of date, or some models may be missing. However, the latest versions of these documents can be downloaded from vehicle manufacturers websites directly. Use the search terms “ERG”, “Emergency Response Guide” or “Rescue Sheet” plus the name of the manufacturer of the vehicle that you require to find them online.

The ADAC website contains a list of links to the many European Manufacturers rescue sheet webpages http://rescuesheet.info/seite_3.html. This website also has translation guides into different languages as some rescue sheets may only be available in German or French.

3.1.2 Visual Inspection

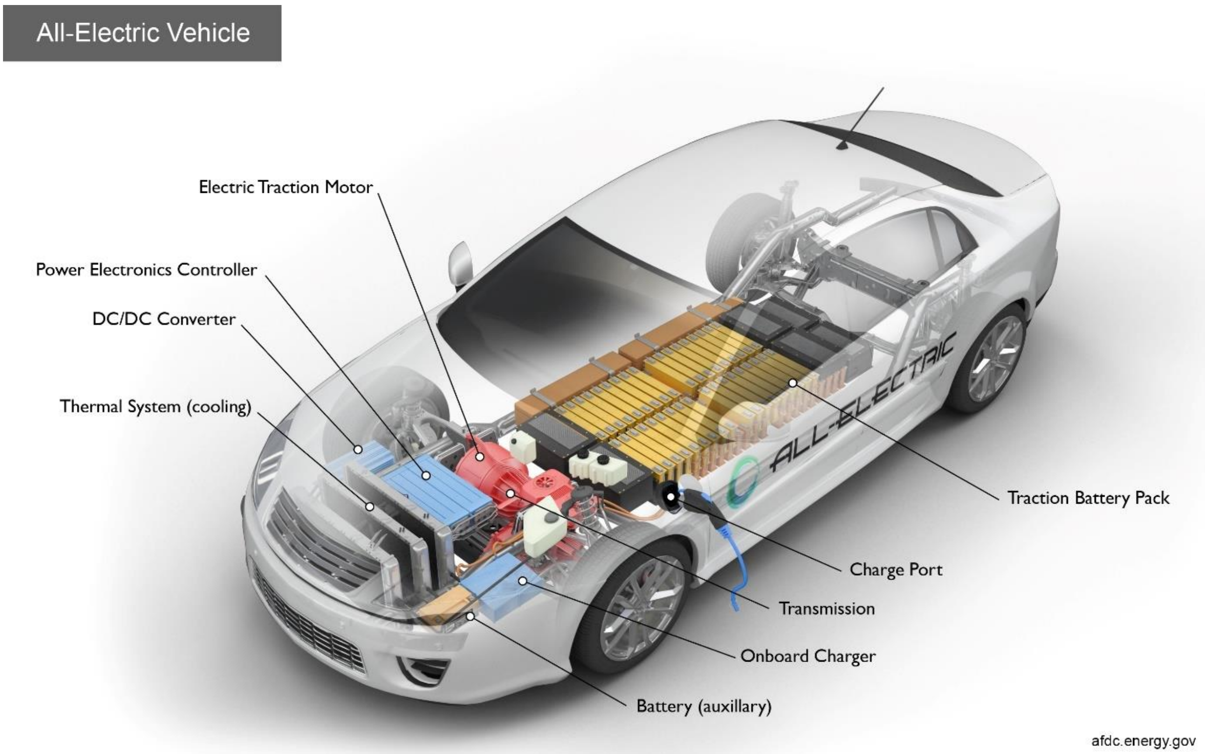
Undertaking a visual inspection of the vehicle is very important. This will enable you to decide if the vehicle is in a safe state and has not been previously damaged, and whether a high voltage powertrain system is present. For example, it may not still be clear that the vehicle is an xEV or indeed if a vehicle may have been retro fitted with a high voltage system and as such conventional documentation does not identify this hazard. You should also undertake a visual inspection of the area where you will be undertaking your work to ensure that it does not pose any additional hazards to the work you plan to commence.

3.1.2.1 Orange cables

All high voltage cables and connectors on xEVs are orange in colour and are easily identified. Mud, dirt, or snow can obscure the colour so be careful and more observant if the vehicle is in an unclean condition. This colour orange is only used on xEVs and so is a clear indication that high voltages are present on the vehicle you are working on.

3.1.2.2 HV components

There are many HV components on these vehicles which will help you to identify an xEV. Some of these components will be easily visible in or under the bonnet or boot area, while others may be more difficult to find as they may be integrated into the vehicle itself. Be aware there is no standard location for any of these components and they may be in different locations in different vehicles, even those made by the same manufacturer. The components you may find are listed below and shown in the following image:



HV Battery – The traction battery pack is needed for any xEV. For hybrid xEVs the batteries are smaller and may be often found via access into the boot area by removing plastic trim. For BEVs the battery will be large and are often fitted on the underside of the vehicle floor and integrated into the vehicle itself and so will not be easily visible other than the battery floor on the underside of the vehicle, although plastic undertrays can also prevent access or visual identification.

Invertor (Power Electronic Controller) – Converts the DC current from the battery into an AC current to power the traction motor, normally located under the bonnet and easily visible. However new technology designs are integrating the invertor into the motor itself and so may not be as visible in the future.

Traction Motor – The electric motor that drives the vehicle down the road using the battery energy. Usually difficult to find as it will be located deeper into the vehicle powertrain.

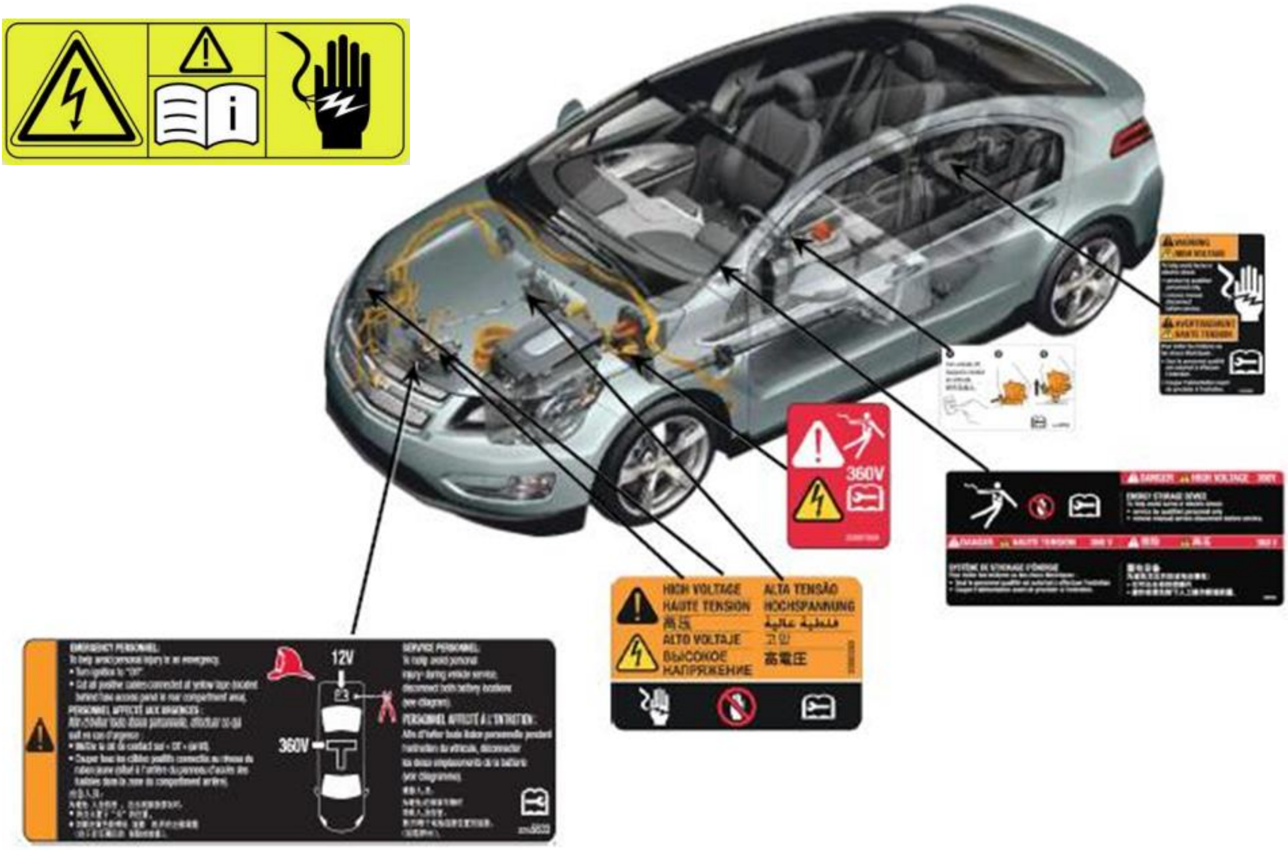
DC/DC Convertor – Drops the HV battery voltage down to a lower voltage to power the auxiliary systems on the vehicle. Usually visible under the bonnet, but some manufacturers package them into the main invertor assembly housing and so may not be visible.

Battery Charger and Battery Charge Port – xEVs have onboard chargers to recharge the onboard HV battery, and while the battery charger may be visible in the bonnet area, they can also be hidden. However, a good BEV or PHEV identification feature is the presence of an external charge port on the vehicle to connect the vehicle to an external power source. While most charge ports are visible and look similar to fuel filler flaps, some vehicle models hide the charge port under flaps integrated into the rear light cluster or under the vehicle manufacturer's logo on the front of the vehicle. Remember that many xEVs, especially HEVs and FCEVs use self-charging technology and so while a HV hazard and components are present they will not have an external charger port.

3.1.2.3 Other visual indicators

Charge Lead – When looking around the vehicle you may find a charging lead stored inside, which again will identify the vehicle as an xEV.

Warning stickers – You will find warning stickers on the vehicle warning you of any electrocution or chemical hazard on various components. The usual electrocution warning symbol that is used is the ISO standard of a lightning bolt within a yellow triangle. Chemical warning symbols may change based on the chemical hazard present.



FCEVs – Fuel cells vehicles have storage cylinders for the hydrogen which may be visible on the underside of the vehicle.

Exhaust pipe - A lack of an exhaust pipe is also a potential indication of an xEV, although remember HEVs and PHEVs will still have an exhaust pipe


Image: Freiwillige Feuerwehr Scheibbs

Gear Selector - Electric vehicles don't use a manual gearbox, so the gear lever is likely to look more like the selector of an automatic model.

Dashboard and Warning Lights – The dashboards display on xEVs will appear to be different and show different information than those seen on ICE vehicles. For instance, where a rev counter used to be, a Charge and Assist meter will show how energy is moving around the xEV systems. The dashboard will also show different warning lights from a conventional vehicle and these symbols can sometimes be different between manufacturers.

3.1.3 Equipment Installation Manuals

Ensure that you have all the latest information for the installation of any equipment that you will be fitting to the vehicle.

Before you begin work, cross reference this information with the vehicle specific ERGs/Rescue Sheets to ensure that the install process will not cause any damage to any vehicle HV systems, such as drilling into the structure for fixtures etc.

If you believe that the installation could cause damage to any HV systems, either during the installation process or at a later date, do not start the equipment fitting and refer back to either your manager, another competent person or the equipment manufacturer for additional support and guidance.

3.1.4 Work Environment

Assess the work environment and location that you will undertaking the installation and understand if this could cause any issues or problems with the task you are about to undertake.

For example, are there emergency exits available in case of a serious incident. Poor lighting may make it harder to identify HV components or cables. Check if there are any trip or slip hazards (i.e., trailing cables on the floor, or wet floors), and also check that emergency safety equipment is available (fire extinguishers. First aid) etc.

3.1.5 Vehicle Condition

An inspection of the vehicle itself should also be undertaken to assess for any hazards. Any signs of damage or abuse could indicate that the vehicle may present an additional hazard.

By using the vehicle diagrams found in the ERGs/Rescue Sheets you can assess whether any damage found could have caused impairment to the HV systems and the associated safety systems. Crush or penetration damage into the HV battery and component locations would be of concern.

If the vehicle shows signs that it has previously been submerged this would also be of concern. This could indicate potential water ingress into the battery compartment which has caused delayed ignition in previous incidents.

An example where this situation could occur would be the removal of equipment from an old, disabled, or damaged vehicle for the equipment to be refurbished and refitted into a new vehicle.

If a vehicle has been involved in a fire, then delayed reignition is possible and the vehicle can be contaminated with chemical residue from the emissions from the fire which could be hazardous to health from both touching the vehicle and breathing in particulate residue left behind on surfaces. Also due to the fire damage the HV system may be compromised, and the vehicle will need to be safely isolated by a competent person with the correct training (IMI Level 4 in the UK or DGUV 3S in Germany for live electrical working) before any work is undertaken on the vehicle.

If work on a fire damaged vehicle is required, then it is recommended that both respiratory protection equipment, which conforms to EN 140 and EN 14387; EN 405; EN 1827 and chemical gloves, conforming to EN 374, are used.

If you are concerned about the state of the vehicle condition do not start any work on it and refer to either your manager, another competent person or the vehicle manufacturer for additional support and guidance

3.2 Assess

Now that the study phase has been completed you will have sufficient information gathered to allow a risk assessment of the hazards that you could be possible exposed to for the work that you plan to undertake.

When undertaking an assessment, consider the following:

3.2.1 Training Requirements

The first thing to consider after you have gathered the information on the task to be done and the vehicle condition, is whether you have the correct training to undertake the work you plan to do.

There are many different Training providers offering xEV safety and maintenance training. Please ensure that they are competent to provide the training and can provide the mandatory legal training required for the country that you operate in.

An example of the levels of training, their equivalence to other training awards and the names of the certified authorities can be found in the Table below for selected countries. Each European country will have a different training governing body; for example, the UK authority is the Institute of the Motor Industry (IMI) and in Germany it is the Deutsche Gesetzliche Unfallversicherung (DGUV). Equivalent training qualifications can be found in most European countries, please ensure that any training meets the syllabus of these training courses.

<table>
<tr><th></th><th colspan="4">Training Level Description</th></tr>
<tr><th>Country</th><th>Vehicle Awareness</th><th>General Maintenance</th><th>HV Maintenance on Isolated System</th><th>HV Live Working & Diagnostics</th></tr>
<tr><td>UK</td><td>IMI Level 1</td><td>IMI Level 2</td><td>IMI Level 3</td><td>IMI Level 4</td></tr>
<tr><td>Germany</td><td>DGUV S</td><td>DGUV 1S</td><td>DGUV 2S</td><td>DGUV 3S</td></tr>
<tr><td>The Netherlands</td><td colspan="2">ev-VOP NEN 9140</td><td colspan="2">ev-VP NEN 9140</td></tr>
<tr><td>France</td><td>NF C 18-550
BOL</td><td>NF C 18-550
B1L & B2L</td><td>NF C 18-550
BRL & BCL</td><td>NF C 18-550
BEL</td></tr>
<tr><td>Italy</td><td>CEI EN 11-27 PAV</td><td colspan="2">CEI EN 11-27 PES</td><td>CEI EN 11-27 PEI</td></tr>
<tr><td>Sweden</td><td>E+ Level 1</td><td colspan="2">E+ Level 2</td><td>E+ Level 3</td></tr>
</table>

For most tasks the Vehicle Awareness or General Maintenance (preferred level) training will be sufficient for people to perform their work. However, if potential interaction with the HV system will be unavoidable then a higher level of training might be required, however, this will only be for a smaller core group of installers within an organisation.

3.2.2 Electrical and Electrocution Hazards

WARNING – The electrical voltages that are used in the automotive high voltage systems on xEVs are hazardous and can cause a fatality if live components are touched.

The common practice of disconnecting the low voltage supply (12V/24V) will in most circumstances also deactivate the vehicle HV systems. This is because it removes power to the battery control system and contactor which operate off the low voltage supply, and they will fail to an open safe state. Ensure that the low voltage supply cannot be inadvertently reconnected. Always refer to the ERGs safe working information as for some vehicle models this may differ.

If you believe the vehicle needs to have the HV system isolated for safe working or the HV system has been damaged during the installation process, then a competent person with a higher level of training is required to do this. They must be at least IMI Level 3 or DGUV 2S certified technician to remove the vehicle manual service disconnect device (MSD) and undertake voltage checks to verify that the system is isolated and safe.

Due to the vehicle design and the safety systems on xEVs, then it is very unlikely that you could come into contact with exposed HV cables or components. However, if the vehicle is damaged or has been unsafely dismantled, then contact with these parts could result in a fatal electrocution. If you believe that contact with a live HV component is possible, you should immediately stop work and seek the help of competently trained person with IMI Level 4 or DGUV 3S certification.

Any person working on a live electrical system, a perceived live electrical system or a system that can not to be successfully isolated must wear electrical safety gauntlets that conform to EN 60903 Class 0 (1000V).

If a person has been electrocuted, you must never put your own safety at risk. Where possible isolate the source of the electricity and if this is not possible only use a certified electrical safety hook to rescue them. Never use your bare hands or other means, i.e., broom, brush, wooden stick etc., as you may also be electrocuted.

The recommended safety hook specification is the 1kV double ended hook. Electrical safety hooks must be prominently displayed on a yellow backboard, and unobstructed for easy access in your work environment, see image below.

A person who has been electrocuted by the vehicle HV system will very likely have been very badly injured, with not only multiple exterior injuries but also unseen internal injuries. A person who has been electrocuted may experience the following injuries:

- Fatality
- Heart rhythm problems
- Cardiac arrest
- Severe burns
- Loss or amputation of body parts
- Confusion
- Muscle pain and contractions
- Broken bones
- Dislocated joints
- Seizures
- Loss of consciousness
- Neurological damage

Any person who has been electrocuted must seek professional medical help immediately, call for your local emergency medical provider to attended, see emergency numbers in Appendix 1. First aiders may be able to attend to the victim while they await for medical first responders to arrive. As electrocution can lead to cardiac arrest or heart fibrillation, AEDs may be available to help with CPR resuscitation.

3.2.3 Fire Hazards

It is very unlikely that you will encounter a fire on the vehicle. Even then it is likely to be associated with the low voltage (12V/24V) system on the vehicle.

If the fire looks to be starting from the low voltage supply (12V/24V battery) then you can successfully attack it using a suitable extinguisher to suppress the fire and stop it from spreading. Use of the ERG or Rescue sheet, which also identify the low voltage power source location, will help you identify the potential source of a fire.

Prior to a HV battery erupting in fire, a vapor cloud is released from the battery. While the cloud may look like smoke, it is actually very fine chemical droplets which can catch fire and explode in a fire ball very easily. So if you see any gas or smoke being released from the location of the HV battery, you must evacuate the area immediately to prevent you being caught in any flash over as the time between the vapour cloud being noticed to ignition can be very short.

A fire to the main HV battery is a very serve incident and you should not attempt to try and tackle this type of fire. Only trained fire service personnel with self-contained breathing apparatus (SCBA) should tackle these types of fires, see emergency numbers in Appendix 1. Trying to fight an HV battery fire would be ineffective using conventional extinguishers and expose you to potentially toxic chemicals form the fumes released.

Evacuate all people around the vehicle and retreat to a safe distance upwind of the fire as during a battery fire, or thermal event, toxic chemicals are released which can cause danger to your health.
While it is very unlikely that a xEV battery will explode in dangerous manner due to the safety systems built into it, there could be defective cells that may exploded or heard to “pop” within the battery casing. In some circumstances these cells could be ejected from a vehicle if the battery has been exposed due to damage sustained in a crash. Airbags, pretensioners and gas struts can explode or be ejected from a burning vehicle.

Current industry guidance is that a vehicle is deemed to be in a safe location if it is 15m away from any anything else.

A battery pack which is hotter than 50°C, or is seeing a temperature increase, may indicate that the battery pack is undergoing a thermal event. If this is observed, then you should stop any other actions and monitor the HV battery pack temperature until you are confident it has stabilised, and the temperature is remaining constant or is reducing.

A non-contact infrared thermometer can be used to measure the temperature of the HV battery pack. Use the ERG or other information to identify the location of the HV battery to undertake any measurements to ensure they are as accurate as possible. Due to the location of HV battery packs it may be that the easiest area to measure may be on the underside of the vehicle. It is good practice to periodically monitor and measure the battery temperature during the work task to establish if it is stable or if it is changing.

A dedicated location for xEV work should be considered, so that safety equipment can be located nearby. When considering a location in your workshop for xEV work activities, an area close to external exits is ideal, as this will enable you to quickly move a vehicle to a safer outside location or to allow the fire emergency service easier access to a unstable or burning vehicle.

Specialist vehicle fire blankets designed for lithium-ion battery fires are available. If you are trained in its use, it can be deployed over a vehicle when there is a danger of thermal runaway, for instance, if measurements show that the battery pack temperature is increasing. While the fire blanket itself will not stop a battery fire, it will contain any flame to stop a fire spreading, diminish its severity, and reduce the amount of chemicals and particulates released into the surrounding environment.

Do not attempt to deploy a fire blanket if an xEV is already on fire. Doing so risks exposure to both the fire itself and its chemical emissions. Retreat to a safe location well away from any fumes and await the emergency services to attend. If suitable RPE is available, then it should be worn for protection. Emergency services may deploy a fire blanket over the vehicle if they have staff who are trained and wearing the correct protective equipment. The vehicle blanket will help to contain any flames and control the release of chemical particulates which will help with clean-up operations.

Vehicle blankets will not prevent a thermal event but will allow the thermal event to progress in a controlled manner and the battery will decompose under high temperatures. By monitoring the outside temperature of the blanket with a thermometer, you will be able to understand if a thermal event has occurred as very high temperature of <300°C will be observed. If high temperatures are measured leave the blanket in place for at least 48 hours or until the temperature measured has dropped back to ambient. Removing the blanket too soon can result in an influx of oxygen rich air causing the fire to reignite.

Vehicles that have been damaged either in a fire, from extensive damage or submersion, have been known to reignite up to 14 days after the original incident. So always monitor damaged vehicles you are storing and keep a record of battery temperature measurements to enable you to identify if a vehicle HV system might be becoming unstable. This will provide you with a window of opportunity for you to move the vehicle to a safer location or to contact the emergency services if required.

3.2.4 Chemical Hazards

Only vehicles that have been severely damaged could expose you to any chemical contamination as the battery itself will need to have ruptured or been on fire.

We are still unsure about many of the chemical compounds which could be created during an xEV fire and further research into this area is still required. To ensure your safety we must assume that these compounds may be detrimental to your health.

If work on a fire damaged vehicle is required, then it is recommended that both respiratory protection equipment, which conforms to EN 140 and EN 14387; EN 405; EN 1827 and chemical gloves, conforming to EN 374, are used.

Badly damaged vehicles may also have compromised safety systems (i.e., melted electrical insulation etc), so the vehicle might be required to be inspected by a competent person (IMI Level 3/DGUV 2S or above) to ensure the vehicle is in a safe state to work on.

3.2.5 Moving xEVs

It is not recommended to tow xEVs on their wheels because this can cause electrical power to be generated, which can cause damage to the HV systems. Many manufacturers recommend that the vehicle should only be transported on a flat-bed truck or on a trailer, with all 4 wheels off the ground, but some may allow towing if the driven wheels are off the ground.

However, it is always permitted to tow or push an xEV a short distance provided that:

- **It is done so at walking pace,**
- **The distance is kept to a minimum, to move the vehicle to a better work location or away from immediate danger,**
- **The vehicle's transmission is in neutral and parking brake is disengaged, and**
- **The vehicle has not been visibly damaged.**

Further information on towing or pushing a vehicle may be found in the owner's manual or vehicle manufacturer's website or in the ERG for the vehicle.

3.2.6 xEVs connected to a charger

Do not undertake any work on an xEV that is connected to a charger or charging station.

3.3 Formulate

Now that you understand the situation and the potential hazards that may exist you can now finalise your work plan to ensure that you can complete it safely and not cause any additional dangers.

Follow normal installation practices but ensure that you have considered the additional hazards involved from the HV systems that you have identified in the Study and Assess phases. If required mitigate these potential dangers as far as is reasonably practicable using competent and trained staff, especially if interaction with the HV system is deemed to be required.

3.3.1 Emergency Procedure Plan (EPP)

As you formulate your work plan, you should also consider what you would do if an emergency did occur and how you would react.

A HV battery fire can occur with very little notice and so it is important to consider potential issues in advanced. This could be a lifesaver if a serious incident occurs.

A useful way to manage this is to create an Emergency Procedure Plan so that personnel know how they should react and what to do if an emergency does occur. This is a six-stage process that develops on from the initial risk assessment and make you think of potential issues that could arise in an emergency. This can be very useful if you have a dedicated workshop where you undertake your work, as you can create dedicated areas for the work to be undertaken and purchase any safety equipment or tool that you may need in advance.

Example questions that you should be considering at each stage can be found in the table below;

1 - HAZARD
Identify any potential risks or hazards that the work task may pose.
2 - PREVENTATIVE ACTIONS
List the mitigation measures in place to either remove or reduce the risks and hazards that have been identified.
3 - INITIAL RESPONSE
What will you do if an incident occurs? How will you monitor the work to assess for hazards arising during the task? What should personnel do? For example, should they evacuate immediately? Will someone be tasked with calling for the emergency services? Will someone quarantine the area to protect others? Should they try to tackle a fire, do they know understand that trying to fight an HV battery fire would be ineffective with conventional extinguishers and expose them to potentially toxic chemicals? Do they understand about the vapor cloud hazard?
4 - INHIBIT HAZARD EFFECT
Consider what other equipment is in the area that could be damaged in an incident? Can we do anything to inhibit the damage or stop the flames from spreading? Can we create a dedicated work area for xEV work, closer to building exits for ingress and egress with the correct safety equipment and tools close by? Is there a dedicated fire detection and fire extinguishing system in the area and how effective will it be? A water sprinkler system will not extinguish a HV battery fire, but it may help to prevent the spread of fire. Should you invest in a vehicle fire blanket?
5 - HAZARD RESPONSE
How will you interact with the emergency responders when they arrive?

Invite fire service in to discuss situation?

What information do you need to provide to them on arrival?

If you have a dedicated workshop, then consider creating a "Grab Pack" with information which can be given directly to the Fire Service, such as a plan of the workshop, the closest water hydrant, water run off drains etc.

6 - POST RESPONSE

How will you tell the vehicle owner?

Do you need to clean up chemical reside after an incident? You may need to get specialist cleaners in to remove the material left behind as it could be dangerous to health.

Consider what other equipment is in the area and if damaged or contaminated how that would affect your business, such as increase in insurance costs, downtime due to equipment or facilities being unavailable.

If we do have an issue could that effect the reputation of the company?

This will enable you to run a "fire drill" for an HV emergency situation prior to an incident occurring. Sometimes running drills will help you identify issues or risks that you would not normally perceive, it also increases the confidence of staff to respond to an emergency.

3.4 Execute

Now that you have a risk-based work plan in place, and you have all the information and support you require then the installation process can commence.

Always ensure that you monitor the progress of the installation and respond to any issues that may occur, such as an increase in battery temperature or unintentional damage to the HV system. An unstable HV battery can ignite very quickly and unexpectedly in a violent manner. Checking battery temperatures regularly and responding promptly to assess any unusual sounds (electrical sparking or hiss of gas release) or smells will provide you with additional time which could be critical in enabling you to reassess the situation and understand if the risk level has changed and poses a danger to you or any other bystanders.

If conditions change and you believe that risk levels have increased, then consider requesting support from specialist teams with advanced training or from emergency services if evidence suggests that a vehicle fire or thermal event could occur.

4 Conclusion & Recommendations

While xEVs are not any more dangerous than conventional vehicles, they are dangerous in a different way. By ensuring that we have adequate training and understanding of these new hazards for both normal working and emergency situations, we can ensure that this new technology will pose no danger to us and protect our world for future generations.

While the guidance in this document is very useful and will help you to develop your own work procedures and understand the new potential hazards, it cannot replace suitable training. You must ensure that the people undertaking the work have received the correct level of training for the work that they will be undertaking from a competent training provider. In many countries this is a legal requirement to ensure compliance with your country's health and safety legislation.

Always use the SAFE process when working to help you study and gather information, assess the risks you may be exposed to, formulate a safe procedure to complete your work and then execute that plan and be ready to respond if the situation changes.

Learn how to use information available, such as Emergency Response Guides and Rescue Sheet, to use in conjunction with your work procedures and equipment manuals to ensure the installation process will not cause any additional hazard to staff or cause damage to the vehicle.

Think of how you would respond in a serious situation and identify when a vehicle HV system may be becoming unstable. Create an Emergency Procedure Plan (EPP) for your workshop, this will help you to understand how an emergency would progress, how you can mitigate the severity of the incident and how you will train staff to responded to the situation. Also consider talking with your local fire service who may have additional expertise to help you.

If you are required to store a damaged vehicle, do so in a safe location as delayed reignition has been observed sometimes up to 14 days later. Recording the battery temperature on a regular basis will provide you with an early warning.

Thinking of the consequences now can be a life saver in the future. Communication is also key to ensure your staff know how to work safely and what to do in an emergency.

Never take chances, always work SAFE and stay SAFE.

Appendix 1 European Emergency Numbers

Country	Police	Ambulance	Fire
EU countries (Single Number)	112		
Akrotiri and Dhekelia	112 or 999		
Åland Islands	112		
Albania	129	127	128
Andorra	110	116	118
Armenia	112 or 911		
Austria	112 or 133	144	122
Azerbaijan	102	103	101
Belarus	102	103	101
Belgium	101 or 112	112	
Bosnia and Herzegovina	122	124	123
Bulgaria	112 or 166	112 or 150	112 or 160
Croatia	112 or 192	112 or 194	112 or 193
Cyprus	112 or 199		
Czech Republic	112 or 158	112 or 155	112 or 150
Denmark	112		
Estonia	112		
Faroe Islands	112		
Finland	112		
France	112 or 17	112 or 15	112 or 18
Georgia	112		
Germany	110	112	
Gibraltar	199 or 112 or 999	190 or 112 or 999	
Greece	100	166	199
Greenland	112		
Guernsey	112 or 999		
Hungary	112 or 107	112 or 104	112 or 105
Iceland	112		
Ireland	112 or 999		
Isle of Man	112 or 999		
Italy	112		
Jersey	112 or 999		
Kosovo	192	194	193
Latvia	112		
Lithuania	112		
Liechtenstein	117	144	118
Luxembourg	112		
Malta	112		
Moldova	112		
Monaco	17	15	18
Montenegro	122	124	123
Netherlands	112		
North Macedonia	192 or 112	194 or 112	193 or 112

Country	Police	Ambulance	Fire
Northern Cyprus	112		
Norway	112	113	110
Poland	112	999 or 112	998 or 112
Portugal	112		
Romania	112		
Russia	102 or 112	103 or 112	101 or 112
San Marino	113	118	115
Serbia	192 or 112	194	193
Slovakia	158	155	150
Slovenia	112		
Spain	112		
Sweden	112		
Switzerland	117	144	118
Turkey	112		
Ukraine	102	103	101
United Kingdom	999 or 112		
Vatican City	112		

Source: https://en.wikipedia.org/wiki/List_of_emergency_telephone_numbers#Europe

Appendix 2 EMG Members at February 2023

ACA	France
Activa Automobil-Service	Germany
Allied Vehicles	UK
AMF Bruns	Germany
API CZ	Czech Rep
API DE Gmbh	Germany
ATM	Israel
Autochair Ltd	UK
Autolift	Italy
Autoproducts DK	Denmark
B&S Autoaanpassing BV	Netherlands
Bever Car Products	Netherlands
Bierman BV	Netherlands
Bilanpassing i Staffenstorp AB	Sweden
Bozzio AG/Joysteer	Switzerland
Braunability	Sweden
Dahl Engineering	Denmark
Dhollandia	Belgium
Dijeau sarl	France
Elap	UK
ETAC Bil AS	Norway
Euromobility SL	Spain
Faiveley Vapor Ricon Europe	UK
Feal AB	Sweden
Focaccia Group	Italy
Gruau	France
Handicare AS	Norway
Handynamic	France
Handytech	Italy
Hurt s.r.l	Czech Rep
Hydrofix	Israel
Iseveien	Norway
K-automobilité	France
Kirchhoff Mobility	Germany
Lewis Reed (WAV) Ltd	UK
Lodgesons	UK
Mobilcenter Zawatzky GmbH	Germany
Mobilitatsmanufaktur Kadomo	Germany
MobilTec	Germany
MobiTEC	Germany
Morice Constructeur	France
Orion s.r.l	Italy
Pimas Orthopedie	France
Q'Straint Europe	UK

Rehatrans	Spain
Schnierle GmbH	Germany
Sojadis	France
Star Mobility	Sweden
TMN	Israel
Tribus	Netherlands
Tripod Mobility	Netherlands
Veigel Automotive	Germany
Welzorg	Netherlands