# Safe Handling of High Voltage Electrical components in Electrical End of Life Vehicles

Common Information by
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V. 2.8

Vehicles containing a high voltage Electrical System have particular removal requirements for the treatment of the high voltage system before the vehicle can be treated as a regular ELV. It is important to recognize and understand the High Voltage Electrical System and its specifications for the safe handling of the vehicle at ELV stage.

This document outlines of the safe handling of high voltage electrical components and has been compiled from information supplied by and in agreement with all car manufacturers producing vehicles with high voltage electrical systems.

## Common Information

Common Information refers to the processes of handling applicable to any manufacturer´s high voltage electrical components, such as a typical method of dismantling high voltage components.

## Manufacturer Specific Information

Manufacturer Specific Information refers to processes of handling that are specific to a vehicle installation. Please refer to the manufacturer's detailed information for additional instruction.

# Introduction

**Electric vehicle (EV)** is the umbrella term for any vehicle that is powered, in part or in full, by a high voltage battery. These vehicles may also contain a conventional combustion engine in addition to the high voltage power source.

When it comes to the disposal of Electrical End-of-Life-Vehicles (ELV), some high voltage electrical components that have not been removed may present a significant risk of injury to people due to their highly energetic properties and, because of the potentially hazardous materials they contain. They may also constitute an environmental hazard if their contents are accidentally released.

Vehicle manufacturers recommend removing the high voltage battery as the safest and most time efficient method for handling EV components. However, when dismantling any EV components from the vehicle it is absolutely essential to use utmost care and to comply with the important safety warnings listed in this document.

**Types of electric vehicles (EV) in terms of ELV treatment:**

- **Vehicles with combustion engine and an additional high voltage electrical power system.**

  There are different types like:
  - Hybrid vehicles **(HEV)**
  - Plug-in Hybrid vehicles **(PHEV)**
  - Electrical vehicles with Range Extender **(E-REV)**
  - Fuel Cell Vehicles (**FCV**)
- **Vehicles with a pure high voltage electrical power system (BEV)**

# 1. Precautions

## 1.1 General Safety Instructions for Removal of EV Components

All EV components have been manufactured in accordance with applicable international laws. They may only be removed by suitably qualified personnel who must follow appropriate procedures defined by the manufacturer, in line with national legislation and applicable safety standards, e.g. EN 50110-2.

Where ELV's with EV components are due for recycling and disposal, care must be taken to ensure that the EV components identified by the vehicle manufacturer are removed and recovered.

In addition, the national legal requirements for other sectors such as accident prevention, hazardous substances legislation, hazardous and dangerous goods, traffic, building regulations and training etc. must be observed.

Vehicle dismantlers must ensure that all employees handling EV components, and their supervisors, familiarize themselves with this information / instruction material & any additional information that may be provided in the manufacturer specific documents. It is strongly recommended to let employees confirm in writing the receipt of and familiarity with the relevant documentation and safety / handling instructions.

It is essential that all relevant health and safety regulations together with the vehicle manufacturers' instructions for the handling and safe treatment of the vehicle itself and the EV components are observed.

Information, safety and instruction materials, provided by the vehicle and EV component manufacturers, as well as the attendance of training courses can be a suitable means of acquiring the necessary expertise.

High voltage electricity is stored in the high voltage battery (commonly referred to as EV battery). Components such as an electric motor, generator, compressor, inverter, heater and air conditioner are typically part of the high voltage electric system in today's EV.

The voltage of the high voltage battery will vary according to the vehicle type and manufacturer. If fully charged high voltage batteries may have an electrical potential from 60V up to several hundred volts DC.

In addition to the high voltage battery there may be one or more standard car batteries with up to 48V DC, which are used to power other low voltage electrical devices such as the radio, horn, headlamps, and instrument cluster gauges, see battery information in IDIS.

Once removed from the ELV, high voltage batteries should not be dismantled by ELV authorized treatment facilities, unless they are permitted and trained to carry out this activity.

## 1.2 Danger of an Electric Current

An electric or hybrid vehicle is no ordinary vehicle, it can be the source of serious accidents if precautions are not taken during certain operations.

Contrary to widespread belief, the risk of electrocution is not directly linked to the voltage but depends principally on the intensity of the current (amperage) and on the length of time it takes to pass through the body.

| Amperes | Phenomenon caused | Consequences |
|---|---|---|
| 10 mA | Repulsion | Uncontrolled reaction (dropping of components) |
| Between 6 and 25 mA | Muscular contraction | Involuntary gripping of components on tough, let-go phenomenon, tetanic contraction |
| From 25 mA | Contraction of the thorax muscles (if the current passes through the upper part of the body) | Asphyxia if no action taken (artificial respiration) |
| Beyond 30 mA | Cardiac fibrillation | Fatality without immediate specialized medical attention |

Table 1: Danger of electric current

Various factors determine the amount of current which may pass through the human body:

- The voltage
- The tightness of grip (piercing of the skin)
- The contact pressure
- Perspiration
- Ambient humidity

## 1.3 Identifying an EV

Each manufacturer has their specific identification method for EV. Please refer to the manufacturer specific information for further information where available.

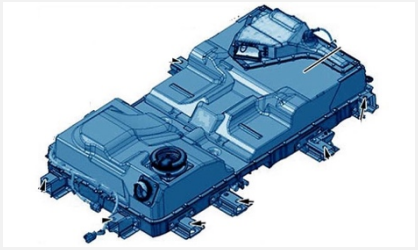
There are several common ways for manufacturers to indicate an EV model:

- Vehicle Identification Number (VIN). This number is given by the manufacturer and may indicate model specifications such as the use of a High Voltage Electrical System. You must refer to manufacturer specific information to locate and read the information contained in the VIN
- Logos/ trademarks located on the exterior or engine compartment of the vehicle indicating use of EV Technology. Specific to each manufacturer.
- Interior: Instrument cluster (power meter/ battery surveillance device) located in the dash.
- Check owner´s manual
- Check the battery area of this vehicle in IDIS

## 1.4 Location of the High Voltage Power Source Components

Electrical power source components can be placed in different locations in the vehicle, actual components and their location can be found in the manufacturer's vehicle specific information.

The general component list may include, but is not restricted to:

| | | |
|---|---|---|
| **High Voltage Battery** | 1) Individually packed battery cells<br><br>2) Integral battery system |  <br>  <br>Examples for HEV and BEV Batteries |

| | | |
|---|---|---|
| **High Voltage Cables** | Orange coloured cables that are labeled with the appropriate warning signs to indicate high voltage.<br><br>From the high voltage battery the high voltage cables are connected to the electric motor. |  |
| **Service Plug or Switch** | Deactivates and disconnects the high voltage system if fitted |  |

Table 2: Examples for EV components

## 1.5 High Voltage Caution Labels

High Voltage Alert Symbol

This symbol indicates the high voltage system components. Relevant safety precautions must be taken at all times.

## 1.6 Other Warning Labels that may be on High Voltage Batteries

## 1.7 Required Protection Equipment

Appropriate personal protective equipment as dry-electrical high voltage safety rubber gloves, safety helmet with visor, goggles, electrical hazard safety shoes, acid resistant apron. Please ensure that your personal safety equipment meets national legislation and the requirements for the specific action.

Additionally, following safety equipment should be prepared:

- Self-adhesive electrical insulation tape
- High voltage rubber insulation mats
- Safety barriers
- High voltage insulated tools
- High voltage insulated stick

Please refer to the manufacturer specific information for potential additional requirements on the protection equipment.

## 1.8 Important General Points Concerning Handling of EVs and it's battery

| | |
|---|---|
|  | The high voltage system may remain powered for up to 10 minutes after being disabled. The method of disabling the high voltage system is manufacturer specific. |
|  | Never assume that the EV is powered down because it is silent. |
|  | Never touch, cut or open any orange high voltage power cable or high voltage components without personal protective equipment. |
|  | Do not cause any impact that could potentially result in any damage. The electrolyte may be flammable and/or toxic and can be damaging to human tissue. |

| | |
|---|---|
|  | Do not have any metal objects in your possession while working on the battery. |
|  | Do not allow open flames near, apply heat to the EV battery or do not expose to high temperature, e.g. long period in direct sunlight |
|  | Do not inhale spray, gas or aerosol emitted from the battery |
|  | Avoid contact of battery contents with skin and eyes |
|  | Wear suitable protective clothing, gloves and eye/face protection |
|  | In case of accident or if you feel unwell, seek medical advice immediately (show label where possible) |
|  | Only isolate and dismantle EV vehicle systems in well ventilated areas |
|  | Avoid release of battery contents to the environment. |
|  | Always refer to additional instructions that may be given by the vehicle manufacturer. |
|  | If battery material is swallowed and the person is conscious, rinse mouth with water and seek medical advice immediately. |
|  | The EV battery is heavy, use mechanical assistance during manipulation. |

| | |
|---|---|
|  | In case of misuse or severe damage of Lithium Ion batteries there is a potential risk of heat, fire or degassing. |
|  | Components with a strong magnetic field are used in this vehicle. Operators with medical electric devices such as pacemakers must not carry out EV dismantling as strong magnetic fields can affect the function of the device. |
|  | Never connect the positive terminal to the negative terminal, and never connect the cell casing to an electrical conductor. |

Table 3: Important safety concerns

# 2. General Removal Procedures

## 2.1 Safety Precautions and Before You Start Working on the EV

- Make sure to wear your personal safety equipment and that it fits properly, is worn correctly and is not damaged in any way.
- Consult the common and manufacturer specific instructions where available
- On receiving an EV first examine the high voltage battery visually for physical, mechanical damage, intrusion and leakage. The inspection of the vehicle should be done by a person with a requisite qualification.
- If the high voltage battery is identified as damaged handle in accordance with manufacturer specific instruction and applicable national legislation and guidelines.
- Before removal of high voltage battery, ensure the area around the EV is restricted and marked.
- Place a “High voltage” sign on the vehicle, incl. the name of the person in charge for the treatment of the EV.
- It is forbidden to carry out operations or electrical checks on the electrical network when it is powered up.

## 2.2 Vehicle Inspection Before Removal of the High Voltage Battery

### 2.2.1 Fire, smoke, spark and heat check

If a visible inspection from outside of the vehicle shows or indicates fire, smoke, sparks and an increased heat of the high voltage battery a thermal reaction inside of the high voltage battery could be the reason.

In such a case the vehicle must be positioned in a quarantine area. The Layout and legal requirements for the quarantine area depend on national legislation on third party requirements such as insurance, fire protection, etc.

### 2.2.2 Flooded check

Inspect the vehicle for exposure to water at a level higher than the vehicle rocker panel.

### 2.2.3 Damage check

Inspect the vehicle for typical roll-over damages (e.g. mirror, body side and / or door is damaged together with roof damages) or deformation with deactivation of airbags.

If, however, high-voltage components or high-voltage cables are damaged in very serious accidents (e.g. exposed components, detached cables), the damaged parts should not be touched. If work at the sites of damage cannot be avoided, the damaged parts should be covered to insulate them electrically.

**In cases described in 2.2.1, 2.2.2 and 2.2.3 it is still possible that the High voltage power system will remain live due to a compromised electrical control system. If this is detected contact the manufacturer representative for further instructions.**

### 2.2.4 Leakage check

Inspect the battery pack underneath or inside of the vehicle for signs of electrolyte leakage. Electrolytic material is oilier than water, smells pungent and penetrative and causes some tussive irritation while sniffling.

Some high voltage batteries have a liquid cooling system. Inspect those underneath and in the vehicle for signs of cooling liquid leakage.

If leakage occurs, absorb the electrolyte and coolant by using conventional binding agents and proceed with utmost care.

### 2.2.5 Operational check

If the vehicle passes the checks above, inspect the vehicle for operational defects of the EV system. Does the vehicle start and / or activate the EV system and do the instruments show any errors, besides “low battery” or similar?

## 2.3 Tooling

Please ensure that your tools comply with national requirements for high voltage work. The list of tools may include, but is not restricted to:

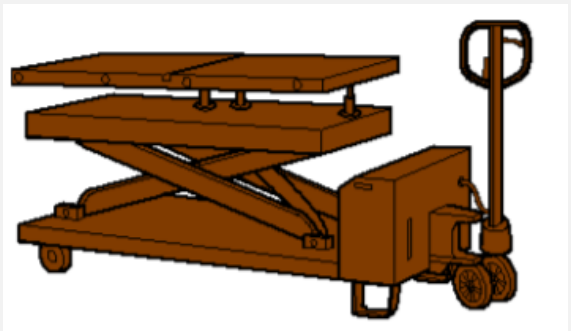
| | |
|---|---|
|   | Voltage absence verifier |
|  | High voltage isolated tooling |
|  | Scissors lift |

Table 4: Examples of tools

## 2.4 Deactivate the High Voltage Electrical System

- EV must NOT be connected to the charging cable!
- Position of the electric vehicle on a suitable lifting platform.
- Check manufacturer specific information if it is necessary to open bonnet and luggage compartment before disconnecting the starter battery.

EVs must be deactivated at **four separate steps**:

| | |
|---|---|
| **1.)** | **Switch off the ignition and remove the key / store the key at least 3m away from the vehicle.** |
| **2.)** | **Disconnect the starter battery and any other auxiliary batteries if available.** Insulate all battery terminals. Ensure that no other internal or external power source, such as slave batteries, jump start or charging equipment is connected to the vehicle. |
| **3.)** | **Remove the service plug or turning off the isolation switch and secure against reconnection.** If the service plug/ switch is not accessible, visible or available, please see manufacturer specific information. |
| **4.)** | **Ensure that the high voltage system is at zero potential by using a voltage absence verifier.** |

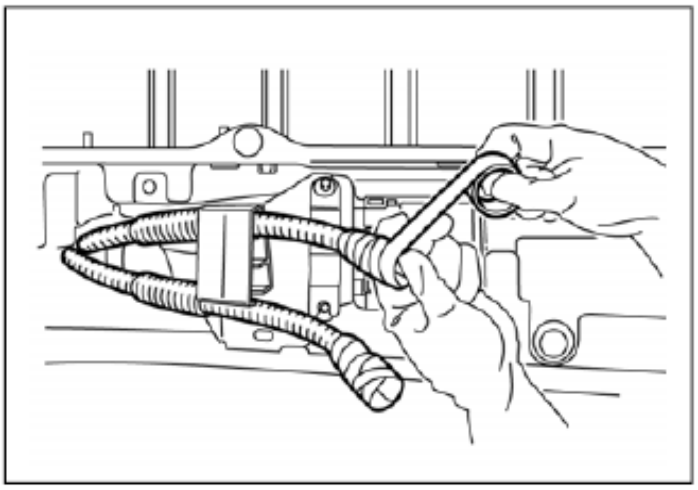
Steps 2, 3 and 4 may be different for some vehicles. Please refer to the manufacturer specific documents.

**By waiting for 10 minutes after above battery deactivation process, the high voltage electrical system external to the battery is discharged and the battery isolated. However, the high voltage battery inside the battery housing still retains its state of charge.**

## 2.5 Disconnection and Removal of the High Voltage Battery

| | |
|---|---|
|  | **Check the manufacturer specific manual for disconnection and removal of the high voltage battery.** |
|  | **Before taking any actions: Test the checking equipment e.g. the voltage absence verifier is working correctly.** |
|  | **Before disconnecting the high voltage cable terminals, make sure that the voltage between the terminals is 0 V with a suitable tool.** |

- Then, disconnect the high voltage battery connection cables from the high voltage battery.
- Insulate the vehicle high voltage battery connection cables using electrical insulation tape.



- Wrap the high voltage battery terminals with electrical insulation tape (to prevent short circuiting)
- Certain vehicles may require fitment of an insulating protection cap to the battery cable socket, please see manufacturer specific information.
- Once the high voltage battery has been removed successfully, the vehicle can then be dismantled the usual way.

# 3. Recommended Handling Procedures

Classification, Storage, packaging and transportation of high voltage batteries must only be performed by suitable, qualified personnel who must follow appropriate procedures defined by the manufacturer and in line with national and international legislation.

## 3.1 Classification of the High Voltage Battery

Once the high voltage battery has been removed from the vehicle it has to be assessed to identify possible damage and to classify it for further treatment. An unclassified high-voltage battery must essentially be treated in the same way as a defective high voltage battery.

In accordance with UN and ADR regulation a removed battery should be classified as normal /used (used, but in normal working condition), damaged or defective. The classification process uses visual / optical, thermal and functional criteria to determine whether the high-voltage battery is in a critical state. Please consult the manufacturer specific information for manufacturer and model specific handling instructions where available.

1. **Normal / used**

   The removed battery **can be** classified as normal / used when **ALL** following criteria are met:

   - No relevant mechanical damage
   - No fluid leakage
   - No perceivable increased temperature
   - No errors, described in **2.2.5 Operational Check**

2. **Damaged**

   The removed battery **must be** classified as damaged when **ONE** of the following criteria is met:

   - Mechanical or physical damage of the battery, e.g. dents, cracks, exposed contacts or conductors
   - Leakage and / or suspicion of fluids in battery system
   - Vented gas
   - Smoke, steam
   - Fire, sparks
   - Noises (hissing, crackling)

3. **Defective**

   Defective describes a high voltage battery that does not show any visible damage but has an internal defect. An internal defect can be verifiably detected only by battery diagnostics or manufacturer specific handling instructions where available.

   The removed battery **must be** classified as defective, when **ONE** of the following criteria is met:

   - The high voltage battery does not show any visible damage or other signs of a damaged high voltage battery but has not been classified by suitably qualified personnel.
   - The high voltage battery did not pass the check described in 2.2.5 Operational check, by showing errors.
   - The high voltage battery cannot be diagnosed by high voltage battery diagnosis tools.
   - Is defective according to manufacturer specific information

A classification as damaged or defective means that special requirements apply to the storage, packaging and transport of the high voltage battery.

## 3.2 High Voltage Battery Storage

The following provides a guideline to store high voltage batteries after removal from the vehicle:

- Store the battery where it will be kept dry and not exposed to high temperatures, fire and/or direct sunlight.
- Protect the battery from mechanical loads and damage (punctured or crushed).
- Batteries should be stored by battery type (i.e. NiMH), according to applicable legislation.
- Keep the battery away from water and rain.
- Never place directly on the floor. Lay a High Voltage rubber insulation mat underneath the battery.
- Always store the battery in its normally installed orientation, never invert.
- Store the battery in well ventilated areas in accordance with applicable legislation.
- Only store batteries which are sufficient insulated against short circuiting.
- Cover the battery with a high voltage rubber insulation mat.
- Mark the storage with a warning sign.
- Please refer to manufacturer specific information where available and national legislation on storage of high voltage batteries.

**Defective and damaged high voltage batteries must be stored in quarantine in a special place on the premises, monitored and marked as "DAMAGED/DEFECTIVE BATTERIES"**

### 3.3 High Voltage Battery Packaging

According to composition (e.g. Lithium-Ion, NiMH) and categorisation (used/damaged/defect) of batteries different packaging may be required. The packaging must be in line with required transport mode and applicable UN / ADR regulations.

For details please contact the manufacturer representative or follow the manufacturer specific information where available.

### 3.4 High Voltage Battery Transport

Please be aware of certain battery compositions (e.g. Lithium-Ion) being subject to dangerous goods transportation regulations.

For details please contact the manufacturer representative or follow manufacturer specific information where available.

### 3.5 Take back of batteries

Please follow the national take back schemes or check the manufacturer specific information for manufacturer take back scheme where available.