



Basic information about risks posed by high-voltage vehicles & systems and measures taken in terms of occupational health & safety – general part designed to provide information about such risks & measures to employees of ŠKODA AUTO a.s., employees of work agencies and business partners providing services on ŠKODA AUTO sites.

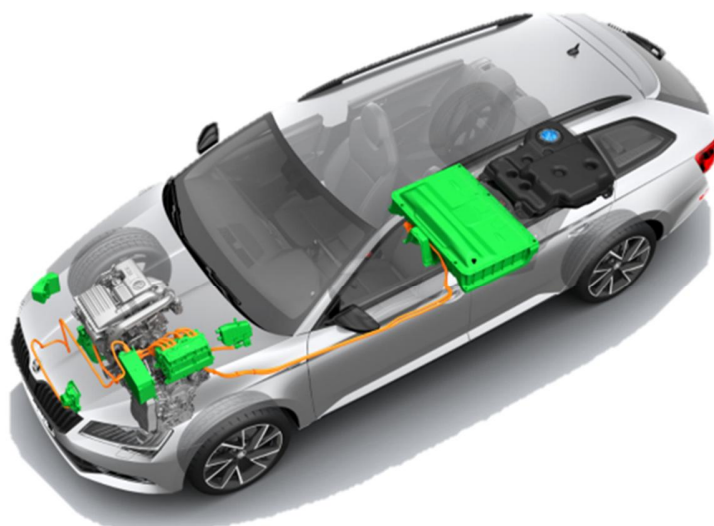




Table of contents

1	Scope of applicability	3
2	Terminology	3
3	Risk factors	4
3.1	Electrical threats	4
3.1.2	Electric arc risks	5
3.2	Chemical threats	6
3.3	Physical-and-chemical treats (risk of fire and explosion)	6
3.4	Thermal threats	6
3.5	Magnetic threats	6
4.	Required qualifications	6
5.	Protective measures	7
5.1	General technical protective measures	7
5.2	Organisational protective measures.....	8
6.	Battery systems	8
7.	Proper conduct in case of emergency (danger)	8
7.1	Electric current injury	8
7.2	Identification of a damaged HV-battery system.....	8
7.3	Protective measures in case of HV-system damage	9
7.4	Damaged HV-components	9

1 Scope of applicability

This occupational health & safety (OHS) information applies to all operations involving various high-voltage systems (HV-systems), including but not limited to HV-battery systems, drivetrains and vehicles. Besides direct work on HV-systems, such operations also include "subsidiary operations", such as installations and replacements of HV-components as part of manufacturing processes, storage, transportation and logistics operations on production plant sites.

2 Terminology

Electric vehicle

Vehicle powered by an electric traction motor. The usual source of energy is a battery system. If the vehicle is fitted with another drivetrain system, e.g. a combustion engine, it is called hybrid vehicle.

High voltage (HV)

High voltage (HV) is voltage of above 30 V of alternating voltage or 60 V of direct voltage in a vehicle; this voltage is used primarily to power the vehicle (drivetrain unit).

HV-safe vehicle

A HV-safe vehicle is a vehicle featuring technical solutions designed to fully protect employees from contact with the vehicle's HV-system and its electric arc.

Non-electrical operations

Non-electrical operations and operations on HV-vehicles and systems that are not performed directly on HV-components or in their immediate vicinity (such as operations on the bodywork, padding installations, vehicle operation).

Electrical operations on HV-systems

Electrical operations on HV-systems are operations performed on or with HV-systems or in HV system hazard areas, such as tests and measurements, repairs, replacements, installations or checks.

Under-voltage operations on HV-systems

Under-voltage operations on HV-systems are any operations on vehicles' HV-systems as part of which the employee concerned touches, whether with parts of their body or with objects (tools, instruments or equipment), parts/components under voltage, or operations in cases where the vehicle is not in voltage-free condition. Under-voltage operations include work on a battery system with the removed cover – during its manufacture, diagnostics and repairs.

Electrical risk

Operations on HV-systems pose an electrical risk, if the voltage between active parts exceeds 30 V (alternating current) or 60 V (direct current) and if the short-circuit current at the point of work exceeds 3 mA (alternating current) or 12 mA (direct current) or if the electric-charge energy exceeds 350 mJ.

Informed staff members (under Section 3 of Decree No. 50/1978 Coll.)

Informed staff members are persons that have been made familiar by the organisation, to the extent of their responsibilities, with regulations governing the handling of electrical equipment and have been warned of possible threats posed by such equipment. These staff members are aware of their responsibilities, the required protective measures and the required personal protection equipment and work aids.

Instructed staff members (under Section 4 of Decree No. 50/1978 Coll.)

Instructed staff members are persons that have been made familiar by the organisation, to the extent of their responsibilities, with regulations governing operations on electrical equipment, trained in such operations, warned of possible threats posed by such equipment and made familiar with first aid processes relevant to electric current injuries. These staff members are entitled to perform repeated operations on operating equipment that are described in the instructions for use.

Knowledgeable staff members, staff members entitled to perform independent work, staff members entitled to manage outsourced operations and operation management staff members (under Sections 5.6.7 and 8 of Decree No. 50/1978 Coll.)


These staff members have relevant technical education and have passed an exam to the extent required under this Decree. Based on their qualifications, experience and knowledge of relevant standards and legislation, these staff members are able to evaluate tasks assigned to them and assess potential risks.

Special-case qualifications (under Section 11 of Decree No. 50/1978 Coll.)

Staff members of science, research and development institutes that have university education, passed exams in electrical engineering, electronics or physics as part of their training, or passed a secondary-technical-school final exam in electrical engineering or nuclear physics, and do experimental work on listed science, research or development sites are considered to be staff members entitled to perform independent work, provided that, after induction training, they have passed the exam under this Decree (to the required extent).

3 Risk factors

3.1 Electrical threats:

<p>None of our sense organ warns us when we get near conductive components under voltage.</p>	<p>A human is unable to perceive threats posed by electric current!</p>
 <p>Warning against dangerous electric voltage</p>	<p>A human is unable to:</p> <ul style="list-style-type: none"> • smell • taste • feel • hear • see <p>electric current</p>

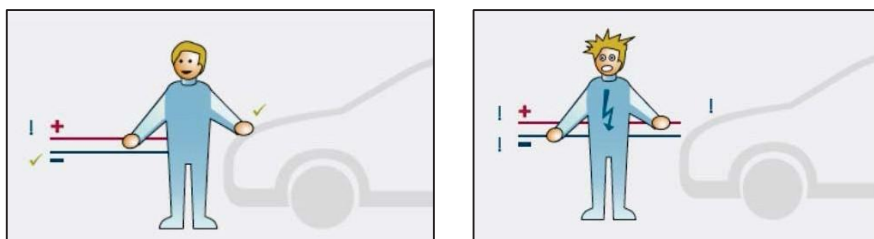
Vehicles with HV-systems are fitted with components that operate at voltage levels of over 30 V (alternating voltage) or 60 V (direct voltage). Such vehicle components need a high electrical output, and that is why HV-networks in electric cars operate at life-threatening voltage levels.

If we touch a HV-component under voltage, the electric current may flow through our body. Depending on the duration of such flow, even direct-current levels of approximately 30 mA may cause reversible heartbeat disorders. Higher currents flowing through a human body cause serious inner burns and pose a risk of ventricular fibrillation.

Besides the above, a short circuit on both poles of a high-voltage system may generate an electric arc that may cause serious bodily burns and eyesight damage. Moreover, inhalation of burned gases may cause serious inner injuries.

3.1.1 Current flow through human body

The HV-system is galvanically separated from the vehicle's body. The current will only flow through a human body if the person concerned touches two points within the HV-system that have different potentials – in such case the current circuit gets closed.



The character/seriousness of harmful effects of such flow through a human body depends on the intensity and duration of the electric current impact.

The consequences of an electric current injury may include:

- Irritation of the nervous and respiratory muscular systems;
- Muscular spasms;
- Heart arrhythmia that may cause ventricular fibrillation;
- Burns at the points where the current enters and exits the body;
- Tissue disintegration in case of a long impact;
- Secondary consequences: incorrect reactions, shock-induced injuries.

3.1.2 Electric arc risks

Conductive materials (such as tools, watches, jewellery) may cause a short circuit between the two poles of the HV-system and thus generate an electric arc. The central part of the electric arc features temperatures of above 1,000 °C and high-intensity brightness, which poses a risk of serious burns, eyesight damage and fire.

3.2 Chemical threats

The battery cell electrolyte contains dangerous chemicals. The manufacturer's safety instructions/instructions for use have to be complied with at all times.

Basically, the rules listed below apply to electrolytes of all cell types:

- Avoid skin contact;
- Avoid eye contact;
- Avoid inhalation;
- Avoid swallowing.

3.3 Physical-and-chemical treats (risk of fire and explosion)

A defect, excessive charging or short circuit may substantially increase the temperature inside the cell. That may cause an increase in the pressure of the electrolyte and a leak of the electrolyte, including toxic products of the electrolyte disintegration. Besides that, the process may generate hydrogen that, together with the highly flammable carbon monoxide, may generate a highly explosive mixture.

Once the disintegration products have been released, work can only be resumed after on-site measurements performed by firefighters.

3.4 Thermal threats

The surroundings of HV-systems pose threats in connection with hot surfaces, e.g.:

- The electric motor warms up to ca 60°C when the vehicle is in motion;
- The interior-heating process may increase the temperature in the heating system to as much as 90°C.

3.5 Magnetic threats

When opening the electric motor compartment, persons with active implants (e.g. pacemakers) may get endangered by the strong magnetic field generated by the permanent magnets. A strong magnetic field may also be generated in the event of a short circuit in the high-voltage circuit.



No access for persons
with pacemakers

4. Required qualifications

Staff members are only allowed to perform HV-system operations for which they are sufficiently qualified. The scope of the required qualifications depends, among other factors, on the degree of electrical risks that occur in their work and on their historical expertise. Staff members with expertise regarding HV-systems are allowed to perform electrical engineering operations exclusively on vehicles for which they have received type-specific or conceptual training.

The requirements for theoretical and practical qualifications depend on the work responsibilities concerned and the outcome of the risk assessment performed. The Company's system of compulsory training relating to electric mobility is governed by internal policies.

The scope of necessary instructions is determined by the specifications of the vehicle or system concerned.

5. Protective measures




5.1 General technical protective measures

- The HV-system is electrically insulated from the vehicle's earth and all other electrical systems;
- The terminal box is secured against contact;
- All HV-components are interconnected with pilot wires (they switch off the battery contactors);
- Isolation covers that can only be opened using a tool;
- HV-battery system control unit (BMS) with hardware separation of power circuits;
- Protective interconnection (potential levelling) of component and body covers;
- Orange HV-cables;
- Targeted discharging of residual energy in condensers;
- Comply with safety instructions and instructions for use when recharging the HV-battery system

Colour-coded identification and warnings:

- Built-in VN-components are fitted with warning labels;
- All VN-cables in the vehicle's electrical system are orange

Hands off all orange cables!

Warning symbol on VN components	Warning symbol in the engine compartment	Warning symbol on the VN battery
		

5.2 Organisational protective measures

- The various operations and vehicles are subject to compliance with the respective manuals, instructions for use and safety instructions & manuals;
- Requirements for under-voltage operations have to be complied with at all times (e.g. staff selection, use of required personal protection equipment, use of suitable tools and auxiliary devices).
- After disconnecting the HV-system and in cases where HV-safety is not guaranteed the vehicle shall be fitted with an information sheet.

- Under-voltage operations and operations performed near under-voltage components:
 - Wearing electrically conductive objects (e.g. rings, watches, chains) is prohibited;
 - No access for persons with electronic life- and health-maintaining devices located on or inside their body;
 - All staff are required to use insulated tools;
 - All staff are required to use suitable tools and/or auxiliary devices;
 - In the event of HV-danger the work site shall be properly marked or separated using mobile barriers.

6. Battery systems

Individual cells and HV-battery systems can only be kept, handled and/or stored in selected locations. All staff are required to comply with individual packaging- and storage-related rules/instructions.

7. Proper conduct in case of emergency (danger)

7.1 Electric current injury

- Put your own safety first!
- Call for first aid;
- Disconnect the electric circuit and rescue the person concerned from the electric current source, using non-conductive aids;
- Continue providing first aid until the doctor's arrival.



Warning against dangerous electric voltage

7.2 Identification of a damaged HV-battery system

- Pungent odour;
- Liquid/steam/smoke leak;
- Sparking;
- Increased surface temperature.



Warning against battery-induced dangers



ŠKODA

7.3 Protective measures in case of HV-system damage

- Avoid inhaling the vapours;
- Avoid skin contact;
- Evacuate the site and close it;
- Call the firefighters;
- Provide first aid;
- Inform the person in charge and your superiors.

7.4 Damaged HV-components

If any HV-components get damaged (bulges or cracks on the cover or connector, damaged insulation, damaged cable bend), disconnect the HV-system, mark the vehicle or the site and inform the staff member in charge or your superiors.

Component diagram:

