Volvo Buses electric safety

SAFETY AND ELECTRIC BUSES

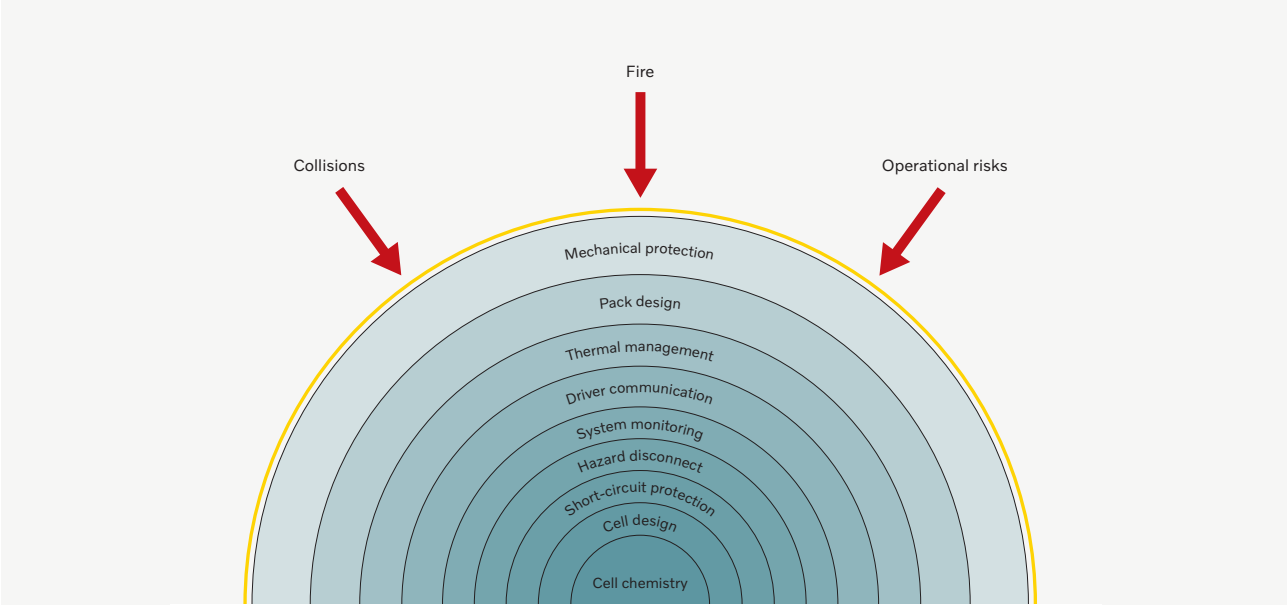
Volvo Buses

VOLVO

Contents

A holistic safety architecture

The introduction of electric buses means a technology shift, and with that comes a degree of uncertainty – especially for new users. Electric buses and conventional buses have mostly the same safety-related features – but important differences include the driveline and the energy storage. This is why Volvo's safety architecture starts at the core and includes all aspects of the vehicle's design.



The integrated Volvo safety system
Safety is not just about specific features and systems, it's also about how they interact. If something untoward should happen, one thing can lead to another. That's why the entire vehicle, from the core of battery cells to the overall vehicle design is seen as one system.

Safety functions
Already in each battery cell there is preventive functionality. On module and pack levels, there are sensors and autonomous functions that prevent escalation in the event of damage. And on vehicle level, all functions are monitored so that the driver, and the traffic control, can be alerted if a risk is detected.

Driver communication
The driver's main assignment is to take the passengers to their destination, safely and on time. The integral safety system in a Volvo electric bus will only alert or warn when a direct driver intervention is required. Avoiding redundant information helps the driver to stay focused.

Regulations and standards
Vehicle safety is subject to a wide range of regulations. For electric powertrains, the R100 standard, with its different versions, is central to automotive manufacturers, and is often mentioned in tender documents. The standard describes a multitude of parameters to be considered and tested. All electric vehicles from Volvo Buses are R100 compliant.

For test methods and procedures there are several international standards. One example is the SAE J2464, which describes a body of tests which may be used as needed for abuse testing of electric or hybrid electric vehicle Rechargeable Energy Storage Systems (RESS).
https://unece.org/sites/default/files/2024-01/R0100r3e.pdf
https://www.sae.org/standards/content/j2464_200911/

For more information, contact your Volvo Buses dealer.

Risk factors

There are no indications that electric buses present more risks than conventional buses. All vehicles involve risks, but electric differ from diesel and gas. The main risks fall into four categories relating to: operations, collisions, fire and service.

Operational risks

Li-Ion batteries are sensitive to operational misuse such as overcharging and excessive discharge. Overcharging can occur if faulty or unsuitable charging equipment is used, or if safety procedures are neglected. However, in a Volvo EV there are several layers of safety functions, with the aim of preventing the harmful effects of such misuse.

Collisions

In the event of a collision, a massive impact could damage high-voltage cables and floor mounted batteries. Roof mounted batteries could be damaged at a roll-over accident. If the vehicle rolls over, roof-mounted batteries could be damaged. And if this damage is sufficiently serious, there could be leakage, and, at worst, a fire caused by internal shortcuts. Traction battery packs weigh hundreds of kilos and can be a risk for other road users in the event of a collision, unless securely fastened to the body structure.

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Fire

It is important to underscore that electric vehicles are not more prone to catch fire than ICE vehicles. In fact, available data suggests the opposite. Reported data* indicates that the fire incident frequencies for EVs are generally 8–20 times lower than for ICE vehicles. However, the statistical data is limited. In the event of an electric vehicle catching fire, it will burn for longer, but more slowly, and the time to peak intensity is longer than for an ICEV. This is because damaged battery cells release electrolyte gradually, while a ruptured diesel or gas tank can cause a very intense fire or even an explosion.

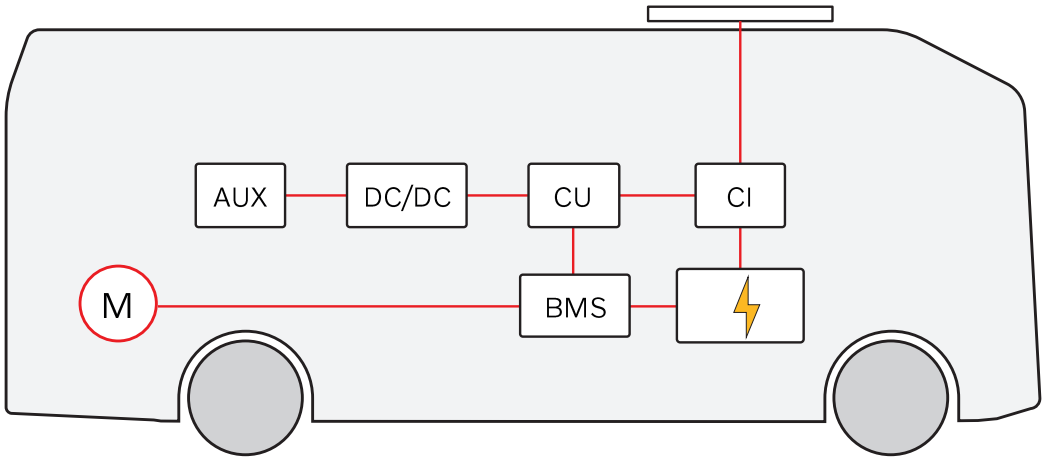
Service

In depots and workshops, the 600V components can be accessed by the service staff. Although Volvo buses have several layers of protection, is present in a Volvo bus, the risk of an electric shock can not be ignored. This is why only certified technicians can perform maintenance on high-voltage components.

** Report from RISE : Electric Trucks – Fire Safety Aspects Jonna Hynynen, 2023-06-26.*

ESS monitoring process

Battery health and performance are crucial factors in electric buses. The battery management system regulates charging and discharge current, and controls the cooling and heating of the battery installations, to ensure the optimal conditions for the batteries.



Monitoring

The central unit, CU, and the battery management system, BMS, continuously performs functional monitoring of temperature, current and pressure on cell, package and system level. Monitoring is performed by several parallel systems. Should any threshold value be exceeded, the power will be switched off.

The safety window

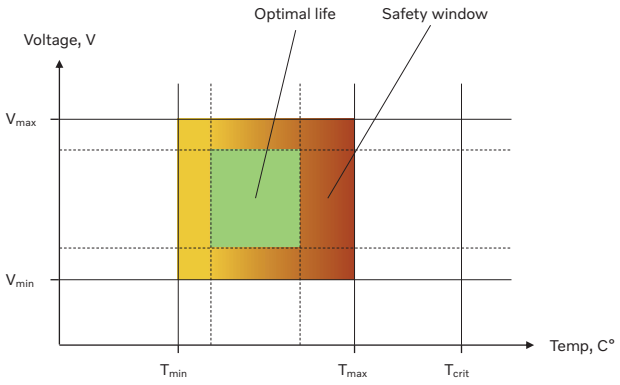
The safety window is a visualization of the battery cell's functional environment. It has a defined range for temperature and voltage, within which operation is safe. Deviations from these values will affect both performance and lifetime:

- Temperature: If the temperature remains above the safety limit, or frequently exceeds it, a cell internal short might occur which in turn is leading to gas venting or thermal runaway.
- Voltage: Voltage outside the safety window will slowly degrade the cell, and could cause a safety concern.

Active control

To keep the cell in optimal condition, and well within the safety window, the CU and BMS continuously:

- monitor temperature and voltage
- control cooling
- control voltage/current
- activate warning and control functions if parameters are outside the safety window
- disconnect battery in case of hazard



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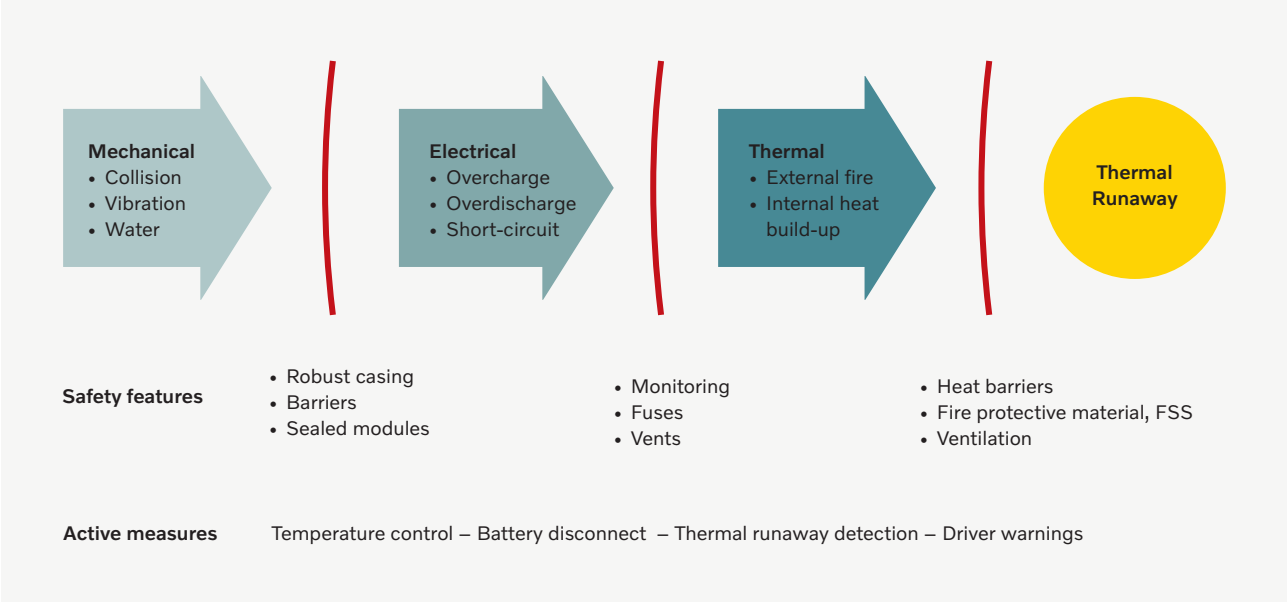
A chain of protective functions

Energy storage must always be protected from all kinds of abuse. Damage to a battery can lead to several risk scenarios and escalation of events. This is why Volvo electric buses have several levels of safety functions that will stop the progression of problems.



The hazardous chain of events

The battery cell is at the center of electric safety. Mechanical damage can lead to electrical problems, resulting in internal heat, and, in the worst case, thermal runaway and ultimately fire.

Mechanical barriers

The battery cell is mechanically protected from collision, vibration and water immersion. Main features are the sealed module casing, the robust steel casing of the battery pack and the collision barriers and energy absorbing structures of the chassis design.

Electrical barriers

If there is a pressure increase in a battery cell, it will automatically disconnect and will no longer be part of the energy storage. This will also happen if voltage outside the permitted interval is detected. At high pressure, a safety vent will open. For the entire battery pack, fuses will disconnect it from the circuitry.

Thermal barriers

A battery cell has a defined range for temperature and voltage, within which the operation is safe. During operation, the entire energy storage system is temperature controlled by a separate cooling/heating liquid-based system. If the temperature rises, adjacent cells and modules are protected by heat-resistant materials.

Active measures

The temperature control of batteries actively reduces the risk of malfunction. In addition, the safety system monitors several parameters and will disconnect batteries to remove further abusive conditions. The system also actively detects signs of thermal runway, and activates warnings to the driver.

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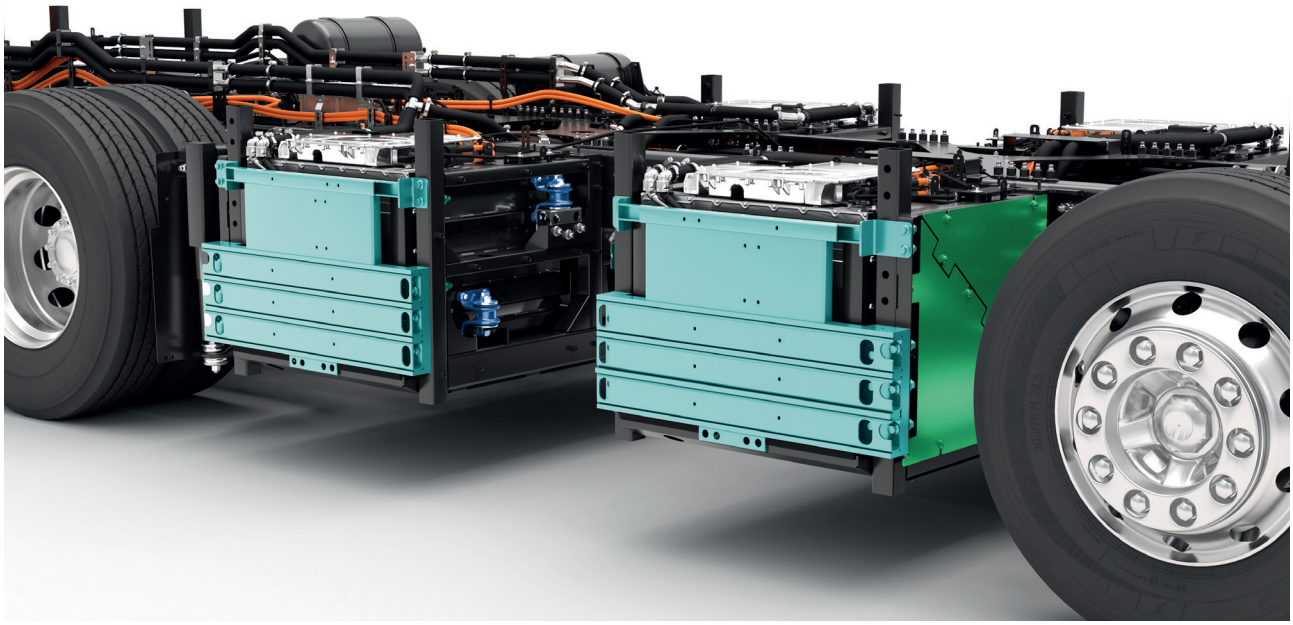
Mechanical protection

Mechanical protection is the first safety layer, after the overall vehicle architecture. Protection from impact in the event of a collision is a main design parameter, as is controlled mechanical behavior in the event of, for instance, a rollover accident.



Protective structural design

The entire driveline and the energy storage are located and packaged to maximize protection in the event of a collision. Electronics and cabling are protected by the main beams of the chassis, to avoid exposure to crash forces. The batteries have their own steel cages, which enclose the battery packs with protective steel beams. The structures surrounding the batteries are tested to withstand the energy from a two-ton car traveling at 60 km/h.

Safety mounting

The batteries are firmly mounted onto the chassis framework with a meticulously calculated balance of firmness and flexibility. In a situation where another vehicle impacts the bus at the battery location, the mechanical structure will be sturdy enough to prevent direct damage, but also to absorb the crash force. For roof-mounted batteries, the mounting meets the same mechanical safety standards as those that apply to high-pressure CNG tanks used in gas buses.

Robust battery pack casing

In Volvo batteries, the cells are assembled in modules, which provides mechanical protection, vibration damping and heat insulation. Each module holds a number of cells, and a number of modules are assembled into a battery pack. The modules are mounted together in a structure, in order to enable heating and cooling, for optimal performance. The robust steel casing of the battery pack is an integral part of the mechanical protection.

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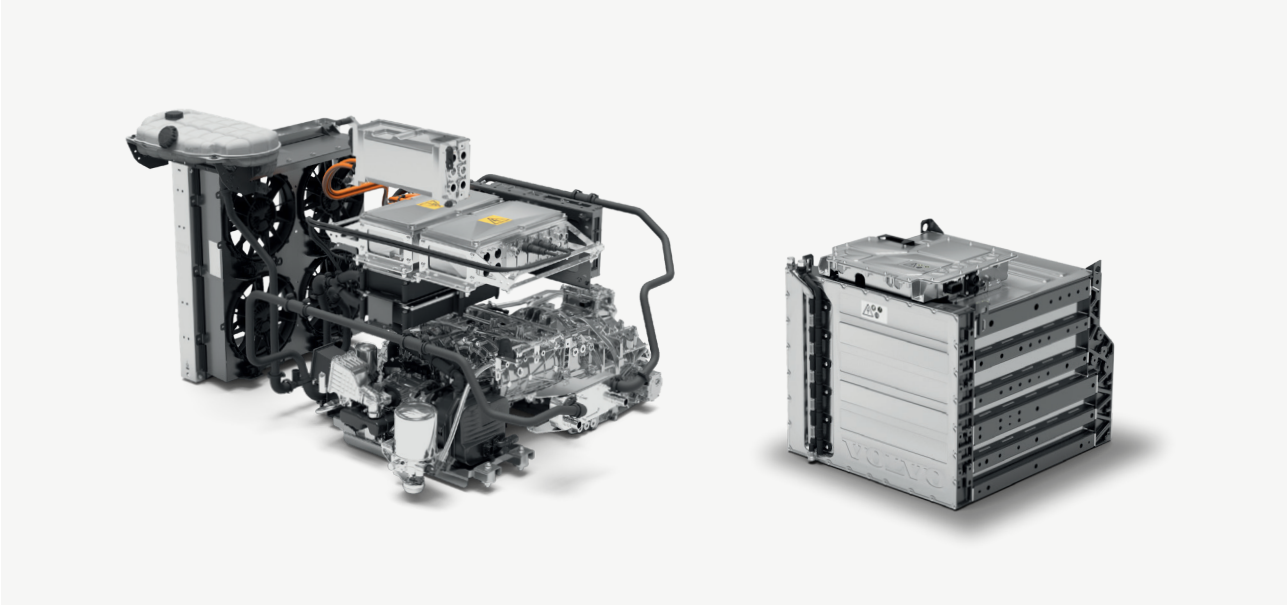
Thermal and electrical protection

An electric bus carries a substantial amount of energy, which is deployed through a high-voltage traction system. If the release of the energy is corrupted, heat is the primary result. This is why electrical and thermal protection functions interact closely.



Electrical protection
The batteries and all electrical components are continuously monitored by the battery management system and the central unit. If an anomaly is detected, cells, packs and the entire traction system can be disconnected. The high-voltage cabling is monitored by the HVIL (Hazardous Voltage Interlock Loop) circuitry. If the circuit is broken, the battery will be cut off at the source. Furthermore, isolation resistance is monitored, and if values are too low, the power will be shut off.

Since overcharging is a risk factor, Volvo electric buses communicate with the charging equipment. In addition, all relevant vehicle parameters are followed up during the charging process. For the driver, there is an emergency cut-off switch.

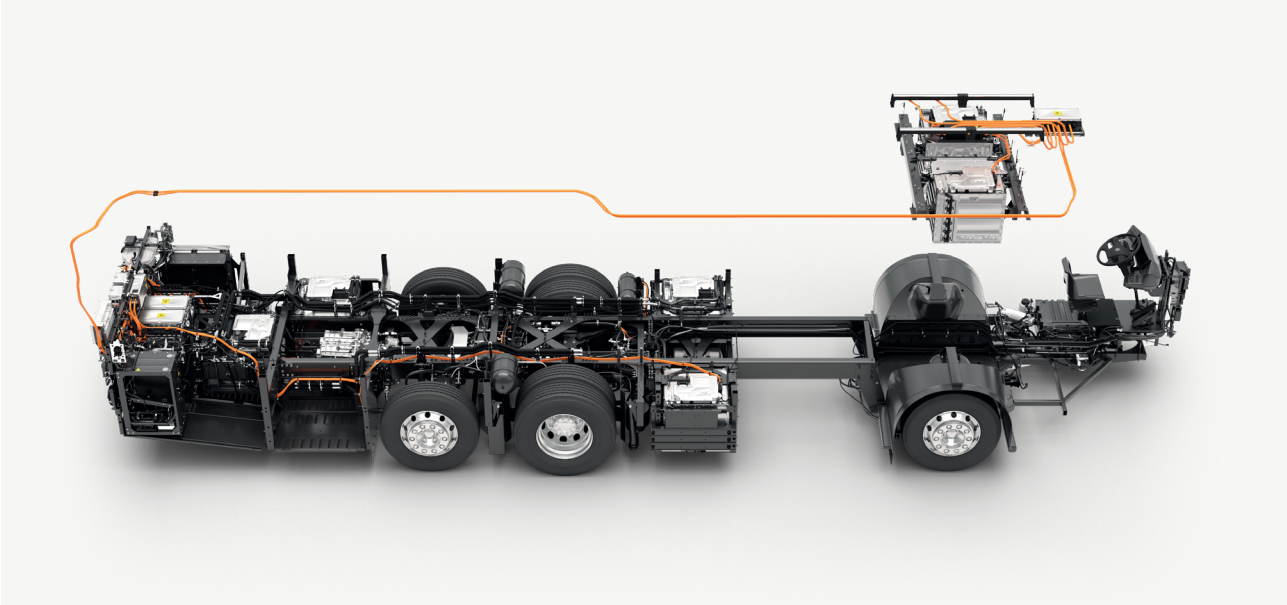
Thermal control
The energy storage system, which includes the batteries, and the entire driveline are monitored and temperature-controlled. For the batteries, it is crucial that all parameters remain within the safety window - both for safety reasons and for long-term battery health. Thermal control is provided by separate liquid-based cooling and heating systems. These systems are independent of the HVAC installation, for maximum reliability and undisturbed operation.

Inside the batteries there are layers of heat barriers to prevent heat transfer from a malfunctioning cell. If heat builds up and causes high internal pressure, the cell is vented and electrically disconnected. If the temperature exceeds the permitted value anywhere, action is taken automatically; ultimately the power will shut off and the driver will be alerted. Thermal runaway (TR) in one cell will lead to disconnect of the entire pack, and the heat from one cell's thermal runaway is not enough to cause TR in other cells.

For more information, contact your Volvo Buses dealer.

Safety in depot and workshop

Maintenance and repair of an electric bus has a lot in common with working with conventional buses. The difference is the driveline, the batteries, and the internal energy management. Working with high-voltage systems requires special training and certification.



Strict procedures
Several components in the electric traction system cannot be repaired, but should be replaced and returned to Volvo. All kinds of work on the traction system requires following of a decommissioning procedure, and after completed work the commissioning procedure puts the vehicle back into operational state.

The strict procedures ensure that the service technician cannot be exposed to hazardous voltage when a component or cable is disconnected and current-carrying parts are uncovered.

Authorization and delegated responsibility
Only authorized persons, i.e. the “technician responsible for work activity”, are allowed to do the decommissioning and commissioning. This person must also have the delegated responsibility from the manager to be allowed to do the work. Performing work on the traction voltage system without proper decommissioning can cause serious injuries or death.

Safety standard documents
For information on work roles related to handling and service of the traction voltage system and traction voltage components, see Volvo STD 871-0003 and 871-0004. For specific safety guidelines, read and follow the applicable IMPACT documentation.

For more information, contact your Volvo Buses dealer.

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