

Testing of High Voltage Vehicles

High voltage storage cells, which are still in the development stage or treated improperly, pose a great threat during dynamic crash events. We therefore abide by the following principles for protection of our employees and test facilities.

- The minimum legal requirements as well as national and international safety rules and regulations have to be adhered to. These include - electrical plant safety and shock-proof protection, as well as the correct dangerous goods declaration, labelling, documentation and safety data sheets.
- Before the customer can deliver vehicles and parts, Continental's electrically skilled people have to be briefed by the customer's own electrical engineers. In the scope of this briefing, all important information regarding the vehicle, the built-in safety installations and possible risks have to be provided.
- Based on the above mentioned points, Continental's electrically skilled people in charge have to conduct a safety evaluation and impose conditions if necessary and provide the 'OK' for the delivery of components or vehicles. Without their 'OK', vehicles and high voltage components will be turned away.
- The use of high voltage storage components in crash or misuse tests will only be performed with proof of the maturity of the development of such high-voltage systems. This applies for energy storage systems in vehicle structures and the position of other high voltage components and cables in the vehicles.
- The safety installations integrated in the high voltage system have to be state of the art.

Sled Tests:

Purpose:

Sled tests serve for providing proof that high voltage components can survive crash relevant loading without damage. During sled tests, battery casings and mountings, cells, live wires and electronic components are checked. Also, the position and performance of the safety shutdown systems incorporated.

Risks:

- Damaging of the Casing and Mounting
 - Battery separating from mountings - causing mechanical damage to the battery and the test facility
 - Mechanical damage of the battery casing with the risk of losing the shock-proof protection
 - Mechanical damage inside the battery, leading to shifting of live parts and cells
 - Mechanical damage in the high voltage circuits
 - Risk of destroying parts of the test facility and measurement data-acquisition
- Damage within the high voltage circuits
 - Mechanical damage of cells with the risk of the leaking of aggressive electrolyte, electrical short circuit of cells or cell groups
 - Thermal reactions, thermal run away
 - Cell combustion/fire and further severe exothermal reactions
 - Undesirable electro-chemical reactions
 - Leaking of poisonous or acidic gases

Minimum Requirements for Sled Testing:

1. Approved battery cells.
The manufacturer must provide information about previous testing to cells, providing some guarantee to proceed with sled testing.
2. Tests with a live battery (charged or un-charged) will only be conducted if casing and mountings have been tested previously with inert batteries with the same test severity
3. Possible critical areas or components from previous testing is to be highlighted by the cell manufacturer. Previous dynamic or sled testing is to be advised by the manufacturer.
4. Self-contained battery case. It must be guaranteed that even after a test, and a failure of the mountings, the shock-proof protection is still intact.
5. Should live cables exit the battery the battery system needs a service-disconnect-mechanism with which the live cables can be deactivated.
6. The battery needs a battery bus or other mechanisms for constantly monitoring the condition of the cells, during and after the test.

Crash Tests:

Purpose:

Crash tests serve for checking the high voltage system within the vehicle, especially regarding the safety of the high voltage components and cables inside the vehicle, during crash events.

During this work, the safety shutdown of the battery (and the discharge characteristics) in various crash scenarios are checked. Also, checks are performed for the installation and position of the energy storage in an intrusion and collision protected area. The stability of the battery mountings, high voltage cables (protection from short-circuits) and other features are also checked.

Risks:

- Electrical short-circuits to the vehicle ground through damage of high voltage wires or peripheral high voltage components (converter, motor, charging plug)
 - ➔ Shock-proof protection is no longer intact
 - ➔ Damage to the test facility and/or measurement data acquisition system through high voltage contacts
 - ➔ Vehicle fire caused by short-circuit
- Damaging of casing and mounting of the battery through vehicle pulse or intrusion
 - ➔ Battery separating from mountings, risking mechanical damage in the test facility
 - ➔ Shock-proof protection is no longer intact
 - ➔ Damage to the test facility and/or measurement data-acquisition system through high voltage contacts
 - ➔ Vehicle fire caused by short-circuit
- Damaging of the high voltage battery's cells and cell groups
 - ➔ Mechanical damage of battery cells with the risk of leaking of electrolyte or other aggressive substances
 - ➔ Electrical short-circuit of cells or cell groups, thermal run away, cell combustion
 - ➔ Undesirable electro-chemical reactions; leaking of poisonous or acidic gases

Minimum Requirements for Crash Tests:

1. Approved high voltage batteries.
The manufacturer demonstrates the results of successful dynamic or sled tests.
2. Tests with a live battery (charged or un-charged) will only be conducted if vehicle crash tests with electrically and chemically inert batteries with the same test severity have been tested beforehand.
3. Possible critical areas or components from previous testing is to be highlighted by the cell manufacturer. Previous crash testing is to be advised by the manufacturer.
4. Should the high voltage cables be 'live' during the vehicle crash (service-disconnect-mechanism has not been pulled/removed), the following safety mechanisms have to be additionally installed:
 - Automatic switch-off of the battery from deceleration on impact (functional demonstration of the installation through a sled test)
 - HV-Interlock system or insulation monitoring with automatic voltage disconnect
 - Emergency switch on the vehicle's outside for manual voltage disconnect
5. The battery needs a battery bus or other mechanisms for constant monitoring of the cell's condition, during and after the test.
6. In case measuring of the high voltage system is to be conducted, the vehicle manufacturer has to provide the voltage taps necessary.

Misuse and Driving Tests:

Purpose:

Misuse and driving tests serve to check the high voltage systems during vehicle operation under normal and extreme circumstances.

In addition, misuse tests serve for recording data for calibrating the airbag control unit. Preferably scenarios are chosen in which signals, similar to those occurring in a crash test, can be expected. Driving on special surface roads and going over obstacles such as kerbs, beams or railway crossings cause high mechanical loading by vibration and extreme shocks through the suspension system. Alternatively, obstacles may contact with the underbody or parts of the car body close to the high voltage batteries or other components.

Risks:

- Damaging of the casing or the mountings of the battery by vibration, acceleration, intrusion or direct contact with obstacles
 - Battery separating from mountings, live parts or other high voltage components
 - Shock-proof protection is no longer intact
 - Putting the driver in danger from electrical energy shorting to the vehicle or upon exiting the vehicle
 - Damaging the measurement data-acquisition system through high voltage
- Damaging of cells and cell groups of the high voltage battery
 - Mechanical damage of battery cells with the risk of electrolyte or other aggressive substances leaking out
 - Electrical short-circuit of cells or cell groups, thermal run away, cell combustion
 - Undesirable electro-chemical reactions; leaking of poisonous or acid gases
 - Contamination of the proving ground
- Accidents caused by loss of control through driving manoeuvres or mechanical and electrical damage to the vehicle
 - Vehicle crash from above mentioned risks

Minimum Requirements for Misuse and Driving Tests:

1. Usage of a vehicle which has been approved in crash tests with an active high voltage system
2. Possible critical areas or components from previous testing is to be highlighted by the cell manufacturer.
3. Should tests be conducted with an active high voltage system (e.g. electrical drive only) the following additional safety mechanisms have to be installed:
 - Automatic switch-off of the battery from deceleration on impact (functional demonstration of the installation through a sled test)
 - Emergency switch on the vehicle's inside and outside for manual voltage disconnect
4. The battery needs a battery bus or other mechanisms for constant monitoring of the cell's condition, during and after the test.
5. In the scope of the testing, only those tests may be conducted, during which direct impact on the vehicle battery through obstacles can be ruled out. Should tests with a direct impact on the battery be required, these can only be conducted with vehicles carrying a dummy battery.