Testing of High Voltage Vehicles

High voltage storage cells, which are still in the development stage or treated improperly, pose a great threat. The following principles serve as protection for the 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, shock-proof protection and others, 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 person has to be briefed by the customer's electrically skilled person. 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 person in charge has to conduct a safety evaluation and impose conditions if necessary and provides their 'OK' for the delivery of components or vehicles. Without the 'OK' of Continental's electrically skilled person, vehicles and high voltage components will be turned away.
- The usage of high voltage storage components in conducting crash or misuse tests will only performed with proof of the maturity of the appropriate development of such high-voltage systems. This applies for energy storage systems in vehicle structures and the order and position of the high voltage components and wires 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 the high voltage component can survive crash relevant loading without damage. With the sled test, mountings and casings, cells, live wires and electronic components as well as the safety shutdown in the battery are checked.

Risks:

- Damaging of the Casing and Mounting

  ➔ Tearing off the battery - causing mechanical damages on the battery and the test facility

  ➔ Mechanical damages on 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 damages in the high voltage circuit
  - Risk of destroying parts of the test facility and measurement data-aquisition

- Damage within the high voltage circuit

  ➔ Mechanical damage of cells with the risk of the leaking of aggressive media, 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 proves by which cell tests the safety for the sled test is guaranteed.
2. Tests with a live battery (loaded or unloaded) will only be conducted if mountings and casing have been tested before with inert batteries with the same test severity
3. Possible incipient damages and preliminary tests for sled tests on the battery have to be indicated by the manufacturer.
4. Self-contained battery case. It has to be guaranteed that even after a test and a failure of the mountings, the shock-proof protection is still intact.
5. Should live leads go out of the battery the battery system needs a service-disconnect-mechanism with which the live leads can be turned off.
6. The battery needs a battery bus or other mechanisms for constantly monitoring the condition of the cell during and after the test.

Crash Tests:

Purpose:

The crash tests serve for checking the high voltage system within the vehicle, especially regarding the safety of the high voltage components and leads inside the vehicle.

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

Risks:

- electrical short-circuits to the vehicle ground through damage of high voltage wires or peripheral high voltage components (A/C, engine, 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
  - ➔ Tearing off the battery, 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 sled tests.
2. Tests with a live battery (loaded or unloaded) 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 incipient damages and preliminary tests for crash tests on the battery have to be indicated by the manufacturer.
4. Should the high voltage leads be live during the vehicle crash (Service Disconnect Plug has not been pulled/removed), the following safety mechanisms have to be installed additionally:
   - 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 switch-off
   - Emergency switch-off on the vehicle's outside for manual voltage switch-off (depending on construction status, usually only in the prototype phase)
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 on 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, extreme shocks through the suspension/absorption system or obstacle contacts with the underbody or parts of the car body close to the high voltage batteries are provoked.

Risks:

- Damaging of the casing or the mountings of the battery by vibration, acceleration, intrusion or direct contact with obstacles
  - ➔ Tearing off or mechanical damaging of the battery, live parts or other high voltage components
  - ➔ Shock-proof protection is no longer intact
  - ➔ Putting the driver in danger through voltage in the car or on exiting the vehicle
  - ➔ Damaging the measurement data-acquisition system through high voltages
- 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 on the vehicle
  - ➔ Vehicle crash with 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 incipient damages and preliminary tests for crash tests on the battery have to be indicated by the 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
   - Emergency switch-off on the vehicle's inside and outside for manually switching-off the voltage
4. The battery needs a battery bus or other mechanisms for constant monitoring the condition of the cells 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.