

Mechanical Testing Solutions for:

**Lithium-Ion Battery Cells, Battery
Modules and Battery Packs**

Zwick / Roell

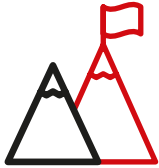


More than 160 years of experience in materials testing.

Li-ion batteries are an essential enabler in the ongoing global quest to electrify the transportation sector, and there is certainty in their key role for electrification of vehicles in the coming years. As the industry continues to experience a high rate of innovation that is not expected to slow down in the foreseeable future, mechanical testing is a critical component for advancement that is becoming ever more important.

ZwickRoell has over 160 years' experience in materials and component testing in more than 20 industries. Our 1,800 dedicated employees have materials testing in their DNA. Our battery testing portfolio covers the entire range from theoretical potential and battery cell chemical operating principles to mechanical testing as the next step in improving battery reliability, quality and performance.

Battery and automotive manufacturers, component and system OEMs, and universities around the world rely on our testing experience. When it comes to finding the best solutions for your requirements, we will be at your side from the very beginning.



160 years

of experience in materials testing.



Intelligent testing

from standard-compliant to customized solutions.



Custom consulting

for battery and fuel cell testing applications.



Ongoing collaboration with battery and automotive manufacturers, component and system OEMs, and universities and research labs.

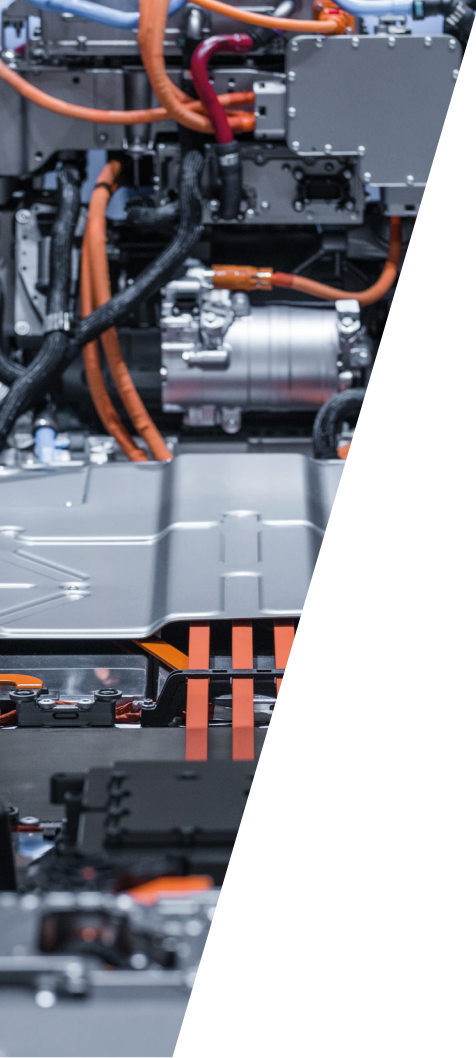


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product and industry experts around the world.



Safe solutions for all phases of battery testing.



Mechanical testing solutions for lithium-ion battery cells, modules and packs.

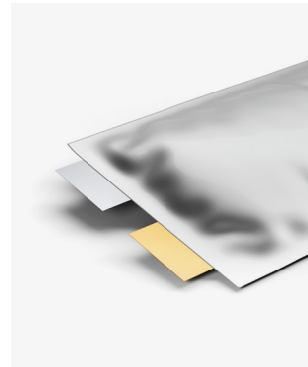
Testing requirements

A lithium-ion battery cell consists of various components that are subject to a number of different load applications based on their various functions. They, therefore, consist of a variety of materials.

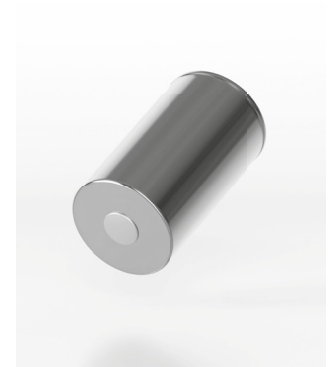
In the production process, materials are subjected to mechanical loading throughout the various manufacturing stages and must be adapted to such loads. While in operation, the battery must reliably withstand mechanical and thermal stress. ZwickRoell is your partner in excellence – we offer testing solutions for all your requirements.



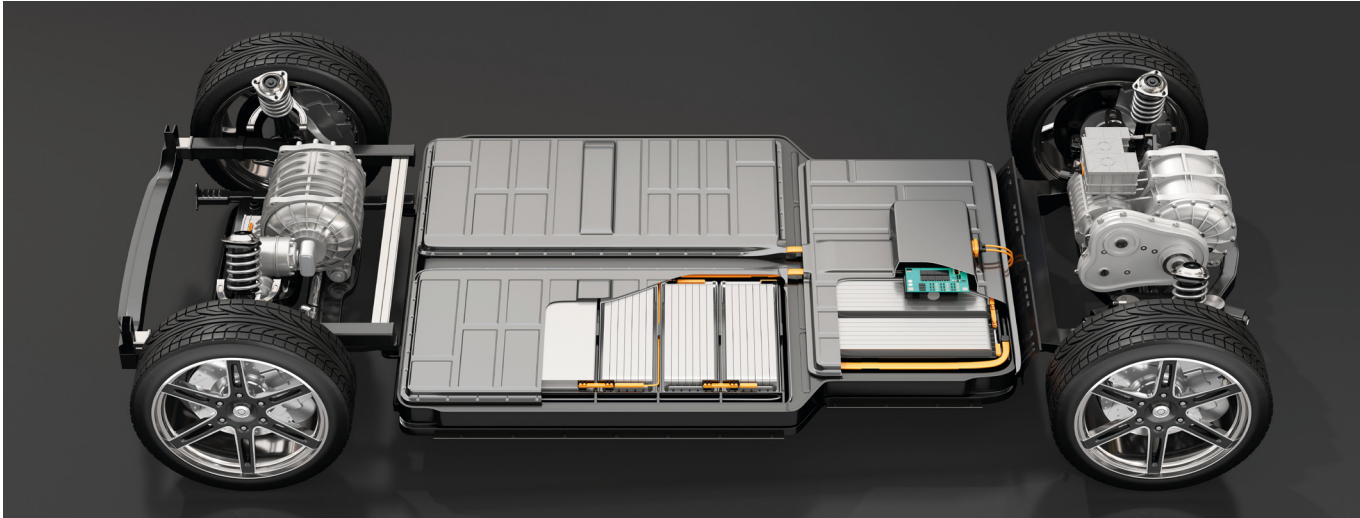
Prismatic cell



Pouch cell



Cylindrical cell



Cell-to-pack design

Testing solutions

We offer standardized solutions for:

- All lithium-ion chemistries and solid-state batteries
- Pouch, prismatic, cylindrical and coin cell formats
- Structural integrity and durability testing
- Battery safety and abuse tests according to global standards
- Analysis of functional behavior
- Mechanical characterization of materials and material bonds

Your benefits

- In-depth materials testing know-how helps you obtain valuable test results
- High-accuracy test equipment guarantees reliable test results
- Free preliminary tests in our battery testing center ensure proper equipment selection

Mechanical testing solutions for foils, separators and pouch composite materials.

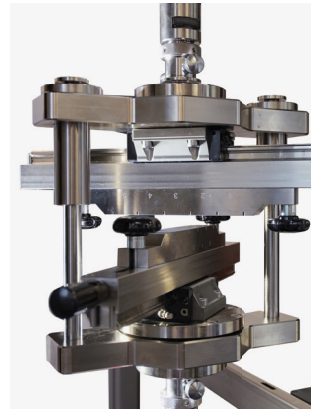
Testing requirements

Tests are performed with our universal testing machines in a force range from 1 N to 10 kN, based on your requirements. Important material characteristics, especially in tensile testing, can be determined with repeatability due to easy alignment and adapted pneumatic grips.

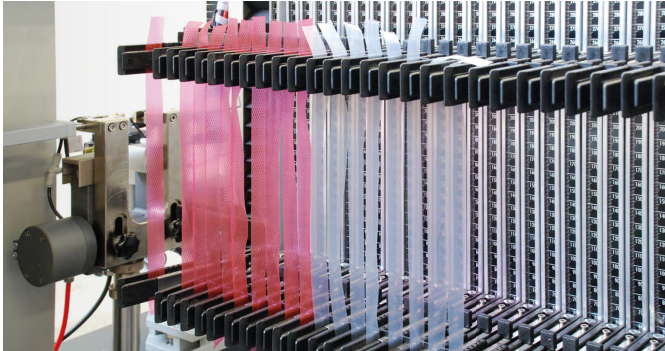
By adding or exchanging different test fixtures, the machine becomes a true universal testing machine and adapts to changing requirements for foils, separators and pouch composite materials.



Z-direction tensile test on electrode coating



Puncture test on separator film



Automated foil testing process

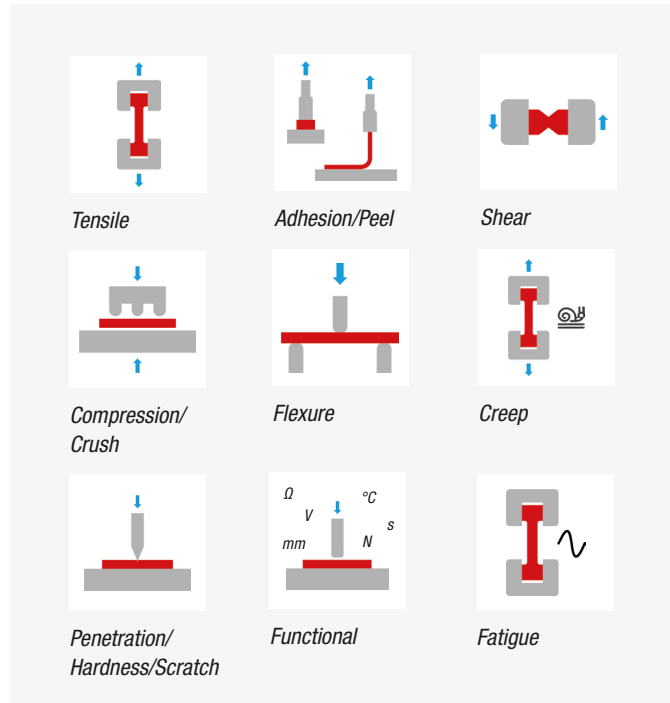
Testing solutions

We offer standardized testing solutions for the determination of:

- Material fatigue data for simulation
- Compressibility of coatings, separators and pouch composites
- Flexural stiffness of coated electrodes
- Tensile strength of battery foils, separators and pouch composite materials
- Joint quality of welded seams and bonds
- Hardness and scratch properties of coatings
- Adhesion strength and quality of electrode coatings
- Friction coefficients of coating surfaces
- Puncture resistance of separator and pouch foils
- Material properties under environmental conditions such as temperature or media

Your benefits

- True universal setup provides unmatched versatility
- Machines can be easily upgraded and adapted to your requirements
- Safety for operators, machines, environment and test data

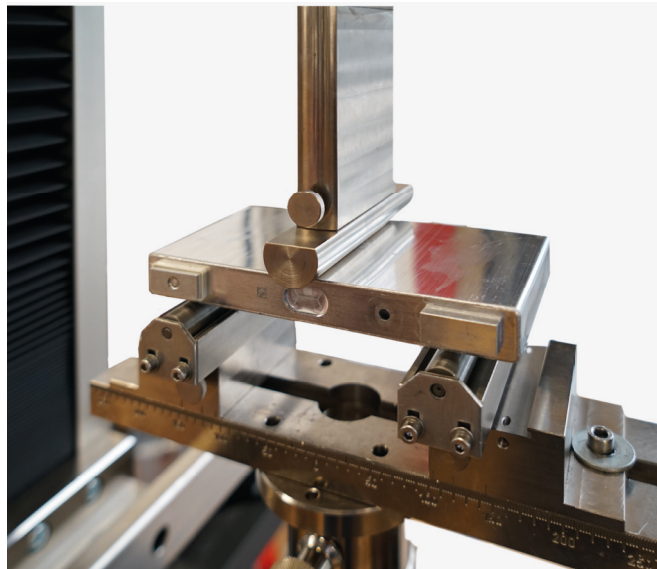




Structure testing solutions.

Testing requirements

In addition to materials testing, it is important to ensure that a battery fulfills maximum safety and quality requirements at a cell, module and pack level. The fast development cycles of complex multi-component battery assemblies require flexible testing solutions that adapt easily to changing test requirements.



3-point flexure test on prismatic cell

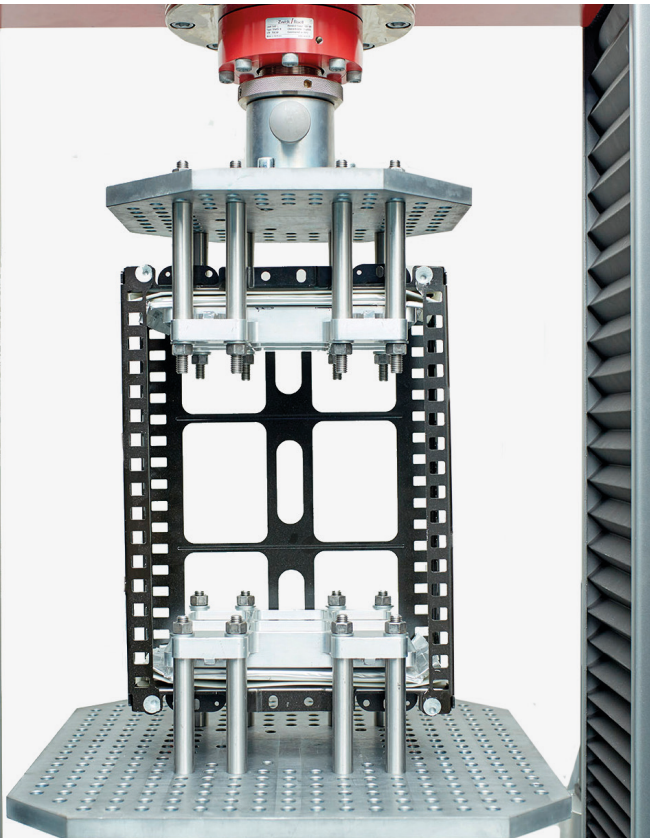
Testing solutions

We offer standardized testing solutions for the determination of:

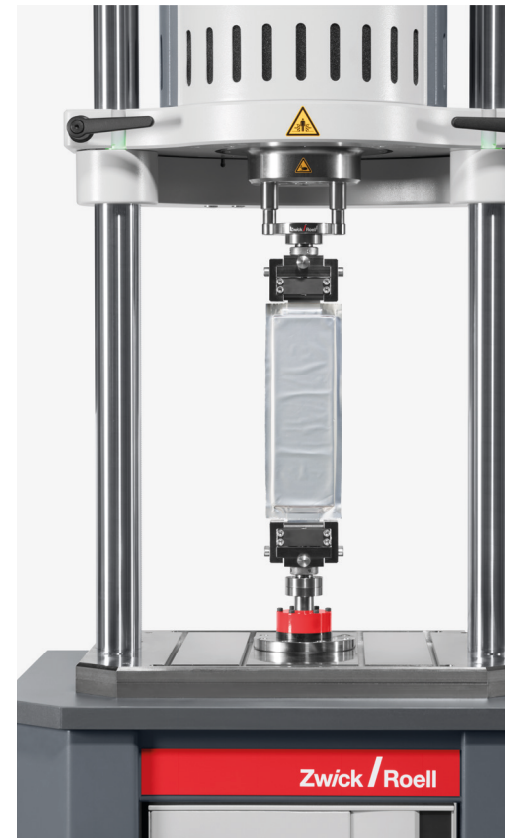
- Mechanical properties of battery cells, modules and packs
- Resistance strength to internal and external compressive forces
- Flexural and torsional stiffness of battery components, i.e. busbars
- Compressive resistance of battery housing
- Mechanical fatigue data of electrical connections
- Material characteristics of compression mats, insulation materials, spacers, etc.
- Joint quality of welded parts and structures, impact resistance to sharp objects
- Mechanical strength under temperature influence up to 1000°C

Your benefits

- The test system provides valuable material data for R&D as well as QC test processes
- Improve simulations with more reliable material data
- Confidence in test data quality helps to optimize production processes
- Fully transparent control via our testXpert testing software
- Thorough and traceable quality inspection throughout the production process guarantees that all functional and safety requirements are fulfilled



Structural test on battery module component



Fatigue test on pouch cell tabs

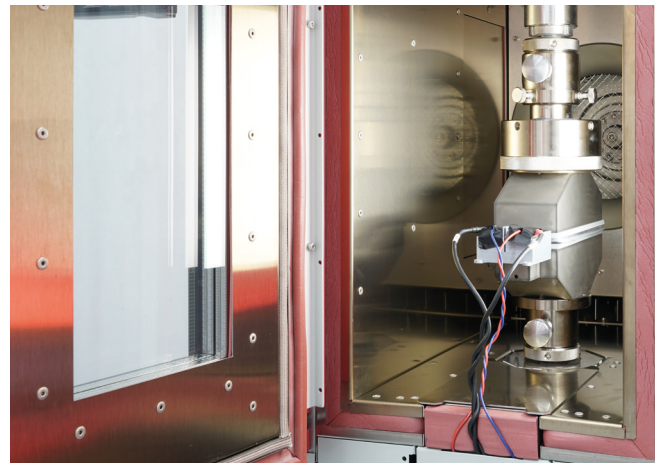


Functional testing solutions.

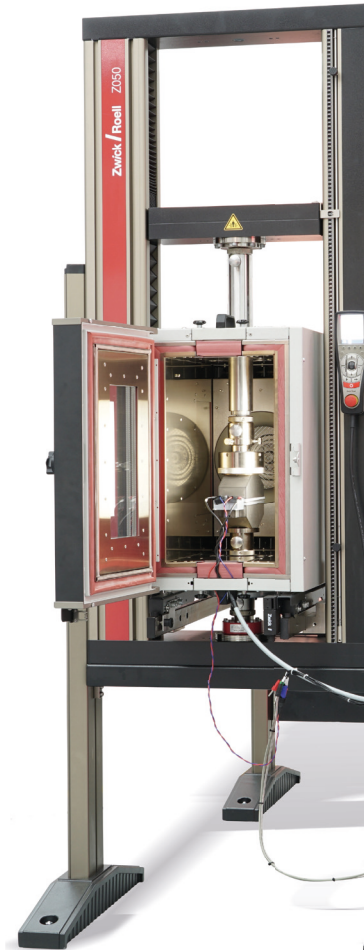
Testing requirements

Battery performance depends on a wide range of parameters, including electrochemistry, cell design, production processes, as well as electrical and environmental conditions.

Our testing machines allow the combination of multiple simultaneous environmental effects on a battery cell or battery system, e.g. combined tests of controlled mechanical loading with other physical properties which play a vital role in the development and production of reliable battery systems.



Battery swelling test



Expansion determination of battery cells during charging and discharging



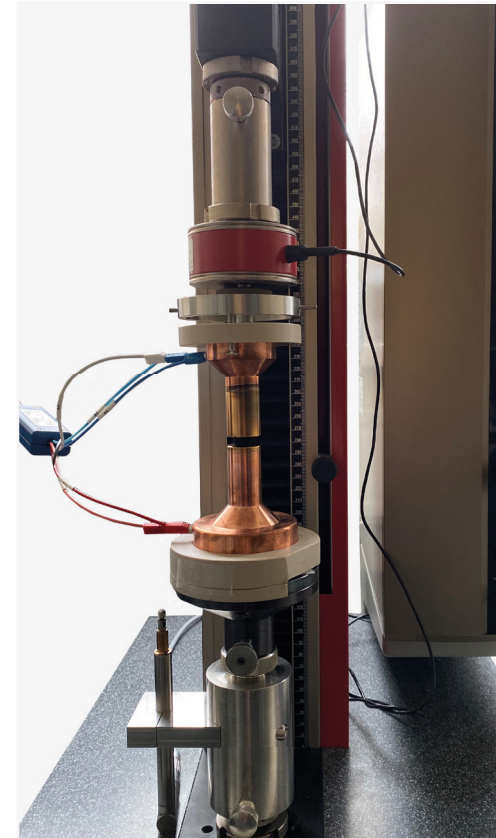
Testing solutions

We offer standardized testing solutions for the determination of:

- Cell swelling under constant or variable mechanical pressure
- Battery performance under constant and variable mechanical pressure
- Cell performance under variable environmental conditions
- Combined measurement of multiple physical properties such as force, deformation, temperature, humidity, cell voltage, charging currents and much more

Your benefits

- Flexibility and scalability
- Simulation of environmental conditions
- Maximum reproducibility



Electrical conductivity test

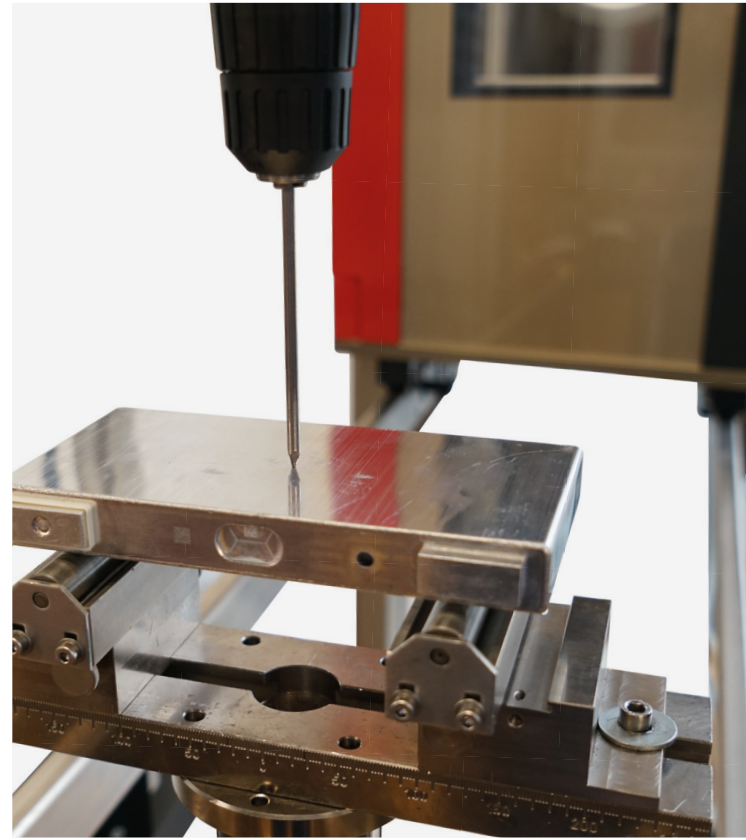


Abuse testing solutions.

Testing requirements

The various test standards for abuse tests are becoming stricter and test requirements are becoming more refined. Mechanical abuse testing requires the device under test (DUT) to be damaged in order to provoke an electrical short circuit within the cell, module or pack.

Universal testing systems from ZwickRoell offer full mechanical abuse functionality: testing of single cells and complete battery packs up to thermal runaway, integration of external test devices and various environmental test conditions, evacuation or isolation of DUTs after testing and full integration of the testing system into safety devices.



Nail penetration test

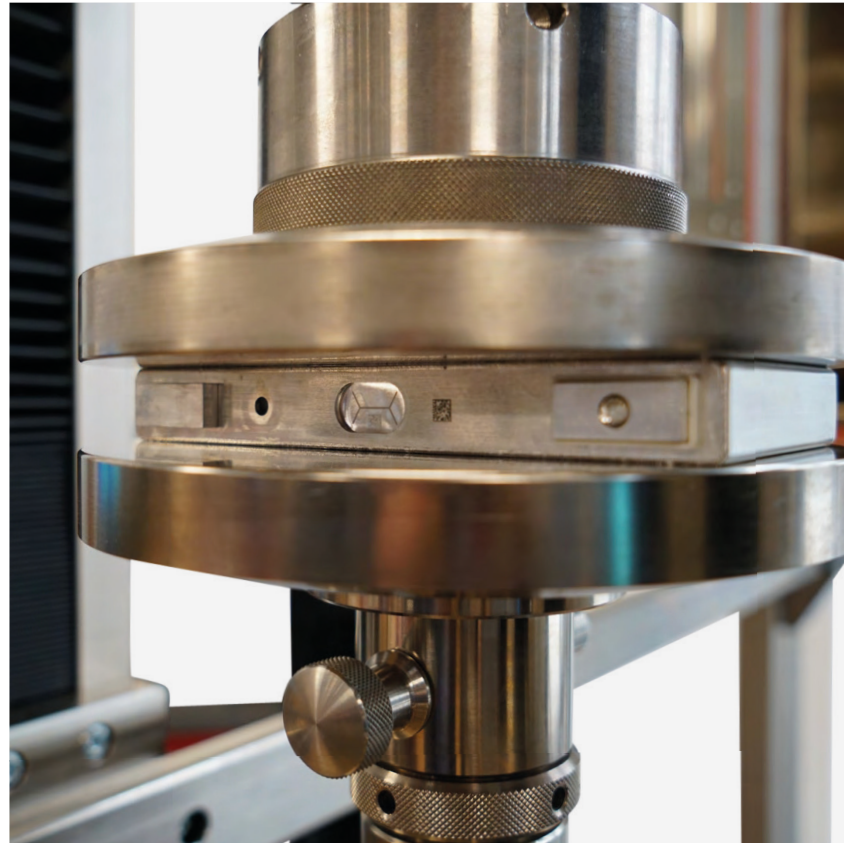
Testing solutions

We offer standardized testing solutions for the determination of:

- Cell, module and pack resistance against mechanical abuse
- Highly accurate loading and deformation profiles
- Resistance to nail penetration, crush and crash loading resistance to multi-directional loading
- Cell safety performance under abuse conditions according to international standards, e.g. UNECE R100-2, ISO 12405 – 3, UL 2580, GTR 20-3, UN38.3, IEC 62660-2, GB/T 31467.3, UL 2580, etc.
- Safety chamber functions up to hazard level 6 with optional evacuation of DUT from test environment

Your benefits

- Seamless integration of testing solution into existing laboratory safety concepts
- Scalable test system configuration adapted to customer's needs
- Solid highly accurate test systems designed for harsh environments



Crush testing of prismatic cell

The right solution for every application.

Hardness testing machines

Nanoindenter



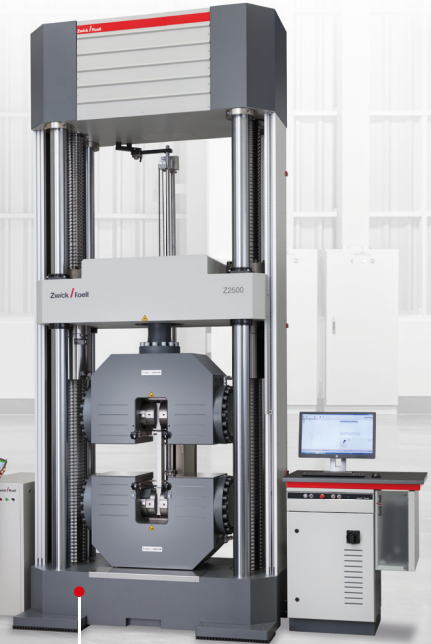
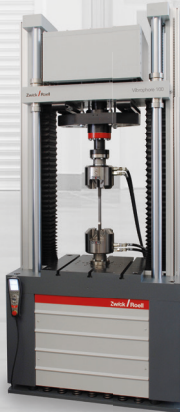
Static materials testing machines



Dynamic and
fatigue testing machines

Automated
testing systems

High-capacity testing
machines up to 5,000 kN





forty
three

Sales and
service partners

347

Sales and
service employees

28.000

Service jobs in the year

ZwickRoell GmbH Co. KG

August-Nagel-Str. 11 • D-89079 Ulm • T +49 7305 10 - 0 • F +49 7305 10 - 11200 • info@zwickroell.com • www.zwickroell.com

Zwick / Roell