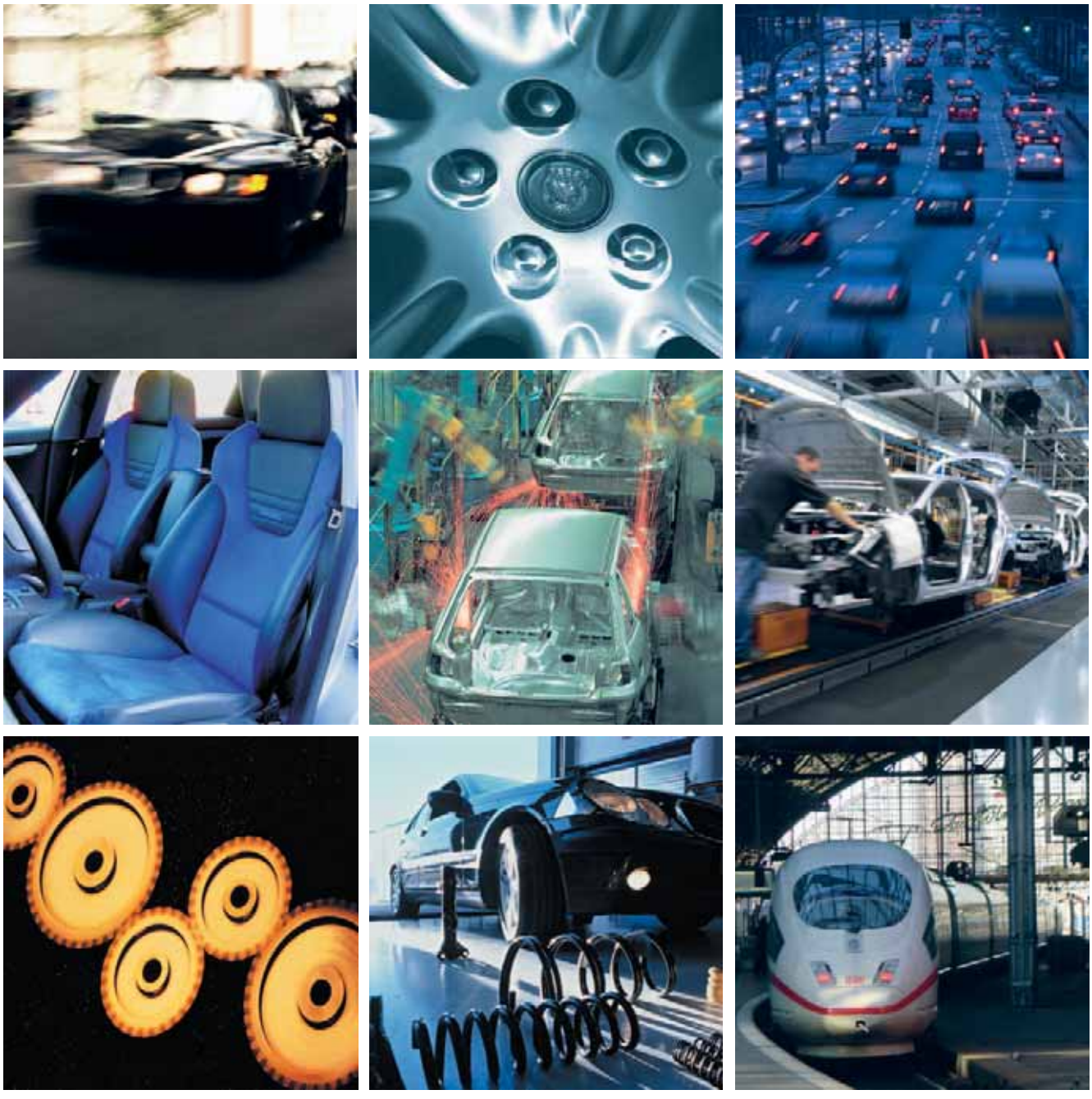
Zwick / Roell

Testing Sytems

Testing Machines and Systems for the Automotive Industry



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Intelligent Testing

Zwick / Roell

This brochure provides an overview of testing machines, instruments and systems produced by Zwick Roell AG and of their applications for testing materials and components used in the various sectors of the automotive industry and associated ancillary industries.

As such this represents only a part of our comprehensive overall program.

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Zwick Roell AG – Over a Century of Experience in Materials Testing

Mechanical testing is one of the oldest forms of materials testing. Da Vinci and Galileo were already turning their attention to bending strain and the elastic properties of materials in the 15th and 16th centuries. Time brought new insights, culminating in the appearance of the first testing machines in 18th-century France.

Roell & Korthaus have been involved in materials testing since 1920, while Zwick began building machines and instruments for mechanical materials testing in 1937. Many years earlier, in 1876, Professor Seger had established a chemical laboratory providing scientific advice on a commercial basis to the stone industry. During the 20th century this evolved into the present-day concern Toni Technik, leading specialists in the field of construction materials testing systems.

These companies have comprised the Zwick Roell Group since 1992. July 2001 saw the group become a corporation under the name of Zwick Roell AG, incorporating Zwick, Toni Technik and Indentec Ltd. Between them these companies provide a comprehensive materials, construction materials and function testing program – from manually operated hardness testing instruments to complex systems for process-parallel applications. Acmel Labo, the French manufacturer of laboratory instruments for the cement, lime and plaster industry, has been part of the group since May 2002.

Zwick Roell AG's expertise in sensor technology for load and extension measurement was enhanced and consolidated by the acquisition of German company GTM in 2007 and Messphysik of Austria in 2006.

Zwick's years of accumulated experience are reinforced by a policy of maintaining regular contact with our many customers. This provides a solid platform from which the company supplies a wide range of products – from economical standard machines to customized versions for specialized testing situations. State-of-the-art engineering, powerful electronics and application-orientated software are the keynote of these modern, versatile, highly intelligent testing machines and systems.

Zwick Roell AG is far more than just a manufacturer, however. As long ago as 1994 the company received DIN EN ISO 9001 certification - a guarantee of consistently high product and service quality. In addition, accredited calibration laboratories allow companies in the Group to inspect and calibrate test equipment and provide internationally recognized certification.

Fig 1: Zwick Roell AG and Zwick GmbH & Co. KG: Administration Building, Ulm, Germany

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Conditions in the Automobile Industry Today

The automotive market is subject to severe global competition, marked by shifts within the vehicle segments and by new markets and suppliers, with resulting over-capacity.

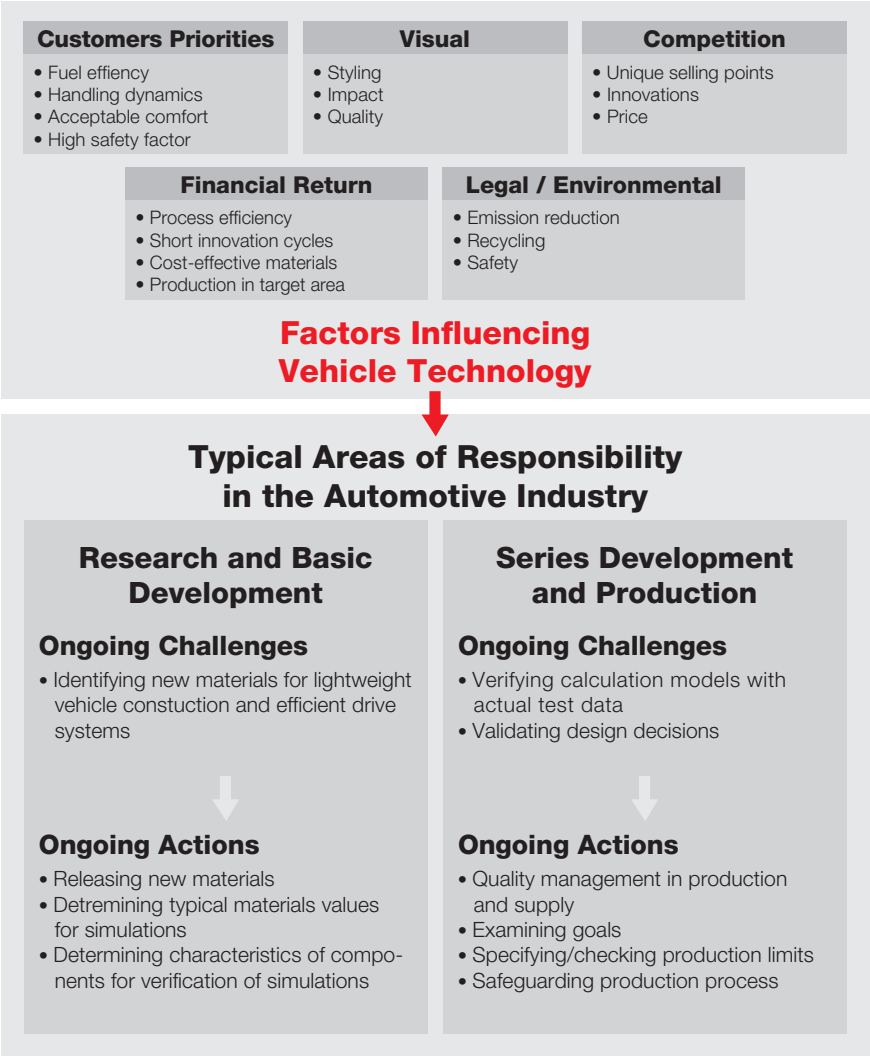
Against this background there is continuous growth in the use of computer-based development techniques. These simulation-based approaches must be accompanied by actual testing during the various development phases. For one thing, the systems require appropriate materials data to dimension for stiffness, rigidity and life expectancy. In addition, the calculation models must be calibrated as early as possible using actual test data. Consequently laboratory tests remain a necessary and important requirement within vehicle development.

Stiffness and rigidity characteristics of materials, components and joining technology, under both standard and crash conditions, together with their fatigue characteristics – all rank alongside the simulation of forming processes as important results.

A Comprehensive Range of Products and Applications

Zwick offers a comprehensive range of testing machines and systems specifically developed for the automotive industry. The program ranges from versatile portable hardness testers for use on rubber, through materials testing machines, fatigue testing machines and computer-controlled systems with actuators for multi-axis testing, up to complex systems capable of simulating actual road conditions for components – or the whole vehicle. An appreciation of the whole breadth of testing applications allows Zwick to provide software, data analysis tools and solutions for laboratory information management (LIMS) – the key to meaningful test results.

Flexible modular programs, a wide range of accessories, digital electronics and intelligent user software – and all subject to continuous development and updating!



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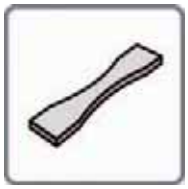

Test Requirements in Research and Basic Development

Raw and Pre-Fabricated Materials

Zwick testing machines are used to determine the mechanical properties of virtually all materials and components employed in the manufacture of automobiles.

Tests on metals play a central role here. For example, steels and light metals are used in lightweight construction of certain areas of bodywork. Their stiffness and rigidity characteristics under standard conditions are determined by means of quasi-static testing machines. As these results are highly dependent on loading rate, they must also be obtained under crash conditions, i.e. using impact or high-speed testing machines. To obtain approval of the material, fatigue and ductility characteristics must also be determined.

Due to the trend to alternative materials and/or hybrid materials and their use in various areas of the vehicle, similar tests on plastics, elastomeres, foams and composites are now routine in vehicle construction.

As the characteristics of the materials vary to a greater or lesser extent with temperature, tests at actual working temperatures must also be carried out. Tests of this nature are equally essential in the field of joining technology: Zwick provides solutions for a temperature range from -80 °C to 1,600° C.

Quasi-Static Testing of Metals

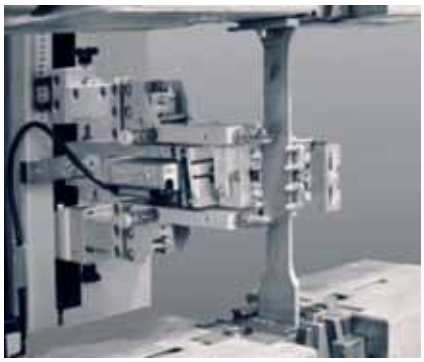

Fig 1: Tensile test on metal specimen

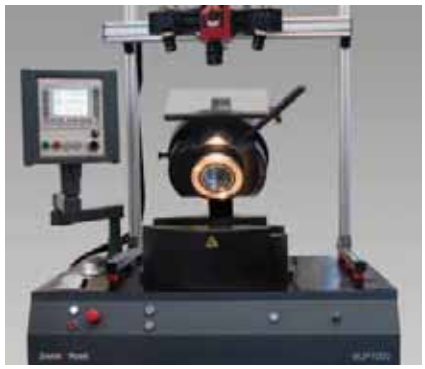

Fig 2: Sheet metal testing

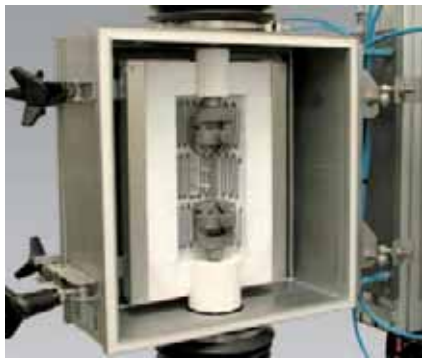

Fig 3: Tensile test using high-temperature furnace

Testing Fatigue Strength and Dynamic Strength of Metals

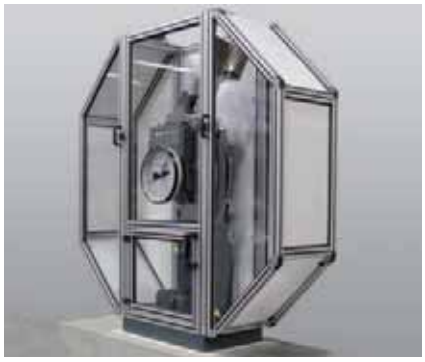

Fig 4: Pendulum impact test

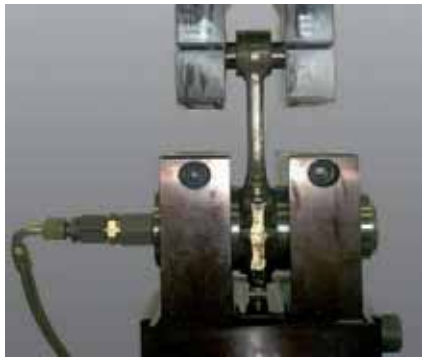

Fig 5: Fatigue test on connecting rods

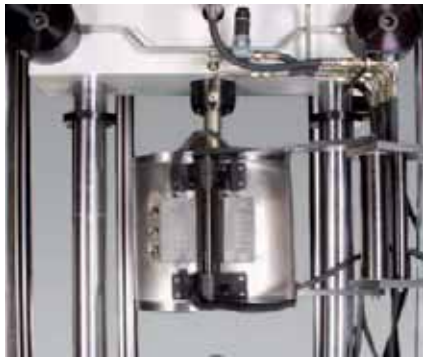

Fig 6: Fatigue test using high-temperature furnace

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Quasi-Static Testing of Plastics, Rubber and Composites

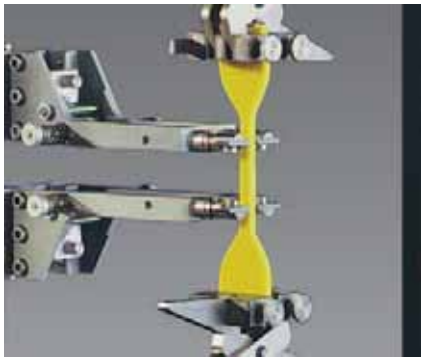

Fig 1: Tensile test on rubber specimen

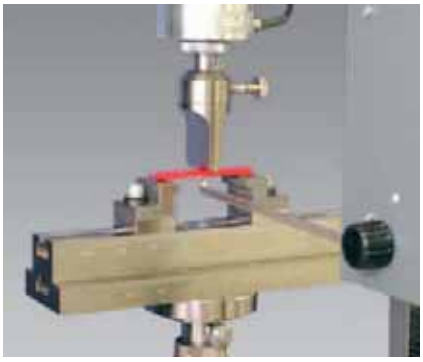

Fig 2: 3-Point flexure test

Fig 3: Compression test on composites

Testing Fatigue Strength and Dynamic Strenght of Plastics, Rubber and Composites

Fig 4: Pendulum impact test

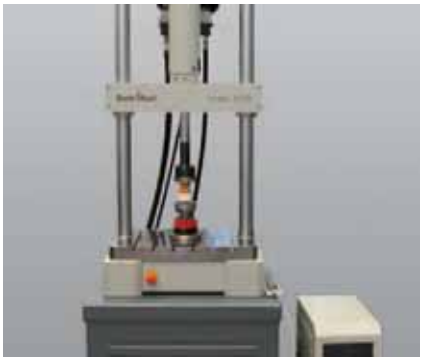

Fig 5: Fatigue test on rubber dampers

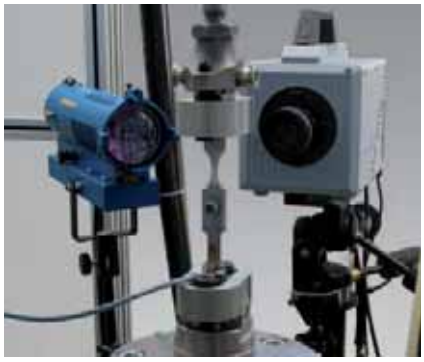

Fig 6: Tear test with temperature conditioning and videoXtens

Testing of Foams

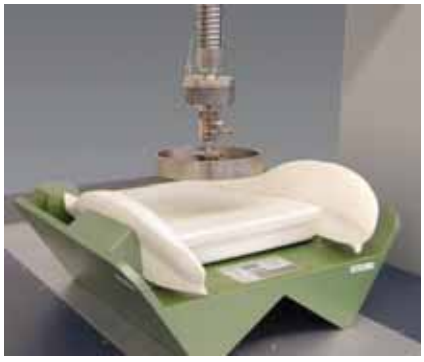

Fig 7: Indentation hardness test

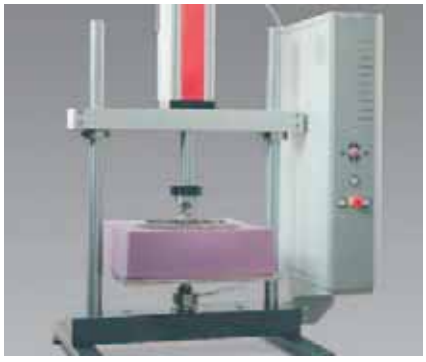

Fig 8: Fatigue test

Fig 9: Rebound resilience tester

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Fatigue Strength in Automobile Construction

Basic Principles

Fatigue strength is an interdisciplinary science, involving interaction between stress, manufacturing process, material and design.

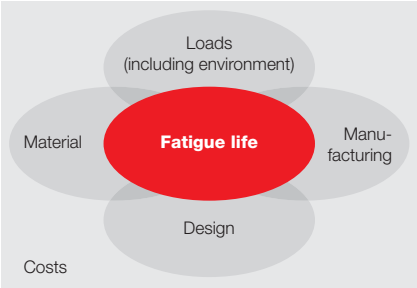

Fig 1: Factors of fatigue strength (Source: Prof. Dr. Sonsino)

Automotive engineers must therefore be aware of the load imposed upon a vehicle and/or its components, including any 'unusual events', in order to estimate the fatigue strength mathematically and by experiment.

The mechanical characteristics of the materials and the manufacturing quality of the components represent the input data required to measure the fatigue strength of the components. To estimate life expectancy mathematically, design details of the component are also required.

Development and Approval Process

The development process of a new component begins with design. If initial stress distribution for the component is available, life expectancy of the components can be estimated using the load-time sequence and material characteristics; the latter can be determined with a servo-hydraulic testing machine or a Zwick Vibrophore® (magnetic resonance pulsator). If the component's estimated life expectancy shows it to be suitable, tests will be carried out on prototypes of the component. Servo-hydraulic testing machines can be used for this; Vibrophores are also used to some extent.

The next step in the development process is the testing of component assemblies and the vehicle as a whole. If these are successful, development can be approved.

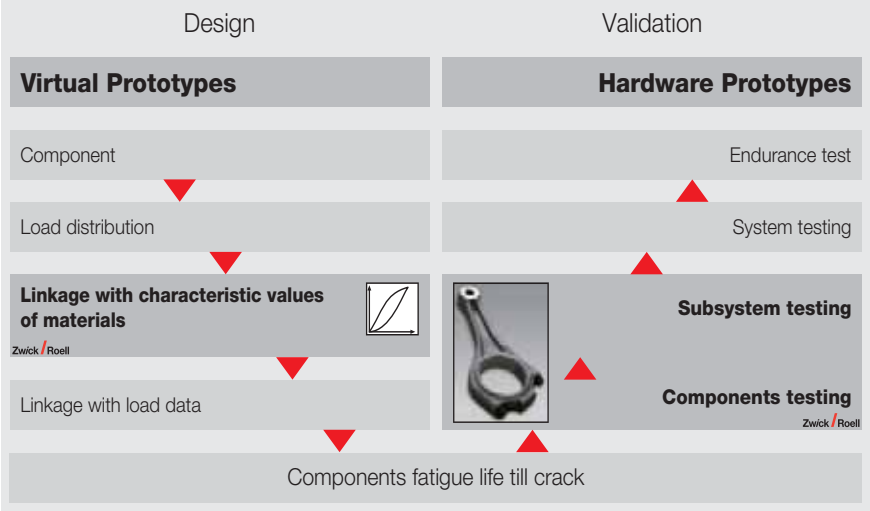

Fig 2: Component design process in automobile development (Source: Prof. Dr. Stauber)

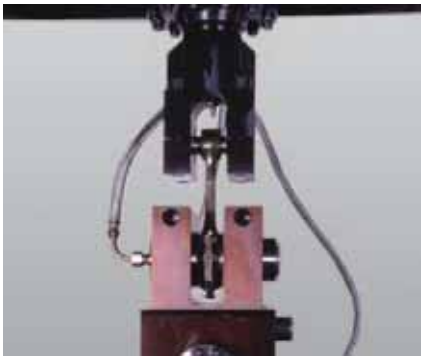

Fig 3: Fatigue test on connecting rods

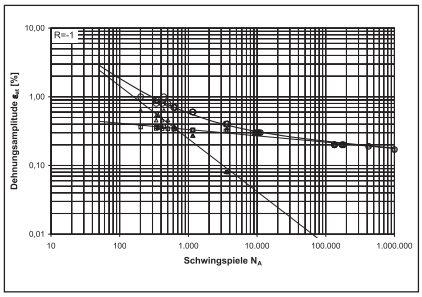

Fig 4: S-N-curve

Determining Material Characteristics

S-N tests are generally sufficient to characterize the material's properties. Component testing increasingly calls for variable amplitudes, which in the simplest case can be represented via a block program test. For complex components, or components with complex requirements, a stress fatigue test is sometimes advocated.

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Joining Technology in Automobile Construction

Various joining methods are used in vehicles, and all must be characterized mechanically. Chassis construction mainly involves linear joining; here the focus is on the life expectancy of the component and/or the join. For the body shell, linear, spot and laminar joining, or various combinations of these, are used.

The emphasis here is on dimensioning components to be crash-proof, but life expectancy must not be neglected.

In addition to life expectancy and crash safety, stiffness is an important criterion when engineering both body shell and chassis.

The mechanical characteristics of joins must be determined under static, dynamic and dynamic impact loading.

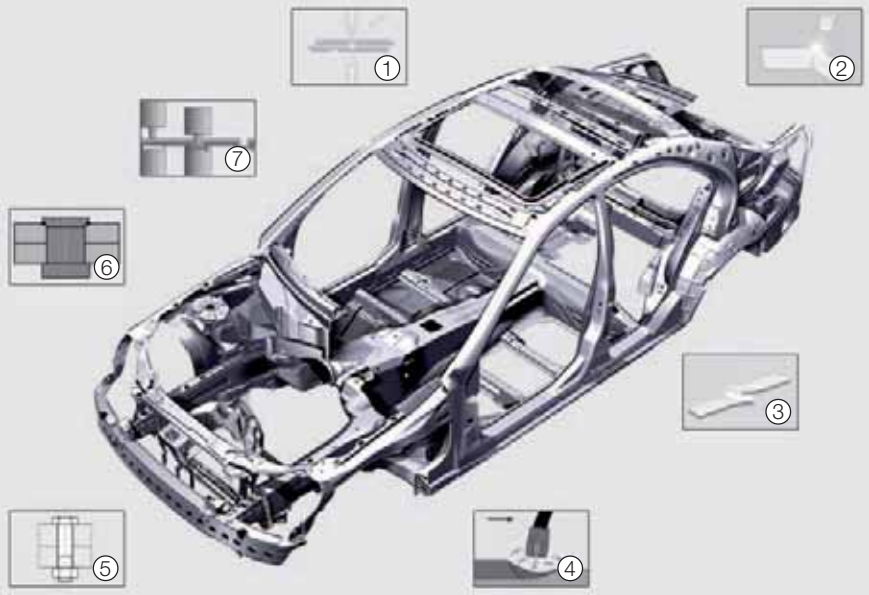

Fig 1: Various joining technology in automobile construction: 1. Resistance-welding, 2. Laser beam welding, 3. Bonding, 4. Gas-shielded arc welding, 5. Screws, 6. Rivets, 7. Clinching

The following table contains a few well-known specimen geometries used for characterising joins. The data obtained from the tests (quasi-static tensile test, fatigue tests, dynamic impact tests) can be used for quality assurance, as input for life expectancy estimates or as input for crash calculations. If specimens resembling components are employed, they can be used to validate life expectancy or crash models.

					
	Shear-stress specimen	**KS-II-Specimen**	**H-Specimen**	**T-Impact**	**Peel-stress**
• Connection category					
• Punctual	•	•	•	•	•
• Lines	•	o	•	•	•
• Laminar	•	•	•	•	•
• Fine sheat metal material	•	•	•	•	•
• Load ratio	R=0, R>0 and R<0	R=0, R<0	R=0, R<0	R=-1, R>0, R≤0	R=0, R>0
• Determination of fatigue characteristics value	-	•	•	-	-
• Components similar effect	-	-	•	•	-
• Effort	•	o	o	-	•
• Load	quasi-static, fatigue, dynamic impact	quasi-static, fatigue, dynamic impact	fatigue	quasi-static, fatigue, dynamic impact	quasi-static, fatigue, dynamic impact

Specimen geometry to determine the mechanical characteristics of joints

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Testing Requirements in Series Development and Production

The aim of series development and production departments is to ensure readiness for series production. To achieve this, among other things the properties of materials must be examined as per specifications from basic development, critical values of joins tested and the operation or characteristic curves of assemblies determined. The following pages contain typical examples from the various vehicle areas.

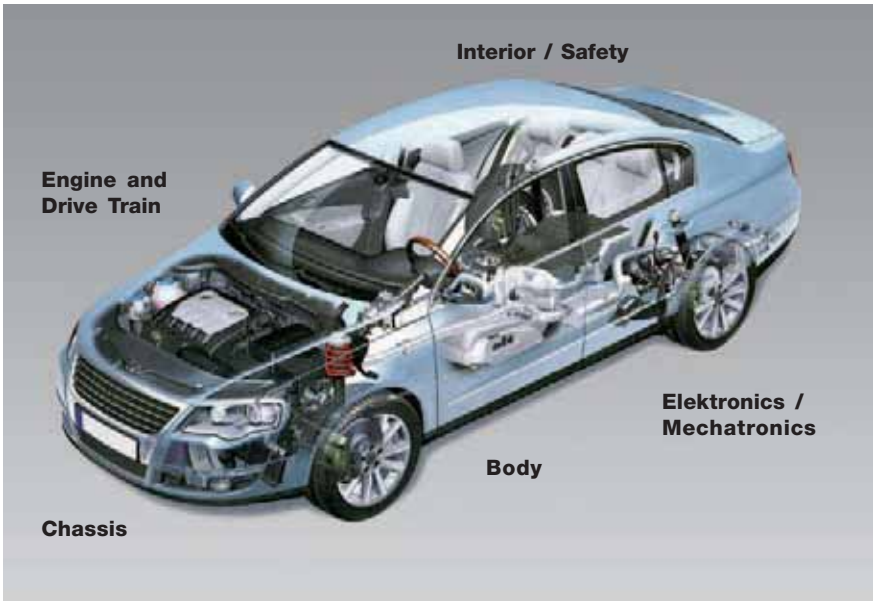

Fig 1: Zwick applications are divided in the following segments

Engine and Drive Train

The primary development aim of series development and production is a consistent and continued increase in the efficiency of drive assemblies, coupled with attractive driving dynamics and a further reduction in emissions, offering climate-friendly mobility. To achieve this, new systems are being developed which are either lighter in weight or have lower energy consumption and/or reduced emissions resulting from optimization of operating parameters (e.g. higher pressures and temperatures). These systems employ new materials or combinations of materials, which must withstand higher stresses under actual working conditions (e.g. temperature extremes, aggressively corrosive environments).

Fatigue Testing of the Cylinder Block

Internal combustion engines consist of three main components: the cylinder block, crankshaft drive and timing drive. The cylinder block may consist of one unit or of individual cylinders and comprises one or more castings. Cast iron is often used, although light metals, such as aluminum and light metal composites (aluminum/magnesium), are increasingly employed.

The cylinder block is subjected to many stresses, including moments of mass inertia, torsional moments and loads arising from the transmission of gas forces from the cylinder head to the crankshaft bearings.

In the example shown:
- Crankshaft forces on bearing shells at $10x10^6$ cycles
- Forces strike inner radius of bearing shells

Advantages of Solution with Vibrophore:
- higher specimen throughput
- lower energy costs
- test at ambient temperature of 150 °C
- compensation for bearing play
- equipment tests all bearing points

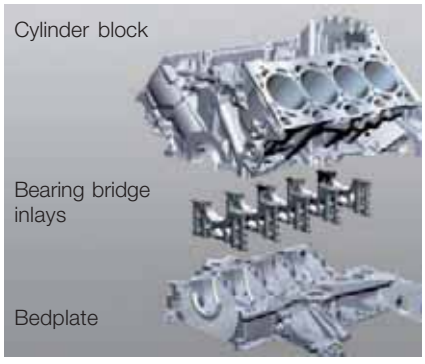

Fig 2: Cylinder block model

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Fatigue Tests on Connecting Rods

The complexity of loads acting on connecting rods requires a design equal to the demands placed on it. This also applies to the materials used. The fatigue limit for connecting rods is assumed to be approximately N=5 x10^6 cycles and the connecting rod can be divided into three load areas. Both eyes must be tested under actual conditions, i.e. with play and in a temperature range from 90 – 120°C, surrounded by oil . The Zwick Vibrophore, with special forked specimen grips, allows a test frequency of up to 250 Hz. High specimen throughput and low energy requirements mean reduced operating costs.

Fig 1: Load areas of connecting rods


Fig 2: Gable-grips for testing connecting rods with Vibrophore Amsler HFP 250

Fatigue Tests on Chains

The Vibrophore is ideal for determining the fatigue characteristics of individual chain components in series production. A test frequency of up to 50 Hz makes it suitable for determining the fatigue characteristics and limits of both continuous chains and chain components (e.g. chain bridges).

The control electronics were developed specifically for chain testing and allow even chains with large variations in amplitude to be measured. They can readily be adapted to company-specific testing standards.


Fig 3: Chain testing with Amsler HFP 5100


Fig 4: Chain testing with Zwick Vibrolino

Zwick / Roell

Testing Catalytic Converter Mats

The aim of this test is to determine the stiffness and friction coefficient of catalytic converter mats under temperature. A materials testing machine with compression platens which can be heated up to 980 °C is used. Two layers of the material, separated by a metal sheet, are placed between the compression platens. The compression platens are then heated and the vertical test load applied; the distance between the compression platens is regulated by means of a laser extensometer with an accuracy of ± 5 µm. Using a second test axis, the metal sheet is then moved horizontally between the two layers. The force required for this can be converted to the temperature-specific coefficient of friction.

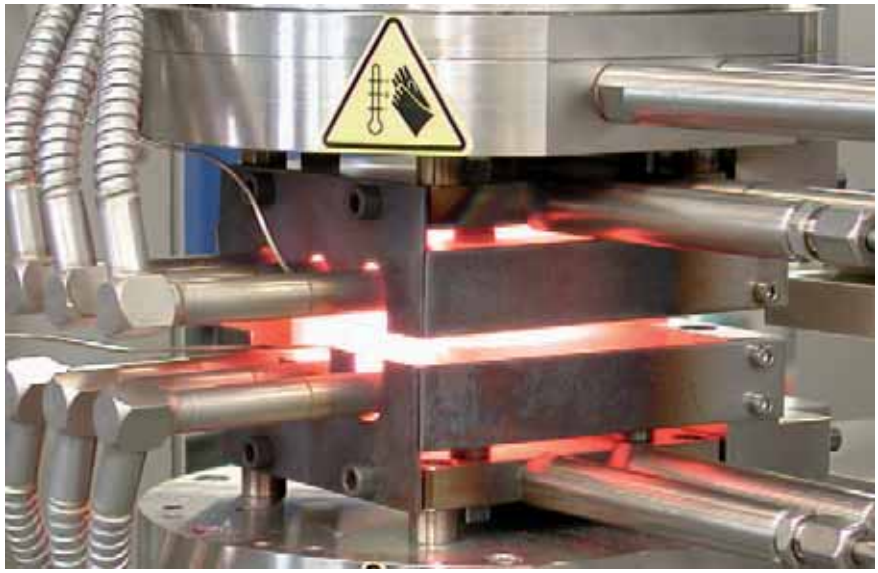

Fig 2: Testing of stiffness and friction on catalytic converter mats

Fig 1: Amsler HB 50 for fatigue testing of crankshafts

Fatigue Tests on Crankshafts

For fatigue tests on crankshafts the Amsler Vibrophore or a servo-hydraulic testing machine can be used. In the case shown the S-N curve is determined according to DIN 50100. In view of the relatively low frequency of 10…30 Hz, a servo-hydraulic testing machine was employed.

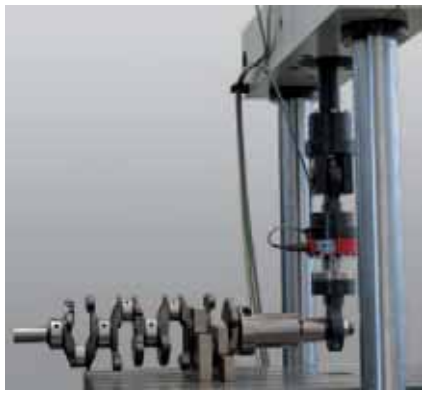

Fig 3: Fatigue testing according to DIN 50100

Fatigue occurs through bending strain. The mounting table and tool can be reconfigured to enable all segments of the crankshaft to be tested.

A fatigue limit of approx. $N = 3 \times 10^6$ cycles is assumed here. Force-controlled sinusoidal cycles are performed as per the staircase method. Fatigue testing via torsional load is possible using the same machine.

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Clutch Testing – Axial

The following characteristic curves are of importance in both development and production control of friction clutches:

- contact force and travel
- release force and travel
- disengagement stroke: clutch pressure plate
- parallelism of pressure plate to clutch plate

For release testing the compression die is pressed against the inner diameter of the diaphragm spring and the force/travel curve recorded. With contact testing a compression die is pressed directly against the clutch pressure plate and the spring characteristic curve of the diaphragm spring between clutch pressure plate and clutch cover is measured. These tests are performed in new and defined use condition. The characteristic curves for disengagement force/travel and contact force/travel are important criteria for comfortable operation and for reliable torque transfer.

Fig 1: Zwick Z020

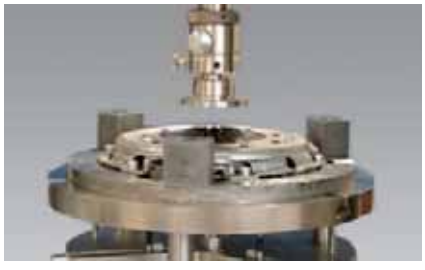

Fig 2: Disengagement test on clutches

Clutch Testing - Axial/Torsion

Fig 3: Horizontal system for testing clutch disks

Dry friction clutches are among the means used for application (moving off from rest without difficulty) and interruption of torque flow.

In addition to the above-mentioned axial characteristic curves, torque characteristic curves are therefore also extremely important:

- zero crossing (average value of angle of rotation between loading and unloading)
- pre-damper and main damper characteristic curve (angle or torque controlled)
- partial curve (similar to pre-damper and main damper curve; here for determining friction coefficient)
- drag torque (min. permissible torque after declutching)

In addition to torque characteristic curves the following axial curves are determined:

- characteristic curve of facing/cushioning springs (force/travel characteristic curve of spring between the clutch plates)
- non-parallelism (measurement of non-parallelism at pre-load)
- thickness of clutch plates (measurement of plate thickness at pre-load)

The test equipment has the following features:

- horizontal layout (component mounting alignment)
- two-axis system with two independently controlled drive shafts

Force/torque measuring platform capable of measuring very low torques (from 1 Nm, e.g. drag torque, zero crossing) and very large moments (up to 1,000 Nm, e.g. main damper characteristic curve) with simultaneous measurement of axial force of up to 20 kN.

Fig 4: Clutch disk test specimen (arrow) and load measurement platform (right side)

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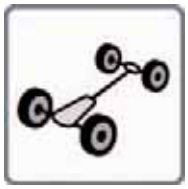


Chassis

As the link with the road, the chassis defines significant properties such as vehicle dynamics, safety, ride comfort and fuel consumption.

In view of the safety-critical engineering of components to the IEC 61508 Standard SIL, considerations regarding lightweight construction potential are accompanied by those concerning reliability in the development of new materials and manufacturing technologies. Important tests in this context are static and dynamic multi-axial loadings (vertical, horizontal, torsional) and the measurement of the resulting load components to determine the load/travel curves and fatigue characteristics.

Testing Steering Linkages

This testing system is used to determine the friction forces and moments, including the 'stick slip effect', inside and outside the test axis.

The multi-axis solution described here consists of:

- a horizontal with Fmax 20 kN testing machine
- 3 *testControl* regulated drive axes (axial, lateral force and torsion)
- 3 manually adjustable axes, allowing the widest possible range of steering linkage configurations to be accommodated
- *testXpert*® software for control of the 3 axes
- complete safety housing to CE standards
- universal multi-hole plate for mounting equipment

Drive axes:

1. Tensile/compression axial 20 kN
2. Torsion 100 Nm
3. Tensile/compression lateral 1 kN

Manual axes:

4. Lateral force: axial position
5. Passive clamping: vertical position
6. Passive clamping: horizontal position

Fig 1: Multi-axis Zwick Z020 for tensile, pressure and torsion testing on steering linkage

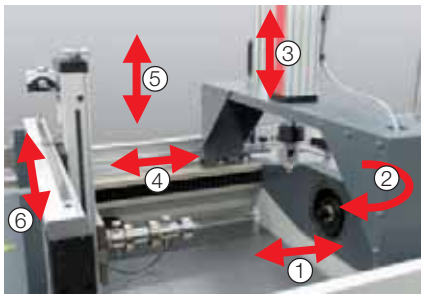


Fig 2: Drive and manual axes

In-Line Production Tests on Telescopic Steering Columns for Large Goods Vehicles

To facilitate automated production of steering shafts, two Zwick testing machines have been integrated into a production line. One testing machine is used to determine the maximum torsion angle in the middle of the production sequence, allowing process-oriented analysis of the previous assembly steps. A special angled sensor was developed for the high precision requirements in connection with relative torsion angle measurement. The second testing machine is located at the end of the production line; its function is to determine the steering shaft displacement load.

Fig 3: Testing system for steering spindles in line production. Machine 1 "torsion angle"

Fig 4: Testing system for steering spindles in line production. Machine 2 "displacement load"

Zwick / Roell

Testing Device for Disc Brake Pads/Linings

Disc brake pads are one of the most important components of a wheel brake. One method of assessing the quality of the pads is by determining the lining thickness change through one-dimensional compression loading in the direction of the normal friction-surface forces. Zwick materials testing machines with a compression test kit equipped with an integrated measuring system are used for this. Measurement of the deformation is via 3 measuring transducers, arranged in a part-circle offset by 120°.

Fig 1: Disc brake pad test fixture

Pressure is applied via a piston plunger mounted securely on a ball head, resulting in circular force application. The flexible suspension of the plunger ensures exactly parallel contact with the brake pad, resulting in absolutely uniform, homogenous pressure application. The testing position of the compression die runs through the middle axis of the centre of area of the brake pad. The testing device is suitable for both one-part and divided brake pads.

Multi-Axial Fatigue Testing of Exhaust System Components

This application comprises a dynamic bi-axial test (10 kN vertical and 1 kN horizontal) on an exhaust muffler. The test is performed with a servo-hydraulic table-top testing machine and *testXpert*® software. The transverse force is applied via a small testing actuator integrated in the lower part of the device, allowing actual loadings of the muffler to be simulated and its fatigue characteristics determined.

Fig 2: Bi-axial test on exhaus system coupling

Shock Absorbers: Multi-Axial Test

This testing system is equipped with three test axes to measure the damping characteristics of hydraulic shock absorbers. The vertical force (wheel load) is applied through the testing machine axis. The horizontal loads and torsion moments generated by bends, moving off and braking etc. are produced via horizontally mounted testing actuator and a torsion drive. The testing axes can be controlled individually and independently of each other. Through this it is possible to determine the characteristics (damping, friction, viscosity) at different axial speeds, with and without lateral force and/or torsion moment.

Fig 3: Multi-axial test on dampers

Zwick / Roell

Elastomer Bearings

Elastomere bearings fulfill a range of functions in the chassis, including joints and equalization and vibration isolation and damping.

Visco-Elastic Characteristics of Rubber/Metal Dampers in Production

A testing system based on a standard testing machine has been developed to determine (among other things) the static and dynamic stiffness plus the loss angle and loss factor of rubber-metal bearings. In addition, the system is equipped with a safety light-curtain and supplementary two-handed control. The test result is displayed via a red/green digital tolerance indicator, with an acoustic prompt via an electronic buzzer, allowing the operator to attend to other tasks during the test. Parameterization of the test sequence plus result evaluation and display are via the proven *testXpert*® software.

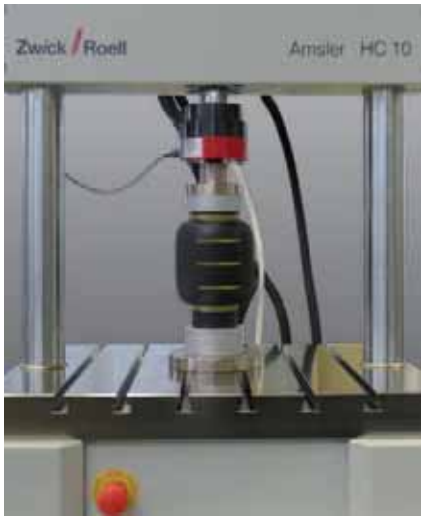


Fig 1: Fatigue testing of rubber/metal dampers

Pneumatic Springs: Multi-Axial Test

This testing system is designed to support quality assurance and development of pneumatic suspension springs to EN 13597. It consists of a 250 kN free-standing testing machine, which is additionally equipped with a horizontal electro-mechanical 50 kN drive and a load measuring platform with five load cells (3 vertical, 2 horizontal). The axial and horizontal stiffness characteristic curves of the pneumatic springs are determined under vertical, horizontal or combined load, with individual control of the following channels:

- load and travel, vertical
- load and travel, horizontal
- air and/or internal fluid pressure

Fig 3: Air bearing test fixture

Specimen positioning is easy as the system is equipped with a loading table via which the specimens can be inserted into the testing machine.

Fig 2: Air bearing rig with axial and horizontal loading

Zwick / Roell

Tests on Pneumatic Springs at Various Temperatures

With this testing system the visco-elastic properties of pneumatic suspension springs and their fatigue characteristics are investigated at various temperatures. The basic machine is a servo-hydraulic testing machine with hydrostatic cylinder bearings. A special compression test kit (mounted on a T-slot-platform) allows various pneumatic spring forms and sizes to be accommodated. The unit is also equipped with two measuring transducers for measurement of the pneumatic spring diameter. The whole unit can be used in a temperature chamber in a temperature range of 80 to +250 °C. A trolley can be used to facilitate connection and disconnection of the temperature chamber.

Fig 1: Temperature chamber with trolley

Fig 2: Amsler HB100 servo-hydraulic testing system with temperature chamber

Zwick / Roell

Precision-Spring Compression Testing Fixture

The combination of Zwick's precision-spring compression testing kit with the zwickiLine single-column testing machine and *testControl* electronics results in the ideal spring-testing machine. High transverse stiffness is a feature of the kit, which comes with overload protection. The ground, demagnetized compression platens have a parallel alignment accuracy of 1µm/10mm and precision guides permit only precise vertical movement. Measuring errors caused by deformation or lateral forces in the springs are reduced to a minimum thanks to the extremely stiff load cell, which is insensitive to transverse forces. The associated *testXpert*® test program is specially designed for the requirements of spring testing, making the precision-spring testing kit a highly capable testing unit.

Fig 1: Testing machine for precision spring

Multi-Channel Spring-Testing System

Multi-channel measuring platforms allow the line of action of force of compression coil springs (used as valve springs or in MacPherson struts) to be determined. Standard testing systems equipped with a six or nine-component load measuring platform are used, permitting specific determination of the spring penetration points and the resulting load from the load components which are under compression when the spring is loaded. These characteristic values are important in assessing the quality attributes such as friction, wear, and life expectancy.

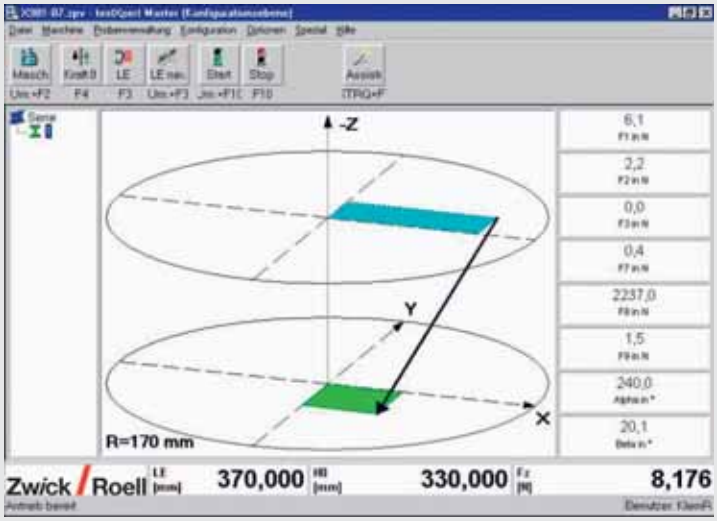


Fig 2: *testXpert*® screenshot indicating the penetration points and the spring characteristic curve

Fig 3: Precision spring testing fixture for forces up to 500 N

Fig 4: Spring testing system with multi-channel measurement platform

Zwick / Roell

Wheels and Tires

The wheel is one of mankind's most significant inventions, and one for which there is no prototype in nature. Wheels in the automobile industry consist of steel, light-metal or composite rims and their associated tires. The tire is a complex composite body made of materials with widely differing physical characteristics. As the link between road surface and vehicle it transmits all loads and moments. Zwick testing systems are used to determine the static and dynamic characteristics of wheels and tires, ranging from standard tests to those on the whole wheel/tire system.

Axial Deformation of Rims

To determine stiffness characteristics, compression tests are performed on the rim edge using a special compression mandrel. The machine employed is a free-standing testing machine with a forward projecting T-slot crosshead, adjustable for height, allowing rims to be loaded and clamped at a comfortable height. The load cell ensures precise measurement of the axial load, even when lateral forces arise due to the geometrical form of the rim. Thanks to its special construction and layout the load cell can be used for measurement in the upper and lower test areas of the machine.

Fig 1: Wheel indentation test

Fig 2: Brinell hardness test on rims

Hardness Testing Rims

Hardness tests, principally to Brinell Method HBW2.5 and/or Rockwell tests (e.g. HRB) are carried out on steel and aluminum rims for production control purposes and also to confirm strength characteristic values. With the Zwick/ZHU250 universal hardness tester, tests with loads up to 250 kg can be performed, using controlled closed loop technology, for all classical hardness testing methods (Brinell, Rockwell, Vickers, Knoop and ball indentation hardness) for metal and plastics applications. Large components are accommodated without difficulty in the 250 x 300 mm (D x H) test area.

Fig 3: Testing systems for rims with two test areas

Zwick / Roell

Test Bench for Stiffness Testing on Automobile Tires

Requirements: determining the stiffness of automobile tires; determining the force relationship under vertical and horizontal load; adjusting tire pressure via *testXpert*® software.

Implementation: A horizontal linear unit with Fmax 10 kN and a multi-component load-measuring platform with Fmax 50 kN are installed in a Zwick Z050 materials testing machine. The linear unit is mounted on the lower fixed crosshead. A multi-component load-measuring platform with vertical and horizontal load cells is installed on this linear unit. The required tire pressure is delivered via a pneumatic regulator unit with pressure sensor, controlled by a program in the Zwick *testXpert*® software. The tests are performed and evaluated using the *testXpert*® test program, under horizontal and vertical load and at various tire pressures.

Fig 1: Axial, horizontal load and tire pressure are controlled with *testContol*

Fig 2: Testing bench to measure tire sidewall deformation

Tests on Tire Components

In this area the following tests were carried out at room temperature and at typical ambient temperatures of -70 to +250 °C:

- tensile and tear growth tests on elastomeres with various specimen shapes
- hardness, rebound and abrasion tests on elastomers
- tear-off tests of steel and textile cords from elastomers
- tensile tests on steel and textile cords
- automatic specimen feed for high specimen throughput when developing new compounds
- determining visco-elastic characteristics.

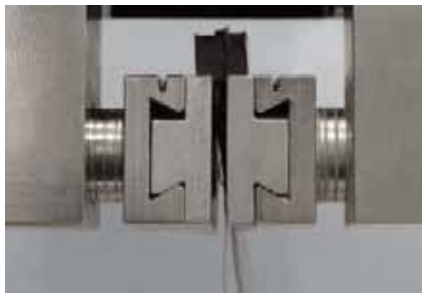


Fig 3: Tear-off tests of steel cord from elastomeres

Fig 4: Tensil test on elastomeres

Fig 5: Tensile test on metal cords

Fig 6: Rebound resilience tester

Body

The self-supporting vehicle body requires highly complex design which must meet many demands, from consistent lightweight construction to effective occupant protection and attractive styling. For lightweight construction new materials and/or material concepts such as temperature-resistant plastics or hybrid designs are necessary, while characteristics relating to possible forming processes and surface treatments are critical when it comes to attractive styling. Zwick has a large range of testing systems for use in determining these material and structural characteristics.

Bumper Stiffness

This testing system is equipped with a large lower and smaller upper T-slot mounting plate. Up to four load cells can be located flexibly on the lower plate, while the upper plate is attached to three load cells. The four load cells are used to measure the axial force components of the attachment points of components. With the three upper load cells the total axial load can be measured, even if the component fails asymmetrically resulting in a load eccentric to the test axis. The example (below, left) shows the load/deformation curve of bumpers being determined using this measuring layout.

Fig 1: Bucking strength test system for bumpers

Draw Bead Test on Steel Sheet

This test has the aim of determining the coefficient of friction between steel sheet and a deep drawing tool in order to determine the ideal lubricant for this forming process, thereby enabling cracks and creases to be avoided and ensuring an optimum deep drawing process. The draw bead kit is easily installed in a materials testing machine.

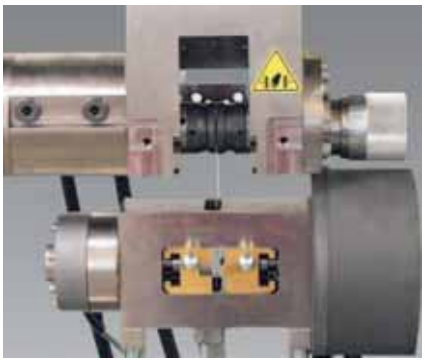


Fig 2: Close-up view of a draw bead test

For the test a strip of steel sheet (typical dimensions 300 mm x 30 mm x 2 mm) is axially clamped in the upper standard specimen grips and the draw bead tool closed. Next the strip is drawn through the draw bead tool. This procedure can be repeated automatically, the number of repeats being variable. Reliable and reproducible measured values are guaranteed by the digitally regulated gripping force of the draw bead tool. The dies of the tool can be exchanged quickly to cover various test specifications.

Fig 3: Draw bead test system for evaluation of deep-drawing dies

Zwick / Roell

Vehicle Door: Buckling Test

To determine the load-deformation curve of large bodywork components (in this case a vehicle door) a widened version of a Zwick materials testing machine with two load cells (the load components are totaled) and a semi-cylindrical bending tool is used. As the components do not fail symmetrically along the length of the bending tool, a bending moment arises relative to the test axis. This presents no difficulty from a measuring point of view as the two load cells employed are insensitive to moments. The upper test area is equipped with specimen grips and an extensometer for standard tensile tests on metals.

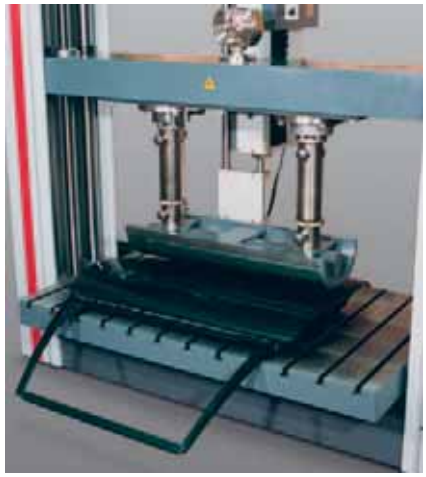


Fig 1: Three-point buckling test on car doors

Window and Door Seal Testing System

These testing systems are used for door and window seals with integrated anti-pinch systems designed to switch window or sunroof motors off if a defined load acts on the seal (if a passenger's head or fingers are trapped). The testing system determines the load at which the electrical signal activates the safety system. The electrical signal is measured and displayed in real time in the test sequence and the system also incorporates a barcode reader for specimen identification and a horizontal positioning unit for multiple loading.

Fig 2: The upper test area is used for tensile testing

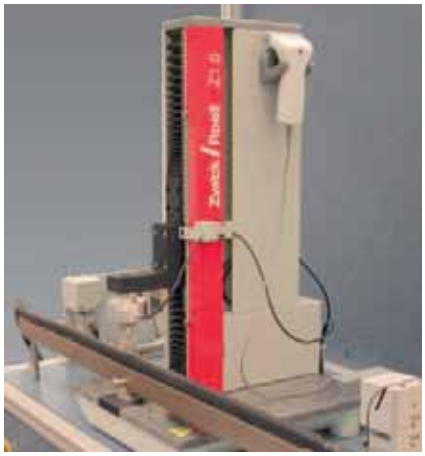
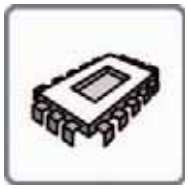


Fig 3: Door seal testing system to test embedded sensors

Zwick / Roell



Electronics/Mechatronics

Electronics and mechatronics are the principal drivers of innovation in automobiles and their value-adding effect is increasing day-by-day. Unfortunately, they also occupy a leading position in failure statistics. The greatest challenge is therefore to master the ever-rising levels of complexity while achieving zero-error production and operational stability over the whole performance range with continuing integration of new features. For this reason, the goal of mechanical testing in this field is to raise production quality and increase operational stability.

Tests on Wire Insulation

A special compression test is performed to determine the indentation resistance of cable insulation according to automobile specifications. The cable is attached to an anchoring point and a load applied via a defined cutting edge. The electrical contact between cutting edge and cable strand is measured and shown in the load/travel curve.

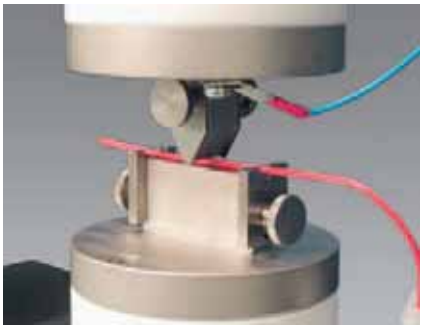


Fig 1: Wire insulation penetration test

Tensile Test on Wire Connectors

The extraction force of electrical connectors is tested as part of a routine quality assurance check on cables and connectors.

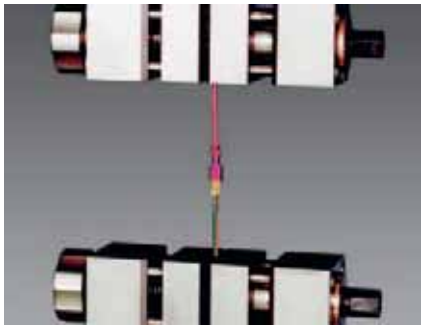


Fig 2: Tensile test on wire connector

Testing Electronic Switches and Buttons

To determine the switching characteristics of electronic switches and switching elements, the electrical signal of the assembly under test is integrated into the *testControl* electronics. The *testXpert*® software assigns the electrical switching contacts synchronously to the relevant load and deformation data. In a hysteresis test (switching on and off) the mechanical load and/or the torque and the electrical switching points are determined and displayed. For torque measurement the testing machine is additionally equipped with a torsion drive and sensor.

Fig 3: Torsion test on rotary switches

Fig 4: Close-up of a 3-position switch test

Zwick / Roell

Solder Point Inspection on Printed Circuit Board

A fully automatic testing system with motorized compound table is used to determine the displacement resistance of soldered components. All testing machine sequences and table positions are controlled automatically by *testControl* and *testXpert*®. The operator only needs to 'teach' the test positions once and no personal supervision is required for the test.

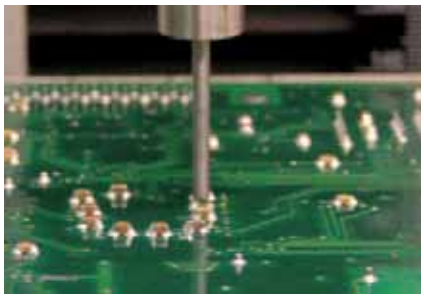


Fig 1: Automated test system to test soldered pins on a printed circuit board

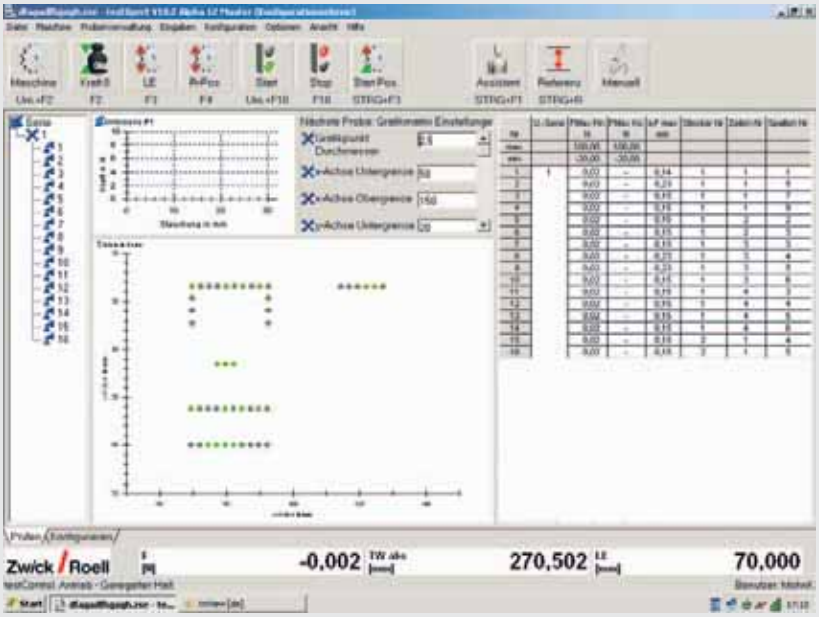


Fig 2: *testXpert*® software shows "at glance" which pins have tested and if they passed the minimal strength requirements (indicated in green)

Function-Testing of Electromagnetic Actuators

Examining the load-travel characteristic curve of solenoids and proportional magnets effectively provides a function test for electromagnetic actuators and is used mainly for final inspections. This curve allows the principal operating characteristics to be identified, while the load-force curve shows whether the actuator is applying the required force within its operating range at a fixed current level. The hysteresis provides information about friction resulting from the quality of the mechanical parts.

The load-current curve is mainly checked in connection with proportional magnets to establish whether the actuator applies the necessary force within a current range at a defined armature position. The ideal curve is a linear relationship between load and current around the operating point. Both curves can be determined using the testing assembly illustrated below.

Fig 3: Testing rig for proportional magnets

Zwick / Roell

Interior and Safety

As vehicles become more personalized, interior design has gained even more importance and significant further developments in interior materials are to be expected. A wide range of materials is used, including textiles, leather, wood, metals and, increasingly, plastics. In addition to appearance and surface 'feel', seating design is an increasingly significant 'feel-good factor'. However, the material properties of stiffness and strength in safety-related materials and components also play an important role.

Static Testing on Car Seats

The testing system shown here is designed to determine the quality of car seats. The loading table is used for both loading and horizontal positioning of the seats in the y-axis. Simultaneous horizontal positioning of the load cell in the x-axis enables the axial stiffness (z-axis) of all areas of the seat surface to be determined. The testing system is also used to test sensor mats incorporated in the seat and used to control the vehicle's automatic settings, e.g. correct airbag deployment.

Bi-Axial Test on Car Seats

A flexible bi-axial servo-hydraulic system is used to determine the fatigue strength of car seats. It features a height-adjustable load frame, movable actuator, horizontal sliding table, adjustable seat retainers and a T-slot table. The flexible mounting of the pressure element and the sliding table allow simultaneous vertical and horizontal acceleration loads to be simulated. The system can easily be reconfigured to test other complex-shaped components in one or two axes.

Fig 2: Seat testing system for embedded-sensor mats

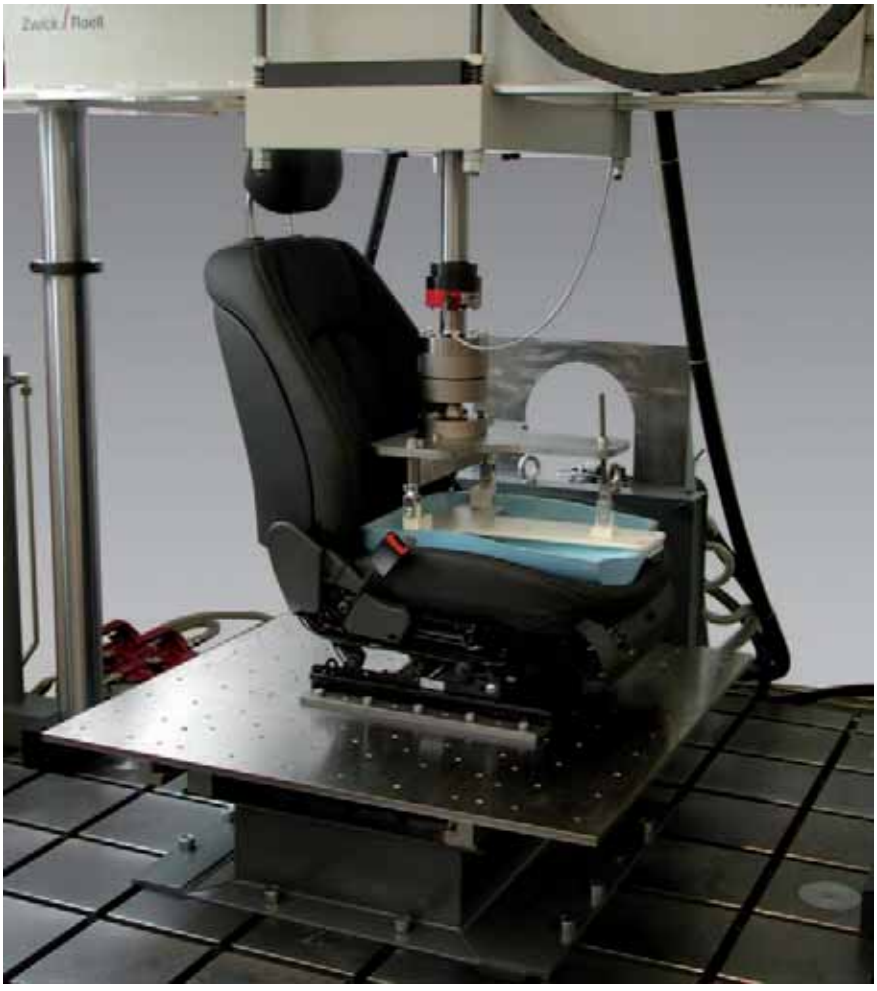


Fig 1: Bi-axial test rig to determine car seat durability

Zwick / Roell

Durability of Headrests

An electro-mechanical actuator offers a straightforward way to determine the stiffness and fatigue limit of car seat headrests. This test is performed to compare the comfort and static strength of headrests from various suppliers, although the actuator can of course also be used for other component testing. Further information on test actuators can be found on page 44.

Fig 1: Electro-mechanical actuator to test the strength and durability of headrests

Tensile Testing on Seat Belts

Zwick testing systems for determining the strength of manufactured seat belts (with or without buckle) are popular with seat-belt manufacturers and OEMs. The test requires special specimen grips and an impact-proof safety housing. A separate test is used to determine the release force of the buckle (unloaded and under tensile load).

Tensile Testing on Airbag Material

A standardized test is performed to determine the tensile properties of airbag material for quality assurance purposes using *testXpert*® software.

Fig 2: Tensile test of seat belt material

Fig 3: Test system for torque testing seat belt components

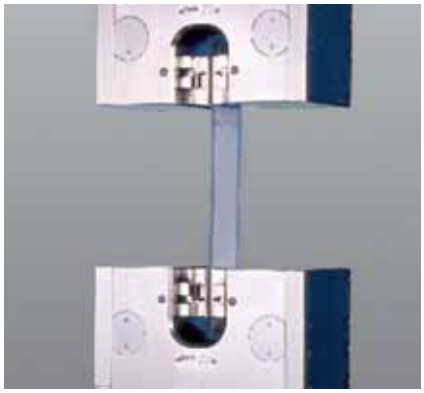


Fig 4: Tensile test on airbag polymer

Zwick / Roell

Quasi-Static Materials Testing: Products and Services

Hardness Testing

Fig 1: Hardness test on a valve

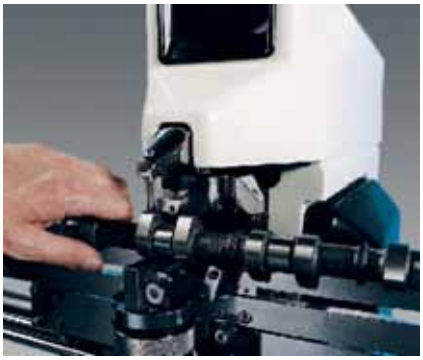


Fig 2: Hardness test on a camshaft

Fig 3: Hardness test on a spherical joint bearing

Zwick/ZHR Rockwell Hardness Testers

The Zwick/ZHR Rockwell hardness testing range caters for the following methods:

- classical Rockwell methods: Zwick/ZHR 4150 (pre-load: 10 kg; test load: 60; 100; 150 kg), Scales A B C D E F G H K L M P R S V;
- super Rockwell method: Zwick/ZHR 4045 (pre-load: 3 kg; test load: 15, 30, 45 kg), Scales N T W X Y
- combined Rockwell and super Rockwell method: Zwick/ZHR 8150 (pre-load: 3, 10 kg; test load: 15,30, 45, 60, 100, 150 kg), Scales A B C D E F G H K L M P R S V N T W X Y;
- Jominy method for sequence testing to Rockwell.

The instruments are available with various levels of operating convenience:

- models with one-button operation for simple testing situations (Type AK, Type BK)
- models with line-display and integrated conversion functions for standard applications (Type LK)
- models with touchscreen, expanded functions and high level of operating convenience for wide-ranging test situations. Used for batch-testing (Type SK) and production control (Type TK).

Additional features:

- pre-setting tolerances
- robust construction with play-free, ball-bearing spindle
- test area up to 292 mm in height for large work pieces
- standard RS 232 interface
- wide range of standard accessories (indenter, support table, hardness comparison platens)
- cost-efficient design with spring-force loading

Fig 4: Jominy Rockwell test with Zwick/ZHR

Zwick/ZHV1 and ZHV2 micro Vickers Hardness Testers

Zwick's micro Vickers hardness testers are available in two versions to suit different load ranges: ZHV1 for weights from 10 g to 1,000 g, and ZHV2 for weights from 25 g to 2,000 g. They comply with the following standards:

- Vickers (HV) ISO 6507, ASTM E 92, and/or Knoop (HK) ISO 454, ASTM E 384

The micro Vickers hardness testers are available in four different operating/function versions: manual; PC supported with CCD camera and *testXpert*® link; semi-automatic with manual focusing and fully automatic, e.g. for fully automatic profile testing.

Zwick offers a complete product range of micro (ZHV1, ZHV2) and low-load hardness testers (ZHV10, ZHV20/zwickiLine, ZHV30) – from manual to fully automatic operation and with manual or motorized compound table with full control via *testXpert*®.

Zwick / Roell

Zwick/ZHU 0.2/Z2.5, ZHU 2.5/ Z2.5 Universal Hardness Testing Machines

These machines feature a zwickiLine materials testing machine fitted with a hardness measuring head suitable for all hardness tests using indentation depth measurement, including:

- Martens hardness HM (macro range)
- Rockwell hardness, scales A to K, N, T plus HMR5/250
- ball indentation hardness H
- Vickers depth measurement HVT and
- Brinell depth measurement HBT.

The measuring head contains a digital travel measuring system (resolution down to 0.02 µm), a load cell (ZHU 0.2/Z2.5: 2 ... 200 N; ZHU2.5/ Z 2.5: 5 ... 2500 N) and an exchangeable indenter.
Special features:

- quick, automatic approach, even with varying specimen heights
- high accuracy and reproducibility of measured values through high measured-value resolution (20 nm) and consistent test conditions
- additional materials data can be obtained from force-indentation test
- can be used for production-parallel testing

An add-on optical unit has been developed for use with the hardness measuring head. It consists of a measuring microscope with up to four lenses and a sliding carrier (optionally with motorized control) so that components to be tested do not need to be moved. In this configuration, this fully automatic hardness testing machine can perform standardized Vickers, Knoop and Brinell hardness tests – in addition to the test procedures already mentioned.

Zwick/ZHU topLine Hardness Tester up to 300kg Test Load

All three Zwick ZHU topLine hardness testers – ZHU250top (1 - 250 kgf / 9.8 - 2,452.5 N), ZHU750top (3 - 750 kgf / 29.4 - 7, 357.5 N) and ZHU3000top (20 - 3,000 kgf / 196.2 - 29,430 N) – use innovative optical zoom technology with integrated image analysis, thus eliminating the need for frequent lens changes.

Depending on load application (closed loop principle with load cell), the hardness testers provide testing solutions for both optical and depth measurement testing in accordance with the following methods:

- Vickers (HV) ISO 6507, Brinell (HB) ISO 6506, Knoop (HK) ISO4545
- Rockwell (HR) ISO 6508, Vickers (HVT), Brinell (HBT), ball indentation hardness (H) ISO 20391 for plastics testing.

Options such as LED ring light illumination (for more precise measurement of materials with ring bulging) or the motorized turret for up to 4 indenters and 2 lenses provide users with a versatile machine for a variety of applications.

Fig 1: Universal hardness tester Zwick/ ZHU2.5/Z2.5 with hardness measuring head

Fig 2: Zwick/ZHU0.2/Z2.5 with HU-measuring head and measurement microscope

Fig 3: The turret could be loaded with four indentors and two lenses

Zwick / Roell

Materials Testing Machines

Applications

Materials testing machines are used to determine the strength and deformation behavior of specimens and components, mostly under tensile, compression and flexure loading. Shear and torsion loads are also used. These testing machines feature long travel, wide test-speed ranges and interchangeable sensors and tools, allowing testing of specimens and components with widely differing forms and dimensions, made from various materials and materials combinations and with correspondingly different characteristics.

Fig 2: ProLine Z050TN with CE conforming protective screen

Basic Concept

Zwick has three series of quasi-static materials testing machines, differing in design, equipment, performance characteristics and expandability. This allows us to provide the most suitable machine for every budget.

Fig 1: The zwicki line is available in three different heights

- The **zwicki-Line** consists of high-quality, compact machines. These portable, easy-to-use single-column load-frames have been specially designed for mechanical testing with low test loads of 0.5 to 5.0 kN.
- The **ProLine** was developed to satisfy the demand for cost-effective testing machines for function- testing components and standard tests on materials. The 'Pure Portfolio' accessory range for the ProLine ensures an attractively priced system and short delivery times. Test loads are from 5k N to 100 kN.
- The **Allround-Line** provides the solution to challenging testing situations and fulfils the most exacting requirements. It can be equipped or upgraded via a comprehensive accessory range and used with special sensors and multi-channel measuring technology.

Load Frames

Our standard production load frames are rated for loads up to 2,000 kN. We design and manufacture special versions for specific applications, e.g. for higher rated loads or horizontally aligned load frames for testing in the component installation position.

zwicki-Line Single-Column Model

This load frame is based on a highly bend-resistant aluminum extrusion, which was developed especially for the zwicki-Line. The workspace is freely accessible from three directions, making the zwicki-Line also suitable for small component testing and for use as a hardness tester. This modular system's low weight and compact base make it easily portable – and it will fit on any laboratory table.

Zwick / Roell

ProLine Single and Double-Column Table-Top Machines

ProLine load frames incorporate two round steel columns, providing precise crosshead guidance, while the integrated spindle and guide protection guarantee reliable operation in industrial applications or when testing splintering materials.

Allround-Line Table-Top and Floor-Standing Testing Machines

The table-top testing machines are equipped with two columns made of patented extruded aluminum. They are light and highly bend-resistant and combine the functions of spindle guide and spindle protection. T-slots on the outer sides allow simple mounting of accessories such as fixtures or safety guards, unrestricted by the moving crosshead. All table-top testing machines can be fitted with stands to bring the workspace to the optimum height for the application or operator. This allows, for example, comfortable seated operation with plenty of leg-room, making the system well suited to wheelchair users also.

Hard-chrome plated guide columns and a precision ball screw with play-free spindle nuts guarantee a high level of precision for the floor-standing machines. Various crosshead configurations are available, providing either an upper or lower test area – or both. All load frames with electromechanical drives can optionally be equipped with a second test area. Benefits include rapid change to a different type of test without having to reconfigure the entire machine.

Fig 1: Allround-Line floor-standing machine Z100

Fig 2: Allround-Line floor-standing machine Z250

Zwick / Roell

Drives for Quasi-Static Test Situations

Electromechanical Drives

All electromechanical drives incorporate play-free, low-wear ball screws and digitally controlled drives and are used with load frames rated for test loads up to 2, 000 kN. Combined with the digital measurement and control system, they offer the following advantages:

- extremely wide, infinitely variable speed-range
- very low speed-settings possible (from about 0.5 µm/min)
- highly precise, exactly reproducible positioning and speeds.

The ProLine and zwickiLine testing machines are fitted with DC motors. All other testing machines have especially low-inertia brushless three-phase AC motors.

Hydraulic Drives

This drive is located centrally to the fixed crosshead, making the test area below easily accessible. A servo or proportional valve regulates the oil flow between the hydraulic unit and differential cylinder. The oil pad in the upper pressure chamber eliminates the familiar problem of plunger pistons „jumping“ when a specimen breaks. For high test loads in particular, the hydraulic drive is an extremely cost-effective solution.

Hybrid Drives

These patented drives combine the advantages of the electromechanical drive (high precision) with those of the hydraulic drive (high forces). As a result, even long-stroke cylinders designed for very high loads can be moved and positioned very precisely.

This approach allows two parallel mounted trough-rod cylinders coupled to the moving crosshead to be traversed with precise synchronism and regardless of their respective loadings. They follow, accurately and virtually without hesitation, the position parameters set by an electromechanical pilot drive. Special features of this drive:

- long travel range (no adjustment of fixed crosshead necessary
- relatively low load-frame height

zwicki-Line Load Frames and Drives

Model	Z0.5	Z1.0	Z2.5	Z5.0
• Max. test load [kN]	0.5	1.0	2.5	5.0
• Test area height				
* Shortened [mm]	570	570	573	-
* Normal [mm]	1070	1070	1073	1030
* Raised [mm]	1370	1373	1373	-
• Test area width [mm]	∞	∞	∞	∞
• Test area depth [mm]	100	100	100	100
• Max. crosshead-speed [mm/min]	2000/3000	2000	1000	600
• Crosshead travel resolution [µm]	0.2453	0.2265	0.0996	0.0399
• Max. power consumption, kVA	0.44	0.44	0.44	0.44

ProLine Load Frames and Drives

Model	Z005	Z010	Z020	Z030	Z050[1)]	Z100
• Max. test load [kN]	5	10	20	30	50	100
• Test area height [mm]	1070	1050	1050	1370	1370	1360
• Test area width [mm]	440	440	440	440	440	640
• Test area depth [mm]	∞	∞	∞	∞	∞	∞
• Max. crosshead-speed [mm/min]	500	1000	500	300	180/600	300
• Crosshead travel resolution [µm]	0.039	0.038	0.018	0.012	0.007/0.016	0.008
• Max. power consumption, kVA	0.8	0.8	0.8	0.8	0.8/2.6	3

[1)] This testing machine is available in two electronics variations.

Zwick / Roell

Allround-Line Load Frames and Drives

Table-top testing machines

Model	Z005	Z010	Z020	Z030	Z050	Z100	Z150
• Max. test load [kN]	5	10	20	30	50	100	150
• Test area height							
* Normal [mm] [1]	1045/1025	1045/1025	1045/1025	-	-	-	-
* Raised [mm] [1]	1445/1425	1445/1425	1445/1425	1355/1325	1355/1325	1355	1535
* Extra high [mm] [1]	1795/1785	1795/1785	1795/1785	1755/1725	1755/1725	1755	-
• Test area width							
* Normal [mm]	440	440	440	440	440	-	-
* Widened [mm]	640	640	640	640	640	640	640
• Test area depth [mm]	∞	∞	∞	∞	∞	∞	∞
• Max. crosshead-speed [mm/min]	3000	2000	1000/2000[3]	1000	600	750/1500[3]	900
• Crosshead travel resolution [µm]	0.0410	0.0272	0.0136/0.0543[3]	0.0271	0.0163	0.0207	0.0123
• Max. power consumption, kVA	2	1.9	2.1/2,6[3]	2.3	2.3	4/6[3]	5.5

Floor-standing testing machines

Model	Z050/Z100	Z150/Z250	Z300E	Z400E	Z600E	Z1200E
• Max. test load [kN]	50/100	50/250	300	400	600	1200
• Teat area hight [mm]	1825/1760[1]	1715/1655[1]	1800 1360[2]	1800	1940	2266
• Test area width						
* Normal [mm]	630	630	630	630	740	800
* Widened [mm]	1030	1030	-	-	-	
• Test area depth [mm]	∞	∞	∞	∞	∞	∞
• Max. crosshead-speed [mm/min]	1000/2000[3]	900/600	250	250	200	400
• Crosshead travel resolution [µm]	0.0270	0.0123/0.0082	0.0035	0.0035	0.002	0.0041
• Max. power consumption, kVA	4/5[3]	5.5/6	7/13[4]	7/13[4]	20/26[4]	20/25[4]

[1] Second dimension applies to version with widened test area [3] Depending on drive selected
[2] Applies to lower-priced special version with only one test area
[4] Higher consumption if hydraulic specimen grips used

High Force Load Frames and Drives (Standard range with hydraulic or hybrid drives)

Model	Z400H	Z600H	Z1200H	Z1600H	Z2000H	Z600Y	Z1200Y	Z2000Y
• Max. test load (kN)	400	600	1200	1600	2000	600	1200	2000
• Test area								
* Width (mm)	670	670	850	800	850	790	860	1200
* Heigth (mm)	1578	1578	1876	2076	2236	1895	2330	2495
* Heigth (mm) with adjustable crosshead	1878	1878	2184	2834	2829	-	-	-
• Max. travel (stroke, mm)	500	500	600	600	600	850	1000	1000
• Crosshead travel resolution (µm)	0.16	0.16	0.16	0.16	0.16	0.05	0.05	0.05
• Max. test speed (mm/min)	340	340	200	250	200	250	250	250
• No. of support/guide columns	2	2	4	4	4	2	2	2
• Max. power consumption (kVA)	8.5	8.5	15	20	20	8.5	15	25

Zwick / Roell

C-Shaped Load Frame

This load frame is ideal for compression and indentation hardness testing of larger cellular plastic items such as automobile and aircraft seat-cushions and mattresses.

Folding table-top extensions can be used to provide a very large surface and the test area of the table is provided with vent holes in accordance with ISO and ASTM standards. The test space is accessible from three sides, allowing quick, convenient operation, while the use of adapter pieces enables this load frame to be employed for tensile and tear testing.

Fig 1: C-shape frame for compression and indentation test on larger foam elements

Fig 2: C-shape frame with Fmax 50 kN for testing rivet joints and components

C Load Frame

Mode	Z005	Z010	Z050
• Version	Stand (C-Form)	Stand (C-Form)	Stand (C-Form)
• Max. test load, kN	5	10	50
• Test area width x height, mm	450[1)] x 680	450[1)] x 680	400 x 900
Optional	1450[2)] x 680	1450[2)] x 680	-
• Depth, mm	1000[1)]	1000[1)]	450[1)]
• Crosshead speed max., mm/min	600	600	600
• Crosshead travel resolution, µm	0.0504	0.0504	0.01627
• Max. power consumption, kVA	1.1	1.1	2.3

[1)] Table dimensions [2)] Table dimensions with extensions

Zwick / Roell

Measurement and Control Systems

The measurement and control system is an essential element of any testing machine. Its design and scope determine which drive system it regulates, which measurement system it is connected to, and which functions can be controlled with it.

Zwick testing machines use *testControl* electronics. Developed by Zwick in-house, *testControl* features state-of-the-art technology and the highest possible quality standards, providing maximum performance and long-term investment security.

Special features include:

- synchronized test data recording of all measuring channels with high resolution and measurement frequency
- 500 Hz real-time processing of test data for monitoring and event-oriented control of the test sequence (e.g. speed change upon reaching offset yield or proof stress limit) and safety limits
- adaptive control for exactly reproducible test speeds and positions
- modular design enables *testControl* to accommodate customers' individual requirements – if these change over time, *testControl* can be adapted to suit (e.g. additional load or strain channels or external input / output channels)
- direct, synchronous correction in *testControl* for testing system elasticity, providing high positioning accuracy, including under load.

In the base model, *testControl* and the testing machine are operated via a PC and *testXpert*® software, making the system easy to expand and configure to suit the most varied applications – and at the same time extremely flexible and convenient in operation.

As an alternative to PC operation, an optional stand-alone variation offers simple, direct operation via a color display, a key pad and a few intuitive function keys. A printer can be connected directly to output test results.

This system can also be connected to a PC, thus providing access to the benefits of *testXpert*® software. Housed in a compact casing mounted directly on the load frame, the electronics ensure high overall availability and reliability of the testing system.

Fig 1: *testControl* controller

Fig 2: Optional input/output modular kit to accommodate additional signals

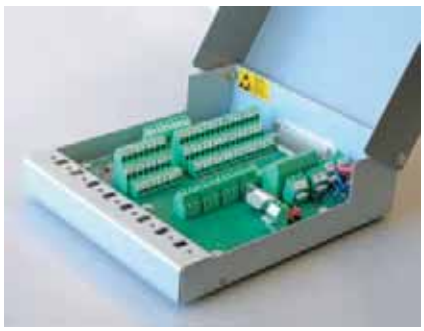


Fig 3: Input/output module box

Zwick / Roell

testXpert® II – Intelligent and Reliable, the New Software Generation for Materials Testing

With *testXpert*®, Zwick Roell has set the standard for intelligent materials testing software. Unlike other software, Zwick has standardized *testXpert*® for all of its applications, no matter whether static or dynamic tests — so you spend less time learning to handle software and more time conducting tests. With *testXpert*® II, you benefit from over 80 years of testing experience and from over 15,000 successful installations worldwide.

Some Significant Benefits of *testXpert*® II

Ingeniously simple – *testXpert*® II is organized so that you can operate it intuitively. Expressive symbols and a clear menu structure enable users quickly to become oriented and reduce the familiarization period dramatically. The menu bar is set up according to the needs of the user, making working with *testXpert*® II ingeniously simple.

Intelligent – wizards help you to set up or change test procedures and test reports. Should you have any questions, our extensive context-sensitive online help feature will quickly deliver the answer.

Modular design – *testXpert*® II gives you a software system tailored to your needs. *testXpert*® II's modular design makes this possible - you only buy what you need. Upgrading your existing system with additional test programs or options is – of course – no problem.

Compatible with your hardware – Zwick *testXpert*® II is compatible with all commercially available PCs and laptops without the need for an additional interface card! This means it is easy to switch system computers or even to develop test methods or perform analyses in the office at your convenience. You always have access to your test data.

Online language swapping – needless to say, you can have *testXpert*® II in your language of choice. *testXpert*® II speaks more than one language – all you need to do is click the mouse in order to change the language online. Regardless of the language used for testing, a test report can be automatically printed and e-mailed in a different language. Flexible *testXpert*® II language swapping offers international teams language-neutral operation of their testing machine and greatly simplifies communication.

Industry-oriented terminology and data export capability – *testXpert*® II not only uses your language but it also adopts your technical terminology. For example, symbols or variables that are specific to your industry (e.g. metals, plastics, rubber) are implemented throughout the software. This provides more relevant, meaningful information for your testing application. Today's quality assurance standards necessitate that the test results may be exported to a company's central laboratory database. So we have created *testXpert*® II to communicate reliably with your IT system by providing flexible interfaces. All test results can directly be processed, exported and archived. MS Office integration is achieved by means of Object Linking Editing (OLE).

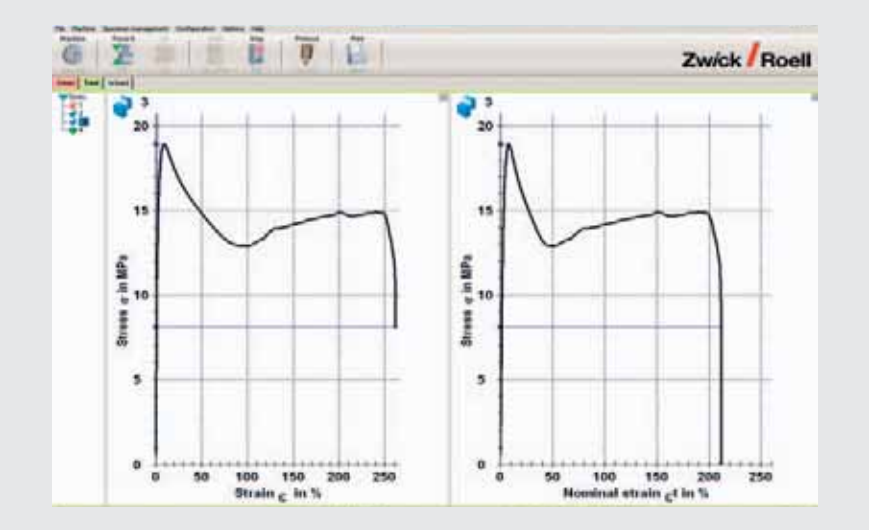


Fig 1: Comparison of strain and nominal strain measured with an extensometer in a tensile test

Simple Testing with *testXpert*® II

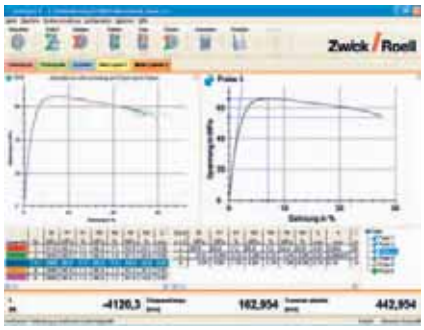
Select Test Standard

testXpert® II already contains the correct test program for every standardized test. Simply select the required test program – all parameters are pre-configured in accordance with standards and can also be adapted as required. For non-standardized tests, *testXpert*® II provides a range of varied, powerful testing programs, allowing the test sequence to be set up completely as desired.

Testing

The individual data are displayed on the monitor – online as part of the test procedure, so you can follow the test procedure live. If desired you can also incorporate an exactly synchronized video recording.

The results are calculated during the test so that the test procedure can be process-controlled, e.g. by speed change after determining the E-modulus or the yield point. Only in this manner can the test be performed quickly and in accordance with the standard.



Evaluation of Test Results

In *testXpert*® II you can create many different screen layouts according to your needs, for example with additional graphs, various presentations of the testing curves, tables and additional statistics. With one click you can switch between the various layouts, thus changing the presentation of your test results.

Synchronized video recording – *testXpert*® II offers you an image-for-image, exactly synchronized video recording of your test. You can interpret the measuring curve of the test efficiently with the help of the recorded image changes of the specimen. You can record the test procedure with a video camera or USB webcam. And *testXpert*® II saves the recorded video images with the measuring data – with 100 % synchronization guaranteed thanks to Zwick's specially designed mechanism. The visual recording shows, for example, when, how, and where the specimen develops cracks, deforms or changes color. Changes in specimen dimensions can be measured exactly from the captured images. In addition, before the test, you can determine which events should be recorded, such as the point in a cycle when compression changes to tensile stress. Afterwards you can print out these images or integrate them into the test report. Thanks to the synchronized video recording, the test procedure can be recalled or compared at any later time.

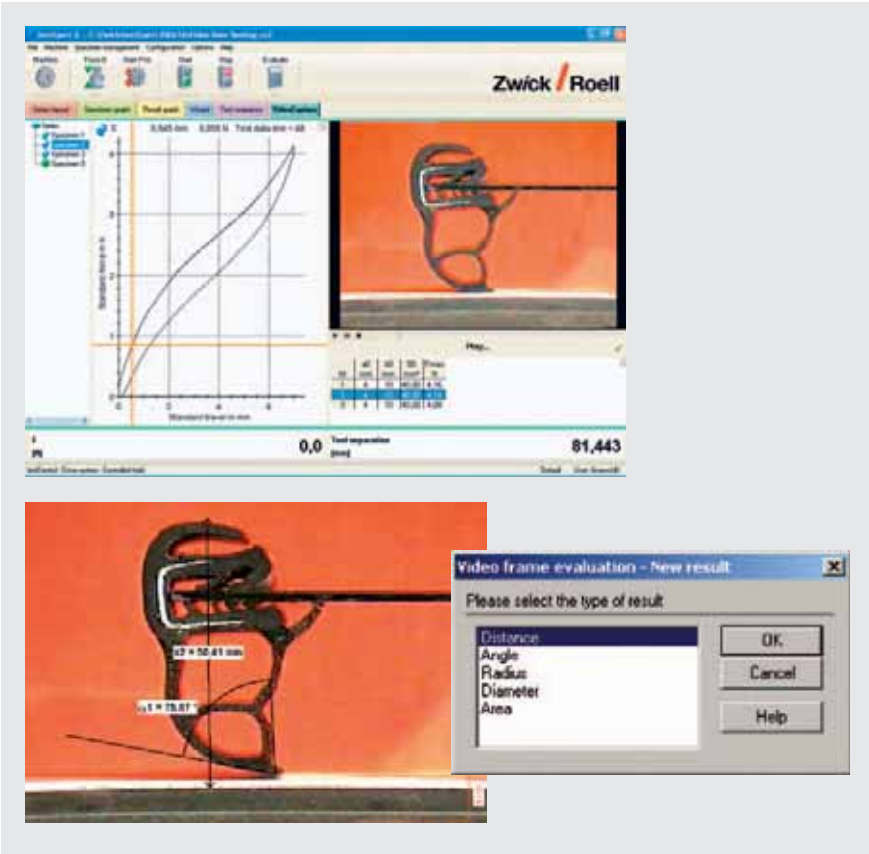


Fig 1: The video picture and the data curves are exactly synchronized with each other. The measured data points are then easily compared.

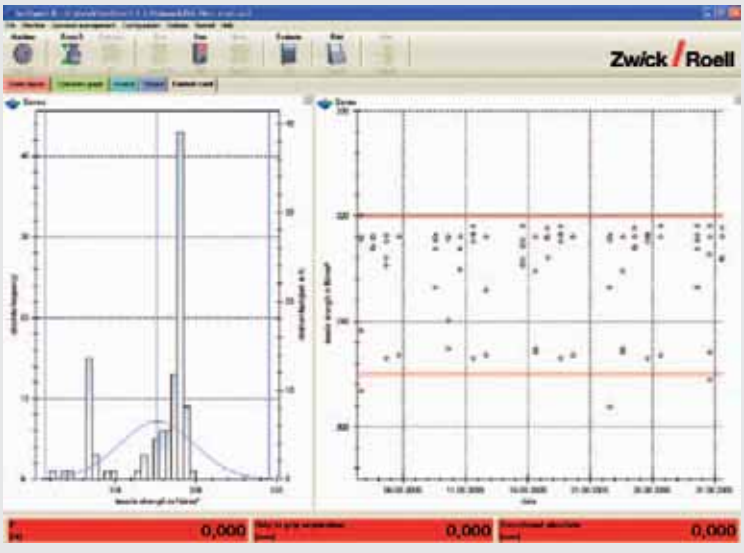


Fig 2: A presentation of a material's tensile strength over a period of days

***testXpert*® II LIMS** – only *testXpert*® II offers this feature: an integrated Laboratory Information Management System (LIMS). A powerful database is available to administer your test results in order to create and archive long-term statistics and reports. All data acquired by *testXpert*® II are available on any testing system in your company.

Graphical Sequence Editor – The *testXpert*® II Graphical Sequence Editor offers all the freedom you could possibly wish for. It enables you to design test programs of any kind, by combining test events, parameters and results exactly as you require. The intelligent design of the graphical sequence editor makes your work easy. You do not require any programming knowledge as the graphical interface makes for quick familiarization. Process safety is assured thanks to the integrated simulation mode, which analyzes the test program you have created. To do this it uses a virtual testing machine with different specimen behavior options (e.g. spring, plastic, metal, etc.), thus filtering errors out of the test procedure in the early stages – all without destroying a single specimen.

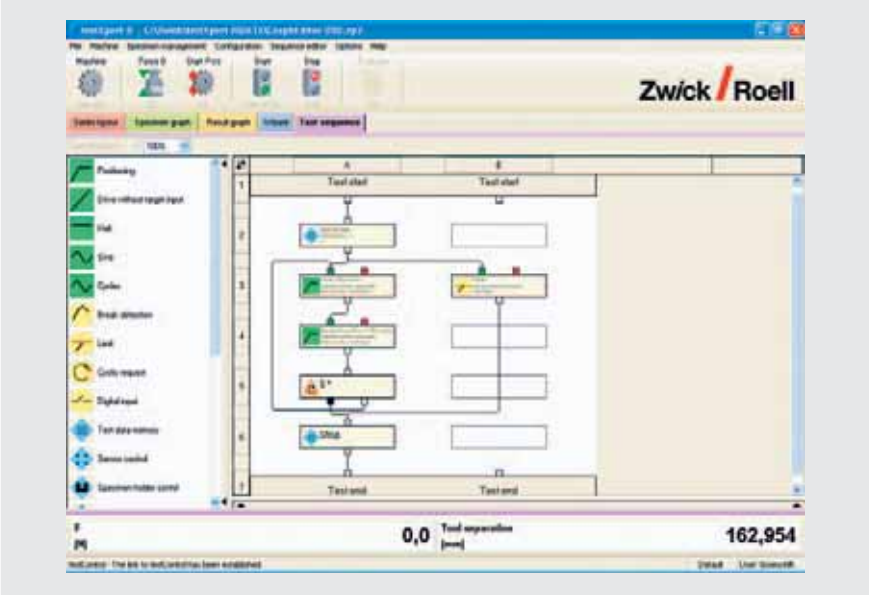


Fig 1: An example of of a graphical sequence editor program

For example: You wish to cycle between two steps (such as load levels) within a test sequence. Use the mouse to select the module of the first step and drag and drop it into the sequence. Decide the parameters for the first step. Proceed accordingly with the second step. You can enter the number of loops in the loop module underneath it, and then reconnect it to the beginning. At the same time, a limit can be monitored during this process, once again, very simply, by selecting the respective limit module.

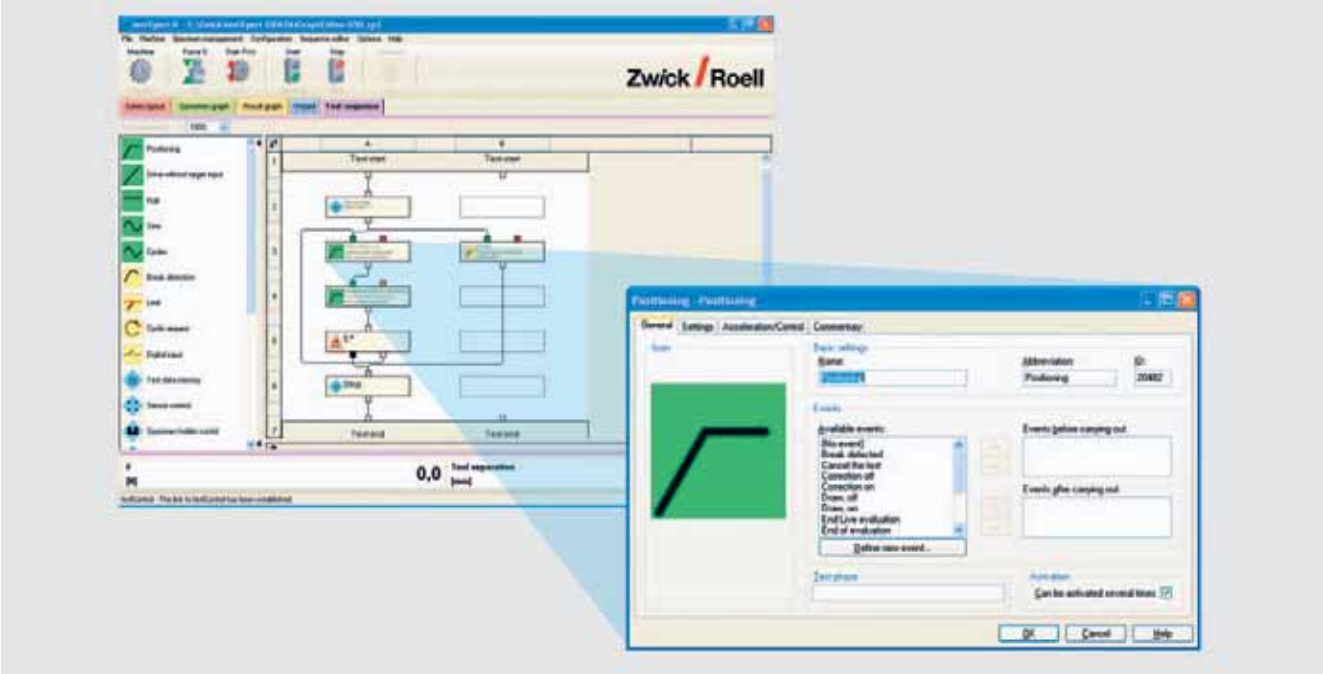


Fig 2: The program sequence illustrated. Details for each step may be shown and changed by clicking on respective boxes.

Zwick / Roell

Load Cells, Torque Cells and Load Measurment Platforms

Load Cells

Load cells are available for accurate load measurement of forces from 0.04 N upwards. Used in conjunction with digital measurement electronics, they offer the following advantages:

- automatic identification and acquisition of all setting and calibration parameters via sensor plug – no need for calibration or setting data alterations when changing the load cell
- insensitive to parasitic interference (bending moments, torsion moments etc.)
- high flexural strength limit and torque strength limit
- automatic zero-point and sensitivity balancing
- temperature compensation
- high measurement frequency
- very high test data resolution
- accuracy: Class 1 (1 % of reading) from 0.2 to 120 % of full scale load (1 to 100 % in the case of load cells smaller than 500 N). Class 0.5 (0.5 % of reading) from 1 % to 100 % of full scale load.
- over-range protection
- manufacturer's test certificate certifying factory calibration.

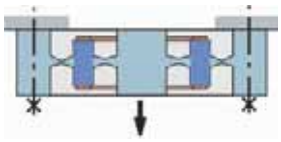
Load cells with one-sided or double-sided mounting studs and self-identifying sensor plugs are available for load capacities from 10 N upwards.

Fig 1: Load cells with sensor plug, type bending ring-torsion

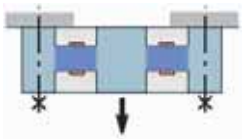
Types and Recommendations for Use

In some tests other factors, in addition to the accuracy of the load cells, may be significant. Temperature sensitivity of zero point and measured value are of importance when temperature conditioning devices are used. During compression and flexural tests in particular, transverse forces and moments may occur and these should not be allowed to produce unacceptable distortion of the measured value or damage the load cell. To cater for these factors, Zwick supplies load cells in various configurations.

- **Type: Bending ring-torsion**
  The body of this rotatoin-symmetric load cell is a bending ring with ring-shaped strain gauges on the face surfaces. It is highly insensitive to excentric load applications and overloads.



- **Type: Multiple beam**
  The outer and inner rings of this load cell are linked by spokes on which the strain gauges are mounted. This load cell is relatively insensitive to excentric load applications.



Torque Cells

Key features:

- wide torque measuring range
- high accuracy and resolution
- high axial loads possible
- alternative mounting on load cell (allowing unlimited revolutions) or on torsion drive.

Fig 2: Torque cell

Load Measurement Platforms

Key features:

- multi-component measurement platform comprising: 3x load cells in z-axis 2x load cells in y-axis, 1x load cell in x-axis, torque measuring on all axes
- transfer and/or measurement of high lateral forces
- transfer and/or measurement of high torques, e.g. clutch testing
- determination of force vectors resulting from compression coil springs
- determination of force penetration points
- determination of transverse force including force vector.

Fig 3: Load measurement platform

Zwick / Roell

Specimen Grips

Materials and component testing in the automobile industry produces a wide variety of applications. These are catered for by Zwick's comprehensive range of specimen grips covering various designs, load ranges and test temperatures. The optimum gripping principle is selected, based on specimen shape, material, load/temperature range and desired specimen throughput level, and standard or custom-made grips supplied as appropriate.

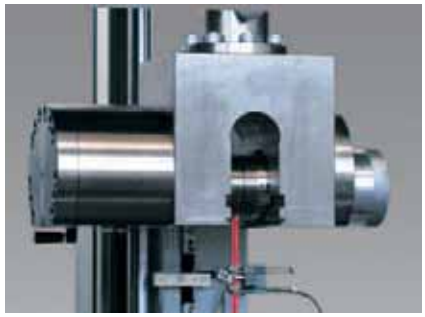


Fig 2: Hydraulic grips

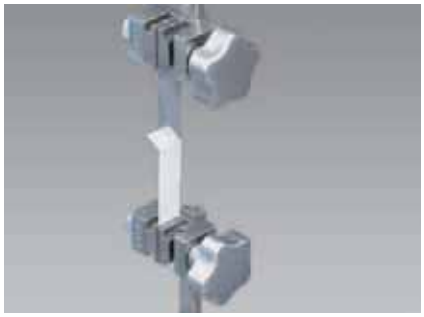


Fig 5: Screw grips

Fig 3: Pneumatic grips

Fig 6: Wedge-screw grips

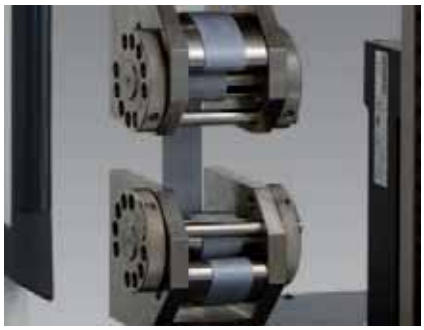


Fig 1: Roller grips

Fig 4: High-temperature grips

Fig 7: Hydraulic-wedge grips

Selection criteria for specimen grips

Characteristics/features	Hydraulic grips	Pneumatic grips	Spring grips	Wedge grips	Screw grips	Wedge-screw grips	Pincer grips	Capstan/roller grips	High-temp. grips	Hydr.-wedge grips
• Size (max. test load)										
* Smallest version, kN	10	0.02	0.02	2.5	0.02	0.5	0.5	0.3	0.5	25
* Largest version, kN	2000	100	0.05	600	50	250	10	400	30	250
• Temperature range										
* Lower limit, °C	-70	-70	-15	-70	-70	-40	-40	-15	+20	-70
* Upper limit, °C	+250	+250	+80	+250	+250	+250	+250	+80	+1200	+250

Zwick / Roell

Extensometers

In most tensile tests the extension against the test load has to be measured; in special cases the change in width must also be measured. In flexure tests, the measured quantity is the deflection. A variety of extensometer types are required to cope with differing specimen shapes and dimensions, material properties (strength, rigidity, extensibility etc.) material characteristics to be determined, measuring accuracies etc.

Requirements for Extensometers

The requirements for an extensometer are determined primarily by the physical characteristics of the material to be tested. Other critical factors include the shape and dimensions of the specimen together with the relevant test standards and results to be obtained. Ambient conditions (temperature, light, vibration) and costs must also be taken into consideration, as should the operating characteristics of extensometers. Whatever the application, Zwick's wide range of extensometers has the right instrument for the job.

The following chart contains an overview of the criteria affecting the choice of extensometer.

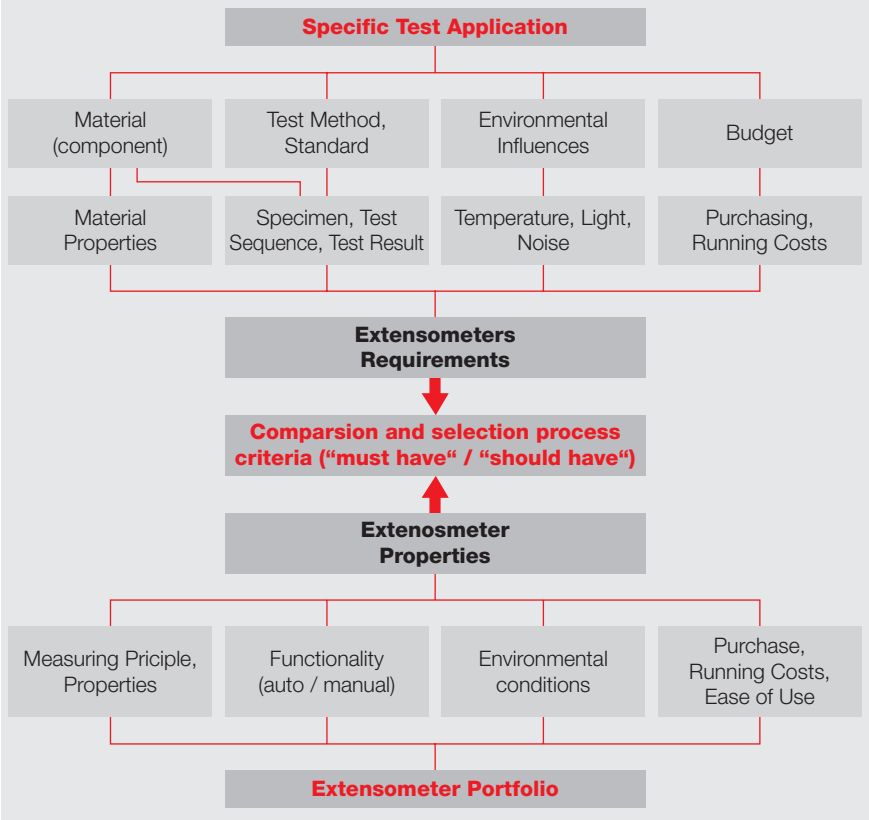


Fig 1: Selection process of extensometers

Crosshead Travel Encoder

A digital crosshead travel encoder is standard equipment on all Zwick Standard or Allround materials testing machines. Its measuring signal is primarily used to provide an actual value for the drive system position and speed control; however, it can also be used for indirect extension measurement .

Analogue Clip-On Extensometers

(clip-on, manual)

The resolution of these extensometers, which can be attached manually or automatically (option) to the specimen, is extremely high, but their test travel is relatively short. They are therefore predominantly used for high precision determination of tensile modulus (ISO 527-1) on rigid and reinforced plastics and to determine Poisson's Ratio (with simultaneous measurement of extension and change in width).

Zwick / Roell

Digital Clip-On Extensometers

These high-resolution extensometers are attached to the specimens manually and feature relatively long test travel, making them suitable for precise determination of the tensile modulus and yield point in accordance with ISO 527-1 and ASTM D 638 on rigid and semi-rigid plastics. They can even be used to determine the elongation at maximum stress and the strain at break for rigid plastics with low extension

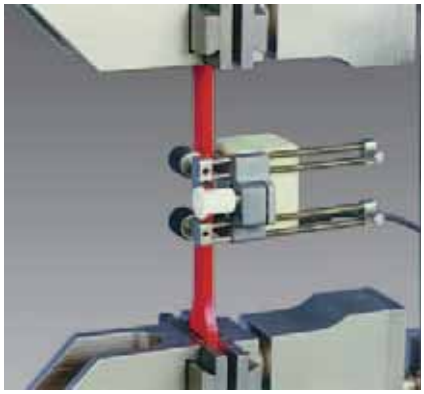


Bild 1: Digital clip-on extensometer

Long-Stroke Extensometer

This is designed for measuring higher strain levels on plastics, rubber and elastomeres, cellular materials, plastic film and thin sheet with maximum forces greater than approx. 20 N and provides a robust and non-sensitive system, particularly suitable for testing rubber and elastomere specimens with a tendency to wrap around the sensor arms after specimen break.

Optical Extensometer

Contact-free, digital extensometer for tensile tests on shouldered test bars made of rubber, elastomeres, flexible cellular materials, thin sheet and plastic film, at room temperature and in temperature chambers (through a heated window).

Macro Extensometer

This digital extensometer is suitable for tensile, compression, flexure and cyclic tests on plastics, composites and rigid cellular plastics showing small to medium extensions. It can also be used for thin sheet, plastic films and flexible cellular plastics provided optical measuring methods are not required.

multiXtens

Fully automatic, multifunctional high-resolution digital extension measurement system for tensile, compression, flexure and creep tests as well as for cyclic tests on materials with low to high extensions

Advantages:
- automatic gauge length setting
- automatic application and detachment of sensor arms
- automatic centering between specimen grips
- very low drag force
- deformation measurement until specimen break without detaching sensor arms
- crosshead contact protection
- exchangeable sensor arms for tensile, compression and flexure tests
- automatic sensor recognition
- suitable for measurements in temperature chambers
- upgradable for transverse strain measurement.

Bild 2: The multiXtens combines high-resolution and long-stroke measurement

optiXtens

Fully automatic high-resolution, optical extensometer using the Laser Speckle method. It is used for tensile and compression tests on materials with low to high extensions, both at room temperature and in conjunction with temperature chambers.

Advantages:
- optical system not requiring measurement marks
- easy to operate
- no drag-force influence
- reliable, accurate deformation measurement until specimen break
- particularly suitable for measurement in temperature and climatic chambers

Zwick / Roell

videoXtens

A contact-free high-resolution extensometer for tensile and compression tests on all kinds of plastics, rubber, composites, sheets and plastic films. Resolution and measuring range can easily be adapted to the prevailing test conditions by selecting suitable easy-to-change lenses.

Advantages:

- adaptable to various materials and test conditions
- parallel measurement of transverse strain (optional)
- reliable, accurate strain measurement until specimen break
- automatic gauge length recognition
- suitable for measurements in temperature chambers through a heated glass panel.

Fig 1: The videoXtens is adapted to the test by selecting field view

laserXtens

laserXtens provides contact-free measuring of deformations on a wide range of materials, its measuring principle rendering gauge marks unnecessary. laserXtens is used for tensile and compression tests on metals, plastics and components.

Advantages:

- no specimen marking required
- high resolution
- automatic gauge-length setting
- suitable for temperature chamber testing
- parallel bi-axaial deformation measurement
- suitable for testing small specimens at high resolution

Fig 2: laserXtens

Extensometers: Overview

	Long-stroke	Optical	Makro	multiXtens	optiXtens	videoXtens[1)]	laserXtens
System	digital	digital	digital	digital[2)]	laser-speckle	image evaluation	laser-speckle
Measuring range, mm	1000 – L_0	1000 – L_0	min. 75 max. 160	700 – L_0	500 – L_0 700 – L_0	50...200 (viewfield)	40
Resolution, µm	5	5	0.12...0.6	0.02...0.04	0.1	1	0.15
Accuracy (ISO 9513)	cl. 1 ≥ 1mm 1% or 0.01 mm[3)]	cl. 1 ≥ 3 mm 1% or 0.03 mm[3)]	class 0.5/1[4)]	class 0.5/1[4)]	class 0.5	class 1	class 1
Gauge lengths, mm	10...1000	10...900	10... 100/205/300	≥ 5	≥ 10	≥ 5	1.5-220
Drag force, N	≤ 0.20	none	≤ 0.050	≤ 0.015	none	none	none
Autom. sensor arm	yes	yes	optional	yes	yes	yes	-
Autom. L_0 pre-set	yes	yes	optional	yes	yes	yes	yes

[1)] Data for 25 mm lens, [2)] Two measuring ranges, [3)] Whichever value is greater, [4)] Depending on feeler arm length

Zwick / Roell

Temperature Conditioning Devices

Application

The mechanical properties of many plastic and rubber materials change significantly with temperature. It is known, for example, that the modulus of elasticity value of some thermoplastic materials can vary by about 3 - 4 % per 1 °C. Knowledge of the behavior of materials under different environmental conditions is of considerable importance with regard to their eventual use, particularly in the automotive and aeronautical industries.

Fig 1: Zwick Z005 with temperature chamber, optiXtens and pneumatic grips

Temperature Chambers

Zwick temperature chambers offer the following features:

- aperture for extensometer sensor arms on the rear left-hand side (except for non-cooling chambers)
- Eurotherm temperature control unit with digital display of set value and actual value.
- interior chamber illumination
- insulated glass panel in front door
- slotted inserts allowing chamber to slide in and out without removal of specimen holders
- insulation and electrical design conform to CE safety regulations.

Options Available

Several options are available depending on testing machine specification and laboratory requirements:

- heated optical glass insert providing homogeneous temperature distribution when using optical extensometers
- guide rails or lift trolley for removing chamber from test area
- temperature measurement and control by *testXpert*® software via RS 232 interface
- direct on-specimen temperature measurement and control
- liquid nitrogen tank, 100 litres, with pressure generation, control valve, filling level indicator and safety device.

High Temperature Furnace

Application

High-temperature testing is used to determine the thermal-elastic behavior, heat resistance and re-crystallization temperature of materials. Zwick provides various options, from a minimum temperature of 200 °C to a maximum temperature of 1,600 °C.

Depending on the materials to be tested, 1-zone or 3-zone furnaces with air or vacuum environment are available. Zwick will provide the optimum combination of furnace (including temperature controller), suitable grips for tensile and flexure tests, plus the appropriate extensometers.

The high-temperature furnaces and extensometers are provided with swivel units, allowing comfortable, convenient operation of the testing machine, which can then be used for room-temperature testing with practically no re-setting. An optional specimen temperature measuring device with up to three thermoelements is available for direct on-specimen temperature measurement, ensuring standard-compliant testing.

Fig 2: Tensile test using high-temperature furnace

Zwick / Roell

Additional Drive Options for Individual Solutions and Machine Expanding

Use Zwick's additional drive options for flexible individual solutions or to expand universal testing machines – several can be used in combination if required.

Electro-Mechanical Testing Actuator

Zwick's full range of electro-mechanical testing actuators offers versatility, high displacement resolution and multiple load and speed combinations. The actuators require no special hydraulic equipment or units and are a cost-effective solution for static and cyclic component-testing. They are compatible with testControl and *testXpert*® and cover a wide range of applications, being available in a load range of 1 - 30 kN and travel of 200 - 400 mm with a speed range between 26 and 500 mm/sec.

Fig 1: Testing actuator for evaluating 'soft brake' effect

Pneumatic Testing Actuator

Zwick's pneumatic testing actuators are used in drive systems for fatigue testing components. Easy to install, they represent a cost-effective alternative for simple tests.

Fig 2: Compression testing child's seat with pneumatic actuator

Fig 3: Fatigue-testing headrests

Torsion Drives

For tests on components or materials which require torsion loading in addition to tensile/compression loads, torsion drives from 2 to 2,000 Nm are available for a wide range of standard testing machines. These drives have been developed as a modular system and can therefore easily be upgraded. A Master Test Program for multiple test axes plus a graphical sequence editor for 4 test axes are available in *testXpert*® II.

Fig 4: Torsion drive (1) and electro-mechanical actuator (2) integrated with Zwick universal testing machine

Zwick / Roell

Fatigue Strength and Dynamic Strength Testing: Products and Services

Fatigue Testing Machines

Servo-Hydraulic Testing Machines

Servo-hydraulic testing machines are universally applicable for materials and component testing under pulsating or alternating load, with periodic or random signals. Quasi-static and continuous loading are also easily achieved.

Special features:

- precisely aligned load frames featuring extremely high stiffness
- hydrostatic bearings, making the actuators virtually frictionless - and also wear-free
- LVDT extensometer with high resolution and linearity integrated centrally in the actuator rod
- precision strain-gauge load-cell for mounting on actuator rod or fixing to crosshead as required
- wide range of hydraulic power packs
- comprehensive range of accessories (specimen grips, extensometers, temperature chambers etc.).

Servo-Hydraulic Testing Machines (STM)
Standard versions[1)]

Model[2)]	HC	HB	HA
• Type/version	table	floor	floor
• Load frame nominal force, kN	5 – 25	50 – 1000	50 - 500
• Test stroke, mm	100	100/250/400	100/250
• Specimen length, mm	100 – 700	100 – 1100	250 - 1500
• Hydraulic power pack			
* System pressure, bar	210/280	210/280	210/280
* Feed rate, l/min	9 – 30	20 – 270	20 – 270
• Motor nominal power, kW	5 – 20	11 – 160	11 – 160

[1)] Load frames available with higher rated actuators and different strokes on request
[2)] Testing actuator mounted on upper crosshead of HC and HB frames, base-mounted on HA frame

Fig 1: Amsler HC 25 servo-hydraulic testing machine

Fig 2: Amsler HB 250 servo-hydraulic testing machine

Fig 3: Amsler HA 100 servo-hydraulic testing machine

Zwick / Roell

Amsler HC-compact

The Amsler HC-compact servo-hydraulic testing machine consists of a hydraulic power pack, test frame and test actuator and is suitable for materials and component testing under static and oscillating loads.

Advantages

- space-saving design with integrated hydraulic power pack
- whisper-quiet power pack allowing installation without additional noise protection measures in virtually any laboratory
- testing actuator mounted in top crosshead permitting easy set-up for flexure and component testing.
- T-slot platform hard-chromed for tests with corrosive media, e.g. saline solutions
- seal-free testing actuator with hydrostatic bearings, guaranteeing significantly longer maintenance-free operation than with any other design.

Specification

• Test frame	Fmax 25 kN
• Testing actuator	Fmax 10 or 25 kN Stroke 100 or 250 mm
• Hydraulic power pack	9 l/min, 210 bar Noise level< 58 db(A)

Amsler HCT and HBT Tensile and Compression/Torsion Testing Machines

The servo-hydraulic testing machines in the Amsler HCT and HBT series are used to test the behavior of materials and components under combined tensile and compression/torsion loading. The tests can be performed with pulsating, cycling and static loading.

Specification

	HCT 25/250	HBT 100/1
• Nominal force	FN ±25 kN, stroke 100 mm	FN ±100 kN, stroke 100 mm
• Nominal moment	MN ±250Nm, angle of rotation 280°	MN ±1 kNm, angle of rotation 100°

Additional figures on request

Features

Standard load frame from HC and HB range.

- Tensile and compression/torsion drive mounted in upper/fixed crosshead and consisting of:
  - longitudinal actuator with hydrostatic bearings
  - length compensation
  - rotary actuator
- The length compensation allows play-free transmission of the torque to the rod of the longitudinal actuator. The rotary activator remains fixed and is not subject to axial movement.
- Combined load cell/moment sensor
- Tests under discrete load can also be performed, e.g. axial load only.

Fig 1: Servo-hydraulic testing machine Amsler HC-compact

Fig 2: Tensiel, compression, torsion testing machine Amsler HBT

Zwick / Roell

Components for Servo-Hydraulic Test Bench Solutions

Zwick supplies a complete range of components for flexible testing systems. The test bench is configured from the individual components to suit the test situation. Single or multi-axial – it makes no difference; the modular approach can handle a wide variety of combinations and applications.

1. Measuring and control electronics for set-value input, control and measurement data recording, with single or multiple-axis testing systems.

2. Testing software for standard-compliant tests, block testing and reconstruction of operating loads.

3. Load and torque sensors for precise measurement of induced loads and moments.

4. Flanges and joints for connecting the specimen to the actuator, even if misalignments occur or the specimen moves in the test area during arrangement.

5. T-slots and platforms plus angle plates for flexible assembly of testing actuators and load frame.

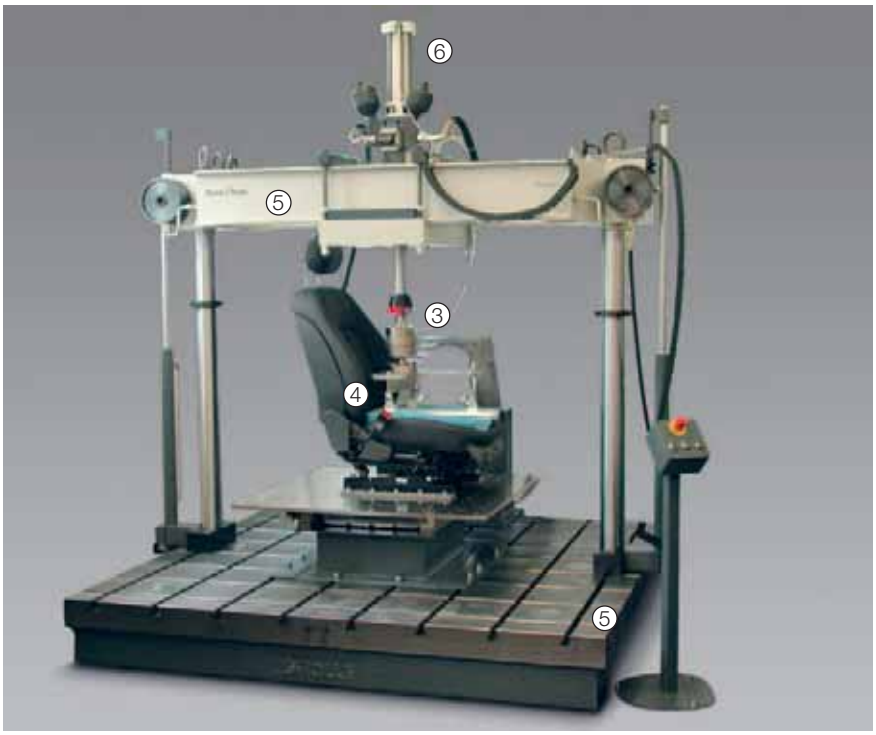


Fig 1: Test bench for multi-axial test on car seats

6. Servo-hydraulic testing actuators apply precisely the required static or oscillating force to the specimen.

7. Hydraulic power packs supply the test rig with the required hydraulic energy.

8. Hydraulic hoses provide a flexible connection between pressure generator and consumer. If these are some distance apart it is advisable to install fixed pipe work.

9. Hydraulic connector assemblies switch the hydraulic energy on and off and enable set-up mode with reduced pressure and flow rate.

Measurement and Control Electronics for Component Testing Systems

Control Cube

The successor to the K7500 is fully compatible with its predecessor, while its even more compact design makes it especially suitable for use with flexible single or multi-axis test rigs. When it is used in conjunction with QanTim simulation software, operating loads can be reproduced with great accuracy.

HydroWin 96xx:

These electronics are especially suitable for tests involving high test and measurement frequencies. The HydroWin 96xx guarantees high measurement accuracy and is designed for use with 1 - 9 axis tests on a fixed servo-hydraulic test rig.

Zwick / Roell

HydroWin 96xx

Outstanding features of the HydroWin 96xx control and measurement electronics include:

- 10 kHz closed-loop control and data acquisition
- 19-bit A/D conversion with real-time linearization
- real-time measurement channels for derived measurands also (e.g. totals or differences)
- 32-bit set-value generation for any required functions up to 1kHz
- adaptive control for non-linear test applications (e.g. testing rubber components or polymers)
- multi-channel control (up to 9 control channels)
- control of external units
- comprehensive basic and application software.

Workshop 96 – Test Software for HydroWin 96xx Controller

Workshop 96 is universal testing software for fatigue and durability tests on materials and components, with a large number of application programs for standard tests such as fracture toughness determination, low cycle fatigue, damper testing and so on. A valuable additional facility is upgrades for modernizing older load frames from most manufacturers.

Function

The HydroWin 96xx digital control and data acquisition system plus Workshop 96 software represent a fully-integrated testing solution in a user-friendly Windows environment, providing test engineers with access to all test-system control-options.

Fig 1: HydroWin 96xx Controller

Configuration 96

This software from the Workshop 96 Framework enables the HydroWin 96xx control and measurement electronics to be configured to use measured-value transducers and channels as required. Analog, digital and mathematically-derived transducers can be configured and assigned to channels. Connection and disconnection of transducers is automatically detected by the HydroWin 96xx controller and the software.

Toolkit 96

Toolkit 96 supports Workshop 96 and with the HydroWin 9600 controller provides an integrated testing environment with real-time graphs, actual value displays (adjustable for running values), upper peak, lower peak, peak to peak or mean values.

testXpert® Dynamic

Zwick also provides a range of *testXpert*® software for specific testing applications, including low cycle fatigue, torsion testing, multi-stage continuous testing, and elastomer-metal component testing.

Fig 3: Workshop 96 screenshot

Fig 2: *testXpert*® screenshot of fatigue test on elastomer

Zwick / Roell

Control Cube

In collaboration with CaTs[3] (Consultants in Automated Test and Structural-dynamic Simulation Systems), Zwick provides easy-to-use software, measurement and control electronics and data acquisition for single and multi-axis servo-hydraulic testing (up to 32 channels).

testXpert® QX

testXpert® QX is comprehensive, modular software covering the full spectrum of fatigue testing and specifically designed for single and multi-axis servo-hydraulic test rigs. *testXpert*® QX integrates configuration, control, data acquisition and analysis into a single state-of-the-art application. *testXpert*® QX is characterized by its extreme ease of use and clever integration of hardware and software. It supports the Control Cube measurement and control system via an ethernet interface to a laptop or PC.

Software and Hardware for System and Simulation Testing

- supports Control Cube via ethernet interface
- optional data acquisition available
- compatible with foreign measurement and control electronics via ±10V interface
- single & multi-axis test rigs
- testing from components to complete structures.

Integrated Application

- test project management
- integrated control & data acquisition
- configuration of the measurement and control electronic
- graphical test editor
- test execution, trend monitoring
- results analysis
- report editor
- training/demo mode.

Supports Wide Range of Tests

- multi-stage continuous program
- reversal point test
- simulated service loads
- multi-axis static test.

Test Rig/Measurement and Control Electronic Configuration

- allocate hardware to test rig
- calibrate transducers
- monitor safety limits
- PID auto-tune
- comprehensive test procedures
- project-oriented configuration.

Procedures

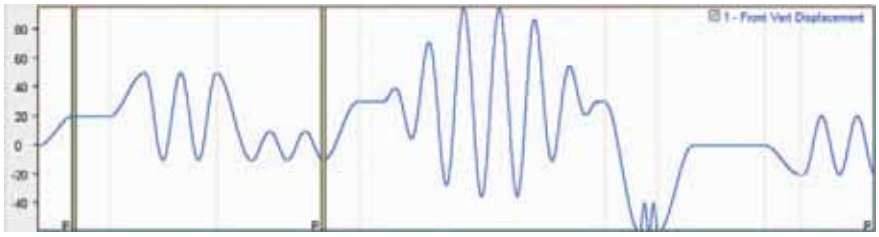
- start/stop acquisition
- digital I/O
- test & hydraulics control
- limit value conditions, if/else etc

Graphical Test Editor

- advanced waveforms
- ramp, dwell, cyclic
- procedures
- nested sequences
- data & reversal point acquisition

Test Management

- test progress
- trend monitoring
- oscilloscope
- test speed



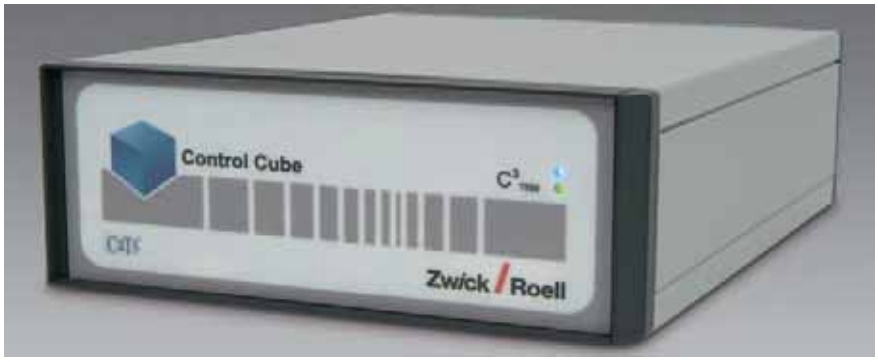


Fig 1: Control Cube

Fig 2: Two-channel multi-stage continuous test on an axle rig

Zwick / Roell

Servo-Hydraulic Testing Actuators

Servo-hydraulic actuators allow complex load sequences to be reproduced with a high level of accuracy, even with loads into the MN range.

The standardized series comprises actuators from 10 kN to 1,000 kN, configured as required for 280 bar or 210 bar. The nominal strokes are 100 mm, 250 mm and 400 mm.

Depending on requirements, there is a choice between cylinders with hydrostatic bearings or polymer plain bearings. The hydrostatic actuators are seal-free and, in normal operation, frictionless, making them particularly suitable for very low test speeds (no slip stick effects) and also for high frequencies and test set-ups where transverse forces can arise.

Fig 1: Testing actuator, LH series

Fig 2: Testing actuator installed on upper load-frame crosshead

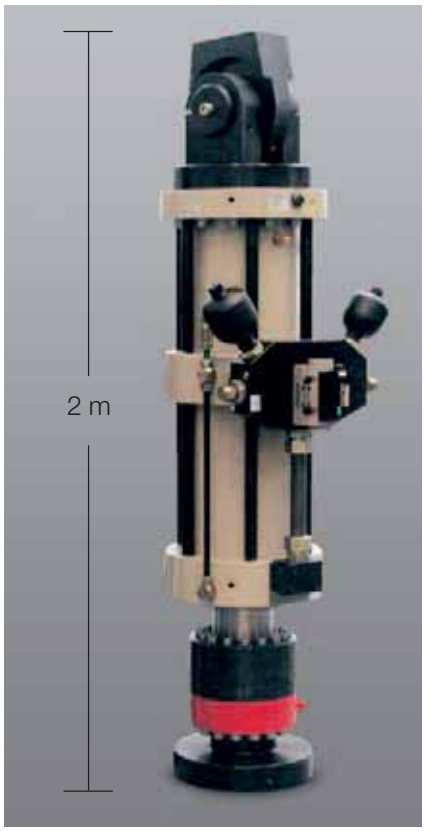


Fig 3: Large structural actuator

Hydraulic Power Packs

A wide range of hydraulic power packs is available to meet the individual performance requirements of various applications. Attention was paid at the development stage to the heavy demands placed by servo-hydraulic units, such as constant pressure and high oil purity.

Two pressure stages are available: 280 bar and 210 bar.

Rates of delivery are between 10 l/min and 270 l/min. If more hydraulic performance is required, power packs can be interconnected to complex hydraulic stations.

Standard versions of the power packs are equipped with a heat exchanger providing water cooling, with water supply controlled by a thermostatic valve.
Oil/air coolers are optionally available and re-cooling systems with water-glycol mixtures can also be used.

The power packs are supplied ready for the fitting of a sound-deadening enclosure if environmental conditions require it. 'Whisper-quiet' power packs with submerged motors can be supplied on request.

Zwick / Roell

Vibrophore with Electro-Magnetic Resonance Drive

Zwick are suppliers of the world-famous Amsler HFP Vibrophore, the first version being introduced by Amsler in 1945. It is valued by test laboratories in the automotive sector for its high-level performance and low operating costs.

Special Features

- minimal energy consumption due to resonance principle
- no hydraulic power pack or other installation outlay required
- maintenance-free operation
- high testing frequencies, short test times.

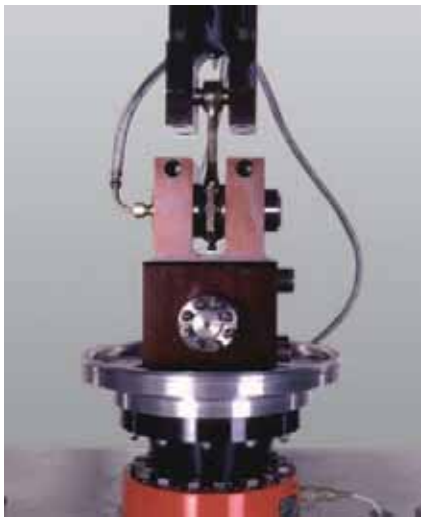


Fig 1: Testing connecting rod with temperature-conditioned oil-film

Applications

- dynamic tests to define the fatigue strength of materials, e.g. fatigue tests in accordance with DIN 50100 (S/N curve), in tensile, compressive, pulsating and alternating load ranges
- fatigue strength and durability tests on components such as springs, crankshafts, connecting rods, fasteners, steering knuckles etc.

Fig 2: Amsler HFP 250 Vibrophore

- fracture mechanics tests on CT or COD specimens
- testing under various environmental conditions (temperature, aggressive media)
- specimen pre-cracking for torsion and bending tests
- production and quality control of components exposed to dynamic loading during their service life

Measurement and Control Electronics

Control and monitoring of these testing machines is via VibroWin control and measurement electronics, with test definition, display and result evaluation by Zwick's proven *testXpert*® software

Vibrophore: Specifications

Model, Amsler HFP	5,10	20,30	50,100,150,200,250	300,400,500,550
• Load frame nominal force, kN	5 – 10	±20 to ±30	±50 to ±250	±300 to ±550
• Max. force amplitude, kN	±5	±10 to ±15	±25 to ±125	±150 to ±225
• Max. elastic specimen deformation, mm	±3	±2	±2 - ±3	±2 - ±3
• Frequency range, Hz	35 - 300	35 - 300	35 - 300	35 - 300
• Working area width, mm	350	530	750	1000
• Max. power consumption, kVA	1	1	1	2.5

Zwick / Roell

Impact Strength Testing Machines

Amsler HTM Servo-Hydraulic High-Speed Testing Machine

Application

Servo-hydraulic high-speed testing machines are predominantly used for high-speed penetration tests and high-speed tensile breaking tests. Speeds are easily selected over a wide range from very slow to maximum. Typical applications are aimed at material characteristics at high elongation rates, crash simulations or better understanding of materials in rapid forming processes. These include:

- tensile tests on flat and round specimens
- tensile, peel and shear tests on joining technologies

Control and Measurement Electronics

testControl electronics plus *testXpert*® software provide comprehensive test-result evaluations, together with report creation and data management.

Amsler HTM Servo-Hydraulic High-Speed Testing Machine
Specifications – standard versions*

Model	Amsler HTM			
	2512	5020	8020	16020
• Hydraulic test load, kN	± 25	± 50	± 80	± 160
• Max. speed, m/s	12	20	20	20
• Min. speed, mm/s	1			
• End damping, mm	50, both ends			
• Total stroke, mm	350			
• Working stroke, mm	250			
• System pressure, bar	280			
• Actuator type	Equal area actuator for tension/compression with hydrostatic bearing mounting			
• Principle of load measurement	piezo-electric			
• Principle of travel measurement	incremental			
• Data acquisition	10 MHz, 12 bit, 4 channels (standard), 8 channels (option)			

* Additional figures on request

Fig 1: *testXpert*® screenshot of a high-speed test

Fig 2: High-speed testing machine Amsler HTM 5020

Zwick / Roell

Pendulum Impact Testers

HIT pendulum impact testers meet the exact specifications of international standards down to the smallest detail – meaning that users can rely on these instruments at all times.

Massive Base – Robust Stand
The base of the tester is a vibration-damping casting and complies fully with Standards relating to frame to pendulum-mass ratio. Three heavy duty locking leveling-feet ensure firm, stable installation.

Pendulum Coding as Standard
Each pendulum is automatically recognized by the instrument, ensuring that the correct pendulum is used for each test.

Fig 2: HIT50P pendulum impact tester with CE-conforming protective screen and motorized pendulum lift

Ergonomic Design
All important operating elements are within easy reach of the operator.

Tool-Free Pendulum Change
Each pendulum is equipped with a quick-change device, allowing pendulums to be changed quickly and without the use of special tools.

Method Changing the Easy Way
The supports for the various methods are securely mounted in dovetail guides. To change over, just slacken a few screws slightly and push the support out. Reliable limit stops ensure exactly reproducible positioning.

Fig 1: HIT5P pendulum impact tester for tests according to ISO standards

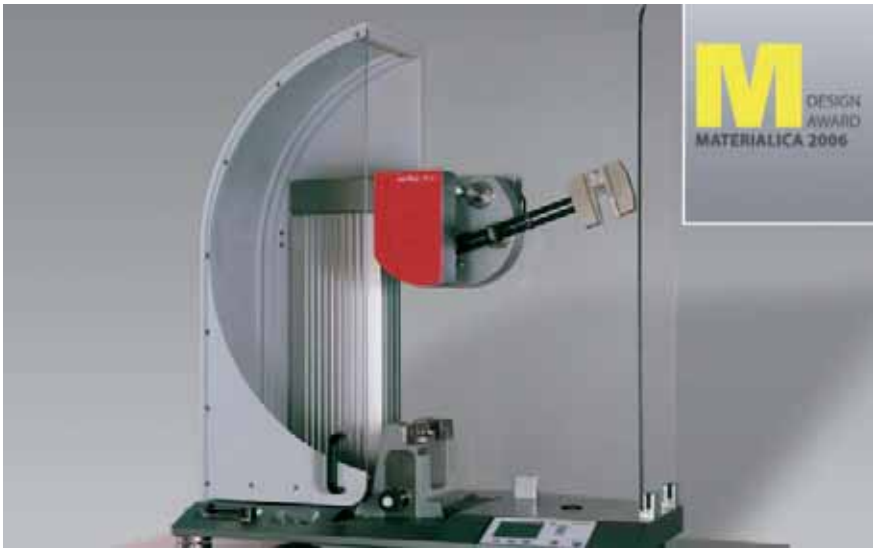


fig 3: The HIT5.5P is universally applicable for Charpy, Izod, tensile impact and Dynstat testing according to ISO, ASTM and DIN standards

Zwick / Roell

Modernization Packages for all Makes of Materials Testing Machines

Zwick ZMART.PRO Modernization and Retrofit Technology

Modernizing a testing system can be an economical alternative to buying a new one, especially with testing machines with high nominal force, special load frames or complex peripherals. Many of the existing components such as extensometers or specimen grips can be adapted to the new technology and continue in use.

Whoever built it – Zwick has the right solution for every make

Zwick provides modular modernization kits which can be adapted individually to suit a wide range of requirements.

Modernization Packages for Materials Testing Machines with Electro-Mechanical and Hydraulic Drives

Quasi-static materials testing machines (with electro-mechanical or hydraulic drive) can be re-equipped to state-of-the-art level using the *testControl* modernization package.

Modernization involves the following basic elements:

- *testControl* digital control and measurement technology
- *testXpert*® testing software
- maintenance-free, precision-controlled AC drive
- adaptation of existing sensors.

Additional elements for hydraulic materials testing machines:

- proportional or servo valves
- new hydraulic power pack or adaptation of existing hydraulic components.

Modernization Packages for Servo-Hydraulic Testing Systems

Zwick's HydroWin 96 and Control Cube modernization packages provide a wide range of options for modernizing servo-hydraulic testing systems of many different makes.

The conversion kits comprise the following components:

- HydroWin 96 and Control Cube digital measurement and control electronics
- *testXpert*® / Workshop 96 testing software
- new hydraulic power pack or adaptation of existing components.

Zwick also provides special modernization options for vibrophores, high-speed test rigs, creep test machines and pendulum impact testers.

New from Old

We only use components from the current production ranges, providing your newly modernized machine with the same level of technology as a comparable new machine.

testXpert® is standard software, so both new and modernized machines are equipped with the same operating platform.
Following modernization, users enjoy renewed long-term reliability, guaranteed spare-part supply and access to the whole Zwick accessory program.

Detailed information regarding control and measurement electronics used can be found on pages 33, 48 and 59.

Fig 1: Servo-hydraulic testing machine Zwick REL2041 after the modernization with HydroWin 96XX

Fig 2: Materials testing machine Zwick 1455 after the modernization with *testControl*

Zwick / Roell

Zwick Services

Applications Laboratory and Contract Testing

In the last few years Zwick's applications laboratory has become to a competence-center of materals testing with active scientific exchange.

Functions:
- demonstrations and pre-testing
- performing and evaluating tests on customers' behalf

Services:
- use of full Zwick portfolio
- design and adaptation of specific testing devices
- documentation and interpretation of component failure
- access to expert knowledge of highly experienced staff
- evaluation and documentation of tests
- fast testing service to international standards, works standards and special regulations
- advice on products, testing methods and test performance

Laboratory for Fatigue Strength and Dynamic Strength

- determining S-N curves for fatigue strength measurement of bonds, structures, and weld seams
- fatigue test investigations under multi-axial load
- fatigue strength investigations under in-service loadings
  - single and multi-stage testing
  - testing under temperature (60 °C to +1,200 °C)
  - connecting rod testing under simulated engine conditions
  - corrosive media on request
- determining cyclic material behavior (LCF)
- determining fracture mechanical characteristic values
- performing tests under impact test force
- application of measuring methods to obtain the relevant mechanical values (crack propagation, crack detection, local strains, temperature sequence etc.) for specimens and components

Laboratory for Quasi-Static Applications

- tensile, compression, flexure and torsion testing
- testing under temperature (-40 °C to +200 °C)
- testing in high temperature range (+200 °C to +900 °C)
- determining impact strength
- hardness testing
- melt index testing
- component testing
- viscosity testing
- fracture mechanics testing

Fig 1: Zwick laboratory for quasi-static applications

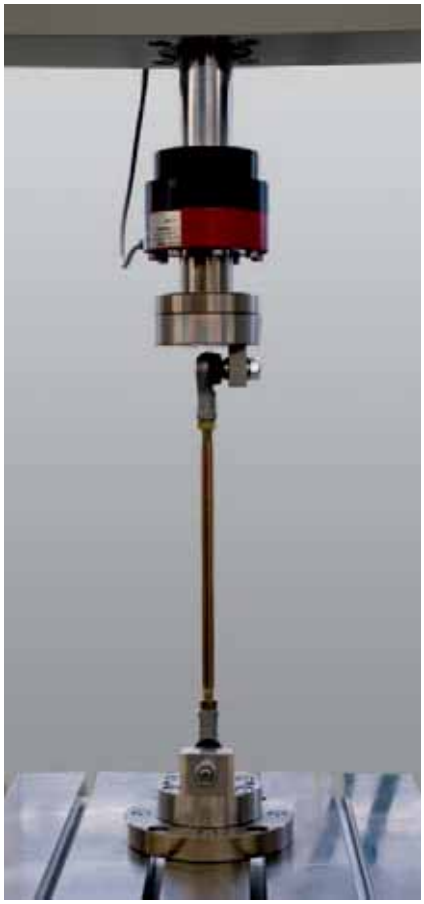


Fig 2: Laboratory for fatigue strength and dynamic strength: Fatigue test on a tie rod

Zwick / Roell

Further Services

Worldwide Service

Customer satisfaction is our first priority at Zwick Roell AG. Local service organizations in over 50 countries work to ensure optimum utilization and maximum availability of your testing system.

Engineer Consultation Service

New testing assignments with changing requirements, building or upgrading a testing laboratory - only with the aid of specialists can you be sure of getting what you want. Experienced Zwick engineers advise at the planning stage of complex projects and then help you achieve the reality.

Demonstration

There are many factors to consider before deciding to acquire a materials testing system and accessories. To make that decision easier, the application technology laboratory at Zwick's headquarters offers you the opportunity to experience various solutions to a wide range of testing situations.

Test drive

For new, altered or highly complex applications, Zwick offers you the opportunity to carry out a practical test. The application technology laboratory's experts and comprehensive range of equipment are at your disposal.

Application Technology Seminars

Active co-operation with associates in research and technology enables the Zwick Academy to organize seminars on the basic principles of materials testing, its applications and the current level of knowledge.

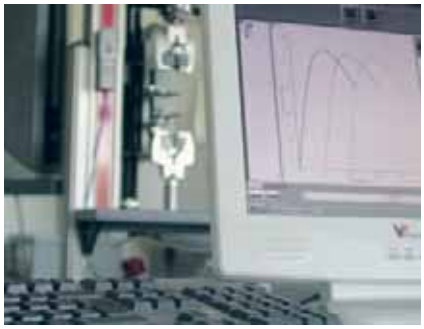
Pre-Delivery Inspection

Before final delivery of a machine, customers have the opportunity to carry out a pre- delivery inspection at our premises, where they can satisfy themselves regarding scope of delivery and try out the functions stipulated in the order. We also provide an introduction to operating the system.

Transport

If required, Zwick Service will, as part of the commissioning process, provide full transport supervision. We can also provide business-to-business transport and deliver the machine to the desired location at your premises.

Installation



With several thousand successful commissionings under our belt, you can rely on Zwick Service to provide the best possible installation service for machine and/or accessories. Pre-handover function tests in the customer's presence help make installation trouble-free.

Hardware Familiarization

Nothing is left to chance at Zwick Service when a new system is commissioned. Professional, systematically constructed checklists help you get the most out of our products.

Zwick / Roell

Software Familiarization

Specially produced checklists using concrete examples from everyday practice help you become familiar with our software, with results being saved for later use. Alternatively, we offer a 2-stage induction course, consisting of a basic introduction as part of the commissioning process, followed by an expanded induction at a later point in time.

Machine Relocation

Zwick Service will organize the relocation of your testing machine from start to finish. Our experienced project management team will take care of the detailed planning of disassembly, transport and recommissioning. Zwick will see to it that your testing machine is ready and waiting at your new premises.

Software Adaptation

With our software engineers' depth of expert knowledge and many years of experience, you can rely on Zwick to deliver programming perfectly adapted to your individual requirements. Working closely with our customers, we identify their testing requirements and – still in close collaboration – deliver the right package for the job.

Product Training

Qualified trainers with industry experience provide product training. We also offer individual training tailored to customers' requirements. This is available in-house or at our premises.

Hotline

First priority is for your testing machine to be in perfect working order. Should faults develop in your machine or software, in spite of their high quality, our expert staff are ready to help you via the Zwick Hotline. Your call will be returned in the shortest possible time.

SupportDesk

For further advice or assistance, such as technical or software support, the Zwick SupportDesk is in many cases a better option than an on-the-spot visit. Our experienced staff will use their wide-ranging technical knowledge to provide you with an answer speedily and effectively.

Rental

Whether for short-term testing requirements or just to try them out, Zwick Service has the specimen grips you need.

Maintenance

Zwick Service can perform the necessary scheduled maintenance of machines and accessories as detailed in the operating manual and will also ensure that service intervals are maintained.

Zwick / Roell

Servicing

Zwick Service helps you reduce downtime significantly through regular servicing of your testing machines.

The condition of the machine is recorded at the service and necessary repairs are carried out and wear parts replaced immediately, where possible. The service engineer will also advise on preventive and/or precautionary measures.

Repairs

If, in spite of careful servicing and maintenance, a fault develops in a machine, one of our many service engineers will be with you in the shortest possible time, while spare parts can be delivered within 24 hours.

Calibration

Zwick's calibration service is accredited by DKD[1], UKAS[2], COFRAC[3] and A2LA[4] to DIN EN ISO/IEC 17025 for on-site calibration of materials testing machines.

The reference measuring equipment used is regularly recalibrated. Depending on the customer's requirements, either a works calibration (Zwick calibration certificate), ISO calibration (Zwick certificate with documentation showing measuring equipment supervision to ISO9001) or DKD calibration (DKD certificate) is performed.

If necessary, the testing machines and associated sensors will be adjusted during calibration.

[1] DKD: Deutscher Kalibrier-Dienst
[2] UKAS: United Kingdom Accreditation Service
[3] COFRAC: Comité Français d´Accréditation
[4] A2LA: American Association for Laboratory Accredition

Software Upgrade/Update

An update gives you access to the ongoing development of *testXpert*® software and opens the door to an expanded range of functions. Changes to testing standards are also incorporated into the latest versions.

Upgrading from an old DOS operating system to the latest Windows equivalent provides a secure, reliable route to the new technology. Upgrade from *testXpert*® to *testXpert*® II and enjoy access to all the latest *testXpert*® developments, with their many benefits for everyday use.

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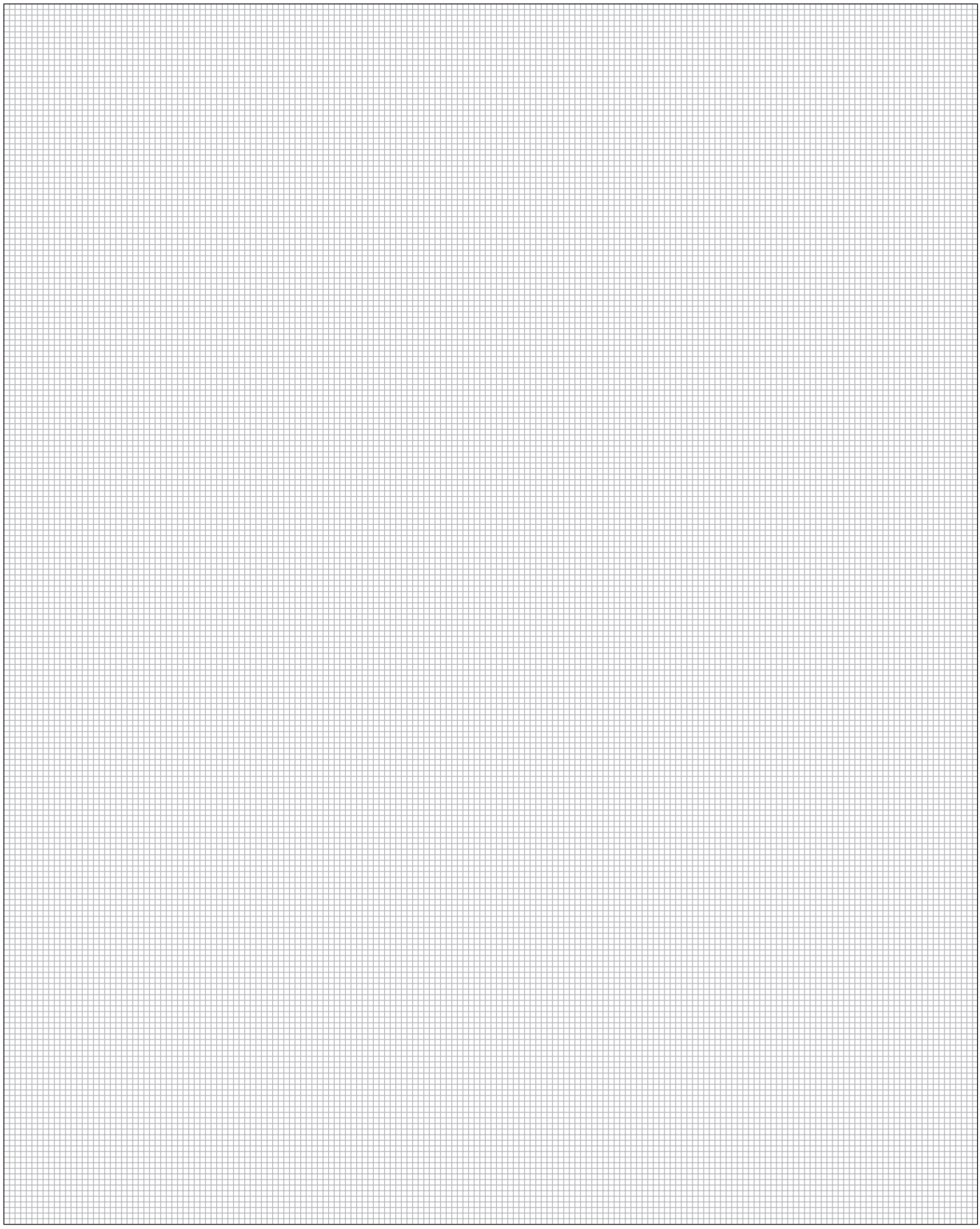
Notes



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