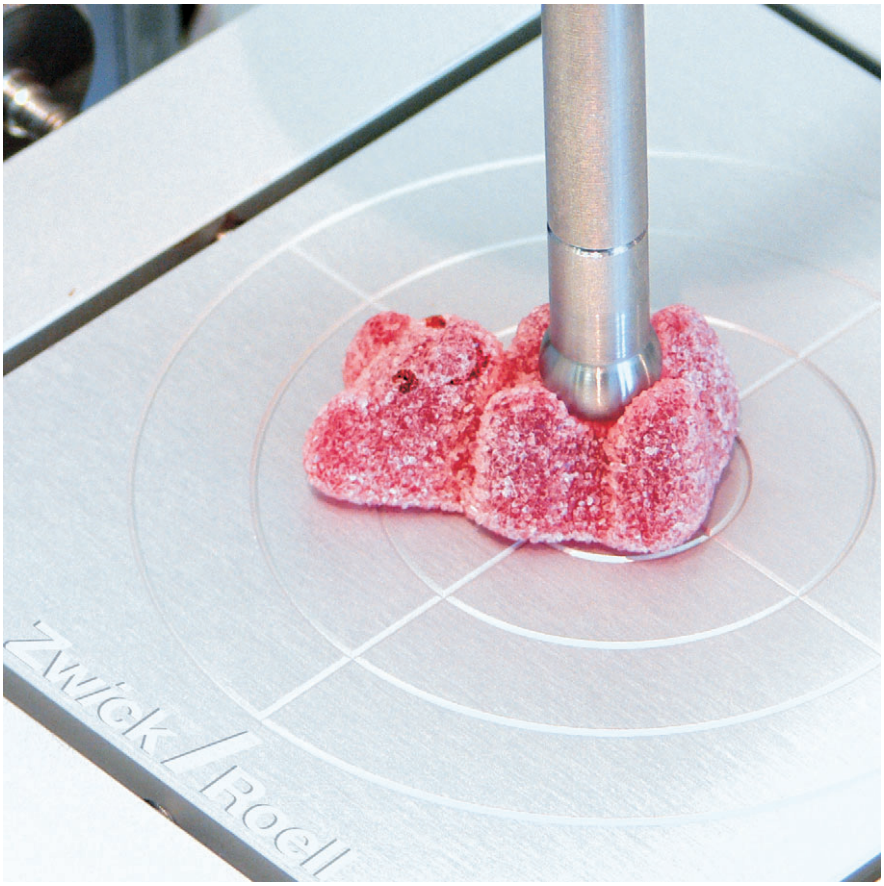
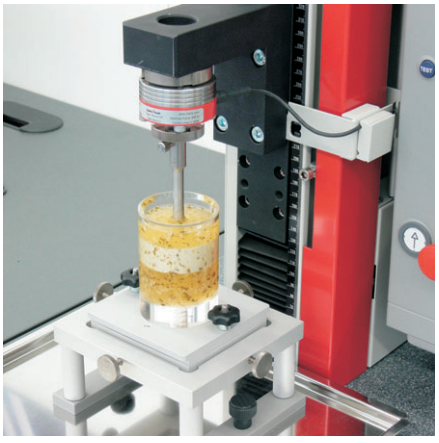
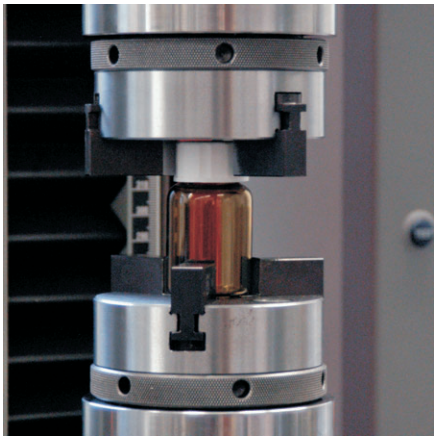
Zwick / Roell

Testing systems for texture analysis, viscosity measurement and packaging testing







FP 485 2.0409

Intelligent Testing

Zwick / Roell

The Zwick Roell AG – More than a century of experience in materials testing

Mechanical-technological testing is one of the oldest disciplines of materials testing. As early as in the 15th and 16th century, Leonardo da Vinci and Galileo Galilei were already considering the flexural stressing and the elastic behaviour of materials. In the course of time further knowledge was obtained. In the middle of the 18th century the first testing machines finally appeared in France.

Since 1920 the company Roell & Korthaus has been involved in the materials testing business. In 1937 Zwick built it first testing machines and systems for mechanical testing of materials. Many years prior to that in 1876, a Professor Seger had already founded a chemical laboratory as part of a scientific techno-logical consulting company for nonmetallic materials. During the 20th century, the present company called Toni Technik has evolved from these origins and is now considered a leading expert in test systems for building materials. Another predecessor of the Zwick Roell is a company MFL (Mohr & Federhaff) – a company that was founded in 1870. Interestingly enough Carl Benz (of Mercedes Benz fame) was one of their employees.

Since 1992, these companies have formed the Zwick/Roell company group. In July 2001, this company group was converted into a stock corporation: the Zwick Roell AG. Part of this stock corporation are the companies Zwick, Toni Technik, Indentec Ltd., and since may 2002 Acmel Labo. These companies supply an extensive program for materials, component, and functional tests – from the manually operated hardness tester up to a complex test system for the process-accompanying application.

Fig. 1: The headquarter of the Zwick Roell AG and the Zwick GmbH & Co. KG at Ulm, Germany

Zwick has many years of experience, combined with a multitude of supplied systems. This experience is continuously supplemented by the constant communication with the users. On this solid basis, the company supplies a wide range of high-performance products – from the economical standard machine up to special versions and designs for special test jobs. Modern mechanics, high-performance electronics and the application-oriented software are the prerequisite for the versatility and the high “intelligence” of these modern testing machines and systems.

However, the services of the Zwick Roell AG go far beyond the supply of products. Already in 1994 the company received the certification according to DIN EN ISO 9001 and thus guarantees a consistently high product and service quality. With accredited calibration laboratories, the companies of the Zwick Roell AG are in addition entitled to verify and to calibrate test systems and to document that with internationally recognized certificates.

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Content

1. Texture analysis

1.1 Instrumental texture analysis - a growing trend in food industry

What is texture?

Texture defines the consistency and structure of foodstuffs. Included are all physical characteristics as well as the perception / sensory feelings such as touching (including the feeling in the mouth), appearance and acoustic behaviour. Size, form, number of cells and their structure also influence the texture characteristics of the foodstuff.

Examples of texture characteristics are the crunchiness of sausages, the firmness of cheese or the crispiness of waffles.

Sensory and instrumental techniques to determine texture properties

Sensory tests

Proof of textural properties via the human senses takes place via the sensorium (tasting foodstuffs) and the textural properties are identified by terms relating to the senses or taste. Examples of such identifiers are compiled in table 1.

The terms vary depending upon the foodstuff in question: The properties of confectionery, jams, etc. are expressed differently to the properties of cornflakes. Standardised terms for foodstuffs are extremely few and far between.

Texture characteristic	Sensoric designations
Hardness	soft, solid, hard
Composition, cohesion	crumbly, crisp, brittle
Elasticity	plastic, elastic
Adhesiveness	adheres, sticky, very sticky
Viscosity	highly fluid, semifluid

Table 1: Texture characteristics of foodstuffs with sensoric descriptions

Instrumental texture analysis / objective texture measurement

Instrumental tests, also known as mechanical texture tests, emulate the sensory effect i.e.what happens with the foodstuffs in everyday life. Chewing is simulated with the help of a cyclic test. Gradients, forces, travel and energy values are recorded during two or more cycles of the test, and are linked to one another and are associated with sensory properties.

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The instrumental texture analysis removes all elements of subjectivity from the testing. Measurement methods are used which, although introduced internationally, are rarely standardised. The main problem of texture analysis is that the shape and consistency of foodstuffs deviates very much.

Reproducible results require a careful preparation of specimens and the testing method. Carefully prepared specimens and tests can, quite often, lead to surprisingly high correlations to sensory tests. Variances in product quality are much more apparent since they are determined by a texture analyser which does not have the subjective rating which a sensoring team might have. In cases of dispute, sensorically determined results are not recognised.

Benefits of instrumental testing at a glance:

- Conversion of sensory tests to objective values - Important test criterias such as freshness, crispiness, spreadability are determined objectively.
- Small deviations can be measured and shown in values.
- By standardisation of testing methods (Company Standards) different production sites can achieve the same product quality. This is very important in highly automated production lines, and for suppliers of semi-finished goods, ingredients and food systems. All of this helps to avoid complaints at the outset by improving quality and consistency of the products.
- The tests deliver reproducible results.
- All results can be shown and interpreted in a graph and documentation of all results is easy.
- Proper documentation of product quality simplifies negotiations between suppliers, processors and customers.

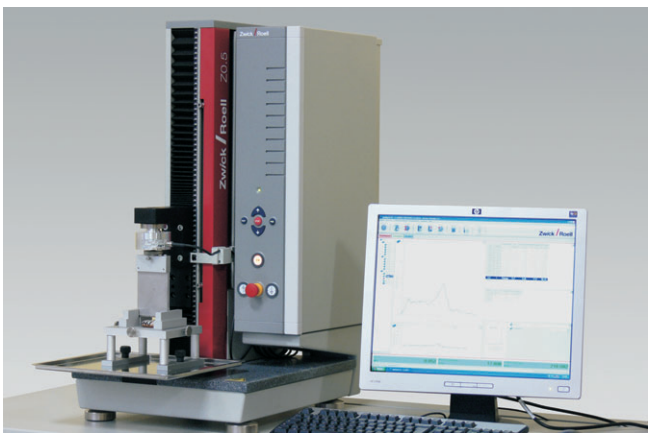

Fig. 1: Simple analysis and documentation with test software *testXpert*® II

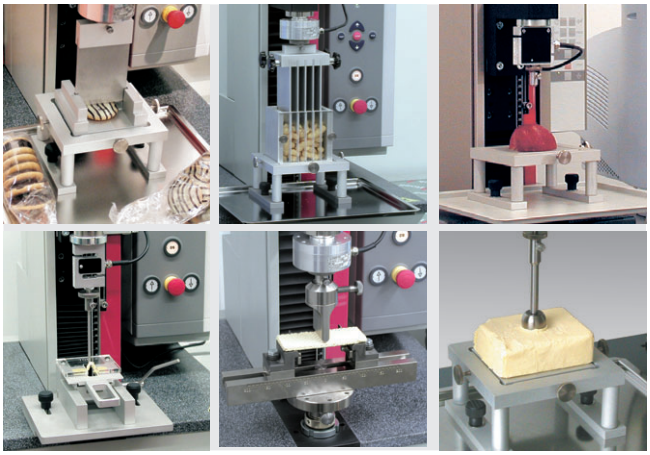

Fig. 2: You can test all types of foodstuffs with Zwick Roell testing tools

Why and where texture analysis is made?

Product research & development

- Evaluation of the quality and processing characteristics of raw foodstuffs.
- Creation of foodstuffs with a desired texture: Testing of different receipts and ingredients and their influence on the foodstuff during the production process.
- Product comparisons: New or alternative ingredients can be compared with existing ingredients for improvements. Producers own products can be compared with competitor´s products (Benchmarking).
- Determination of influence of packaging on the foodstuffs for a good choice of packaging.

Quality control purposes

- Goods receipt: Tolerances can be defined to ingredient suppliers and incoming batches can be checked. In this way, batch to batch variations or trends in quality from a partcular supplier can easily be monitored.
- Before and during production: Characterisation of structural changes during the production process and determination of the influence of process variations such as temperature, humidity and cooking or baking time. Quality control during production or of finished products to ensure a constant quality.
- Transport/Storage: The determination of stacking ability, strength and shelf life allow transport and storage influences to be assessed.
- Freshness at POS (point of sale) and storage time at consumer's home. Are the products characteristics guaranteed at the end of the minimum durability?

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1.2 How to carry out instrumental texture analysis

The inhomogenity of a product is very difficult in instrumental texture analysis and leads to large differences in the test results.

For dependable and interpretable test results, you need suitable test methods and a careful specimen preparation. Identical specimens give identical starting points so that the real characteristics of a product can be determined, and not the characteristics of an individual specimen.

Identical specimens are not possible with food products because of the inhomogenity. However, with a couple of basic rules you can create a relative consistent starting point.

a) Specimen size

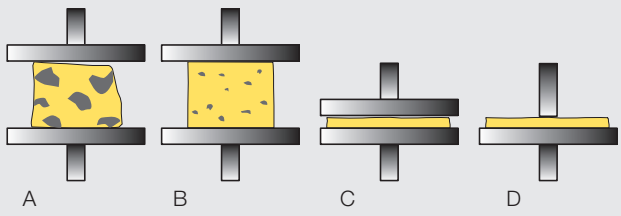
Select the specimen with 5 to 10 times the medium composition size. A cheese cube with large macro composition (holes), should be a minimum of 5 times larger than the largest hole. 10 times larger would be better.

If suitable specimen sizes cannot be made, one of the following is recommended:

- a larger number of tests in order to even out the outliers, or
- make smaller specimens without composition variances, although then the basic material will be tested and not the total product with its typical characteristics.

b) Extraction location/direction

The specimen extraction should always be at the same place, e.g. with cheese, always at the same distance from the rind. In addition, attention should be paid to the direction of the specimen extraction when the testing subject has a composition direction such as the fibers in meat (anisotropy).



A: Specimen size too small since the relation to the size of the holes is too small. Furthermore the specimen has not been cut at a right angle. This leads to misinterpretations at the start of the test since the upper compression plate does not lie fully on the surface of the specimen.
B: Sufficient specimen size, clean cut edges
C: The large surface compression plates do not cover the specimen surface completely, therefore D is recommended
D: Set-up with a penetration die of small diameter

Fig. 1: Specimen size and interaction with the testing tool

c) Specimen cut/form

Unclear edges may be caused by cutting tools which are not sharp. This increases the inhomogenity of a specimen and can therefore influence the test, e.g. the breakage of noodles or lasagna dough. In addition, parallel cuts are important for homogenious stress distribution during the test (please see Fig. 2)

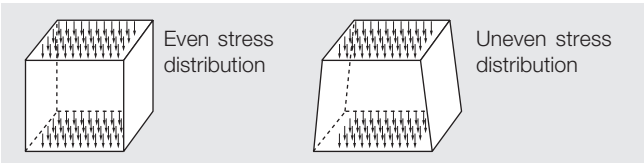


Fig. 2: Stress distribution on a specimen

d) Specimen loading

The loading should be applied to the specimen so that only the desired influences go into the test results. This is best explained with the test on apples (see Fig. 3).

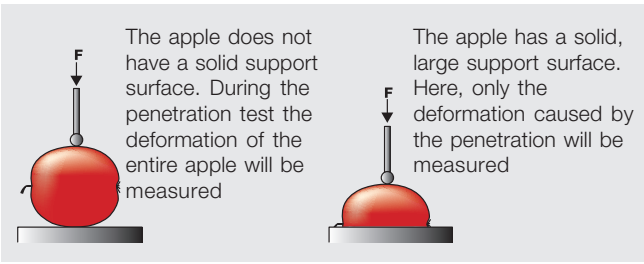


Fig. 3: Application of force to the specimen

e) Interaction between testing tool and specimen

Tools and specimen must fit each other. Example: compression test on cheese. If the surface of the cheese cube cannot be made level so that a full surface, even loading of the compression plate is possible, then a penetration test with a small die is suitable. However, it is important to note that this changed test method creates other forces on the specimen. In this case shear forces are applied in addition to compression forces (see Fig. 1 D).

The specimen size must also fit to the testing tool;
In a compression test, the specimen cannot extend beyond the edge of the compression plate because shear forces would be created. However during a penetration test, deformations may not occur on the specimen edges since the forces and resistance within the material should be measured.

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1.3 Test software *testXpert*® II: Test sequence and results

Cyclic tests simulate chewing (fig. 1). In the first compression phase the specimen is loaded up to a preselected strain. The specimen is released in the following tensile phase.

The energy under the force travel curve is split through the maximum force into two parts (see fig. 2). The second cycle runs in the same manner.

The number of cycles depends on the specimen: two or more cycles are possible, in some cases only the first compression phase is required. Gradients, forces, travel and energy values are recorded during the test, and are linked to one another and are assigned to sensory properties. Fig. 2 shows these results in a force travel curve.

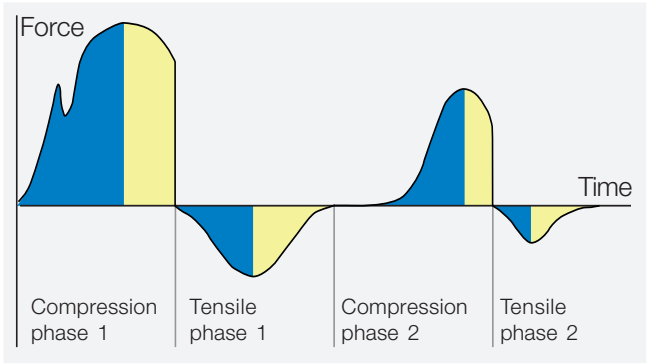
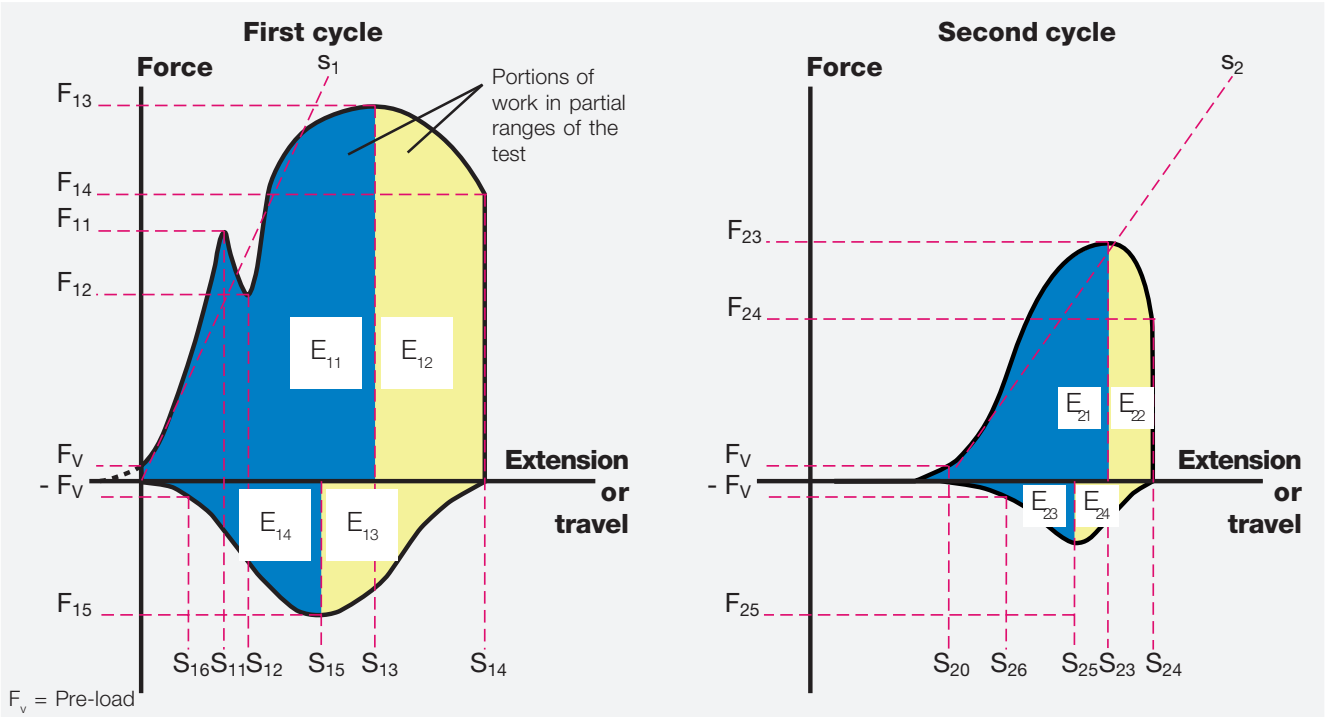


Fig. 1: Principle sequence of a cyclic test (2x mastication) / procedure of instrumental texture profile analysis (TPA)



Test result	Description	
s_i (s_1, s_2)	Modulus, degree of maturity	i = Index (no. of cycle)
F_{11}	Fracturability	
F_{11} - F_{12}	Brittleness	
F_{13}	Hardness	
S_{13}	Indentation	
ΔF_{i4}	Relaxation at point of load change (only when holding time at this point is defined)	
F_{15}	Cohesion strength, adhesive force	
$E_{13} + E_{14}$	Adhesiveness	
Springiness	$(S_{23}-S_{20}) / (S_{13})$	
Gumminess	$F_{13} * (E_{21} + E_{22}) / (E_{11} + E_{12})$	
Chewiness	$F_{13} * (E_{21} + E_{22}) / (E_{11} + E_{12}) * (S_{23}-S_{20}) / (S_{13})$	
Cohesiveness	$(E_{21} + E_{22}) / (E_{11} + E_{12})$	

Fig. 2: Selected test results from the *testXpert*® II Standard Test Programm for texture analysis

testXpert® II Standard Test Program for texture analysis

This *testXpert*® II test program is arranged analogical to the procedure of instrumental texture profile analysis (TPA). The chart on the previous page shows selected results being recorded during the test sequence. We displayed the two cycles next to each other to provide a clear overview.

The Standard Test Program offers various results of course including the essential characteristics for texture analysis. By activating only the required results you receive a clearly arranged result table. With the option result editor you can create your own results if desired.

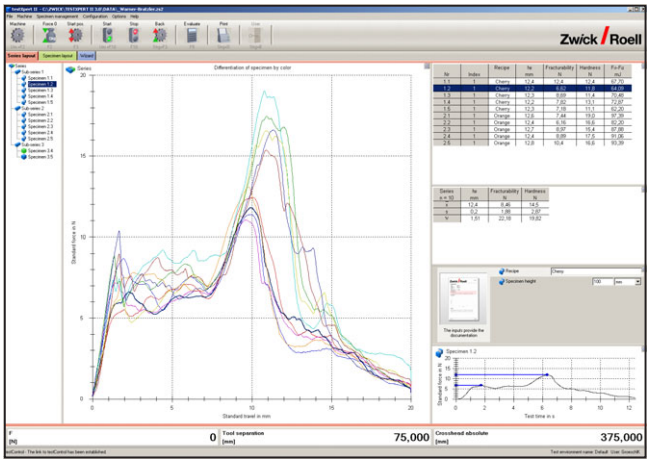


Fig. 1: Usually texture samples are very inhomogeneous and give very strongly scattered single curves. Anyhow you can clearly identify the characteristics of different batches or types.

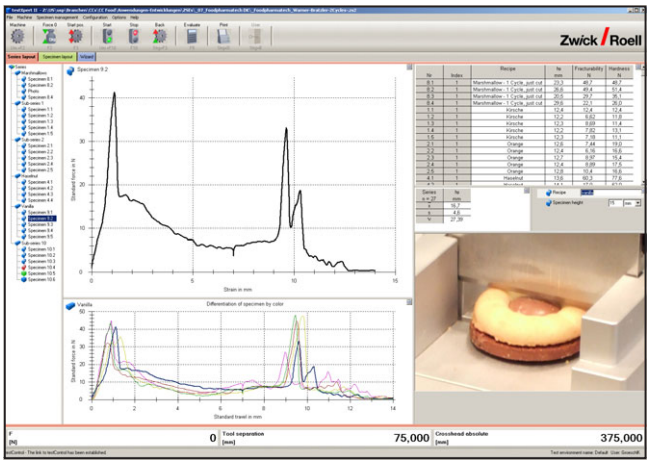


Fig. 2: This curve shows clearly the procedure in the specimen during the test

Determination of the crispness with *testXpert*® II

Another test procedure is recommended for the determination of the crispness of cereals, potato chips, peanut snacks or other extrudates with the Kramer shear cell. There is no standard definition for crispness. One approch whereby the „crispness“ can be determined, is to measure the breaking tendency of a material.

Every break, that means, every snap in a testing material means that energy has been released. These releases of energy are easily seen by the so-called peaks in the curve. The number of these peaks can be a significant value for the crispness. In order to achieve dependable values, a data transfer rate of 500 Hz is absolutely necessary.

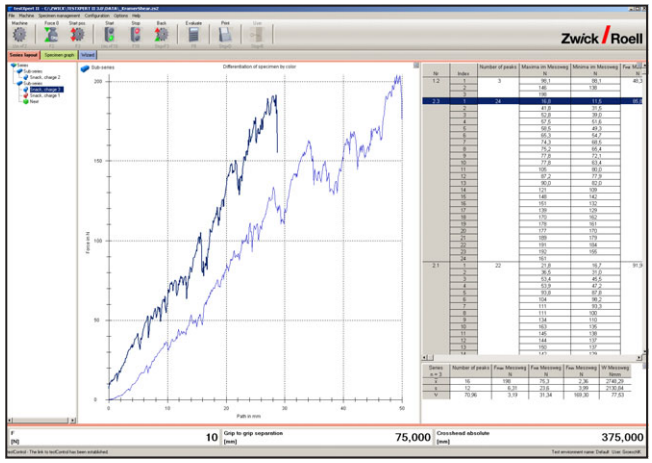


Fig. 3: Crispness determination via peaks

testXpert® II Test Programs for texture analysis

Standard Test Program for texture tests on food (Type xct054_14): This test program includes all results for tests as described on the previous page

Standard Test Program for evaluating the properties of dough (Type xte051_47): This test program has been developed especially for the dough tensile test rig

For the determination of crispness with the Kramer Shear cell we recommend the Master Test Program for tear growth tests as described above

On request we offer Customized Test Programs that are especially developed for your application.

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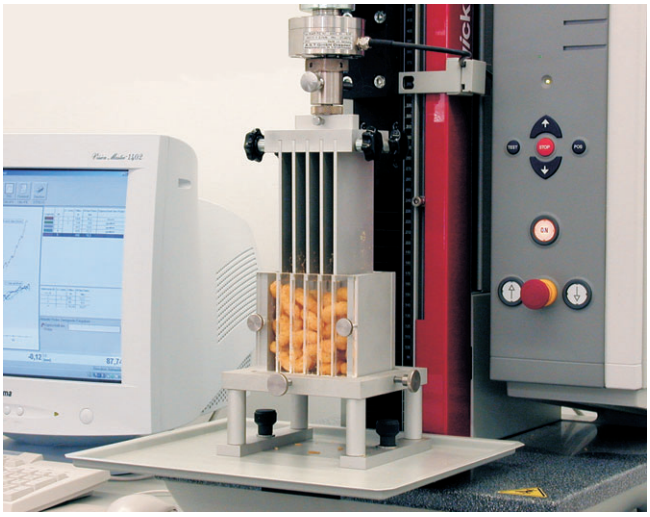
1.4 Selected examples for foodstuffs and possible test methods

Foodstuff	Test method	Determined characteristics
Bread and baked goods		
Bread, cake	Cyclic compression or penetration test	Firmness, Gumminess, Springiness
Bread slices	AACC 74-09: Penetration test with cylindrical die	Firmness, Hardness
Pastry, cookies, waffles	Warner-Bratzler shear test	Firmness, Bite Characteristic
	3-point flexure test	Hardness, Fracturability, Brittleness
Dough	Dough tensile test	Extensibility, Elasticity, Stickiness
	Penetration test with ball die	Softness, Stickiness, Cohesiveness
Snacks		
Peanut flips, chips, croutons, cereals	Shear test with Kramer shear cell	Crispiness, Firmness, Bite Characteristic
	Compression test on single specimens	Crispiness, Firmness
	Extrusion test with OTMS cell (rod blades)	Firmness, Extrusion Work
Pretzel sticks	3-point flexure test	Fracturability, Brittleness
Noodle and Rice Products		
Cooked spaghetti	Warner-Bratzler shear test	Firmness, Bite Characteristic
Cooked spaghetti / rice	Compression test, also cyclic test	Firmness, Stickiness
Raw noodle products	3-point flexure test	Flexure strength, Breaking Strength
Sweets		
Chewing gum dragée, Chewable hard candy	Compression test, also cyclic test	Gumminess, Firmness
	Warner-Bratzler shear test	Firmness, Bite Characteristic
Chewing gum	Tensile test with dough tensile test rig	Extensibility, Elasticity, Stickiness
Chocolate bar	Warner-Bratzler shear test	Firmness, Bite Characteristic
	3-point flexure test	Flexure strength, Breaking Strength
Milk Products		
Butter, Margarine	Cutting test with the butter-cutter	Firmness, Cutting Strength
	Penetration test, also cyclic test	Firmness, Spreadability, Hardness
	Multiple back extrusion test	Work softening, Remaining Hardness
Creame cheese, parfait	Penetration test, also cyclic test	Spreadability, Hardness, Stickiness
Hard cheese	Compression or penetration test, also cyclic test	Firmness, Hardness
	Warner-Bratzler shear test	Cutting Strength, Bite Characteristic
Fruit, Vegetables, Vegetable products		
Uncooked fruit / vegetable	Penetration test	Degree of Ripeness, Skin Strength
	Compression or penetration test	Firmness, Hardness
	Warner-Bratzler shear test	Firmness, Bite Characteristic
Peas, beans, corn	Compression test on single specimens	Firmness
	Extrusion test with OTMS cell	Firmness, Consistency, Extrusion Work
	Shear test with Kramer shear cell	Firmness, Bite Characteristic
Potatoe salad, mashed potatoes	Extrusion test with OTMS cell (perforations)	Firmness, Consistency, Extrusion Work
Sausage, meat and fish products		
Pasties, minced meat	Extrusion test with OTMS cell	Toughness, Tenderness, Extrusion Work
Uncooked meat, fish, seafood	Shear test with Kramer shear cell	Shear strength , Toughness, Tenderness, Bite Characteristic
Frankfurters	Warner-Bratzler shear test	Crunchiness, Cutting Strength, Bite Characteristic
Sausage	Compression or penetration test, also cyclic test	Firmness, Hardness

(1 American Association of Cereal Chemists

Zwick / Roell

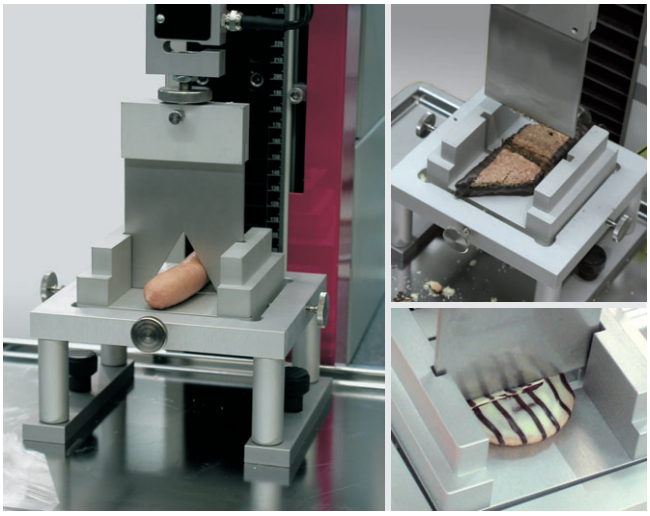
1.5 Zwick Roell tools and fixtures



Kramer Shear Cell

The Kramer shear cell simulates a single bite on foodstuffs and provides information about bite characteristic, crispness and firmness. It is used for meat and fish products, small sized fruit and vegetables as well as for cereals and snacks like potato chips.

The 5 or 10 shear blades drive at a constant speed through the specimen material, compressing, shearing and extruding it through the slotted base. The test is made on a defined sample quantity. The multiple blades provide a measurement on several positions at the same time thus local texture deviations are compensated for with this method.

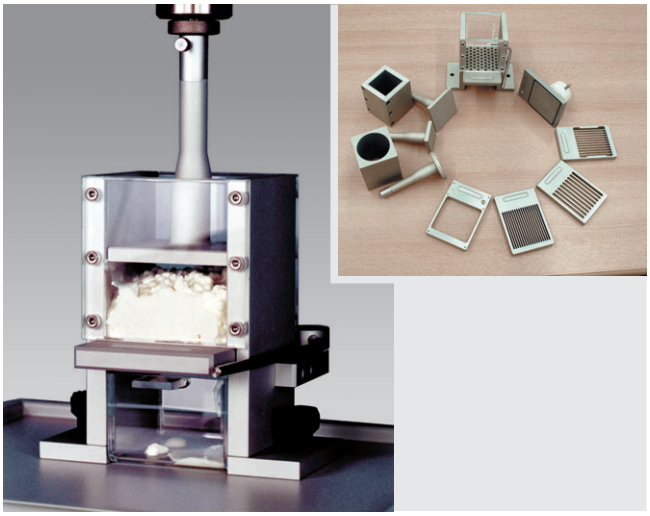


Warner-Bratzler Shear Device

In the Warner Bratzler test a blade cuts through a specimen. The shear behavior gives information about the toughness and tenderness of meat and fish products, the crunchiness of sausages as well as the bite characteristic of cakes and pastries.

The straight blade is mainly used for rectangular specimens and the notched blade for round specimens like sausages.

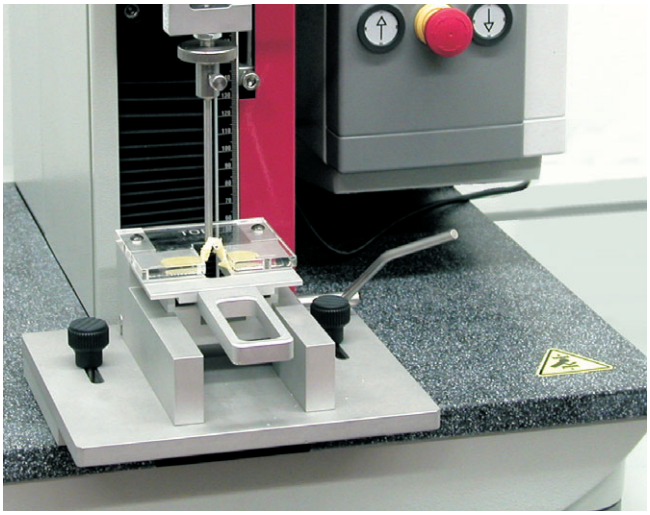
Because of the good reproducibility of the results, this test is widely used.



OTMS cell

The OTMS cell (Ottawa Texture Measuring System) determines the firmness of products by compression and extrusion. This shows characteristics like ripeness, tenderness, crispness or extrusion work on a defined sample quantity. This method is suited for products which are easy to extrude such as canned vegetables, cream cheese and pastries. But also for extrudates and cereals it can be used.

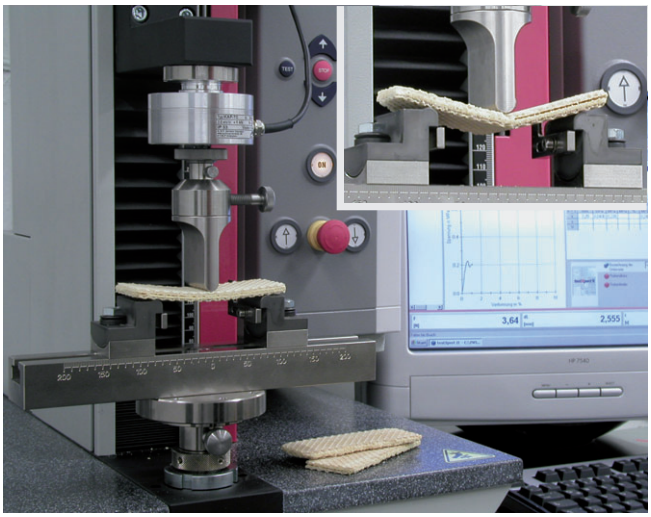
Various extrusion plates and reduction inserts for the reduction of the volume enable an adaption for different specimen materials. The measurement of pure compression forces is possible with the use of the sealing plate.



Dough tensile test rig
The dough tensile test is a micro-scale tensile test: Only a small volume of flour or dough is sufficient. The test determines the processing characteristics, extensibility, elasticity and stickiness of dough and glutens.

This is useful for the comparison of different flours and baking ingredients as well as for the determination of their influence on the baked good. Various recipes, processing types and times, as well as additives can be improved in order to have the optimal end product.

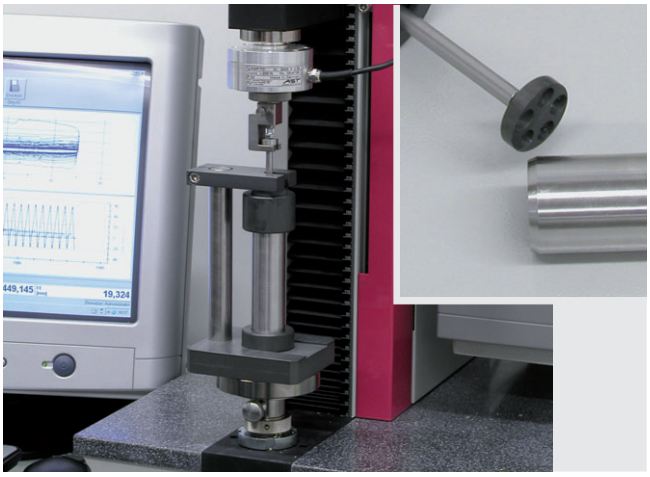
Alternatively the rig can be used for the determination of the elastic characteristics of chewing gum.



3-point flexure test kit
In a 3-point flexure test the specimen lies on two anvils and is centrally loaded with an upper anvil. The span is adaptable to the specimen.

This test is particularly suitable for brittle products, additionaly with same specimen sizes by production. For example waffles, cookies, chocolate bars or also noodle products are suited.

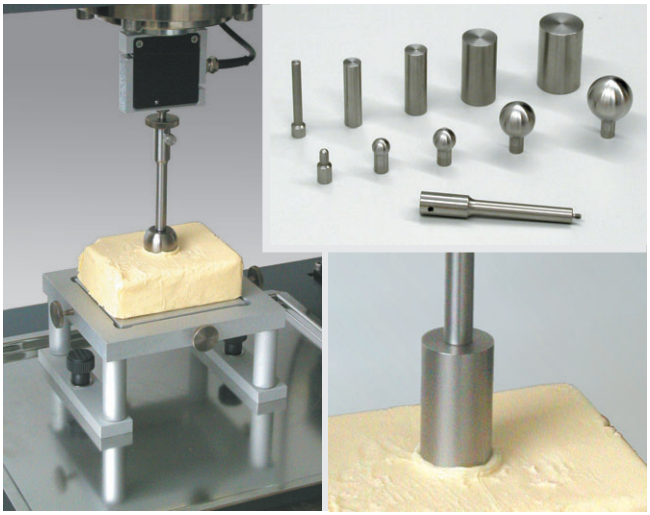
Flexure strength and breaking strength, fracturability and brittleness enable conclusions to be drawn for different recipes. Furthermore you can analyse the influence of moisture, baking time and temperature as well as packing and storage to the products characteristics.



Multiple Back Extrusion Cell
Several working processes gradually break down the fat crystal network of fats like butter and margarine.This change of material is measured by the work softening or the remaining hardness.

The back extrusion die with multiple holes extrudes the fat in several cycles. The test determines the remaining hardness after a defined number of cycles or the number of cycles that is required to reach a defined remaining hardness.

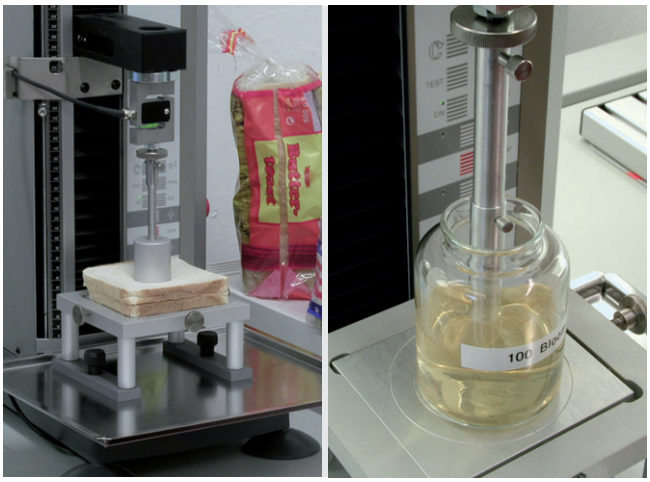
With a slightly modified test procedure the rig is also used for ice cream, fresh cheese or cooked pasta.



Penetration dies
These dies are used mostly for penetrations tests to determine the hardness of foodstuffs. These tests are widely used and find their application with many foodstuffs.

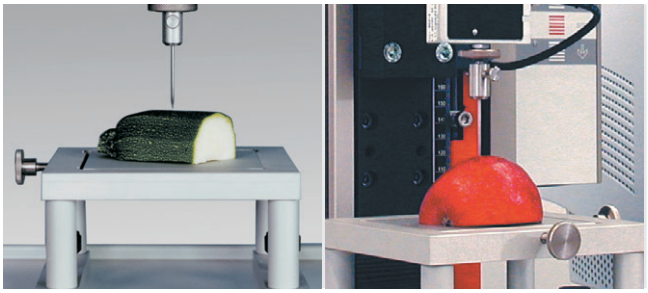
Fundamental is the choice of the appropriate die: Cylindrical dies apply compressive stress by the surface and shear stressing by the edges and the outer surface area of the die. Whereas ball dies start with vertical forces. During the test more and more horizontal forces are added.

Zwick Roell offers penetration dies with various shapes, sizes and materials, also completely to your requirements.



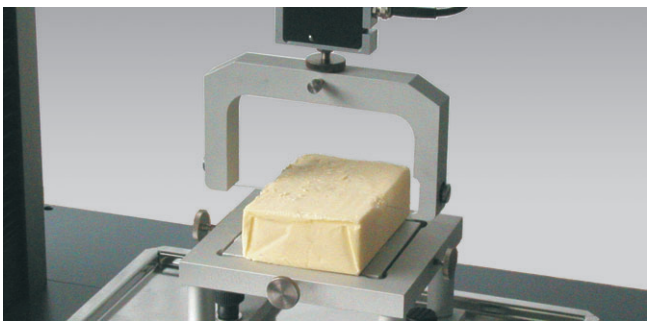
Special dies for tests to Standard: Bread firmness to AACC, gel strength (Bloom)
For the determination of the bread firmness according to AACC 74-09 a cylindrical die compresses defined bread slices up to 40% in two cycles. At a compression of 25% the CFV (Compression force value) is determined.

The gel strength according to Bloom (GME Monograph 2005, ISO 9665) is measured by many gelatin producers and fabricators. The gel strength in grams Bloom is the mass necessary to impress a cylindrical die 4 mm into the gel at constant speed. The method includes a comprehensive specimen preparation in special Bloom jars.



Puncture needle
The penetration test, also called puncture test or force penetration, is used frequently to test the degree of ripeness of fruits and vegetables as well as of the skin strength.

The puncture needle is pushed into the specimen to a certain depth. Depending on the skin and the consistency of the pulp distinctive curves arise.



Butter cutter
This test tool is used for the determination of butter firmness according to ISO 16305. In this test a stainless steel wire cuts through a defined cube of butter. This test is very dependant on temperature and is performed to a Standard method in a temperated water bath.

The butter cutter is also used for the determination of the cutting strength of cheese, eggs, vegetables and fruit.

Compression dies

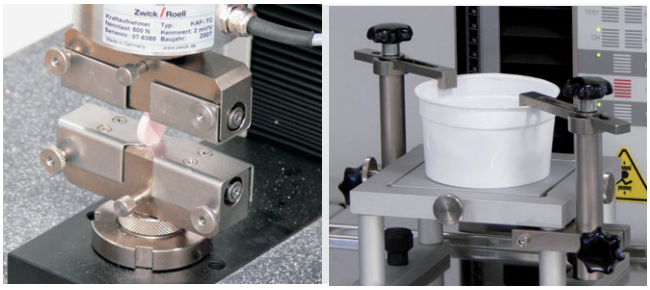
In a compression test the specimen is smaller than the compression die. Also under compression the specimen should not extend over the edges of the die.

The compression test is made on brittle specimens such as candies or coffee beans to determine the brittleness, freshness and firmness, or on fruits also to determine the stacking behaviour.

The test is carried out as a cyclic procedure on elastic specimens such as bread, cake, cheese, fish and marshmallows: The specimen is compressed twice to a certain degree and decompressed. The compression and recovery behavior shows firmness, stickiness, degree of ripeness and visco-elastic properties.

Hardness test on sausage products and fish

Zwick Roell has developed a range of hardness testers for fish, sausage and luncheon meat. A compression cylinder with a large surface area is used as penetrator to measure the hardness of sausage or the freshness of fish and obtain comparable quality control data.



Customized test tools & fixtures

You have a product with singular properties and want to choose the most suitable test method? This requires a unique test tool or fixture. Zwick Roell develops and produces for you the most suitable tool for your product and your test method. And if required, you will receive a customized test program which is a special software for your exact test sequence and your test results.

Temperature and climate chambers

Foodstuffs change their characteristics depending on the humidity and environmental temperature. According to the sensitivity of the product it may be necessary to precondition the specimens or test under defined, constant temperature. Examples for this are the testing of ice cream at a storage temperature of -20 °C, or the testing of pizza cheese at +80 °C.

Zwick Roell developed a temperature chamber especially for these applications that fits on the zwicki texture analyzer. Also separate temperature or climatic chambers according to your requirements can be offered.

2. Viscosity measurement

Viscosity
The term viscosity describes the flow characteristics of liquid systems. Two liquid layers, which slide one against the other generate a mechanical resistance against the movement (toughness, inner friction). This is called flow stress. If several layers are moved with different speeds, viscous forces are generated. These forces decelerate the layers with higher speed and accelerate the layers with lower speed. These phenomena follow physical laws and can be defined by equations, with regard to shear rate and shear forces. Viscosities are always dependent on temperature.

Viscosity measurements are frequently performed to optimise the consistency of pasty materials or to optimise its viscosity for food processing lines.

Yogurt with and without fruit pieces, sauces, mustard, tomato puree and oils are frequently tested products of the food industry.

Medical gels, paint, emulsions, cremes and oils are examples for tested products in other industries.

Fig. 1: Zwick Roell back extrusion rig

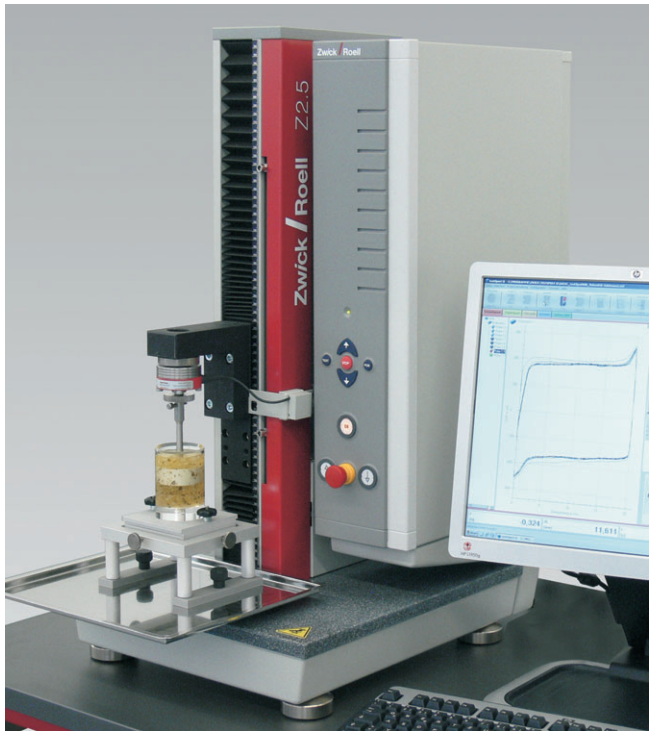


Fig. 2: Thanks to the simple interchanging of tools and fixtures the ProLine Z0.5 can also be used for viscosity tests

The back extrusion rig - an alternative to rotation viscometers
With the back extrusion rig Zwick Roell offers an alternative solution to rotation viscometers.

The principle of the back extrusion rig is based on the displacement of the test material through an annular gap between piston and back extrusion cell. The cell is filled with the test substance and the piston is lowered into the container, pressing the material up through the annular gap. When the piston is raised, the material flows back through the annular gap into the cell.

The force is measured in the down- and up-cycle at a defined position. The dynamic viscosity is evaluated, from the measured force difference and the flow rate of the liquid in the annular gap.

The Zwick Roell system can repeat this cycle as often as desired with freely adjustable shear rates. Thus the test can be optimally adapted to your test material, and with only one single test you can measure the viscosity across the entire shear range.

Zwick / Roell

Advantages of tests with the back extrusion rig

- The viscosity can be determined directly in containers from the running production. This rules out pre-stressing of the material caused by transfilling.
- Flow influences which occur in the production plants can be reproduced by altering the annular gap and the moving speed.
- This method enables tests on materials with chunky pieces as fruit preparations and food systems: Fruit pieces or other bigger ingredients are not pushed aside and thus are measured together with the yogurt or the fluid.
- Individual selection of the number of test cycles and the possibility of increasing the shear rate for each of these cycles enables recording of the viscosities over the entire shear rate in just one test.
- The test results on Newtonian fluids correlate with the results from measurements with rotation viscometers. For non-Newtonian fluids reproducible, comparable test results are obtained, usually with more sensitive characteristics than those gained from rotation viscometers.

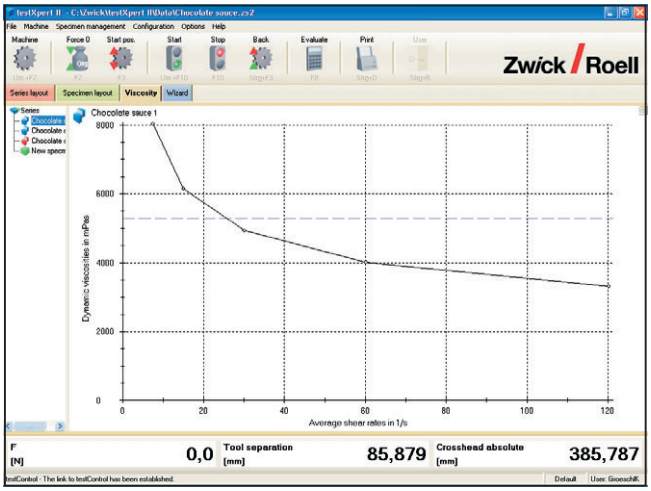


Fig. 1: Only one test is required to determine and represent the viscosities over the entire shear rate

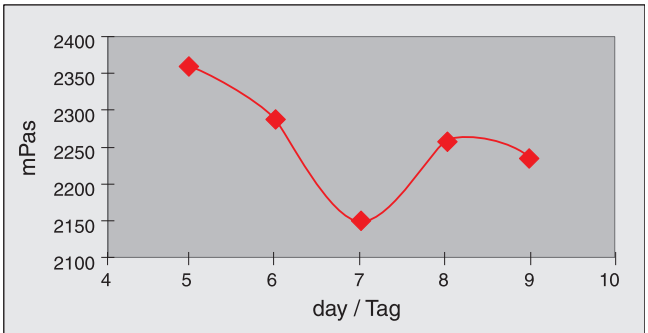
Our application note „viscosity testing“ provides more detailed information and is available on request.

Fig. 2: Viscosity measurement directly in the container

The additional benefit: *testXpert*® II test program especially developed for viscosity testing

This special Standard Test Program includes a lot of extras especially for viscosity testing. Examples: automatic pre-conditioning, determination of cycle numbers and speed, selection of results etc.

The test software is clearly arranged and enables comprehensive evaluation and presentation of data as well as graphical evaluation and reporting.



Always on the seventh day the yogurt shows a break of viscosity, caused by maturation processes. The results of the rotation viscometer have not been as clear.

Fig. 3: Example for interpretation of viscosity tests on yogurt

3. Packaging testing

3.1 Requirements for packaging

Originally, packaging served to protect a product or to make it transportable. Today it must fulfil many other requirements according to its type and its function.

Examples for the use of packaging:
- Food stuffs, pleasure foods, drinks
- Cosmetics
- Medicines
- Chemicals
- Transport packagings (e.g. palettes, crates)
- Industry packagings (e.g. big bags, containers, barrels)
- Electronic instruments
- Consumer goods

Packaging has a large influence on the quality of the contents, on the other hand it encourages the purchasing decisions of the consumers. Both targets together are big challenges for product development, especially the packaging of foodstuffs.

For no other packaging product as much new and further development has been realized as for foodstuff packagings. Nanotechnology, convenience, bio-degradable packaging, intelligent and active systems are the catchwords.

Intelligent systems, for example, show the condition of the packaged foodstuff and the local environment. Gas indicators detect when a certain gas concentration has been exceeded inside the package. Active systems help to extend the shelf-life, e.g. a sprayed plastic which absorbs ethylene or provides a filter effect against light and rays of the UV range.

In addition, the desire for convenience grows constantly: the packaging should be easily manageable, easy to open and reseal, or directly heatable in the microwave without putting the food in another container.

Easy opening and pressing out of contents is also important in the areas of cosmetics and medicines. Furthermore packaging for medical instruments must be hermetically sealed and withstand sterilisation processes.

Since packaging is very different in shapes and materials, it requires especially developed, flexible testing units. For this reason, following you will see examples of testing units which will give you an idea of the testing possibilities which are available.

Fig. 1: Different packagings for food

Possible requirements on a packaging

Production
- Quality of delivered raw material
- Good processible, high throughput possible
- Stability in production processes
- Temperature and pression resistance
- Printability, foldability
- Reusableness (e.g. pallets)

Transport, product protection, shelf life
- Safe and resistant against damage
- Stackability
- Long shelf and storage life for the content
- Barrier characteristics
- Interaction between packaging and content
- Leak tightness
- Active / intelligent systems
- Freshness seal / tamper evident closures

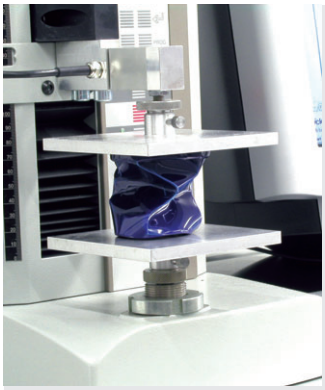
Marketing
- Appearance, haptics, weight
- Lower priced manufacturing with lower priced materials

User friendlyness
- Easy to open and reclosable
- Convenience aspects
- Can be emptied easy & completely
- Requirements of elder people
- Free from harmful substances
- Recyclability, disposal

Zwick / Roell

3.2 Zwick Roell tools and fixtures

Constant materials testing is required to ensure that packaging materials achieve their optimum value. The most important mechanical tests on finished packaging are described on the following pages. Information for specific material testing of other materials can be seen in the industry brochures for plastics, metals, papers or textiles.



Compression test on plastic beakers, buckets, boxes, containers, barrels and similar dimensionally stable packagings

Compression tests have different purposes. Examples:

- Determination of stacking characteristics
  There are various methods for this type of test according to Standard and material. Individual or several packages are loaded until failure. This will indicate the maximum stacking height which can be used. For plastic yogurt pots, this test is also made with completely filled trays. Or a certain load may be applied for a pre-set length of time or until failure.

- Determination of inherent rigidity
  This test gives information for the process of packaging: The packaging has a certain load applied when it is closed (when the lid is put on), and it must withstand this closing process without any problems.

- Fatigue tests
  A hysteresis test is performed on a pail to see how often a certain load can be applied before it breaks. In practice this happens when palettes are loaded and unloaded. Not every loading and unloading cycle is shown. Only the 1st, 100th, 500th and 1000th cycles are displayed for monitoring.

Customer specific test devices

On the basis of customer specific requirements, we develop and produce various testing tools and fixtures on short notice, customised to your packaging product and test requirements in an optimum way.

For examples rigs to determine the push-out force on blister packs, fixtures for special-shape containers or testing tools to test the pull-out force of wine corks.

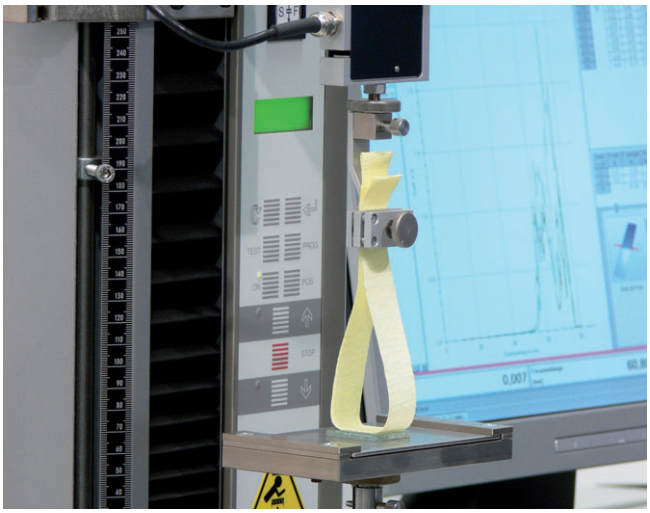
90°- / 180° Peel tests
This type of test is used to control the adhesive characteristics as adhesion and tear strength. There are a lot of peel and tear tests with the same principle. Some examples: EN 1719, EN 1939, FINAT test method no. 2, DIN 30646, DIN 55475, DIN 55477.

The reason for the high number is, that different substrate materials and adhesives are used for many different applications.

Test plates of glass or stainless steel with a standardised surface are used to compare the adhesion of the different materials.

The tests determine the adhesive or adhesion strength: The force that is necessary to tear a strip of a tape constantly from a test plate or glass. The result is the force referred to the width of the tape.

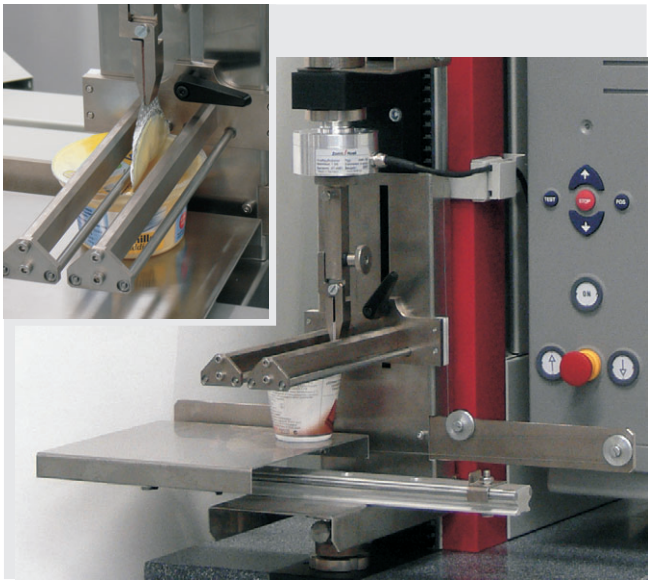
Also the tacking often is meaningful: This is ability to adhere to a surface, and to get a measurable tearing force. The adhesion on a substrate is achieved by touching or small contact without using a force.



Tack loop test for testing the adhesive strength of adhesive tapes
Tack is the initial adhesion. It is expressed as the tearing force of a loop material which has been brought into contact with the surface of a test plate.

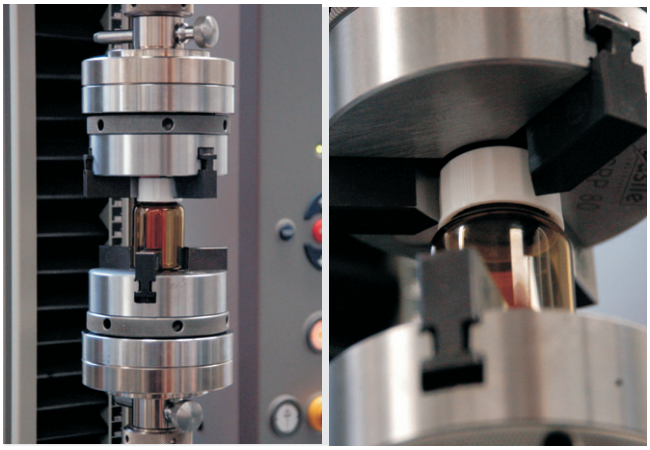
A strip coated on one side with adhesive is formed into a loop with the adhesive side outwards. With the testing machine the loop is brought in contact with a test plate. When a defined contact area is reached, the loop is pulled off.

This test is described in Finat test method No. 9.



Peeling of covers or sealing materials (Peel Test).
The ability to peel off dimensionally stable or inflexible packagings depends on material combinations, machine parameters as well as on sealed seam and tear-off geometries. A test of the peel forces with a special peel test kit can help to optimize these elements. The most important value is the cracking force but the regularity of the sealing is also significant.

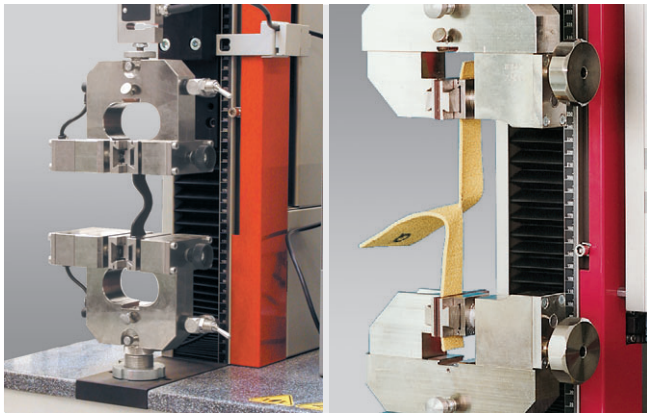
A benefit of the Zwick Roell peel test kit is the exact alignment of the delaminated area with the test axis: The packaging is tracked automatically by the sliding specimen table and this ensures a consistent and reproducible measurement of the load because the peeling angle of 90° is always guaranteed. Furthermore the kit enables a flexible adjustment to fit to different packaging shapes and heights.



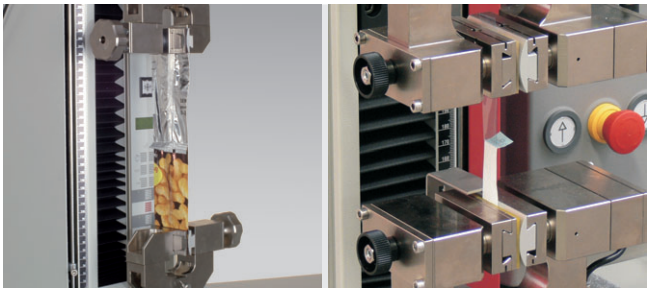
Opening of screw caps / torsion tests
To open screw caps a torsion drive combined with a linear axis is used. This test determines tightening and release torques as well as the free movement of the screw cap considering the thread pitch.

The complete testing process is controlled by a specially configured *testXpert*® II Master Test Program.

Zwick torsion drives can perform uni and multiaxial tests which combine tensile or compression tests with torsion. Thus barrier packagings, that require simultaneous pushing & twisting to open, can be easily tested.

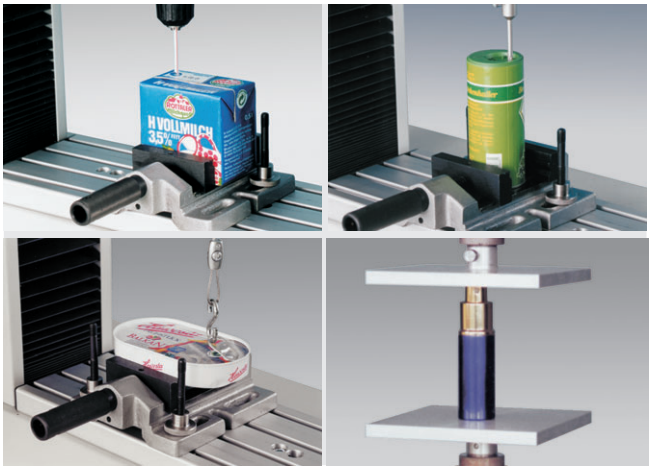


Tear test
Standards ISO 34-1, ISO 6383-1, EN 495-2 and DIN 53363 relate to tear tests on plastic foils. The test simulates the behaviour of packaging foils when the package is opened. When opening a plastic bag, the initial force should be approximately as much as the tear growth force. If the maximum force at initial tearing is too high, the danger exists that the plastic bag will suddenly tear open completely and the contents will spill out. The ideal behaviour is not easy to adjust because the tear growth resistance (as well as the tensile strength) of stretched foils is very depending on the direction.



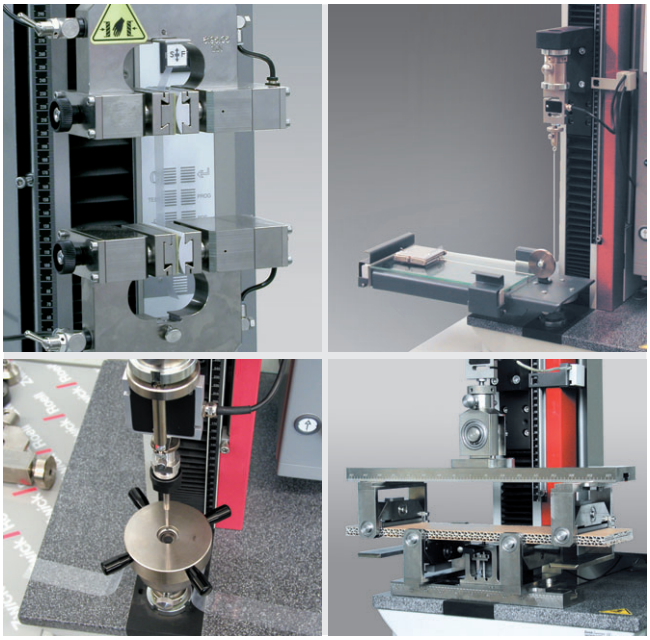
Sealed-seam strength
The determination of the sealed-seam strength of sealings made of flexible packaging material is carried out according to DIN 55529 and other Standards.

The test is a tensile test on a 15 mm wide strip with a pull-off angle of 180°. The sealing must have a certain strength according to the use of the packaging material.



Function tests on packagings
Packaging is manifold and also its function and type of opening. Individual values must be determined since normally no Standards exist.

Examples of such testing:
- Penetration of a straw in a composite carton for drinks
- Penetration of pre-perforated openings
- Opening forces of ring-pull cans
- Tearing off an opening flap, e.g. from lids
- Pulling out of carrying handles
- Opening and closing tests of snap closures
- Operating forces of pump bottles



Pure materials testing
Basic materials such as plastic, paper and metals have the most varied material tests performed on them mainly according to Standards. Some examples:

- Tensile test on plastic foils for the determination of the stress-strain-characteristic
- Determination of the coefficient of friction (COF)
- Penetration test on elastic packaging materials for the determination of the penetration resistance
- 4-Point flexure test for tests on single and multi-layer corrugated board

For more detailed information about pure materials testing please request our industry brochures for the respective basic materials, plastics, metals, paper or textiles.

Zwick / Roell

4. Texture analysers / packaging testing machines and components

Testing machines made by Zwick Roell can be used for completely different applications because they utilise a flexible and very clever connection system for tools and fixtures. Saving valuable laboratory space the same testing machine can be used for texture analysis as well as packaging tests.

In order to be able to offer the best testing machine for each requirement, there are three distinct versions (see table on the right).

Using Zwick Roells unique software *testXpert*® the user can fix the settings for the test arrangement.
This includes:

- Grip to grip separation (essential to get repeatable test results)
- Software limits for crosshead travel
- Crosshead position (even after machine is switched off)
- Force and travel limits to protect grips and tooling

Fig.1: zwicki Z2.5 TH with optional second test area

zwicki-Line

- Space-saving, single column testing machine for test loads up to 0.5/1/2.5/5 kN (50/100/250/500 kg)
- 3 different test area heights are available
- Modular system that can be used also for sophisticated test tasks
- Very stiff extruded aluminium profile load frame (patented by Zwick)
- Optional second test area
- 500 Hz Online test data transmission in combination with electronics *testControl* (for reliable tests of brittle specimens)

ProLine

- Twin column testing machines for routine packaging tests
- Excellent value for money and two weeks delivery time when ordering a standardised package (ProLine Pur-Portfolio)

Allround-Line

- Twin column testing machines for sophisticated test tasks
- Comprehensive configuration equipment: Connection of special sensors, multi-channel measurement, second test areas and many other options
- Table-top testing machines with extremely high bending stiffness due to the patented extruded aluminium load frames

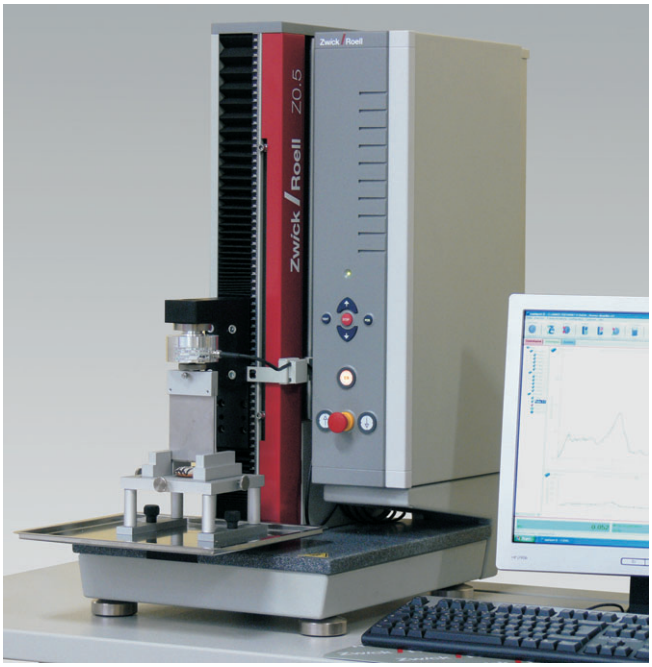


Fig.2: The perfect texture analyzer: zwicki-Line Z0.5 TS

These settings are stored with the test procedure to allow operators to change configuration without needing to make manual adjustments. This is a major advantage when changing test types and tooling and provides a much safer working system compared to other systems currently on the market.

Zwick Roell testing machines are without question the most accurate available today. The crosshead position system is very important for repeatable results and operator safety (see table on following page).

All testing machines have robust, durable electro-mechanical industry standard drive systems. They provide the machines with further benefits:

- Extremely large, stepless, speed range
- Very low and very high speeds can be set regardless of the test load (from approx. 0.5 µm/min to > 3000 mm/min)
- Highly precise and exactly reproducible speeds and positioning without overshooting effects reduce variance in test results

Fig.1: The Allround-Line provides manifold possibilities for superior and complex test tasks

Xforce load cells

Xforce load cells fulfill all five criteria of the accuracy grades as specified in the Standard over a very wide measurement range. For example a load cell type Xforce HP with 500 N capacity can be used from 500 N down to 1 N and still satisfies the requirements of ISO 7500: Class 1. In practise the typical linearity of load cells type Xforce HP and Xforce K is even more accurate than the Standard requires (relative accuracy <±0.25% from 0.4% of the capacity rsp. <±1 % from 0.1% of the capacity).

This very wide measurement range often avoids the need for a second load cell, thereby saving the cost of a second load cell and subsequent annual calibration costs.

All Xforce load cells are highly insensitivity to transverse forces, bending moments and torque moments. Furthermore the smart load cells have an unique electronic identity system:

- No daily calibration required
- Automatic identification of all settings and calibration data as well as the serial number which can be recorded or printed together with all test result data
- Load limits are read in automatically

Before delivery Zwick Roell calibrates each load cell together with the machine, its drive system and the electronics as a complete system. This ensures that tests can be carried out to the highest possible accuracy from the first test after commissioning.

Xforce load cells are only available from Zwick Roell.

Fig. 2: For standard tests on packagings a cost-efficient solution: Twin column ProLine testing machines

Zwick / Roell

Overview of testing machines

For the applications in texture analysis, viscosity measurment and packaging testing test loads under 20 kN are most common. Therefore we listed in the following overview only testing machines within this range. In addition we sell testing machines for loads up to 2,000 kN as standard. We will be glad to send you information on request.

Single column testing machines - perfect for texture analysis

Type	zwicki-Line			
	Z0.5 TS/TN/TH	Z1.0 TS/TN/TH	Z2.5 TS/TN/TH	Z5.0 TN
Max. test load	0.5 kN, 50 kg	1 kN, 100 kg	2.5 kN, 250 kg	5 kN, 500 kg
Max. height of test area	570/1070/1370 mm	570/1070/1370 mm	570/1070/1370 mm	1030 mm
Test area depth, approx.	100 mm	100 mm	100 mm	100 mm
Crosshead resolution	0.0002 mm	0.0002 mm	0.0001 mm	0.00004 mm
Positioning, repetition accuracy	± 2 µm	± 2 µm	± 2 µm	±2 µm
Number of test areas	1 / optionally 2	1 / optionally 2	1 / optionally 2	1 / optionally 2
Crosshead speed	0.001 ... 3000 mm/min [2]	0.001 ... 2000 mm/min	0.001 ... 1000 mm/min	0.001 ... 600 mm/min
Accuracy of the set speed [1]	0.02 %	0.02 %	0.01 %	0.02 %
Weight approx.	57/66/71 kg	57/66/71 kg	57/66/71 kg	70 kg

Twin column testing machines - for higher loads

Type	ProLine			Allround-Line		
	Z005	Z010	Z020	Z005	Z010	Z020
Max. test load	5 kN 500 kg	10 kN 1000 kg	20 kN 2000 kg	5 kN 500 kg	10 kN 1000 kg	20 kN 2000 kg
Max. height of test area	570/1070 mm	1050 mm	1050 mm	1045/1445/1795 or 1025/1425/1785 mm		
Test area depth, approx.	440 mm	440 mm	440 mm	440 or 640 mm		
Crosshead resolution	0.039 µm	0.038 µm	0.018 µm	0.041 µm	0.027 µm	0.014 µm
Positioning, repetition accuracy	± 2 µm	± 2 µm	± 2 µm	± 2µm		
Number of test areas	1	1	1	1 / optionally 2		
Crosshead speed	0.001 ... 500 mm/min	0.001 ... 1000 mm/min	0.001 ... 500 mm/min	0.0005 ... 3000 mm/min	0.0005 ... 2000 mm/min	0.0005 ... 1000 mm/min
Accuracy of the set speed	0.05 %[1]		0.05 %[1]			
Weight approx.	95/110 kg	135 kg	135 kg	between 150 and 250 kg		

[1] Measured over a crosshead travel of at least 1 mm from the maximum speed down to a minimum of 0.5 mm/min and under test loads up to the load frame capacity. For requirements beyond this specification please consult Zwick Roell

[2] Up to 2000 mm/min as standard, optionally up to 3000 mm/min

Load cells (extract)

We offer load cells with max. test loads from 5 N in several load steps, e.g. 10 / 20 / 50 / 100 / 200 / 500 N etc.

Examples for accuracy and resolution of the load cells (in combination with electronics *testControl*):

Max. capacity	5 N / 500 g	100 N / 10 kg	500 N / 50 kg	2.5 kN / 250 kg
Accuracy grade 1	from 0.02 N / 2 g	from 0.4 N / 40 g	from 1 N / 100 g	from 5 N / 500 g
Resolution better than	0.00001 N / 0.001 g	0.0002 N / 0.02 g	0.001 N / 0.1 g	0.005 N / 0.5 g

Electronics *testControl*

Measurement and control electronics *testControl*	
Internal recording rate	500 Hz/pps
Data transmission rate to PC	100 Hz/pps, 500 Hz/pps optionally[3]
Data sampling rate	320,000 Hz/pps
Electronic Interfaces: Standard PC interface (RS 232), USB optional	

[3] Option 500 Hz online test data transmission is recommended in texture analysis for brittle / short breaking products

Zwick / Roell

Test software *testXpert*®

Zwick Roell has set the standard with *testXpert*® and *testXpert*® II for intelligent materials testing software. You benefit from over 80 years of testing experience and from over 15,000 successful installations worldwide.

By its modular design we offer a specific testing solution to meet your requirements. Additional testing capabilities can be added as needed.

testXpert® II is organized so that you can operate it intuitively. Expressive symbols and a clear menu structure enable users to become quickly oriented and reduce the familiarization period to the minimum. Intelligent assistants help you set up or change test procedures and test reports.

You can install *testXpert*® II on all commercially available PCs and laptops without the need for an additional connection card. Moreover, you can install *testXpert*® II on as many computers in your company as you like, and thus have access to your data from various places. Test programs can be prepared on PCs without connection to a test machine, or test series can be called up later and further evaluated.

Useful options (Selection)

- Language swapping: All you need to do is make a few mouse clicks in order to change the language online. This offers international teams not only language-neutral operation of their testing machine but also considerably simplified communication.

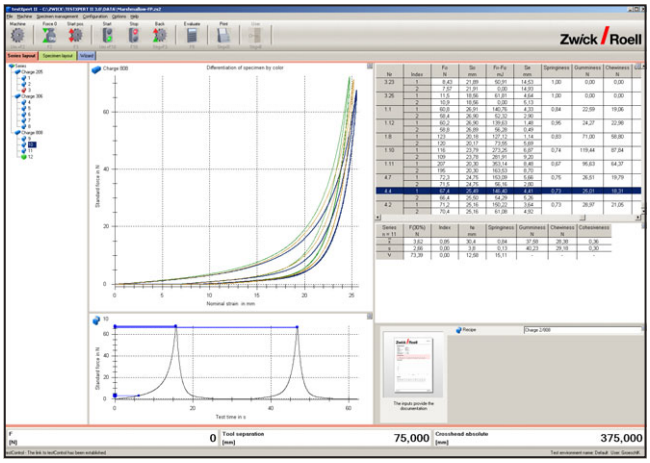


Fig 1: *testXpert*® II provides a quick and good overview over all test results. During the test you can watch the curve online on the display

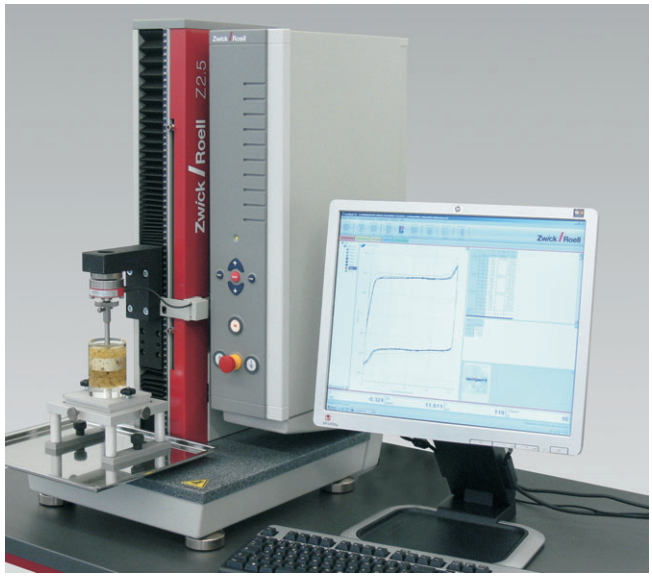


Fig. 2: *testXpert*® II offers for each application Standard Test Programs that already include the particular test sequence, test results and other settings

- LIMS – integrated Laboratory Information Management System: A powerful database is available to administer your test results in order to create and archive long-term statistics and reports. All data acquired are available from any testing system in your company.

- Result Editor: If you want additional results to analyze your specimen, this Editor offers you intelligent wizards to create these in no time at all.

- Export Editor: You want to export your results through ODBC in a variety of databases? (ODBC = Open database connection - used for transfering data between many different commercial systems) Or you wish to save them as ASCII format? With this function you can manage all that very easily with a click of the mouse. The same is true for transmitting complete test reports in Word, converting to PDFs, or automatic transmission by e-mail...

- Expanded traceability according to FDA 21 CFR Part 11: This function offers all the tools needed - together with organizational procedures - to comply with the requirements demanded by FDA 21 CFR part 11. This option records all activities before during and after the test, in order to make your results traceable and to protect against manipulation.

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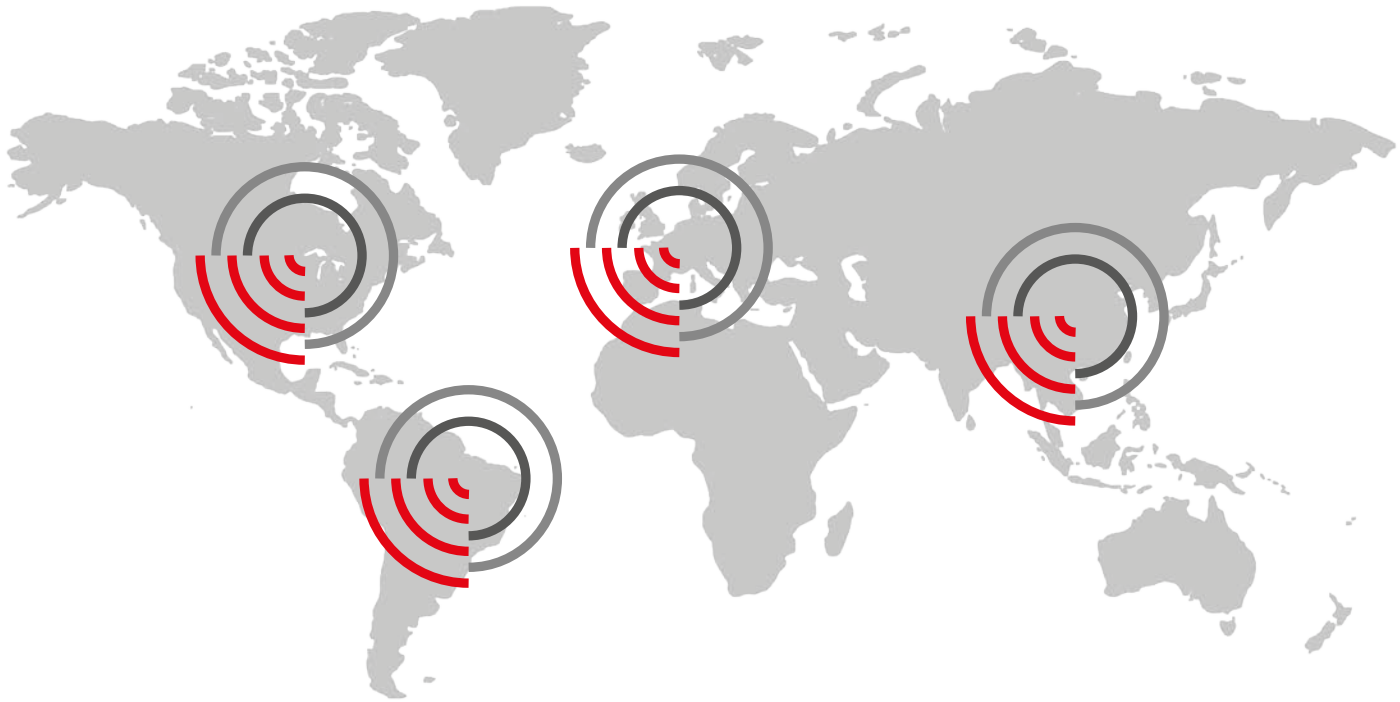

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