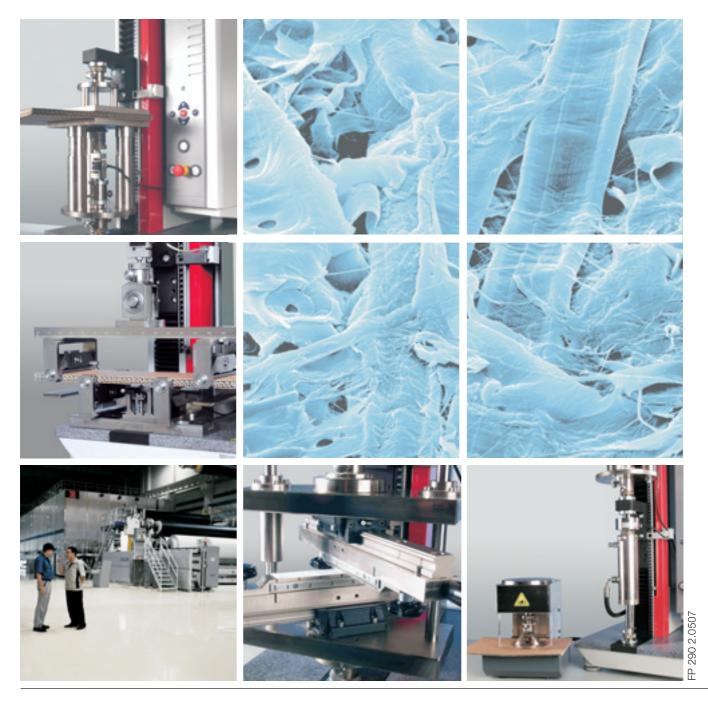


# **Testing Machines for Paper Materials**



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#### The Zwick Roell Group

Mechanical-technological testing is the oldest discipline in materials testing. Its importance has constantly grown to date. In the 15th and 16th centuries, Leonardo da Vinci and Galileo Galilei already expressed thoughts about flexure loading and the elastic properties of materials. The first testing machines for these purposes were made in the middle of the 18th century in France.

The Amsler company in Gottmadingen (formally in Schaffhausen, Switzerland) has been involved with materials testing since the middle of the 19th century. The Roell & Korthaus company started producing instruments, machines and systems for material testing in 1920. Zwick started producing instruments in 1937. The Zwick Roell group of companies was brought together in 1992, and now markets a complete line of systems from hand operated hardness testers to complex computerized testing systems.

This brochure gives an overview of the instruments, machines and systems of the Zwick Roell Group for paper-based materials. Its purpose is to give suggestions and hints to all, who have even the smallest interest in paper testing.

Many years of experience, a multi-tude of delivered equipments and constant communications with users, are the basis of our machines and instruments.

We achieve high flexibility and "intelligence" of our systems with modern mechanics, high performance electronics and user-oriented software.

The performance of the Zwick Roell Group reaches far beyond the delivery of testing instruments. The company was certified to DIN EN ISO 9001 in 1994, which guarantees a high degree of product and service quality. As an accredited DKD Calibration laboratory, Zwick is also authorized to check and calibrate testing systems. Internationally recognized certificates help to compete in international markets.



Fig. 1: Paper then and now



#### Paper and paper materials

Paper has accompanied man since ancient times (Fig. 1, page 2). Papyrus rolls show that man searched for, and found, a medium with which information could be stored and spread, while saving space and weight. This did not remain the only use. Books, and later industrial production of paper found new applications for this material. In the broadest sense, paper can be a structural material today, which carries and protects contents on the inside, while being an attractive information carrier on the outside (Fig. 1). Paper is technically a highly exacting product, which works dependably in its application and is easily recyclable at the end of its useful life.

Paper in technological areas cannot be forgotten. Filter, protection and special papers must be tested for their characteristics and they must be monitored (Fig. 2).

In a close relationship to plastics and metals, we find paper also as a compound material (Fig. 3). The combination of characteristics of the compound partners gives the end product its special capabilities.

Paper is around us in everyday life: as sanitary or cosmetic tissues in hygienic and care areas (Fig. 4).

### Quality control - a key leading to cost- and function optimized products

Although continuous quality control makes some effort, it anyway helps to save material and complaint costs.

Example in corrugated board testing: If the raw papers are tested in a separate test lab, fluctuations of the strip crush resistance (SCT) can be recognized impartially and considered. Furthermore, if strength values and bending stiffness of the corrugated board and the boxes are monitored, variations in the corrugator or in the following converting machines can be discovered and adjusted.

The tests mentioned above may also be used for the strength prediction of a box from the crush results of their related papers. A good estimation assures the merchantability of packagings during their lifetime, even under consideration of environmental influences during transport and storage.

Zwick machines accept all the necessary test tools for these tests (Fig. 1, next page). Thus, using one machine, one can perform the incoming inspection quality control on papers, tests on corrugated board, and the final quality control of boxes. (Fig. 2, next page)



Fig. 1: Paper as robust packing

Fig. 2: Paper for technical uses



Fig. 3: Paper compounds in daily use



Fig. 4: Hygienic articles give protection

### Test standards - required for comparable results

An important task of test standards is the creation of equal requirements for test specimen and test sequences; and this must be independent of when, where and by whom the testing is performed.

The National European Standards Commission as well as ANSI (U.S.A.) and JISC (Japan), are harmonizing their standards step-by-step with ISO (International Standard Organization). The goal is to improve the comparison of test results and reduce the costs for the present multitude of different testing systems in a growing global market.

This brochure is based mainly on International (ISO, EN) and important National Standards (TAPPI, JIS). Zwick Roell-instruments also meet most of the corresponding national standards.

Fig. 1: Accessories for strip crush, edge crush and flexural tests

The separation of paper-based materials into 6 groups should assist you to easily finding your own area of use and prompt you to take a look at new possibilities.

Testing of paper for corrugated board production



Testing of corrugated board and its products



Testing of special papers, graphic papers and printing papers



Testing on tissue and hygienic papers



Testing on cardboard and its products



Testing of paper compound materials



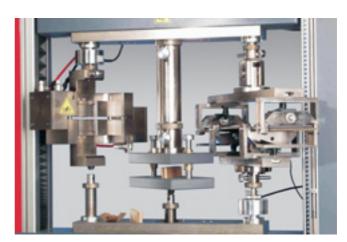


Fig. 2: Materials testing machine for all tests to predict the box's strength



### Test Methods, Standards and testing instruments

Type of test	Standard	Material group	Test unit	Page
Advanced Crush Test	-		Testing Machine, loading frame	24
Burst test	ISO 2758 TAPPI T 403	27	Testing Machine, Burst Tester Balance Cutter	13 25 35
Burst test	ISO 2759 TAPPI T 807 TAPPI T 810		Testing Machine, Burst Test instrument Balance Cutter	13 25 35
Bend test, 2-point (Creasing strength)	ISO 5628 ISO 2493 DIN 55437	30 00 20	Testing Machine, Bending unit Strip cutter 50 mm	14 35
Bend test, 3-point	ISO 5628 ISO 11093	00 30	Testing Machine, Bending unit Bending unit for carton sleeves	16 16
Bend test, 4-point	ISO 5628	30 00	Testing Machine, Bending unit	16
Corrugating medium test	ISO 7263 TAPPI T 809	000	Testing Machine with compr. plates Medium Fluter Strip cutter 12,7 mm	22 35 35
Thickness measurement	ISO 534 EN 20534 TAPPI T 411	27 30 00	Thickness measuring unit Cutter	17 35
Thickness measurement	ISO 3034 TAPPI T 411		Thickness measuring unit Cutter	17 35
Puncture test (PET, LPET)	ISO 3036 TAPPI T 803 DIN 53142-2		Testing machine, puncture test device	18
Puncture test (Tissue)	ISO 12625	<b>30</b>	Testing Machine, Penetration unit	19
Elmendorf tear test	ISO 1974 EN 21974 TAPPI T 414	005 ZZ	Elmendorf-Pendulum Impact Tester	21



### Test Methods, Standards and testing instruments

Type of test	Standard	Material group	Test unit	Page
Flat crush test	ISO 3035 EN 23035 TAPPI T 825		Testing Machine with compr. plates Circular cutter	22 35
Basis weight determination	EN ISO 536 ISO 5638 TAPPI T 410 FEFCO Nr. 2		Balance Circular cutter Cutter Balance	25 35 35 25
Edge Crush Test	EN ISO 3037 TAPPI T 811		Testing machine, compr. plates Specimen saw	23 35
Compressibility test	none	27	Testing machine, test head	36
Pin-adhesion-test	TAPPI T 821		Testing machine, fixture	30
Crease test	DIN 55437	27 30 00	Testing machine, creasing tool	28
Friction test	ISO 15359 TAPPI T 549 TAPPI T 816	27 30 30	Testing machine, friction unit Cutter	27 35
Ring Crush Test	ISO 12192 TAPPI T 822	005	Testing mach., compr. plates, inserts Strip cutter 12,7 mm	23 35
Box Crush Test	ISO 12048 EN 22872 TAPPI T 804		Testing machine, compression plates	29
Plybond resistance	DIN 54516	ZZZ 30 00	Testing machine, specimen grips Strip cutter 50 mm	27 35
Stacking Crush Test	EN 22874		Testing machine, compression plates	29



### Test Methods, Standards and testing instruments

Type of test	Standard	Material group	Test unit	Page
Strip Crush Test	ISO 9895 TAPPI T826	005	Testing machine, specimen grips Strip cutter 15 mm	25 35
Water Absorbtion (Cobb)	ISO 535 TAPPI T 441 EN 20535	00%	Cobb-Testing Unit Balance	30 25
Tear Test	ISO 11897	00	Testing machine, specimen grips	30
Tensile test (initial wet)	in process	27	Specimen grip	34
Tensile test (wet)	ISO 3781 TAPPI T 456	<b>301</b>	Testing machine, specimen grips Strip cutter Balance (50 g)	31 35 25
Tensile test (dry)	EN ISO 1924 TAPPI T 494	To aux 30	Testing machine, specimen grips Strip cutter 15 mm Balance (50 g)	35 35 25
Tensile test (Zero Span)	TAPPI T 231	27	Testing machine, specimen grips, Zero-span-Extension	33
Internal bond test (z-direction tensile test)	TAPPI T 541	30 27 00	Testing machine, testing unit Strip cutter 25,4 mm	26 35



#### **Materials Testing Machines**

#### Scope of applications

Materials testing machines are employed to determine the strength and deformation performance of specimen and components. These are stressed primarily with regard to tension, pressure, and deflection but also shear and torsion. These testing machines are characterized by large testing travel, high testing speed ranges, exchangeable measurement heads, and testing tools. This allows specimens and components of various shapes and dimensions and made from diverse materials and material combinations and accordingly different characteristics to be tested (Fig. 1).

Most of all Zwick-Roell Materials Testing Machines allow the extension to 2 test areas. The advantage: different tests can be performed time sharing without changing tools and using the same PC-user interface.

#### **Basic concept**

In order to be able to offer the optimal machine with the best cost/performance ratio for every demand, the Zwick Roell machine concept consists of three series for static materials testing. The series differ in their construction, equipment, performance and upgradeability.

- The zwicki-Line contains high-quality and spacesaving testing machines. These simple to operate and transportable single-column load frames were conceived especially for mechanical tests with small test loads up to 2.5 kN.
- The ProLine was developed to satisfy the demand for cost-efficient testing machines for functionality testing of components and standard testing of materials. The "Pure Portfolio", containing the accessories for ProLine, guarantees the best system price as well as the shortest delivery times.
- The Allround-Line solves the most demanding testing challenges and meets the highest requirements. It can be equipped or upgraded from an extensive selection of accessories. Among other things, this line allows the connection of special sensors and allows multi-channel measurements.

#### Load frames

Load frames are developed and produced for rated loads up to 2000 kN in our standard procedure. Zwick manufactures special models for special applications, for example for higher rated loads or lateral load frames.

#### The Single-Column Design of the zwicki-Line

This load frame is based on a very bending resistant extruded aluminum sheath which was developed especially for the zwickis. The test area is freely accessible from three directions, so that zwickis find their application in component testing and as Zwick hardness testers. Their low weight and small base make this modular system easy to transport and simple to find room for on any laboratory table.

### The Single- and Double-Column Table-top machines of the ProLine

The double-column load frames of the ProLine are equipped with two round steel columns which guarantee precise guiding of the crosshead. In addition, the integrated spindle and guide protection guarantees reliable operation in industry or for testing splintering material.

Single-column load frame ProLine models are available especially for testing with small loads up to 500 N.

### The Table-top and Floor testing machines of the Allround Line

The Table-top testing machines are equipped with two columns made from a patented ectruded aluminum sheath. They are light, very bending resistant and also serve as the spindle guide and spindle protection. T-slots on the outer sides allow simple mounting of accessories such as protectors of furniture free from interference by the moving crosshead.



All Table-top testing machines can be equipped with a pedestal to position the workspace at the optimal height for the application or operater. This allows comfortably seated operation with sufficient legroom so that the system is also suited for wheelchair users.

The Floor testing machines achieve a high accuracy from hard chromium-plated guide columns and a precision ball-type linear drive with play-free spindle nuts. Zwick offers different variations on the crosshead installation, so that either an upper, a lower or both workspaces can be available.

All load frames with electromechanical drives can optionally be equipped with a second workspace which, for example, makes it possible to quickly change the type of test without having to convert the machine.

#### **Drives**

#### **Electromechanical Drives**

All electromechanical drives are based on play-free and low-wear ball-type linear drives and digitally controlled drives. They are equipped with load frames for test loads up to 600 kN. Combined with digital measurement and control systems, they offer the following advantages:

- Extremely large, infinitely variable speed range
- Very low speed settings possible (from about 0.5 µm/min up)
- Highly precise and exactly reproducible positioning

The ProLine testing machines with Standard Electronics assemblies as well as those of the zwicki-Line are equipped with cost-efficient DC drives, all other testing machines are equipped with especially low inertia, brushless AC drives.

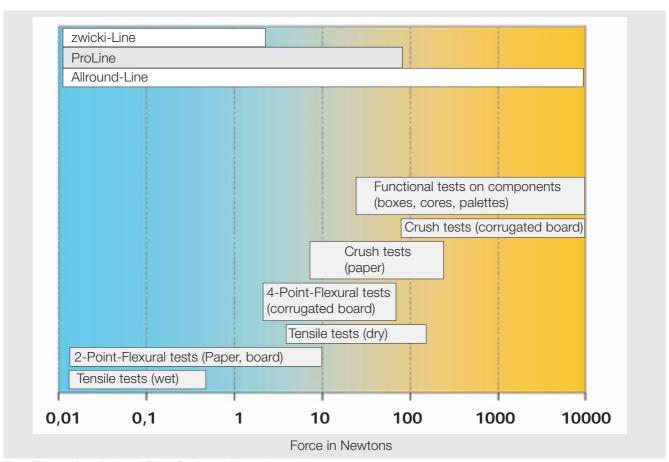


Fig. 1: Range of application of Zwick Roell materials testing machines



### Machines series:

- The advantages of the Zwick Materials Testing Highly precise and exactly reproducible positioning
- Extremely large, infinitely variable speed range
- Very low speed settings possible (from about 0.5 µm/min up)

### Characteristics of the zwicki-Line, ProLine and Allround-Line

Machine Compenent /Function	zwicki-Line	ProLine	Allround-Line
Load frame			
• Type			
Table-top testing machine (nominal force)	1 2.5 kN	500 N up to 100 kN	5 150 kN
Floor testing machine (nominla force)	-	-	50 up to 250 kN
Support and guide columns			·
Number of round columns	-	2	2 or 4
		(Z005 up to Z100)	(Floor testing machines)
Number of aluminium profile columns	1	1 (Z0.5)	1, optional 2
Number of test areas	1, optional 2	1	1, optional 2
Drive system			
Electro-mechanic			
Number of ball screws	1	1 or 2	2
DC-Motor	Yes	up to Z050	-
AC-Motor	-	from Z050	up to Z600
		(with testControl)	
Number of connectors	Standard Electronics: 2,	2	2 (optional increase to 4
(e.g. for measurement sensors)	testControl: 4		or 10)
Measurement sensors			
Strain gage load cell	Yes	Yes	Yes
Digital crosshead travel monitor	integrated	integrated	integrated
<ul> <li>Optical measurement systems</li> </ul>	Yes		Yes



### Zwick Roell test software test Xpert® II - Intelligent and Reliable, The New Software Generation for Materials Testing

Zwick Roell has set the standard with <code>testXpert®</code> for intelligent materials testing software. Unlike other software, Zwick has standardized on <code>testXpert®</code> for all of its applications, both static and dynamic tests meaning you spend less time learning software and more time conducting tests.

With *testXpert*® II, you benefit from over 80 years of testing experience and from over **10,000 successful installations worldwide.** 

### Some of the significant benefits of *testXpert*® II include:

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

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

**Modular design** – this means that we can offer a specific testing solution to meet your requirements. Additional testing capabilities can be added as needed.

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

**Online Language Swapping** Needless to say, you can have *testXpert*<sup>®</sup> II in your language of choice. *testXpert*<sup>®</sup> II speaks more than one language – all you need to do is click the mouse in order to change the language online.

Language swapping is a function which can be changed at any time, e.g. in setting the test report. Flexible testXpert® II language swapping offers international teams language independent operation of their testing machine as well as considerably simplified communication.

Industry-Oriented Terminology and Data Export Capability  $testXpert^{\otimes}$  II not only uses your language but it also adopts your technical terminology. For example, symbols or variables that are specific to the paper industry are implemented throughout the software. This provides more relevant meaningful information for in your testing application.

Today's quality assurance standards necessitates that the test results may be exported to a company's central laboratory database.  $testXpert^{\circledast}$  II communicates reliably with your IT system by providing flexible interfaces and MS-Office integration via Object Linking Editing (OLE).

**Exactly Synchronized Video Recording -** Only *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 an USB webcam. *testXpert*® II saves the recorded images **synchronized with the measuring data**. The visual recording shows, for example, when, how and where the specimen necks, buckles or changes color.

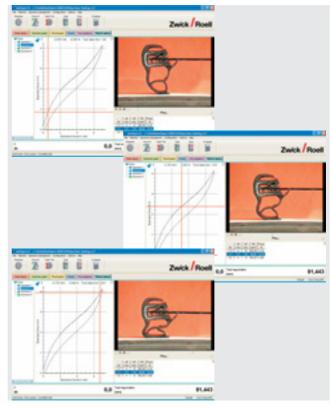
The alterations in specimen dimensions can be measured exactly from the captured images. In addition, before the test you can determine which events images should be recorded, for example the point in a cycle when compression switches over into tensile stress.

Afterwards you can print these pictures 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.

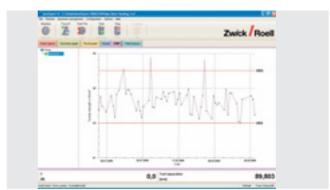
**testXpert® II LIMS** - Features only offered by testXpert® II: An integrated Laboratory Information Management System (LIMS). Here you have a powerful database available to administer your test results in order to create and archive long-term statistics and reports. All data determined by testXpert® II are available from any testing system in your company.

**Graphical Sequence Editor** - The *testXpert*® II Graphical Sequence Editor offers all the freedom you could possibly hope for. It enables you to design test procedures of any kind very individually, by combining test events, parameters and results exactly as you require.

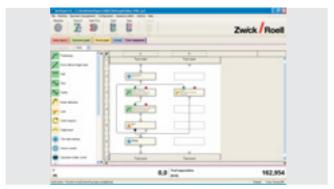
The **intelligent** construction of the graphical sequence editor makes your work easy. You do not require any programming knowledge: The graphic base makes for quick familiarization with the functionality. The integrated **simulation mode** offers you **safety**: It analyzes the test procedure you have created incorporating a virtual testing machine, with different specimen behaviour (e.g. spring, plastic, metal, etc.). You thus filter out errors from the test procedure in the early stages, and all this without destroying a single specimen.



Synchronized video system in  $testXpert^{\circ}$  II



Screenshot of testXpert® II Lims



Screenshot of the graphical sequence editor



#### Test Methods in the Paper Industry

The scope of instruments for mechanical, chemical, and optical testing of paper is very large. It is understandable, that Zwick Roell does not have all of these instruments in its production program.

Articles on products, for which Zwick does not produce, are listed in the technical part of this brochure with the note "on request". If you want such instruments, we recommend that you acquire them from our partners. You can also request them through us since "all from one source", is familiar to us. Speak to our field sales engineer. He will work with our sales department to find the correct solution for you.



#### The burst test

The Zwick Roell burst tester is an accessory of the testing machine for performance of the burst test (Fig.1). The testing machine takes over the functions of the hydraulic pump, the data acquisition and evaluation. This makes the burst test a program controlled test which assures correct test results with a minimum of manual operation.

When clamping a corrugated board specimen, it is important for the reproducibility of test results, to apply and maintain an accurate clamping force. For easy use, Zwick offers a pressure preselector, which allows for the application of 5 different clamping pressures by simply turning the selector knob.

Special attention must be paid to the dynamics of the testing instrument when determining the burst strength. Since a burst test is performed within a few seconds, the maximum pressure should applied precisely, the data acquisition rate of the testing instrument must be correspondingly high. If comparing results between different laboratories, the data acquisition rate of the instruments must be identical. Zwick Roell instruments can control the data acquisition rates so that systematic deviations between different laboratories can be prevented.

Similar conditions are true for the stability of the volume flow during the test. Zwick Roell testing machines work with a digital control to insure a constant volume flow, independent of the loading (Fig. 1, next page).

Further, the easy serviceability and the simple membrane monitoring must be pointed out. If a constant volume is pumped into the test chamber without a specimen, the maximum pressure indicates if the membrane is still in good condition or if it has become weak. The time dependant membrane behavior is automatically displayed and stored with the connected PC.

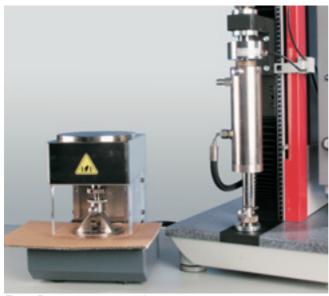


Fig. 1: Burst tester as a machine accessory

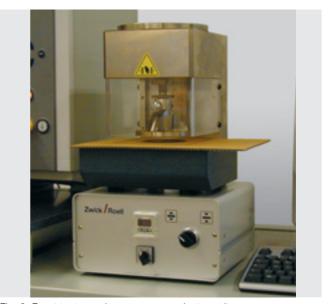


Fig. 2: Burst tester and pressure pre-selector unit

For burst testing of paper materials, there are two standards: ISO 2758 describes tests on paper, ISO 2759 describes the requirements for carton, corrugated board and corrugated base paper. Zwick offers a test instrument for each of these standards and thereby covers the range from paper to heavy corrugated board.

The advantages	The	advantages:
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- The operator does not need to worry about the details and is free to concentrate directly on the test at hand.
- The tests are performed under constant conditions even when there is a change in operators.
- The bursting of the specimen is recognized by the machine and the test is ended. This way, the membrane is stressed less and has a longer lifetime.
- A variable data acquisition rate guarantees comparable results between producer and processor.
- The flow is controlled in a very narrow tolerance range and remains constant even at high loading.
- With the real-time graphics, the operator immediately sees if the test has been performed correctly.
- Service interfaces and maintenance friendly construction reduce idle times and consequential costs.

Standard	ISO 2758
Material	paper
Item numbers	
Burst tester	320348*
Test Program	374150
For specimens	from 100 x 100 mm
To testing machines	from zwicki-Line

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.

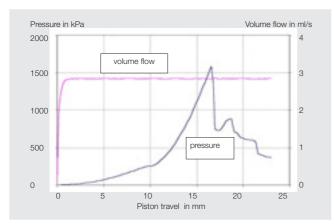


Fig. 1: Volume flow-stability guarantees constant test conditions

Standard	ISO 2759
Material	corr. board and raw paper for
	corr. board, solid board
Item numbers	
Burst tester	320348*
Test Program	374150
For specimens	from 100 x 100 mm
To testing machines	from zwicki-Line
Accessories	
Item number	
Pressure preselector	324538

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.



#### The 2-point bending test

Bending stiffness is very important in the processing of paper and carton. So that processing operations in packaging and filling machines run dependably and without problems, the paper or carton must be flexible within certain limits. During the changing of paper charges, a uniform stiffness characteristic is also required for constant working conditions of a packing machine.

The 2-point bending test unit from Zwick Roell (Fig. 2) covers two applications: calculation of bending stiffness and the determination of the folding behavior at an angle of 90°. Zwick's high resolution and exact measurement technology allows for one load cell to cover a wide range of applications.

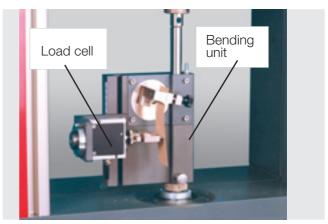


Fig. 2: 2-Point bending unit

When testing fine paper at 15 mm bending length, the forces may be below the lower measuring limit. In such cases, bending lengths from 1 mm should be applicable. Zwick offers a unit which covers bending lengths of 1, 2 and 5 mm in fixed precision steps. Its jaws are spring operated, so that specimens are always clamped under constant conditions without pre-damaging the sample (Fig. 1). In a limited range, this bending rig allows crease tests according to DIN 55437.

#### Advantages:

- Bending forces from 50 mN to 10 N are measured with one load cell.
- The force measurement error is 1% of the measured force.
- The load cell is placed separately from moving machine parts so that the data at the lower forces are reproducible.
- Bending angles larger than 90° are precisely measured without changing the load cell or tools
- An extremely high angle resolution of 0,001° guarantees highest dependability of measured values.
- Specimen can be gripped with widths up to 38 mm.
- The bending lengths can be easily adjusted to 1, 2 and 5 mm in precise steps.
- The test program simultaneously determines the bending resistance, modulus, and bending stiffness.
- Graphik display always shows the force-deformation behaviour (Fig. 2)

Standard	ISO 2493 / ISO 5628
Material	paper, board
Item numbers	
Bending rig	353100*
Load cell (from 10 N)	e.g. Type I, 318928
Test Program	374160
For specimens	
width	to 40 mm
thickness	from 0.1 to 4 mm
bending length	5 to 100 mm
To testing machines	from zwicki-Line
- · · · · · · · · · · · · · · · · · · ·	
Standard	ISO 2493 / ISO 5628
	ISO 2493 / ISO 5628 from fine paper, foils
Standard	
Standard Material	
Standard Material Item numbers	from fine paper, foils
Standard Material Item numbers Bending rig	from fine paper, foils 320663*
Standard  Material Item numbers Bending rig Load cell (from 10 N)	from fine paper, foils  320663* e.g. Type I, 318928
Standard Material Item numbers Bending rig Load cell (from 10 N) Test Program	from fine paper, foils  320663* e.g. Type I, 318928
Standard  Material Item numbers Bending rig Load cell (from 10 N) Test Program For specimens	from fine paper, foils  320663* e.g. Type I, 318928 374160
Standard  Material Item numbers Bending rig Load cell (from 10 N) Test Program For specimens width	from fine paper, foils  320663* e.g. Type I, 318928 374160  to 40 mm

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.



#### Creasing strength

This bending rig is available for combined bending and creasing tests. Creasing tests can then be performed from free spans > 30 mm and angular speeds up to 10 °/s.

Standard	DIN 55437 Part 3
	max. ca. 10°/s
Material	Paper, board up to 250 g/m <sup>2</sup>
Transmission	Angle/Displacement: 1,2 °/mm
Item numbers	
Bending rig	373835*
Load cell (from 10 N)	e.g. Type I, 318928
Test Program	003125
For specimens	
Length	from 30 mm
Width	ca. 15 up to 40 mm
To testing machines	with test speeds
	≥ 500 mm/min

 $<sup>^{\</sup>star}\,$  These accessories require connecting elements and software to be specified according to the machine.



Fig. 1: Bending test on fine paper at 1 mm bending length

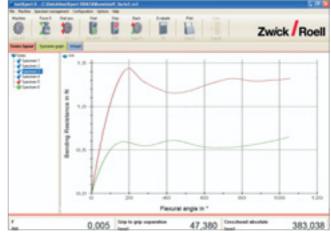


Fig. 2: Bending resistance before and after creasing



#### The 3-point bending test

The 3-point bending test has only limited use on paper based materials. Possible applications are on cardboard, paper based compounds or cores. However, the 4 point bending test is standardized on cores. 3 point bending tests are carried out following company internal standards.

#### The advantages:

- Bending units from the Zwick Roell building block system are light and simple to mount and to operate.
- Economical solution, since a bending transducer is not required.
- Customer specific solutions for core testing.

Standard	ISO 5628
Material	board, composites
Item number	
Bending rig	316485*
Load cell from Fmax 10 N	e.g. Type I, 318928
Test Program	374160
For specimens	
width	from 50 mm
thickness	from 2 mm
bending length	from 100 mm
To testing machines	from zwicki-Line
Standard	ISO 11093
Material	cores, sleeves
Item number	on request
For specimens	length to 3200 mm
To testing machines	from ProLine

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.

With the knowledge gained from the bending units for structural materials, (aerospace, ceramics and high performance metals), Zwick developed a 4-point bending unit for carton and corrugated board (Fig. 1). The result is a tool that is comparable to other existing solutions at a moderate cost. Another important point is that the bending unit can be used on the smallest machine, the zwicki.

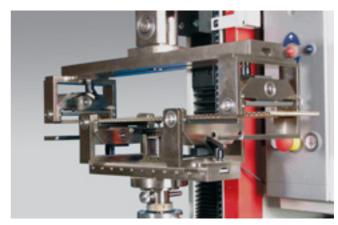


Fig. 1: 4-point bending test rig with high resolution extensometer

Compared to bending instruments which use dead weights for specimen loading, handling is uncomplicated and fast: the specimen is simply placed on the bending unit and the test is started. The stiffness is calculated automatically, taking in consideration of the elasticity limits.

Because of rotatable and swivable supports, shrinked or warped specimens can be tested within wide limits.



#### The 4-point bending test

With the use of the McKee-formula, bending stiffness is important for the prediction of the box crush resistance. With the 4-point bending method, dependable stiffness values are measured in the machine and cross direction. This is particularly important for miniature flute corrugated board, where stiffness plays an increasing role, compared to standard flute heights.

Standard	ISO 5628
Material	corrugated board, cardboard
Item numbers	
Bending test rig	320364*
Load cell (from 500 N)	e.g. Type II, 318946
Test Program	374160
For specimens	
width	max. 100 mm
length	max. 400 mm
To testing machine	from zwicki-Line

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.



#### The advantages:

- Test time below 60 s
- The test graph allows a fast plausibility control even during the test (Fig. 1)
- Supports of the bending unit are optimized for the characteristics of carton or corrugated board.
- Measured results are mostly independent of warp or shrink of the specimens caused by production. The test is performed within the elastic range of the specimen.

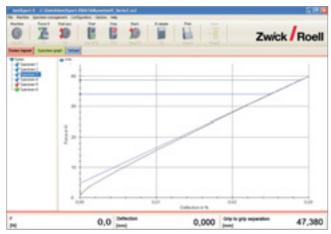


Fig. 1: Stiffness determination on corrugated board



#### Thickness measurement

Paper thickness is measured for various reasons:

The stiffness of paper and carton are dependent on the thickness. Therefore, an exact thickness measurement is critical in the stiffness of a carton and processability in a packing or printing machine. If the weight per unit area and thickness of a paper is known, the weight-referenced volume can be calculated. This is important for the transportation of larger amounts as well as for the processing of these materials.

Digital thickness measuring instruments, which work correctly to Standards and pass their values on to subsequent systems, save time and ensure secure data (Fig. 1).

Standard	ISO 534 / EN 20534 TAPPI T 411
Material	paper, board
Item number	
Thickness gage	320410
Standard	ISO 3034 / TAPPI T 411
Material	corrugated board
Item number	
Thickness gage	320408

#### The advantages:

- Pressure foot area, loading weight and lowering speed are available for all normal standards.
- Individual and series measurements are possible.
- PC-connection via built in RS 232 interface.



Fig. 2: Thickness gage for corrugated board



#### The penetration test

The quality of a corrugated board box is not dependent on the stiffness of the material in just the machine or cross directions. During the penetration test, the material is loaded in all directions due to the pyramid formed penetrator. Therefore, the tensile, compression, bending, and shear forces, appear simultaneously. The result of this test is the energy absorbed during penetration of the material. According to recent standards, this test is performed with a pendulum impact tester or with a materials testing machine. This instrument can be used Stand Alone or connected to a computer.



Fig. 1: LPET test curves

Since the penetration test with a pendulum has several weaknesses, (oscillation of the pendulum, no linear movement, no constant test speed, test results depend on the test speed, difficult handling), Zwick offers an alternative, standardized test with a material testing machine. With the linear motion penetration test (LPET), the penetration pyramid is pressed through the specimen in an even movement. The pyramid is driven and controlled by a testing machine. The force-path curve is acquired by the electronics. The result is the energy required for penetration, which is similar to the pendulum impact test (Fig. 1).

The standard deviation of the data due to testing machines is significantly better than that from a PET pendulum. The result correlation to PET impact testers has been evaluated in cooperation with the german wfp institute for corrugated board research and is of 5 % (Standard deviation) (Fig. 2, page 19).

Since the measurements, force and travel are acquired electronically, the measurement range is much larger than a pendulum impact test.

Theoretically, materials from a basis weight of 80 g/m², up to heavy duty corrugated board with a thickness of 17 mm, and an energy of approx. 40 Joule, can be tested without mechanical changement of weights (Fig. 2). These characteristics make the testing machine much quicker and secure.



Fig. 2: LPET-Test in a testing machine



Zwick Roell is working with technical paper institutes and well known industrial companies, on the industrial introduction and standardization of this test. For tests on tissues, a similar test method has been set up using a ball indenter. Zwick Roell is able to offer this test equipment.

Standard	DIN 56142-2
Material	corrugated board, cardboard
Item numbers	
Puncture test rig	318619*
Load cell Fmax 2.5 kN	e.g. Type I, 318914
Test Program	374162
For specimens	
width	180 mm
length	from 180 mm
To testing machines	from zwicki-Line

 $<sup>^{\</sup>star}$  These accessories require connecting elements and software to be specified according to the machine.



Fig. 1: Puncture phase

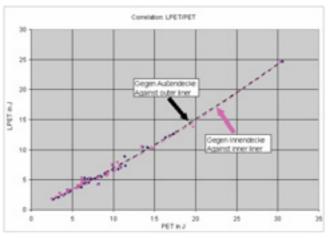


Fig. 2: Very close correlation between PET- and LPET-tests.

#### The advantages:

- small deviation in the results
- no changing of weights
- no system friction
- no erroneous oscillations
- no manipulating hold-back collars
- tests can be performed on materials from 80 g/m² up to heavy corrugated board without retro-fitting
- ability to perform wet tests



### The burst test on tissue (Ball-Burst Test)

Additionally to the tensile strength, the bursting strength is an important characteristics of tissue materials. With a burst test the penetration of a sheet by a rigid body is simulated.



Fig. 1: Burst test on tissue

The specimen is horizontally clamped between two plates, which have a centric circular clearance. With a constant speed, a posished ball penetrates the specimen in the center of the clearance (Fig. 1). Measured values are the maximum force (bursting force) and the bursting index (bursting force related to the specimen's grammage) (Fig. 2).

The test fixture is designed for a most simple handling. The specimen is placed upon the lower plate of the fixture and the machine is then started. Specimen clamping is performed automatically and consequently the test is carried out without any influence of the operator (Fig. 3).

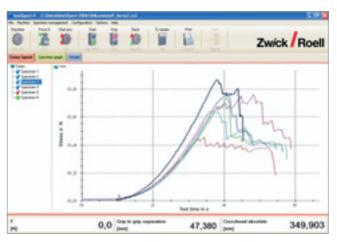


Fig. 2: Typical force-deformation graphs from tissue

The wide force measuring range avoids that a load cell must be changed: using a 100 N load cell, even forces below 1 N are measured with the required accuracy. Therefore, materials having extreme characteristics or research investigations can be carried out with high reliability.



Fig. 3: Puncture test rig configuration



Even results exceeding the usual range of 5 to 20 N are exactly captured. Additionally, the force-deformation-behaviour of a material can be analysed, as a testing machine always captures the deformation values, too.

Standard	ISO 12625
Material	tissue
Item number	
Test rig	324914*
Load cell Fmax 100 N	e.g. Type I, 318922
Test Program	374160
For specimens	
angle length	from 175 mm
To testing machines	from zwicki-Line and ProLine

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.



#### The tear test

By using a tear test, this gives paper processors an estimated value of the future behavior of the end product (multi-layered carton, corrugated board). The tear test according to Elmendorf, is used as the quality control criteria for the paper producer (final inspection) as well as for the processor (incoming goods quality control).

A tear test is performed in seconds therefore, the test data must be quickly acquired and evaluated.

The Elmendorf-Pendulum fulfills these requirements with a simple connection to a PC. Thus the raw data (energy values) can be converted into force values and then easily transferred to a QDA-System.

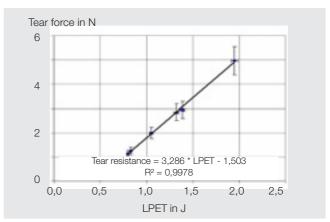


Fig. 1: Correlation between the LPET and the Elmendorf test

Empirical tests can be performed on a testing machine. Tensile grips or the LPET penetration test rig may be used for such tests. Test results from LPET and Elmendorf showed a strong linear correlation (Fig. 1). The correlation should be crosschecked for individual paper grades.

#### The advantages:

- easy PC connection via RS 232 interface
- Connection to testXpert® II offers all advantages of electronic data processing
- established robust instrument

ISO 1974 / TAPPI T 414
paper
636687 / 355559
62 mm (ISO)
63 mm (TAPPI)
50 mm (ISO)
53 mm (TAPPI)



### Crush tests on corrugated board and corrugated board raw paper

It is important for these tests (Fig. 1), that the forces are applied exactly vertically to the specimen during the test. Precision guided compression plates provide an extremely high transverse stiffness. They insure the reproducible results of the crush characteristics in corrugated board raw paper and corrugated board.

#### The Corrugating medium test

The Corrugating medium test provides information about the behavior of a corrugated paper after it has been formed in a fluter. A section of corrugated paper is glued one-sided, to a carrier paper and then loaded in compression. The maximum load characterizes the behavior of the paper during the converting processing steps (punching, printing) after board production. A disadvantage of this method is that only the A-corrugation is tested.

For other types of corrugations, the behavior in compression mode must be mathematically calculated.

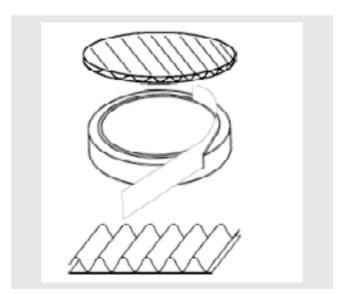


Fig. 1: Specimens for: flat crush test, ring crush test and corrugating medium test

In addition, this method takes a lot of time and requires much skill in making the specimen. For these reasons, Zwick-fluters are delivered which include a "third hand". With its help, a specimen can be easily and quickly prepared (see page 35, Fig. 4).

ISO 7263 / TAPPI T 809
corr. medium paper
318539*
374012
320625
155 mm
12.7 mm
from zwicki-Line

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.

#### The Flat Crush Test

In the flat crush test, a single-flute corrugated board specimen is loaded perpendicular to its surface. The resistance this corrugated board presents to the force, gives an indication of its behavior in further processing and use.

Characteristic curve: according to the height of the individual flutes, the highest flutes break first, then the middle ones and then finally, the rest of the flutes.

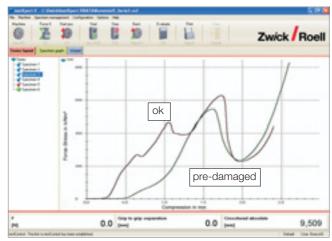


Fig. 2: Flat crush test: test curves showing correct and pre-damaged material



If the corrugated board has leaning or crushed flutes, it has been pre-damaged, and the curve is fundamentally different. The crush energy and data curve, provide the user with valuable information about the degree of damage.

Modern miniature flutes tend to crush only at forces greater than 10 kN, requiring excessive lateral stiffness on the compression plates. For these applications, Zwick offers the suitable compression test rig, too (Fig.1).

N 23035
ard
Line

 $<sup>^{\</sup>star}$  These accessories require connecting elements and software to be specified according to the machine.

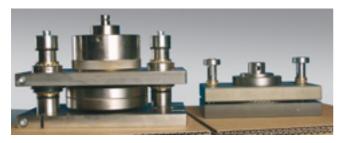


Fig. 1: Compression plates for the flat crush test on miniature corrugated board (left, F > 10 kN) and on standard corrugated board (right, F < 10 kN)

#### The Edge Crush Test

This gives information about the strength of corrugated board at standing flute orientation (Fig. 2).

The edge crush resistance goes into the McKee formula that is so important for quality control in corrugated board factories. The specimen must have clean, parallel and perpendicular edges, and the material must be free of pre-damage.

A hinged scissors or a knife is not suitable for cutting. Good results have been achieved with a circular saw from Zwick (see page 35, fig. 3).

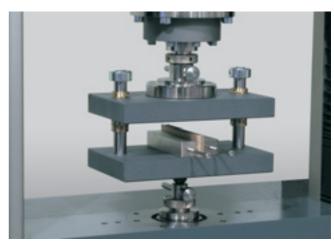


Fig. 2: Edge crush test using guided compression plates

Standard	ISO 3037 / TAPPI T 811
Material	corrugated board
Item numbers	
Compr. test kit up to Fmax 10 kN	318539*
Test Program	374152
ECT-saw	320629
For specimens	
length	100 mm
height	25 mm
To testing machines	from zwicki-Line

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.

#### The Ring Crush Test

The ring crush test is similar to the strip crush test in that the strength of liner or fluting is measured in the machine and cross directions.

The results in this test are highly dependent on proper specimen preparation. The specimen, as well as the test fixture must be parallel in order to insure an exact determination with the ring crush strength.

Since the ring crush test provides more information about the buckling behavior rather than about crush behavior, it is being replaced by the strip crush test.

The advantages:

- light, precision guided compression plates prevent lateral yielding of the specimen during the test
- suitable compression plates for miniature flute board in Zwick's standard program
- automatic recognition of breaking on all flutes prevents misinterpretation in the flat crush test
- inserts for the ring crush test fit into the compression plates without a problem. Lateral yielding of the specimen is also prevented.
- a data graph of the test run is standard with all tests.

Standard	ISO 12192 / TAPPI T 822
Material	corr. medium paper
Item numbers	
Compr. test kit up to Fmax 10 kN	318539*
Inserts	316243
Test Program	374158
Strip cutter	on request
For specimens	
length	152 mm
height	12.7 mm
To testing machines	from zwicki-Line

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.

#### **ACT-Test**

This tool is used for compressive tests on microcorrugated board sqare disks.

The disk is placed into a frame, which can be opened at its right side. The frame itself consists of 90° notched legs. At the left side of the frame, a screw drive ist notched leg frame together with the side load simulate the glued edges of a box, made of the same material.

During the test, the compression fin (upper frame part) pushes against the sample and squeezes it until it fails. The fin is supported via ball bearings and remains its position constant over the entire test sequence.

In the test, the sample's deformation is similar to that of a box (bulge effect).

Therefore (customer's statement) there is a very close correlation between this test an a crush test on a box. As a result the first maximum of the monitored force is used.

Item numbers	
ACT-Test	362886
Fmax	500 N
Height x Width	80 mm x 80 mm
Diameter	0,5 mm up to 2 mm
Connection dia.	
upper and lower	20 mm
Test Program	372430
To testing machines	from ProLine
Additional required	
Load cell Fmax 2.5 kN	e.g. Type I, 318914
(as integral part)	



Fig. 1: Test rig for the ACT-Test

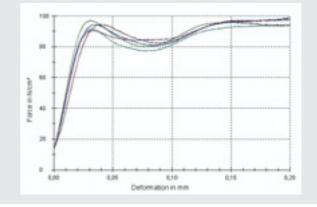


Fig. 2: Force-deformation behaviour in the ACT-Test





#### The Strip Crush Test

The paper's characteristic "compressive strength" can be determined by the strip crush test with high accuracy. Because of the short test length of only 0.7 mm, the load bearing fibre portion of the material is taken into consideration more than with the traditional testing methods (ring crush test, corrugated crush test or linear crush test). The Zwick test arrangement (Fig. 1) has unique characteristics compared to the normal horizontal machines:

- Zwick uses a load cell with a high nominal load. This
  makes the measuring chain very stiff and keeps posttest effects from the machine to the specimen
  reduced to a minimum.
- Specimen and load cell lie in the same symmetrical axis. Erroneous bending moments are nonexistent.

Since resolution and accuracy of the Zwick measurement electronics is extremely high, paper can be accurately measured from ca. 100 g/m² up to 400 g/m² and higher (Fig. 2). Because of its technological advantages, the Strip Crush Test is being more accepted worldwide.



Fig. 1: Strip crush test grips

#### The advantages:

- an inexpensive accessory to be used with a Zwick machine
- has the necessary stiffness for compression tests because of the load cell with high nominal load
- very little retroactive affect on the specimen due to the symmetrical design
- Easy-to-use user interface for quick control of the test run

ISO 9895 / TAPPI T 826
raw paper for corrugated board
317990*
e.g. Type II, 318942
069002.58.00 / tc-xxx
320412
> 110 mm
15 mm
from zwicki-Line
on request

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine

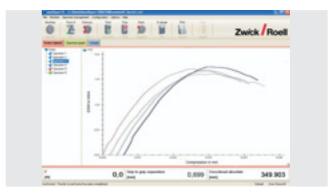


Fig. 2: Strip crush test-series



#### **Determination of basis weight**

Selection criteria are: accuracy and resolution of the balance and the electronic transfer of the weight to a computer. In order to balance feature and price requirements, Zwick Roell and its partners offer a range of precision balances from highly accurate analytical balances to balances with a limited range.

Standard	EN ISO 536 / ISO 5638
Material	paper, board
Item numbers	
Balances	
50 g	318230
220 g	001410
For specimens	
diameter	113 mm
or	any area, to 1 %
	accurate

Standard FEFCO Nr. 2 Material corrugated board

Item number

001410

Balance 220 g For specimens

length 250 mm width 200 mm



Fig. 1: Balance



#### **Internal Bond Test** (z-direction tensile test)

For multi-layered materials (duplex paper, coated paper), the internal bond strength of the layers to one another is an important characteristic. It determines the further processability. When testing to TAPPI T 541, the load on the specimen must be perpendicular to the surface of the specimen. In order to eliminate the effects from grips or fixtures to the separation of the layers in a test, the tensile force must be maintained in its vertical direction through rupture. High lateral stiffness and absolute parallelism of the specimen holders is critical for a proper test. Therefore, Zwick developed a special test rig for holding the specimens, which are crossed over at an angle of 90°, and which accept a paper strip of 5 specimens. Thus, using one single application, 5 tests can be performed without further handling of the specimen (Fig. 3, page 26 and fig. 1, page 27)

The specimen holders are mounted on precision compression plates and are parallel and stiff in all directions. How the specimen is applied: using a double sided self adhesive tape, a paper strip is glued onto one specimen holder. The second holder is applied with only a double adhesive tape. During the test, the specimen is at first pressed against the two specimen holders. Compressive loads, as well as pressing time are freely adjustable. After the compressive phase, the tensile test is performed within half a second (Fig. 2).

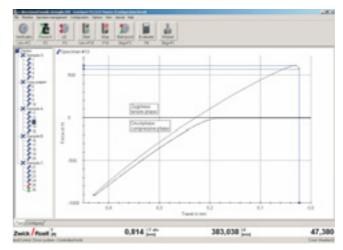


Fig. 2: Internal Bond Test - Compressive sticking and tensile test in one procedure

The test result is the tensile strength, which is the maximum tensile load, related to the sample's surface area. The z-tensile test rig is available as a manual version, as well as a semi-automatic one. With the semiautomatic test rig, a second paper sample can be prepared during the time while testing the first sample set of 5 specimens.

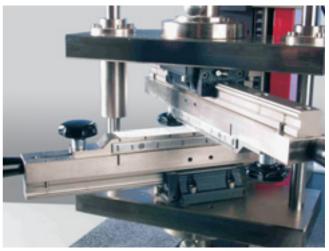


Fig. 3: Internal bond test, test run

Compared to Scott bond tests, the z-tensile test has proved to have much less result dispersion.

Similar tests: ply bond strength to DIN 54516 and Scott Bond Test to TAPPI T 403. In these tests, the specimen is subjected to peel loading. The Scott Bond Test is performed with a pendulum impact tester. This takes into consideration the high processing speeds of this material.



Fig. 1: Internal Bond Test - test rig and sample preparation unit (bottom right)

The advantages (TAPPI T 541):

- quick placement of the specimen by using a semiautomatic machine even while running a test series
- pressure step and z-tensile test without specimen handling
- compressive strength and compression time are freely adjustable
- Use of only half the standard area for tests on high strength papers

Standard	TAPPI T 541
	ISO -> in process
Material	duplex-papers, plybonds
Item number	
Test rig	
manual	623069
automatic	623286
Test Program	on request
For specimens	
length	approx. 140 mm
width	25.4 mm
To testing machines	from zwicki-Line
Equipment for	on request
ply bond strength	
to DIN 54516	
Scott bond tester	on request



#### **Measuring Coefficient of Friction**

Friction of paper and paper compounds is important for further processing in automatic systems. For the determination of the coefficient of friction, an important factor is the material of the two surfaces to be measured, "paper against paper", or "paper against other materials". Another deciding factor is whether the static friction or the dynamic friction is to be measured. Zwick Roell offers tools and software programs for all of these methods. This gives the user confidence in the test results and then ultimately in finding a solution for packing or printing problems. Two basic measuring techniques are available:

- the "Horizontal Plane Method" (Fig. 2, page 27 and fig. 1, page 28), in which the static and kinetic friction are determined with one sled
- The "Strip Method": two material strips are pulled over pressed rolls in opposition to one another. The advantage of this method is that the only surfaces that are tested are the ones that have not been in contact with each other (Fig. 2, page 28).

Most tests using the "Horizontal Plane Methods", are tested to TAPPI. The ISO methods are more complicated, since the entire measuring operation (application and driving of the sled) must not be performed manually. Initial studies of tests on corrugated board [1] showed that the values tested to ISO correspond to TAPPI.

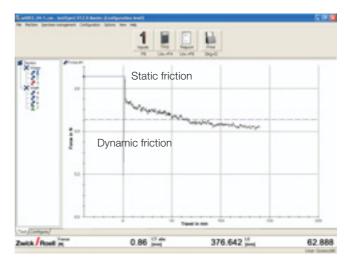


Fig. 2: Determination of static and dynamic friction

Zwick-Software testXpert® II determines a wide range of friction results: static and dynamic friction, peak values, upper and lower median of peaks. This provides the user with results that are needed for subsequent material processing.



Fig. 1: Horizontal plane method

Standard	TAPPI T 549 / TAPPI T 816
Material	paper, foils
Item numbers	
Friction test rig	319395*
	316251*
Test Program	319190
Cutter	on request
For specimens	
length	300 mm
width	150 mm
To testing machines	from zwicki-Line/ProLine

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.

Standard	without (strip method)
Material	paper, foils
Item numbers	
Friction test rig	618538
Test Program	374014
Strip cutter	
15 mm width	320412
25 mm width	320416
For specimens	
length	300 mm
width	25 mm and 15 mm
To testing machines	from zwicki-Line
Standard	ISO 15359
Item number	on request
Standard	DIN 53119
Item number	on request

#### The advantages:

- Friction units to TAPPI with fast placement of the specimen
- A wide variety of friction tests results are available in testXpert® II
- Strip friction unit for tests on "virgin" surfaces

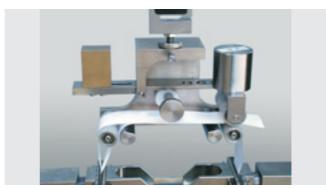


Fig. 2: Friction test, strip method



#### Laboratory creasing

A testing machine can be used for the determination of creasing parameters. In a laboratory test a specimen can be creased with freely adjustable values for:

width of the creasing tool, width of the nut, nut depth and creasing stroke. Because of the high creasing speed and the excellent positioning accuracy, as compared to manual creasing presses, creasing can be determined very precisely. For fast and easy determination of best fitting creasing parameters, creasing channel and knife blade are changeable.



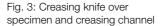




Fig. 4: Creasing tool

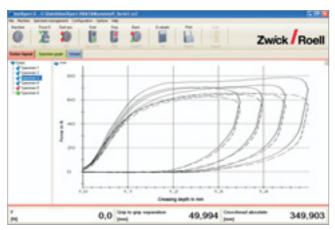


Fig. 1: Laboratory creasing: force-deformation characteristics

Standard	DIN 55437
Material	paper, board
Item numbers	
Creasing tool	618337
Load cell Fmax 2.5 kN	e.g. Type II, 318942
Test Program	618336
For specimens	
length	40 mm
width	50 mm
To testing machines	from zwicki-Line

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.



#### **Box Crush and Stacking Crush Tests**

These tests are used to determine the strength and the stacking capabilities of corrugated board boxes (Fig. 2). The complete box is compressed to a specified load or until failure.

The European Standards require rigid compression plates if the behaviour of a box is being tested by loading it on opposite corners or sides. The upper plate must be spherically pivoted when loading the box on opposite surfaces. However, TAPPI always requires rigid compression plates. The European Standards distinguish between the Box Crush Test and the Stacking Crush Test.

In the Box Crush Test, the corrugated board carton is loaded steadily to nominal load or until failure. In the Stacking Crush Test, a certain load is held constant for a certain time or until failure of the box.

Machines, either standard or to customer specifications, also offer correct applicable solutions for combined tests.

#### The advantages:

- Standard and customer specific machines for optimal testing
- Available solutions for box widths up to 2000 mm

Standard	
Box crush test	ISO 12048 / EN 22872 TAPPI T 804
Stacking test	EN 22874
Material	corrugated board
Item numbers	
Compression plates	
400 x 400 mm	317942*
400 x 600 mm	317944*
Special versions	on request
Load cell (from Fmax 5 kN)	e.g. Type II, 318940
Test Programs	
Box crush test	347178
Stacking test	357693
For specimens	
length x width x height	Boxes according to the machine's test space
To testing machines	from Allround-Line

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.



Fig. 2: Box-crush tester for specimen up to a footprint of 2 m by 2 m (authorized by SCA Packaging Research, European Technical Centre, Aylesford)



#### Water absorbtion to Cobb

Water absorbtion of raw paper is determined with the Cobb Test.

The principle is:

- The dry specimen is weighed
- The specimen is placed under a cylinder with an inner diameter of 100 cm<sup>2</sup>. Specimen and cylinder lie on a rubber and a steel plate
- Approx. 100 ml water is poured into the cylinder
- After a specified waiting time, the water is poured out. Excess water is removed from the specimen with blotting paper and roller.
- The specimen is weighed while wet and the amount of water is calculated that 1 m<sup>2</sup> of specimen material would absorb.

#### The advantages:

- Operator friendly instrument with quick clamping
- also available for corrugated board

Standard	ISO 535 / EN 20535 TAPPI T 441
Material	paper
Item number	
Cobb test kit	on request
For specimens	
diameter	112.8 mm



#### **Tear Propagation Test**

This characteristic is important for finding and avoiding weak spots in packaging with folded edges or bonded seams. It can be performed on a low cost testing machine such as ProLine machines for tight budgets. In addition, it gives valuable information about the quality of materials and about the consistency of the production process.

#### The advantages:

- Tensile and tear propagation tests can be performed with the same equipment.
- Peaks and median values are calculated in one operation
- Easy to use menus simplifies the work

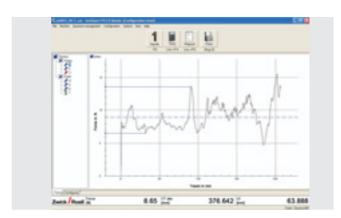


Fig. 1: Tear test: diagram

Standard	ISO 11897
Material	paper-foil, compounds
Item numbers	
Grips	316264*
	316322*
Test program	318035
For specimens	
dimensions	acc. to the product
To testing machines	from zwicki-Line/ProLine

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.

#### Tensile tests

They inform about a number of characteristics: stiffness, modulus, tensile strength, tearing length and energy absorbtion.



#### Pin adhesion test

In a pin adhesion test, the upper and lower layer of a corrugated board strip are separated from the fluting with two rows of inserted steel pins (Fig. 1, page 31). Test result is the maximum force, related to the total glue line length between layers and the fluting. The Zwick test rig is stiff (Fig. 2, page 31), works in tensile mode and requires no compression plates.



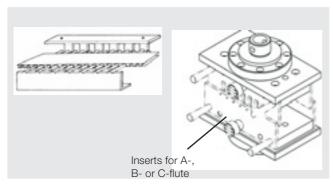


Fig. 1: Corrugated board strip over steel pins

Fig. 2: PAT-Test rig

Standard	TAPPI T 821	
Material	Corrugated board	
Item numbers		
PAT-Test rig	638412	
Test program	374010	
For specimen		
A- and C-flute:	50 x 150 mm	
B-flute:	32 x 100 mm	
To testing machines	from ProLine	



#### Wet tensile test

These tests are useful for determining several different paper characteristics such as usage properties of tissues, printing quality of offset printing papers, and runability characterisics in the wet end of a paper machine.

#### Tissue

The wet strength is one of the most important material characteristics for papers that are used wet or are subsequently processed. Zwick offers a quick, dependable method for the determination of wet tensile to Finch (Fig. 3). Simple handling of the Finch clamp and a fast change over between wet tensile and other tests highlights the use of Zwick's testing technology.

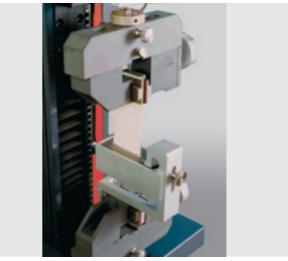


Fig. 3: Wet Tensile Test

ISO 3781 / TAPPI T 456
tissue
318512*
316264*
374120
lever shear on request
approx. 200 mm
50 mm
from zwicki-Line

 $<sup>^{\</sup>star}\,$  These accessories require connecting elements and software to be specified according to the machine.

#### Offset-printing papers

When running paper through the printing units of a 4-color offset printing machine, the humidity of the paper increases steadily on the printed areas. This increase of humidity causes an elongation of the paper in the machine and cross directions. While the elongation in machine direction can be corrected by gage pins, it cannot be corrected or adjusted in the cross direction. In order to avoid "fan out" of the individual color prints, the elongation in cross direction must remain within specific limits.

The importance of not exceeding these limits increases with increasing recycling rate and decreasing basis weight of the paper. Testing the force-deformation behavior during incoming quality control, is a powerful costs saving tool. For a valid test, the paper must be preconditioned at a well-defined humidity and then tested within a very short time.



Fig 1: zwicki, equipped with horizontal test space and automatic test start

The slope of the elongation-force-curve can be used to determine the limits of high quality offset printing. For this type of test, Zwick has developed a testing machine system that can test a specimen within seconds after taking a specimen out of a conditioning box (containing a water-acetone-solution in an exact ratio). Thus, the degree of humidity does not change within this short test time.

Only the elongation between the grips is needed for determining the force-elongation behavior of the specimen. Zwick's standard grips and jaw faces fulfill these requirements and prevent grip slippage and failures within the clamping area of the sample (Fig. 4).

Standard	ISO 1924	
Material	paper	
Item number		
Materials testing machine	623336	
Test Program	374010	
Strip cutter	320416	
For specimens		
length	approx. 240 mm	
width	25 mm	

Helpful for paper optimizing is its Z-dimensional forcedeformation behaviour. Using the videoXtens (Fig. 3), extension and transverse strain can be measured simultaneously, when using a wider specimen. Fig. 4 shows the conventional force-elongation curve together with the paper's Poisson ratio.



Fig. 3: videoXtens measures extension and transverse strain

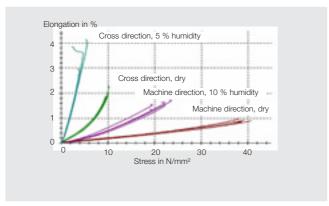


Fig. 2: Tensile test at defined humidity, elongation as a dependant variable

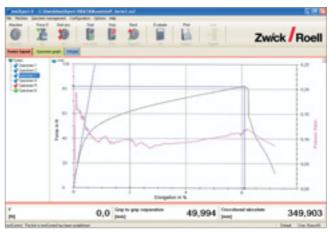


Fig. 4: Force and Poisson ratio vs. elongation



Standard	without
Material	Paper
Item numbers	
Test Program	374010
For specimens	
Length	ca. 150 mm
Width	ca. 40 mm
To testing machines	from zwicki-Line
Specimen grips	Pneumatic grips Fmax 500 N
	(320723)
Longstroke	
extensometer	325934

**Zero Span Test** 

The web's fibre strength is measured with the Zero Span Test. Using an initial gage length near zero, a tensile test is performed. Now, mainly the pulp fibres are loaded (Fig. 1).

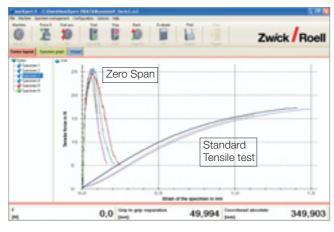


Fig. 1: Force- deformation behaviour in tensile test and in Zero Span Test

The Zero Span Test is usually performed with dedicated instruments, being accordingly complex and expensive. If Zero Span Test are not frequently used, Zwick's modular system of grips and accessories offers an affordable solution:

For an exact horizontal and angular grip alignment, Zwick offers a mechanical extension kit. The grip already must despond to some minimum accuracy requirements, which is achieved by pneumatic grips. The Zero Span jaws protrude from the grips inner edge and allow a free span of approximately 0.1 mm (Fig. 2). This can only be achieved with numerically controlled machine such as Zwick's ProLine or zwicki-Line, which guarantee best reproduceability and reduce the risk of danger to a minimum.

Standard	TAPPI T 231
Material	Paper
Item numbers	
Specimen grips	320723
Accessories for	
Zero Span Test	373921, 373749 and 003779
Jaws for conventional	
tensile tests	373748
Test Program	317972
Load cell	from 500 N
For specimens	
Length	from approx. 80 mm
Width	20 mm
To testing machines	from ProLine

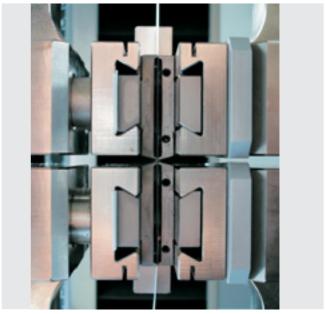


Fig. 2: Zero Span Test



#### Runability at the wet end

The paper is very susceptible to web breaks when it leaves the paper former machine and runs without any support by a felt or a screen. Adjusting and controlling the web tension, as well as using wet paper with minimal initial tensile strength values, can avoid web breaks. The minimal tensile strength of the paper depends on the stock composition (ratio of long and short fibers, chemical additives). The optimal price-strength-ratio can be evaluat-ed through initial wet tensile tests. Special tensile grips (Fig. 1) assure correct clamping, draining within the clamping area of the specimen, and prevents specimen breaks within the clamping area.

Standard	In process
Material	initial wet paper
Item number	
Grips	358182*
Test program	374010
For specimens	
length	approx. 200 mm
width	50 mm
To testing machines	from zwicki-Line

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.

#### The advantages:

- correct specimen gripping
- fast and easy handling
- high flexibility through the *testXpert*® II Master Test Program

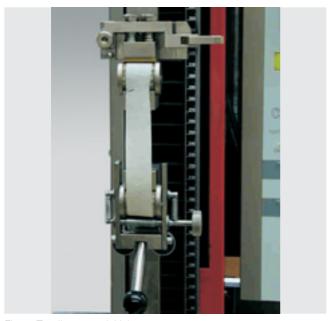


Fig. 1: Tensile test on initial wet paper

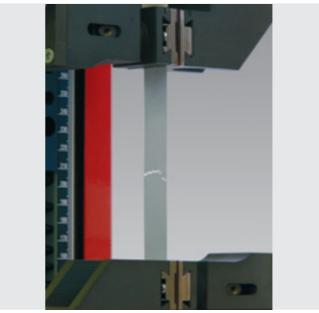


Fig. 2: Tensile test according to ISO 1924, dry specimen





#### Tensile test

Since only the tear strength or tearing length result is to be determined in many cases, other results can be hidden by software. The <code>testXpert</code> Il software from Zwick accomplishes this with two functional levels. The first level is the use of built-in Standard tests.

Standard tests contain only test sequences and results which are required by test standards. The adavantage of using the Standard tests is that training can be accomplished in a short time. The second level is the Master program. This level will provide functionality to meet all current and future needs for maximum flexibility.

Standard	EN ISO 1924 / TAPPI T 494
Material	paper
Item number	
Specimen grips	318512*
Test program	374010
Strip cutter	
width 15 mm	320412
width 25 mm	320416
width 50 mm	320422
For specimens	
length	approx. 200 mm
width	15, 25, 50 mm
To testing machines	from zwicki-Line/ProLine

 $<sup>^{\</sup>star}\,$  These accessories require connecting elements and software to be specified according to the machine.

#### The advantage:

New: With videoXtens for Poisson's ratio determination



#### **Specimen preparation**

Specimen preparation is critical to obtaining good results. The factors that effect creating a good specimen are, clean cuts perpendicular to the specimen, parallelism, service life of cutters, and speed. Zwick Roell has partners that specialize in manu-facturing high quality cutting units. Figures 1 to 4 show a segment of the instruments used for specimen preparation.



Fig. 1: Circular cutter for FCT specimen

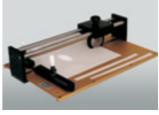


Fig. 2: Strip cutter







Fig. 4: Fluter

Description	Item number
Strip cutter	
15 mm width	320412
25 mm width	320416
50 mm width	320422
15 & 25 mm width	320446
Circular cutter	
dia. 112.8 mm	320450
dia. 79.8 mm	320452
ECT-saw	320629
Medium fluter	320625
Other instruments for	On request
specimen preparation	

#### **Customer specific tests**

The area of paper materials does not begin with paper manufacturing and does not end at the processor for Zwick. Suppliers and end users also profit from Zwick Roell solutions. A partial list of potential canidates for this equipment would be, suppliers who must test their chemicals on finished paper, printers who must optimise the stiffness values of bindings, large packaging customers. Our customized tests could enhance your quality control:

#### **Dimension measurement**

Boxes for consumer goods are filled and closed by automatic systems, and they are often sold from automatic machines. Size accuracy is an important characteristic so that these automatic operations are per-formed without hindrance.

Zwick Roell testing machines are very well suited for statistical size controlling because of their broad measurement range and accuracy. In such a test, the machine measures several height differences relative to a reference point (Fig. 1). The measured points can be approached purely manually or automatically. The data may be exported in many ways for subsequent evaluation of measured values, from local printer up to PC programmes for statistical quality control.

#### Location dependent deformation measurement

Good stackability of goods lowers storage costs. However, due to safety and economic concerns, there is a limit to how high goods can be stacked. The location and mode of failure of packaging is an important factor for an engineer to consider when optimising the packaging.

Oversize

Nominal size

Fig. 1: Measuring the local variation deformation of a packing box

A Zwick Roell machine, equipped with several travel measurement systems, determines the deformation of a corrugated board carton including the inner packing and contents (Fig. 2). The location of the maximum deformation can be mathematically calculated from several individual deformations measurements. The developer of the packaging can gain valuable information about possible weak spots. Box Crush Tests and Stacking Crush Tests can also be performed correctly to Standards with this machine.

#### Compressibility characteristics

The compressive force-deformation-behaviour is important for the developer of high quality offset papers. Proper printing, without missing or blurred dots can be achieved by optimizing the elastic and plastic behaviour of the paper.

Both characteristics can be evaluated through a compressibility test. In this test, a sample is loaded until a compresive force is reached that is similar to that in an offset printing unit. Force and deformation are measured simultaneously. Because of the small deformation sin the µm-range, a high resolution extensometer is required. The Zwick solution comes from hardness testing, where comparably small deformations must be measured.



Fig. 2: Measurement of the buckling of a filled, folded box

A floating compression plate is loaded via a spheric loading bar and applies the compressive force to the paper (Fig. 1 and 2). The deformation of the paper is measured with a resolution of 64 nanometres. The test graph shows the specimen's behavior during the loading phase as well as during the unloading phase. From both sections of the graph, the following test results are calculated (Fig. 3):

- the maximum stress
- the total deformation before and after a dwell time
- the plastic deformation
- the elastic deformation

From these results, the design - engineer gets a complete picture of the force deformation variables that effect the paper during the offset printing process.

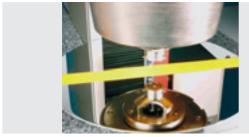


Fig. 1: Compressibility test head prior to test



Fig. 2: Compressibility test using zwicki

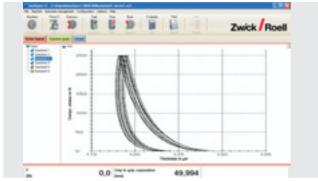


Fig. 3: Compressibility diagram

Standard	customer specific
Tr. T	

Item numbers
Determination of

proportionality load on request
Dimension measurement on request
Measurement location dependent
deformation measurement on request
Test Program 374016

Compressibility measurem. 318531\* (Hardness measure-

ment head, Fmax 200 N) 623146 (Transducer foot) 623147 (Transducer foot) 623192 (Test Program)

#### The advantages:

- Cost efficient equipment through use of standard components
- Deformation of a single sheet of paper can be measured directly and with very high resolution.

#### **Dynamic tests**

For endurance test on packages, static tests are necessary, but not sufficient. Acceleration forces as applied during loading, transport or stacking that can only can simulated with dynamic machines. Zwick-Roell manufactures these type of testing machines within Zwick-Roell Group. *testXpert*® II can use the same user-interface as the static systems on dynamic systems to perform endurance tests under realistic conditions, high-speed tests (Fig. 4), and shock tests. This makes packaging design more efficient by shortening the development time, costs, and failures.

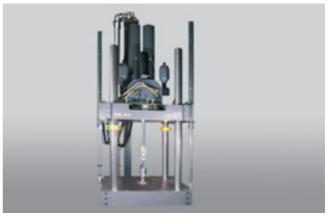


Fig. 4: High speed testing machine, up to 20 m/s

<sup>\*</sup> These accessories require connecting elements and software to be specified according to the machine.

#### Laboratory data acquisition, Subsequent data evaluation

Quality Control does not end with the testing of the end product. The consistency of all production processes can be measured with the aquired data. However, this is only possible if the acquired data is studied over a long period of time and if data can be correlated from various tests. By applying conclusions to the production, the control loop is closed from the initial material to the end product.

With this completely integrated solution in  $testXpert^{@}$  II you can

- Perform a complete evaluation of materials and components from various tests,
- Display long-term statistics and trends of individual characteristics.
- Create interdependent test reports.
- Histogram function

Thus you can ensure higher product quality quickly and efficiently. *testXpert*<sup>®</sup> II does all of the above for you automatically!



Fig. 1: testXpert® II test report

In the ideal case, the following complement each other:

- the test protocol (Fig. 1) provides a snapshot of the product's quality
- medium observation time frames
- export to databases in-house
- Control card (Fig. 3) and histogram (Fig. 4)

#### testXpert® II LIMS

Features only offered by testXpert® II: An integrated Laboratory Information Management System. Here you have a powerful database available to administer your test results in order to create and archive long-term statistics and reports – also for spanning a number of test series.



Fig. 2: testXpert® II LIMS

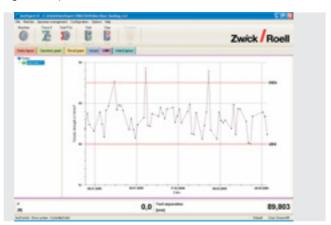


Fig. 3: Control card

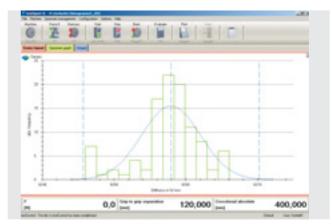


Fig. 4: Histogram



#### **Automation**

Since quality control is not an end in itself, cost efficiency is very important in testing and evaluation. Automation can be a valuable tool to save costs and obtain reproducible results with fewer variations.

Automated specimen feeding is available in "Clip" type construction that is suitable for non-stable samples such as paper or fleece. When the corresponding specimen clamps are used, tests on carton or compounds can be automated as well.

The testing system in Fig. 1 consists of a tensile testing machine and an automatic specimen feeding system (Handling System). The Handling System has two controlled driving axes and a circulating carrier chain with up to 200 specimen positions. The positions can be made of metal clips or clamps and are optimised for various specimen forms.

With the freely programmable, servo- controlled driving axes, the carrier chain can be prepared with the most varied specimen holders. The system is monitored by a control which is storage programmable. The test evaluation is performed by  $testXpert^{\otimes}$  II. The possibility of manual testing without retro-fitting is standard.

Good-bad sorting, via tolerance inputs, and controlled removal of specimen remains are options.



Fig. 1: Automatic testing machine: tests on sanitary products

#### List of sources

[1] Urs Ernst: Determination of the static coefficient of friction on corrugated board and liner paper Corrugating International, April 1999

#### **Product illustrations**

Title page: FOGRA, München

Page 3, Fig. 4: Paul Hartmann AG, Heidenheim

Page 3, Fig. 2: Hengst Filterwerke, Münster

Page 3, Fig. 3: Staatl. Molkerei Weihenstephan AG

Page 29, Fig. 2: SCA Packaging Research

Page 34, Fig. 1 Voith GmbH & Co KG, Heidenheim

Reserved to technical modifications

#### **Zwick Roell AG**

August-Nagel-Str. 11 D-89079 Ulm Phone ++49 7305-10-0 Fax ++49 7305-10-200 www.zwickroell.com info@zwickroell.com

#### Zwick GmbH & Co. KG

August-Nagel-Str. 11 D-89079 Ulm Phone ++49 7305-10-0 Fax ++49 7305-10-200 www.zwick.com · info@zwick.de

#### Toni Technik Baustoffprüfsysteme GmbH

Gustav-Meyer-Allee 25
D-13355 Berlin
Phone ++49 30-46 40 39 21/23
Fax ++49 30-46 40 39 22
www.tonitechnik.com · info@tonitechnik.com

#### Indentec

#### **Hardness Testing Machines Ltd.**

Lye Valley Industrial Estate, Bromley Street Lye, Stourbridge West Midlands DY9 8HX · Great Britain Phone ++44 1384-896949 www.indentec.demon.co.uk · mail@indentec.demon.co.uk

#### **Acmel Labo**

10/12 rue de l'Orme Saint Germain 91160 Champlan · France Phone ++33 1-69109595 Fax ++33 1-69100186 www.acmel.fr · info@acmel.fr

#### Zwick Asia Pte Ltd.

25 International Business Park #04-17 German Centre Singapore 609916 · Singapore Phone ++65 6 899 5010 Fax ++65 6 899 5014 www.zwick.com.sg info@zwick.com.sg

#### **Zwick USA**

1620 Cobb International Boulevard Suite #1 Kennesaw, GA 30152 · USA Phone ++1 770 420 6555 Fax ++1 770 420 6333 www.zwickusa.com info@zwickusa.com

#### **Zwick Testing Machines Ltd.**

Southern Avenue
Leominster, Herefordshire HR6 OQH
Great Britain
Phone ++44 1568-61 52 01
Fax ++44 1568-61 26 26
www.zwick.co.uk
sales.info@zwick.co.uk

#### Zwick France S.a.r.l.

B.P. 45045 F-95912 Roissy CDG Cedex France Phone ++33 1-48 63 21 40 Fax ++33 1-48 63 84 31 www.zwick.fr info@zwick.fr

#### Zwick Ibérica S.L.

Marcus Porcius, 1
Pol. Les Guixeres, s/n Edificio BCIN
08915 Badalona (Barcelona) - Spain
Phone ++34 934 648 049
Fax ++34 934 648 048
www.zwick.es
info@zwick.es