Zwick / Roell

Zwick
Materials Testing

Testing Machines for Paper Materials

FP 290 2.0903.202

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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 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 multitude 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.

Paper and paper materials

Paper has accompanied man since ancient times (Fig. 1). 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

Fig. 1: Paper then and now

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. 2). 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. 3).

In a close relationship to plastics and metals, we find paper also as a compound material (Fig. 4). 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. 5).

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.

Fig. 2: Paper as robust packing

Fig. 3: Paper for technical uses

Fig. 4: Paper compounds in daily use

Fig. 5: Hygienic articles give protection

Zwick machines accept all the necessary test tools for these tests (Fig. 6). 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. 7)

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.

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. 6: Accessories for strip crush, edge crush and flexural tests

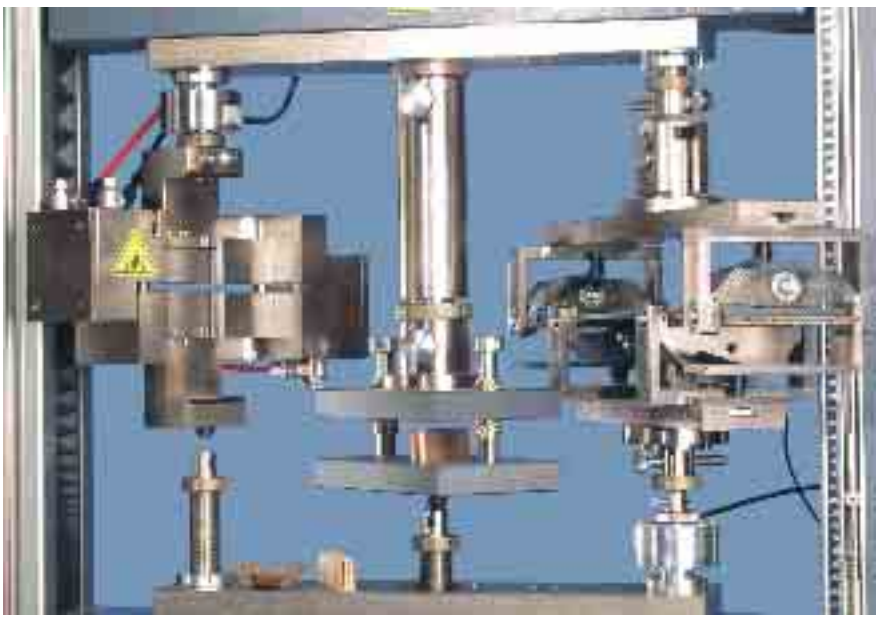
Fig. 7: Materials testing machine for all tests to predict the box´s strength

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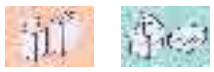
Test Methods, Standards and testing instruments

Type of test	Standard	Material group	Test unit	Page
Burst test	ISO 2758 TAPPI T 403		Testing Machine, Burst Tester Balance (50g) Cutter	12 20 27
Burst test	ISO 2759 TAPPI T 807 TAPPI T 810		Testing Machine, Burst Tester Balance (100 g) Cutter	11 20 27
Bend test, 2-point	ISO 5628 ISO 2493		Testing Machine, Bending unit Strip cutter 50 mm	14 27
Bend test, 3-point	ISO 5628 ISO 11093		Testing Machine, Bending unit Bending unit for carton sleeves	14 14
Bend test, 4-point	ISO 5628		Testing Machine, Bending unit	15
Corrugating medium test	ISO 7263 TAPPI T 809		Testing Machine with compr. plates Medium Fluter Strip cutter 12,7 mm	18 27 27
Thickness measurement	ISO 534 EN 20534 TAPPI T 411		Thickness measuring unit Cutter	16 27
Thickness measurement	ISO 3034 TAPPI T 411		Thickness measuring unit Cutter	16 27
Puncture test (PET)	ISO 3036 TAPPI T 803		Pendulum Impact Tester	16
Puncture test (LPET)			Testing Machine, Penetration unit	16
Elmendorf tear test	ISO 1974 EN 21974 TAPPI T 414		Elmendorf-Pendulum Impact Tester Strip cutter 50 mm	17 27
Flat crush test	ISO 3035 EN 23035 TAPPI T 825		Testing Machine with compr. plates Circular cutter	18 27
Basis weight determination	EN ISO 536 ISO 5638 TAPPI T 410		Balance Circular cutter Cutter	20 27 27
Basis weight determination	FEFCO Nr. 2		Balance	20

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Test Methods, Standards and testing instruments

Type of test	Standard	Material group	Test unit	Page
Internal bond test (z-direction tensile test)	TAPPI T 541		Testing machine,testing unit Strip cutter 25,4 mm	21 27
Edge Crush Test	EN ISO 3037 TAPPI T 811		Testing machine, compr. plates Specimen saw	19 27
Compressibility test	none		Testing machine, test head	28
Crease test	DIN 55437		Testing machine, creasing tool	23
Friction test	ISO 15359 TAPPI T 549 TAPPI T 816		Testing machine, friction unit Cutter	22 27
Ring Crush Test	ISO 12192 TAPPI T 822		Testing mach., compr. plates, inserts Strip cutter 12,7 mm	19 27
Box Crush Test	ISO 12048 EN 22872 TAPPI T 804		Testing machine, compression plates	23
Plybond resistance	DIN 54516		Testing machine, specimen grips Strip cutter 50 mm	21 27
Stacking Crush Test	EN 22874		Testing machine, compression plates	23
Strip Crush Test	ISO 9895 TAPPI T826		Testing machine, specimen grips Strip cutter 15 mm	20 27
Water Absorbtion (Cobb)	ISO 535 TAPPI T 441 EN 20535		Cobb-Testing Unit Balance (50g)	24
Tear Test	ISO 11897		Testing machine, specimen grips	24
Tensile test (wet)	ISO 3781 TAPPI T 456		Testing machine, specimen grips Strip cutter Balance (50 g)	25 27 20
Tensile test (dry)	EN ISO 1924 TAPPI T 494		Testing machine, specimen grips Strip cutter 15 mm Balance (50 g)	26 27 20

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Zwick/Roell Materials Testing Machines: BasicLine, Standard- and Allround Line

Range of application

Materials testing machines are used for the performance of tensile, compression and bending tests with quasistatic loading.

Basic concept

The Zwick/Roell product line contains tabletop and floor standing testing machines with various frame configurations and drives as well as a comprehensive line of accessories. This enables the Zwick/Roell group to offer a wide range of testing applications for paper materials.

However, in order to determine the correct machine, with optimum price/performance ratio for any requirement, Zwick/Roell has developed an applications related concept. It consists of three basic types of machines, which vary in price, performance characteristics, and expansion possibilities.

- BasicLine testing machines
- Standard testing machines
- Allround testing machines

The most important testing machine component is the measurement and control electronics. The type of electronics determines the performance capability, which components can be added to the system, and cost. The electronics will determine the range of applications and the expansion possibilities of the testing machine. Following is a description of the main advantages for each type of testing machine:

- BasicLine testing machines are used for routine and functional tests in quality control (Fig. 8). Its technical capabilities are complemented by its short delivery time and its attractive price.

- Standard testing machines provide standard testing capability with some flexibility in order to provide a solid solution to for most common test requirements, but is also favorable in price.

- The Allround-Version is a machine that can be expanded for more demanding testing tasks. The flexible modular electronics strength is in research and development applications. Expansion possibilities include the connection of special sensors, multi-channel measurement technology and modular expansion (Fig. 9).

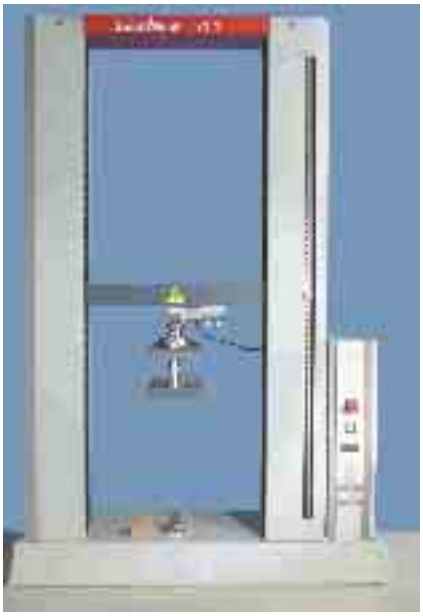

Fig. 8: BasicLine table top testing machine

Fig. 9: 2.5 kN zwicki testing machines: *testControl* stand alone version (left), PC variant (mid and right)

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Features of the BasicLine, Standard- and Allround-Line

Measurement and control system *testControl*

(for standard and allround version)

By using the most recent technologies and by implementing the highest quality standards, *testControl* offers the maximum of technical performance and long term investment:

- time-synchronous test data acquisition with high resolution and frequency
- real time processing of the test data in a 500 Hz cycle
- adaptive control for precise reproducible speeds and positions

Load frames

Zwick/Roell develops and manufactures load frames for nominal loads of up to more than 6,000 kN. As opposed to the normal single-purpose testing instruments in the paper field, Zwick/Roell offers material-testing machines with two testing areas with separate configurations for two testing tasks. By using two testing areas in one testing machine, a maximum is achieved use at the lowest cost. Fig. 10 illustrates the use of two testing areas.

Single column load frame (zwicki)

These load frames are designed with very rigid aluminum high precision extruded profiles. The working area is freely accessible from 3 sides. Thus, it is designed to be flexible for testing on small parts. The lowest measurable force is determined by the installed load cell and is typically in the millinewton-range. The maximum load is 2.5 kN.

Load frame In table top version

These load frames are used for all tests with higher loads. They are available as BasicLine, Standard- or Allround versions. The Load frame's patented aluminum high precision extruded columns are light, very rigid, and serve both as lead screw guide and protection. T-shaped grooves on the outer side allow a simple fitting of accessories such as safety devices without being impeded by the crosshead. All load frames with two columns, except for the BasicLine, can be equipped with profile legs. Advantages are:

- Positioning of the working area to an optimum height for the user
- Comfortable seated operation with absolute freedom for leg movement and suitable for wheelchair users

Load frame As floor standing model

These load frames are equipped with 2 or 4 hard-chrome plated round columns and 2 precision ball screws. They are preferably used for the testing of specimens with large extensions such as corrugated board boxes or roll on sleeves. As multifunctional machines, they are particularly qualified for all tests to predict a box's strength from paper characteristics to McKee. According to the specific testing requirements, the floor models are equipped with Standard or Allround electronics.

Fig. 10: Table top machine, profile legs: for tensile, burst and box crush test

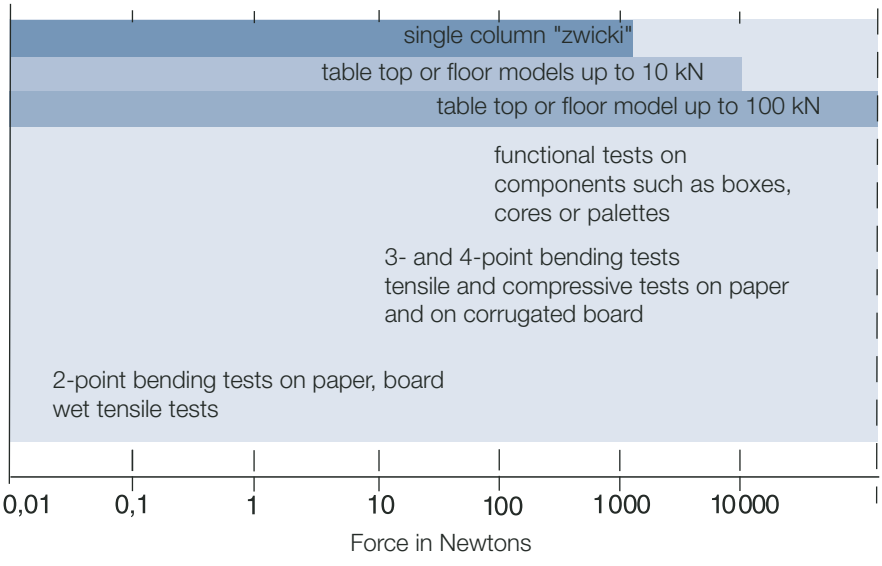

Fig. 11: Range of application of Zwick/Roell materials testing machines

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Machine component or function	BasicLine	Standard Line	Allround Line
Load frame			
• Type of set-up			
* Table-top machine (nominal force)	500 N to 20 kN	1 to 100 kN	up to 100 kN
* Floor stand. machine (nominal force)	-	50 to 250 kN	50 to 250 kN
• Support and guiding columns			
* No. of columns	2	2 or 4	2 or 4
* No. of Alluminium profiles	1 (Z0.5)	1 or 2	1 or 2
• No. of working areas	1	1 or 2	1 or 2
• Expanded design (higher and/or larger)	-	✓	✓
Drive system			
• Electro-mechanical			
* No. of ball screws	1 or 2	1 or 2	1 or 2
* DC-Motor	✓	only zwicki	only zwicki
* AC-Motor	no	✓ (without zwicki)	✓ (without zwicki)
Measurement and control system			
• BasicLine (also usable without PC)	✓	-	-
• *testControl* PC-variant (Standard)	-	✓	✓
testControl Stand Alone variant (Option)	-	optional	optional
Software			
• test software *testXpert*® (with PC)	optional	optional	optional
Transducer			
• Strain gauge load cell	1 (interchangeable)	1 (optional up to 2)	1 (optional up to 3)
• Digital crosshead monitor	integrated	integrated	integrated
• Digital extensometer	-	optional 1	✓ (optional up to 3)
• Analogue Extensometer	-	optional 1	✓ (optional up to 3)
Connection of external systems			
• Digital extensometer	-	✓	✓
• Analogue extensometer	-	✓	✓
• Analogue reduction-in-width-monitor	-	✓	✓
• Video Capturing	-	✓	✓
• Switch Contact	-	✓	✓
• Switch Control	-	✓	✓
• Further measurement systems	-	✓	✓
Control of external systems			
• Specimen grips (mot., pneum., hydr.)	-	-	✓
• Extensometer systems	-	semi-automatic	full-automatic
Supplementary units for special applications (optional)			
• Torsion drive	-	-	✓
• Torque transducer	-	-	✓
• Multi-channel force measuring system	-	-	✓
• High-temperature testing equipment	-	conditional	✓
• Low-temperature testing equipment	-	conditional	✓

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Zwick/Roell test software *testXpert*®

Applications area

testXpert® is Zwick/Roell´s universal test software for material, component and functionality testing. It can run a variety of instruments from materials testing machines (tensile, compression, bending), pendulum impact testers, balances, automatic testing systems as well as refurbished testing machines of various construction types and producers

Tasks and functions

The important functions of *testXpert*® are:

- Preparation and changing test fixtures of the testing machine.
- Preparing parameter sets for tests or test series.
- Performance of tests, evaluation, and documentation.
- Data management.
- Quality management.
- Data exchange between *testXpert*® and other applications (Word, Excel among others).

testXpert® supports the user in all areas with the software-assistants and editors, clear pictures, videos, context specific user tips, warnings, error messages and on-line help.

Future-oriented concept

Test software *testXpert*® uses the special characteristics of object oriented programming for a clear organization according to tasks and functions. Structure and performance are determined by applications and ”software-know-how” from Zwick. The *testXpert*®-concept is therefore a guarantee for high flexibility and functional security as well as simple operation.

The important characteristics are:

- Common software basis for all applications,
- Software building blocks for test requirements
- Software tools for user support.

Modular system

Zwick/Roell creates the test programs from a selection of several hundred software building blocks. The building blocks are placed in groups such as test parameters, test sequence phases, and screen views. They are constantly being updated and expanded with new information and requirements. This makes *testXpert*® an intelligent software and enables the realization of test programs that conform strictly to test standards, as well as test programs related to practical applications (Fig. 12).

Its versatility makes it possible for *testXpert*® to meet a variety of testing applications as well as to be used in most types of testing machines.

Test programs

The test programs determine how a test will be performed. These programs are built from pre-selected software building blocks. These building blocks connect the required functions to each other with pre-configured, fixed parameters. Zwick delivers a finished „test template“, in which the user only enters a few testing parameters. *testXpert*® is available in three levels according to the general testing requirements:

- Master test programs
- Standard test programs
- Customized test programs

International quality standard

To comply with international quality standards, each and every version must be transparent, documented and archived for 10 years. The *testXpert*® test software fully meets these requirements and even the particularly strict guidelines of the Good Manufacturing Practices (GMP).

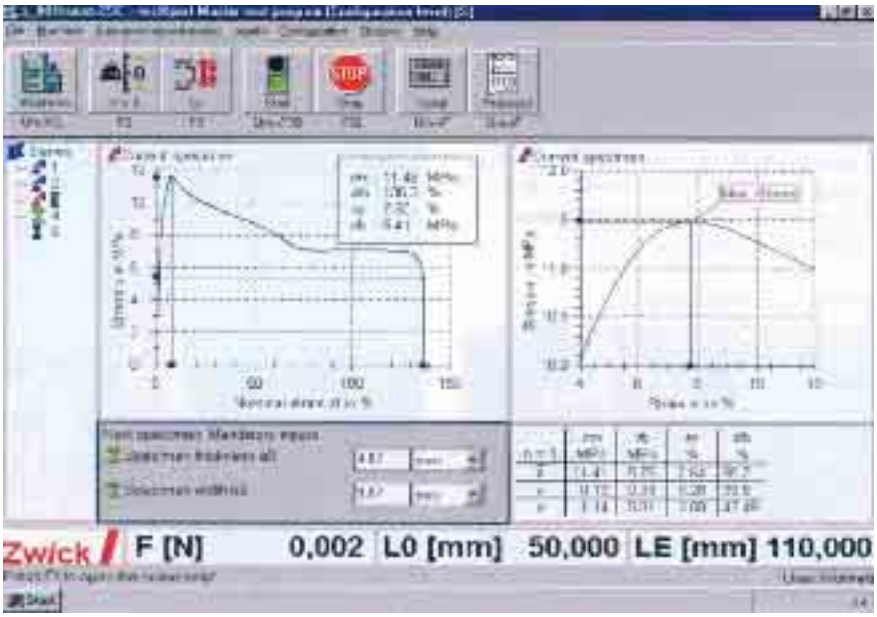

Fig. 12: *testXpert*®, variable screen layout

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Zwick/Roell test software *testXpert*®

The complete development process of the software and its components is carefully documented and archived for every version and for every phase from analysis to specification, design, implementation, and up to test. This is done from the source code up to the software tools used. Conformity with Standard ISO 9000-3 has been confirmed with audit report No. QM-F-96/1016.

Security in detail

Windows-Software is normally used in offices. However, *testXpert*® takes over an additional, especially critical task: monitoring and controlling machines. *TestXpert*® does not use overlapping windows in the test mode in order to avoid hiding important displays or key fields. This will prevent injury to personnel and damage to the machine.

Automatic acceptance of system data

Various test jobs require separate testing machines with different interchangeable components. The specific jobs are characterized by the system data (nominal force, travel, speed range, mounting height, calibration factors etc.). System data also belongs to the above, e.g. the series number or date of the last calibration.

testXpert® reads in this data automatically after starting the program:

- for the specific test settings,
- for determination of safety limit values,
- for the correct measurement signal evaluation.

In addition, *testXpert*® checks if
- the test can be performed with the specified configuration,
- all settings have been made and
- the data has been changed for the new testing.

Simple operation

Operation is reduced to a one-button, i.e. activating the start button, for standard applications. This is possible because *testXpert*® automatically records the test data, controls and monitors the test sequence, and determines and stores the test results.

Only two steps to testing

Preparation of a test series requires only 2 steps:

- Loading the desired test program.
- Input of the variable parameters

Optimum user information

All displays necessary for carrying out a test and a test series can be grouped together in a clear and concise manner in one single screen setting:

- Input fields for specimen-specific testing parameters
- Curve diagrams (individual or multiple curves)
- Table for test results
- Table for test result statistics

Data saving for further use

Depending upon specific selections in the test program, selected results and test parameters of a single test or test series can be saved along with the data curve. Saving of all data offers the possibility of tracing the result data from the original data to the configuration and settings for the testing machine. The standardized measurement data, i.e. the data converted to its basic units, can be repeatedly displayed in the simulation mode as well as evaluated according to other criteria.

Video capturing

The test software *testXpert*® not only supports the user by means of „help“ videos. It is also possible to carry out multimedia tests by using a video camera and a video capture card, with the pictures being recorded time-synchronously with test data (Fig.13).

- With the cursor keys, a ”video window” can be moved over thetest curve displaying the corresponding picture.
- The pictures can be captured at pre-selected measuring points or at a specified event.
- The video can also be played alone apart from the testing machine.
- The picture can be used to measure distances between two points, angles between three points, radii, diameters, and areas.
- Alternatively, the pictures can be exported with dimension lines and test data.

Fig. 13: Box compression test using video-capturing

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Test Methods in the Paper Industry

Product program for paper testing

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.14). 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 pre-selector, 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 be captured 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. The data acquisition rate of Zwick/Roell instruments can be controlled, 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. 16).

Fig. 14: Burst tester as a machine accessory

Fig. 15: Burst tester and pressure pre-selector unit

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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.

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.

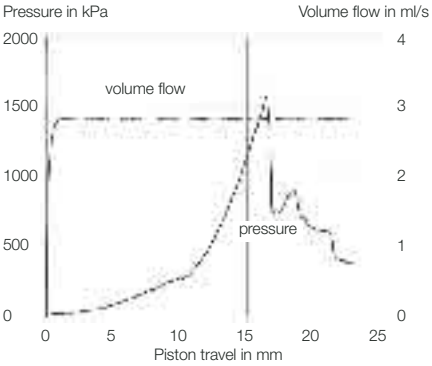

Fig. 16: Volume flow stability guarantees constant test conditions

Standard	ISO 2758
Material	paper
Zwick-Item-No	
burst tester	070376.01.00*
test program	069002.54.ff
for specimens	from 100 x 100 mm
to machines	from zwicki
Standard	ISO 2759
Material	corr. board and raw paper for corr. board, solid board
Zwick-Item-No	
burst tester	070376.00.00*
test program	069002.54.ff
for specimen	from 100 x 100 mm
to machines	from zwicki
Zwick-Item-No Accessories	
pressure pre-selector	8096.00.00

The advantages:

- 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 (Fig. 16), the operator immediately sees if the test has been performed correctly.
- Service interfaces and maintenance friendly construction reduce idle times and consequential costs.

* 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.17) 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.

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

Fig. 17: 2-Point bending unit, set-up

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. 19).

Standard	ISO 2493 ISO 5628
Material	paper, board
Zwick-Item-No	
bending rig	070289.04.00*
load cell	
(from 10 N)	066140.03.00 ff
test program	069002.59.ff
for specimens	
width	to 40 mm
thickness	from 0,1 to 4 mm
bending length	5 to 100 mm
to machines	from zwicki

Standard	ISO 2493 ISO 5628
Material	fine paper, foils
Zwick-Item-No	
bending rig	070289.05.00*
load cell	
(from 10 N)	066140.03.00 ff
test program	069002.59.ff
for specimen	
width	to 40 mm
thickness	to 0,2 mm
bending length	1 to 100 mm
to machines	from zwicki

* These accessories require connecting elements and software to be specified according to the machine.

Fig. 18: Measurement of the folding moment at 90° deflection

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 (Fig. 18).
- 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.

Fig. 19: Bending test on fine paper at 1 mm bending length

Fig. 20: Test series: board at 90° deflection

- The test program simultaneously determines the bending resistance, modulus, and bending stiffness.
- The test curve allows the recognition of possible irregularities during the test (Fig. 20).

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.

Standard	ISO 5628
Material	board, composites
Zwick-Item-No	
bending rig	070292*
3-point	
load cell	066140.03.00 ff
test programm	069002.20.ff
for specimens	
width	from 50 mm
thickness	from 2 mm
bending length	from 100 mm
to machines	from zwicki
Standard	ISO 11093
Material	cores, sleeves
Zwick-Item-No	on request
for specimens	length to 3200 mm
to machines	from Z 005

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.

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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.

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. 21). 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.

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. Testing specimens with excessive shrink or warp, the validity of the test can be decided with unambiguous criteria.

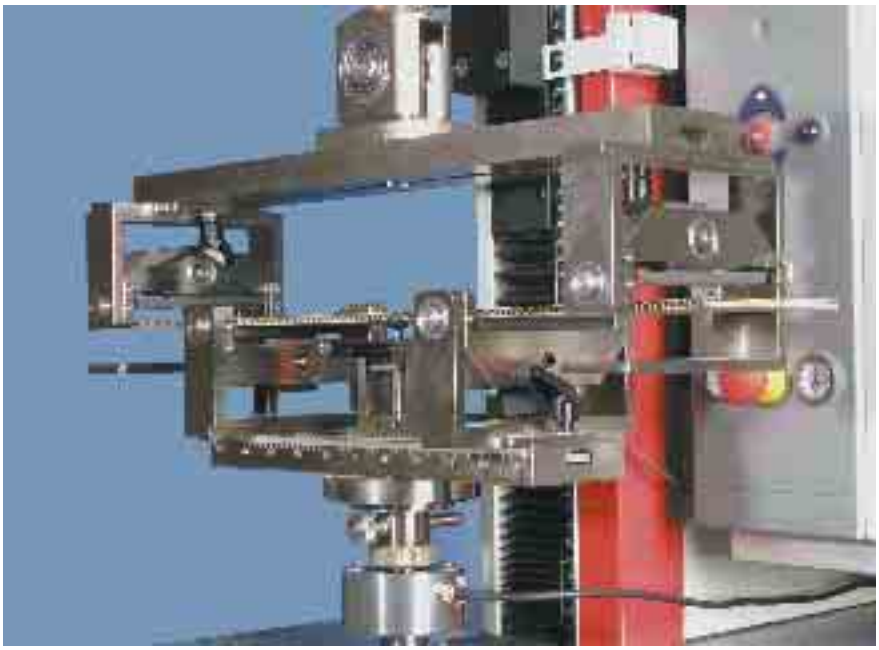

Fig. 21: 4-point bending test rig with high resolution extensometer

Standard	ISO 5628
Material	corrugated board, cardboard
Zwick-Item-No	
bending test rig	070290.00.00*
load cell	TC-LC0500N.F02 ff
test program	069002.20.ff
for specimens	
width	max. 100 mm
length	max. 400 mm
to machines	from zwicki

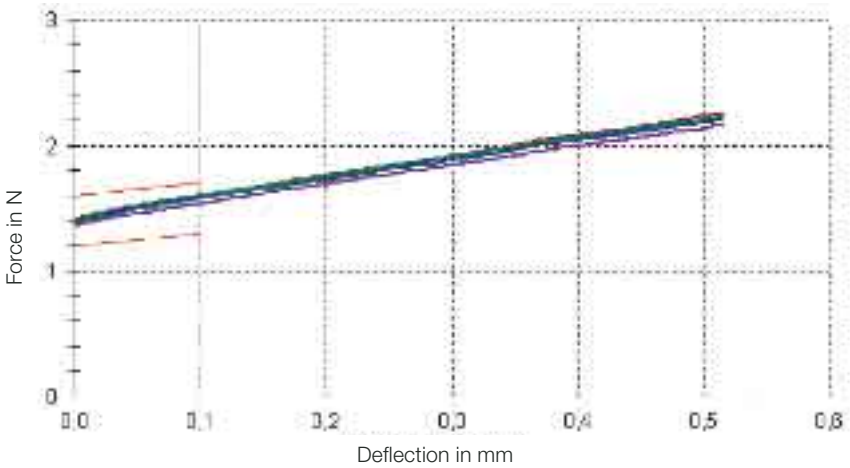

Fig. 22: Stiffness determination on corrugated board including monitoring of start phase. Recognition of excessively shrunk or warped specimens by limits.

The advantages:

- Test time below 60 s
- The test graph clearly shows if a test is valid or not (Fig. 22).
- 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.

Zwick / Roell

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 process-ability 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. 23).

Standard	ISO 534 EN 20534 TAPPIT 411
Material	paper, board
Zwick-Item-No	
thickness gauge	W070550.00.00
Standard	ISO 3034 TAPPIT 411
Material	corrugated board
Zwick-Item-No	
thickness gauge	W070540.00.00

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.

The penetration test

The quality of a corrugated board box is not only 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. This instrument can be used stand-alone or connected to a computer. Since the penetration test with a pendulum has several weaknesses, (oscillation of the pendulum, no linear movement, no constant test speed, high measured values deviation, poor handling), Zwick offers an alternative test with a material testing machine.

Standard	ISO 3036 TAPPIT 803
Material	corrugated board cardboard
Zwick-Item-No	
pendulum tester	on request
for specimens	
width	300 mm
length	300 mm

With the linear motion penetration test (LPET), the penetration pyramid is pressed through the specimen in an even movement (Fig. 24 and 26). The pyramid is driven and controlled by a testing machine. The force-path curve (Fig. 25) is acquired by the electronics. The result is the energy required for penetration, which is similar to the pendulum impact test.

The standard deviation of the data due to testing machines is significantly better than that from a PET pendulum (Fig. 27 and 28). On a lot of materials, the correlation between a PET pendulum and the LPET method is very close. It is never the less recommended to individually check and measure the correlation of different materials.

Fig. 23: Thickness gauge for corrugated board

Fig. 24: LPET-Test in a testing machine

Zwick / Roell

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 J, can be tested without mechanical changement of weights. These characteristics make the testing machine much quicker and secure.

Zwick/Roell is working with technical paper institutes and well known industrial companies, on the industrial introduction and standardization of this test, which is in its introductory stage.

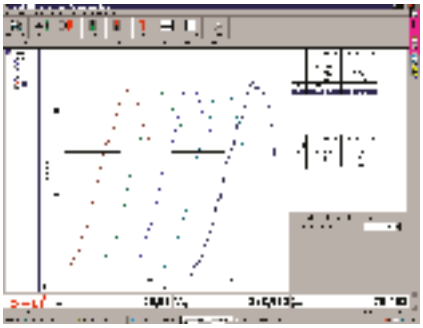

Fig. 25: LPET test curves

Fig. 26: Puncture phase

Standard	DIN 53142-2 in preparation
Material	corrugated board, cardboard
Zwick-Item-No	
puncture test rig	070378.00.00*
load cell	066070.03.00 TC-LC2:5KN.P01
test program	069002.63.ff
for specimens	
width	180 mm
length	from 180 mm
to machines	from zwicki

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.

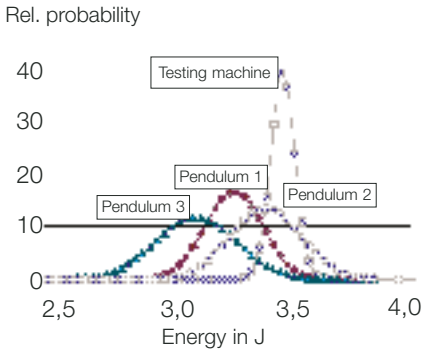

Fig. 27: Test result distribution on single-flute corrugated board

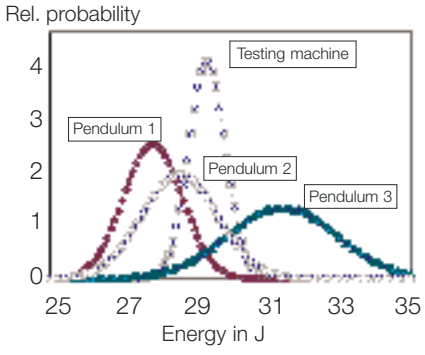

Fig. 28: Test result distribution on triple-flute corrugated board

Standard	prEN ISO/FDIS 12625-9
Material	tissue
Zwick-Item-No	
puncture test rig	X070378.00.00-001*
load cell	066140.03.00 TC-LC0010N.P01
test program	UZV001
for specimens	
width	180 mm
length	from 180 mm
to machines	from zwicki

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
- similar test rig for tissue tests

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.

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. 29). The correlation should be crosschecked for individual paper grades.

Standard	ISO 1974 TAPPIT 414
Material	paper
Zwick-Item-No	
Elmendorf-pendulum tester	on request
for specimens	
length	62 mm (ISO) 63 mm (TAPPI)
width	50 mm (ISO) 53 mm (TAPPI)

The advantages:

- easy PC connection via RS 232 interface
- established robust instrument

Crush tests on corrugated board and corrugated board raw paper

It is important for these tests (Figures 30 to 33), 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.

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.

Standard	ISO 7263 TAPPI T 809
Material	corrugated medium paper
Zwick-Item-No	
compression plates	070457.00.00*
test program	069002.67.ff
fluter	XW90000-016
for specimens	
length	150 mm
width	12,7 mm
to machines	from zwicki

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. If the corrugated board has leaning or crushed flutes, it has been predamaged, and the curve is fundamentally different. The crush

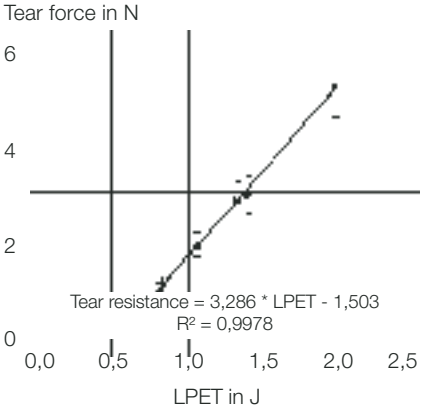

Fig. 29: Correlation between the LPET and the Elmendorf test

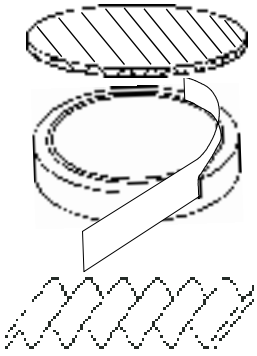

Fig. 30: Specimens for: flat crush test, ring crush test and corrugating medium test

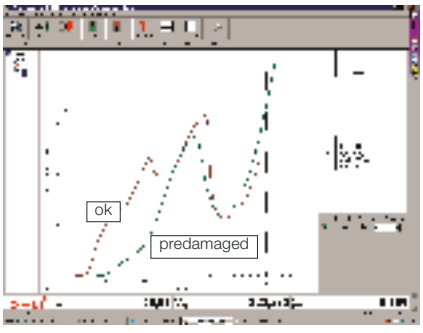

Fig. 31: Flat crush test: test curves showing correct and pre-damaged material

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. 32).

Standard	ISO 3035 EN 23035 TAPPI T 811
Material	corrugated paper
Zwick-Item-No	
compr. plates up to 10 kN	070457.00.00*
compr. plates up to 250 kN	070456
test program	069002.67.00
circular cutter	W070560.00.00
for specimens	
diameter	112,8 mm
to machines	from Z005/TS1S

The Edge Crush Test

This gives information about the strength of corrugated board at standing flute orientation (Fig. 33). 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 that Zwick offers for this purpose (see page 27).

Standard	ISO 3037 TAPPI T 811
Material	corrugated paper
Zwick-Item-No	
compression plates	070457.00.00*
test program	069002.68.ff
ECT-saw	W070600.00.00
for specimens	
length	100 mm
heigth	25 mm
to machines	from zwicki

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 of 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.

Standard	ISO 12192 TAPPI T 822
Material	corrugated medium paper
Zwick-Item-No	
compression plates	070457.00.00*
inserts	070455
test program	069002.51.ff
strip cutter	on request
for specimens	
length	152 mm
heigth	12,7 mm
to machines	from zwicki

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.

* These accessories require connecting elements and software to be specified according to the machine.

Fig. 32: Compression plates for the flat crush test on miniature corrugated board (left, F > 10 kN) and on standard corrugated board (right, F ≦ 10 kN)

Fig.33: Edge crush test using guided compression plates

Zwick / Roell

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 or corrugated crush test). The Zwick test arrangement (Fig. 34) 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 backlash 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 80 up to 400 g/m² and higher (Fig. 35).

Because of its technological advantages, the Strip Crush Test is being more accepted worldwide.

Standard	ISO 9895 TAPPI T 826
Material	corrugated board raw paper
Zwick-Item-No	
grips	070377.00.00*
load cell	066070.02.00 TC-LC2.5KN.F02
test program	069002.58.ff
strip cutter	W070500.00.00
for specimens	
length	≥110 mm
wight	15 mm
to machines	from zwicki
special grips for cardboard	on request

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

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 (Fig. 36).

Standard	EN ISO 536 ISO 5638
Material	paper, board
Zwick-Item-No	
analysis balances	
50 g	W40022.01.00
100 g	W40022.02.00
for specimens	
diameter	113 mm
or	any area, to 1 % accurate
Standard	FEFCO Nr. 2
Material	corrugated board
Zwick-Item-No	
analysis balances	
up to 400 g	on request
for specimens	
length	250 mm
width	200 mm

Fig. 34: Strip crush test grips

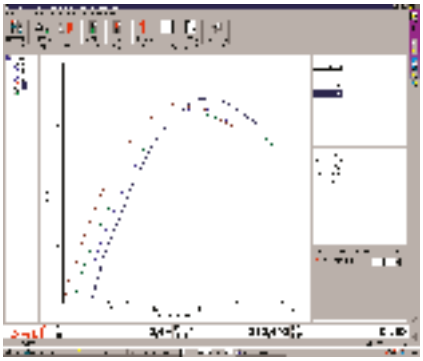

Fig. 35: Strip crush test-series

Fig. 36: Laboratory balance

Zwick / Roell

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 process-ability. 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. 37 and 38). 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.

The test result is the tensile strength, which is the maximum tensile load, related to the sample's surface area (Fig. 39).

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.

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

Standard	TAPPI T 541
Material	duplex-papers, plybonds
Zwick-Item-No	
test rig	
manual	X070457.00.00-01
automatic	X070457.00.00-02
test program	on request
for specimens	
lenght	appr. 140 mm
width	25,4 mm
to machines	from zwicki
Equipment for plybond strength to DIN 54516	on request
Scott bond tester	on request

* These accessories require connecting elements and software to be specified according to the machine.

Fig. 37: Internal Bond Test – test rig and sample preparation unit (bottom right)

Fig. 38: Internal bond test, test run

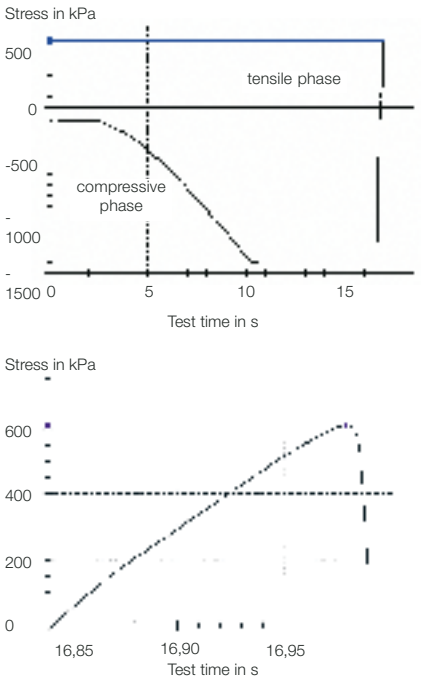

Fig. 39: Internal Bond Test – total test curve (top) and tensile phase (bottom)

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 (Fig. 39).
- compressive strength and compression time are freely adjustable
- Use of only half the standard area for tests on high strength papers

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. 40 and 41), 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. 42).

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.

Zwick-Software *testXpert*® 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.

Standard	TAPPI T 541 TAPPI T 816
Material	paper, foils
Zwick-Item-No	
friction test rig	070415.00.00*
manuall	070412.00*
test programm	069003.02.ff
cutter	on request
for specimens	
lenght	300 mm
width	150 mm
to machines	from zwicki/ BasicLine
Standard	w/o (strip method)
Material	paper, foils
Zwick-Item-No	
friction test rig	X8100.00.00-032
test programm	069003.00.ff plus XD069003-002
strip cutter	
15 mm width	W070500.00.00
25 mm width	W070510.00.00
for specimens	
lenght	300 mm
width	25 mm und 15 mm
to machines	from zwicki
Standard	ISO 15359
Zwick-Item-No	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
- Strip friction unit for tests on „virgin“ surfaces

* These accessories require connecting elements and software to be specified according to the machine.

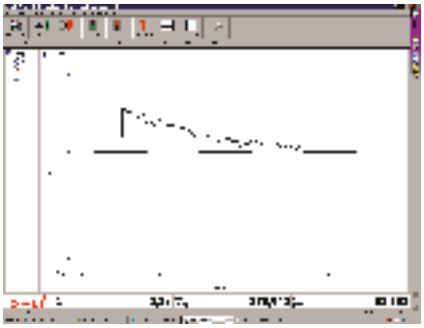

Fig. 40: Determination of static and dynamic friction

Fig. 41: Horizontal plane method

Fig. 42: Friction test, strip method

Zwick / Roell

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
- 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. The diagram (Fig. 43) shows that a decrease in force occurs during the reversal of the creasing tool. This is a measurable indication that the internal fibre bond is partially damaged, which corresponds to the creasing characteristics in the production process.

Standard	DIN 55437
Material	paper, board
Zwick-Item-No	
creasing tool	on request
test programm	on request
for specimens	
length	140 mm
width	50 mm
for specimens	from zwicki

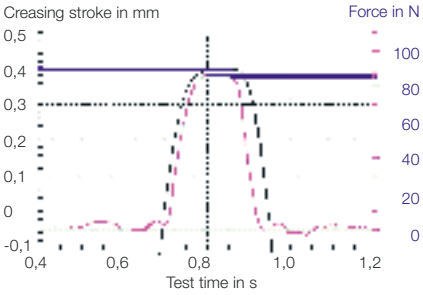

Fig. 43: Laboratory creasing diagram

Box Crush and Stacking Crush Tests

These tests are used to determine the strength and the stacking capabilities of corrugated board boxes. 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 (Fig. 44), also offer correct applicable solutions for combined tests.

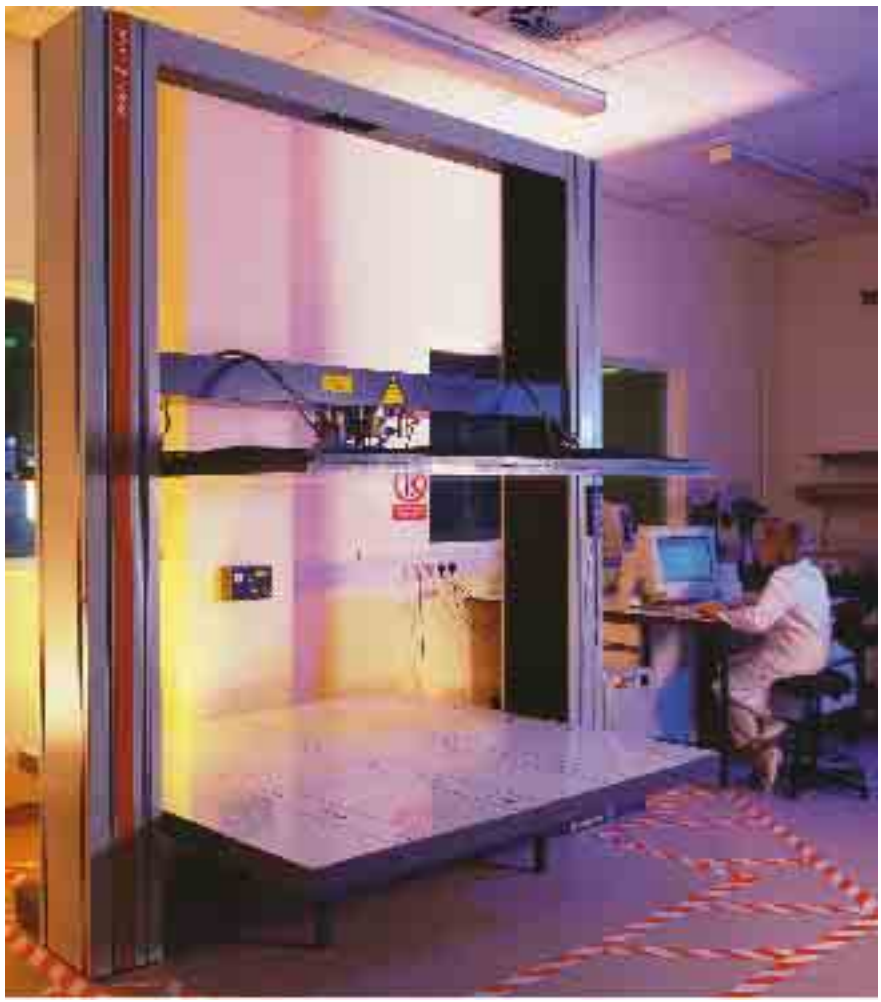

Fig. 44: Box-crush tester for specimen up to a footprint of 2 m by 2 m (authorized by SCA Packaging Research, European Technical Centre, Aylesford)

Standard	
box crush test	ISO 12048 EN 22872
stacking test	TAPPI T 804 EN 22874
Material	corrugated board
Zwick-Item-No	
compression plates	
400 * 400 mm	070091.55.10*
400 * 600 mm	070091.55.14*
special versions	on request
load cell	066050.02.00 ff TC-LC005KN.F02ff
test programs	
box crush test-	069000.00.ff
stacking test	069015.09.ff
for specimens	
length wight hight	boxes according to the machine´s test space
to machines	from Z005/TN2Sff

The advantages:

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

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^2. 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 1m^2 of specimen material would absorb.

A complete Cobb-Test-Kit can be obtained from Zwick or its partner.

Standard	ISO 535 EN 20535 TAPPI T 441
Material	paper
Zwick-Item-No	
Cobb test kit	On request
for specimens	
diameter	112,8 mm

The advantages:

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

Tear Propagation Test

This characteristic is important for finding and avoiding weak spots in packaging with folded edges or bonded seams (Figures 45 and 46). It can be performed on a low cost testing machine such as BasicLine machines for tight budgets. In addition, it gives valuable information about the quality of materials and about the consistency of the production process.

Standard	ISO 11897
Material	paper-foil-compounds
Zwick-Item-No	
grips	8133.00.00* 8253.00.00* TC-LC2.5KN.F02
test program	069003.01.ff
for specimens	
dimensions	acc. to the product
to machines	from zwicki/ BasicLine

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

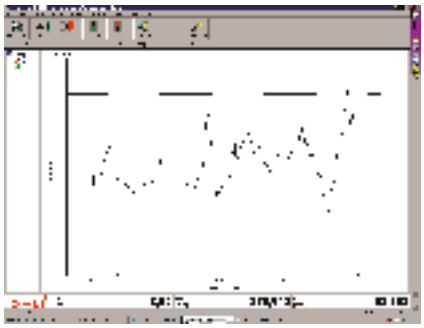

Fig. 45: Tear test: diagram

Fig. 46: Packing edge with bonded seam in a tear test

Zwick / Roell

Wet tensile test

These tests are useful for determineing several different paper characteristics such as usage properties of tissues, printing quality of offset printing papers, and runability characteristics 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. 47). 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.

Standard	ISO 3781 TAPPI T 456
Material	tissue
Zwick-Item-No	
Finch grips	070465.10.00*
to grip	8133.00.00*
test program	069001.47.00
strip cutter	lever shear on request
for specimens	
lenght	appr. 200 mm
width	50 mm
to machines	from zwicki

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 gauge 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. The slope of the elongation-force-curve can be used to determine the limits of high quality offset 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.

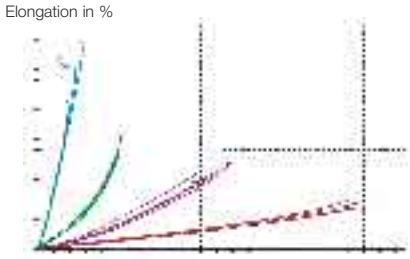

Fig. 48: Tensile test at defined humidity, elongation as a dependant variable

* These accessories require connecting elements and software to be specified according to the machine.

Fig. 47: Wet Tensile Test

Fig. 49: Zwicki, equipped with horizontal test space and automatic test start

Standard	ISO 1924
Material	paper
Zwick-Item-No	
machine	XZ2.5/TS1S-005
test program	XD069001-005 069001.00.ff
strip cutter	W070510.00.00
for specimens	
lenght	appr. 240 mm
width	25 mm

Zwick / Roell

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 evaluated through initial wet tensile tests. Special tensile grips (Fig. 50) assure correct clamping, draining within the clamping area of the specimen, and prevents specimen breaks within the clamping area.

Standard	ISO 1924
Material	initial wet paper
Zwick-Item-No	
grips	X8100.00.00-058*
test program	069001.00.00
for specimens	
lenght	appr. 200 mm
width	50 mm
to machines	from zwicki

The advantages:

- correct specimen gripping
- fast and easy handling
- high flexibility through the *testXpert*® master program

Tensile test

As a common test on paper materials (Fig. 51), tensile tests provide valuable information about properties such as stiffness, modulus, tensile strength, tearing length and energy absorbtion.

Since only the tear strength or tearing length result is to be determined in many cases, other results can be hidden by software. The *testXpert*® 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 804
Material	paper
Zwick-Item-No	
grips	070465.10.00*
test programm	069001.00.00
strip cutter	
width 15 mm	W070500.00.00
width 25 mm	W070510.00.00
width 50 mm	W070520.00.00
for specimens	
length	appr. 200 mm
wight	15, 25, 50 mm
to machines	from zwicki/ BasicLine

* These accessories require connecting elements and software to be specified according to the machine.

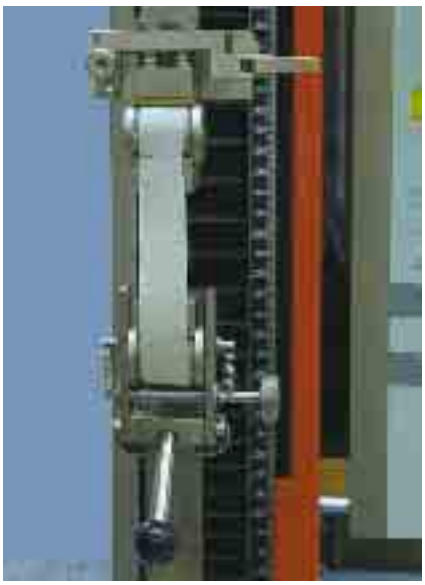

Fig. 50: Tensile test on initial wet paper

Fig. 51: Tensile test on dry paper, pneumatic specimen grips

Zwick / Roell

Specimen preparation Customer specific tests

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 manufacturing high quality cutting units. Figures 52 to 55 show a segment of the instruments used for specimen preparation.

Customer specific tests

The area of paper materials does not begin with paper manufacturing and does not end at the processor

Zwick-Item-No	
Strip cutter	
15 mm width	W070500.00.00
25 mm width	W070510.00.00
50 mm width	W070520.00.00
15 & 25 mm width	W070530.00.00
Circular cutter	
diam. 112,8 mm	W070560.00.00
diam. 79,8 mm	W070570.00.00
ECT-saw	W070600.00.00
Medium fluter	W070600.00.00
Other instruments for specimen preparation	on request

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:

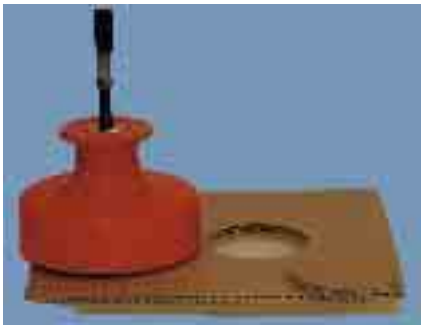

Fig. 52: Circular cutter for FCT specimen

Fig. 53: Saw for ECT specimen

Bild 54: Strip cutter

Fig. 55: Fluter

Determination of Proportionality Load F_{prop}

During the storage of packed goods, the packaging is subject to load variations in stacking and removal operations. They are also subject to static force changes created in transport. Therefore, testing is performed so that packaging can be manufactured that can withstand long term elastic form changes. The limit of the elastic deformation (Proportionality Load) is measured as follows:

- the maximum slope on the force-deformation curve is determined
- from the maximum, a slope declination of x % is defined in the direction of the tests end
- the load found here is the applicable Proportionality Load F_{prop} (Fig. 56).

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 performed without hindrance.

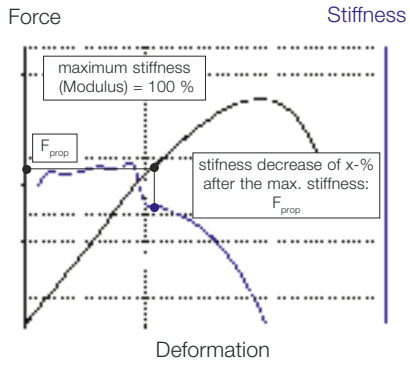

Fig. 56: Measuring the proportionality load

Zwick/Roell

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. 57). 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. 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. 58). 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. A floating compression plate is loaded via a spheric loading bar and applies the compressive force to the paper. 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. 60):

- the maximum stress (1)
- the total deformation before and after a dwell time (2) (3)
- the plastic deformation (4)
- the elastic deformation from the difference of (3) and (4)

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

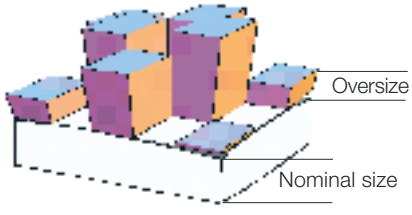

Fig. 57: Measurement of the buckling of a filled, folded box

Fig. 58: Measuring the local variation deformation of a packing box

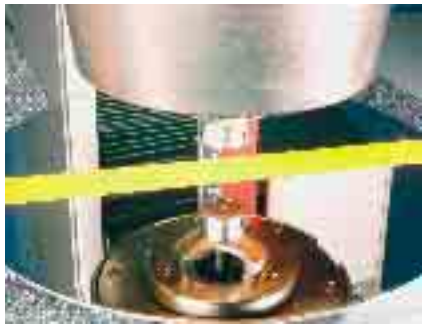

Fig. 59: Compressibility test head prior to test

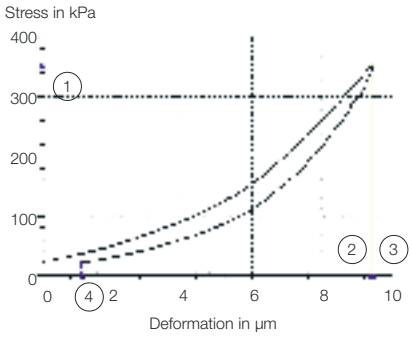

Fig. 60: Compressibility diagram

Customer specific tests

Standard Zwick-Item-No	customer specific
determination of propertionality load	on request
dimension-measurement	on request
location dependent deformation measurement	on request
compressibility measurement	065241.00.00* X065240.21.00-001 X065240.21.00-002 X069006.00.00-24

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.

* These accessories require connecting elements and software to be specified according to the machine.

Fig. 61: Compressibility test using zwicki

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 Group manufactures these type of testing machines. *testXpert*® can use the same user-interface as the static systems on dynamic systems to perform endurance tests under realistic conditions, high-speed tests (Fig. 62), and shock tests. This makes packaging design more efficient by shortening the development time, costs, and failures.

Fig 62: High speed testing machine, up to 20 m/s

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. 63 consists of a tensile testing machine and an automatic specimen feeding system (Handling System). The Handlng 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*®. The possibility of manual testing without retro-fitting is standard.

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

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.

Fig. 63: Automatic testing machine: tests on sanitary products

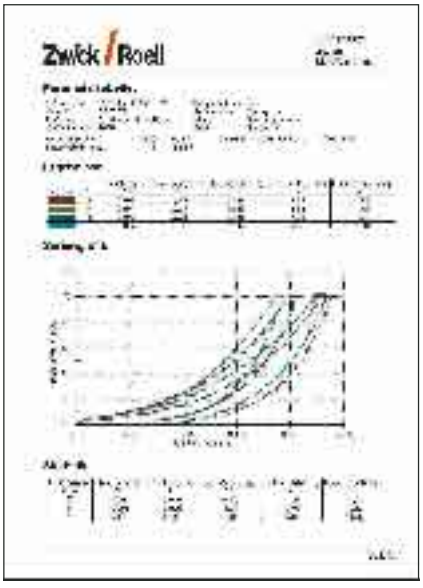

Fig. 64: *testXpert*® test report

The ddw-GmbH in Lübeck and Zwick have worked together for years in the area of statistical process control. The target of both companies has been to collect and analyze data from various testing processes in different departments of a company. (Fig. 65). The Quality Data Analysis-(QDA) Software of ddw fulfills this function and offers an extensive spectrum of performance.

In the simplest case, the following complement each other:

- the test protocol (Fig. 64) provides a snapshot of the product's quality
- the control card as a control in strument (Fig. 65) for medium observation time frames
- the long-time diagram (Fig. 66) for an ideal overview.

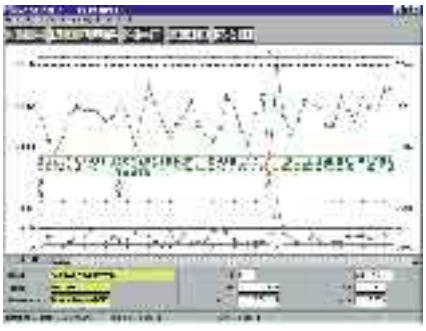

Fig. 65: Process control card

Fig. 66: Long time diagram

Histograms (Fig. 67), frequency distribution of sums and technical statistical evaluations, make the QDA-Program a very useful instrument for the control of a product's quality.

It is natural that all data must be collected before the evaluation. Modern instruments are equipped with a standard data interface. With this, the test data are written into the corresponding fields of the QDA-program. If instrument data transfer interfaces are missing, the QDA-software also offers manual input possibilities. Special Zwick instruments can be connected into the data network quickly and without problem via *testXpert*®.

Data acquisition, data storage and analyses are not just limited to the quality data of the end product and mechanical testing. Just as important is the tie-in of important data from the raw materials as well as energy and emission values. Zwick/Roell and its partners are also ready to help you in this area through know how and expert personnel.

Fig. 67: Histogram, classification of test results

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:
Papiertechnische Stiftung, München

Fig.3:
Paul Hartmann AG, Heidenheim

Fig.4:
Hengst Filterwerke, Münster

Fig.5:
Staatl. Molkerei Weihenstephan AG

Fig. 43:
SCA Packaging Research, European Technical Centre Aylesford

Reserved to technical modifications