Zwick / Roell

Testing systems

Testing of plastics and rubber









FP 269 2.0504.202

Intelligent Testing

Zwick / Roell

This catalogue provides an overview of devices, machines, and systems of the Zwick Roell AG for the use in the plastics and rubber industry and in the corresponding research and test institutes and training centers.

This is only a part of the extensive overall program of the Zwick Roell AG.

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Picture sources, front page: BASF AG, Bayer AG, Continental AG, Solvay SA, Recaro GmbH & Co. KG, BIG-Spielwarenfabrik

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

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

Since the middle of the 19th century the company Amsler (formerly in Schaffhausen, Switzerland) has been involved in materials testing and the company Roell & Korthaus since 1920. Since 1937 Zwick has been building devices, machines and systems for mechanical-technological materials testing. Long before that time, i.e. in 1876, Prof. Seger had already founded a chemical laboratory as a scientific-technological consulting company for the industry of nonmetallic minerals. During the 20th century, the present company Toni Technik has developed from these fundamentals and is now considered a leading expert for test systems for building materials. Excellent performances were also supplied by the company MFL (Mohr & Federhaff) – a company that was founded in 1870. By the way, Carl Benz was one of the employees.

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

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

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

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

Zwick / Roell

Plastics and rubbers- development, structure and properties

Plastics

In 1861, the first polymeric plastic was patented under the name Parkesine for Alexander Parkes. It was a kind of celluloid then patented by Hyatt in 1870. In 1908, Bakeland and Lebach made the chemistry of phenolic resins more transparent. Bakeland discovered Bakelite, the first plastic to be broadly used. Hermann Staudinger described the structure of polymeric materials as macromolecules and thus discovered the basis of macromolecular chemistry. Ziegler and Natta worked on the polymerization of ethylene. On this basis, Montedison produced polypropylene in 1957 for the first time.

Today, the most important raw material is petroleum which – decomposed in its elements – supplies the basic materials of plastics. These molecules are linked to large chains: the polymers. When talking about plastics you can think of a mass of molecule chains. Depending on how these chains are linked to each other, different groups of plastic will result:

Thermoplastics

The molecule chains are linear and branched. Very often a large portion of spaghetti is taken as example. At room temperature, thermoplastics are often hard or even brittle. When heated, the material softens or is given plasticity because the molecule chains slide past each other more easily. Thermoplastics are the largest group of plastics. The four most important thermoplastics are PE, PP, PVC and PS.

Thermosetting plastics
(thermohardening plastics)

The molecule chains of thermosetting plastics are linked more closely. The cross-links are thermally not soluble. Therefore, thermosetting plastics do not melt. The classical thermosetting plastic material is Bakelite, building material of the former telephones and of many other commodities. Modern materials are unsaturated polyester, linked polyurethanes and epoxy resins.

Elastomers

Elastomers are polymers which are built up of macromolecules and which are three-dimensionally cross-linked. The elastic rubberlike properties of these materials are the result of the cross-link of single polymer chains (vulcanization). In modern usage, elastomers are therefore also called rubber.

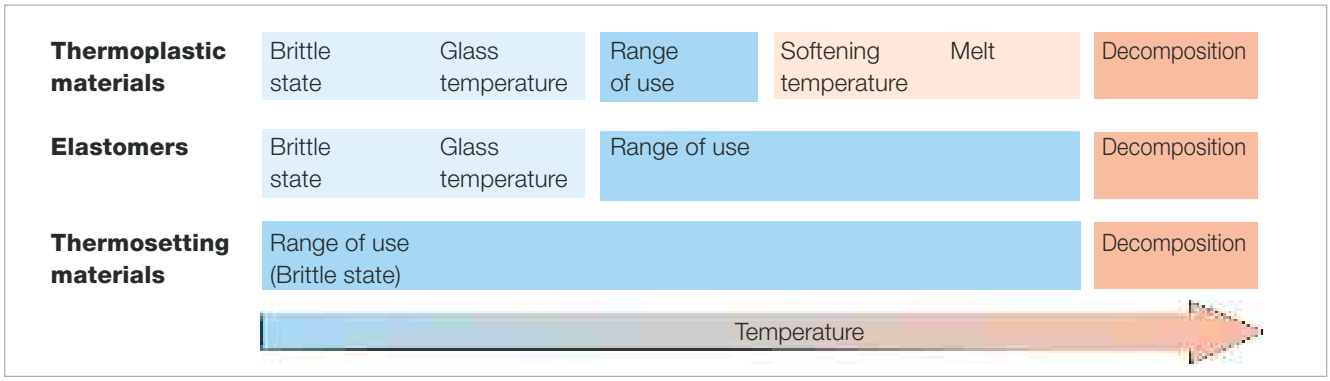
Trade names and trademarks

Among the trade names by which the above-mentioned plastics are widely known are:

Hostaform, Kematal, Rhepanol, Vestolen, Hostalen PP, Novolen, Baylon, Hostyren, Styropor, Novodur, Lopak, Plexiglas, Perspex, Solvic, Hostalit, Saran, Vinylite, Polyviol, Pioloform, Rilsan, Ultramid, Grilon, Perlon, Nylon, Desmopan, Urepan, Vulkollan, Elastodur, Araldit, Bakelite, Trefoil, Hostaphan, Makrolon, Buna, Perbunan, Cariflex.

Thermoplastic materials	Elastomers	Thermosetting materials
Structure of the molecule chains		
Simple chains or shrub-type ramifications	Wide-range cross-linked	Closely cross-linked in all directions
		
Properties		
• Almost soft • Deformable under temperature • Deformation process is repeatable	• Molecular structure similiar to a fischermans flue • swellable • rubber-like elasticity	• Hard and brittle • Temperature-resistant • Not deformable • Not meltable
Types of plastics		
Polyethylene Polystyrene Polyamide Polyester	Rubber Silicone Polyurethane	Epoxy resins Polyester resins Phenolic resins Polyurethane

Structure of plastics



Glass temperatures mark the transition point to different material properties

Further processing of plastics

Thermoplastics are supplied as granules, grain or powder. The mechanical properties can be decisively influenced by fillers. Filled plastics are known as compounds or blends. Typical fillers and binders are carbon, glass, chalk, minerals, French chalk as balls, powder, fibres, ground material or lamina.

To obtain certain properties, polymeric and non-polymeric fibre structures are embedded in plastics. These plastics are known as composites or fibre-reinforced composites.

Reinforcing materials are: Prepregs (preimpregnated materials), rovings, cloths, mats, cut fibres, composites made of thermosetting plastics or thermoplastics with glass fibre reinforcement are known as GFK, those with carbon fibre reinforcement are known as CFK and those with aramide fibres are known as AFK.

Testing of plastics

The list of standards in the last part of this document gives an impression of the great variety of test methods. Materials behaviour as well as functional characteristics are to be determined. The CAMPUS® working group indentified those characteristics that are to be used for the description of molding materials.

CAMPUS® (Computer Aided Material Preselection by Uniform Standards) supplies tested values for example for mechanical, thermal, electrical and process-specific properties of nearly all types of plastics. The list of rheological, mechanical, thermal, electrical and other properties to be tested are standardized in ISO 10350 (single point data). Many material properties required as construction data are standardized in ISO 11403 (multipoint data). ISO 17282 provides details for design data.

CAMPUS® – An international database for standardized properties of plastic materials

Many manufacturers of plastics make the CAMPUS® -database for tested properties of their products available to their users. This helps the users to select the perfect material for a certain application.

For further information please refer to the website www.campusplastics.com

The product portfolio of the Zwick Roell Group encompasses all machines and devices for the testing of the mechanical and processing properties in accordance to the CAMPUS® - catalogue.

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Rubbers

When the Spanish conquerors came to Mexico and South America in the beginning of the 16th century, they saw Indians playing with a strange bouncing ball. The Indians called the material of the ball « Ca hu chu » (crying tree). Today we call this Latex-tree Hervea brasiliensis.

More than 200 years later, rubber was used in Europe as well. In 1770, the English mechanician Priestley was credited with the discovery of the use of rubber as an eraser.

Finally, in the 19th century, people discovered the precious properties of rubber: its waterproofness and elasticity. Rubber mixed with turpentine oil was used to manufacture bags, hot-water bags and life buoys. In 1824, the first braces and suspenders were manufactured. The rain coats that were available at that time were hard as stone in winter and sticky in the summer.

In 1844, Charles Goodyear patented his decisive discovery. For many years he had been experimenting with rubber. One day, some rubber mixed with sulfur dropped onto a hot stove. During carbonization, the grey, raw rubber turned into a smooth and solid material with good properties. That was how Goodyear discovered vulcanization.
At that time, the demand for rubber was exclusively covered by supplies from the Brazilian rain forest. Brazil held the monopoly and suspiciously watched that no seeds of the tree were taken to other countries. In 1876, the adventurer Sir Wickham smuggled rubber seeds to London. The resultant seedlings were sent to India where they could be planted on English plantations. In 1880, Asian rubber was sold on the world market for the first time. Today, the world economy gets 3.5 million tons a year from the plantations of different countries from all over the world.

Synthetic rubber

As early as 1826 Michael Faraday discovered the chemical structure of rubber. In 1909, the German chemist Fritz Hofmann was the first to patent the production of synthetic rubber. After World War I, the patent was expropriated and the production was discontinued. In 1930, the Americans began large-scale manufacture of synthetic rubber and - since they had lost their plantations due to Japan's entry into war - they built up huge production capacities of 840,000 t until 1945. The rubber industry strongly depends on the availability of petroleum. About 70% of the world requirements are manufactured synthetically.

There are about 20 different types of synthetic rubber, many of them with special properties. Just as natural rubber, they consist of long molecule chains creating a convoluted network. For vulcanization, the chains are provided with cross-links. Classical example is the sulfur vulcanization of natural rubber. The number of cross-links determines the properties of rubber: soft rubber with a few links, hard rubber with many links.

Overview of rubber

Short sign	Designation	Application examples
NR	Natural Rubber	Med. gloves, latex, blending component for synthetic rubber
SBR	Styrene Butadiene Rubber (originally "Buna – S")	All-purpose rubber, tire industry
CR	Polychloropren Rubber	Contact adhesives, conveyor belts, sealings, hoses
IIR	Isobutene-Isoprene (Butyl) Rubber	Sealings, membranes, cable insulations
EPDM	Ethylene-Propylene-Diene Monomer	Roof and pond foils, sealings in automotive industry
NBR	Nitrile Butadiene Rubber	Oil and fuel resistant sealings, membranes, hoses
SI/MQ/ PMQ/ VMQ	Silicone Rubber	Sealings for freezers, stoves, window and cabin sealings of airplanes.
FPM	Fluorocarbon Rubber	Sealings, molded parts, hoses with a high temperature and chemical resistance, belts
PUR	Polyurethane	Foams

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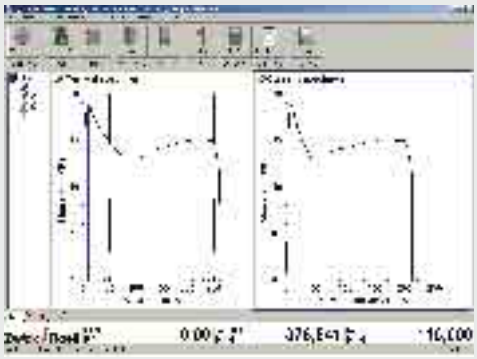
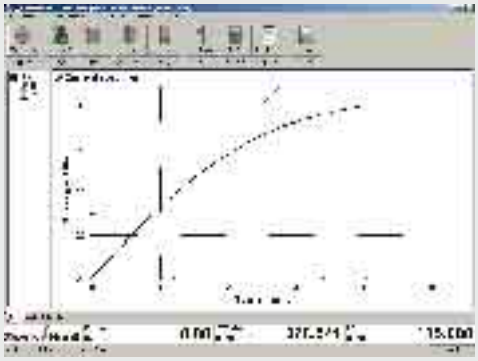
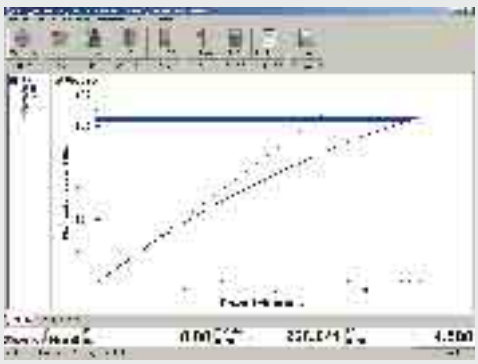
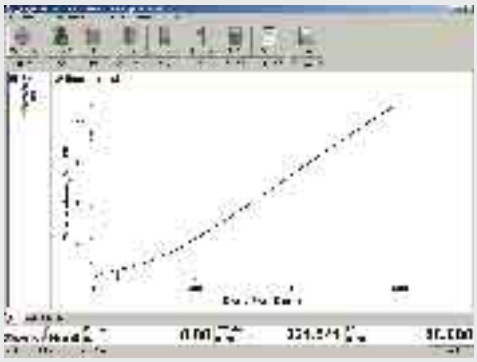
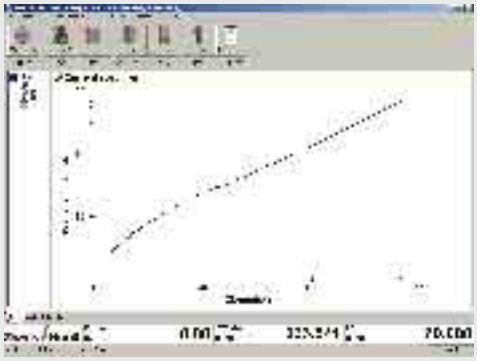
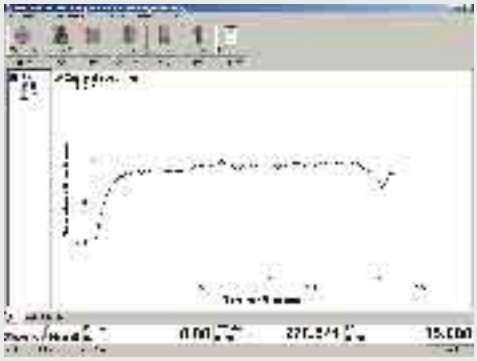
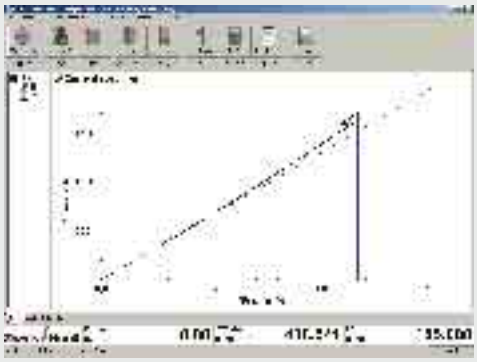
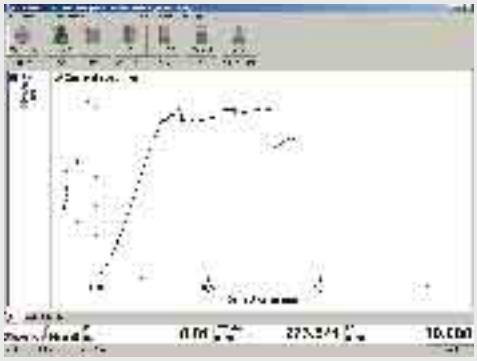
Application	test-curve in *testXpert*®	Example of mounting
Thermoplastic and thermosetting materials Standard: ISO 527-2 Type: tensile Material: semi-rigid plastic Grips: wedge-screw Extensometer: Multisens Test speed: 1 mm/min, 50 mm/min *testXpert*® 069001.02.00		
Standard: ISO 527-2 Type: tensile Material: rigid plastic Grips: wedge Extensometer: Macro Test speed: 1 mm/min, 50 mm/min *testXpert*® 069001.02.00		
Standard: ISO 178 Type: flexural(3-point) Material: rigid plastic Grips: flexural tool Extensometer: crosshead monitor Test speed: 2 mm/min, 50 mm/min *testXpert*® 069002.05.00		
Rubbers and elastomers Standard: ISO 37 Type: tensile Material: PIB dumbbell Grips: pincer Extensometer: mechanical long stroke Test speed: 500 mm/min *testXpert*® 069001.01.00		

Application	test-curve in testXpert®	Example of mounting
Standard: ISO 34-1 Type: tear test Material: SBR Specimen: angle Grips: pneumatic Extensometer: crosshead monitor Test speed: 500 mm/min *testXpert®* 069003.13.00		
Standard: ISO 34-1 Type: tear test Material: SBR Specimen: trouser Grips: pneumatic Extensometer: crosshead monitor Test speed: 500 mm/min *testXpert®* 069003.13.00		
Fibre reinforced composites Standard: ISO 527-4 Type: tensile Material: CRC Specimen: type 3 Grips: hydraulic Extensometer: Macro Test speed: 2 mm/min *testXpert®* 069001.02.00		
Standard: ISO 14130 Type: interlaminar shear Material: CRC Grips: flexural device Extensometer: crosshead monitor Test speed: 1 mm/min *testXpert®* 069002.36.00		

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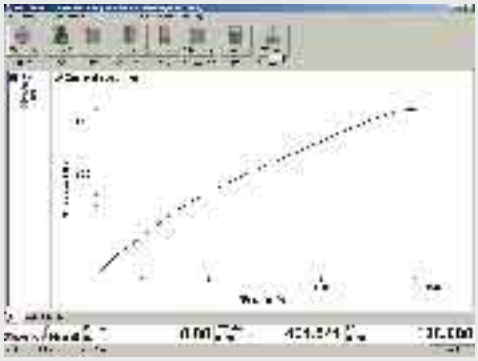
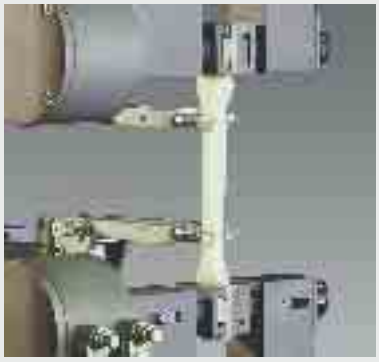
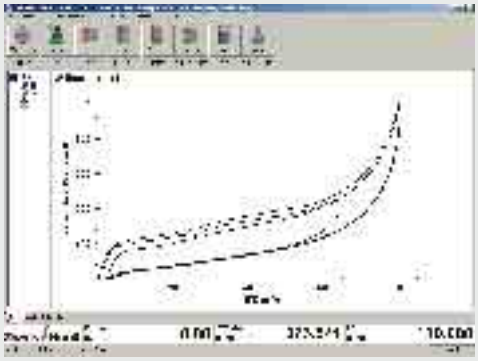
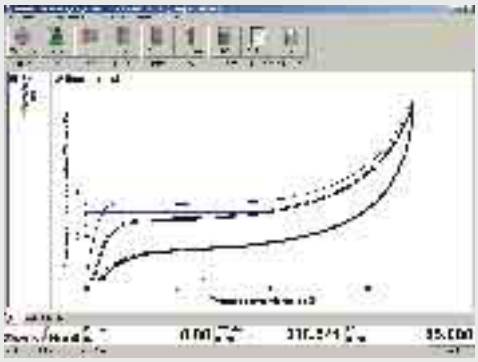
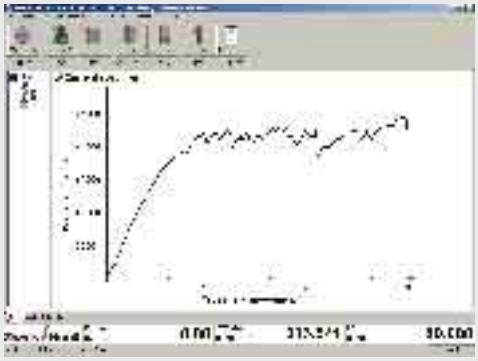
Application	test-curve in testXpert®	Example of mounting
Flexible cellular plastics Standard: ISO 1798 Type: tensile Material: PUR Grips: pneumatic Extensometer: mechanical long stroke Test speed: 500 mm/min *testXpert®* 069001.46.00		
Standard: ASTM D 3574 - B1 Type: indentation hardness Material: PUR Grips: indentor Extensometer: crosshead monitor Test speed: 48 mm/min *testXpert®* 069009.05.00		
Standard: ISO 3386 Type: compression properties Material: PUR Grips: compression plates Extensometer: crosshead monitor Test speed: 50 mm/min *testXpert®* 069009.00.00		
Standard: ISO 8067 Type: tear test Material: PUR Specimen: trouser Grips: pincer Extensometer: crosshead monitor Test speed: 50 mm/min *testXpert®* 069001.49.00		

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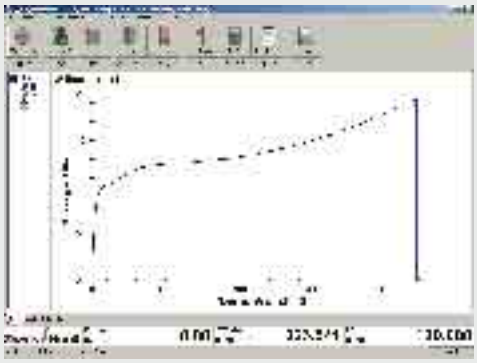
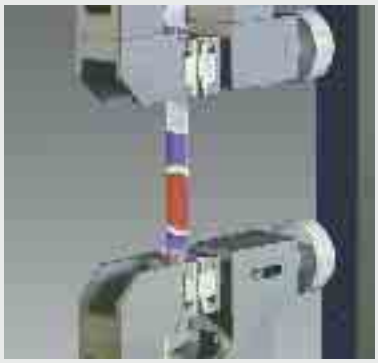
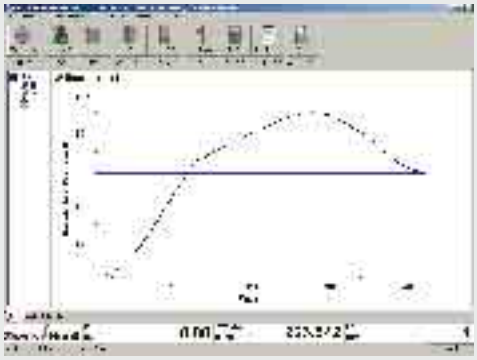
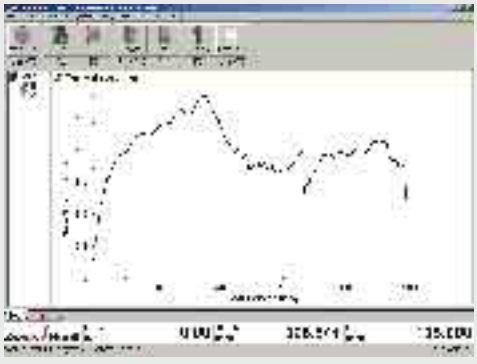
Application	test-curve in testXpert®	Example of mounting
Thin sheeting and plastic film Standard: ISO 527-3 Type: tensile Material: PVC film Specimen: strip, 10mm large Grips: screw Extensometer: crosshead monitor Test speed: 100 mm/min *testXpert®* 069001.02.00		
Standard: pr EN 14477 Type: puncture test Material: PE film Grips: test device Extensometer: crosshead monitor Test speed: 100 mm/min *testXpert®* 069002.87.00		
Adhesives and sealings Standard: ISO 4578 Type: 90° peel test Material: tape Grips: test device Extensometer: crosshead monitor Test speed: 100 mm/min *testXpert®* 069003.41.00		
Standard: customer specific Type: opening of sealing Material: petfood packages Grips: special device Extensometer: crosshead monitor Test speed: 100 mm/min *testXpert®* 069003.01.00		

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Sample preparation

Injection moulding and compression moulding

To characterize thermoplastic and thermosetting materials, specimens are made by injection or direct compression moulding. The applied processing parameters such as pressure, temperature and shear-rate strongly influence the materials behavior.

Thermosetting materials:
- Compression moulding (ISO 295)
- Injection moulding (ISO 10724-1)

Thermoplastic materials:
- Compression moulding (ISO 293)
- Injection moulding (ISO 294, part 1-4)

Multipurpose specimen, ISO 3167

The local shear-rate during processing is influenced by the shape of the specimen. This means that the results of specimens with different shapes are not normally coherent.

For this reason a multipurpose specimen has been fixed in ISO 3167, which is to be used for a variety of different tests as for example tensile, compression, flexure, creep, hardness and impact.

Machining

For testing semi-products and finished parts, it is generally required to know the materials characteristics in the state after having achieved its final shape. The specimens are then machined in accordance to ISO 2818 or other material-specific standards.

Specimens made of softer materials showing a hardness of less than 85 Shore A, in particular rubber, elastomers and soft plastics, as well as specimens made of thin sheetings and film are manufactured relatively simple with cutting presses and special cutting tools. A greater hardness leads to an increased wear of the cutting dies.

In particular greater specimen thicknesses cannot be cut if the material is harder. These materials are machined by milling, sawing, planeing or blanking.

Zwick cutting presses and tools

Zwick offers a wide range of standardized cutting devices for standardized and special specimen shapes. A listing of the most used types is shown in the following tables.

Cutting presses

Reference	H04.7101[1)]	ZCP020	H02.7108
Application	circular specim.	all shapes	all shapes
Max. applicable load, kN	5	20	35
Push rod stroke, mm	25	41	30
Max. distance push rod-table, mm	65	155	70
Adjustment of push rod stroke, mm	12	25	-
Adjustment of table elevation, mm	-	-	70
Projection, mm	46	125	110
Anvil table, mm	swiveling	250 x 250	350 x 215
Compressed air supply, bar	-	-	6
Net weight, kg	40	55	75

[1)] Cutting dies can be used for
- ring-shaped specimen up to a diameter of 80 mm,
- square-shaped specimen up to 75 mm and
- rectangular and dumbbell shaped specimens up to a size of 160 x 30 mm

Excentric cutting press 7101 with ring centering device for circular specimens

Knee-lever cutting press ZCP020 for all specimen shapes

Pneumatic cutting press 7108 for all specimen shapes

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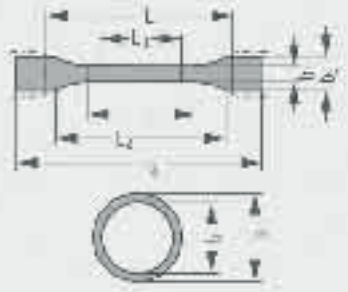
Advantages of cutting devices:
- simple change of cutting dies
- mechanical specimen rejecting system (reducing the risk to get injured by the sharp cutting edges)
- possibility to sharpen the cutting die several times
- cutting die and rejector are two modular parts so that the cutting die is available as spare part for later changement



L_0 - gauge length
L - distance between grips
l_1 - length of narrow parallel-sided portion or inner diameter
L_2 (l_e) - distance between broad parallel-sided portions
l_3 - overall length or outer diameter
b_1 - width of narrow portion
b_2 - width at ends
h - thickness

Specimen shapes, specimen dimensions and cutting dies

Note: The item numbers in the following tables have to be prefixed by H06.710

Thermoplastic and thermosetting materials

Standard	Type	Application	l_3 mm	l_1 mm	b_2 mm	b_1 mm	h mm	L_0 mm	L mm	Shape	Cutting die/ spare die[1]
ISO 3167	A	Injection moulded multipurpose specimen	≥150 (170)	80±2	20±0.2	10±0.2	4.0±0.2	-	-		B.089 / 090[2]
ISO 3167	B	Compr. moulded or machined multipurpose specimen	≥150	60±0.5	20±0.2	10±0.2	4.0±0.2	-	-		B.019 / 020
ISO 527-2	1A	Injection moulded specimen (preferred shape)	≥150	80±2	20±0.2	10±0.2	4.0±0.2 (preferred)	50±0.5	115		B.089 / 090[2]
ISO 527-2	1B	Compression moulded or machined specimen (preferred shape)	≥150	60±0.5	20±0.2	10±0.2	4.0±0.2 (preferred)	50±0.5	l_2 + 5[3] l_2 = 106 ... 120		B.019 / 020
ISO 527-2	1BA	Specimen proportional 1:2 to type 1B	≥75	30±0.5	10±0.5	5±0.5	≥2	25±0.5	l_2[3] +2[3] l_2=58±2		B.201 / 202
ISO 527-2	1BB	Specimen proportional 1:5 to type 1B	≥30	12±0.5	4±0.2	2±0.2	≥2	10±0.2	l_2 + 5[3] l_2=23±2		B.153 / 154
ISO 527-2	5A	Specimen identical to ISO 37 type 2	≥ 75	25±1	12.5±1	4±0.1	≥2	20±0.5	50±2		B.005 / 006
ISO 527-2	5B	Specimen identical to ISO 37 type 4	≥ 35	12±0.5	6±0.5	2±0.1	≥1	10±0.2	20±2		B.083 / 084
ASTM D 638	I	Preferred specimen for rigid plastics	≥165	57±0.5	19+6.4	13±0.5	3.2±0.4	50±0.25	115±5		B.155 / 156
ASTM D 638	II	Preferred if type 1 does not break in the narrow section	≥183	57±0.5	19+6.4	6±0.5	3.2±0.4	50±0.25	135±5		B.157 / 158
ASTM D 638	III	for thickness > 7 mm (rigid and non-rigid plastics)	≥246	57±0.5	29+6.4	19±0.5	7...14	50±0.25	115±5		B.057 / 058
ASTM D 638	V	Smaller specimen taken from parts or semi-products	≥63.5	9.53	9.53+3.1	3.18±0.5	3.2±0.4	7.62	25.4±5		B.161 / 162
ASTM D 638	IV	For comparison between rigid and non-rigid platics (similiar to ISO 37 type 1)	≥115	33±0.5	19+6.4	6±0.05	3.2±0.4	25±0.13	65±5		B.159 / 160
ASTM D 638	M-I	Preferred metric size for rigid and semi-rigid plastics	≥150	60±0.5	20±0.5	10±0.5	< 10	50±0.25	115±5		B.019 / 020
ASTM D 638	M-III	Smaller metric size to M-I	≥60	10±0.5	10±0.5	2.5±0.5	< 4	7.5±0.2	25±5		B.165 / 166
ASTM D 638	M-II	Metric size for non-rigid materials	≥115	33±0.5	25±0.5	6±0.5	< 4	25±0.5	80±5		B.009 / 010
ISO 178		flexural properties (middle part of ISO 3167 specimen)	≥80		10±0.2	4 (preferred)					only machining

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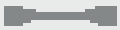
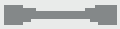
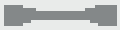
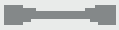
Standard	Type	Application	l_3	l_1 inch	b_2 inch	b_1 inch	h inch	L_0 inch	L inch	Shape inch	Cuttind die/ spare die[1]
ASTM D 638	I	Preferred specimen for rigid plastics	≥6.5	2.25	≥0.75	0.5	0.13±0.02	2	4.5		B.167 / 168
ASTM D 638	II	Preferred if type 1 does not break in the narrow section	≥7.2	2.25	≥0.75	0.25	0.13±0.02	2	5.3		B.061 / 062
ASTM D 638	III	For specimen thickness > 7 mm (rigid and non-rigid plastics)	≥9.7	2.25	≥1.13	0.75	0.28/0.55	2	4.5		B.057 / 058
ASTM D 638	V	Smaller specimen taken from parts or semi-products	≥2.5	0.375	≥0.375	0.125	0.32±0.02	0.3	1		B.161 / 162
ASTM D 638	IV	For comparison between rigid and non-rigid plastics (similiar to ISO 37, type 1)	≥4.5	1.3	≥0.75	0.25	0.32±0.02	1	2.5		B.163 / 164

Rubbers and elastomers

Standard	Type	Application	l_3 mm	l_1 mm	b_2 mm	b_1 mm	h mm	L_0 mm	L mm	Shape	Cuttind die/ spare die[1]
ISO 37	1	Preferred size	≥115	33±2	25±1	6+0.4	2±0.2	25±0.5	-		B.009 / 010
ISO 37	2	Smaller preferred size	≥75	25±1	12.5±1	4±0.1	2±0.2	20±0.5	-		B.005 / 006
ISO 37	3	Smaller size	≥50	16±1	8.5±0.5	4±0.1	2±0.2	10±0.5	-		B.121 / 122
ISO 37	4	Very small size	≥35	12±0.5	6±0.5	2±0.1	1±0.1	10±0.5	-		B.083 / 084
DIN 53504	S1	Larger size	115	33±2	25±1	6+0.4	2±0.2	25	-		B.009 / 010
DIN 53504	S2	Preferred size	75	25±1	12.5±1	4±0.1	2±0.2	20	-		B.005 / 006
DIN 53504	S3a	Smaller size	50	16	8.5	4	2±0.2	10	-		B.121 / 122
DIN 53504	S3	Very small size	35	12±0.5	6±0.5	2±0.05	1±0.1	10	-		B.083 / 084
ASTM D 412	C	Preferred size	≥115	33	25±1	6+0.05	1.3...3.3	25±0.25	-		B.009 / 010
ASTM D 412	A	Possible size	≥140	59±2	25±1	12+0,05	1.3...3.3	50±0.5	-		B.145 / 146
ASTM D 412	B	Possible size	≥40	59±2	25±1	6+0.05	1.3...3.3	50±0.5	-		B.143 / 144
ASTM D 412	D	Possible size	≥100	33±2	16±1	3+0.05	1.3...3.3	25±0.25	-		B.123 / 124
ASTM D 412	E	Possible size	≥125	59±2	16±1	3+0.05	1.3...3.3	50±0.5	-		B.147 / 148
ASTM D 412	F	Possible size	≥125	59±2	16±1	6+0.05	1.3...3.3	50±0.5	-		B.149 / 150
ISO 37	A	Normal size	52.6	44.6±0.2			4±0.2	152.7	-		C.003 / 004 + C.099 / 100
ISO 37	B	Small size	10	8±0.1			1±0.1	28.26	-		C.065 / 066 + C.119 / 120
DIN 53504	R1	Preferred size	52.6	44.6			4±0.2	152.7	-		C.003 / 004 + C.099 / 100
DIN 53504	R2	Small size	44.6	36.6			4±0.2	127.5	-		C.005 / 006 + C.007 / 008
ASTM D 412	1	Preferred size	17.9	15.9			1...3.3	50	-		C.121 / 122 + C.123 / 124
ASTM D 412	2	Larger size	35.8	31.8			1...3.3	100	-		C.125 / 126 + C.127 / 128
ISO 34-1		Tear test, trouser preferred size	≥100	-	15±1	-	2±0.2	-	-		D.007 / 008
ISO 34-1 ASTM D 624		and Tear test, angle cutting die C, without nick	≥100	-	19±0.05	12.7±0.05	2±0.2	-	-		D.001 / 002
ISO 34-1 ASTM D 624		and Tear test, Crescend cutting die B, without nick	≥110	-	25±0.5	10.5±0.05	2±0.2	-	-		D.029 / 030
ASTM D 624		Cutting die A	42	-	-	10.2	-	-	-		D.033 / 034
ISO 34-2 ISO 816		and Delft test pieces including slit	60	-	-	9±0.1	Slit: 5±0.1	30			D.013 / 014

[1] Cutting is only possible for specimen showing a hardness less than 85 Shore A. Harder materials shall be machined by use of milling machines or other convenient machinery acc. to ISO 2818.
[2] This specimen shape is specially designed for moulding. Cut specimens do not correspond to any standard.
[3] Value indicates the upper and lower tolerances..

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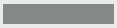
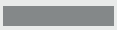
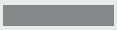
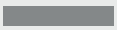
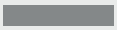
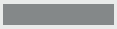
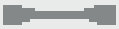
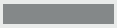
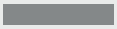
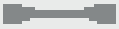
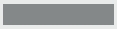
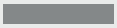
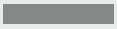
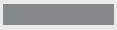
Flexible cellular polymeric materials (soft foams)

Standard	Type	Application	l_3 mm	l_1 mm	b_2 mm	b_1 mm	h mm	L_0 mm	L mm	Shape	Cutting die/ spare die[1]
ISO 1798		Tensile specimen	152	55	25	13	10...15	25/50	-		B.015 / 016
ASTM D 3574 - E		Tensile specimen	139.7	34.9	25.4	6.4	12.5±1.5	20/25			B.039 / 040
ISO 8067		Tear strength, method A	125±25		25±1		25±1	-	-		D.093 / 094
		Tear strength, method B	≥100	19	12,7	-	-	-	-		D.001 / 002
ASTM D 3574 - F		Tear resistance test	152.4		25.4	-	25.4	-	-		D.081 / 082

Thin sheetings and films

Standard	Type	Application	l_3 mm	l_1 mm	b_2 mm	b_1 mm	h mm	L_0 mm	L mm	Shape	Cutting die/ spare die[1]
ISO 527-3	2	Recommended shape.	≤150			10	≤1	50 ±0.5	100 ±5		A.149 / 150
		Strip taken with any	≤150			12	≤1	50 ±0.5	100 ±5		A.121 / 122
		kind of cutting device.	≤150			13	≤1	50 ±0.5	100 ±5		A.123 / 124
		L_0 may be reduced	≤150			15	≤1	50 ±0.5	100 ±5		A.125 / 126
		to 50 mm for high	≤150			20	≤1	50 ±0.5	100 ±5		A.079 / 080
		elongations	≤150			25	≤1	50 ±0.5	100 ±5		A.127 / 128
ISO 527-3	5	Specimen shape for quality and control purpose	≥115	33 ±2	25 ±1	6 ±0.4	≤1	25 ±0.25	80 ±5		B.009 / 010 or B.125 / 126 (130 mm long)
ISO 527-3	1B	Specimen shape for quality and control purpose	≥150	60 ±0.5	20 ±0.5	10 ±0.2	≤1	50 ±0.5	115 ±5		B.019 / 020
ISO 527-3	4	Specimen shape for thin sheets	≥152	50 ±0.5	38	25.4 ±0.1	≤1	50 ±0.5	73.4		B.085 / 086
ASTM D 882		Strip for quality control	≥150			5...25.4	≤1	100	100		on request
		Strip für modulus measuring	≥300			5...25.4	≤1	250	250		on request

Reinforced plastic composites

Standard	Type	Application	l_3 mm	l_1 mm	b_2 mm	b_1 mm	h mm	L_0 mm	L mm	Shape
ISO 527-4	1B	Preferred for isotropic and orthotropic reinforced composites and for	≥150	60 ±0.5	20 ±0.2	10 ±0.2	4.0 ±0.2	50 ±0.5	115	
ISO 527-4	2	multidirectional and fibre-reinforced materials	≥250		25 ±0.5 or 50±0.5		2...10	50 ±1	150 ±1	
ISO 527-4	3		≥250		25 ±0.5 or 50±0.5		2...10	50 ±1	136	
ISO 527-5	A	Unidirectional fibre-reinforced plastic composites, longitudinal	250		15 ±0.5		1 ±0.2	50 ±1	136	
ISO 527-5	B	For transverse direction	250		25 ±0.5		2 ±0.2	50 ±1	136	

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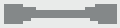
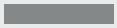
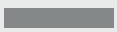
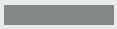
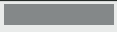
Plastic piping

Standard	Type	Application	l_3 mm	l_1 mm	b_2 mm	b_1 mm	h mm	L_0 mm	L mm	Shape	Cutting die/ spare die[1)]
PVC-Pipes											
ISO 6259-2	1	Machined specimen	≥115	33 ±2	≥15	6 +0.4	wall thickness	25 ±1	80 ±5		
ISO 6259-2	2	With cutting die produced specimens	≥115	33 ±2	25 ±1	6 +0.4	wall thickness	25 ±1	80 ±5		B009/010
Polyolefin pipes (PE, PP)											
ISO 6259-3	1	Wall thickness >5 mm (similiar ISO 527-2, type 1B)	≥115	60 ±0.5	20 ±0.2	10 ±0.2	wall thickness	50±0.5	115 ±0.5		
ISO 6259-3	2	Wall thickness ≤5 mm (similiar ISO 37, type 1)	≥115	33 ±2	25 ±1	6 +0.4	wall thickness	25 ±1	80 ±5		B009/010
ISO 6259-3	3	Wall thickness >12 mm	≥250	25 ±1	100 ±3	25 ±1	wall thickness	20 ±1	165 ±5		

Specimen for pendulum impact tests

Standard	Type	Application	l_3 mm	l_1 mm	b_2 mm	b_1 mm	h mm	L_0 mm	L mm	Shape	Cutting die/ spare die[1)]
ISO 179-1	1	Charpy (from multipurpose specimen)	80 ±2	-	-	10 ±0.2	4 ±0.2	62 +0.5 (preferred)			only moulding or machining
ISO 179-1	2	Charpy, materials exhibiting	25 x h	-	-	10 oder 15	3 (pref.)	20 x h			only machining
	3	interlaminar shear	(11 od. 13) x h		-	10 oder 15	3 (pref.)	(6 od. 8) x h			only machining
ISO 180	1	Izod (from multipurpose specimen)	80 ±2	-	-	10 ±0.2	4 ±0.2	-			only machining
ISO 8256	1	Tensile impact, notched type	80 ±2	30 ±2	10 ±0.5	6 ±0.2		-			D.095 / 096
	2	Tensile impact	60 ±1	25 ±2	10 ±0.2	3 ±0.05		10 ±0.2			D.101 / 102
	3	Tensile impact	80 ±2	30 ±2	15 ±0.5	10 ±0.5		10 ±0.2			D.103 / 104
	4	Tensile impact	60 ±1	25 ±2	10 ±0.2	3 ±0.1		-			D.097 / 098
	5	Tensile impact	80 ±2	50 ±0.5	15 ±0.5	5 ±0.5		10 ±0.2			D.105 / 106
ASTM	S	Tensile impact	60	25	10/12.5	3 ±0.05		-			D.087 / 088
D 1822M	L	Tensile impact	60	25	10/12.5	3 ±0.05		10 ±0.05			D.090 / 100

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Dimension measurement

The reproducibility of test results is significantly influenced by accurate and reproducible measurement of the linear specimen dimensions.

Methods for determining the linear dimensions are fixed in different standards according to the material´s behavior and their dimensions to be measured.

Vernier calliper

The use of vernier callipers is convenient to determine dimensions of >30 mm on plastics and rubbers (see ISO 178, ISO 4648, ASTM D 3767, DIN 53534), as well as for dimensions ≥ 10 mm of rigid cellular plastics (DIN 53570)

Reference	Range	Resolution
W40031	150 mm	0.01 mm
W40038	500 mm	0.01 mm

Digital micrometers with ratchet

Micrometers with ratchet, able to generate a constant measuring force, are convenient to measure dimensions >0.25 mm of rigid and semi-rigid plastics.

Reference	W40032
Range:	0 to 25 mm
Contact surface, shape:	circular/flat
Contact surface diameter:	6.35 mm
Measuring force:	5 to 10 N
Display resolution:	0.001 mm

Vernier callipers and micrometers can be connected via RS232 interface and a multiplexer to the PC. Multiplexers for 2, 3 or 6 measurement devices are available.

Dead weight thickness gauges

are used to measure the dimensions of rubbers, elastomers, non-rigid plastics, flexible cellular plastics, thin sheetings and plastic films.

As the surface pressure to be applied on the test piece by the thickness gauge is important for accurate measurement, the different standards fix the shape and surface of contacting surfaces such as the pressure foot and the anvil as well as the weight to be applied. Different contact elements can be used with the same device.

A choice of standards and contact elements is shown on the next page.

Reference	THICK GA.000	THICK GA.H00
Range:	12 mm	12 mm
Resolution:	1 µm	0,5 / 1µm
Anvil dia.:	50 mm	50 mm
Connection:	Multiplexer	RS 232

Digital vernier calliper (Ref. W40031)

Digital hand micrometer with ratchet (Ref. W40032)

Dead weight thickness gauge providing a constant measuring force (DM-THICKGA.00 + DM-PLASTFOI.S00)

Requirements of standards for measurements by use of a micrometer with ratchet or an automatic cross-section measuring device

Standard	Material	Test type	Measurement of	Reading req.
ISO 527-1	Rigid and semi-rigid plastics	Tensile	Thickness, width	≤0.020 mm
ASTM D 638	Rigid and semi-rigid plastics	Tensile	Thickness, width	≤0.025 mm
ISO 178	Rigid and semi-rigid plastics	Flexural	Thickness, width	≤0.010 mm
ASTM D 790	Rigid and semi-rigid plastics	Flexural	Thickness, width	≤0.010 mm
ASTM D 374	Plastic sheet and film	General	Thickness >0,25mm	≤0.010 mm
ISO 1923	Rigid cellular plastics	General	Dimensions ≤10 mm	≤0.05 mm

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Requirements of standards - Measurement carried out by use of dead weight thickness gauges

Standard	Material	Test-type	Specimen	Measure-ment of	Pressure-foot, shape	Pressure-foot, diam. mm	Anvil diam. mm	Contact pressure kPa	Contact force N	Reso-lution mm	Recomm. contact elem. Reference
ISO 37	Rubber	Tensile	Dumbbell	Width	(nominal distance between cutting edges)						
	Rubber	Tensile	Ring	Thickness	circul./flat	(same device as for dumbbell test pieces)					
		Tensile	Ring	Rad. Width	2 cylinders						on request
ISO 4648/	Rubber/	Tensile	1 / (S1)	Thickn. <30	circul./flat	10	>10	10 ±2	0.562	0.001	
DIN 53534	IRHD<35	Tensile	2 / (S2)	Thickn. <30	circul./flat	10	>10	10 ±2	0.388	0.001	
		Tensile	3 / (S3a)	Thickn. <30	circul./flat	10	>10	10 ±2	0.388	0.001	
		Tensile	4 / (S3)*)	Thickn. <30	circul./flat	10	>10	10 ±2	0.201	0.001	
			larger specimen*)	Thickn. <30	circul./flat	6	>6	10 ±2	0.282	0.001	DM-ELASTOM.S00
	IRHD ≥35	Tensile	1 / (S1)	Thickn. <30	circul./flat	10	>10	22 ±5	1.236	0.001	
		Tensile	2 / (S2)	Thickn. <30	circul./flat	10	>10	22 ±5	0.853	0.001	
		Tensile	3 / (S3a)	Thickn. <30	circul./flat	10	>10	22 ±5	0.853	0.001	
		Tensile	4 / (S3)	Thickn. <30	circul./flat	10	>10	22 ±5	0.441	0.001	
			larger specimen	Thickn.<30	circul./flat	6	>6	22 ±2	0.622	0.001	
ASTM D412/	Rubber/	Tensile	Dumbbell	Thickn. ≤30	circul./flat	3...10	35	10 ±2	-	0.001	
ASTM D3767	IRHD≤35	Tensile	Dumbbell	Width	(nominal distance between cutting edges)						
	IRHD>35	Tensile	Dumbbell	Thickn. ≤30	circul./flat	3...10	≥35	22 ±5	-	0.001	DM-ELASTOM.S00
	IRHD≤35	Tensile	Ring	Thickn. ≤30	circul./flat	3...10	≥35	10 ±2	-	0.001	
	IRHD>35	Tensile	Ring	Thickn. ≤30	circul./flat	3...10	≥35	22 ±5	-	0.001	
	all IRHD	Tensile	Ring	Rad. width	2 cylinders	15.5 ±0.5 (length 12 mm)					on request
ASTM D374	Shore A 30...80	General	All types	Thickness 0.76...6.35	circul./flat	6.35 ±0.25	≥50	26 ±4	-	0.002	on request
ASTM D3767	Rubber	Compr. set plot		Thickness	Spheric	9.5...10 (Spheric rad. 12.5 ±0.1)			0.8 ± 0.1	-	on request
ISO 527-1	Non-rigid plastics	Tensile	Dumbbell	Thickness	circul./flat	-	-	20 ±3	-	0.02	DM-PLASTFOI.S00
		Tensile	Dumbbell	Width	circul./flat	-	-	20 ±3	-	0.1	
ASTM D 638	Non-rigid plastics	Tensile	Dumbbell	Thickness	circul./flat	6.35 ±0.025		>6.4	25 ±2.5	-	on request
		Tensile	Dumbbell	Width	circul./flat	6.35 ±0.025		>6.4	25 ±2.5	-	-
		Tensile	Large spec.	Thickness	circul./flat	15.88 ±0.08		>6	25 ±2.5	-	-
ISO 527-3/	Sheet & film	Tensile	Strip &	Thickness	circul./flat	2.5...10	2.5...10		0.5...1	≤0.001	DM-PLASTFOI.S00
ISO 4593		Tensile	Dumbbell	≥10 µm							
		Tensile		Width	(nominal distance between cutting edges)						
ASTM D882	Sheet & film	Tensile	Strip & Dumbbell	Thickness ≥0,025...0,25	circul./flat	25...55	3...13	≥51	-	0.0025	DM-PLASTFOI.S00
ASTM D374	Sheet & film	General	All types	Thickness ≥0,025...0,25	circul./flat	25...55	3...13	≥51	-	0.002	DM-PLASTFOI.S00
ISO 1923/ DIN 53570	Cellular plastics	General	All types	Dimensions ≥10 mm	circul./flat	35.7	>36	0.1 ±0.01	-	0.05	on request

*) Measurement only with thickness gauge DM-THICKGA.H00

Remark: Standards for elastomers and rubbers generally require the median out of 3 measurements.
Standards for plastics generally require the average out of 3 measurements.
Standards for cellular plastics generally require the average out of 5 measurements.

Zwick / Roell

Automatic cross-section measurement device

Automatic cross-section measurement devices are used for fast, comfortable and reproducible measurement of specimen thickness, width or diameter on rigid and semi-rigid plastics.

The operator places the specimen into the measurement device where one or several measurements can be carried out. By this method, the influence of the operator is minimized.

Reference	066998.00.00
Shoulder width, max:	40 mm
Parallel length, min:	60 mm
Specimen length, min:	100 mm
Thickness, range:	0,2 to 25mm
Thickness, contact foot:	spherical
Width/diameter, range:	6,0 to 40mm
Width, contact foot shape:	flat, Ø 1 mm
Resolution:	0,001 mm
Accuracy (gauge block):	± 0,003 mm
PC-Connection:	RS 232
including certified gauge block.	

Measurement of cross section by weight

This method is convenient for the cross-section determination of rubber and elastomer ring specimens as well as for strip specimens of very thin (≤ 10 µm) or embossed plastic film.

Available balances

Reference	2.01.00	W4002-2.02.00	3.01.00
Meas. range	≤51 g	≤101 g	≤151 g
Resolution	0,1 mg	0,1 mg	1 mg
PC-connec.	RS232	RS232	RS232
Power supply	220 V	220 V	220 V

Automatic cross-section measuring device (Ref. 066998.00.00)

Determination of ambient density according to ISO 1183, DIN 53479-A

The method consists of weighing the material in air and in distilled water, normally at ambient temperature. The kit consists of weighing mechanism and a thermometer. A balance is needed.

Digital balance and kit for the determination of density

Material testing machines

Zwick produces material testing machines with capacities up to 6000 kN and more. For plastic materials and rubbers most of the standard tests are covered by forces up to 20 kN.

Typical fields of application

Loads up to 1 kN
- Tensile and tear tests on rubbers, non-rigid plastics, thin sheets and film, cellular plastics
- Creep and flexural tests on rigid and semi-rigid plastics
- Peel resistance of adhesives

Loads up to 10 kN
- Indentation and compression tests on cellular plastics

Loads up to 20 kN
- Tensile, compression, creep and shear tests on rigid and semi-rigid plastics as well as fibre reinforced compounds

Loads higher than 20 kN
- Tensile and compression properties of reinforced plastic composites
- Compression properties of plastic piping as well as other plastic and rubber parts

Basic concept

The Zwick program includes universal testing machines as table-top and floor standing designs with different measurement and control systems, load frames, drives and versatile function and supplementary units.

However in order to be able to offer the best machine for each requirement, Zwick has developed a user-related concept. The user can choose among three machine

versions, each of them being completely different as to equipment, performance features and also as to the capability of expansion:

- BasicLine
- Standard Line
- Allround Line

The decisive testing machine component is the measurement and control system. Its conception and its scope of performance decide which drive can be controlled, which measurement system can be connected to it and which functions can be controlled with it - and they thus determine the range of application and the testing machine's capability for future expansion.

The advantages to the user of the three different testing machine versions are as follows:

- The BasicLine is particularly suitable for functional tests on component parts and for the simple materials test
- The Standard line is ideal to solve simple test jobs reliably. It is a low-cost, sturdy solution which covers many testing needs
- The Allround line is the basis for a large spectrum of demanding test jobs and can easily be expanded with the requirements becoming more demanding. It is thus a solution that can be relied on for future requirements

Measurement and control system BasicLine

The electronics taken from existing Zwick machine types guarantees a very high availability and reliability of the test system. The measurement and control electronics is compactly packed in a housing.

Materials testing machines of the BasicLine are preferably used for functional and component tests

BasicLine testing machines can be operated in the Stand Alone mode without a PC and they can be operated directly via function keys on the testing machine. As standard it is additionally possible to operate the BasicLine with the test software *testXpert*®, thus profiting from all the advantages of standardized test programs and from the many years of experience on the development sector.

Measurement and control system *testControl*
(for standard and allround version)

By using most recent technologies and by granting highest quality standards *testControl* offers a maximum of technical performance and a long-term investment guarantee. These are the particular features of *testControl*:

- Time-synchronous test data acquisition with high resolution and measuring frequency
- Real-time processing of the test data in a 500 Hz cycle for the monitoring and event-related test sequence control (e.g. speed change when reaching the yield or proof stress) and for safety limit values
- Adaptive control for exactly reproducible speeds and positions
- The measurement and control electronics and the power electronics for the drive system in question are integrated in a housing in a space-saving way. Thus, the usual cabling can be dispensed with

The measurement and control system *testControl* is available in 2 variants:

Stand Alone Variant
Easy and reliable operation via coloured display, 10-key keyboard and a few function keys – without PC. A printer may be connected directly for the printout of test results.

PC-Variant
The system may be configured and expanded to cope with the most different applications. PC and user software *testXpert*® make applications very comfortable and extremely flexible.

Zwick / Roell

Load frames

Different load frame versions for test loads up to 2.000 kN are available as standard. For special applications special versions can be developed and manufactured, e.g. load frames in horizontal position suitable for the testing of long ropes.

Single-column table-top loadframe (zwicki)

These load frames are designed with very rigid aluminium high-precision extruded profiles. The working area is freely accessible from 3 sides. Thus, it is ideal for the various tests on small parts and for Zwick hardness testing machines. It only requires a small space. Due to its light weight, it is easy to transport.

Two-column table-top testing machines

The load frames of the BasicLine are designed with 2 round steel columns. The load frames of the Standard and Allround Line are designed with patented aluminium high-precision extruded profiles. They are light, very rigid and serve simultaneously as lead-screw guide and protection. T-shaped grooves on the outer sides allow a simple fitting of accessories as e.g. safety devices without being impeded by the crosshead.

All load frames with two profiles - except for the BasicLine – can be equipped with legs. Advantages are:

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

Materials testing machine zwicki Z.2.5 with test tool for the determination of the coefficient of friction on plastic films

Determination of the stacking height of plastic buckets with a materials testing machine BasicLine Z010

Zwick / Roell

Load frame as floor standing model

Patented aluminium high prescision extruded profiles are also used for floor standing loadframes up to 150 kN. In case of lager loadframes, two or four hard-crome plated round steel columns serve for crosshead guiding and support.

All load frames with an electro-mechanical drive system may optionally be equipped with a second working area allowing e.g. a rapid change of the test mode without having to change the equipment.

Materials testing machine Z100 with pneumatic grips and Macro extensometer

Materials testing machine Z005 for the determination of tensile properties of plastics.

Materials testing machine Z050 in extended version for determination of tensile properties and ring stiffness of plastic pipes.

Zwick / Roell

The C-shape frame

This load frame is specially adapted for compression and indentation testing of larger cellular plastic parts as used for seats in cars and aircraft. The table can be opened on both sides in order to get a large anvil surface. In the test area the table is perforated with holes to allow rapid air escape during indentation tests (acc. to ISO and ASTM standards).

The test space is accessible from three sides to allow a very comfortable and fast operation. By use of adaptors, this load frame can be used for tensile and tear testing as well.

The C-shape frame is used for compression and indentation tests on larger parts of cellular plastics

Drive systems

Electro-mechanical drive systems

The basis of all electro-mechanical drive systems are backlash-free and low-friction ball screws and digitally controlled drive systems. They are used with load frames for test loads of up to 600 kN. Together with the digital measurement and control system they have the following advantages:

- Extremely high, stepless speed range
- Very low speeds adjustable (from about 0.5 µm/min on)
- High-precision and exactly reproducible positions and speeds

The testing machines designed with single-column load frames (zwicki and BasicLine) are equipped with D.C. motor drives, all others with low-intertia brushless drives.

Hydraulic drive and hybrid drive systems

These drives will only be used with load frames for testing forces 400 kN and higher.

Zwick / Roell

BasicLine - Load frames and drive systems

Series	Z0.5	Z005	Z010	Z020
• Load frame type	Table top	Table top	Table top	Table top
• Max. load, kN	0.5	5	10	20
• Working area, width x height, mm	∞ x 596	420 x 561	420 x 1041	420 x 1041
Option	-	420 x 1061	-	-
• Working area, depth, mm	99.5	unlimited	unlimited	unlimited
• Max. test speed, mm/min	1500	500	1000	500
• Crosshead travel resolution, µm	0.226	0.05	0.09	0.045
• Max. power consumption, kVA	0.4	0.6	0.6	0.6

Standard and Allround - Load frames and drive systems (motor driven machines)

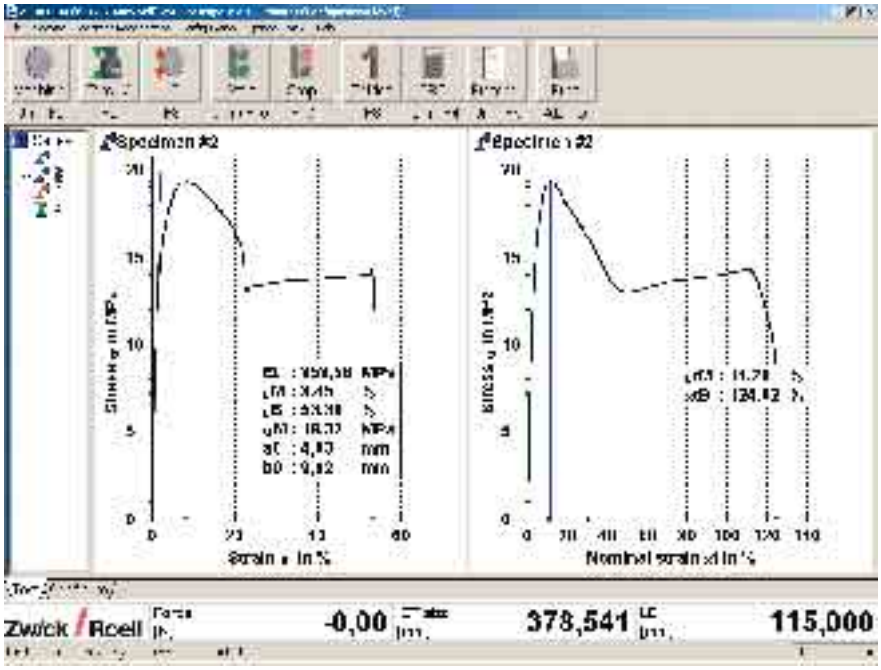
Series	Z1.0	Z2.5	Z005	Z010	Z020
• Load frame type	Table top	Table top	Table top	Table top	Table top
• Max. load, kN	1	2.5	5	10	20
• Working area, width x height, mm	∞ x 1373	∞ x 573	440 x 1058	440 x 1058	440 x 1058
Option	-	∞ x 1073	440 x 1458	440 x 1458	440 x 1458
	--	∞ x 1373	-	640 x 1787	640 x 1787
Working area, depth, mm	99.5	99.5	∞	∞	∞
• Max. test speed, mm/min	1800	800	3000	2000	1000/2000[1)]
• Crosshead travel resolution, µm	0.0002	0.0001	0.041	0.027	0.014/0.054
• Max. power consumption, kVA	0.4	0.4	2/1.9	1.9	2.1/2.6

Series	Z030	Z050	Z050	Z100	Z100
• Load frame type	Table top	Table top	Floor standing	Table top	Floor standing
• Max. load, kN	30	50	50	100	100
• Working area, width x height, mm	440 x 1380	440 x 1380	630 x 1824	640 x 1360	630 x 1824
Option	-	-	1030 x 1765	640 x 1760	1030 x 1765
• Working area, depth, mm	∞	∞	∞	∞	∞
• Max. test speed, mm/min	1000	200/1500[1)]	200/1000[1)]	900	
• Crosshead travel resolution, µm	0.027	0.026	0.0136	0.0123	
• Max. power consumption, kVA	2.3	6	5	5.5	

Series	Z150	Z150	Z250	Z005 C	Z010 C
• Load frame type	Floor standing	Table top	Floor standing	C-shape	C-shape
• Max. load, kN	50	100	100	5	10
• Working area, width x height, mm	630 x 1715	640 x 1539	630 x 1750	450[3)] x 680	450[3)] x 680
Option	1030 x 1660	-	1030 x 1660	1450[4)] x 680	1450[4)] x 680
• Working area, depth, mm	∞	∞	∞	1000[3)]	1000[3)]
• Max. test speed, mm/min	900	900	600	600	600
• Crosshead travel resolution, µm	0.0123	0.0123	0.0082	0.0504	0.0504
• Max. power consumption, kVA	5.5	5.5	6	0.8	0.8

[1)] Depending on the selected drive system
[2)] With hydraulic grips
[3)] Dimensions of the table
[4)] Dimensions of the table in opened position

Test software *testXpert*®



testXpert® - the strictly object-orientated software is available in several language versions; among others in english, french and german (screenshot: tensile test acc. to ISO 527-1)

Range of application

testXpert® is the universal Zwick test software for materials, component, and functional testing. It's application range goes from Zwick materials testing machines (for tensile, compression, flexure and functional testing) to hardness testers, pendulum impact testers, extrusion plastometers, automated test systems, etc. right up to the refurbishment of testing machines of a variety of makes and models.

Duties and functions

The essential fields of use of *testXpert*® are:

- verification and re-equipping of the test machine
- preparation of the test or test series
- performance of the test
- evaluation and documentation
- data management
- quality management and
- data exchange between *testXpert*® and other applications (Word, Excel etc.)

testXpert® supports the user for all tasks with software wizards and editors, explanatory pictures and video sequences, situation-specific user tips, warnings, error messages and online help.

Future-oriented concept

The *testXpert*® test software uses the special properties of the object-oriented programming with respect to a clear grouping in tasks and functions. Structure and contents are determined by the Zwick application and software know-how. The *testXpert*® concept is therefore a guarantee for highest flexibility, functional safety as well as simple usability.

The essential characteristic features are:

- uniform basic software for all applications
- modular system for test programs
- user support through software tools

Modular system

The test programs are compiled by Zwick from a selection of several hundred software modules. The modules are sub-divided into classes such as test parameters, test sequence phases, screen views etc. They are continuously updated and expanded with respect to new states of knowledge and necessary supplements. This makes *testXpert*® an intelligent software, and thus enables the realization of test programs strictly to test standards and test programs related to practical applications. Thanks to the numerous possibilities of this system, *testXpert*® can be put to universal use for a wide applicational spectrum and for a variety of testing machines.

Zwick / Roell

Test programs

The test programs compiled by Zwick stipulate how tests are to be run. Their basis are selected software modules that are linked to one another and are pre-configured through fixed parameters depending upon the functions required. Thus the user receives from Zwick a "test template" in which only variable parameters must be entered.

There are three variants available for a wide range of requirements:
- Master test programs
- Standard test programs, and
- Customized test programs

International quality standards

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).

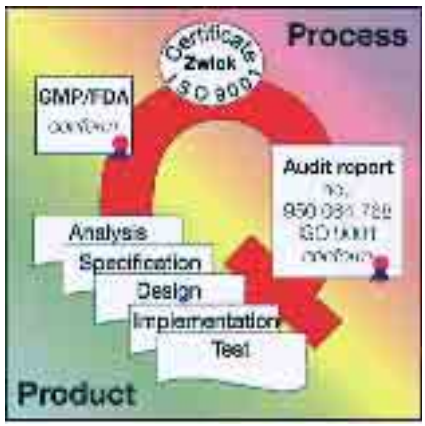
The entire software development process and its components are diligently documented and archived from the source code through to the software tools used, for each and every version. This is valid for each phase from the analysis via the specification, design and implementation up to the test. Conformity to the standard ISO 9000-3 for development of *testXpert*® has been confirmed via audit report no. QM-F-96/1016.

Safety in detail

Windows software is normally used in offices. However, *testXpert*® takes over an additional and especially critical task: monitoring and controlling machines. Machine damage and potential danger to persons must be ruled out. That's why *testXpert*® doesn't use any overlapping windows in the test mode to avoid hiding important displays or key fields.

Automatic acceptance of system data

Different test jobs require different test machines with different and usually, interchangeable components. Their specific properties are characterised by the system data (nominal force, travel, speed range, mounting height, calibration factors, etc.). Organisational data also belong to the above, e.g. the series number or the date of the last calibration.



testXpert® meets highest quality standards. This concerns both the product and the entire process of the software development

testXpert® accepts this data automatically directly following the program start
- for the necessary settings
- for the determination of safety limit values
- for the correct measurement signal evaluation

Furthermore *testXpert*® checks whether or not
- the test can be carried out with this configuration
- all settings have been made
- the data have changed for the current test

Simplest operation

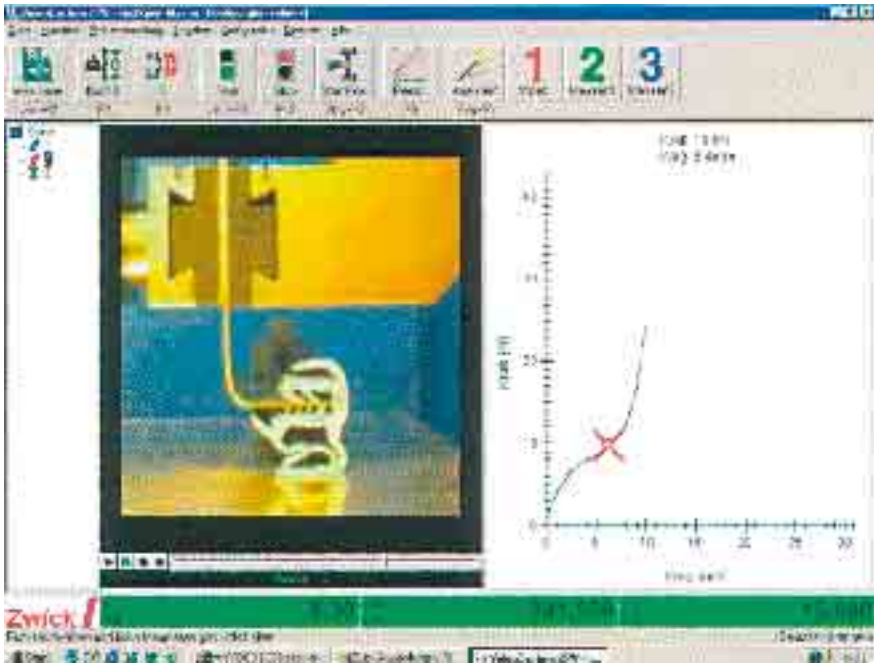
Operation is reduced to a one-button operation, i.e. activating the start button, for standard applications. This is possible because *testXpert*® automatically records the test data, and dependent upon this, controls and monitors the test sequence and determines and documents the test results.

Preparation of a test series requires only two steps:
- call-up the test program foreseen for the required application
- input or selection of 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 test parameters
- curve diagram (single or multiple curves)
- tables for test results
- tables for result statistics

Zwick / Roell



Video-Capturing during the functional test of a rubber joint

Data saving for further use

Depending upon the preselection in the test program, not only all data but also selected result data from a test or test series can be saved. Saving of all data offers the possibility of tracing the origin of the result data up to configuration and settings for the test machine. The standardized measurement data, i.e. the data converted to its basic units can be repeatedly displayed in the simulation mode and can also be evaluated according to other criteria.

Video Capturing

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 video pictures being recorded time-synchronously with the test data.

- With the cursor keys, a "video reticle" can be moved over the test curve and the corresponding picture can be displayed
- The pictures can be captured at a preselected distance of the measuring points or in dependence on the event
- The video can also be played alone, irrespective of testing machine
- Distances between two points and angles between three points, radii, diameters and areas can be measured from the specimen in pictorial representation
- Optionally, the pictures can also be output with dimension lines and test data

Expanded traceability for electronic records, e.g. for FDA 21 CFR Part 11

This option can be applied for all safety critical tests that impose expanded requirements on the traceability and documentation of data gathered during testing. This option is also ideal for creating the necessary prerequisites for fulfilling the requirements as in FDA 21 CFR Part 11. These guidelines as published by the US foodstuffs and health department FDA (Food and Drug Administration) contain technical and organisatory requirements on electronic recording of data.

The *testXpert*® option offers tools that, together with organisatory procedural sequences in the companies in question, fulfill the regulations of 21 CFR Part 11.

Zwick / Roell

Load cells

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

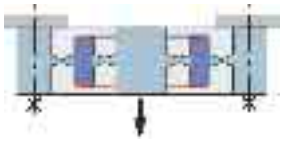
- Automatic identification and acquisition of all setting and calibration parameters via sensor plug. An exchange of the load cells neither requires a calibration nor a modification of the setting data.
- Automatic zero-point and sensitivity balancing
- Temperature compensation
- High measurement frequency
- Very high test data resolution
- Accuracy:
  Class 1 (1 % of reading) from 0.2 to 120 % of full scale load. Class 0.5 (0.5 % of reading) from 1 % to 100 % of full scale load.
- Overload protection
- Manufacturer's test certificate to certify the factory calibration

Load cells with one or two sided mounting stud and self-identifying sensor plugs are available for nominal loads from 10 N on.

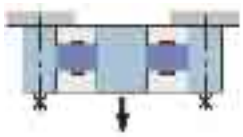
Types and recommendations for their use

Depending on the test job, the accuracy of the load cells and other features are important. For the use with temperature devices, these are the temperature sensitivity of zero-point and measured value. Particularly during compression and flexural tests, transverse forces and moments may occur which should not falsify the value in an inadmissible way and which should not damage the load cell. For this reason, Zwick offers different types of load cells.

- GTM Load cell
  The body of this circular load cell is a bending ring with ring-shaped strain gauges on the face sides. It is very insensitive to excentric load applications and overloads.

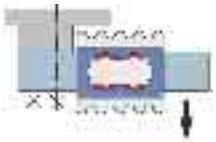


- KAF Load cell
  The outer and the inner ring of this load cell are linked by spokes on which the strain gages are applied to. This load cell is relatively insensitive ot excentric load applications.



- KAP Load cell
  The body of this flat, S-shaped load cell is a double beam. It is relatively sensitive to excentric load applications.

- Type Z6
  This load cell consists of a double beam-shaped body. The centrically acting test load is traversed laterally and transmitted to the crosshead of the testing machine. Therefore it is quite sensitive to excentric load applications.



Note:
The measurement body of the load cell is illustrated in dark blue and the strain gauges applied onto them are illustrated in red.

Type/test conditions	GTM	KAF	KAP	Z6
Tension force with axial load application	+ + +	+ + +	+ + +	+ + +
Compressive force with safe axial load application	+ + +	+ +	+ +	+ +
Compressive force with excentric load application	+ + +	- [1]	- [2]	- [2]
Bending tests	+ + +	+ +	+ +	+ +
Extended temperature range	+ + +	+ +	+ +	+ +
Creep tests	+ + +	+ +	+ +	+ +
Axial alignment under load	+ + +	+ + +	+ +	+

[1] Limited measuring accuracy
[2] Risk of destruction

Force transducer with sensor plug, type KAP (above) and GTM (below)

Zwick / Roell

Specimen holders

Specimen grips for tensile, creep and cyclic tests

Zwick offers a large product range of specimen grips in various designs, test load ranges and test temperatures to cover the wide range of applications for the plastics and rubber testing (see table „selection criteria for specimen grips").

The specific range of application of a specimen grip particularly depends on the operating principle and the max. permissible test load. For tests inside a temperature or climatic chamber, the temperature range is another important factor.

Force transfer between specimen and specimen grips

The clamping principle defines the type of force transfer between specimen and specimen grips. Most of the grips are named according to the clamping principle.

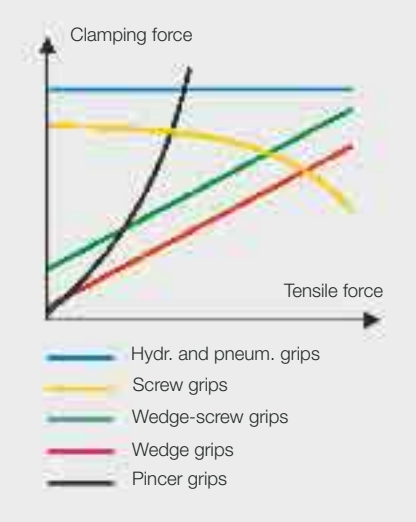
For the majority of specimens, the test load can only be transferred by a force-holding gripping principle, i.e. friction. The frictional force between specimen ends and gripping jaws of the specimen grips must always be greater than the test load. The required gripping forces acting vertically to the test load are generated externally (e.g. by means of pneumatic pressure) or are generated mechanically from the test load (e.g. by means of sliding wedges).

In order to avoid specimen break within the grips – particularly for gripping-sensitive and flexible specimens (plastic films, strips, monofilaments) - the test load is prior to gripping slightly reduced by a frictional force applied by wrapping around. For this purpose, the specimen ends are led over cam plates (e.g. circle segments or rollers) and are subsequently clamped.

For rubber-made ring specimens, the force is transferred according to the form-fitting gripping principle. They are led over pulleys.

Gripping force

For specimen grips with an external gripping force application, the set gripping force is effective during the entire test. Particularly when using thick and soft specimens, specimen material may during load application flow out of the gripping range (slip) causing a reduction of the specimen thickness. When using hydraulic or pneumatic specimen grips, the gripping force remains constant because the pressure generator immediately supplies pressure oil or compressed air. When using screw grips, the gripping pressure is reduced in accordance to the rigidity and the resilience of the specimen grip.



Dependence of the clamping force on the test load for different types of specimen grips

Due to the high gripping force of these specimen grips, specimen material is "pushed" out of the gripping range already when closing the grips. The specimen is compressed and may be pre-damaged. A similar behaviour may also occur with wedges type grips because during closure the gripping jaws are moved in direction of the center of the specimen. This effect can be avoided by means of a corresponding regulation of the machine drive during the closure of the clamps. ("Zero-Force-Regulation").

In case of self-clamping grips, the initially low gripping force increases in relation to the acting tensile force and the function principle of the grips (Wedge, pincer, etc.).

Gripping surfaces

The frictional force does not only depend on the gripping force, but also on the coefficient of friction of the contacting surfaces. For this reason, exchangeable gripping jaws or jaw faces with different surface types (shape, surface structure, material etc.) are availalable for many specimen grips.

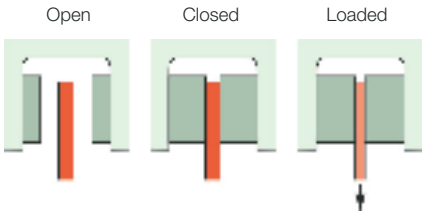
Gripping travel and opening width

Specimen grips with an external gripping force application have a long gripping travel and consequently a large opening width. This means an easy specimen feed even when testing thicker specimens. Exchangeable gripping jaws for different specimen thicknesses are not required.

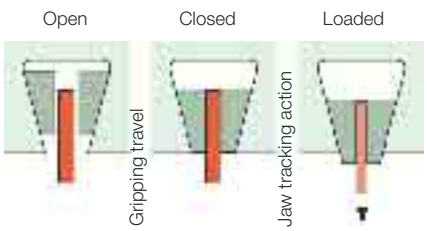
When using self-clamping grips, each change of the gripping travel causes a larger displacement of the gripping jaws in direction to the center of the specimen. Therefore, gripping travel, opening width and thus the range of specimen thicknesses and thickness variations are limited for these types of specimen grips. Differently thick gripping jaws might be required to cope with different thickness ranges.

Gripping jaw tracking action

During the test, the specimen thickness may be reduced with the increase of the test load; this is particularly the case when testing thick and soft specimens. This change in thickness has to be compensated by an additional gripping travel. For self-clamping grips, the gripping jaws are moved in direction to the center of the specimen. This gripping jaw tracking action which is considerably greater than the changing thickness of the specimen



Gripping process for specimen grips with external load application (long gripping travel, no gripping jaw tracking action)



Gripping process for increasing force wedge grips (short gripping travel, large gripping jaw tracking action)

(for wedge grips with a wedge angle of 15 degrees, a change in thickness of 0.1 mm causes a gripping jaw tracking action of about 1 mm at both ends of the specimen!) results in a corresponding error of the indirect extension measurement for the determination of the nominal strain.

Handling and control

The opening and closing of the specimen grips for low test loads is mostly done via lever or handwheel.

When using specimen grips for higher test loads and frequent operation, the manual operation can be very tiring. Relief is given by hydraulic, pneumatic or motorized grips which are operated via push buttons or foot switch. In case of semi-automatic operations, the user only has to close the specimen grips. In dependence on the specimen dimensions, it is even possible to set the hydraulic or pneumatic pressure – and thus the gripping force – automatically. The opening is done automatically after the specimen break.

Types of specimen holders

Hydraulic grips

These universally usable specimen grips are predominantly used for average and high test loads. The gripping force is applied via directly acting hydraulic cylinder. The grips are available in two versions:

- With a manually adjustable and a closing gripping jaw. So shear tests with an excentric gripping can also be performed.
- With gripping jaws closing symmetrically on both sides

The required hydraulic energy is supplied by a hydraulic unit (see photo: hydraulic grips).

Hydraulic grips

Pneumatic grips

Pneumatic grips

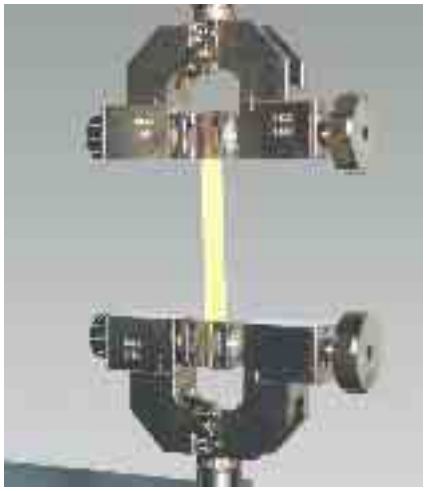
With these specimen grips, the gripping force is applied via pneumatic cylinders which, depending on the size, are acting directly or via a lever system on the gripping jaws. They are mainly used for low and average test loads.

Versions with single or double-sided closing gripping jaws are available. The required pneumatic energy is mostly supplied by the in-house compressed air ductwork system (see photo: pneumatic grips).

Zwick / Roell

Screw grips

One gripping jaw is operated manually via screw drive. The other gripping jaw can be set in fixed steps, steplessly or may be positioned stationary (see photo: screw grips).



Screw grips

Wedge grips

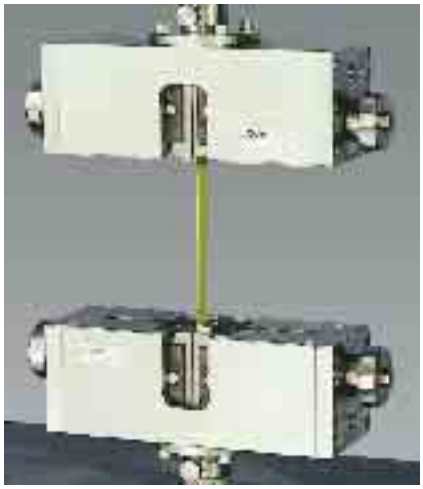
Two wedges actuated manually via lever are pressed against the specimen at a low pre-load generated by a spring. The wedges cause an increasing force effect. The gripping force increases with the increase in tensile force (see photo: wedge grips)

Wedge grips

Wedge-screw grips

These specimen grips are a combination of screw and wedge grips. With the screw drive, the gripping jaws are closed and opened – and the initial gripping force is generated. If the clamp is closed, the wedges generate the increasing force effect.

Optionally, the screw drive can either be driven by motor, be controlled manually via push buttons or externally (see photo: wedge-screw grips).



Wedge-Screw grips

Spring loaded grips

Pincer grips

This pincer-type specimen grip also has the increasing force principle. The initial gripping force is applied by a pre-stressed spring. The pincer principle generates a gripping force which increases superproportionally to the tensile force. It is particularly suitable for tensile specimens made of soft, highly extensible rubber and elastomers which become extremely strong prior to the specimen break (see photo: pincer grips).

Pincer grips

Spring loaded grips

These grips are particularly suitable for tests at very low forces. The mass of the specimen grip is of particular importance here: Its weight is compared to the nominal force of the connected load cell so small that its load measuring range is not restricted.

The gripping force is generated by a spring with adjustable spring force. Thus, sensitive materials can be tested by using a predefined and constant gripping force (see photo: spring loaded grips).

Zwick / Roell

Toggle grips

These grips are particularly suitable for thin, strip-shaped plastic films. Its ends are wrapped around round bolts (functioning as cam plates) by 180 degrees. These round bolts are acting at the same time as gripping jaw actuated by the tensile force (see photo: toggle grips).

Toggle grips

Tools for flexural tests

Flexure tests are carried out with specimens of different dimensions on thermoset and thermoplastic materials, composites etc. and in accordance to different standards. Accordingly, there is a large number of components the test unit in question can be combined of:

- Tables for 3-point and 4-point flexure tests with manual or motorized setting of the support span and for different test load levels
- Flexure die with different flexure die radii
- Flexure supports with different support radii and with fixed or rotatable bearing

Flexural tool according to ISO 178

Ring testing device

The rubber rings are wrapped around two pulleys with defined diameters. One pulley is turned synchronously to the crosshead movement; driven by a toothed belt or a roller spring band (see photo: roller grips.

Pulley diameter:

ISO 37:	22,3/4 mm
DIN 53504:	22,3/18,3 mm
ASTM D 412:	4,75 mm

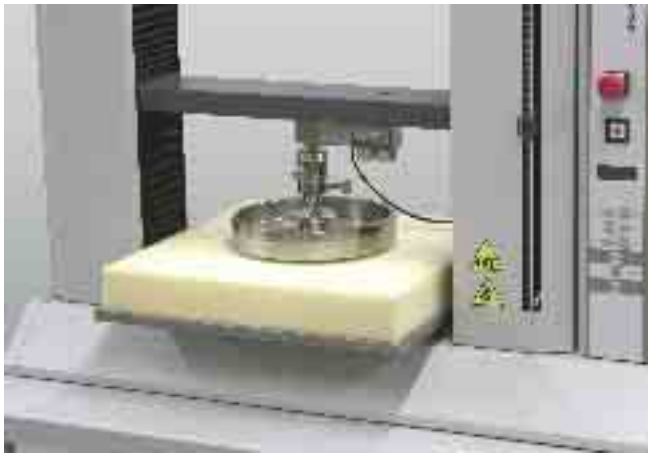
Ring testing device acc. ISO 37

Zwick / Roell

Selection criteria for specimen grips

Features	Specimen grips (Function principle)								
	Hydraulic-	Pneumatic-	Spring loaded	Wedge-	Screw-	Wedge-screw	Pincer-	Toggle-	Ring testing
Load range (max. load)									
• Min. size, kN	10	0.02	0.02	2.5	0.02	0.5	0.5	0.3	2.5
• Max. size, kN	250	100	0.05	250	50	250	10	2.5	2.5
Temperature range									
• Lower limit, °C	-70	-70	-15	-70	-70	-40	-40	-15	-40
• Upper limit, °C	+250	+250	+80	+250	+250	+250	+250	+80	+150
Main range of application									
• Sheets, strips		●	●		●			●	
• Tapes	●	●			●				
• Monofilaments	●	●		●					
• Strings, ropes		●			●				
• Dumbbells	●	●		●	●	●	●		
• Rings									●

Determination of the compression properties



Determination of the indentation hardness

Test tools for the determination of compressive properties of flexible cellular materials

Depending on the standard in question, square specimens with an edge length of 50 or 100 mm are tested. The lower, perforated compression platen must be larger than the specimen's cross-section. It is therefore available in different sizes.

The table plate of the materials testing machine Z005 and Z010 with C-frame is designed as compression platen. The upper, non-perforated compression platen is rigidly fixed.

Test tools for the determination of the indentation hardness

This test is also carried out on flexible cellular materials. The upper compression platen however has a spherical seating. It has a diameter of 203 mm. The lower compression platen must be perforated.

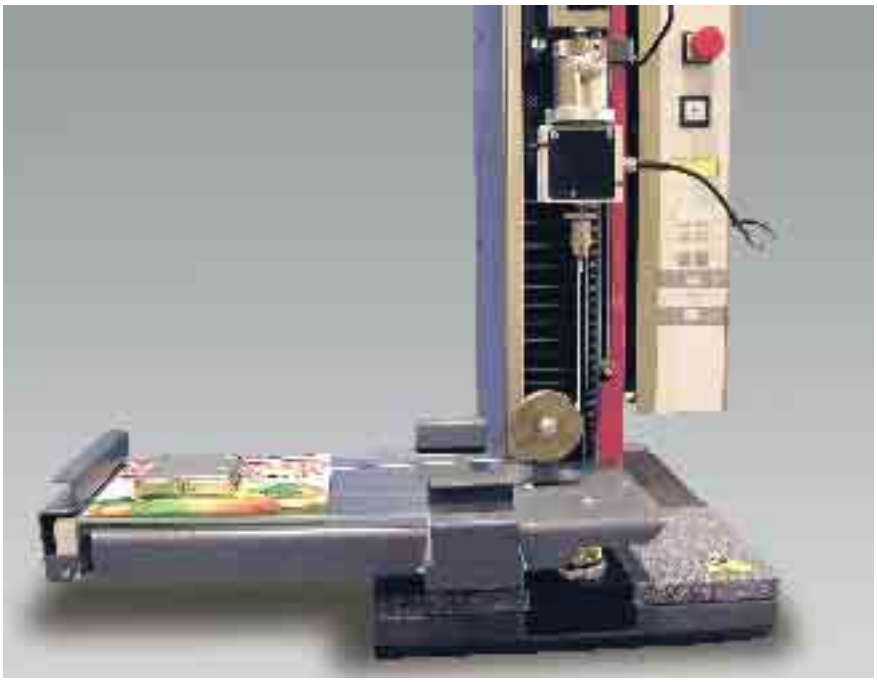
Puncture test device acc. to prEN 14477

Puncture test device

For tests on packing foils, the specimen which is clamped in the lower specimen holder is penetrated by an exchangeable indentor. The puncture force is measured and evaluated.

Unit for the determination of the coefficient of friction

For the determination of the static and dynamic coefficient of friction, the specimen is clamped on a horizontally arranged mirror glass table and a defined weight is put onto it. This weight is pulled over the specimen via a deflection pulley. This tensile force is measured and evaluated.



Equipment for the friction determination

90° peel test unit

Unit for 90° peel tests

For the determination of adhesive forces e.g. on glued joints, sealings, adhesive tapes etc., the specimen is applied to a rigid base material and is then peeled off at a constant angle of 90°. The peeling force is measured and evaluated.

Zwick / Roell

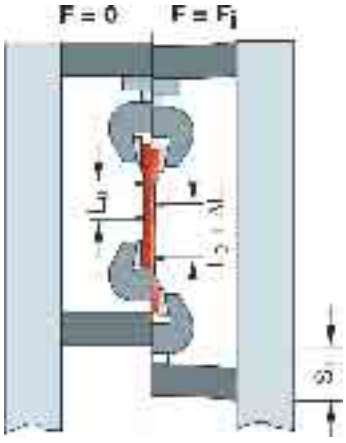
Extensometers

In tensile tests the extension versus the tensile force has to be measured; in special cases the reduction in width has to be measured additionally. In flexural tests, the measured quantity is the deflection. Different specimen shapes and dimensions, material properties (strength, rigidity, extensibility etc.) and material characteristics to be determined, measuring accuracies etc. require different extensometers.

Crosshead travel monitor

Each standard or allround materials testing machine is equipped with a standard digital crosshead travel monitor. Its measuring signal is primarily used as the actual value for the position and speed control of the drive system. It is however also used for the indirect extension measurement as for example for the determination of the nominal strain in accordance to ISO 527 (determination of the tensile properties of plastics).

The indirect measurement is suitable for many compression, indentation hardness, flexure, tear and shear tests, and also for tensile tests on ring and strip-shaped specimens made of materials with a high elongation.



For tests on dumbbell specimens for the determination of the tensile modulus and other extension-dependent characteristic values in a deformation range up to the yield point, the standards require the direct extension measurement. (Remark: For the acquisition of single-point-data in the framework of ISO 10350-1, only strains up to 50 % are relevant.)

Analogue clip-on extensometers

(clip-on, manual)

The resolution of these extensometers that can be attached manually or automatically (option) to the specimen, is extremely high, but the test travel is relatively short. Therefore they are predominantly used for the high-precision determination of Poisson's ratio (ISO 527-1) on rigid and reinforced plastics – measuring at the same time the extension and the reduction in width.

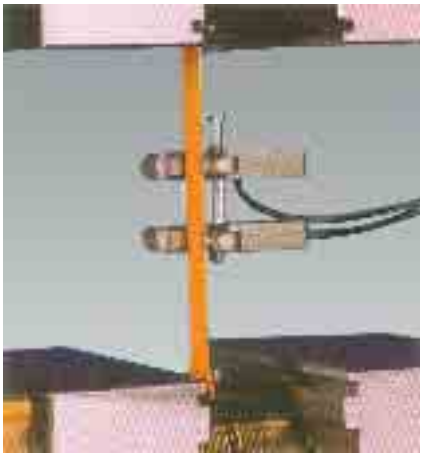
Advantages of the extension measurement:

- High-resolution measurement of the tensile modulus according to ISO 527-1 and ASTM D 638
- Resolution better than 0.02 µm at a test travel of ±2 mm
- Optionally with counterweight (compensation of the extensometer weight)
- To be used at ambient temperature or at a temperature range from -70°C to +220°C

Advantages for the reduction-in-width measurement:

- Determination of Poisson´s ratio on fibre-reinforced composites according to ISO 527-1.
- Resolution better than 0.03 µm at a test travel of ±4 mm
- Choice of different measuring pins for adaptation to the specimen dimensions

Analogue clip-on extensometer



Analogue reduction-in-width monitor

With the crosshead travel S_T (indirect extension measurement) not only the extension ΔL of the gauge length L_0 is measured, but also the deformation of the testing machine and specimen parts outside the gauge length.

Zwick / Roell

Incremental clip-on extensometers

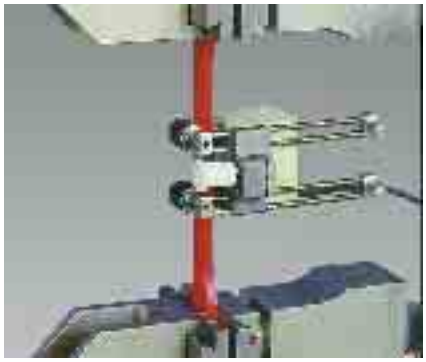
These extensometers are manually attached to the specimens and have a high resolution and a relatively long test travel. Therefore, they can e.g. be used for the precise determination of the tensile modulus and the yield point according to ISO 527-1 and ASTM D 638 on rigid and semi-rigid plastics. When testing rigid plastics showing a low extension, even the elongation at max. force and the elongation at break may be determined.

Advantages:
- Measuring range until beyond the yield point
- High-resolution determination of the modulus according to ISO 527-1 and ASTM D 638
- Suitable for tensile, compression and creep tests
- Exact fixing to the specimen
- Measurement until specimen break without removing the extensometer
- Also available as reduction-in-width monitor and as biaxial system

Macro extensometer

This extensometer is used for tensile, compression, flexure and cyclic tests on plastics, composites and rigid cellular plastics showing small to medium extensions. It is also useful for thin sheetings and plastic films and flexible cellular plastics if optical measuring methods are not required.

Advantages:
- Automatic setting of the gauge length
- Automatic attachment and lifting of the sensor arms
- Low drag forces of the sensor arms
- Deformation measurement until specimen break without lifting the sensor arms (rotatable knife edges)
- Crosshead contact/collision protection
- Exchangeable sensor arms for tensile, compression and flexure tests
- Suitable for measurements in temperature chambers
- Suitable for the determination of the modulus according to ISO 527-1 and ASTM D 638



Incremental clip-on extensometer

Bi-axial incremental extensometer

The Macro-extensometer covers all standard requirements for a wide range of plastics

Incremental clip-on extensometers

Series	Usual variant	Extended variant	Reduction-in width	Bi-axial extensometer
Measuring system	Incremental	Incremental	Incremental	Incremental
Measuring range				
Tensile, mm	13.5 / 8.5 mm	40 / 35 mm	-	40 / 35 mm
Compression, mm	0.2 / 5.2 mm	0.2 / 5.2 mm	-	0.2 / 5.2 mm
Width, mm	-	-	1.5 / 11.5	1.5 / 11.5
Gauge length, mm	20/25/30/ 50*/80*	50/55/65/70/80* 85*/100*/105	-	80
Specimen width, mm	-	-	10 / 20	10 / 20
Temperature range, °C	10 ... 35	10 ... 35	10 ... 35	10 ... 35
Resolution, µm	0.1	0.1	0.1	0.1
Accuracy (ISO 9513)	Class 0.5	Class 0.5	Class 0.5	Class 0.5

* with extension parts

Zwick / Roell

The Multisens-extensometer combines high-resolution and long-stroke measurement

Multisens extensometer

Fully automatic, multifunctional and high-resolution extension measurement system for tensile, compression, flexure and creep tests as well as for cyclic tests on materials which have low to high extensions, e.g. all kinds of plastics, foams, thin sheetings and plastic films, composites, rubber and elastomers which do not wrap around the sensor arms in case of failure.

Advantages:
- Easy-to-use technology
- Automatic centering between the specimen holders
- Very low drag force
- Deformation measurement until specimen break without lifting the sensor arms
- Crosshead contact protection
- Exchangeable sensor arms for tensile, compression and flexure tests
- Suitable for measurements in temperature chambers
- Suitable for the determination of the modulus according to ISO 527-1 and ASTM D 638

OptiXtens extensometer

Fully automatic high-resolution, optical extensometer functioning according to the Laser Speckle method. It is used for tensile, compression and creep tests as well as for cyclic tests on non-transparent materials with low to high extensions both at ambient temperature and in connection with temperature chambers.

Advantages:
- Optical system which does not require measurement marks
- Easy-to-operate
- No influence of drag forces
- Secure and accurate deformation measurement until specimen break
- Particularly suitable for measurements in temperature chambers
- Suitable for the determination of the modulus according to ISO 527-1 and ASTM D 638, also in temperature chambers

The optiXtens recognizes and follows the surface structure of the specimen. Thus, the extension can be measured without prior specimen marking

Video extensometer

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

Advantages:
- Adaptable to various materials and test conditions
- Optical, contact-free measuring system for the testing of plastic films on dumbbell specimens according to ISO 527-3
- Suitable for the determination of the modulus according to ISO 527-1 and ASTM D 638
- Secure and accurate extension measurement until specimen break.
- Automatic gauge length recognition
- Suitable for measurements in temperature chambers through a heated glass window.

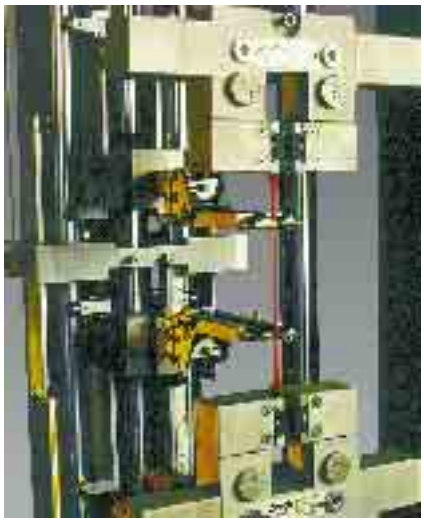
The video extensometer is adapted to the job in question by selecting suitable objectives and the object distance

Zwick / Roell

Mechanical long-stroke extensometer

It is designed for the measurement of higher extensions on plastics, rubber and elastomers, cellular materials, plastic film and thin sheetings showing maximum forces greater than approx. 20 N. A rigid and non-sensitive system which is particularly suitable for the testing of rubber and elastomer specimens showing a tendency to wrap around the sensor arms after specimen break.

Advantages:
- Robust and easy-to-use technology
- Particularly developed for tests on elastomers and rubber
- Measurement until specimen break without lifting the sensor arms (rotatable knife edges)
- Self-identifying sensor plug
- Exchangeable sensor arms
- Suitable for measurements in temperature chambers



The mechanical long-stroke-extensometer is designed for measurements on rubber and plastics.

Optical extensometer

Contact-free, digital extensometer for tensile tests on rubber, elastomers, flexible cellular materials, thin sheetings and plastic film at ambient temperature and in temperature chambers through a heatable window.

Advantages:
- Proven, easy-to-use measurement system for high elongation materials
- Secure and accurate measurement until specimen break
- Self-identifying sensor plug
- No influence of drag forces
- Suitable for measurements in temperature chambers through a heated glass window.

The optical long-stroke-extensometer allows a contact-free measurement on dot-marked specimen

Laser extensometer

Contact-free extensometer for tensile and compression tests on rubber and elastomers.

Transducers for 3-point flexure tests according to ISO 178 and ASTM D 790

With this simple and easy-to-use mechanical transducer, deflection is directly measured below the specimen. The sensor arm is attached manually or automatically (option) to the specimen.

The 3-point flexure transducer has been developed particularly for this test

Zwick / Roell

Extensometers, technical data

	Macro	Multisens	OptiXtens	Video[1)]	Mechan. long stroke	Optical long stroke	Laser
Measuring system	Incremental	Incremental[2)] (no marking)	Laser-Speckle	Image processing	Incremental	Incremental	Rotational laser
Measuring range, mm	min. 75 max. 160	740 – L_0	500 – L_0	50 ... 200 (field of view)	1000 – L_0	1000 – L_0	approx. 400
Resolution, µm	0.12...0.6	0.2...0.4	0.1	1	5	5	12
Accuracy (ISO 9513)	Class 1	Class 1	Class 0.5	Class 1	1% or 0.01 mm[3)]	1% or 0.03 mm[3)]	Grade B (ISO 5893)
Gauge length, mm	10 to 100/205	≥10	≥10	≥5 mm	10...1000	10...900	10 (tensile) 20 (compr.)
Drag force, N	≥0.050	≥0.015	none	none	≥0.20	none	none
Mot. sensor arm attach.	Optional	yes	yes	-	yes	yes	-
Autom. pre-set of L_0	Optional	yes	yes	-	yes	yes	-

[1)] Data for 25 mm-lens, [2)] 2 measuring ranges, [3)] whatever is greater

Indications for the choice of extensometers and deformation transducers

Application		Extensometer type											
Test results	Standard	Reduct.-in -width transducer (anal.)	Analogue clip-on extensometer	Incremental clip-on extensometer	Macro-extensometer	Multisens-extensometer	OptiXtens extensometer	Opt. long stroke extensometer	Mech. long stroke extensometer	Laser-extensometer	Video[1)]-extensometer	3-pt flexural transducer	Crosshead travel monitor
Poissons ratio	ISO 527	●	-	-	-	-	-	-	-	-	-	-	-
Tensile modulus	ISO 527	-	●	●	●	●	●	-	-	-	●	-	-
Compr. modulus	ISO 604	-	●	●	●	●	●	-	-	-	-	●	-
Flexural modulus	ISO 178	-	-	-	●	●	-	-	-	-	-	●	X
Tensile creep modulus	ISO 899-1	-	●	●	●	●	●	-	-	-	●	-	-
Flexural creep modulus	ISO 899-2	-	-	-	●	●	-	-	-	-	-	●	X
3,5% flexural strain	ISO 178	-	-	-	●	●	-	-	-	-	-	●	X
Deflection at break	ISO 178	-	-	-	●	●	-	-	-	-	-	●	X
Strain at yield point	ISO 527	-	-	O	●	●	●	●	●	-	●	-	-
	ISO 37	-	-	-	●	●	●	●	●	●	O	-	-
Stress at X% strain	ISO 527	-	-	O	●	●	●	●	●	-	●	-	-
	ISO 37	-	-	-	O	●	●	●	●	●	●	-	-
Strain at max. force.	ISO 527	-	-	O	O	●	●	●	●	-	●	-	-
	ISO 37	-	-	-	O	●	●	●	●	●	●	-	-
Strain at max. force, strips	ISO 527-3	-	-	-	O	●	●	●	●	-	●	-	●
Strain at break	ISO 527	-	-	O	O	●	●	●	●	-	●	-	-
	ISO 37	-	-	-	O	●	●	●	●	●	●	-	-
Strain at break, strips	ISO 527-3	-	-	-	O	●	●	●	●	-	●	-	●
Nominal strain	ISO 527	-	-	-	-	-	-	-	-	-	-	-	●
	ISO 604	-	-	-	-	-	-	-	-	-	-	-	●

[1)] = The lenses of the video extensometer can not be changed while testing
o = Only useful if the strain does not exeed the range of the extensometer
x = Measurements using the crosshead displacement show lower results due to the system deformation and contact pressure on the specimen
• = Convienient system

Zwick / Roell

Automatic Specimen Feeding by Handling Systems (HASY)

Automatic specimen feeding systems are mainly used for the efficient testing of large series, especially in reseach centers where statistically safe results are needed.

Specimen **ha**ndling **sy**stems (HASY) are available in different task-specific designs for plastic and rubber testing. (see table below)

They are designed for executing different test-types alternatively, i.e. tensile and flexural, as well as testing alternatively different materials, i.e. thermoplastics and cellular materials.

Common features

- fulfills the CE directives for safety
- data exchange with each Zwick universal testing machine
- data storage in ASCII or ODBC for LIMS (Laboratory Information Management System) or other databases.
- complete traceability of test results
- use of any conventional PCs

Benefits of automatic testing

- user-independent test results
- no temperature degradation of the material as the specimens are not touched by a user thus ensuring high reproducability of the results
- more test capacity as the systems can run “ghost-shifts” during the night and weekends
- one-task handling systems are very simple to operate by different users
- good/bad sorting of broken specimen
- magazine filling is possible while the system is running
- manually controlled tests are also possible
- simply adapted and expanded to specific requirements
- short amortisation time

MiniHasy-System

The MiniHasy-System inserts the specimen in the testing machine. The operator effort is minimized and the statistical scatter of test results is reduced.

Clip-on system

is used for tensile tests on rigid and non-rigid specimen like plastic film. It consists of a movable unit with a chain running in an oval, with spring clips for horizontal holding of the specimen. The clips are situated outside the gauge length of the specimen to avoid any kind of damage.

Specimen handling systems

System type		MiniHasy	Clip-on	X-linear	Light portal	Polar	Ring testing
Nº of storage places, standard		5 ... 20	100 ... 200	120 ... 450	100 ... 400	200	50
Type of test	Tensile Test	●	●	●	●	●	●
	Compression test	-	-	-	●	●	-
	Flexural test	●	-	●	●	●	-
	Tear test	-	●	-	●	●	-
	Creep test	●	-	●	●	●	-
Material	Thin sheetings, plastic films	-	●	-	-	-	-
	Flexible specimen	-	●	-	-	●	-
	Rigid and semi-rigid plastics	●	-	●	●	●	-
	Composites	●	-	●	●	●	-
	Rigid an flexible cellular plastics	-	-	-	●	●	-
	Rubber and elastomer rings	-	-	-	-	-	●
Specimen dimensions							
Shoulder or strip width, mm		6 ...25	10 ... 50	6 ...25	acc. specimen	acc. specimen	-
Thickness, mm		max. 15	max. 5	max. 15	acc. specimen	max. 10	4 ... 6
Over-all length, mm		max. 260	max. 350	max. 260	max. 260	max. 260	-
Options							
Thickness measurement		-	-	●	●	●	●
Cross-section measurement		-	-	●	●	●	-
Barcode identification		●	●	●	●	●	●
Temperature chamber		-	-	-	-	●	-

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Depending on the nature of the specimen, the broken specimen can be returned to the storage place.

X-linear system

using pneumatic or pincer-type gripping devices for various materials in the range of thermosetting and thermoplastics materials, composites, rubbers, elastomers and cellular materials, is designed for tests on tensile, flexural and angle tear specimens.

A movable substructure with electronic units, a linear handling axis and a movable magazine table form the basic system. The cross-section or specimen width can be measured and barcode identification options are available.

Clip-on system for strips

X-linear system for dumbells

X-linear system for rubber rings

Light portal system

is often used when larger specimens, i.e. compression specimens of cellular plastics need to be tested as well. This type covers the range of the X-linear systems, but leaves more space for specimens as well as for further test apparatus as for example instrumented ball indentation hardness testers.

Polar system

is based on an industrial type digital controlled robot with high positioning performances and flexibility. This handling system covers the range between x-linear-systems and light-portal-systems and is adapted for testing in hot and cold conditions using a temperature or climatic chamber.

Fast testing in temperature is assured by an intermediate magazine inside the chamber with exact pre-heating time control. This system is also designed for the testing of components of different sizes.

Further applications

Zwick supplies further automation applications for the field of materials testing.

- automated pendulum impact testers including temperature devices
- automated hardness testers
- automated milling of specimens for Charpy and Izod including notching.

System MiniHasy for dumbells

Polar system with temperature chamber

Polar system with pendulum impact tester

Zwick / Roell

Testing in Hot and Cold Conditions

Many types of plastic and rubber materials strongly change their mechanical properties depending on the temperature. For some thermoplastic materials it is known that the modulus value can change about 3 to 4 % for 1°K.

According to the later use of the material, especially in automotive and aeronautic industries, it may be very important to know the behavior of materials in different environmental conditions.

Temperature chamber, optiXtens extensometer and pneumatic grips mounted in a material testing machine Z005

Temperature chambers

Zwick temperature chambers show the following characteristics:

- Aperture for extensometer sensor arms on the rear left side (except for chambers without cooling)
- Eurotherm temperature control unit with digital display for actual value and set value.
- Illumination inside the chamber
- Front door with insulated window
- Sliders for removing the chamber without demounting the grips
- Insulating and electrical design meet the CE requirements for safety

Available options

Several options are available according to the specification of the testing machine and the needs in the laboratory.

- heatable optical glass insert when using optical extensometers
- guiding rails or trolley to move the chamber out of the test area
- temperature measurement and control by *testXpert*® software via RS 232 interface
- direct temperature measurement and control on the specimen
- liquid nitrogen tank, 100 litres, with pressure device, control valve, filling level indicator and security device.

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Temperature chambers

Use with		Table top and floor standing load frames		Only for floor standing load frames	
Height		normal	extended	normal	extended
Width		normal	normal	extended	extended
Dimensions (external / internal)					
Height, mm		650 / 500	850 / 700	800 / 650	1000 / 850
Width, mm		400 / 260	400 / 260	600 / 450	600 / 450
Depth, mm		840 / 360	840 / 360	1080 / 540	1080 / 540
Power supply		230 V / 3 kVA	230 V / 3 kVA	400 V / 4 kVA	400 V / 4 kVA
Type of cooling	**Temp. °C** [2]	**Reference**	**Reference**	**Reference**	**Reference**
No cooling	amb. /+250	B091260 [1]	B091265 [1]		
CO_2	-60 /+250	W91251	W91256	W91117	W91118
N_2	-80 /+250	W91250	W91255	W91122	W91123

[1] Without opening for mechanical or optical extensometers, without removal sliders
[2] Zwick supplies further temperature-ranges on request

Temperature chambers are usually mounted on guide rails

Sliders for removing the chamber without removing the grips

The controller and the opening for extensometers on the rear left side

Refrigeration by liquid nitrogen (LN_2) or carbon dioxide (CO_2)

This type of cooling is advantageous if required from time to time only. The cooling effect is generated by vaporizing the liquid nitrogen or carbon dioxide. Even if these gases are non-toxic, a sufficient ventilation of the test laboratory is absolutely required.

The consumption depends on the size of the chamber and its capacity. For standard applications the consumption values are as follows:

Temperature –20 °C		–80 °C
LN_2, l/h	appr. 10	appr.. 20
CO_2, kg/h	appr. 20	appr.. 40

The consumption costs for CO_2 are usually higher than for LN_2.

The optional 100 litres LN_2 tank is sufficient for several hours of tests.

Nitrogen connector: 3/8" Whitworth

Optical extension measurement in a temperature chamber

Zwick / Roell

Servohydraulic Testing Machines

Field of Application

Servohydraulic testing machines are used extensively for universal dynamic testing, and materials testing applications requiring very accurate measurement and control.

Typical applications

- Dynamic analysis and characterisation of rubber mountings, airsprings and elastomer dampers
- Characterisation of plastics, fibre reinforced and composite materials
- Durability testing of synthetic materials and components
- Dynamic peel and separation tests on bonded materials and adhesive tapes

Unique Features

Zwick universal servohydraulic testing machines combine structural rigidity with precise alignment to guarantee test data of the highest possible integrity.

All load frames boast smooth hard chromium plated columns, friction clamped by one-piece cross heads producing a structural platform of exceptional stiffness and rigidity with infinite fatigue life at rated capacity.

The testing machines are equipped with high performance fatigue rated servo-hydraulic actuators, available with hydrostatic bearings or polymer based plain bearings. Displacement transducers are mounted concentrically inside the actuator body. Machines are matched with hydraulic power units and servo-valves to ensure application specific performance and efficiency.

Additional options to test machines include protective enclosures, environmental simulation chambers and application specific specimen fixtures.

Load Frames

- Type HA
  The actuator is semi-integrated into the lower crosshead. Hydraulic adjustment and clamping of the upper crosshead are available on all models.

- Type HB
  The actuator is mounted in the upper crosshead. The HB design proves a flexible test space for optimal specimen mounting possibilities. Hydraulic adjustment and clamping of the upper crosshead are available on all models.

- Type HC
  These tabletop test machines are designed to be of a light-weight construction, with very high frame stiffness. The actuator is mounted in the upper cross-head resulting in a versatile frame, which can be tailored to customer requirements. Hydraulic upper crosshead adjustment is optional. The optional T-slotted table allows easy mounting of components.

Measurement and control

Unrivalled performance is offered using the HydroWin 96xx controller series

- 10 kHz closed loop control and data acquisition
- 19 bit A/D conversion with real time linearisation
- Real-time derive channels MIMICS advanced adaptive control for non-linear test applications
- Environmental control
- Multi-channel control

Servo-hydraulic testing machine
Amsler HC 15 for testing rubber mountings

Servo-hydraulic testing machines, standard designs[1)]

Type/series[2)]	HC 5/10/15/20/25	HA/HB 50	HA 100/250/600
Construction form	table top	floor standing	floor standing
Nominal force, kN	5/10/15/20/25	50	100/250/500
Testing stroke, mm[3)]	100	100/250/400	100/250/400
Specimen length, mm	100 ... 700	100 ... 1100	250 ... 1500
Working area, mm	410	565	670/800

[1)] Load frames can be supplied for higher forces, different dimensions and testing strokes
[2)] Piston located below (HA) or above (HB, HC) the working area
[3)] Maximum stroke 250 mm with the test cylinder being arranged below the working area

Zwick / Roell

Pendulum Impact Testing Machines

Charpy and Izod impact strength

According to ISO 179-1 and ISO 180 these testing methods, used to investigate the specimen behavior under impact conditions and for estimating the brittleness, are suitable for:

- rigid thermoplastics moulding materials and extrusion materials, including filled and reinforced compounds in addition to unfilled types, rigid thermoplastics sheets.
- rigid thermosetting moulding materials, including filled and reinforced compounds, rigid thermosetting sheets, including laminates.
- fibre-reinforced thermoset and thermoplastics composites incorporating unidirectional or non-unidirectional reinforcements such as mats, woven fabrics, woven rovings, chopped strands, combination and hybrid reinforcements, rovings and milled fibres; sheets made from pre-impregnated materials (prepregs)
- thermotropic liquid-crystal polymers

The method is not normally suitable for use with rigid cellular materials and sandwich structures containing cellular material.

Specimen

The specimens are primarily cut from multipurpose test specimens complying with ISO 3167, type A.

Pendulum impact tester

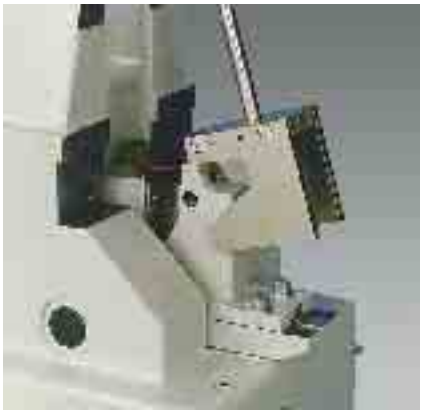
Standard requirement		Pendulum impact tester						
Pendulum energy	Velocity at impact m/s	5102.201 5102.202	5102E	Pendulum no.	5113.301	5113.300	5113E	Pendulum no.
ISO 179-1 - Charpy								
0.5		●	●	5102.114	-	●	●	5113.319
1.0		●	●	5102.113	-	●	●	5113.318
2.0	2,9 m/s	●	●	5102.112	-	●	●	5113.317
4.0	(± 10 %)	●	●	5102.111	-	●	●	5113.316
5.0		●	●	5102.110	-	●	●	5113.315
7.5		-	-	-	●	●	●	5113.314
15.0	3,8 m/s	-	-	-	●	●	●	5113.313
25.0	(± 10 %)	-	-	-	●	●	●	5113.312
50.0		-	-	-	●	●	●	5113.311
ASTM D 256, Method B - Charpy								
2.7		-	-	-	-	●	●	5113.364
5.4	3,46 m/s	-	-	-	-	●	●	5113.363
10.8		-	-	-	-	●	●	5113.362
21.6		-	-	-	-	●	●	5113.361
ISO 180 - Izod								
1.0		●[1]	-	5102.123	-	●	-	5113.345
2.75		-	-	-	-	●	-	5113.344
5.5	3.5 m/s	-	-	-	-	●	-	5113.343
11.0	(± 10 %)	-	-	-	-	●	-	5113.342
22.0		-	-	-	-	●	-	5113.341
ASTM D 256, Methods A, C, D, E - Izod								
2.7		-	-	-	-	●	-	5113.324
5.4	approx.	-	-	-	-	●	-	5113.323
10.8	3.46 m/s	-	-	-	-	●	-	5113.322
21.6		-	-	-	-	●	-	5113.321
ISO 8256 - tensile-impact								
2.0	2.6 to 3.2 m/s	●	-	5102.132	-	-	-	-
4.0	"	●	-	5102.131	-	-	-	-
7.5	3.4 to 4.1 m/s	-	-	-	●	●	-	5113.334
15.0	"	-	-	-	●	●	-	5113.333
25.0	"	-	-	-	●	●	-	5113.332
50.0	"	-	-	-	●	●	-	5113.331
Crosshead masses of 15 g, 30 g, 60 g, 120 g								
ASTM D 1822 - tensile-impact								
2.7		-	-	-	-	●	-	5113.374
5.4	approx.	-	-	-	-	●	-	5113.373
10.8	3.45 m/s	-	-	-	-	●	-	5113.372
21.6		-	-	-	-	●	-	5113.371

[1] The velocity at impact is 2.9 m/s using this pendulum

Zwick / Roell

Charpy test

Izod test



Tensile-impact test

These specimens can be used:
- unnotched
- notched
- reversed-notch

where notch types A, B and C are standardized.

Direction to blow:
The standards state out:
- edgewise impact
- flatwise impact
- normal impact
- parallel impact

Charpy impact strength

The method has a larger range of application than Izod and is more suitable for the testing of materials showing interlaminar shear fracture or exhibiting surface effects due to environmental factors. It is recommended in ISO 10350-1.

Tensile impact strength

Acc. to the ISO and ASTM standards, this method can be used for materials too flexible or too thin to be tested acc. to the Charpy or Izod method, and for more rigid materials in quality control and in production control.

Specimens are prepared from moulding materials or from finished or semi-finished products (mouldings, films, laminates, extruded or cast sheets)

Impact velocity and energy

The impact velocity is among the principal characteristics of a pendulum impact testing device.

For low capacity impact testers as mentioned in ISO 179-1 the impact speed of 2.9 m/s is achieved by using a shorter pendulum available for different base units of pendulum impact testers.

Higher capacity impact testers shall use higher impact velocities. The different velocities are given by raising the pendulum to two different angles:
- 124,4° for 3,46 m/s and
- 160° for 3,85 m/s.

Analogue or digital display

The pendulum impact testers can alternatively be equipped with an analogue display or with a calculator including a digital display.

Automatic pendulum recognition

Pendulum impact testers with calculator can be equipped with a device for automatic pendulum recognition. This optional function is very useful to ensure complete traceability of the test results if different pendulums are to be used. The pendulum recognition device attributes the method and the nominal impact energy to the measured loss-angle so that the result can be directly expressed in Joules.

***testXpert*® enhancement for comfortable protocolling and data storage**

Using a PC and testXpert® opens a large flexibility for creating comprehensive test protocols, statistics and graphics as well as data storage in currently used formats such as ASCII or ODBC for databases in LIMS systems.

Users of different Zwick test devices, (Universal testing machine, Melt flow tester, hardness testers, pendulum impact testers) gain the advantage of working with the same software interface and structure.

Zwick / Roell

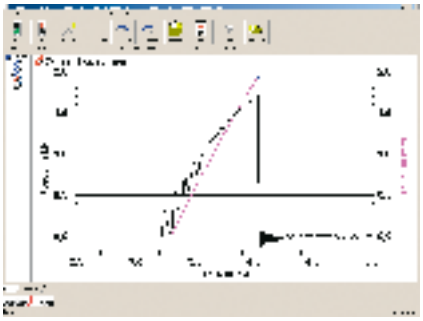
Instrumented Pendulum Impact Testers

The international standard ISO 179-2 specifies the instrumented pendulum impact testers for the Charpy method.

Using the standard instrumentation kit ImpactWin®, the striking edge of the pendulum is equipped with a strain-gauge-type force transducer able to measure the force during the instant of impact.

ImpactWin® - *testXpert*®

With this system, the load and displacement measuring signals are acquired at a high frequency, saved, speed, deflection and energy are evaluated. The comprehensive software allows a comfortable protocoling and recording, different graphic presentations and data storage.



Force and pendulum travel on a time scale

Pendulum impact tester Zwick 5113 (50 Joule) with digital display

Pendulum impact tester Zwick 5102 (5 Joule) with analog display

Rebound Resilience Tester Zwick 5109

The device is perfectly suitable for investigating the rebound resilience on rubber, elastomers and flexible cellular materials in accordance to the following standards:

- ISO 4662, DIN 53512: Rebound resilience of rubber and elastomers
- DIN 13014, DIN 53573: Rebound resilience of flexible cellular materials

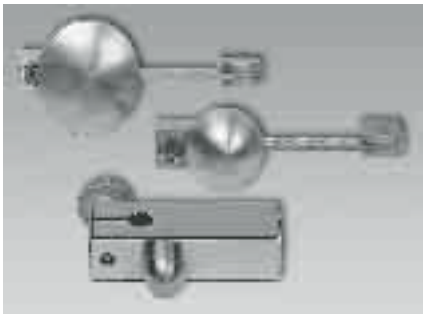
Specimen shapes

Rubber and elastomers are tested in form of circular or square plates from 28 to 50 mm. The specimen thickness should not exceed 15 mm. Flexible cellular materials are tested by taking square specimens 80 x 80 mm with a thickness of 50 mm.

Technical Data

Order no.:	Zwick 5109
Pendulum length:	200.4 mm
Release angle:	90°
Impact velocity:	1.98 m/s
Electr. connection:	220V/50Hz

Rebound resilience tester Zwick 5109 with digital display



Pendulums for different types of tests

Pendulum acc. to ISO 4662 and DIN 53512

Impact energy:	0,5 J
Pendulum mass:	252 g
Shape of impact fin:	hemisphere
Diameter:	15 mm
Application:	rubber, elastomers

Pendulum acc. to DIN 13014

Impact energy	0,196 J
Pendulum mass	101g
Shape of impact fin:	hemisphere
Diameter:	30 mm
Application:	mattresses

Options

Electrically heatable specimen fixtures (Ambient to 100 °C)

***testXpert*® - Extension for a comfortable protocol recording and data storage**

The use of a PC with *testXpert*® opens up a large flexibillity for the creation of comprehensive test protocols, statistics and graphics as well as data storage in generally used formats as ASCII or ODBC for databases in LIMS systems (LIMS: Labor Information Management System). Abrieb-Prüfmaschine

Abrasion tester

The abrasion tester conforms with the standard DIN 53516. It is used to evaluate the resistance of rubbers and elastomers to frictional wear.

The method consists to comparing the wear of an unknown test piece to that of a known material.

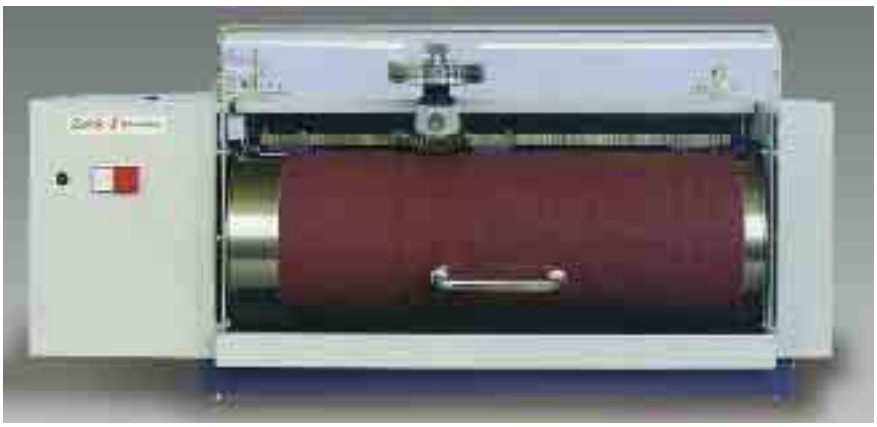
A sheet of abrasive paper is attached on the drum. The specimen is placed into a specimen holder, which enables the sample to move laterally and to rotate during the test. The necessary load is applied by a dead weight to the test-piece. The result is given by weighing the test piece before and after the test.

Technical data

Reference:	H04.6102.000
Sample diameter:	16 mm
Sample height:	6 ... 16 mm
Loading forces:	2.5/5/7.5/10 N
Lateral movement:	4.2mm/revolut.
Sample rotation:	0 / 0.9 rpm
Abrasion path:	20 or 40 m
Abrasion speed:	19.2 m/min
Drum diameter:	150 mm
Drum length:	460 mm

Accessories and options

- Abrasive sheet
- Sheet of rubber comparison sample (for approx. 100 samples)
- Circular cutting tool for use with a drilling machine
- Additional weights for loading forces 12.5 / 15 / 17.5 and 20 N
- Drum cleaning unit
- Precision balance (see chapter: dimension measurement)
- Dust cover



Abrasion tester Zwick 6102

Zwick / Roell

Hardness testers and hardness testing machines

In general, hardness is defined as the resistance of a material against the penetration of a specified indentor. Since hardness is not directly measurable, it is determined from other measurement variables such as penetration depth or penetration force. The determination of reproducible and comparable measurement values requires defined conditions, e.g. the shape and dimensions of the indentor and the force acting on it. The different conditions and requirements for practical application resulted in different hardness test methods.

Application ranges

Method	Hardness
Barcol, EN 59 ASTM D 2583	0 - 100
Shore A ISO 868	10 - 90
IRHD smooth ISO 48	10 -40
IRHD normal ISO 48	40 -98
Shore D ISO 868	30 - 90
Ball indentation hardness ISO 2039	8,6 - 467

Shore A and Shore D durometers

These hardness testers, using a spring-loaded indentor of two different shapes according to the definition of Shore A and Shore D, are available with analog display, optionally also with drag pointer indicating the maximum hardness value, as well as digital display and microprocessor for the data storage, statistical evaluation, printout and data transfer to a PC.

Shore A hardness testers are used for non-rigid to semi-rigid plastics and for rubbers and elastomers of a minimum thickness of 6 mm. Plastics showing greater hardness values shall be tested with the Shore D hardness tester or other convenient methods.

Analog Shore A and D hardness tester
Photo above: Hand-held devices
Photo middle: With test stand
Photo below: With control unit

Digital Shore hardness tester
Photo above: With integrated electronic unit, installed in the test stand
Photo below: Hand-held device with separate electronic unit and extended functionality

Test stand for Shore durometers

The manual hardness testers can be mounted into a test stand (additional device) to improve the repeatability of the test method by eliminating operator influences.

Attachable prisms for measurements on printing rollers

An attachable prism facilitates the measurement on drums and printing rollers.

Zwick / Roell

Control unit

In accordance to the standards, the spring characteristics and the display are to be controlled at regular intervals.

A simple control is obtained by using calibrated rings to verify the displayed value at a defined penetration
depth.

For the control of the spring characteristics, a special control unit is used.

Further scales according to Shore
Hardness testers according to ASTM D 2240

- with analogue display for Shore B, Shore C, Shore 0 and Shore 00
- with digital display for Shore B, Shore C, Shore 0, Shore 00 and Shore D0.

IRHD Micro Compact Hardness Tester Zwick 3103

This hardness tester is preferably used for O-rings, sealings, machined parts and flexible tubes of rubber, elastomers and plastics with a thickness from 0.5 to 5 mm. Thus, the hardness is determined as penetration at a defined force acting on the ball indentor (0.40 mm diameter).

Standards:
- ISO 48
- DIN 53512-2
- ASTM D 1415
- NF T 46003
- BS 903 part A26

Device configuration:
- Test stand with integrated electronics and LCD display
- Vertically adjustable support table
- Measuring device IHRD micro
- Quick adjustment for series tests

Options:
- Control unit
- Quick centering device for O-rings
- Centering device for rubber hoses
- Magnifying glass
- Manufacturer's test certificate according to DIN 53519-2

Digital IRHD/Shore hardness tester Zwick 3105 digi test

This device is a microprocessor-controlled hardness tester. It can be equipped with different measuring devices and indentors thus covering the following hardness scales

- IRHD-M (micro)
- IRHD-N (normal)
- IRHD-H (hard)
- IHRD-L (soft):
- IHRD-ss (supersoft)
- Shore A and Shore C
- Shore B and Shore D
- Shore D0 /0 / 00
- Shore 000

Standards:
- DIN 5305
- DIN 53519 page 1 and 2
- ISO 868
- ASTM D 2240
- ASTM D 1415
- NF T 51123
- NF T 46003
- BS903 part A26

Options:
- Control unit
- Quick centering device for O-rings
- Centering device for rubber hoses
- Magnifying glass with swivel arm
- Precision balances for different measuring ranges

IRHD Micro Compact hardness tester 3103

IHRD/Shore hardness tester 3105 digi test

Zwick / Roell

Pusey & Jones hardness tester Zwick 3108

With this device standardized according to ASTM D 531, the penetration depth of rubber and similar materials (e.g. rubber rollers, standardized blocks) with thicknesses from 13 mm are measured.

Indentor: Ball, diameter 3.175 mm
Loading weight: 1.000 ± 1 g
Reading unit penetration depth: 0.001 mm

Hardness tester 3108 acc. to Pusey & Jones

Barcol hardness tester Zwick 3350

The Barcol method is described in the standards EN 59 and ASTM D 2583. It is used for the testing of harder plastics (e.g. glass fibre reinforced plastics, thermosetting materials, hard thermoplastics).

Indentor: Truncated cone with a cone angle of 26° and a truncated cone surface diameter of 0.157 mm.
Test travel max. 0.76 mm.
The device is supplied with an electronic unit for the display and storage of the test data. A test stand is optionally available.

Ball indentation Hardness tester Zwick 3106

This method according to ISO 2039-1 is used for the testing of rigid plastics and ebonite. The range of application starts at approximately 60 Shore D. The ball indentation hardness may provide values for research, development, quality control and acceptance or rejection according to specification.

With this method, a ball with a diameter of 5 ± 0.02 mm is forced under a specific test load into the surface of a specimen. The penetration depth is measured under load and is related by an equation to the measured hardness in N/mm^2 .

Technical data:

Order no.:	Zwick 3106
Load application:	Weights
Loads:	49 / 132 / 358 / 961 / 1471 N
Pre-loads:	9.8 to 98 N
Standard ball:	5 mm
Further balls:	1.58 ...12.7 mm
Penetration depth measurement:	incremental
Resolution:	0.001 mm
Anvil diameter:	25 mm

Further standards using the ball indentation hardness tester:

- EN 10109: Rockwell hardness
- DIN 1168-2: Hardness of plaster
- DIN 1996: Indentation test method for asphalt
- DIN 51917: Rockwell hardness of carbon materials

Photo above: BARCOL hardness tester, installed in the test stand,
Photo below: Ball indentation hardness tester 3106

Zwick / Roell

Melt flow plastometers

Melt flow testers deliver standard values of melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastic materials under specified conditions of temperature and load. The MVR is normally useful when comparing filled and unfilled thermoplastics.

According to ISO 1133 the relationship between two values of MFR (MVR) measured at different loads is called flow rate ratio (FRR). It is commonly used as an indication of the way in which the rheological behavior is influenced by the molecular mass distribution.

Measurement principle

The thermoplastic material which is contained in a vertical cylinder, is extruded through a die by a loaded piston. A high precision balance can be used to determine the weight of the extruded filaments.

Standardized measurements

Method A, ISO 1133, ASTM D 1238

The time elapsed for each interval of cutting is measured, several extruded filaments are taken and the average mass is determined.
Equipment:
- basic melt flow tester
- timer
- balance
- Result: MFR in g/10min

Method B, ISO 1133, ASTM D 1238

a) measurement of the distance which the piston moves in a specified time
b) measurement of the time in which the piston moves a specified distance

Equipment:
- melt flow tester
- piston travel monitor
- timer
- known density at temperature
- Result: MVR in ccm/10min
  MFR using known density

Determination of density at melt temperature by combination of standardized methods

By combining method A and method B, using a piston travel monitor and a balance, it is possible to determine the MFR and the MVR value. As the relationship between MFR and MVR is the density at temperature, it is possible to calculate the density at melt temperature of the material.

Minimelt - the melt flow tester complying with method A

The melt flow testers series 4100 are designed for manual dead weight load application without measurement of the piston movement for PS, PS/HI, PE, PP, PC, PB, PET, PBT, POM, PMMA, E/VAC in the test conditions A, B, D, H, M, N, S, T, W, Z using maximum 5 kg load.

Available options:
- automatic filament cutting device including timer
- PC interface
- balance, verification thermometer,
- special dies and cylinder for PMMA

Plastometer type Zwick 4100 for measurements acc. to method A

Zwick / Roell

Zwick 4106 - the melt flow testers complying with method A and B

The Zwick 4106 melt flow testers cover the complete range of applications shown in the standards. Simplified operation is ensured by automatic load release devices controlled by a built-in microprocessor.

The optional weight change unit is specially designed for the use in quality control. In multi stage tests the weights can freely be selected from high to small loads or invers. Also, the travel and time for each test sequence is freely programmable.

Advantages:
- motor driven dead weight release
- good access for cleaning
- automatic result calculation
- pre-setting for heating time
- controlled piston positioning
- test parameter storage
- PC connection via RS232 interface

Available options:
- automatic weight changing unit
- PC interface, *testXpert*® software
- balance, verification thermometer
- special dies for PMMA
- Angular drilling machine for easy barrel cleaning

Cleaning of the extrusion barrel with an angle drill

Plastometer Zwick 4106 including piston travel measurement and weight release system for MFR and MVR determination

Plastometer Zwick 4106 including automatic, freely programmable weight change unit.

Zwick / Roell

ZMART – Zwick Modernization and Retrofit Technology

Modernization packages

With the modernization packages *ZMART.KIT®* and *ZMART.PRO®* both electro-mechanical and hydraulic materials testing machines of different manufacturers can be upgraded and brought to the most recent state-of-the-art. After a modernization the guaranteed spare parts supply for modernized components, the entire accessory program including extensometers or specimen grips and in particular also the most recent version of the test software *testXpert®* are available.

The decision regarding the purchase of a new machine and a modernization primarily depends on the value and technical condition of the machine components to be taken over. Due to the fact that in addition to the load frame other components can be used furthermore, as e.g.: load cell and extensometer, the costs for a modernization remain relatively low compared to the costs incurring for the purchase of a new machine.

The modernization packages are composed of the following components:

- Digital measurement and control electronics
- Test software *testXpert®*
- Maintenance-free AC-drives
- Proportional valves or servo valves and hydraulic units for hydraulic testing machines

Special features or services	*ZMART.PRO®*				
	testControl		Allround (DUPS)		
	M[1]	H[2]	M[1]	H[2]	I[3]
Connection to					
• Electro-mechanical testing machines	●	-	●	-	-
• Quasi-static hydraulic testing machines	-	●	-	●	●
• Can also be used without Personal Computer (PC)	●	●	-	-	-
• Can be used with up to 3 hydraulic testing machines	-	-	-	●	-
Test data acquisition and display					
• Test force and crosshead or piston travel resp.	●	●	●	●	●
Connection of:					
• Analog extensometers (inductive)	●	●	●	●	●
• Analog extensometers (strain gauge system)	●	●	●	●	●
• Incremental extensometers	●	●	●	●	●
• Several load cells (changeover via *testXpert®*)	●	●	●	●	●
Test data storage and processing					
• Display of maximum force and travel when reaching the test end criterion (without PC)	●	●	-	-	-
• Optional display of test force or stress, travel and/or deformation or strain (only with PC)	●	●	●	●	●
• Output of XY-curves with the coordinates force/stress, travel and/or deformation/strain or test time (only with PC)	●	●	●	●	●
• Automatic determination and documentation of materials characteristic data and statistical data (only with PC)	●	●	●	●	●
Test sequence and test speed control					
• Automatic recognition of the test end (specimen break, force-travel or time limit value or number of test cycles reached)	●	●	●	●	-
• Automatic stop at test end or return to start position	●	●	●	●	-
• Automatic speed changes according to the test program (only with PC)	●	●	●	●	-
• Test speed control in dependence on the measured force or deformation („closed-loop“-control), only with PC and optional program)	●	●	●	●	-
Monitoring of safety limit values					
• Test force	●	●	●	●	-
• Crosshead- resp. piston travel	●	●	●	●	-

[1] For electro-mechanical testing machines [2] For hydraulic testing machines, [3] Only data aquisition and display

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Services

Customer satisfaction is given top priority to at Zwick/Roell. Therefore, nearly one third of the employees are active in the service field. Extensive services guarantee the best use possible and a high availability of the supplied testing machines and systems.

Advice and support

Our technically competent and experienced service personnel support the user directly at site, by phone, fax or e-mail. Detailed information may also be looked up in the internet or may be downloaded in case of need.

Maintenance and repair

A service contract with individually agreed service intervals for a careful and thorough maintenance and calibration guarantees the correct and trouble-free operation of the supplied testing machines and systems. Whereby it is not important which manufacturer supplied the testing machine. In case of a malfunction, a service-engineer or – technician is quickly available at site. Modern auxiliary means such as a telediagnostic service via modem allow a quick and exact fault localization at an early stage. Different reaction models guarantee the availability of a technician within the shortest period of time possible.

Calibration service according to ISO 9000

The Zwick/Roell maintenance and calibration service is accredited as DKD[1)]-, UKAS[2)] or COFRAC[3)] calibration laboratory resp. Thus, it is authorized to check the testing machines and systems at the place of installation and to issue DKD or UKAS calibration certificates for the measured quantities force, extension, energy and hardness. These calibration certificates are not only recognized within the European Union, but also in almost every country of the world.

Particular advantage:
The technicians of the calibration service can, on the occasion of their service visit, not only service, adjust and calibrate the Zwick/Roell testing machines and systems, but also the machines and systems of other manufactures. This saves time and costs.

The regular maintenance and calibration of the testing machines is also a prerequisite for a quality management system according to QS-9000 and VDA 6.1.

Hotline – Quick assistance in case of malfunctions

For Zwick/Roell, the perfect functioning of the testing machine is very important. Should, in spite of the high quality standard, any malfunctions occur on the machine or within the software, then competent specialists are available on the free hotline.

Creation and adaptation of test programs

With the test software of the Zwick/Roell Group already many different test programs can be acquired. The test requirements are however not always standardized. Experts will adapt your existing test programs individually or will create a new test program which is tailor-made to comply with your requirements.

Seminars

Studies have shown that more than half of the problems with technical systems are not caused by the technology itself, but rather by the user. A good training of the users helps to avoid troubles and, as a result, to reduce the costs.

The Zwick/Roell seminars inform about theory and practice of the materials and component part testing, the evaluation and the valuation of the test data, test results and the operation and maintenance of the testing devices. These seminars either take place directly at the user's place or at the locations of Zwick/Roell companies or representations.

Support line – Assistance for operation and application

Alternatively to the visit of a seminar or to the service visit of a technician at site, you can talk to our experts on the support line – against charge – whenever you have any questions. They will assist you with the adaptation of the test software, with the creation of test programs, when having questions regarding the operation of the software or the machine and they will give you an application-specific support.

Spare parts

Standard components are mostly available on stock and will be sent to you by courier service on the day of order. Special components, not being carried on stock, will be manufactured „just in time“ by means of the latest production technology.

[1)] DKD: Deutscher Kalibrier-Dienst (German Calibration Service)
[2)] UKAS: United Kingdom Accreditation Service
[3)] COFRAC: Comité Francais d´Accreditation

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Annex: Overview of standards and test equipment

Subject	Standard	Testing device	Page
Testing equipment: design, verification, accuracy, environmental conditions			
• Tensile, compression and bending machines	ISO 5893, ISO 7500-1, ASTM E 4, ISO 9513		
• Impact testing machines	ISO 13802, JIS B7756, EN 10045-2		
• Standard atmospheres for testing	ISO 291, JIS K 7100, ASTM D 618		
• Conditioning and test conditions for rubber	ISO 471, DIN 53500, ASTM D 1349, ASTM D 832		
• Performing of round robin tests	ASTM E 691		
• Temperature devices for rubber testing	ISO 3383		
Sample preparation			
• Injection moulding	ISO 294-1/-2/-3/-4	Injection moulding machine	-
• Compression moulding	ISO 293, ISO 295	Moulding press	-
• Machining	ISO 2818	Cutting press	11
• Rubbers	ISO 4661-1, ASTM D 1485, ASTM D 3183	Cutting press	12
• Multipurpose test specimen for plastics	ISO 3167, JIS K 7139		12
• Test specimen for PS	ISO 1622-2		-
Dimension measurement			
• Multipurpose specimen	ISO 527-1, ISO 16012, ASTM D 5947	Micrometer	16
• Thickness of plastic film	ISO 4593, DIN 53370, ASTM D 374, ISO 4591, ASTM E 252	Dead weight thickness gauge, balance	16/18
• Rubbers	ISO 37, ISO 4648, DIN 53504, DIN 53534, ISO 3302, ASTM D 3767,	Dead weight thickness gauge, balance	16/18
• Cellular plastics and rubbers	ISO 1923, DIN 53570	Dead weight thickness gauge, vernier calipper	16
Thermoplastic and thermosetting plastics			
• Tensile properties	ISO 527-1/-2, ASTM D 638, ASTM D 1708, EN 2747	Material testing machine	18
• Poissons ratio	ISO 527, ASTM E 132	Material testing machine	
• Flexural properties (1 point method)	ASTM D 747	Material testing machine	18
• Flexural properties (3 point method)	ISO 178, ASTM D 790M, ASTM D 5934	Material testing machine	18
• Flexural properties (4 point method)	ASTM D 6272	Material testing machine	18
• Compression properties	ISO 604, ASTM D 695	Material testing machine	18
• Shear properties	ASTM D 732	Material testing machine	18
• Creep behaviour, tensile	ISO 899-1, ASTM D 2990	Material testing machine	18
• Creep behaviour, flexural (3 point method)	ISO 899-2, ISO 6602	Material testing machine	18
• Creep behaviour, compression	ASTM C 1181	Material testing machine	18
• Dynamic mechanical properties	ISO 6721-4/-5/-6, ASTM D 5023, ASTM D 5024, ASTM D 5026, DIN 53442	Servohydraulic testing machine	43
• Fracture toughness	ISO 13586, ASTM E 813	Material testing machine	18
• Barcol hardness	EN 59, ASTM D 2583	Barcol hardness tester	50
• Ball indentation hardness	ISO 2039-1	Ball indentation hardness tester	50
• Rockwell hardness (R, L, M, E, K)	ISO 2039-2, ASTM D 785	Instrumented hardness tester	-
• Rockwell α hardness	ISO 2039-2, ASTM D 785	Instrumented hardness tester	-
• Instrumented hardness	ISO 14577-1, DIN 50359-1	Instrumented hardness tester	-
• Shore A- and Shore D-hardness	ISO 868, DIN 53505, ASTM D 2240, ISO 7619, ISO 21509	Shore hardness tester	48
• Shore B, C, 0, 00, D0	ASTM D 2240	Shore hardness tester	48

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Subject	Standard	Testing device	Page
• Pendulum impact strength, Charpy	ISO 179-1, ASTM D 6110	Pendulum impact tester	44
• Pendulum impact strength, Izod	ISO 180, ASTM D 256	Pendulum impact tester	44
• Pendulum impact strength, tensile	ISO 8256, ASTM D 1822	Pendulum impact tester	44
• Impact brittleness temperature	ISO 974	Pendulum impact tester	44
• Instrumented impact strength, Charpy	ISO 179-2	Pendulum impact tester	44
• Falling dart test	ISO 6603-1, ASTM D 5628, ASTM F 736	Drop weight impact tester	-
• High speed impact tests	ISO 6603-2, ASTM D 5420, DIN 53443-2,	Drop weight impact tester,	-
	ASTM D 3763, ASTM D 5628	High speed testing machine	-
• High speed tensile test	ISO/CD 18872	High speed testing machine	-
• Melt index (MFR, MVR, FRR)	ISO 1133, ASTM D 1238	Melt flow Plastometer	51
• Determination of density	ISO 1183-1	Density kit	18
• Vicat softening temperature (VST)	ISO 306, EN 2155-14, JIS K 7206,	Vicat VST apparatus	-
	ASTM D 1525		
• Temperature of deflection	ISO 75	Vicat HDT apparatus	-
Rubbers and elastomers			
• Tensile properties	ISO 37, ASTM D 412, DIN 53504	Material testing machine	18
• Tensile, rubber condoms	ISO 4074	Material testing machine	18
• Test methods for rubber threads	ISO 2321, ASTM D 2433	Material testing machine	18
• Tension set	ISO 2285, ASTM D 412	Material testing machine	18
• Compression properties	ISO 7743, ASTM D 575	Material testing machine	18
• Compression set	ISO 815, ASTM D 395, ASTM D 1229	Material testing machine	18
• Tear properties, Graves method	DIN 53515, ASTM D 624, ISO 34	Material testing machine	18
• Tear properties, trouser, angle, crescent	ISO 34-1	Material testing machine	18
• Tear properties, Delft	ISO 34-2	Material testing machine	18
• Adhesion properties	EN 28033, ISO 814, ISO 5600, ISO 5603,	Material testing machine	18
	ISO 8033, ASTM D 429, ASTM D 1871,		
	ASTM D 413, ISO 813		
• Analysis of multi peak traces	ISO 6133	Calculations	
• Shear properties	ISO 1827	Material testing machine	18
• Creep, relaxation	ISO 3384, ISO 8013, DIN 53537, ISO 6914	Material testing machine	18
• Friction properties	ISO 15113	Material testing machine	18
• Visko-elastic properties	ISO 4664, DIN 53513, DIN 53 535	Servohydraulic testing machine	43
• Fatigue	ASTM D 430, ASTM D 4482		
• Test methods for O-rings	ASTM D 1414		
• Requirements for pipe joint seals	EN 681		
• IRHD hardness	ISO 48, ISO 7619, ASTM D 1415, DIN 53519	IRHD hardness tester	49
• Shore A and D hardness	ISO 868, ISO 7619, ASTM D 2240,	Shore hardness tester	48
	DIN 53505, ISO/CD 18898		
• Shore B, C, D0, 00, 000, 000-S, R hardness	ASTM D 2240	Shore hardness tester	48
• Pusey & Jones hardness	ASTM D 531	Pusey & Jones hardness tester	
• Abrasion resistance	ISO 4649, DIN 53516	Abrasion tester	47
• Rebound resilience	ISO 4662, DIN 53512, ASTM D 1054	Rebound resilience tester	46
• Density	ISO 2781, ASTM D 792, DIN 53479	Density kit	18

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Subject	Standard	Testing device	Page
Rubber or plastic coated fabrics			
• Tensile properties	ISO 1421, ASTM D 751	Material testing machine	18
• Adhesion properties	ISO 36, ISO 4637, ISO 4647, ASTM D 413	Material testing machine	18
• Blocking resistance	ISO 5978, EN 25978	Material testing machine	18
• Tear resistance	ISO 4674, ASTM D 751, DIN 53356	Material testing machine	18
Rigid cellular plastics			
• Test methods	ISO 9054, ISO 7214		-
• Tensile properties	ISO 1926, ASTM D 1623	Material testing machine	18
• Flexural properties	ISO 1209-1/-2, JIS K 7221	Material testing machine	18
• Shear strength	ISO 1922, DIN 53427	Material testing machine	18
• Compression properties	ISO 844, ASTM D 1621	Material testing machine	18
• Compression creep test	ISO 7616, ISO 7850	Material testing machine	18
• Thickness measurement	EN 12431	Material testing machine	18
• Pendulum impact strength	ISO 179	Pendulum impact tester	44
• Density	ISO 845, ASTM D 1622	Balance	18
Flexible cellular polymeric materials			
• Tensile properties	ISO 1798, ASTM D 3574-E	Material testing machine	18
• Compression properties	ISO 3386-1, ISO 3386-2, ASTM D 3574-C, ASTM D 1055	Material testing machine	18
• Indentation properties (hardness)	ISO 2439, DIN 53577, DIN 53579-1 ASTM D 3574-B, ASTM D 3579	Material testing machine	18
• Compression load deflection	ISO 11752	Material testing machine	18
• Tear strength, trouser specimen	ISO 8067, ASTM D 3574-F	Material testing machine	18
• Creep in compression	ISO 10066, ISO 1856	Material testing machine	18
• Rebound resilience	DIN 13014	Rebound resilience tester	18
• Constant load pounding	ISO 3385		
• Accelerated ageing tests	ISO 2440		
• Dynamic cushioning performance	ISO 4651	Drop weight impact tester	-
• Appearant density	ISO 845, ASTM D 3574-A	Balance	18
Reinforced plastic composites			
• Tensile properties	ISO 527-4/-5, ISO 4899, ISO 14129, ASTM D 3039, ASTM D 3916, ASTM D 5083, DIN 65378, DIN 65466	Material testing machine	18
• Hole opening properties	DIN 65562	Material testing machine	18
• Compression properties	ISO 14126, DIN 65375, DIN 65380, ASTM D 3410	Material testing machine	18
• Flexural properties	ISO 14125, ASTM D 4476, DIN 53390	Material testing machine	18
• Interlaminar shear strength	ISO 14130, EN 2377, EN 2563, JIS K 7078, DIN 65148, ASTM D 4475	Material testing machine	18
• Shear strength	ASTM D 3846, ASTM D 3914, DIN 53399-2	Material testing machine	18
• Shear modulus	ISO 14129, ASTM D 3518, JIS K 7079	Material testing machine	18
• Fracture toughness, K_c, G_c (LEFM),J-R	ISO 13586, NASA R.P.1092, ISO 17281, ASTM D 5045, ASTM D 6068	Material testing machine	18
• Fatigue properties	ISO/DIS 13003, ASTM D 3479	Servohydraulic testing machine	18

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Subject	Standard	Testing device	Page
Thin sheetings and films			
• Tensile properties	ISO 527-3, ASTM D 882, ASTM D 5323	Material testing machine	18
• Tear resistance, Graves, angle specimen	ISO 34, DIN 53515	Material testing machine	18
• Tear resistance, trouser specimen	ISO 6383-1, ASTM D 1004, ASTM D 1938	Material testing machine	18
• Tear resistance, trapezoidal specimen	EN 495-2, DIN 53363	Material testing machine	18
• Blocking strength	ISO 11502, DIN 53366, ASTM D 3354	Material testing machine	18
• Puncture tests	pr EN 14477, ASTM D 5748, ASTM F1306	Material testing machine	44
• Pendulum impact strength, tensile	ISO 8256, ASTM D 1822	Pendulum impact tester	-
• Impact resistance, free falling dart	ISO 7765-1/-2, ASTM D 4272 ASTM D 1709, ASTM D 3763, JIS K 7124 DIN 53373	Dead weight impact tester	
• Coefficient of friction	ISO 8295, ASTM D 1894, JIS K 7125, DIN 53375	Material testing machine	18
Plastic piping			
• Specifications for pipes	EN 1555, EN 1852		
• Tensile properties	ISO 6259-1/-2/-3, ISO 8521, ISO 8513, ISO 8533, ASTM D 2105, ASTM D 2290, EN 1393, EN 1394	Material testing machine	18
• Compression properties	EN 802, EN 1446, ISO/DIS 4435, DIN 53769-3, ASTM D 2412	Material testing machine	18
• Flexural strength	EN 12100	Material testing machine	18
• Creep test	ISO 7684, EN 761, EN 1862	Material testing machine	18
• Ring stiffness	ISO 9969, ISO 9968, ISO 13967, EN 1226, EN 1227, EN 1228, ASTM D 5365	Material testing machine	18
• Cyclic compression test	ASTM D 2143		
• Vicat softening temperature	EN 727	Vicat VST apparatus	-
• Impact characteristics	EN 744, EN 1411, EN 12061, ISO 3127, ASTM D 2444	Dead weight impact tester	-
• Melt flow index	ISO 4440-1/-2	Melt flow Plastometer	
Adhesives			
• Tensile properties (butt joints)	ISO 6922, EN 26922, EN 1940, EN 1941, EN 14410	Material testing machine	18
• Peel resistance	ISO 4578, ISO 8510-1/-2, ISO 11339 EN 1464, EN 1939, EN 28510-1/-2, EN 60454-2	Material testing machine	18
• Contact adhesion	EN 1945		
• Shear strength	ISO 4587, ISO 10123, EN 1465, ISO 11003, ISO 13445, ASTM D 3163, ASTM D 3164	Material testing machine	18
• Bending-shear strength	ISO 15108	Material testing machine	18
• Creep properties	ISO 15109	Material testing machine	18
• Shear impact strength	ISO 9653, EN 29653		
• Fatigue properties	ISO 9664	Servohydraulic testing machine	43
• Resistance to flow	ISO 14678		

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Further informations about standards	
DIN:	www.din.de
AFNOR:	www.boutique.afnor.fr
BS:	www.bsi-global.com
ASTM:	www.astm.org
JSA:	www.jsa.or.jp, www.webstore.jsa.or.jp
CEN:	www.cenorm.be
ISO:	www.iso.ch