Zwick / Roell

Intelligent testing

Reliable Test Results

testXpo 2016

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Reliable Test Results - Agenda

Zwick / Roell

Reliable test results are a fundamental and highly topical aspect of materials testing.

Using suitable examples we would like to show you how we view this topic, what we are doing in support of it and what practical use this is to you, our customers.

We would like to consider the following questions.

- *Terminology/definition - what does 'Reliable Test Results' actually mean?*

- *Examples - you will see examples of solutions which will help to make your test results accurate, repeatable, reproducible and traceable.*

- *Customer benefits - what advantages do reliable test results offer?*

Terminology – reliable test results

Reliable Test Results rest on 4 key overriding themes.

accurate

repeatable

reproducible
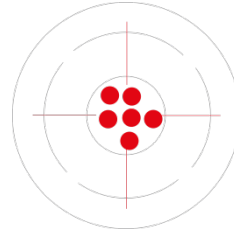
Video

traceable

Definition: accurate

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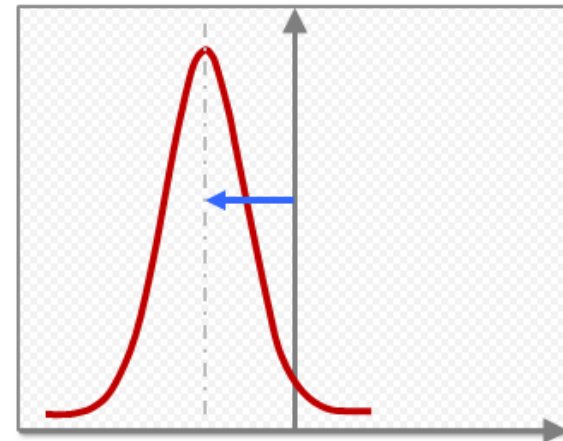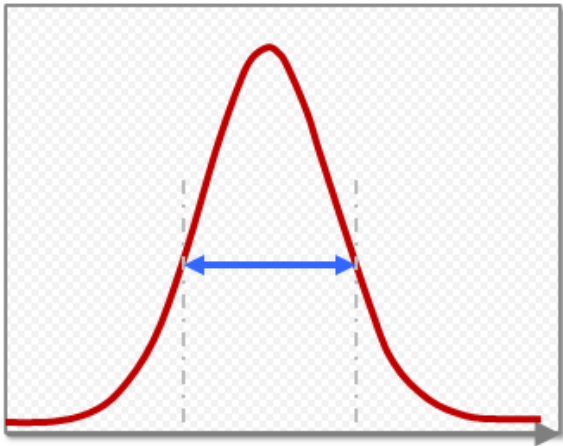## Measurements which are 'precise, <u>and</u> 'true' are 'accurate'.

- **Precision**
  the closeness of agreement between independent test results obtained under stipulated conditions

- **Trueness**
  the closeness of agreement between a quantity value obtained by measurement and the true value of the measurand

Definition: accurate

Measurements which are 'true' and 'precise' are 'accurate'.

True but not precise
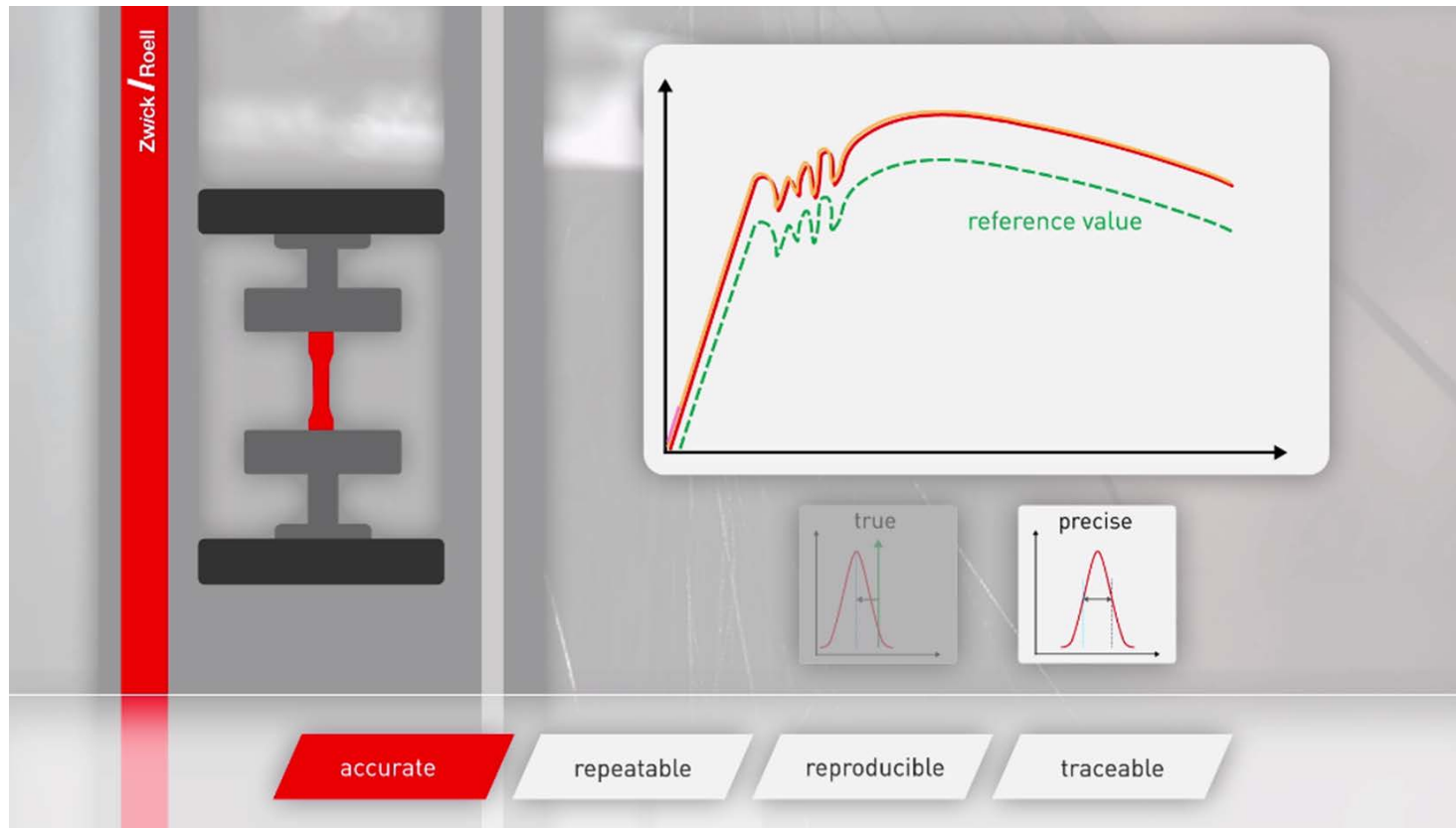
Precise but not true
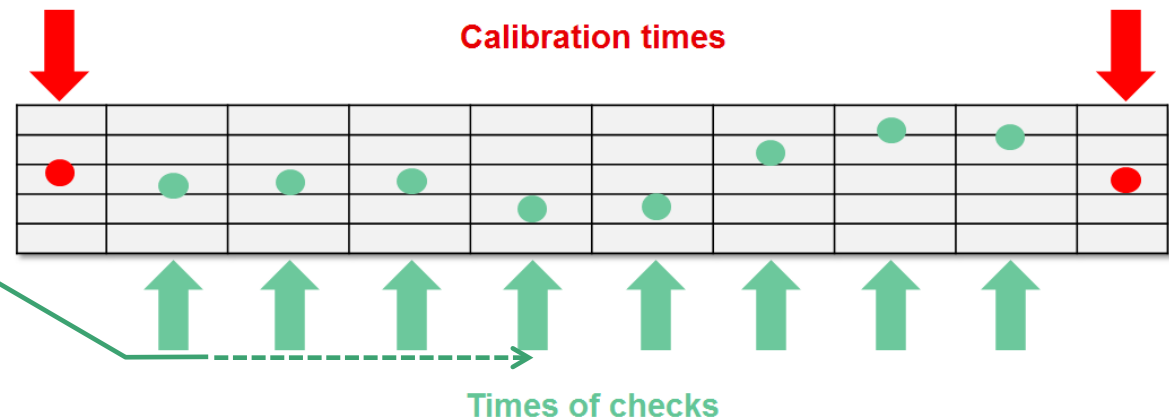
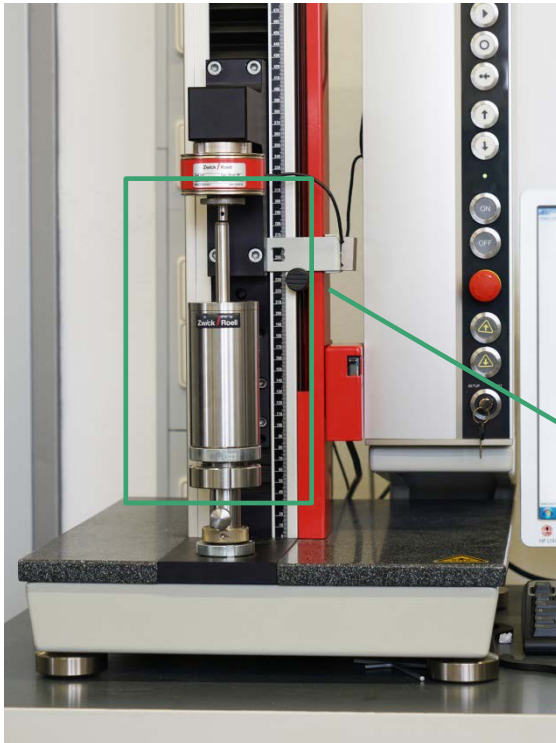**Not true and not precise**

True and precise

Definition: accurate

Individual test results which are close to each other and in average are close to the reference value, are accurate.

Example: accurate – regular checks

Regular checks ensure that test results are only obtained using correctly functioning testing equipment.

Calibration times

Times of checks

ⓘ testXpert II suppports regular checks. The result can be stored and documented together. An overview is available whenever required.

Example: accurate – testXpert II correction curve Zwick / Roell

Accurate results are ensured by means of automatic real-time correction of machine deformation.
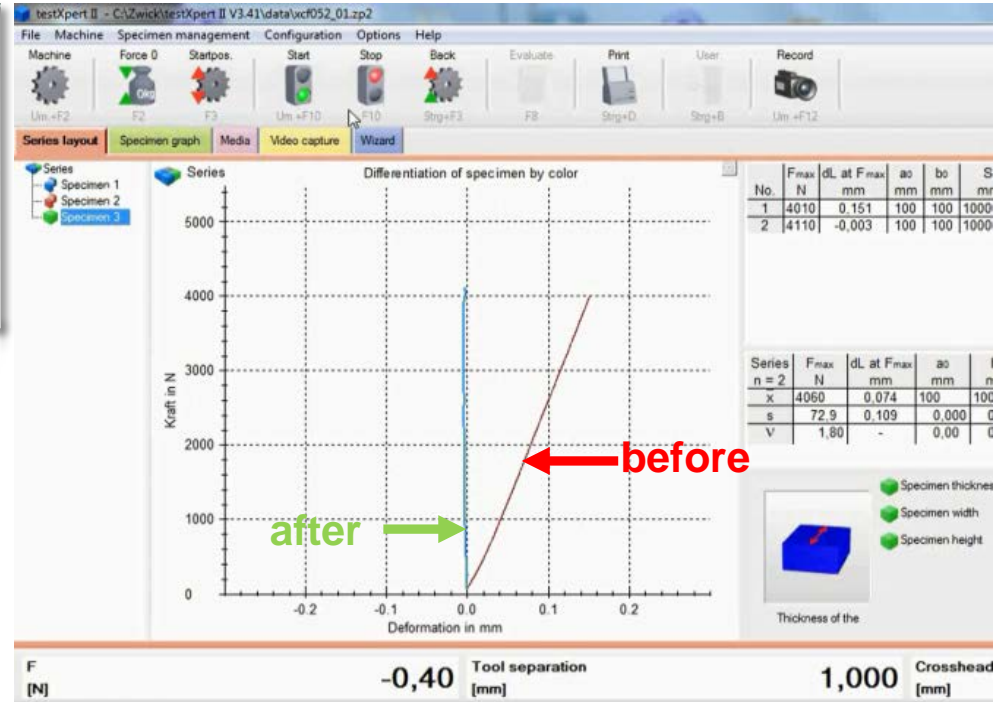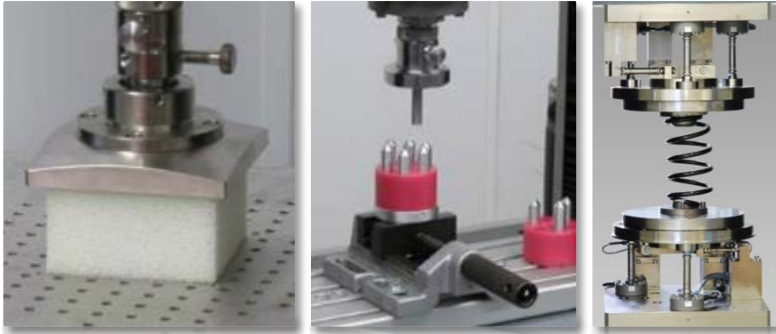

_i_ maximum possible displacement measurement and positioning accuracy in compression tests using the crosshead travel encoder.

_i_ control is directly through the corrected channel, allowing displacement targets to be attained exactly

Example: accurate – testXpert II alignment SW

Zwick / Roell

In the case of brittle specimens, or in creep and fatigue tests, the exact alignment of the load string is critical to obtaining accurate test results.
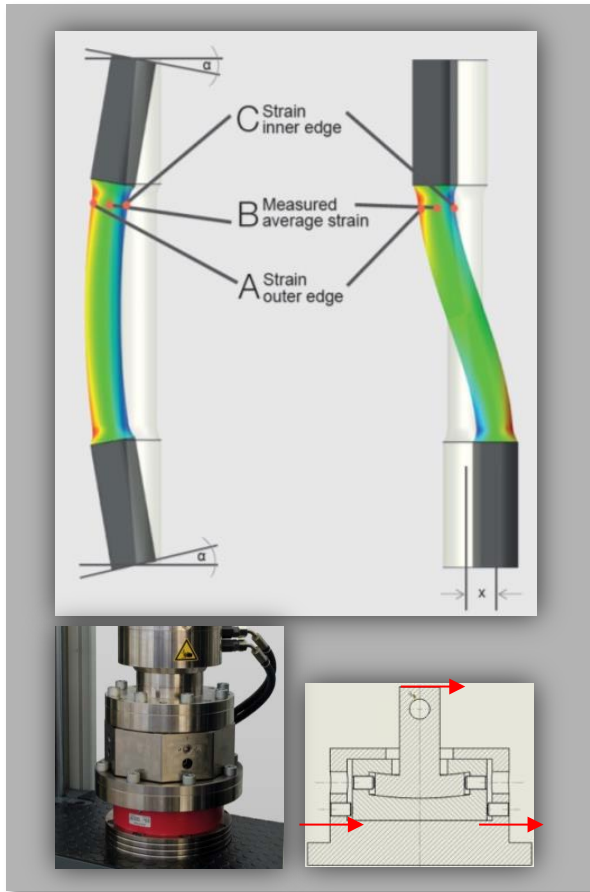
Correct specimen alignment

- determination of angular error and offset error using a strain-gaged alignment transducer

- mechanical correction via alignment unit + software (testXpert II)
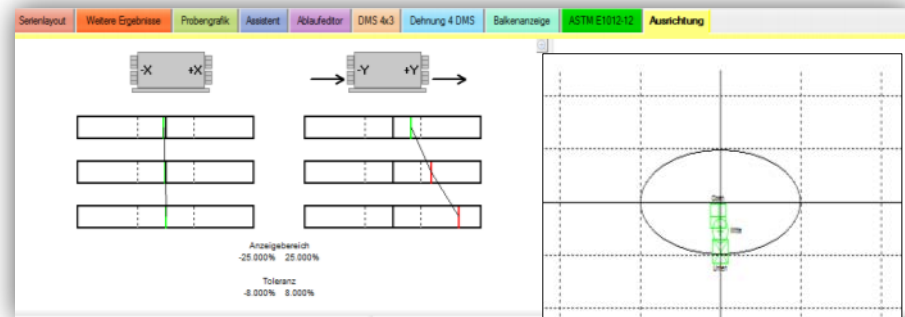
Example: accurate – measuring tensile modulus Zw*i*ck / Roell

The severe demands of tensile modulus measurements on plastics mean that high-accuracy extensometers are an essential requirement

Requirements

- calibration as per ISO 9513, Class 1

- determination of tensile modulus measured distance with an accuracy of ± 1%
  (ISO 527:2012, normative Annex C)

$$E = \frac{\Delta\sigma}{\Delta\varepsilon}$$
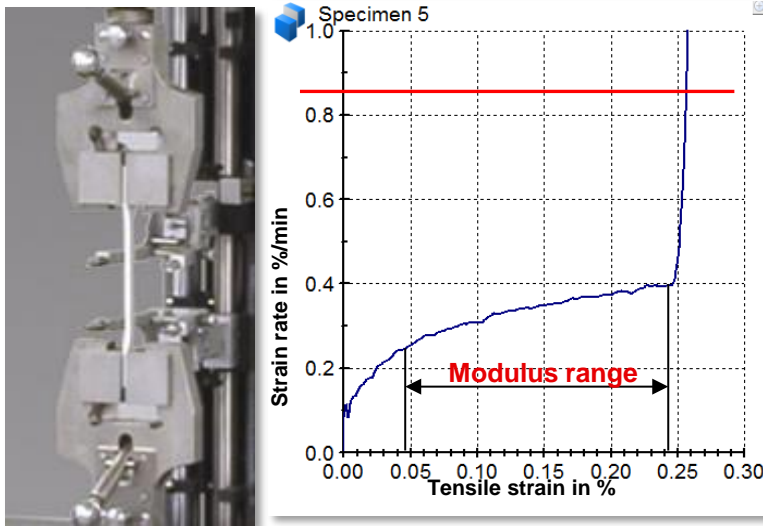
Graph as per ISO 527-1, Fig. 2
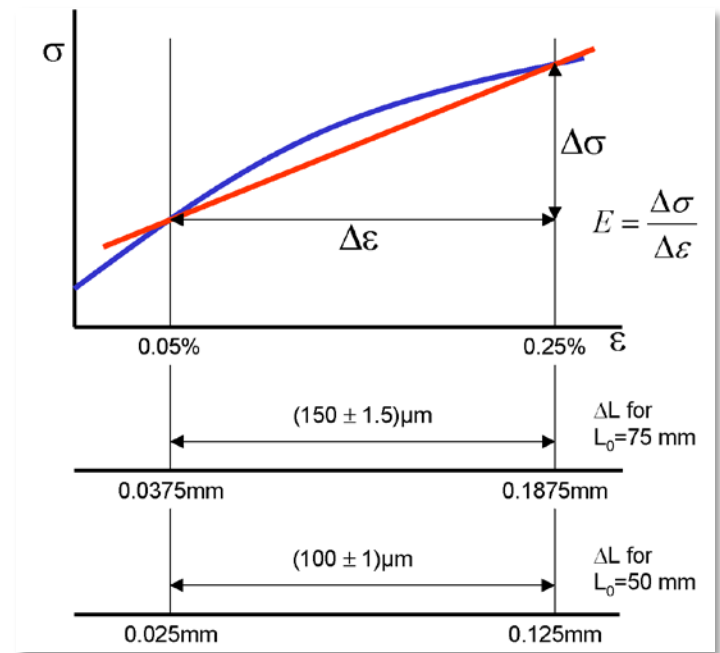
Determination of the tensile modulus of plastics is performed using both, contact and non-contact extensometers.

Example: accurate – measuring tensile modulus Zwick / Roell

Accurate strain rates can be achieved by use of parallel closing grips. This is important when testing viscoelastic materials.
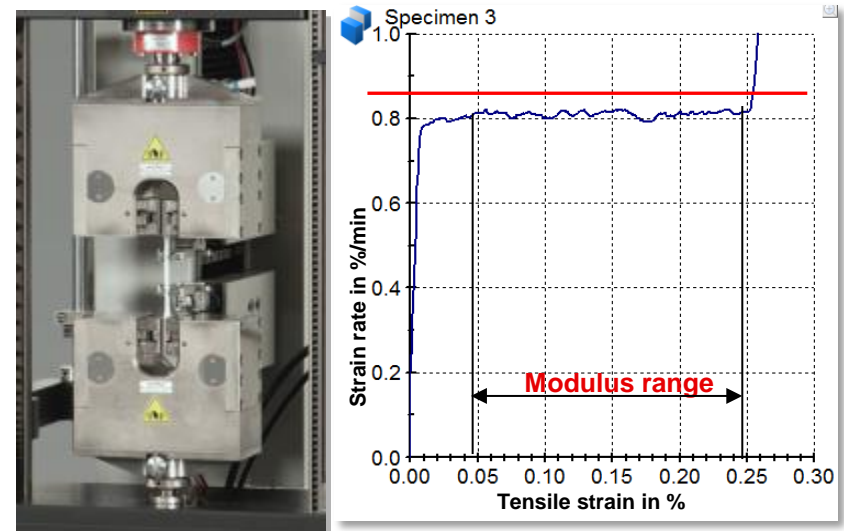
Precise tensile modulus results

The strain rate is constantly too low, due to the movement of the wedges.

The laboratory generates precise, but not true results.

Accurate tensile modulus results

Parallel closing grips constantly provide the correct strain rate.

The laboratory generates precise and true and therefore accurate results.

Example: accurate – strain rate control

laserXtens Array is a universal non-contacting extensometer for accurate strain measurement according to latest ISO standard

- Initial gage length from 1.5 mm – 240 mm for smallest samples

- Multiple cameras guarantee a wide FOV and high resolution measurements

- Reliable strain rate controlled test speeds
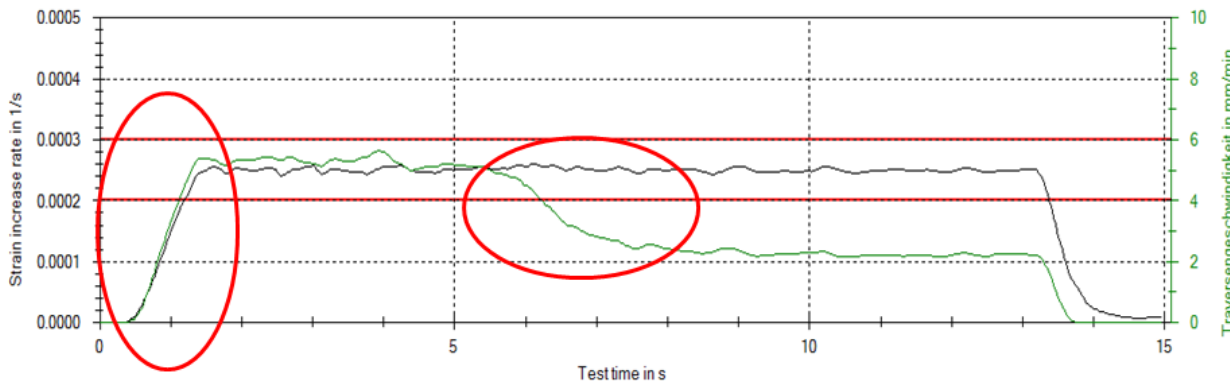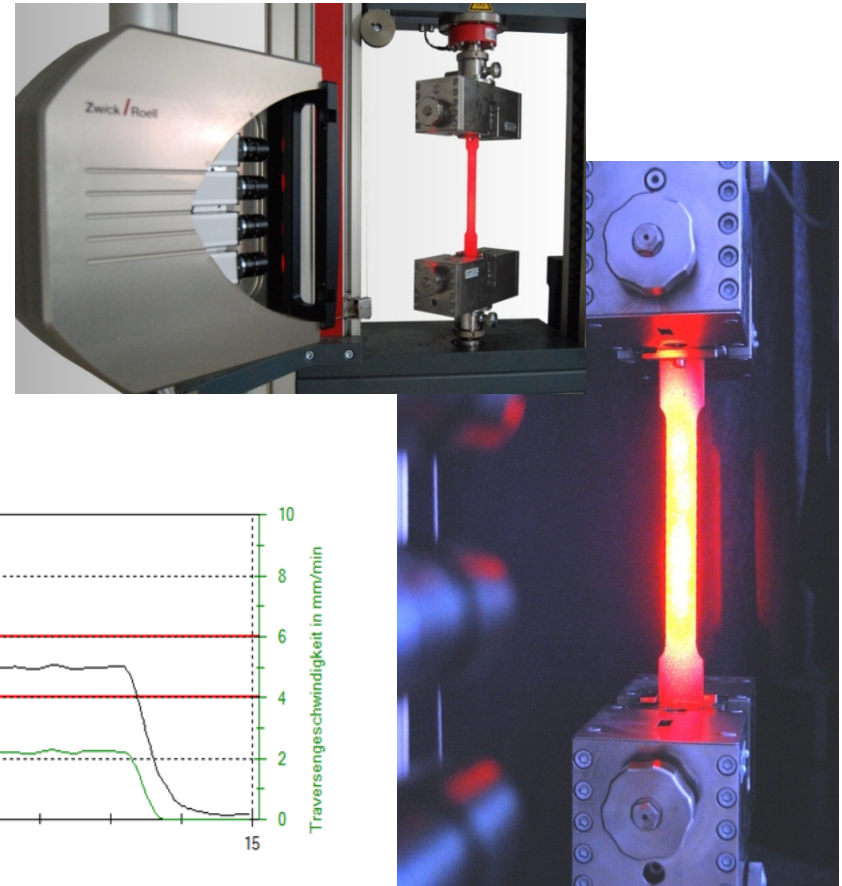
Definition: repeatable

'Repeatable' refers to a statistical measure for measurements in a laboratory over a short period under the same conditions, usually with a single operator and testing instrument.

- **Repeatable = precision under repeat conditions**

  - the same measurement procedure

  - the same operator

  - the same measuring equipment

  - the same location

  - the same test conditions

  - repetition of measurements within short time intervals
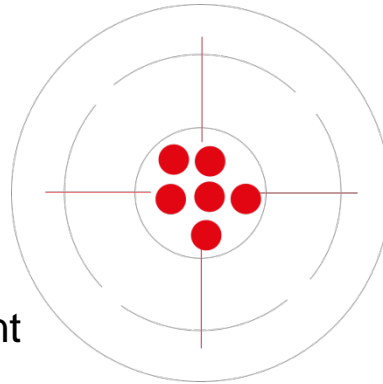
Definition: repeatable

The same measurement procedure, the same operator, the same measuring equipment, the same location and the same test conditions. The repetition of measurements within short intervals of time is the only variable factor.

accurate   repeatable   reproducible   traceable

Example: repeatable – automation

By automating tests, optimum test-result repeatability is achieved.

During a comparison between a manual testing machine and an automated testing machine at a customer, significant improvements in standard deviation σ were achieved.

- Tensile, flexural testing
- Barcode identification
- Easy change between automatic and manual operation.
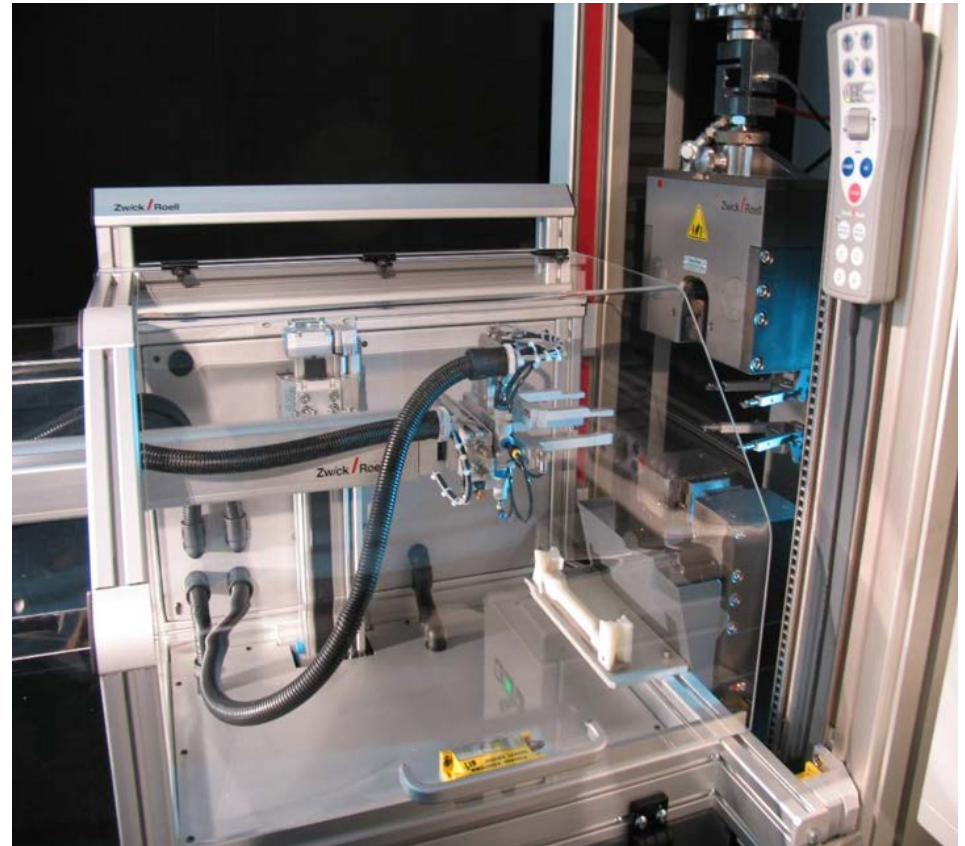
Automated testing ensures highly uniform insertion of specimens into the testing machine and exact repetition of test sequences.

Example: repeatable – compression test

Zwick / Roell

Compression tests on long-fiber-reinforced composites are particularly demanding; the correct test fixture is an essential requirement.

- Specimen alignment must be very accurate to prevent bending and buckling during the test.

- An axial offset of just 10 μm will result in an invalid test to ASTM D6641 due to bending.


IITRI compression fixture, ASTM

Celanese compression fixture
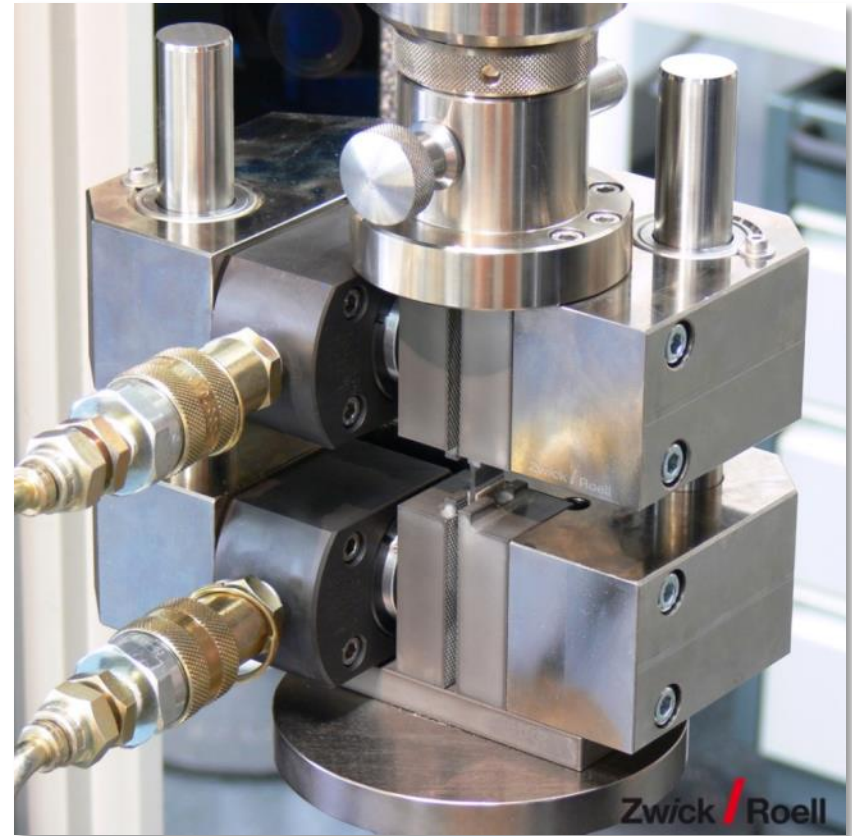
HCCF – Hydraulic Composites Compression Fixture

Example: repeatable – compression test

Zwick / Roell

The HCCF enabled considerably more valid tests to be performed compared with the Celanese compression fixture.

Test conditions

- specimen as per compression test standard prEN 2850

- specimen geometry A1 (10 x 2 mm)

- 18 measurements per fixture

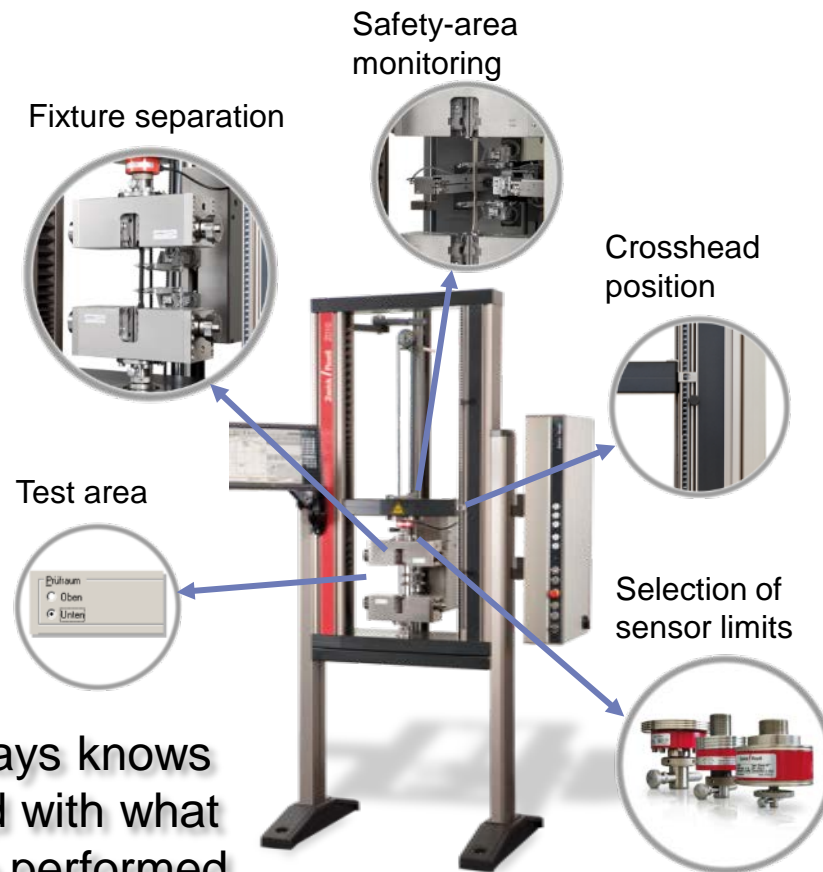- force application: shear loading via tabs

Objective: evaluation of bending criterion at 10 %F$_{max}$
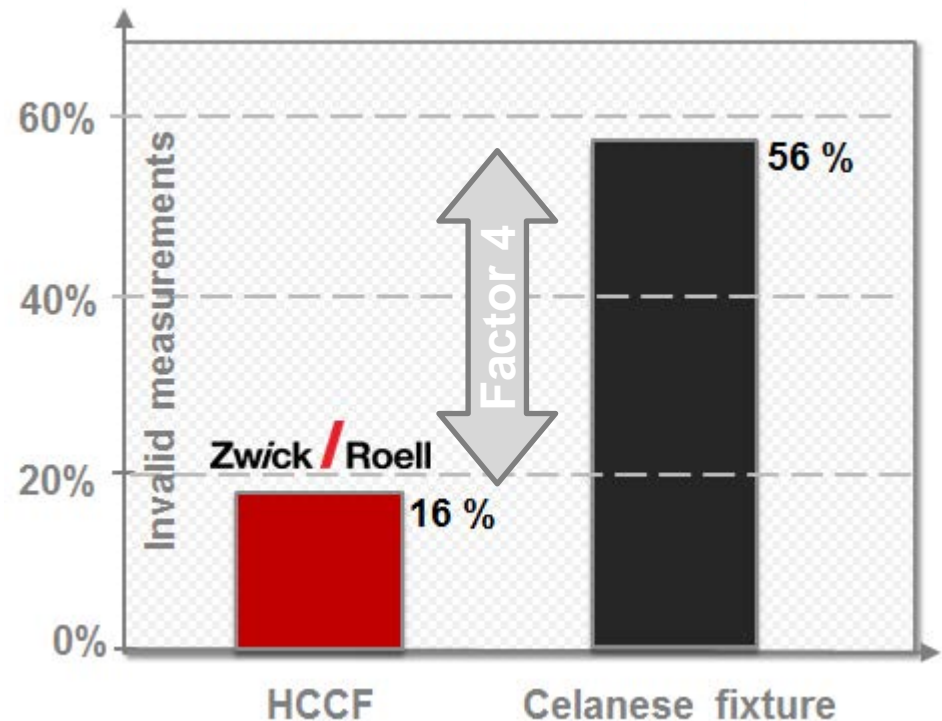
i A statistically assured result is achieved with significantly fewer specimens.

Example: repeatable – test environment concept

The testXpert II test environment concept guarantees an identical test configuration every time, enabling optimum test-result repeatability.

Safety-area monitoring

Fixture separation

Crosshead position

Test area

Selection of sensor limits

i testXpert II always knows how, where and with what the test is to be performed.

Example: repeatable – Specimen grips

Patented hydraulic grips allow repeatable test of standard and even very short specimen sizes.
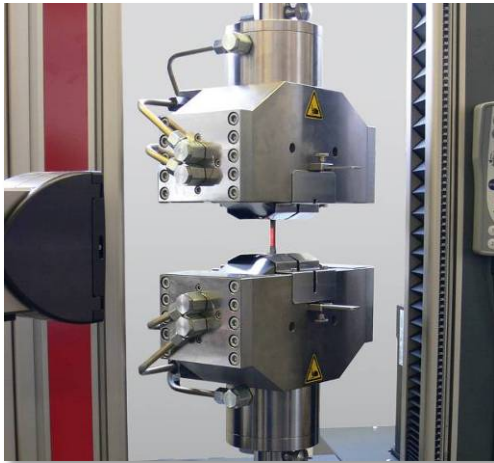

- Material savings due to shorter clamping length
- Small specimens taken from components can be tested
- No visual or physical obstructions for optical or mechanical extensometers, even with very short grip-to-grip-separation

Stabilizing force

Gripping force

Gripping force

Specimen with short clamping length
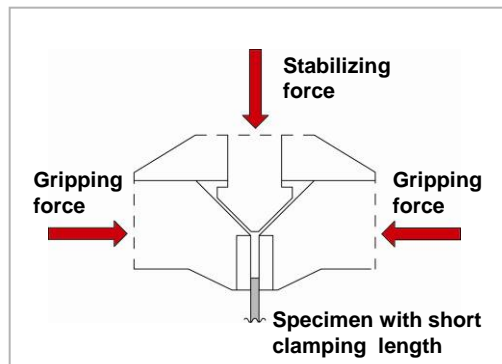
The gripper actuators are stabilized and kept parallel by a third actuator.

Example:
Shoulder width 20 mm,
Fmax 50 kN,
Gripping force 100 kN
➔ Required clamping length only 6 mm!
(surface pressure up to 1,000 N/mm²)

Standard specimen grips

Short-clamping specimen grips

Jaw

Jaw surface area

a

40 mm

b

Specimen

b

c 6 mm
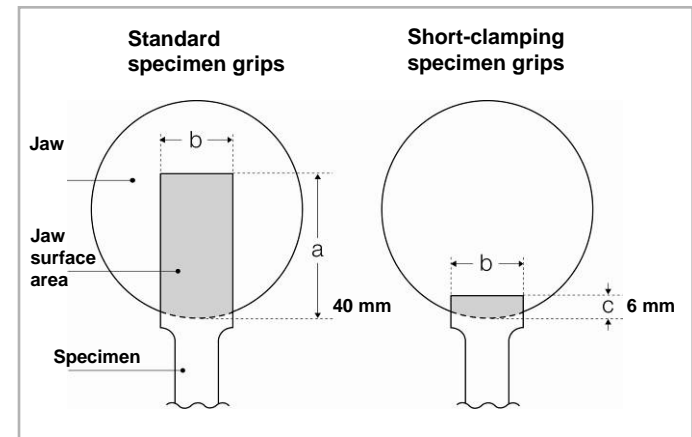
Definition: reproducible

'Reproducible' refers to a statistical measure for measurements over a lengthy period, usually with multiple operators and testing equipment.

- **Reproducible = precision under reproducibility conditions**

  - same measurement procedure

  - similar measuring equipment

  - different locations or times for measurement

  - different operators peforming the measurement

  - different test conditions
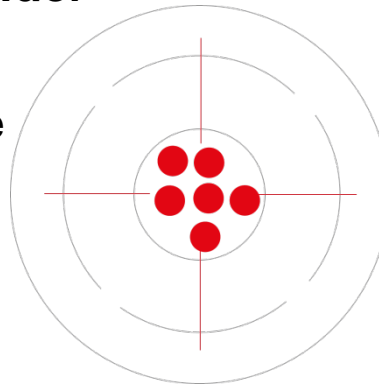
Definition – Reproducible

The same measurement procedure, Similar measuring equipment, generally at different locations, multiple operators and test conditions, as well as performing the measurement over a lengthy period of time.
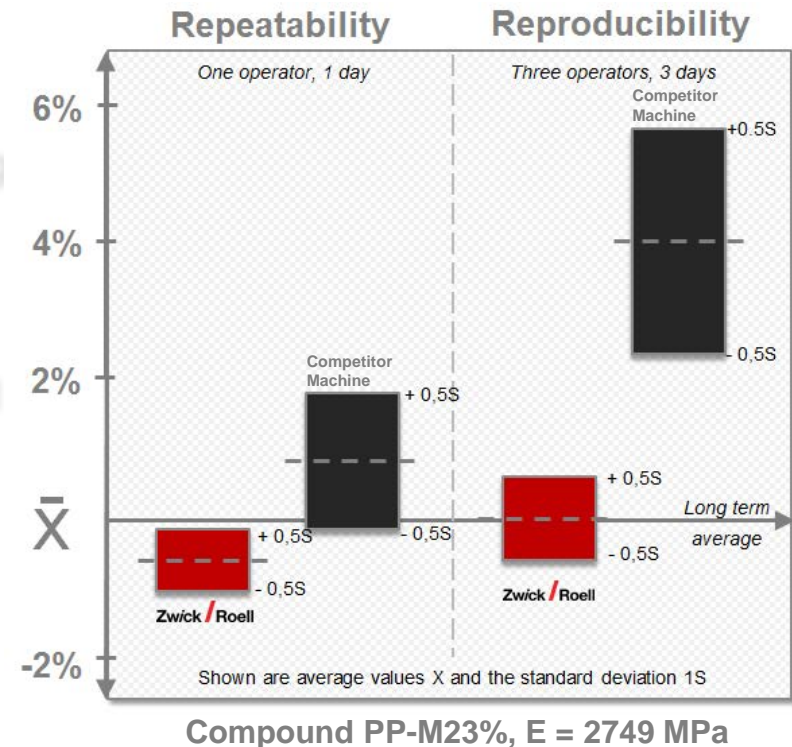
Example: reproducible – test equipment

In a direct comparison Zwick showed up to 4x better reproducibility .
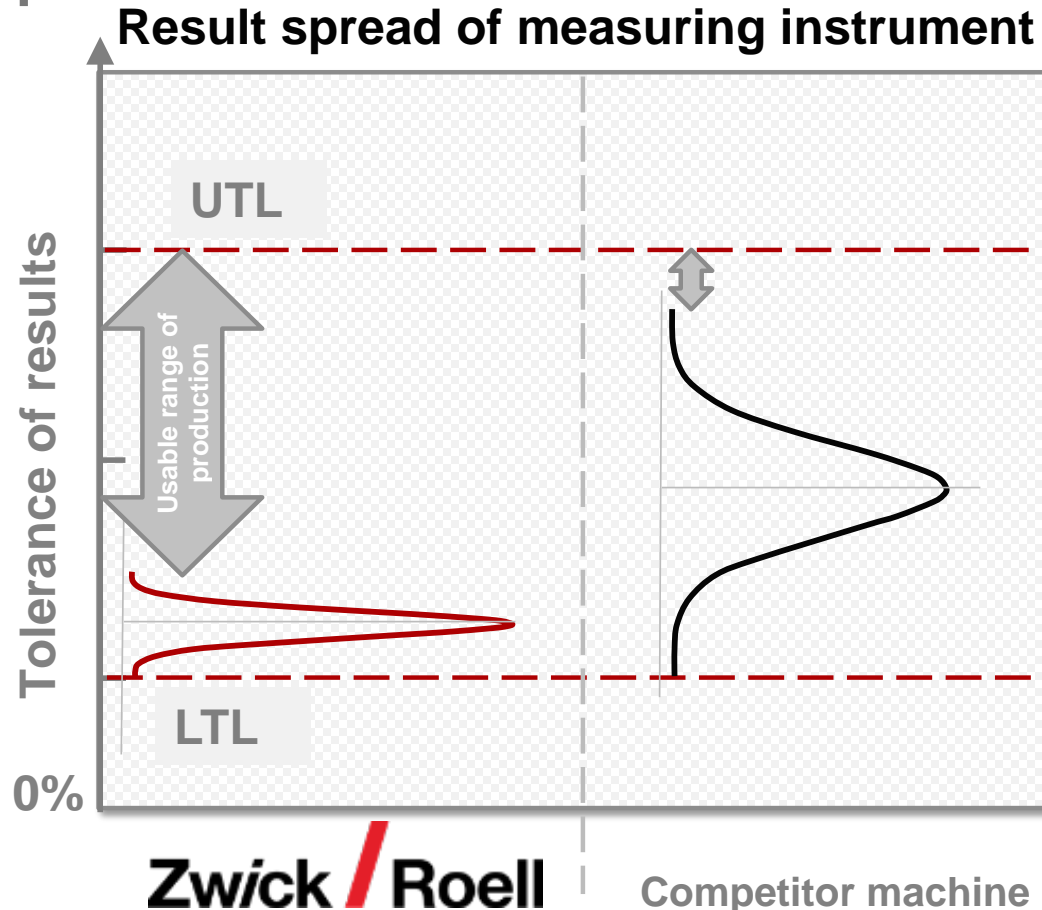
Test conditions

- two sets of technologically comparable testing equipment: load cells to Class 1, pneumatic grips and automatic extensometers

- test as per ISO 527-2/1A, conditioning in standard climatic environment as per ISO 291

- comparative measurements with 3 operators on 3 different days (May 2015)


Compound PP-M23%, E = 2749 MPa

The difference was in the reproducibility of the results. The competing model displayed up to 4 times greater scatter.

Example: reproducible – test equipment

Measuring instruments with a smaller results spread, means that a larger assured tolerance band is available for the production process.

Result spread of measuring instrument

UTL

Tolerance of results

Usable range of production

LTL

0%

Competitor machine

Example: reproducible – strain rate control

The revised standard for metallic materials (ISO 6892-1 (2009)) recommends the strain rate based test speed control for best accuracy and reproducibility of results
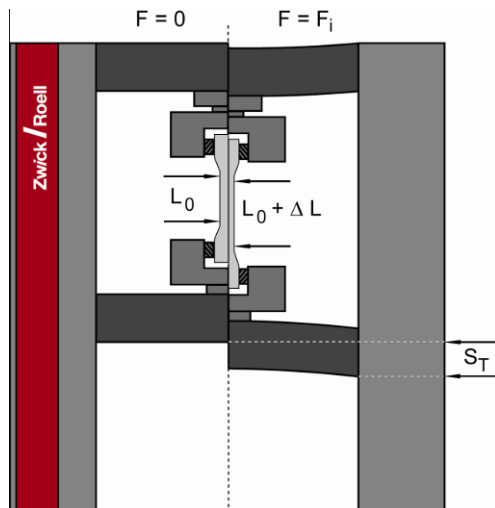
No load   **Under load**

Please note: Measurements are in the micrometer range and therefore sensitive to external influences

- The measured extension of the sample defines the crosshead speed in the strain control 'closed loop' technology.

- Actual tensile speed at the sample is taken into account and has to be kept to the given standard value -> Correct speed = correct results

- Rp0.2 and ReH are more stable and more repeatable

- The test cycle (time) is optimized

- The influence of system stiffness is clearly reduced

Example: reproducible – standard tests

Over 600 Standard test programs preconfigured in accordance with test standards ensure a high degree of reproducibility.

- **all parameters, results** and the report are already preconfigured **in accordance with test standards** and contain the terminology used in the industry concerned

- operated by simpy selecting the test program in testXpert II

- testXpert II Standard test programs typify Zwick's practical applicational expertise

e.g. EN ISO 6892-1, 12/2009 (Method B) Tensile test on metallic materials

Example: reproducible – Test Re-Run module
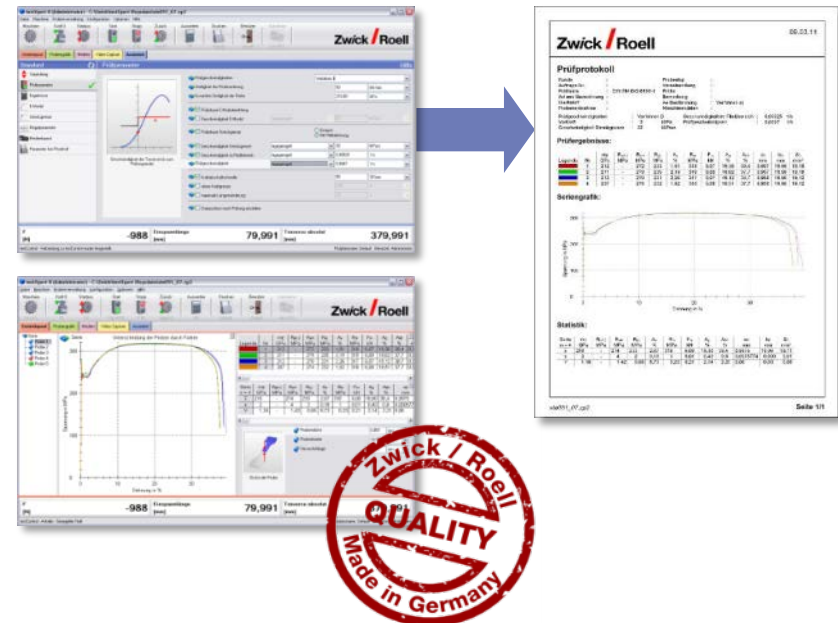
testXpert II Re-Run with videoXtens enables retrospective determination of true (= correct) strain values in the event of specimen breaks outside the original gage-marks.

26% strain   50% strain
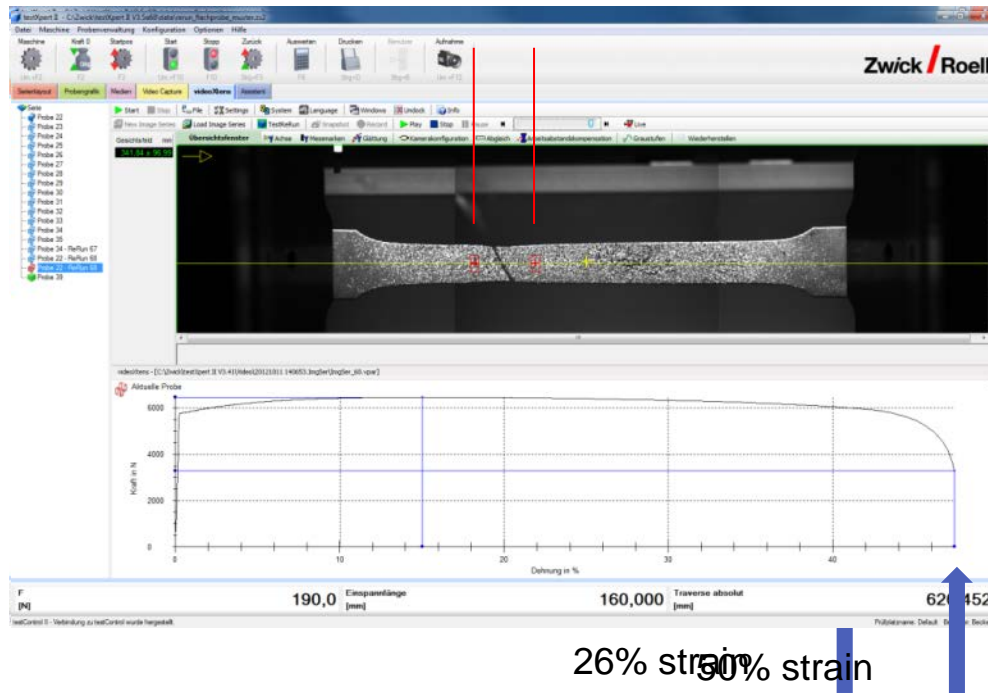
- correction of initial gage-length position possible if necking of specimen outside original initial gage-length has occurred

- evaluation of local strains at different points (component testing)

Customer can correct initial gage-lengths, avoiding the need for an additional test with a new specimen.

The width and thickness of a specimen must be measured correctly; deviations may have significant effects.

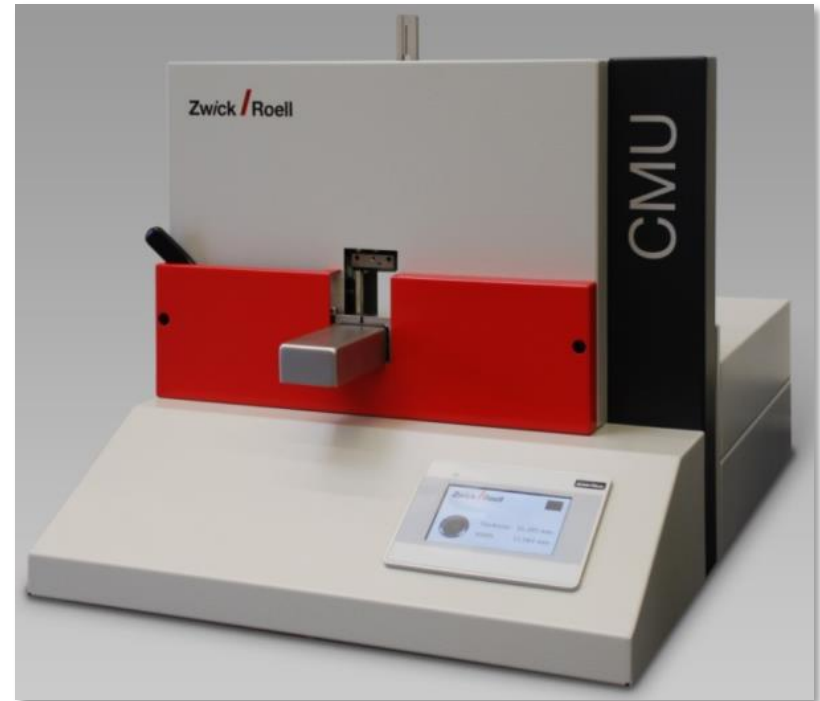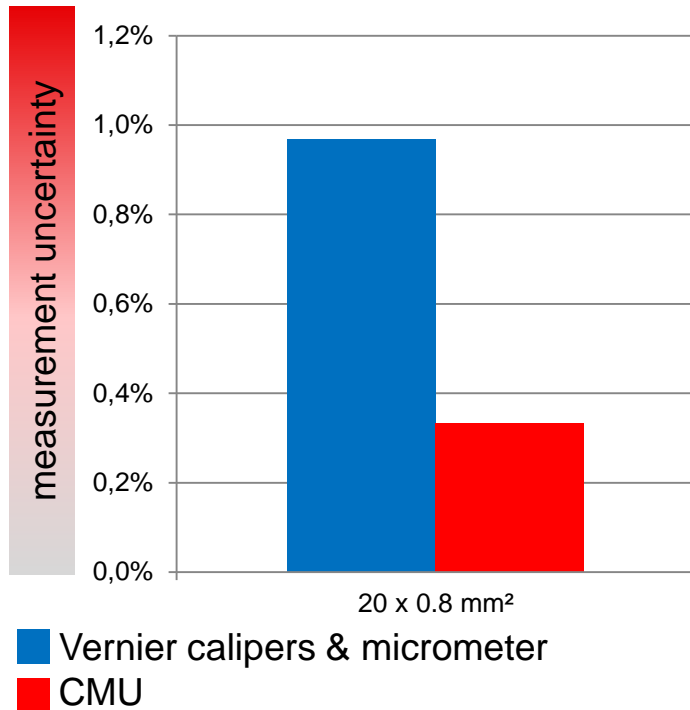## What must attention be paid to?

- zeroing
- application/ force
- tilting/twisting
- positioning
- de-burring
- cleaning

19.92 mm

20.08 mm

0.800 mm

0.814 mm
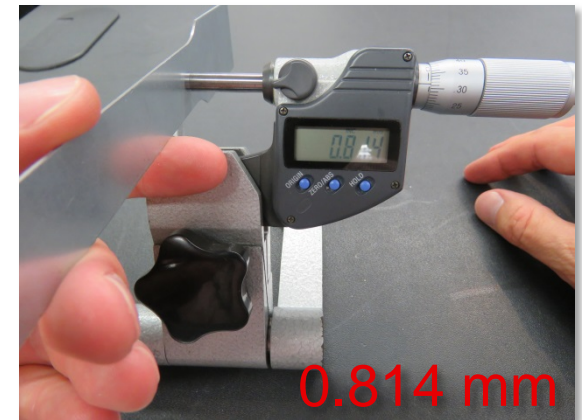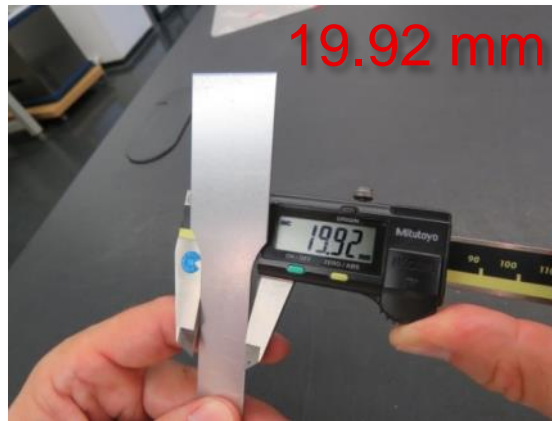
# Example: reproducible – cross-section S_0

The Zwick cross-section measuring unit (CMU) improves measurement uncertainty, thereby significantly improving test-result reproducibility.

Definition: traceable

Zwick / Roell

'Traceable' refers to the full and complete documentation of the development of a product or a measurement.

- **In metrology, 'traceable' refers to the <u>testing equipment</u>.**
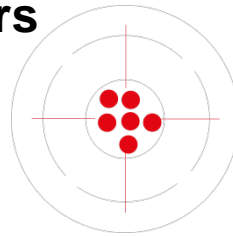
  Traceability is the continuous documentation of the calibrations of all measurement chains and thereby the establishment of a reference to a national or international measurement standard.

- **In medical engineering, 'traceable' refers to the <u>end product</u>.**

  Traceability is the documentation of the development process of a product for its entire life-cycle.

The test result was determined how, when, where, and by whom?

Example: traceable – testXpert II/Medical

Customers require reliable and traceable data.

- **Restrictions on access - user management**
  - special requirements for passwords
  - account blocked in the event of unauthorized ac
  - LDAP (uses Windows u
  - auto log-off
  - user-groups with indivi

- **Traceability – electron**
  - logging system & test p

- **Data are safeguarded against manipulation - electronic signature**
  - **User groups**
  - signed test program
  - signed test series

EU GMP Guideline Ann

New! testXpert II v3.7

No menu

Start button only

Example: traceable – system monitoring

testXpert II provides a detailed overview of the utilization and status of the testing system in use.

- machine run-times (operating time, drive on, testing time)

- number of tests at different load levels

- total crosshead travel

- sensor actions (application/removal)

- validity of calibration

- sensor and load frame overloads

- in the event of reaction-value violations an e-mail to the laboratory manager can automatically be generated

Maschine: testControl II 111111

Steuerung WN: 111111

| Kennung	Wert
Werknummer	111111
Gesamtlaufzeit	3231.452 h
Laufzeit mit eingeschaltetem Antrieb	985.402 h
Prüfzeit	812.534 h
Anzahl Systemstarts	338
Anzahl Prüfungen - Zug 0-5% Fnom	8457
Anzahl Prüfungen - Zug 5-10% Fnom	13
Anzahl Prüfungen - Zug 10-20% Fnom	4
Anzahl Prüfungen - Zug 20-50% Fnom	19
Anzahl Prüfungen - Zug 50-80% Fnom	0
Anzahl Prüfungen - Zug > 80% Fnom	0
Anzahl Prüfungen - Druck 0-5% Fnom	217
Anzahl Prüfungen - Druck 5-10% Fnom	0
Anzahl Prüfungen - Druck 10-20% Fnom	0
Anzahl Prüfungen - Druck 20-50% Fnom	0
Anzahl Prüfungen - Druck 50-80% Fnom	0
Anzahl Prüfungen - Druck > 80% Fnom	0
Anzahl Lastrahmenüberlastungen	0
Wert der maximalen Lastrahmenüberlastung	0.000 kN
Datum der letzten Lastrahmenüberlastung	- - -
Anzahl Schutztürzuhaltungen	226
Anzahl Schutztürverriegelungen	280

..and, and, and,…

Result-related deviations can easily be traced.

Example: traceable – video capture

Crack propagation measurements become traceable and more comfortable by use of the motorized Video-capturing system.

- videos synchronized exactly with the test

- repositioning of crack points after testing

- additional single frames from the video can be generated for interesting points in the test sequence
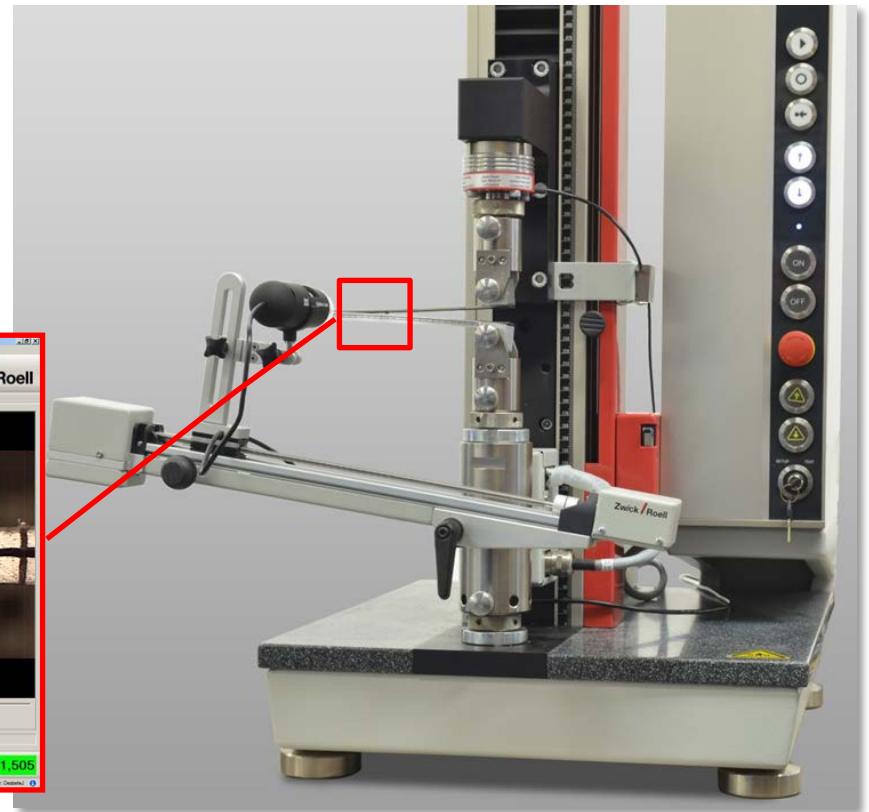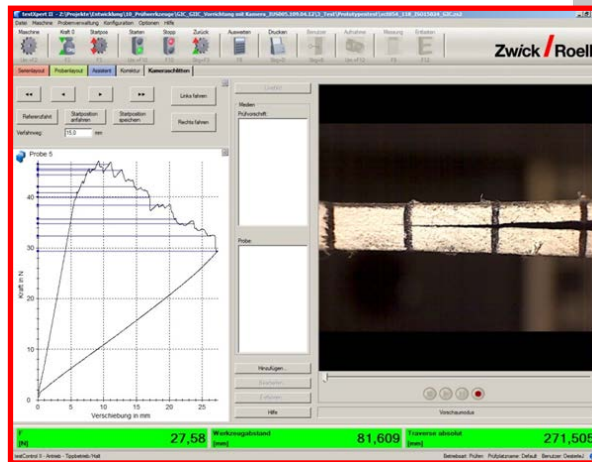
At the end of the test the user has the option of visually reconstructing the specimen behavior.

Conclusions - reliable test results

Zwick, together with its machine and software solutions, stands for accuracy, repeatability and reproducibility and for seamless result traceability.

Our machines operate with precision. The average of the test results obtained is very close to the reference value.

When tests are repeated under the same conditions, the results obtained are closely grouped.

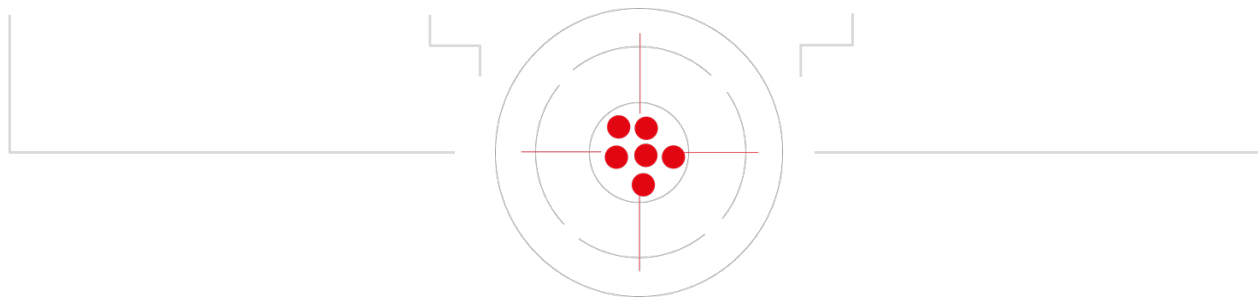When Zwick machines performing the same test are compared, the results are reproducible.

The continuous documentation of calibrations and tests makes all results transparent and traceable.

accurate　　　**repeatable**　　　**reproducible**　　　**traceable**

![Zwick Roell]

Thank you very much for your attention !

We wish you reliable test results at all times with Zwick!

accurate   **repeatable**   **reproducible**   **traceable**