

Company: Zwick GmbH & Co KG  
 Author: Manfred Dripke  
 August-Nagel-Str. 11, D-89079 Ulm  
 Tel. 07305-10-0, Fax 07305-10-200  
[www.zwick.com](http://www.zwick.com) Email: [info@zwickroell.eu](mailto:info@zwickroell.eu)

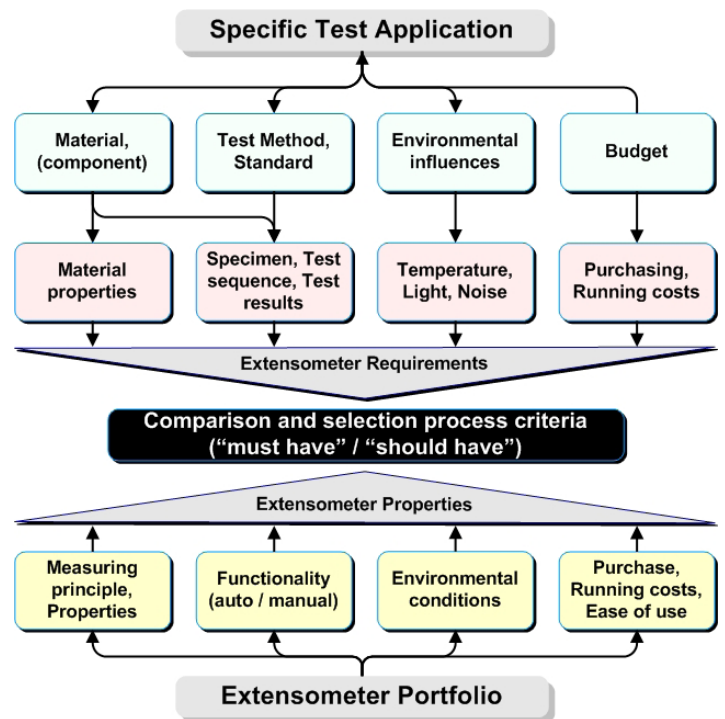
## Choosing the right extensometer for every materials testing application

In materials and component testing the range of applications where extensometers are used is extremely diverse. As a result, the technical requirements for these devices are multifaceted, and means that there is no single device which satisfies all needs. As a pioneer and global leader in modern extensometry, the Zwick Roell Group believes that it offers its customers the widest range of technical advice, products, and solutions.

### Specimen properties which influence the choice of extensometer

The requirements for an extensometer are determined primarily by the characteristics of the material to be tested. This includes its shape and dimensions, test requirements, and the formal Standards which must be met. These define the gauge length, accuracy, test sequence, and environmental conditions. (Fig. 1)

Having said this, the right choice of extensometer cannot be limited to the basic material characteristics such as specimen dimensions, stiffness, strength and plasticity alone. It is also necessary to decide whether an



(Fig.1) Selection process for extensometers

extensometer can be connected directly to the specimen without influencing the load measurement or mechanically damaging the specimen itself.

Very thin specimens such as foils can be sensitive to clamping forces, whilst very small wire specimens do not provide enough visible area for reliable non-contact measurements.

A high stiffness in the initial extension range, followed by high plasticity traditionally requires more than one extensometer. The first measures small strains (typically up to 5 mm) very accurately in the elastic range, and the second measures very high extensions (typically  $\approx 500$  mm).

Specimen with very smooth surfaces, or made of transparent materials are not suitable for non-contact measurements without first fixing measuring marks onto the surface of the specimen.

One very important consideration is the behavior when the specimen fails. Metals and hard plastics will slip through the knife edges of a contact extensometer without damaging them, and rotatable knife edges should be used to further reduce the risk of damage even if the surface of the specimen is particularly rough.

High extension or flexible specimens can damage or destroy the knife edges and even the extensometer itself due to whiplash, splintering, or de-lamination of specimens (for example steel rope). For these applications non-contact measurement is a must.

### Criteria for accurate measurements

#### Measurement travel (range) and gauge length

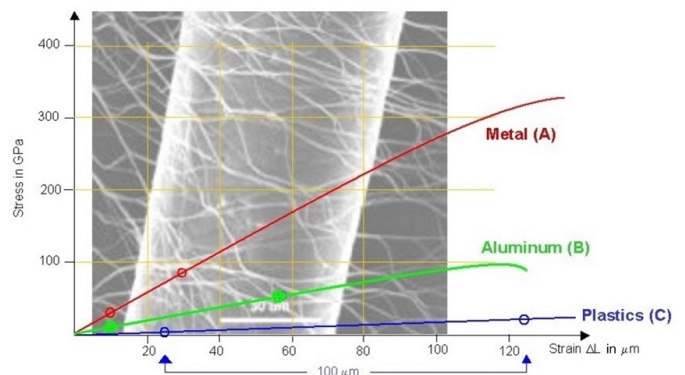
With contact type measuring extensometers, the measurement travel is normally an engineered and fixed value which is dependent upon the range of the measurement transducer and, with fulcrum hinged sensor arms, the leverage ratio. The initial gauge length is set manually with fixed steps or automatically over a defined range.

Non-contact extensometers that use a video camera must have the field of view larger than the required range plus the initial gauge length. Since the specimen portions which are outside the gauge length, and the machine components themselves deform in the direction of loading, the position

of the measuring marks on the specimen changes during the test. For extension and/or gauge lengths which are expected to be outside of the field of view then the objective lens must be changed or the distance between the specimen and the video camera must be increased. All these actions decrease the measuring accuracy, and in addition, every changed measurement configuration must be adjusted and calibrated.

### Measurement accuracy

“Accuracy” is a commonly used, qualitative term. To qualify the integrity of a measured signal Standards use quantitative terms such as “resolution”, “deviation” or “uncertainty” and definitive values are given for these. Requirements for the accuracy of extension measurements are normally given in application specific test requirements and International Standards. Many test Standards, for example, tensile test on metals [1] and plastics [2] refer to Standards for calibration of extension measurement systems and the required accuracy classes [3,4] contained therein (Fig. 2).



(Fig.2)

The required measuring points for the calculation of Elastic Modulus for metal and plastic shown in comparison to a human hair highlighting the accuracy requirements for extensometers.

### Ergonomics and economy

Devices which are easy to set-up and sequences which can be automated reduce personnel time and effort and at the same time improve the quality of the test results because subjective influences are minimized. Higher initial acquisition costs can be quickly amortized, especially when the extensometer can be used for a wide range of applications.

When using a video extensometer the time and costs for marking the specimen must also be considered as well as any potential human error introduced in attaching or aligning the marks.

## Contact type measurement extensometers

**Clip-on extensometers** are, as the name implies, mounted directly onto the specimen. The mechanical parts which transfer extension, via knife edges, from the specimen to the internal transducer are short and stiff. There is practically no relative movement between the specimen and the extensometer and for this reason the measurement accuracy is exceptionally high.

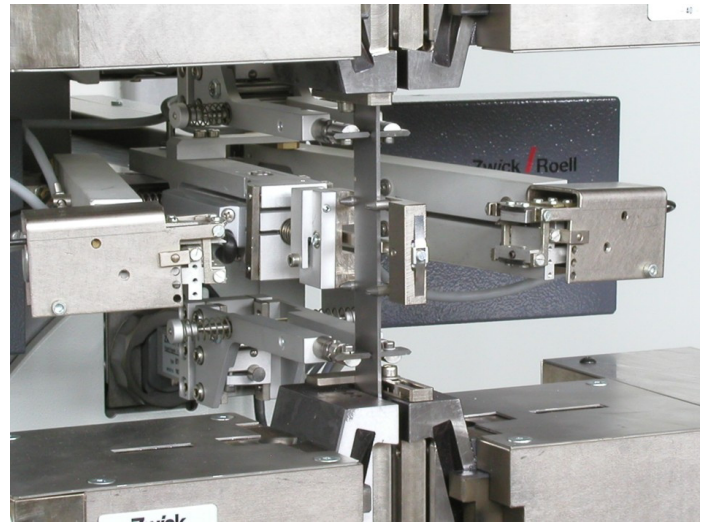
The range of a clip-on extensometer is limited to a few millimetres and it applies a load directly to the specimen. Some extensometers are available with counter-balance weight and double-sided measuring systems are used to compensate for superimposed bending stresses. The application and removal is normally manual, however, to minimise setting errors certain products are equipped with motorised application and removal systems (Figs. 3 and 4).

**Feeler arm extensometers** offer the major advantage of automatic operation and a large measurement range with high measurement accuracy and are suitable for many different applications. Precision designs with a very smooth and balanced mechanical operation apply minimum loading to the specimen (as little as the measurement marks used for non-contact extensometers). Since the feeler arms are in contact with both sides of the specimen, superimposed bending strains are largely compensated.

Clip-on and feeler arm extensometers are in direct mechanical contact with the specimen via knife edges which are perpendicular to the gauge length. The extremely small contact force from the knife edges can cause a microscopic indentation into the specimen surface which gives a light form-fit and thereby a precisely positioned contact point. This is an important factor for the large measurement accuracy and small scatter band width of the measured values. Because of the direct contact with the specimen, feeler arm extensometers can be damaged or even destroyed by whip-lash at the failure point of high elasticity / high extension specimens.

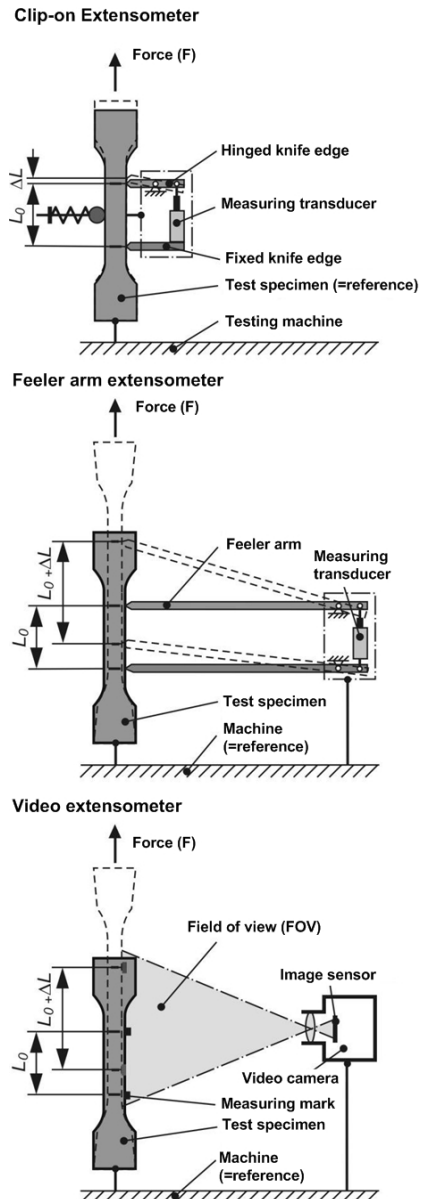
## Non contact extensometers (video and laser scanning)

The main advantage of non-contact video and laser scanning extensometers is that they can be used up to break without damage even when testing specimens that exhibit whiplash. They require measurement marks to be attached to the specimen which are optically distinct from the surrounding area of the specimen.



(Fig.3)

Combination of fully automatic feeler arm extensometers, with dual averaging axial and transverse strain extensometer.



(Fig.4)

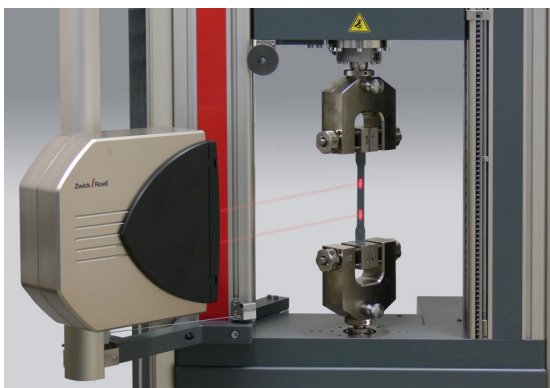
Schematic diagram showing the operating principle of various extensometers.

The measurement marks are clipped, tacked, or glued onto the specimen, or the specimen is marked with a coloured pen. In every case, this introduces additional sources of error as the marks can become indistinct, move, or fall off the specimen surface as it deforms during loading. The application of the measurement marks is also an additional process by the operator and can introduce higher costs as well as inaccuracies to the test results (Fig. 4).

The position of the measurement marks on the specimen is evaluated by software algorithms which determine a certain area around an Optical Centre Point. This becomes the gauge length and as the specimen is loaded the movement of the marks is converted to extension values. Special lighting for surface or background illumination of the specimen optimises the contrast to the measurement mark. During the deformation of the specimen, the lighting changes on the measurement marks as well as specimen and surrounding influences (reflections etc.) can influence the optical centre point. This is often the cause of scatter in the test results.

### **Non contact extensometers (laser interferometry)**

The latest extensometer from Zwick, the laserXtens, is a non contacting device which does not require measurement marks. It uses the unique structure of a specimen's surface as a "fingerprint" to generate a virtual measurement mark. Laser light directed on these measurement positions is reflected in various directions corresponding to the surface structure and creates a specific pattern of speckles. Selected measurement points are constantly followed and converted to direct extension values. The change in the surface structure, which is the basis of the speckle pattern, is continuously evaluated during specimen deformation (Fig. 5).



(Fig.5)  
Zwick's latest laserXtens® non-contact extensometer operating without specimen marks.

### **Summary**

Contact type extensometers measure extension extremely accurately and are very cost effective. However, clip-on extensometers require much more manual intervention and without care can introduce scatter in the test results. Feeler arms extensometers offer extremely high accuracy, excellent repeatability, and ease of use due to fully automatic operation which includes the setting of variable gauge lengths.

Non contact extensometers are required when the specimen is sensitive to notching knife edges or when the extensometer might be damaged at specimen break. They are also still relatively expensive and time consuming to set up and calibrate especially when testing different specimen types.

In short, there is no such device as a universal extensometer. The large range of applications demands various devices with different functions and characteristics, and the extensometer must be selected for each application.

Users of Zwick testing equipment benefit from the wide range of extensometers available, as well as expert advice and consultation together with the possibility to carry out pre-testing in the applications laboratory before purchase to make sure that the optimum device is chosen for each testing application.

### **About the Zwick Roell Group**

*Zwick Roell Group customers benefit from more than 150 years of experience in the manufacturing of high quality testing systems. Zwick is the global leader in static testing and is experiencing significant growth with its dynamic test systems. A financially strong and family run business, its innovative product developments, diverse product range, and global support provide tailored solutions targeted specifically at the needs of both Research and Development and Quality Assurance customers. Serving more than 20 industry sectors with 960 employees, via manufacturing facilities in Germany, regional headquarters in Atlanta, Georgia, USA and Singapore, as well as offices in 56 countries worldwide, the brand name Zwick is a guarantee of the highest quality and support. For more information see: [www.zwick.com](http://www.zwick.com)*

### **Literature**

- 1 DIN EN 10002 Metallic Materials – Tensile tests
- 2 DIN EN ISO 527 Thermo-plastics and duro-plastics – Determination of Tensile Characteristics
- 3 DIN EN ISO 9513 Calibration of extension measurement systems for testing with single axis loading
- 4 ASTM E 83-02 Standard Practice for Verification and Classification of Extensometer System