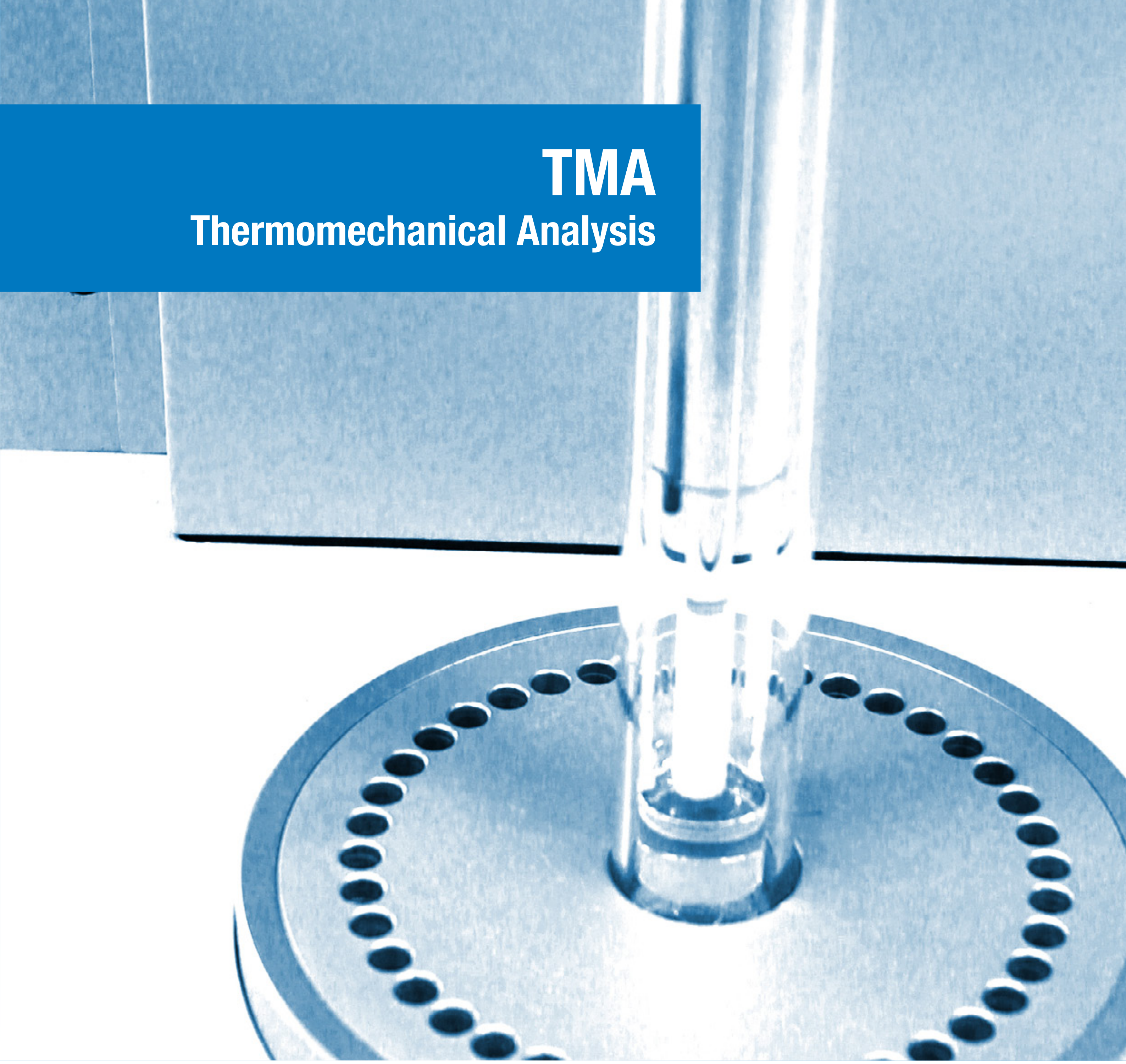


TMA

Thermomechanical Analysis

LINSEIS

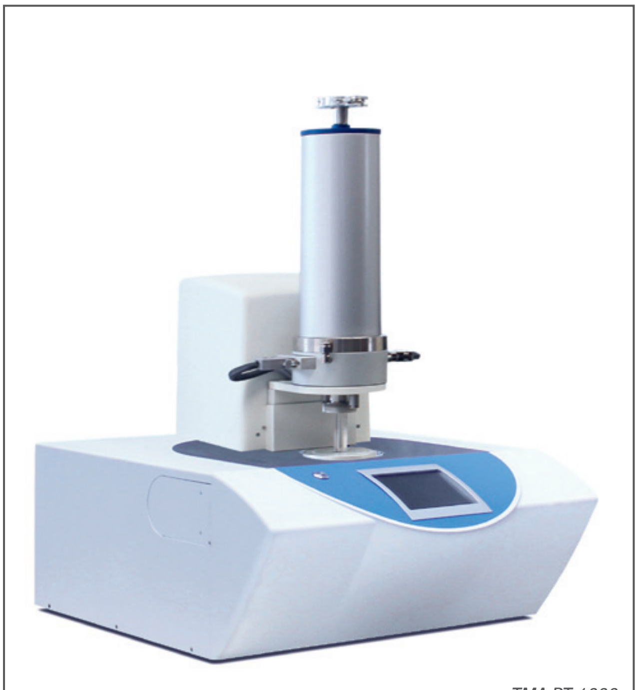
General

TMA / DTMA the method

Thermo mechanical analysis (TMA) easily and rapidly measures sample displacement (growth, shrinkage, movement, etc.) as a function of temperature, time, and applied force. Traditionally, TMA is used to characterize linear expansion, glass transitions, and softening points of materials by applying a constant force to a specimen while varying temperature. For expansion measurements, a probe rests on a sample on a stage with minimal downward pressure. Other constant force experiments include measurement of penetration, bending, tension, shrinkage, swelling, and creep (sample motion measured as a function of time under an applied load).

Typical Applications

- Tension studies of the stress/strain properties of films and fibers
- Determination of softening behavior
- Glass transition temperatures and secondary transitions
- Phase change determination
- Determination of mechanical behavior under applied force
- Determination of expansion coefficient (dilatometry)
- Sintering behavior
- Volumetric expansion
- E modulus
- Slipping and friction resistance



TMA PT 1000

- **Highest Resolution**
  allows to measure smallest nanometer changes
- **Dynamic Load TMA**
  measures weak transitions and elasticity
- **Wide measuring range**
  from - 150°C to 1600°C*
- **Calculated DTA**
  simultaneous measurements of thermal effects
- **Modular design**
  allows future expansion of instrument
- **Gas tight cell**
  controlled measurement environment
- **Hyphenated techniques**
  evolved gas analysis

TMA PT 1600

** Different furnaces (TMA PT1600)*

The concept

Sample chamber
The easily accessible chamber is located in the center of the furnace. Both temperature and atmosphere can be controlled. In addition an optional mass flow controller is available for purge gas regulation. The gas tight cell can be evacuated and allows you to measure under a defined atmosphere. Only such a system can provide definitive information concerning the samples sensitivity to oxidation.

Furnace
The TMA Platinum Series comes with a robust and reliable furnace. Its customized design enables rapid heat up and cool down times and an excellent heating rate control over the entire temperature range.

The expansion and temperature sensor
Every dimensional change of the sample is transmitted via the pushrod to the highly precise inductive transducer (LVDT sensor). Its precise and reliable response over the entire temperature range guarantees highest reproducibility of the TMA results. The temperature sensor is located right beside the sample leading to the high accuracy.

The Dynamic TMA mode
This feature allows you to study the visco-elastic behavior of materials. In D-TMA the force exerted on the probe alternates automatically by the given frequency.

Sample Holders
A broad range of sample holders is available for the TMA. Hence the best method for testing can be selected for every application. Furthermore LINSEIS can certainly provide aid for special customer requirements.

Automatic pressure control
The contact pressure can be continuously varied between 10mN and 20 N depending on the system. This feature continuously adjusts the contact pressure throughout expansion and/or shrinkage of the sample.

Cooling system
The liquid nitrogen cooling system has been completely automated; manual refilling is not necessary. This simplifies operation, improves reproducibility and allows measurements to be performed over a long period of time.

Integrated DTA signal:
All LINSEIS TMA models are optionally equipped with the DTA evaluation feature. This provides the user with valuable additional endo- and exothermic sample information

Technical Specifications

	TMA PT 1000 EM	TMA PT 1000	TMA PT 1600
Temperature range	-150 up to 1000°C	-150 up to 1000°C	-180 up to 500°C RT up to 1400/1600/ 1750 /2000/2400°C
Force	1 or 5.7N	1, 5.7 or 20N	1 or 5.7N
Frequency	1 or 5Hz	—	0.05 to 1 or 50Hz
Resolution	0.125 nm/digit	0.125 nm/digit	0.125 nm/digit
Sample size	30/50mm	30/50mm	30/50mm
Atmosphere	inert, reduced react. gas	inert, reduced react. gas	inert, reduced react. gas

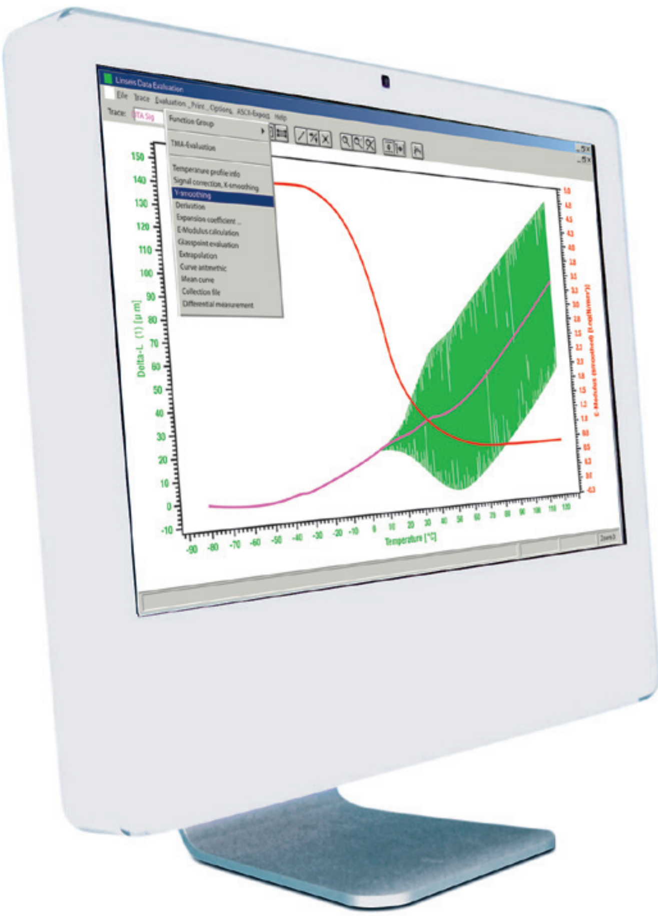
Software

Software

All LINSEIS thermo analytical instruments are PC controlled. The individual software modules exclusively run under Microsoft® Windows® operating systems. The complete software consists of 3 modules: temperature control, data acquisition and data evaluation. The 32 bit software incorporates all essential features for measurement preparation, execution, and evaluation of a TMA/DTMA run. Thanks to our specialists and application experts, LINSEIS was able to develop comprehensive easy to understand user friendly application software.

Features -Software

- Program capable of text editing
- Data security in case of powerfailure
- Thermocouple break protection
- Repetition measurements with minimum parameter input
- Evaluation of current measurement
- Curve comparison up to 32 curves
- Storage and export of evaluations
- Export and import of data ASCII
- Data export to MS Excel
- Multi-methods analysis (DSC TG, TMA, DIL, etc.)
- Zoom function
- 1st and 2nd derivation
- Programmable gas control
- Statistical evaluation package
- Automatic axis re-scaling
- E-Modulus
- Several system correction features
- Automatic zero point adjustment
- Auto-scheduler for up to 16 uninterrupted runs



Features

TMA / DTMA Features

With low constant load

- Linear thermal expansion evaluation
- Change of volume
- Phase transformation
- Sinter process evaluation
- Softening point determination
- Transformation points
- Swelling behavior
- Tension

With increased constant load

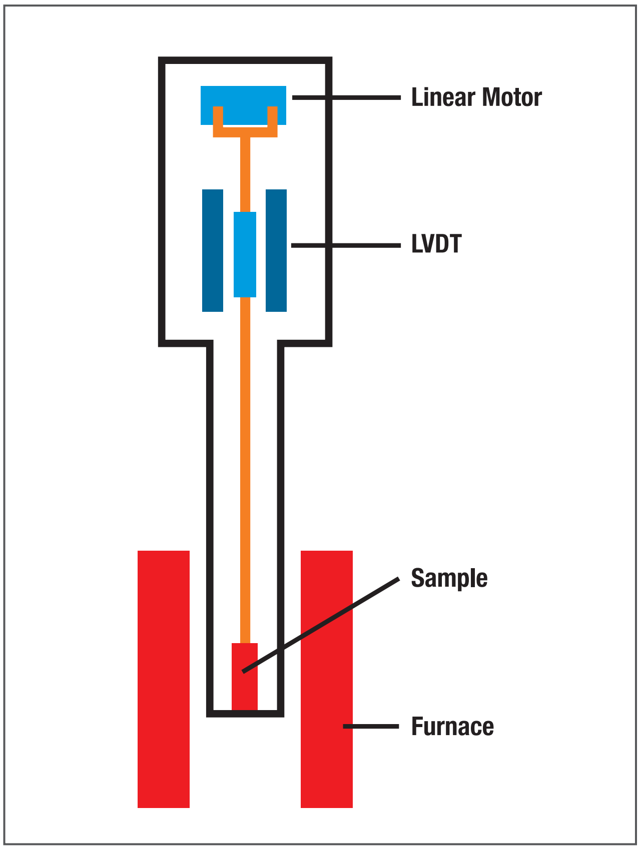
- Penetration
- Transition and comparison tests
- 3 point bending test

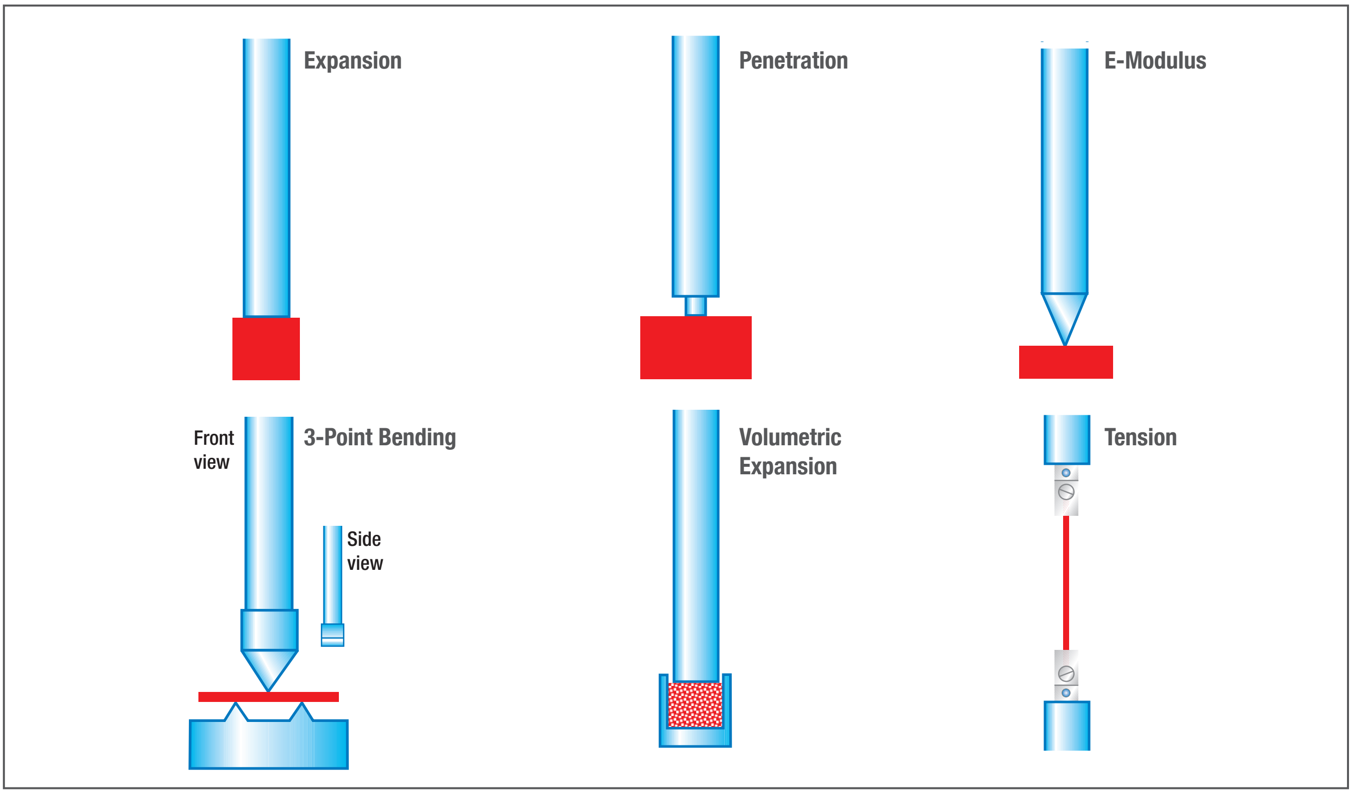
With dynamic load

- Visco-elastic behavior

Additional optional features

- DTA evaluation
- (RCS) Rate controlled sintering software

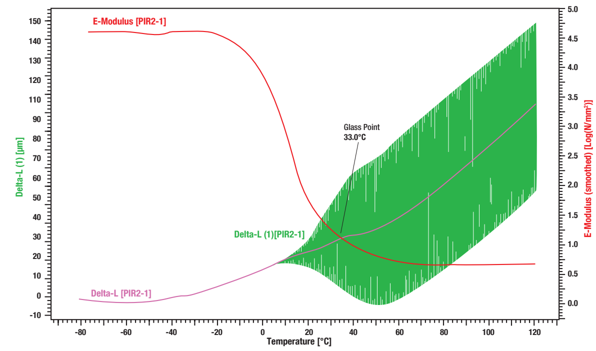


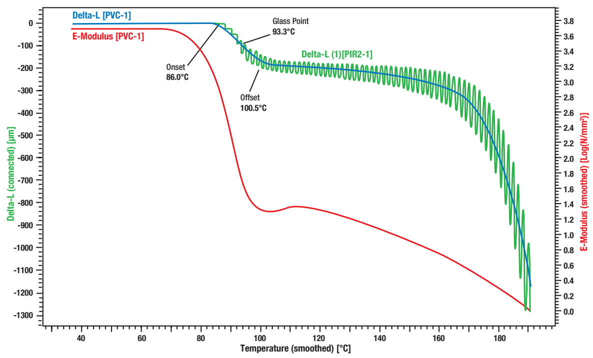


Applications

Elastomers

Because of their very special and versatile properties, polyurethanes Elastomers have found wide application in virtually every industry, varying from the automotive, electrical and electronic industry, design and textile industry, to the mining and heavy duty industry.
Evaluation of Elastomers specifically developed for applications above 0°C. The glass point was detected at 29.9°C. When further increasing the temperature, additional expansion of the material in the elastic range occurs. The plastic range of the material has not been reached during this evaluation.



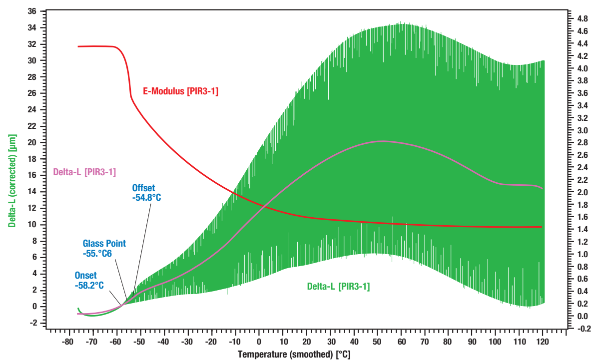


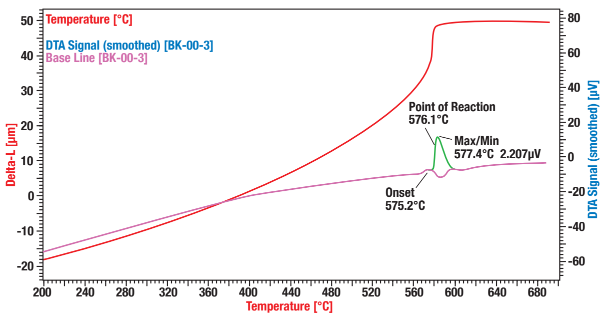
Polyvinylchloride

This plastic has found extensive use as an electrical insulator for wires and cables. Cloth and paper can be coated with it to produce fabrics that may be used for upholstery materials and raincoats. The glass point of the PVC sample was detected at 93.2°C. The elastic range starts from approximately 150°C. At higher temperatures the change of the sample into the plastic range can be detected very well.

Silicon rubber

The nature of its origin gives silicone a number of significant advantages over conventional rubber polymers. These include the ability to perform in extreme operating temperatures, excellent resistance to weather and ozone, electrical resistance or conductivity, flame retardency, and the ability to match nearly any colour. This type of rubber was especially developed for use at low temperatures. The glass point is at -54.9°C. The E-modules is shown over the entire temperature range and the mean value of the expansion. The length change is up to 50°C an expansion (elastic range) and thereafter a change into the plastic range was detected.



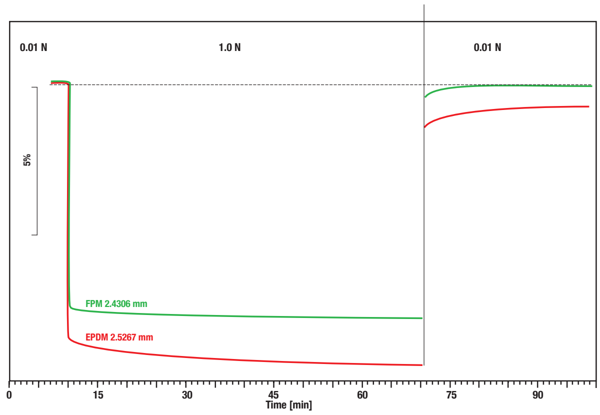


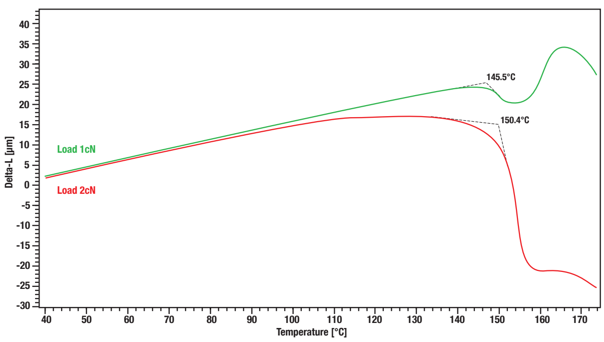
DTA - Feature

The thermal expansion of rock crystal (α-SiO_2) can be easily evaluated with the L75 Dilatometer. The additional DTA feature enables an in depth view of the thermal behavior of the material. The DTA measurement is a mathematical routine based on the sample temperature. Exo- and endothermic effects influence the change of the sample temperature during the dynamic heating or cooling cycle. At app. 575°C the phase transition from α- to β-SiO_2 takes place. The deviation of the measured temperature from the literature value (574°C) can be used for a temperature calibration.

Creep Behaviour of Elastomers

The recovery behavior of sealing rings can be determined by the use of Creep measurements. In the two different experiments a force of 1N was applied to two different sealing rings for 60 minutes at room temperature. The recovery behavior was measured with an applied force of 0.01N. This measurement allows to determine the elastic deformation, the viscoelastic deformation (gradual change in thickness), and the viscous flow (irreversible change in shape, creep). The deformation of the EPDM sealing ring is grater than that of the FPM ring. In comparison FPM, the EDPM used has a greater degree of viscous flow and has a smaller elasticity modulus.





Polycarbonate PC

An important limiting factor for thermoplastic applications is the glass transition point. With the different loads on the polycarbonate molded parts investigated here, the TMA shows that softening occurs long before the glass transition temperature is reaches. During this investigation the material has been penetrated by a pushrod with two different forces (1cN and 2cN). Depending on the load, the depths of the penetrations have varied. The heating rate for both evaluations has been 5K/min.

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