NETZSCH® GABO

High-Force DMA EPLEXOR® HT Series up to 1500°C

Dynamic-Mechanical Testing Systems

Leading Thermal Analysis

NON-DESTRUCTIVE HOT MODULUS

OF CERAMICS, GLASSES, METALS, ALLOYS AND COMPOSITES

Need to know the stiffness and damping properties of your high-temperature-resistant material?
From only one non-destructive DMA test, you can obtain a complete characterization across a broad temperature range.

The main application fields for DMA tests to 1500°C are:
- Aeronautics
- Energy generation
- Transportation

The new EPLEXOR® HT series by NETZSCH GABO Instruments offers the technique:

DYNAMIC-MECHANICAL ANALYSIS TO 1500°C

The EPLEXOR® HT series features unrivaled technology backed by more than 40 years of experience in developing and manufacturing high-quality DMA testing devices.

The high-temperature EPLEXOR® portfolio comprises instruments with a dynamic force range of up to:
- ± 25 N
- ± 100 N
- ± 150 N
- ± 500 N

Dynamic-Mechanical Analysis

Principle

During a dynamic-mechanical (DMA) test, a sinusoidal force (stress, σ) with a certain frequency is applied to a sample (Fig. 1). The result is a sinusoidal deformation (strain, ε) as a material response (fig. 2). The delay between the excitation and response is called phase shift (δ). Theoretically, it exhibits a value of 0° for fully elastic samples and a value of 90° for completely viscous substances. In fact, the phase shift of most materials is somewhere in between 0° and 90°, depending on the elastic and viscous proportions.

Mathematical processing of the measured data yields the complex modulus E*, storage modulus E', loss modulus E'' and loss factor tanδ.

The storage modulus E', the real part of the complex modulus E*, refers to the elastic part of the response and is a measure for the material's stiffness. The loss modulus E'', the imaginary part, corresponds to the dissipated oscillation energy. The loss factor (tanδ), which is the ratio between E'' and E', describes the mechanical damping or internal friction of a visco-elastic system.

DMA/DMTA Results

- Dynamic modulus
- Damping factor (tanδ)
- Young's (static) modulus
- Frequency dependence
- Temperature dependence
- Phase transitions
- Secondary transitions
- Master curve
- Hysteresis
- Relaxation and retardation
- Creep testing
- Aging behavior
- Fatigue testing
- Predictive testing
- Durability testing
- Impact testing
- Softening

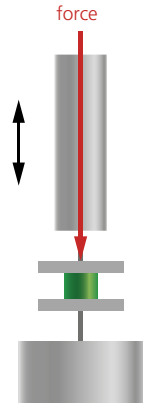


Figure 1: Example of an oscillatory stress on a sample in compression mode

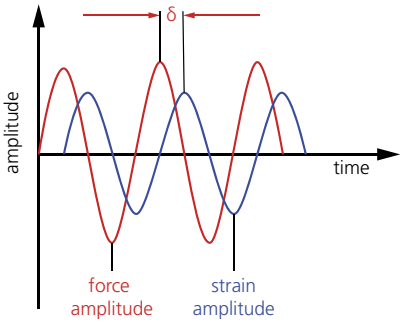


Figure 2: Schematic of the relationship between the dynamic force and strain for a visco-elastic sample; δ stands for the phase shift between the two curves

By NETZSCH GABO Instruments

Premium manufacturer of dynamic-mechanical analyzers

EPLEXOR® HT Series

UNIQUE SYSTEMS

The EPLEXOR® HT series comprises the only DMA instruments on the market which are able to perform measurements in the high-temperature field!

Made in Germany

FOR DYNAMIC TESTS TO 1500°C

Rigid Design

High temperatures make high demands on the flexural strength of the set-up within the hot temperature zone. EPLEXOR® HT instruments are equipped with sample holders made of sintered silicon carbide (SSiC), a dense and stiff ceramic which upholds this property even at 1500°C.

All Set for Future Changes

Due to its modular design, the EPLEXOR® HT series allows for easy upgrading of the system with a variety of force sensors as well as different furnaces, depending on the application range.

Broadest Temperature Range

By combining the high-temperature furnace to 1500°C with a refrigerable low-temperature furnace, a range from -160°C to 1500°C can be covered in one DMA instrument. The image on the left illustrates this dual chamber operation mode.
The furnaces can be easily changed out by the user.

Variable Force Range

This one-of-a-kind DMA system offers the ability to install different force sensors to meet individual users' needs, with a total force range from 10 N to 2500 N. This allows for applications of the best possible conditions in order to optimize results. The force sensors can be changed easily by the operator with a minimum of effort.

Two Independent Drives for Static and Dynamic Force

Just as with the base EPLEXOR® series, EPLEXOR® HT instruments operate with two independent drives for static and dynamic force. Application of this principle is the only way of utilizing the entirety of the broad range of force when carrying out DMA measurements.

Extraordinary Performance Based on an Elaborated Conceptual Design

Maximum Flexibility

The EPLEXOR® HT series is an instrument line for all kinds of mechanical measurements. Dynamic-mechanical standard parameters (tanδ, E′, E′′, etc.) can be determined and creep, relaxation or fatigue tests can be carried out.

The quasi-continuous frequency range with high data acquisition rate allows for operation between 0.001 Hz and 100 Hz. Frequency sweeps are suitable for detecting even weak transitions and can be taken for master curve generation. The frequency range can be extended (0.0001 Hz; 200 Hz).

The optional Digital Signal Processor (DSP) is a prerequisite for generating excitation signals of various shapes including pulses by harmonic synthesis. Predefined signal shapes (e.g., sine, sine^2, half-sine, double-sine, triangular, rectangular, saw tooth, Hanning, Hamming, Blackman, Blackman-Harris, or user-defined shapes) can be generated by optional software tools*.

* Please contact your local representative for more information

Extended Force Range Through Independent Drives

Static and dynamic force transducers can be actuated independently. The static force is realized by a servo motor; the dynamic force is generated by an electrodynamic shaker system. This allows the application of a dynamic force of up to ± 500 N plus a static force of up to ± 1500 N.

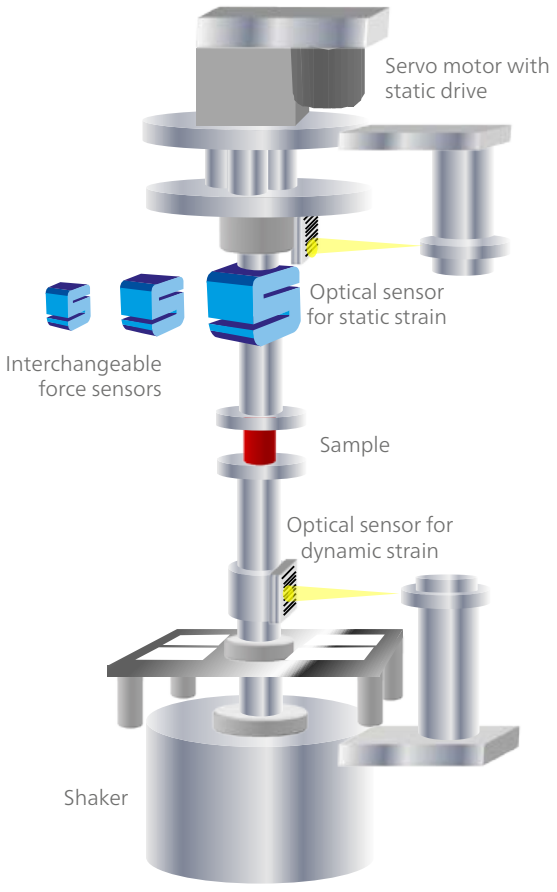
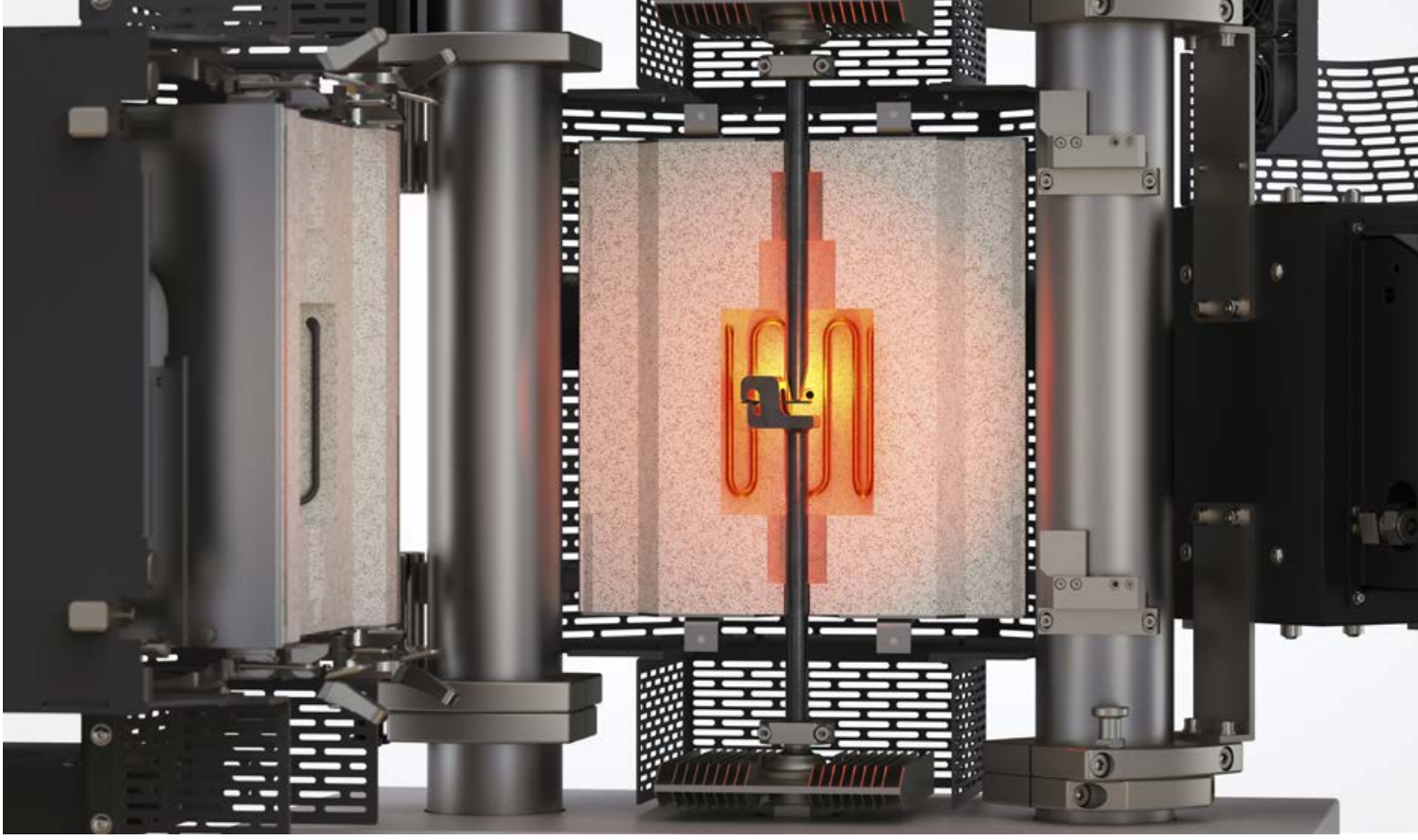


Diagram of the EPLEXOR®: Force sensors are interchangeable.



View inside the 1500°C high-temperature furnace; the sample chamber is displayed in red. The system can be purged, either via a manual or an electronic gas flow controller.

Broadest Temperature Range from -160°C to 1500°C

The user can choose between three different furnaces: a standard furnace which runs from -160°C to 500°C and two high-temperature furnaces which run from ambient to 1000°C or 1500°C.

In order to take advantage of the full temperature range, one standard and one high-temperature furnace can be mounted together on the same system.

Designed to Investigate Metals, Glasses, Ceramics or Composites

The EPLEXOR® series up to ± 500 N uses a very stiff frame which allows for direct compression tests on solids in strain-controlled measurements. The low compliance enables ideally suited conditions for studying even very stiff samples. The digital dynamic strain resolution amounts to 1 nm!

Determination of Linear and Non-Linear Mechanical Behavior

The EPLEXOR® HT and EPLEXOR® series are the only DMA systems on the market which are able to reveal both the linear and non-linear mechanical characteristics of materials under investigation. Non-linear material properties can be evaluated via Fourier transformation (FFT) and hysteresis analysis (optional). All dynamic parameters (E', E'', tanδ) are provided for linear and non-linear sample stimulations.

... OPENS UP NEW APPLICATION PERSPECTIVES

The Perfect Sample Holder for Any Application

In order to ensure that reliable measurement results are achieved, sample holders for a variety of sample geometries and temperature ranges are available:

- Compression holder made of SSiC – to 1500°C/1000 N
- 3-point bending (20- and 40-mm free bending length, SSiC) to 1500°C/500 N
- Asymmetric bending holder, SSiC – to 1500°C/25 N
- Tension holder made of a high-temperature-resistant alloy – to 900°C

Sintered silicon carbide (SSiC) is high-temperature- and thermal-shock-resistant, stiff and features high thermal conductivity as well as high wear resistance. Therefore, it is the optimal material for measurements up to 1500°C.

Additionally, all sample holders related to the EPLEXOR® 500 N system such as double shear or single-/dual cantilever bending can be used for lower temperature applications to 500°C.

3-point bending
20 mm

3-point bending
40 mm

Asymmetric bending

Compression

Tension

Technical Specifications

EPLEXOR® HT Series up to 500 N

	EPLEXOR® HT 25 N	EPLEXOR® HT 100 N	EPLEXOR® HT 150 N	EPLEXOR® HT 500 N
Dynamic force range	± 25 N (50 N)*	± 100 N (200 N)*	± 150 N (300 N)*	± 500 N (1000 N)*
Static force range	150 N (Optional: 1500 N)	1500 N	1500 N	1500 N
Dynamic strain	± 1.5 mm (3 mm)*	± 1.5 mm (3 mm)*	± 1.5 mm (3 mm)* Optional: ± 3 mm (6 mm)*	± 1.5 mm (3 mm)* Optional: ± 6 mm (12 mm)*
Static displacement	Up to 60 mm	Up to 60 mm	Up to 60 mm	Up to 60 mm
Frequency range	0.001 Hz to 100 Hz Optional range: 0.0001 to 200 Hz	0.001 Hz to 100 Hz Optional range: 0.0001 to 200 Hz	0.001 Hz to 100 Hz Optional range: 0.0001 to 200 Hz	0.001 Hz to 100 Hz Optional range: 0.0001 to 200 Hz
Temperature	RT to 1500°C RT to 1000°C RT to 500°C Optional**: -160°C to 500°C	RT to 1500°C RT to 1000°C RT to 500°C Optional**: -160°C to 500°C	RT to 1500°C RT to 1000°C RT to 500°C Optional**: -160°C to 500°C	RT to 1500°C RT to 1000°C RT to 500°C Optional**: -160°C to 500°C
Cooling devices for 500°C furnace	LN_2 (down to -160°C) or pressurized air (-60°C to 300°C)	LN_2 (down to -160°C) or pressurized air (-60°C to 300°C)	LN_2 (down to -160°C) or pressurized air (-60°C to 300°C)	LN_2 (down to -160°C) or pressurized air (-60°C to 300°C)
Max. heating rates for 1000°C/1500°C furnaces	50 K/min (up to 1000°C)	50 K/min (up to 1000°C)	50 K/min (up to 1000°C)	50 K/min (up to 1000°C)
Heating time during ballistic heating	30 min between RT and 1500°C	30 min between RT and 1500°C	30 min between RT and 1500°C	30 min between RT and 1500°C

* Peak force (peak-to-peak)
** A low-temperature and a high-temperature furnace can be mounted together on the frame for EPLEXOR® HT instruments.

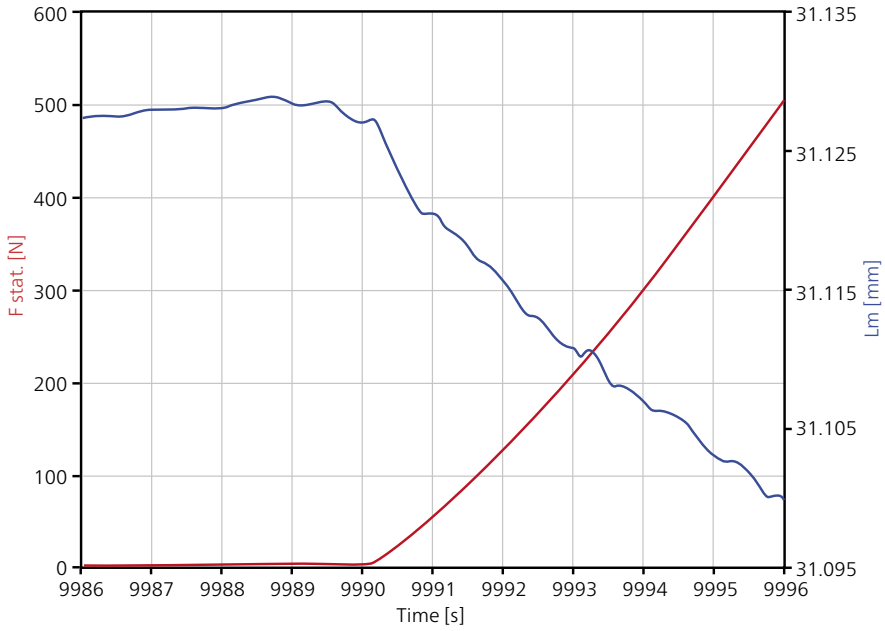
Applications

Bending Test on Bauxite*

Bauxite is an aluminum ore and the basis for the production of metallic aluminum.

In order to characterize the mechanical behavior of bauxite, a bar of material was measured in this example at 800°C using a 3-point bending fixture. The temperature was kept constant while increasing the static force by 85 N per second (i.e., approx. 510 N within 6 seconds); under these conditions, the sample exhibited approx. 30 µm of bending.

DMA instruments are not specifically engineered to handle destructive experiments. However, if such an event were to occur, the unique blade spring system in the EPLEXOR HT series does offer the greatest possible degree of safety.



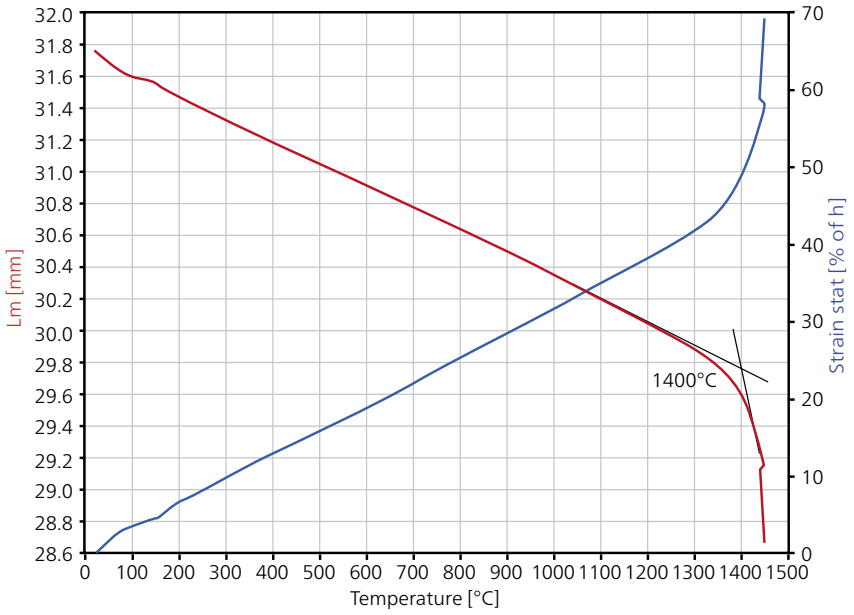
Universal test on bauxite; 3-point bending mode; isothermal temperature: 800°C; static force: up to 500 N. The static force is shown in red; the deflection of the sample is shown in blue.

* Both measurements were provided by Fraunhofer ISC in Bayreuth, Germany, to whom we extend our sincere appreciation.

Bending and Softening of an Al_2O_3/Metal Compound*

Heating a ceramic/metal compound with Al_2O_3 as the ceramic component in the 3-point bending mode to 1450°C results in heavy deformation of the sample. Between RT and 1250/1300°C, a bending of about 2 mm takes place, which corresponds to a static strain of approx. 40% (relative to the original specimen height). At about 1400°C (extrapolated onset temperature), the bending becomes even more pronounced. This is due to softening of the sample resulting from the melting phase of the included metal.

The EPLEXOR® HT series is specifically designed to reach such high temperatures.



DMA test on Al_2O_3 + metal; 3-point bending mode; heating rate: 5 K/min; static force: 50 N. The static strain is shown in blue; the deflection of the sample is displayed in red.

Expertise in Service

TECHNICAL SERVICE

- Maintenance and Repair
- Software Updates
- Exchange Service
- Calibration Service
- Spare Part Assistance
- Moving Service

TRAINING

- Training
- Comprehensive Instrument and Method Training

LABORATORY

- Contract Testing

The NETZSCH Group is a mid-sized, family-owned German company engaging in the manufacture of machinery and instrumentation with worldwide production, sales, and service branches.

The three Business Units – Analyzing & Testing, Grinding & Dispersing and Pumps & Systems – provide tailored solutions for highest-level needs. Over 3,400 employees at 210 sales and production centers in 35 countries across the globe guarantee that expert service is never far from our customers.

When it comes to Thermal Analysis, Calorimetry (adiabatic & reaction) and the determination of Thermophysical Properties, NETZSCH has it covered. Our 50 years of applications experience, broad state-of-the-art product line and comprehensive service offerings ensure that our solutions will not only meet your every requirement but also exceed your every expectation.

Leading Thermal Analysis.

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