Advanced Materials Testing
Thermal Analysis, Methods for Determination of Thermophysical Properties, Cure Monitoring, Accelerating Rate and Isothermal Calorimetry
Since 1962, NETZSCH-Gerätebau GmbH has consistently provided our customers with the latest thermal analysis techniques, the broadest range of highest quality products, the most complete technical support and the most comprehensive service.

Thanks to our experienced team, NETZSCH Analyzing & Testing consistently offers the “utmost”: the most complete product line, the widest temperature range and the highest measurement pressure, to name a few. The series of patents and international R&D awards which we have received attest to our products’ leadership in terms of technique and quality. Our branches, representative offices and application laboratories worldwide offer our customers excellent instruments and technical support, wherever on the globe they may happen to be.

At NETZSCH, we regard customer satisfaction as our first priority. We are looking forward to working with you.
The physical and chemical properties of any material change under the influence of temperature. Such changes can be systematically analyzed for almost any sample by applying specified variations in temperature, atmosphere and pressure.

At NETZSCH, you will find solutions for Thermal Analysis, thermo-physical properties testing, cure monitoring, dynamic-mechanical testing, multiple module and accelerating rate calorimetry that will meet your every need.

Our instruments and methods allow for material characterization and the study of properties such as specific heat capacity, enthalpies, weight change, Young’s modulus, dimensional changes, thermal conductivity, thermal diffusivity and evolved gases including determinations with regard to purity and composition, polymorphism, thermal stability and application temperature limits, aging and thermomechanical behavior, visco-elastic properties, and processing conditions.

NETZSCH Analyzing & Testing develops sensitive, versatile, and reliable instrumentation for research and development, quality control, process safety and failure analysis. We offer our customers broad applications knowhow through publications, demonstrations, contract testing, seminars and users’ meetings.

Let NETZSCH open up a whole new perspective on the materials in your world.

**Thermal Analysis**
- DSC/DTA
- TGA
- STA (TGA-DSC, TGA-DTA)
- DIL
- TMA
- DEA
- Coupling to EGA (MS/FT-IR/GC-MS)

**Dynamic-Mechanical Testing**
- DMA
- High-Force DMA

**Thermal Conductivity and Thermal Diffusivity**
- HFM
- GHP
- LFA

**Seebeck Coefficient and Electrical Conductivity**
- SBA

**Refractory Testing**
- RUL/CIC
- HMOR
- PCE

**Accelerating Rate Calorimetry/Battery Testing**
- ARC®
- MMC

**Standard and Advanced Software**
- Proteus® Standard Software
- Thermokinetics
- Component Kinetics
- Peak Separation
- Thermal Simulations
DIFFERENTIAL SCANNING CALORIMETRY

Differential Scanning Calorimetry (DSC) determines transition temperatures and enthalpy changes in solids and liquids under controlled temperature change. DSC is the most frequently used method in the field of Thermal Analysis. Rapid analyses, high significance for research and quality control tasks, and easy handling of the measuring instrument contribute to its versatility.

The Pathfinders

The premium systems DSC 204 F1 Phoenix® and DSC 404 F1/F3 Pegasus® integrate a number of hardware and software features which are useful in the lower temperature range including application fields such as polymers, foods, pharmaceuticals, composite materials and the higher temperature range including application fields such inorganics, metals, alloys, and ceramics, etc.

DSC 204 F1 Phoenix®

- Temperature range: -180°C to 700°C
- Gas-tight
- Highest Indium Response Ratio
- Choice of sensors for high resolution and high sensitivity
- Unique correction modes incl. Advanced BeFlat® and Tau-R®
- AutoEvaluation and Identify for curve evaluation and interpretation (incl. database)
- Temperature-modulation*
- Automatic sample changer*: up to 204 samples and references
- UV-extension*

DSC 404 F1/F3 Pegasus®

- High-temperature DSC: -150°C to 2000°C
  (DTA above 1750°C)
- $c_p$ determination up to 1500°C
- Defined atmospheres or vacuum
- Quickly interchangeable sensors (DSC-$c_p$, DSC, DTA)
- Automatic sample changer* or double-furnace operation
- Temperature-modulation* (only for DSC 404 F1 Pegasus*)

* Optional feature
Day-to-Day Excellence – The Benchmarks of NETZSCH

**DSC 214 Polyma**
Optimized not only for polymer analyses, this DSC takes the entire analytical process chain into account, from sample preparation to evaluation and interpretation of the resulting data.

- Temperature range: -170°C to 600°C
- Heating/cooling rates up to 500 K/min
- High Indium Response Ratio
- Automatic sample changer*
- AutoEvaluation and Identify for curve evaluation and interpretation (incl. database)

**DSC 204 HP Phoenix**
This unique high-pressure DSC features one of the highest working pressures. It is well-suited for energy materials (e.g., hydrogen storage) and petrochemistry (e.g., oxidation of oils).

- Temperature range: -150°C to 600°C
- Pressure range: vacuum up to 15 MPa
- Inert, reducing, oxidizing atmospheres under static or dynamic conditions
- Precise flow control under high pressure (precision 0.02 bar)*

**DSC 3500 Sirius**
The DSC 3500 Sirius is the ideal tool for daily work in your laboratory. This gas-tight instrument is a reliable entry-level heat-flux DSC for quality assurance and failure analysis.

- Temperature range: -170°C to 600°C
- Various cooling systems*
- Automatic sample changer*
- Easy-to-use
- Low cost of ownership

---

*DSC 214 Polyma*  
*DSC 204 HP Phoenix*  
*DSC 3500 Sirius*
**THERMOGRAVIMETRY**

**SIMULTANEOUS THERMAL ANALYSIS**

Thermogravimetry (TG)/Thermogravimetric Analysis (TGA) investigates materials’ thermal stability and decomposition, whereas Simultaneous Thermal Analysis (STA) combines thermogravimetric analysis and differential scanning calorimetry in one measurement giving perfectly identical test conditions (same atmosphere, gas flow rate, etc).

More than Trapping Mass Changes – TG 209 **F1 Libra**, TG 209 **F3 Tarsus**

TGA is used for quality control and assurance of raw materials and incoming goods as well as for failure analysis of finished parts, especially in the polymer processing industry. Various international standards describe the general principles of TGA for polymers (ISO 11358) or other specific applications, such as compositional analysis for rubber (ASTM D6370) and evaporation loss of lubricating oils (ASTM D6375).

**TG 209 F1 Libra**
- Temperature range: 10°C to 1100°C
- Weighing range/sample load (incl. pan): 2000 mg
- Resolution: 0.1 μg
- Automatic evacuation
- Vacuum-tight: 10⁻² mbar
- 3 mass flow controllers
- Cooling speed: <11 min (to 25°C) in He atmosphere
- c-DTA
- SuperRes
- TGA-BeFlat
- AutoEvaluation and Identify for curve evaluation and interpretation (incl. database)
- Automatic sample changer for 204 samples with lid piercing device
- Optimized for coupling: MS, FT-IR, GC-MS

**TG 209 F3 Tarsus**
- Temperature range: RT to 1000°C
- Air-cooled
- Weighing range/sample load (incl. pan): 2000 mg
- TGA-resolution: 0.1 μg
- Gas-tight
- Atmospheres: inert, oxidizing
- c-DTA
- SuperRes
- AutoEvaluation* and Identify* for curve evaluation and interpretation (incl. database)
- Automatic sample changer*: 20 samples
- Easy sensor change

*Optional feature

---

**TG 209 F3 Tarsus**

**TG 209 F1 Libra**
STA 449 F1/F3/F5 Jupiter® Series – The Result of 50 Years in Fulfilling Customer Requirements

The STA Jupiter® series combines DSC and TGA methods and is thus capable of measuring both heat flow and mass change under completely identical conditions. The application fields of the STA series include plastics, rubbers, resins, fibers, coatings, oils, ceramics, glass, cements, refractories, metals, fuels, pharmaceuticals, etc.

<table>
<thead>
<tr>
<th></th>
<th>F1</th>
<th>F3</th>
<th>F5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>-150°C to 2000°C</td>
<td>-150°C to 2400°C</td>
<td>RT to 1600°C</td>
</tr>
<tr>
<td>Furnaces</td>
<td>9, incl. water-vapor, high-speed</td>
<td>9, incl. water-vapor, high-speed</td>
<td>SiC furnace</td>
</tr>
<tr>
<td>Sample weight, weighing range</td>
<td>5 g</td>
<td>35 g</td>
<td>35 g</td>
</tr>
<tr>
<td>TGA resolution</td>
<td>0.025 μg</td>
<td>0.1 μg</td>
<td>0.1 μg</td>
</tr>
<tr>
<td>Vacuum</td>
<td>10⁻³ mbar</td>
<td>10⁻⁴ mbar</td>
<td>10⁻² mbar</td>
</tr>
<tr>
<td>Sensors</td>
<td>TGA, TGA-DSC, TGA-DSC-cₚ· TGA-DTA</td>
<td>TGA, TGA-DSC, TGA-DSC-cₚ· TGA-DTA</td>
<td>TGA, TGA-DSC, TGA-DTA</td>
</tr>
<tr>
<td>Temperature-modulation</td>
<td>Yes</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Automatic sample changer*</td>
<td>20 samples</td>
<td>20 samples</td>
<td>20 samples</td>
</tr>
<tr>
<td>DSC-BeFlat*</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
</tr>
<tr>
<td>Tau-R® Mode</td>
<td>Yes</td>
<td>Yes*</td>
<td>Yes*</td>
</tr>
<tr>
<td>TGA-BeFlat*</td>
<td>–</td>
<td>Yes* (*)</td>
<td>Yes</td>
</tr>
<tr>
<td>Glove box version</td>
<td>Yes</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

1) If configuration is compatible to STA 449 F5

STA 2500 Regulus

This TGA-DTA analyzer uses a differential balance system which cancels out buoyancy and convection influences over a broad temperature range. Time-consuming correction measurements are no longer required.

- Temperature range: RT to 1600°C
- Differential balance, top-loading
- Sample load (incl. crucible): 1 g
- Weighing range: ± 250 mg
- TGA resolution: 0.03 μg
- Atmosphere: inert, oxidizing
- Vacuum: 10⁻⁴ mbar
- Built-in mass flow controllers
- Low cost of ownership
THE NETZSCH NEVIO LINE
A NEW CONCEPT FOR UNPARALLELED EASE OF USE

Carrying out investigations in the fields of pharmacy, cosmetics or foodstuffs? Your top choice is the new NETZSCH Nevio instrument line.

DSC 204 F1 Nevio

- Premium differential scanning calorimeter
- Various exchangeable sensors optimized for different applications
- Extremely efficient – automatic sample changer for up to 192 samples and automatic piercing device (optional)
- Unsurpassable indium response ratio (outstanding sensitivity with simultaneous high resolution)

DSC 214 Nevio

- Heat-flux DSC with the fastest heating and cooling rates on the market
- Space-saving design
- Perfectly synchronized sensor/crucible arrangement for excellent reproducibility
- High sample throughput thanks to the automatic sample changer for up to 20 samples (optional)

NETZSCH – MORE THAN 60 YEARS OF EXPERIENCE IN MANUFACTURING TOP-CLASS THERMAL ANALYSIS DEVICES
TG 209 F1 Nevio

High-quality ultra-microbalance for research and development
- Vacuum-tight design
- Corrosion-resistant ceramic furnace
- c-DTA® for monitoring caloric effects
- Large filter system for direct trapping of decomposition products
- Pre-configured for coupling to gas analyzing systems (FT-IR, MS or GC-MS)
- High sample throughput for measurements over night or during the weekend – automatic sample changer for up to 192 samples and automatic piercing device (optional)

TG 209 F3 Nevio

The workhorse for quality assurance and process optimization
- Robust and extremely reliable
- Variety of sample carriers for greatest flexibility
- c-DTA® for monitoring caloric effects (optional)
- Large filter system for trapping decomposition products (optional)
- Gas-tight design
- High sample throughput thanks to the automatic sample changer for up to 20 samples (optional)

STA 449 F3 Nevio

Specialized for demanding tasks
- Modular setup, adjustable to a variety of requirements, e.g., for measurements under relative humidity
- Vacuum-tight
- Pre-configured for coupling to gas analyzing systems (FT-IR, MS or GC-MS)
- Automatic sample changer for up to 20 samples (optional)
NETZSCH offers the widest range of Dynamic-Mechanical Analysis (DMA or DMTA) instruments and testing machines for the investigation of the temperature-dependent visco-elastic properties by applying an oscillating force – up to the highest force range— to the sample. The product range includes flexometers, also for thermal fatigue tests of rubber materials and instruments for the measurement of the dynamic shore hardness or the adhesive properties (autohesion), for instance for rubber compounds before vulcanization.

DMA 242 E Artemis® – The All-Rounder in the Lower Force Range

This all-rounder offers a high resolution of the deformation measuring system which enables precise measurements on both very rigid and very soft samples. The system offers a variety of deformation types, digital signal filtering, kinetic evaluation and frequency extrapolation.

- Temperature range: -170°C to 600°C
- Frequency range: 0.01 Hz to 100 Hz
- Modulus range: $10^{-3}$ MPa to $10^6$ MPa
- Force range: up to 24 N (static and dynamic)
- High resolution force range: 8 N
- Deformation modes: bending, tension, shearing, compression/penetration
- Accessories*: immersion bath, humidity generator (see picture), UV lamp, dielectric analyzer (DEA)
- Fast Fourier Transformation (FFT)

GABOMETER® Series – Tests up to 4000 N

The GABOMETER® series can be used as Goodrich flexometers for heat build-up tests and upgraded for fatigue tests in tension, compression and shear mode. The GABOMETER® fulfill: ASTM D623, DIN 53 533, ISO 4666/3, 4, BS 903 part A50 and JIS K 6265.

- Temperature range: -160°C to 300°C
- Sample diameter: 17.8 mm to <40 mm*
- Sample thickness: 25 mm
- Force range: up to max. 4000 N
- Static strain: up to 60 mm*
- Dynamic strain: up to ± 10 mm*
- Automatic sample changer
- Compression set
- Heat build-up
- Blow out test
- Temperature measurements in the sample and on the surface
- Dynamic visco-elastic properties*
- Tension flexometers*
EPLEXOR® Series High-Force DMA up to 6000 N

Various EPLEXOR® systems with different maximum forces and strains are available. A fully automatic testing instrument is realized by the automatic sample changer. The instruments are based on: DIN 53513, ISO 6721/1 und 4, ISO 6721/5, ISO 6721/6, ISO 4664, ASTM D4065, ASTM D4473.

- Temperature range: -160°C to 1500°C
- Two independent drives for static and dynamic load
- Force range: up to 6000 N
- Changeable force transducers
- Frequency range: 0.01 Hz to 200 Hz
- Deformation modes*: bending, tension, shear, compression/penetration
- Accessories*: immersion bath, humidity chamber, automatic sample changer
- Special sample holders* for liquids, fibers or tire cord testing

GABOTACK® Tackiness Tester for Green Tires, Adhesives and more

GABOTACK® provides an efficient and reliable tool for the determination of the tackiness and adhesion of green tires, adhesive tapes and paints.

- Temperature range: ambient
- Force range: 150 N or 500 N
- Changeable force transducers
- Pressing speed: up to 3 mm/s
- Pressing force: up to 500 N
- Pressing time: up to 1000 s
- Absolute values of deformation, force, initial sample length, time and speed
- Determination of tack force and tack energy
THERMOMECHANICAL ANALYSIS
DILATOMETRY

Many materials undergo changes to their thermomechanical properties when they are exposed to temperature changes, e.g., phase changes, sintering steps or softening which can occur in addition to thermal expansion. TMA analysis provides valuable insight into the composition, structure, or application possibilities for materials such as plastics, elastomers, paints, composites, adhesives, films, fibers, ceramics, glass, and metals. Dilatometry (DIL) is the method of choice to study length change phenomena of ceramics, construction materials, glasses, metals, etc.

More than just Thermal Expansion – TMA 402 F1/F3 Hyperion®

With its compact design and user-friendly operation, the TMA 402 sets new standards for the analysis of a variety of materials. The sample holder (for expansion, penetration, bending or tension measurements) is freely accessible once the top-mounted furnace has been raised. This ensures easy sample selection for fast measurement start.
- Temperature range: -150°C to 1000°C and RT to 1550°C via two interchangeable furnaces
- Vacuum-tight thermostatic measuring system
- Easily interchangeable sample holders made of fused silica or alumina
- Max. sample length 30 mm
- High resolution: 0.125 nm/digit
- Force range: 1mN to 3 N
- Modulated force* (only for F1)
Dilatometry Redefined – DIL 402 Expedis Series

The dilatometer DIL 402 Expedis series offers state-of-the-art dilatometer technology and is designed for a wide range of sophisticated applications. All instruments of the DIL Expedis series feature the revolutionary NanoEye measuring cell – a new dimension in measuring range and accuracy.

DIL 402 Expedis Classic

The Classic version stands out by its all-in-one design and ease of use which make it very suitable for routine measurements in the fields of ceramics, building materials and glasses.

DIL 402 Expedis Select/Supreme

The comprehensive, fully-equipped Supreme model and the upgradable Select type are designed for research & development and sophisticated industrial applications.

<table>
<thead>
<tr>
<th></th>
<th>Classic</th>
<th>Select/Supreme</th>
<th>Supreme HT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature range</strong></td>
<td>RT to 1150°C, RT to 1600°C</td>
<td>-180°C to 2000°C, Various furnaces</td>
<td>RT to 2800°C</td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Single or double dilatometer</td>
<td>Single or double dilatometer</td>
<td>Single or double dilatometer</td>
</tr>
<tr>
<td><strong>Measuring range</strong></td>
<td>10 mm</td>
<td>25 mm/50 mm</td>
<td>50 mm</td>
</tr>
<tr>
<td><strong>NanoEye</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Δl resolution</strong></td>
<td>2 nm/digit</td>
<td>1 nm/0.1 nm/digit</td>
<td>0.1 nm</td>
</tr>
<tr>
<td><strong>Automatic sample length detection</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Controlled contact</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Force range</strong></td>
<td>0.01 N to 3 N</td>
<td>0.01 N to 3 N</td>
<td>0.01 N to 3 N</td>
</tr>
<tr>
<td><strong>Force modulation</strong></td>
<td>–</td>
<td>Optional/yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Sample length</strong></td>
<td>0 to 52 mm</td>
<td>0 to 52 mm</td>
<td>0 to 52 mm</td>
</tr>
<tr>
<td><strong>Vacuum-tightness</strong></td>
<td>–</td>
<td>–</td>
<td>≈10⁻⁴ mbar</td>
</tr>
</tbody>
</table>

* Optional feature
COUPLING TO EVOLVED GAS ANALYSIS

Our Thermal Analysis equipment incorporates vertical gas flow systems in the furnaces. This yields perfect gas transport in the natural upward flow direction and requires only low purge gas flow rates, resulting in low dilution of the evolved sample gases. Sensitive and complete detection and analysis of evolved gas species result from our many years of experience in coupling gas analyzers. The temperature range of the coupling is according to the coupled thermal analysis instrument.

The All-Encompassing Coupling to Gas Chromatograph-Mass Spectrometer (GC-MS) and Infrared Spectrometer (FT-IR)

All vacuum-tight thermobalances (TGA) and Simultaneous Thermal Analyzer (STA) are the ideal basis for coupling with one or two evolved gas analyzers (EGA) – even when equipped with the automatic sample changer (ASC). Simultaneously recorded data about weight changes, enthalpy changes and evolved gases provides an optimum platform for comprehensive material characterization.

The all-encompassing coupling is possible in the following combinations:
- STA 449 F1/F3/F5 Jupiter® or TG 209 F1 Libra® + GC-MS+FT-IR,
- DSC 404 F1/F3 Pegasus® or DSC 204 F1 Phoenix® + MS+FT-IR.

- Analysis of decomposition steps
- Solid-gas reactions
- Evaporation, outgassing
- Detection of volatiles
- Analysis of additives
- Compositional analysis
- Analysis of aging processes
- Desorption behavior

PulseTA® – Quantification, Adsorption and Desorption

The unique PulseTA® is the perfect tool for achieving quantitative gas detection. It allows for the studying of gas-solid reactions and simplifies adsorption/desorption experiments.
Coupling to Mass Spectrometers via Capillary or **SKIMMER**

**STA 449 Jupiter** – **QMS 403 Aēolos** *Quadro*

The vacuum-tight STA systems offer fast atmosphere adjustment, especially with very pure and non-oxidizing sample atmospheres.
- Optimized gas transfer
- No dead volume or cold spots
- Low dilution – high sensitivity
- Up to 300 u/512 u
- 3D presentation of results
- Detection limit: > 100 ppb (gas dependent)

**STA-MS SKIMMER** Coupling

The MS SKIMMER coupling is the shortest possible solution for the transfer of gas from the sample to the QMS. All components of the system are heated to at least the sample temperature, thus preventing the possibility of any condensation. Even metal vapors are detected by this unrivalled coupling system.
- Temperature range: RT to 2000°C
- Mass range: 1 u to 512/1024 u
- Electron impact ionization
- Operation modes: MID, scan, scan/bar-graph
- Detection limit: > 100 ppb

**PERSEUS – Integrated FT-IR Coupling**

**PERSEUS TG 209 F1/PERSEUS STA 449 F1/F3**

The PERSEUS coupling is an alliance between the TG 209 *Libra* or STA 449 *F1/F3 Jupiter* and a compact FT-IR spectrometer by Bruker Optics. Its design is both unprecedented and unmatched, and sets a benchmark for coupling techniques.
- Affordable gas analysis
- No separate transfer line
- Built-in heated gas cell
- Optimized low-volume design
- Space-saving
- Minimized risk of condensation

---

*Optional feature*
THERMAL CONDUCTIVITY

Thermal conductivity is a significant thermophysical property and can be determined by means of heat flow meters or the Guarded Hot Plate for insulators, and the hot-wire method for refractories.

Accurate Thermal Conductivity Testing of Insulation Materials

HFM 446 Lambda Series

With the Heat Flow Meter series, HFM 446 Lambda, the thermal conductivity of insulation panels can be investigated. Precise measurement data is obtained after a short compensation time. It is suitable for insulation and building materials such as fiber boards, loose fill fiberglass, rock wool, synthetics, ceramic fiber boards, cellular plastics, powders, foams, evacuated panels, gypsum boards, wood, concrete, sand, and soil.

- Temperature range of plates: -20°C to 90°C
- Thermal conductivity range: 0.02 W/(m·K) to 2.0 W/(m·K)
- Thermal resistance range: 0.02 to 3.0 (m²·K)/W
- Sample dimensions:
  - HFM 446 Lambda Small: 203 mm x 203 mm, thickness up to 51 mm
  - HFM 446 Lambda Medium: 305 mm x 305 mm, thickness up to 105 mm
  - HFM 446 Lambda Large: 611 x 611 mm, thickness up to 200 mm
- Repeatability: 0.5% (verified with NIST SRM 1450D)
- Accuracy: ±1% - 2 % (verified with NIST SRM 1450D)
- Unmatched test speed
- Four-corner thickness determination
- Variable contact force, density variation of compressible materials; contact pressure calculated by software
- Instrumentation kit for extension of conductivity range (available for HFM 446 Lambda Small and Medium)
- Based on ASTM C518, ISO 8301, JIS A1412, and EN 12667

1 Depending on the instrument; when testing near the limits of these ranges, special techniques may be required for sample preparation, instrument calibration, and temperature measurement.
Absolute Measurement of the Thermal Conductivity

GHP 456 Titan®

For advanced measurements, the GHP 456 Titan® Guarded Hot Plate is recommended for measuring the thermal conductivity of insulations with outstanding reliability and accuracy. This system is the ideal tool for researchers and scientists.

- Temperature range:
  - Low-temperature version: -160°C to 250°C
  - High-temperature version: -160°C to 600°C
- Absolute technique: Symmetric test configuration
  (2 specimens; tests on one specimen are also possible)
- Cooling systems*: compressed air, liquid nitrogen, chiller
- Thermal conductivity range: 0 to 2 W/(m·K)
- Atmospheres: inert, oxidizing, vacuum
- Accuracy: typically 2%
- Sample thickness: up to 100 mm
- Plate dimension: for standard 300x300 mm, for GHP 456 HT Titan 500x500 mm
- Vacuum-tight by design
- 31 separately calibrated sheeted Pt-100 temperature sensors for optimum temperature measurement

* Optional feature

HFM 446 Lambda Large
THERMAL DIFFUSIVITY

The characterization of highly conductive materials at cryogenic and moderate temperatures or ceramics and refractories at elevated temperatures is of high interest. Many challenges can only be met with precise knowledge of the thermal diffusivity and conductivity. One accurate and robust solution for the direct determination of the thermal diffusivity is offered by the Laser/Light Flash Methods (LFA). The thermal conductivity is then calculated by using the LFA results. The software already includes various corrections, calculation models and mathematical operations for improved evaluation of the LFA data.

LFA 467 HyperFlash® Series – Optimized Field of View Between -100°C and 1250°C

The HyperFlash® series features an intelligent lens system (ZoomOptics) between the sample and the detector, an extremely fast data acquisition and a wide temperature range, which is handled by a single instrument setup, without changing either the detector or the furnace. These systems are capable of measuring thin films.

### LFA 467 HyperFlash®
- Temperature range: -100 to 500 °C
- Various cooling devices*
- Thermal conductivity range: 0.1 W/(m·K) to 4000 W/(m·K)
- Light source: Xenon flash lamp
- Data acquisition: up to 2 MHz
- Min. measurement time (10 half times) down to 1 ms → for highly conducting and/or thin samples
- Max. measurement time up to 120 s → for low-conducting and/or thick samples
- Automatic sample changer for up to 16 samples, round and square
- Specimen dimensions: 4 x Ø 25.4 mm (max.), 6 x Ø 12.7 (max.), 16 x 10 mm (max.)
- Special sample holders*: liquids, pastes and powder, fibers, etc.
- Various combinable software models
- Model wizard

### LFA 467 HT HyperFlash®
- Temperature range: RT to 1250 °C
- Thermal conductivity range: 0.1 W/(m·K) to 4000 W/(m·K)
- Light source: Xenon flash lamp
- Data acquisition: up to 2 MHz
- Min. measurement time (10 half times) down to 1 ms → for highly conducting and/or thin samples
- Max. measurement time up to 120 s → for low-conducting and/or thick samples
- Vacuum: 10⁻⁵ mbar (with turbo pump)
- High-speed mini-tube furnace for up to 4 round or square specimens (4 x Ø 12.7 mm, 4 x 10 mm)
- Small foot print
- Various combinable software models
- Model wizard

* Optional feature
LFA 457 MicroFlash®

This tabletop LFA system offers excellent versatility for research and development. It is suitable for the characterization of high-performance and standard materials in automobile manufacturing, aeronautics, astronautics and energy technology. Its innovative infrared sensor technology enables measurement of the temperature increase, even at lowest subambient temperatures.

- Temperature range: -125°C to 1100°C
- Thermal conductivity range: 0.1 to 2000 W/(m·K)
- Vacuum: 10^{-2} mbar
- Various specimen dimensions:
  - \( \square \): 6 x 6, 8 x 8 or 10 x 10 mm²;
  - \( \Ø \): 6, 8, 10, 12.7 or 25.4 mm;
  - thickness 0.1 mm to 6 mm
- Special sample holder for liquids, pastes, powders, fibers, lamellas, in-plane, etc.
- ASC for up to 3 samples
- Various combinable software models
- Model wizard

LFA 427

The LFA 427 is the most versatile instrument allowing tests on solids, powders, laminates, or even liquid metals and slags up to 2800°C.

- Temperature range: -120°C to 2800°C
- Thermal conductivity range: 0.1 W/(m-K) to 2000 W/(m-K)
- Vacuum: 10^{-5} mbar
- Atmospheres: inert, oxidizing, reducing
- Sample dimensions:
  - \( \square \): 8 x 8 or 10 x 10 mm²;
  - \( \Ø \): 6,8,10 or 12.7 mm, 20 mm (special version); thickness: 0.1 to 6 mm
- Special sample holder for liquid metals, slags, pastes, powders, etc.
- Various combinable software models
- Model wizard

1 Lower values possible, depending on sample's properties
2 Special dimensions on request
SEEBECK COEFFICIENT 
AND ELECTRICAL CONDUCTIVITY

NETZSCH offers an all-embracing product line for the determination of the thermophysical properties. When it comes to thermoelectrics, simultaneous determination of the Seebeck coefficient and electrical conductivity under identical conditions is of paramount importance for the determination of the figure of merit \(ZT\).

SBA 458 Nemesis® – Pushing the Limits for Thermoelectric Materials

The clever measurement setup of the SBA 458 Nemesis® with fixed thermocouple positions allows for the use of various sample geometries without the need for tools to insert and remove the sample. An outstanding two-heater system immediately identifies deviations in linearity and hysteresis in case of measurement inaccuracies.

- Temperature range: -125°C to 1100°C
- Integrated quality check by two-heater system
- Sample geometries: Square, round, rectangular, strips
- Sample dimensions:
  - Ø 12.7 mm to 25.4 mm
  - Length: 12.7 to 25.4 mm
  - Width: 2.0 to 25.4 mm
  - Thickness: 100 nm to 3 mm, depending on the material's thermophysical properties
- Plug-and-measure sample holder for easy sample change
- Vacuum-tight: \(10^{-2}\) mbar
- Thermocouples: Inconel-sheathed type K (NiCr/NiAl), fixed position
- Temperature setting range: Unlimited number of temperature steps
- Quality check
Dielectric Analysis (DEA, or Dielectric Thermal Analysis (DETA), is a technique for monitoring changes in the viscosity and cure state by measuring variations in the dielectric properties—even during processing. The DEA 288 Ionic series is used for most thermosets, adhesives, paints, and coatings, including fast-curing thermosets such as SMC/BMC and UV curing.

DEA 288 Ionic Series – Clear-Cut Determination of the Curing Behavior

The DEA 288 Ionic covers a wide range of measurement frequencies in order to accurately determine the changes in dielectric properties during reaction. With their minimum data acquisition time of less than 5 ms, the instruments can even handle fast curing systems such as UV curing.

### Portable Version

With up to 7 channels, this DEA is the flexible version for your day-to-day work. It can be easily transported between different measurement locations.

- Frequency range: 1 mHz to 1 MHz, freely selectable values
- Temperature range: -140°C to 400°C (with furnace)
- True simultaneous operation of all channels
- Minimum data acquisition time: < 5 ms
- Wide spectrum of implantable and reusable sensors
- Accessories*: furnace, press, and UV lamp

### Rack Version for Integration into an Industrial Process

The 19” Rack version is designed for an electrical cabinet. It supports 8 simultaneous measuring channels which can be extended up to 16 modules.

* Optional feature
REFRACTORIES TESTING

Special strength-testing methods have been established for refractory ceramics, which are of a mostly heterogeneous composition. All NETZSCH refractories testing instruments conform to the pertinent instrument and applications standards, e.g., ISO 1893, ISO 3187, ISO 5013, DIN EN 993-7/8/9/12/14/15, DIN 51048, DIN 51053, DIN 51063, DIN 51046, ISO 8894-1, ISO 8894-2, ASTM C1113.

Refractoriness Under Load (RUL) and Creep in Compression (CIC)

RUL/CIC 421

Refractoriness under load (RUL) is a measure of the resistance of a refractory product to deform when it is subjected to the combined effects of load, rising temperature, and time. The RUL 421 reliably checks the use of refractory products in high-temperature applications. Creep in compression (CIC, according to ISO 3187) refers to the percent of shrinkage of a refractory test piece under a constant load and exposed to a constant high temperature over a long period of time. The RUL/CIC 421 allows for precise dilatometer measurements on large and even inhomogeneous samples.

- Temperature range: RT to 1700°C
- Heating elements: 4 Super-Kanthal 1800
- Specimen size: Ø 50 mm, 50 mm height
- Load range: 1 N to 1000 N, in steps of 1 N and 100 N
- Test atmosphere: static air, inert gas purge*
- Vacuum-tight version*
Comprehensive Refractories Testing – Hot Modulus of Rupture, Pyrometric Cone Equivalent

HMOR 422

Measuring the modulus of rupture of refractories at elevated temperatures has become a widely-accepted method of evaluating materials at operating temperatures. It is a very important parameter for quality control which, together with other thermophysical properties, gives information about the behavior of refractory materials used for furnace linings. This method is described in ISO 5013.

- Temperature range:
  - RT to 1500°C
  - HMOR 422: RT to 1500°C
  - HMOR 422 E: RT to 1450°C
- Heating elements: SiC
- Chamber furnace with pre-heating zone
- Specimen dimensions:
  - HMOR 422:
    - 150 mm x 25 mm x 25 mm
  - HMOR 422 E:
    - 45 mm x 4.5 mm x 3.5 mm
- Bending mode:
  - HMOR 422: 3-point
  - HMOR 422 E: 4-point
- Load range: 0 N to 5000 N
- Load rate: 10 to 2000 μm/min
ACCELERATING RATE CALORIMETRY
BATTERY TESTING

Accelerating Rate Calorimeters help secure safe and cost-effective operations in industry. As highly versatile miniature chemical reactors, they measure thermal and pressure properties of exothermic chemical reactions. The resulting information helps engineers and scientists to identify potential hazards and address key elements of process safety design including emergency relief systems, process optimization, and thermal stability. For all NETZSCH Accelerating Rate Calorimeters with internal heaters, the patented VariPhi option enables measurements at constant heating rates (exo/endo) and monitoring pressure data.

Multiple Module Calorimeter

MMC 274 Nexus®

Interchangeable calorimeter modules of the MMC 274 Nexus® allow adiabatic and scanning tests accompanied by pressure measurements. For coin cell studies a dedicated coin cell module is available. Data generated from the MMC test is merged seamlessly with the data generated from the cycler/analyzer.

- ARC and scanning module:
  - Tracking rate: 50 K/min
  - Temperature range: RT to 500°C
  - Max. pressure: 100 bar
  - Max. tracking rate: 50 K/min
  - Container volume: 0.1 to 8.5 ml, depending on module
- Coin cell module for testing coin cells as a whole:
  - Temperature range: RT to 300°C
  - Heating rate: 5 K/min
  - Coin cell: e.g., CR2032
  - Energy measurement reproducibility: 1%
  - Discharge tests, battery cycling
Accelerating Rate Calorimeters – Tracking Exothermic Reactions

ARC® 244/254

The models allow to safely measure the amount and rate of heat release associated with the processing or storage of chemicals. In addition, the 254 model offers options for the stirring, venting, VariPhi and injection of chemicals.

- Temperature range: RT to 500°C
- Max. pressure: 200 bar
- Max. tracking rate:
  - ARC 244 20 K/min
  - ARC 254 200 K/min
- Sample volume: 0.5 ml to 7 ml
STANDARD AND ADVANCED SOFTWARE

One of the most complete and easy-to-handle software solutions in Thermal Analysis, Proteus®, has grown over the years. Developed by our experienced software team and tested by many application experts, this software for measurement and evaluation supports you with a practice-oriented structure, easy-to-understand user guidelines and a comprehensive help system. Raw data security and sample calibration and correction functions allow you to work conforming to standardized procedures. Documentation and data export are flexible for many report formats.

Proteus® – Measurement and Evaluation at its Best

- User-friendly
- Multi-tasking system
- Multi-mode, simultaneous control of up to 4 instruments
- Combined analysis of different methods
- Storage and restoration of analyses
- SmartMode*
- Expert Mode
- Fully-automatic evaluation* (AutoEvaluation)
- Polymer identification* (Identify, database)
- Automatic baseline correction
- Purity Determination
- Tau-R* mode (thermal resistance, time constant)
- Specific heat capacity \( c_p \)
- c-DTA* (calculated DTA for TGA and DIL)
- Rate-controlled mass change, SuperRes® (TGA)
- Rate-controlled sintering (DIL)
- Export result to ASCII file
- Temperature-modulated DSC/TGA-DSC (STA)
- Context-sensitive help system
- Fully compatible with other Windows® applications
- ISO 9001 certified by BVQI

Advanced Software* – Extensions for Comprehensive Evaluation

Kinetics Neo

This software module creates kinetic models of chemical processes based on a series of laboratory measurements under different temperature conditions. It can be used to predict the behavior of chemical systems under user-defined conditions for process optimization. Curves obtained by DSC, TGA, DIL, DMA, DEA and FT-IR can be analyzed.

A thermokinetics analysis makes it possible to determine the number of reaction steps and the following values for each step:
- Reaction type
- Activation energy
- Order of reaction
- Other kinetic parameters

* Optional feature, not available for all instruments
Temperature- Modulated DSC – TM-DSC

In TM-DSC, the underlying linear heating rate is superimposed by a sinusoidal temperature variation. The benefit of this procedure is the chance to separate overlapped DSC effects by calculating the reversing and the non-reversing signals. The reversing heat flow is related to the changes in specific heat capacity (e.g., glass transition) while the non-reversing heat flow corresponds to temperature-dependent phenomena such as curing, dehydration or relaxation.

Peak Separation

This program allows for the separation of overlapped peaks using profiles from the following peak types: Gaussian, Cauchy, pseudo-Voigt (linear combination of Gaussian and Cauchy), Fraser-Suzuki (asymmetric Gaussian), modified Laplace (double-sided rounded) and Pearson. With it, the experimental data is fitted as an additive superposition of peaks.

Thermal Simulations

The Thermal Simulations is used for simulation of the thermal behavior while accounting for both heat generation and thermal conductivity. The kinetic decomposition mechanisms often change with temperature. Correct description of the decomposition reaction process is the essential basis for an accurate prediction.
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