

# NETZSCH

Proven Excellence.



## Advanced Materials Testing

Thermal Analysis, Methods for Determination of Thermophysical Properties, Cure Monitoring, Rheology, Fire Testing, Accelerating Rate and Isothermal Calorimetry

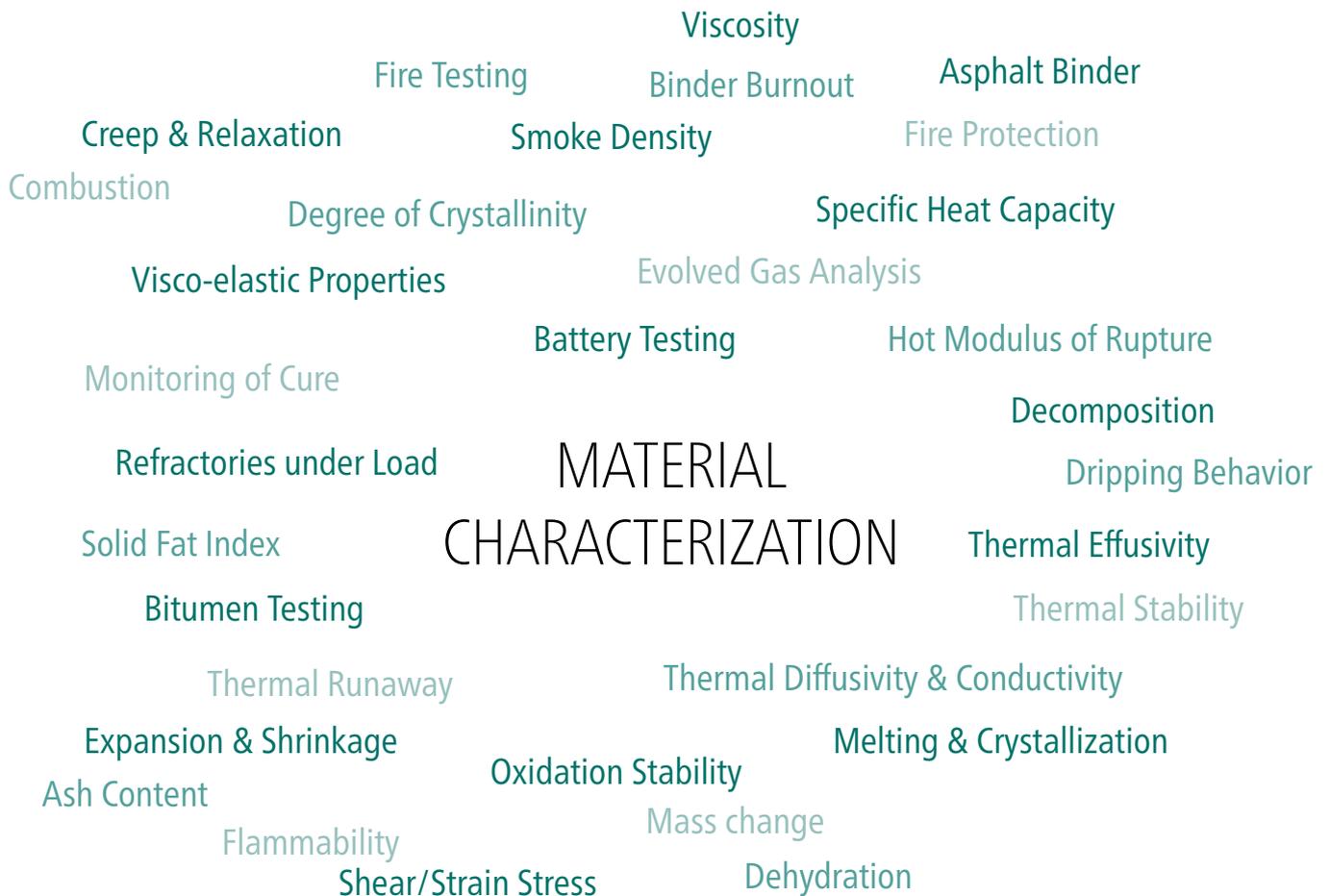
Analyzing & Testing

# Leading Thermal Analysis

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.



# Product Portfolio

At NETZSCH, you will find solutions for Thermal Analysis, thermo-physical properties testing, cure monitoring, dynamic-mechanical testing, rheology, multiple module and accelerating rate calorimetry as well as for fire testing.

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, viscosity and evolved gases including determinations with regard to purity and composition, poly-morphism, thermal stability and application temperature limits, aging and thermomechanical behavior, visco-elastic properties, processing conditions, and fire behavior.

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.

Diversified  
Product Range  
for Eclectic  
Applications

## 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

## Rheology

- Rotational Rheometer
- Capillary Rheometer

## Thermal Conductivity and Thermal Diffusivity

- HFM
- Guarded Heat Flow Meter (GHFM)
- Guarded Hot Pipe
- Guarded Hot Plate (GHP)
- LFA
- Time Domain Thermoreflectance

## Accelerating Rate Calorimetry/ Battery Testing

- ARC®
- MMC

## Fire Testing Systems

- KBT 916, SBI 915, TBB 913, TNB 912, KBK 917, TRDA, UL 94, LOI 901, HBK 919, TCC 918, TDP T4

## Refractory Testing

- RUL/CIC

## Standard and Advanced Software

- *Proteus*® Standard Software
- Kinetics Neo
- *Peak Separation*
- Temperature-Modulation

# 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 300 *Caliris*<sup>®</sup> *Select* and *Supreme* and DSC 500 *Pegasus*<sup>®</sup> 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 as inorganics, metals, alloys, and ceramics, etc. The economic entry-level DSC 300 *Caliris*<sup>®</sup> *Classic* combines a robust instrument with excellent performance. With its small footprint it is ideal for quality control and fits great into teaching environments.

## DSC 300 *Caliris*<sup>®</sup> Series

| <i>Supreme</i>  | <i>Select</i>  | <i>Classic</i>   |
|---|--|--|
| Currently three modules available:  |  |  |
| <ul style="list-style-type: none"> <li>■ H: widest temperature range (-180°C to 750°C)</li> <li>■ P: fastest heating-cooling rates (500K/Min)</li> <li>■ S: high metrological stability for routine measurements</li> </ul> |  | S-module   |
| H-Module: -180°C to 750°C   | H-Module: -180°C to 650°C  |  |
| P and S-Module: -170°C to 600°C   | P and S-Module: -170°C to 600°C  | -170°C to 600°C  |
| Interchangeable module  | Exchangeable module  | No module exchange   |
| Gas-tight   | Gas-tight  | Gas-tight  |
| Integrated 3-fold MFC, 4-fold MFC*  | Integrated 3-fold MFC  | Integrated 3-fold MFC*   |
| Automatic sample changer*: for up to 192 positions and 12 reference materials   |  | Automatic sample changer for 20 samples  |
| <b>Software</b>   |  |  |
| <i>AutoEvaluation</i> and <i>Identify</i> for curve evaluation and interpretation   | <i>AutoEvaluation</i> and <i>Identify</i> for curve evaluation and interpretation* | <i>AutoEvaluation</i> and <i>Identify</i> for curve evaluation and interpretation* |
| <i>Proteus</i> <sup>®</sup> Search Engine*  | <i>Proteus</i> <sup>®</sup> Search Engine*   | <i>Proteus</i> <sup>®</sup> Search Engine*   |
| Temperatur-modulation   | Temperatur-modulation *  | Temperatur-modulation*   |

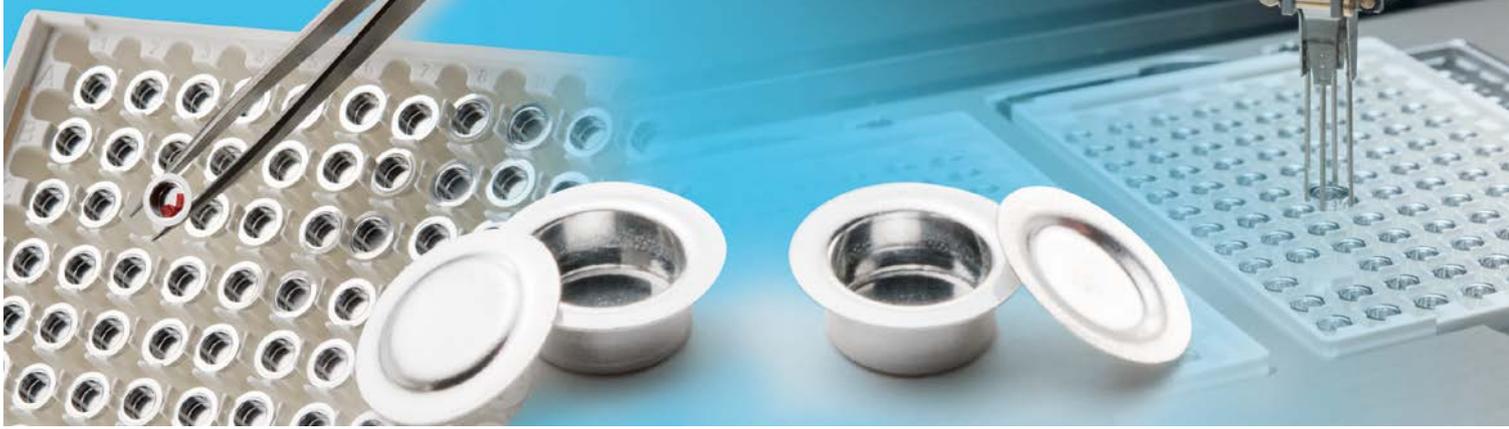


DSC 300 *Caliris*<sup>®</sup> *Select/Supreme*



DSC 300 *Caliris*<sup>®</sup> *Classic*

\* Optional feature



### DSC 300 Caliris® Classic

This is a robust, gas-tight instrument for routine measurements in your laboratory. It is a reliable entry-level heat flux DSC for use in quality assurance and failure analysis, as well as in an educational environment.

- Temperature range: -170°C to 600°C
- Thoroughly informed and in full control thanks to integrated touch display\*
- Perfect for routine applications thanks to predefined and user defined methods
- Automatic sample changer\*
- Speed up results with *AutoEvaluation\** and *Identify\**

### DSC 500 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\*

### DSC 204 HP Phoenix®

The 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 (precision 0.02 bar)\*



DSC 500 Pegasus® with two furnaces



DSC 204 HP Phoenix®

# THERMOGRAVIMETRY

## SIMULTANEOUS THERMAL ANALYSIS

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

### Supreme Determination of Mass Changes – the TG 309 *Libra*® Series

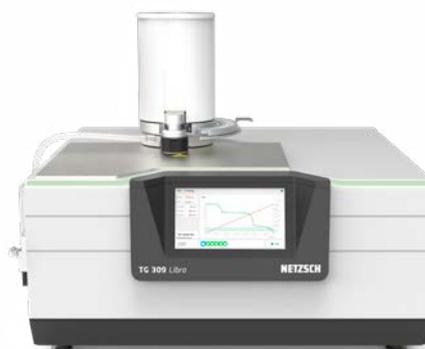
TGA is used for quality control and assurance of raw materials and incoming goods as well as for failure analysis of finished parts, especially in the polymer-processing industry. Various international standards stipulate the general principles of TGA for polymers (ISO 11358) or other specific applications, such as compositional analysis for rubber (ASTM D6370/ISO9924) and evaporation loss of lubricating oils (ASTM D6375).

|  | <i>Supreme</i>                                | <i>Select</i>                                 | <i>Classic</i>                                 |
|--|---|---|--|
| Temperature range                          | (10°C) RT to 1100°C                           | (10°C) RT to 1025°C/1100°C                    | (10°C) RT to 1025°C                            |
| Max. sample weight/<br>Max. weighing range | 2 g/2 g                                       | 2 g/2 g                                       | 2 g/2 g  |
| Balance resolution                         | 10 ng   | 20 ng   | 50 ng  |
| <i>AutoVac</i>                             | Optionally available<br>when MFC was selected | Optionally available<br>when MFC was selected | Optionally available<br>when MFC was selected  |
| Vacuum                                     | $\ll 10^{-1}$ mbar                            | $\ll 10^{-1}$ mbar                            | 1 mbar   |
| Gas Flow                                   | 3-fold MFC,<br>4-fold MFC*                    | 3-fold MFC,<br>4-fold MFC*                    | Gas switch block <sup>1</sup> ,<br>3-fold MFC* |
| Automatic Sample<br>Changer                | up to 204 samples*                            | up to 204 samples*                            | up to 20 samples*                              |
| Coupling options                           | FT-IR, QMS, GC-MS                             | FT-IR, QMS, GC-MS                             | -  |
| <b>Software</b>                            |   |   |  |
| <i>AutoEvaluation</i>                      | incl.   | incl.   | incl.  |
| <i>Identify</i>                            | incl.   | incl.   | *  |
| <i>Peak Separation</i>                     | incl.   | *   | *  |
| <i>Proteus</i> ® Search Engine*            | incl.   | *   | *  |
| Temperature modulation                     | incl.   | *   | *  |
| Eco Mode                                   | incl.   | incl.   | incl.  |

<sup>1</sup> Gas switch block (3 gases incl. protective) required if no MFC is selected



TG 309 *Libra*® Select/Supreme



TG 309 *Libra*® Classic

\* Optional feature



## STA 509 Jupiter® Series – The Result of 50 Years in Fulfilling Customer Requirements

The STA 509 Jupiter® series combines DSC and TGA methods and is thus capable of measuring both heat flow and mass change. The application fields of the STA series include plastics, rubbers, resins, fibers, coatings, oils, ceramics, glass, cements, refractories, metals, fuels, pharmaceuticals, etc.

|                               | <i>Supreme</i>                                 | <i>Select</i>                                  | <i>Classic</i>        |
|-------------------------------|--|--|-----------------------|
| Temperature range             | -150°C to 2000°C                               | -150°C to 2400°C                               | RT to 1600°C          |
| Furnaces                      | 9, incl. water-vapor, high-speed               | 12, incl. water-vapor, high-speed              | SiC furnace           |
| Sample weight, weighing range | 5 g  | 35 g   | 35 g                  |
| TGA resolution                | 0.025 µg                                       | 0.1 µg   | 0.1 µg                |
| Vacuum                        | 10 <sup>-4</sup> mbar                          | 10 <sup>-4</sup> mbar                          | 10 <sup>-2</sup> mbar |
| Sensors                       | TGA, TGA-DSC, TGA-DSC-c <sub>p</sub> , TGA-DTA | TGA, TGA-DSC, TGA-DSC-c <sub>p</sub> , TGA-DTA | TGA, TGA-DSC, TGA-DTA |
| Temperature-modulation        | Yes  | Yes  | Yes                   |
| Automatic sample changer*     | 20 samples                                     | 20 samples                                     | 20 samples            |
| DSC-BeFlat®                   | Yes  | Yes  | Yes                   |
| Tau-R® Mode                   | Yes  | Yes*   | Yes*                  |
| TGA-BeFlat®                   | Yes  | Yes  | Yes                   |
| Glove box version             | Yes  | Yes  | –                     |

## 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

- Top-loading
- Sample load (incl. crucible): 1 g
- Weighing range: ± 250 mg
- TGA resolution: 0.03 µg
- Vacuum: 10<sup>-4</sup> mbar
- Built-in mass flow controllers
- Low cost of ownership



STA 2500 Regulus



STA 509 Jupiter®

# DYNAMIC-MECHANICAL ANALYSIS

NETZSCH offers the widest range of Dynamic-Mechanical Analysis (DMA) 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 303 Eplexor® – The All-Rounder for Forces up to 50N

This all-rounder offers a high resolution of the deformation measuring system which enables precise measurements of visco-elastic properties 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 800°C
- Frequency range: 0.001 Hz to 150 Hz
- Modulus range: 10<sup>-3</sup> MPa to 10<sup>6</sup> MPa
- Force range: up to 50 N (static and dynamic)
- Static deformation: 30 mm
- Dynamic deformation: ± 2500 µm
- Deformation modes: bending, tension, shearing, compression/penetration
- Accessories\*: immersion bath, dielectric analyzer (DEA)



DMA 303 Eplexor®

## The DMA 503 Eplexor® Series – High-Force DMA

The DMA Eplexor® high-force series offers different maximum forces and strains.

- Dynamic force range: ± 500 N, ± 150 N, ± 100 N
- Temperature range: -160° to 1500°C
- Maximum Sample dimensions:
  - Tension: 80 mm x 10 mm x 10 mm (80 mm length)
  - Shear: ø 4 mm to 20 mm (standard: 10 mm)
  - 3-point bending: up to 70 mm free bending length (up to 120 mm sample length)



DMA 503 Eplexor®

\* Optional feature



## DMA 523 *Eplexor*® High-Force and the HBU 523 *Gabometer*® up to 4000 N

The DMA 523 series comes in two instrument variations, the DMA 523 *Eplexor*® and the HBU 523 *Gabometer*®. The HBU 523 *Gabometer*® can be used as Goodrich flexometer for heat build-up and fatigue tests.

- Temperature range:
  - DMA 523: -160°C to 500°C
  - HBU 523: -160°C to 300°C
- Two independent drives for static and dynamic load
- Force range: static 6000 N, dynamic up to 4000 N
- Changeable force transducers
- Frequency range: 0.0001 Hz to 100 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
- HBU 523 *Gabometer*®:
  - Heat build-up
  - Blow-out test



DMA 523 *Eplexor*®  
HBU 523 *Gabometer*®

# RHEOLOGY

Rheology is the study of flow and deformation of materials under applied forces which is routinely measured using a rheometer. The measurement of rheological properties is applicable to many materials from fluids such as dilute solutions of polymers and surfactants through to concentrated protein formulations, to semi-solids such as pastes and creams, to molten or solid polymers as well as asphalt.

## Rotational Rheometers

### Kinexus Prime Series

The Kinexus Prime isn't just a rheometer – it is redefined the way it interacts with you. Kinexus Prime is the next generation rotational rheometer platform that's been developed from extensive market feedback, integrating innovative instrument design with a revolutionary software interface, to deliver a solution that will exceed your rheological expectations.

The Kinexus Prime series includes standard rheometers (Kinexus Prime lab+, Kinexus Prime pro+) and rheometers for advanced testing (Kinexus Prime ultra+).

- Temperature Range: -40°C to 450°C
- Torque Range: 0.5 nNm to 250 mNm, depending on instrument version
- Torque resolution: 0.05 nNm to 0.1 mNm, depending on instrument version
- Force Range: 0.001 N to 50 N



Kinexus Prime ultra+



Kinexus Prime DSR-III

### Kinexus Prime DSR Series – Especially for Asphalt Binder and Bitumen Testing

The Kinexus Prime DSR Series is the next generation rotational rheometer platform for asphalt testing that's been developed from extensive market knowledge and feedback, integrating innovative instrument design with a revolutionary software interface, to deliver an intelligent solution that will exceed your rheological expectations.

- Temperature Range: -40°C to 450°C
- Torque Range: 1 nNm to 225 mNm
- Torque resolution: 0.1 nNm
- Force Range: 0.001 N to 50 N



## Advanced Capillary Rheometers for Research, Product Development and Quality Control

### Rosand RH7/RH10

The current RH7 and RH10 models retain the robust *H* frame design principle, which lies at the heart of the instruments' ability to operate under high loading conditions. A digital drive system gives the RH7 and RH10 unsurpassed performance in terms of speed control, accuracy, and dynamic operating range. This hardware is supported by the latest generation of Windows® based software, Flowmaster, with many new experimental possibilities.

- Temperature Range: Ambient to 400°C (500°C optional), 5°C to 300°C (cooling coil option)
- Force Range:
  - RH7: 50 kN
  - RH10: 100 kN
- Maximum Speed:
  - RH7: 600 mm/min
  - RH10: 1200 mm/min
- Bore diameter: 15 mm standard (9.5, 12, 19 and 24 mm bore options)



Rosand RH10



Rosand RH2000

### Rosand RH2000

The Rosand RH2000 series of benchtop capillary rheometers are compact systems capable of most testing requirements encountered in capillary rheometry.

- Temperature Range: Ambient to 400°C (500°C optional), 5°C to 300°C (cooling coil option)
- Force Range: 12 kN standard (20 kN optional)
- Maximum Speed: 600 mm/min standard (1200 mm/min high speed option)
- Bore diameter: 15 mm standard (9.5, 12, 19 and 24 mm bore options)

# 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 512 Hyperion®

With its compact design and user-friendly operation, the TMA 512 series 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: -70°C to 1500/1600°C and -150°C to 1600°C via interchangeable furnaces
- Measurements down to -70°C using intacooler and down to -150°C using LN<sub>2</sub>
- Measurement of length change and corresponding force
- 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 4 N (only for *Supreme*, 3N for *Select*)
- Modulated force\* (*Select*)



TMA 512 Hyperion®



## Dilatometry Redefined – DIL 502 *Expedis* Series

The dilatometer DIL 502 *Expedis* series offers state-of-the-art 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 unique dimension in measuring range and accuracy.

### DIL 502 *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 502 *Expedis Select/Supreme*

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



DIL 502 *Expedis*® *Classic*



DIL 502 *Expedis*® *Supreme*

|                                   | <i>Classic</i>               | <i>Select</i>                      | <i>Supreme</i>                     |
|-----------------------------------|------------------------------|------------------------------------|------------------------------------|
| Temperature range                 | RT to 1600°C                 | -180°C to 2000°C, various furnaces | -180°C to 2800°C, various furnaces |
| Type                              | Single or double dilatometer | Single or double dilatometer       | Single or double dilatometer       |
| Measuring range                   | ± 5000 µm                    | ± 10000 µm                         | ± 25000 µm                         |
| <i>NanoEye</i>                    | Yes                          | Yes                                | Yes                                |
| ΔL resolution                     | 2 nm                         | 1 nm                               | 1 nm                               |
| Automatic sample length detection | Yes                          | Yes                                | Yes                                |
| Force range                       | 0.01 N to 3 N                | 0.01 N to 3 N                      | 0.01 N to 3 N                      |
| Force modulation                  | Optional                     | Optional                           | Yes                                |
| Sample length                     | 0 to 52 mm                   | 0 to 52 mm                         | 0 to 52 mm                         |
| Vacuum-tightness                  | –                            | ≈10 <sup>-5</sup> mbar             | ≈10 <sup>-5</sup> mbar             |

# EVOLVED GAS ANALYSIS – COUPLED TO THERMAL 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.

## Thermal Analysis and Evolved Gas Analysis – A Smart Combination

All vacuum-tight thermobalances (TGA) and Simultaneous Thermal Analyzers (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 coupling to thermal analyzers (STA, TGA, DSC) can be realized with the following types of spectrometric gas analyzers: MS, FT-IR and GC-MS.

### Possible Applications

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



Bruker INVENIO with external gas cell

STA 509 Jupiter®

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



Mass spectrometer

Gas chromatograph

STA 509 Jupiter®

\* Optional feature

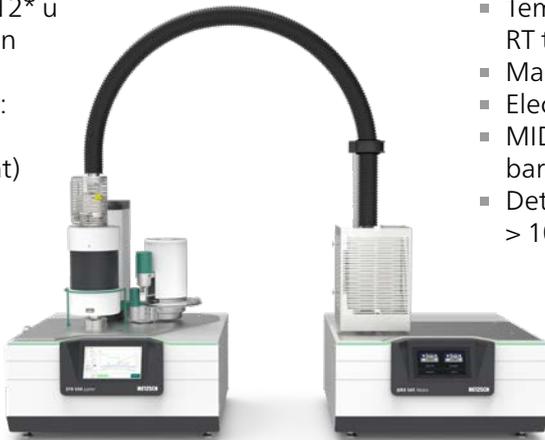


## Mass Spectrometer Coupling via Capillary or SKIMMER

### STA 509 Jupiter® – QMS 505 Aëolos

The 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  $\mu$ /512\*  $\mu$
- 3D presentation of results
- Detection limit: > 100 ppb (gas dependent)



STA 509 Jupiter® coupled to QMS 505 Aëolos

### STA 449 F3 Jupiter® with SKIMMER Furnace

The 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 1450°C or RT to 1950°C
- Mass range: 1  $\mu$  to 512  $\mu$
- Electron impact ionization
- MID, scan, scan/ bar-graph
- Detection limit: > 100 ppb



STA 449 F3 Jupiter® with SKIMMER Furnace

## PERSEUS – Integrated FT-IR Coupling

### PERSEUS TG 309 Libra® / PERSEUS STA 509 Jupiter®

The PERSEUS coupling is an alliance between the TG 309 Libra® Select/Supreme or STA 509 Jupiter® Classic/Select/Supreme 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



PERSEUS TG 309 Libra®



## THERMAL CONDUCTIVITY

Thermal conductivity is a significant thermophysical property and can be determined by means of heat flow meters or the Guarded Hot Plate.

### Heat-Flow Meters – HFM 706 *Lambda* Series

The Heat Flow meter is suitable for insulation and building materials such as different fiber boards, loose fill, cellular plastics, powders, foams, evacuated panels, etc. The HFM series is based on standards ASTM C518, ISO 8301, JIS A1412, and EN 12667.

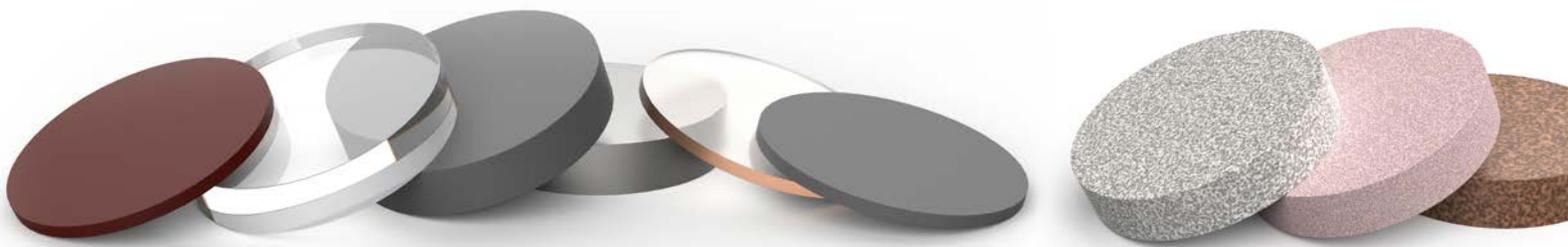
- Temperature range of plates:  $-30^{\circ}\text{C}$  to  $90^{\circ}\text{C}$
- Thermal conductivity range:  $0.001 \text{ W}/(\text{m}\cdot\text{K})$  to  $2.0 \text{ W}/(\text{m}\cdot\text{K})$
- Thermal resistance range:  $0.05$  to  $10.0 (\text{m}^2\cdot\text{K})/\text{W}$
- Sample dimensions: from  $203 \text{ mm} \times 203 \text{ mm}$  up to  $611 \text{ mm} \times 611 \text{ mm}$  and thickness up to  $200 \text{ mm}$
- Four-corner thickness determination
- Automatic measurement of mean sample thickness
- Variable contact pressure up to  $1930 \text{ N}$  for density variation of compressible materials



HFM 706 *Lambda* Small

HFM 706 *Lambda* Medium

HFM 706 *Lambda* Large



## Guarded Heat Flow Meter – TCT 716 *Lambda*

The use of a guarded heat flow meter makes it possible to accurately measure thermal conductivity and thermal resistance. The system consists of a heat source and a temperature sensor, both enclosed in an insulating layer known as a “guard”. At elevated temperatures, the use of a guarded furnace effectively reduces heat leakage to the sides and improves the accuracy of measurements. The TCT 716 *Lambda* is based on ASTM E1530.

- Mean temperature: -10°C to 300°C
- Thermal conductivity range: 0.1 ... approx. 45 W/(m·K)
- Thermal resistance range: 0.001 ... 0.030 m<sup>2</sup>·K/W
- Sample dimensions: Round with ø 51 mm (2 inch; +0 in, -0.005 in); height up 30 mm (1¼ inch)
- Number of samples: Two test stacks for the measurement of one or simultaneously two specimens



TCT 716 *Lambda*

# GUARDED HOT PLATE

## Absolute Measurement of the Thermal Conductivity by Means of Guarded Hot Plate

All NETZSCH and NETZSCH TAURUS Instruments GHP systems are based on various international standards including ISO 8302, ASTM C177, EN 1946-2, EN 12664, EN 12667, and EN 12939.

### Guarded Hot Pipe for Pipe Insulations

The TRL 1000 offers the absolute method for determining the thermal conductivity of pipe insulations in accordance with DIN EN ISO 8497, DIN EN 1946-5, DIN 52613, ASTM C 534, and ASTM C 335.

- Measuring range:  
0.001 W/(m·K) up to 0.25 W/(m·K)
- Specimen diameter:
  - inner: 18 mm to 89 mm
  - outer: 30 mm to 220 mm
- Temperature range:
  - test chamber: -15°C to 140°C
  - hot pipe: 20°C to 200°C



TLR 1000

### GHP 456 Titan®

For the absolute determination of the thermal conductivity, the GHP 456 Titan® is the ideal tool for researchers and scientists. It features outstanding reliability and accuracy.

- Temperature range<sup>2</sup>: from -160°C up to 600°C
- Accuracy: typically 2%
- Symmetric test configuration for one or two specimens
- Thermal conductivity range: 0 to 2 W/(m·K)
- Atmospheres: inert, oxidizing, vacuum
- Sample thickness: up to 100 mm
- Plate dimensions<sup>2</sup>: up to 500mm x 500mm
- 31 separately calibrated sheeted Pt-100 temperature sensors for optimum temperature measurement



GHP 456 Titan®

<sup>1</sup> Depending on material and thickness

<sup>2</sup> Depending on the instrument; when testing near the limits of these ranges, special precautions must be taken



## GHP 500 and GHP 600

Measuring devices of the GHP series (GHP 500/600) are robust, user-friendly cabinet devices which are especially suited for testing thicker specimens.

- Measuring range<sup>1</sup>: 0.005 to 2.0 W/(m·K)
- Specimen size (L x W): 500 mm x 500 mm/600 mm x 600 mm
- Temperature range:
  - Cooling plate: -15°C to 60°C
  - Heating plate: -5°C to 70°C
- Specimen thickness:
  - 1x 15 mm to 200 mm (1-specimen)
  - 2x 15 mm to 100 mm (2-specimen)



GHP 500

## GHP 900 and GHP 900 S

The GHP 900 permits samples to be inserted into the test chamber from any side. The GHP 900 S offers a tiltable test chamber especially for insulating glass, e.g., windows and skylights. It is able to measure the thermal conductivity as a function of temperature and mounting angle.

- Measuring range<sup>1</sup>: 0.005 to 2.0 W/(m·K)
- Specimen size (L x W): 900 mm x 900 mm
- Temperature range:
  - Cooling plate: -10°C to 60°C
  - Heating plate: 0°C to 70°C
- Specimen thickness: GHP 900/900S:
  - 1x 15 mm to 280/380 mm (1-specimen)
  - 2x 15 mm to 140/180 mm (2-specimen)



GHP 900 S

# 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 717 *HyperFlash*<sup>®</sup> Series – Optimized Field of View Between -100°C and 1250°C

The *HyperFlash*<sup>®</sup> 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 717 *HyperFlash*<sup>®</sup>

- Temperature range: -100°C to 500°C
- Various cooling devices\*
- Thermal conductivity range: 0.1 W/(m·K) to 3000 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 (4 x Ø 25.4 mm, 6 x Ø 12.7, 16 x □ 10 mm)
- Special sample holders\*: liquids, pastes and powder, fibers, etc.
- Most advanced calculation models and corrections

### LFA 717 *HyperFlash*<sup>®</sup> HT

- Temperature range: RT to 1250°C
- Thermal conductivity range: 0.1 W/(m·K) to 3000 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<sup>-5</sup> mbar (with turbo pump)
- High-speed mini-tube furnace for up to 4 specimens (4 x Ø 12.7 mm, 4 x □ 10 mm)
- Small foot print
- Most advanced calculation models and corrections



LFA 717 *HyperFlash*<sup>®</sup>



LFA 717 *HyperFlash*<sup>®</sup> HT



## LFA 427

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

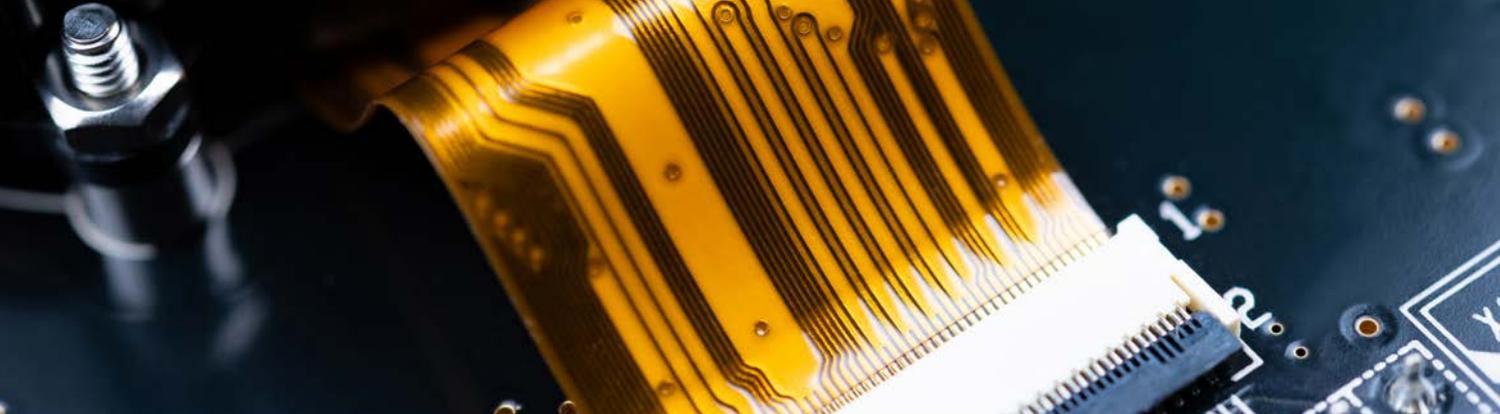
- Temperature range: -120°C to 2800°C
- Thermal conductivity range<sup>1</sup>: 0.1 W/(m·K) to 2000 W/(m·K)
- Vacuum: 10<sup>-5</sup> mbar
- Atmospheres: inert, oxidizing, reducing
- Sample dimensions<sup>2</sup>:
  - : 8 x 8 or 10 x 10 mm<sup>2</sup>,
  - ∅: 6, 8, 10 or 12.7 mm, 20 mm; thickness: 0.1 to 6 mm
- Special sample holder for liquid metals, slags, pastes, powders, etc.
- Model wizard

<sup>1</sup> Lower values possible, depending on sample's properties

<sup>2</sup> Special dimensions on request



LFA 427



# TIME DOMAIN THERMOREFLECTANCE BY PULSED LIGHT HEATING – NanoTR/PicoTR

## The Laser Flash Method for Thin Films

With the significant progress in the design of electronic devices and the associated need for an efficient thermal management, accurate thermal diffusivity/thermal conductivity measurements of thin films with thicknesses in the nm and  $\mu\text{m}$  range are more than ever crucial.

The thicknesses of nanometer-thin films are often less than the typical grain size. Consequently, their thermophysical properties differ significantly from the bulk material.

Both the nano-second thermoreflectance device *NanoTR* and pico-second thermoreflectance device *PicoTR* allow for absolute measurements of the thermal diffusivity of thin films. The determination of thermal diffusivity and interfacial thermal resistance can be achieved by Rear Heating/Front Detection (RF mode) and Front Heating/Front Detection (FF mode).

|                                   | <i>NanoTR</i>  | <i>PicoTR</i>   |
|-----------------------------------|--|---|
| Pump laser                        | Pulse width: 1 ns<br>Wave length: 1550 nm<br>Beam diameter: 100 $\mu\text{m}$  | Pulse width: 0.5 ps<br>Wave length: 1550 nm<br>Beam diameter: 45 $\mu\text{m}$        |
| Probe laser                       | Pulse width: continuous<br>Wave length: 785 nm<br>Beam diameter: 50 $\mu\text{m}$  | Pulse width: 0.5 ps<br>Wave length: 775 nm<br>Beam diameter: 25 $\mu\text{m}$         |
| Measurement properties            | Thermal diffusivity and effusivity, interfacial resistance   |   |
| Sample film thickness (RF method) | Organics: 30 nm ... 2 $\mu\text{m}$<br>Ceramics: 300 nm ... 5 $\mu\text{m}$<br>Metals: 1 $\mu\text{m}$ ... 20 $\mu\text{m}$  | Organics: 10 nm ... 100 nm<br>Ceramics: 10 nm ... 300 nm<br>Metals: 100 nm ... 900 nm |
| Sample film thickness (FF method) | Thicker than 1 $\mu\text{m}$ (min.)  | Thicker than 100 nm (min.)  |
| Substrate                         | Material: Opaque/Transparent<br>Size: 10 ... 20 mm square<br>Thickness: max. 1 mm  |   |
| Thermal diffusivity               | Range: 0.01 ... 1000 $\text{mm}^2/\text{s}$<br>Accuracy: $\pm 6.2\%$ with 40 min measurement time, for CRM 5808A in RF Mode, 400 nm thickness Mo<br>Repeatability: $\pm 5\%$ |   |



*PicoTR*



*NanoTR*

# 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*<sup>®</sup> option enables measurements at constant heating rates (exo/endo) and monitoring pressure data.

### Multi-Module Calorimeter

#### MMC 274 Nexus<sup>®</sup>

Interchangeable calorimeter modules of the MMC 274 Nexus<sup>®</sup> 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 cyclor/analyzer.

- ARC and scanning module:
  - Tracking rate of 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
- Module for testing coin cells (e.g., CR2032):
  - Temperature range: RT to 300°C
  - Discharge tests, battery cycling



MMC 274 Nexus<sup>®</sup>

### Accelerating Rate Calorimeters – Tracking Exothermic Reactions

#### ARC<sup>®</sup> 244/305

The models allow to safely measure the amount and rate of heat release associated with the processing or storage of chemicals. In addition, the 305 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 305 200 K/min
- Sample volume: 0.5 ml to 7 ml



ARC<sup>®</sup> 305



# DIELECTRIC ANALYSIS

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 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.



DEA 288 *Ionic*: Portable version (left) and Rack version (right)



## *FIRE TESTING*

For preventive fire protection, the appropriate choice of materials and components is essential in order to prevent fires completely or prevent them from spreading. Fire tests are according to German, European and international standards and used to classify the flammability and the burn rate of materials for the construction, textile, automobile and electrical industry. Material development and production should consider low flammability, prevention of rapid ignition and generation of the least possible amount of smoke.



SBI 915 – Single Burning Item

## Preventive Fire Protection

The selection of materials is decisive for fire prevention and the spread of fire. Fire tests according to German, European and international standards for classifying the flammability and burn rate of materials for the construction, textile, automotive and electrical industries play a major role.

## Building Materials

The fire resistance of components and the fire reaction of building materials with the resulting parameters of flammability, flame spread, flaming droplets, flammability, heat release, calorific value, smoke production and toxicity are particularly important for the construction industry.

## Mobility

Tests in the field of mobility focus on the flammability and flame spread rate of materials are for the interior of vehicles (e.g., lining, trim, seats and floor coverings of aviation vehicles, railed and road vehicles, etc).

## Electrical Industry/Cable

Reactions to fire – especially issues such as flame spread and flaming droplets for electronic and electrical parts, smoke density, insulation integrity and the formation of corrosive gases upon flame impact for electrical, control and data cables.

## Textile Products

Upholstery fabrics, curtains and drapes, decorative materials, floor coverings and protective clothing are primarily tested and classified for flammability, reaction to fire, and dripping behavior.



UL 94 –  
Fire Tester



TBB 913 – Floor  
Radiant Panel



TCC 918 –  
Cone Calorimeter



KBT 916 – Fire Testing  
for Cables



TNB 912 –  
Non-Combustibility Tester

| Product  | KBT 916               | SBI 915  | TBB 913       | TNB 912         | KBK 917            | TCC 918                        | UL 94                           | LOI 901                            | HBK 919  | TRDA/ TRDL          | TDP T4                            | TDP T3                            |
|--|-----------------------|----------|---------------|-----------------|--------------------|--------------------------------|---------------------------------|------------------------------------|--|---------------------|-----------------------------------|-----------------------------------|
| Heat release                                   | x                     | x        |               |                 |                    | x                              |                                 |                                    |  |                     |                                   |                                   |
| Smoke development                              | x                     | x        | x             |                 |                    | x                              |                                 |                                    |  | x                   |                                   |                                   |
| Flame spread                                   | x                     | x        | x             |                 |                    |                                |                                 |                                    |  |                     | x                                 | x                                 |
| Flaming droplet                                | x                     | x        |               |                 |                    |                                | x                               |                                    |  |                     | x                                 | x                                 |
| Non-combustibility                             |                       |          |               | x               |                    |                                |                                 |                                    |  |                     |                                   |                                   |
| Ignitability                                   |                       |          |               |                 | x                  |                                |                                 |                                    |  |                     | x                                 | x                                 |
| Burning time/speed                             |                       | x        |               |                 |                    |                                | x                               |                                    | x  |                     | x                                 | x                                 |
| Time to ignition                               |                       |          |               |                 |                    | x                              |                                 |                                    |  |                     |                                   |                                   |
| Mass loss                                      |                       |          |               |                 |                    | x                              |                                 |                                    |  |                     |                                   |                                   |
| Heat of combustion                             |                       |          |               |                 |                    | x                              |                                 |                                    |  |                     |                                   |                                   |
| Combustion gas                                 |                       |          |               |                 |                    | x                              |                                 |                                    |  |                     |                                   |                                   |
| Oxygen index                                   |                       |          |               |                 |                    |                                |                                 | x                                  |  |                     |                                   |                                   |
| O <sub>2</sub> , CO <sub>2</sub> , CO analyzer |                       |          |               |                 |                    | x                              |                                 |                                    |  |                     |                                   |                                   |
| Euro classification/<br>Euro fire testing lab  |                       | x        | x             | x               | x                  | x                              | x                               |                                    |  | Mostly integrated   | x                                 | x                                 |
| Industry                                       | Cables                | Building | Building      | Building        | Building           | Building, Automotive, Polymers | Building, Automotive, Polymers  | Polymers                           | Automotive   | Single/ Stand-alone | Roofs                             | Roofs                             |
| Standards                                      | EN 50399, IEC 60332-3 | EN 13823 | EN ISO 9239-1 | DIN EN ISO 1182 | DIN EN ISO 11925-2 | ISO 5660-1, ASTM E 1354        | UL94, DIN EN 60695-11, ISO 9773 | ISO 4589-2, DIN 22117, ASTM D 2863 | ISO 3795, DIN 75200, MVSS 302, GB 8410, IS 15061, CMVSS 302, U.T.A.C. 18-502, FAR 25.853 | DIN 50055           | DIN CEN/TS 1187, test procedure 4 | DIN CEN/TS 1187, test procedure 3 |



TRDA – Smoke Density Tester with Light Measurement System



KBK 917 – Small Burner Box



LOI 901 – Oxygen Index Analyzer



HBK 919 – Horizontal Burner Box



TDP T4 – Fire Testing for Roofs



## REFRACTORIES TESTING

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.

### 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. Creep in compression (CIC) 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 reliable RUL/CIC tests and precise dilatometer measurements on large and even inhomogeneous samples.

- Temperature range: RT to 1700°C
- 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\*



RUL/CIC 421

\* Optional feature



All over the world, the name NETZSCH stands for comprehensive support and expert, reliable service, both before and after sale. Our qualified personnel from the technical service and application departments are always available for consultation. In special training programs tailored for you and your employees, you will learn to tap the full potential of your instrument. Choose your preferred training method: Online, on-site or at our NETZSCH training center.

To maintain and protect your investment, you will be accompanied by our experienced service team over the entire life span of your instrument.

# Expertise in SERVICE

## TECHNICAL SERVICE



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Software Updates



Exchange Service



IQ/OQ Documents



Calibration Service



Spare Part Assistance



Moving Service

## TRAINING



Basic Seminars



NETZSCH Online Academy



Comprehensive Instrument and Method Training

## LABORATORY



Application Service and Contract Testing

# STANDARD AND ADVANCED SOFTWARE

One of the most complete and easy-to-handle software solutions in Thermal Analysis, *Proteus*<sup>®</sup>, 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.

## *Proteus*<sup>®</sup> – Measurement and Evaluation at its Best

- Multi-tasking system
- Combined analysis of different methods
- Storage and restoration of analyses
- *SmartMode*<sup>\*</sup> – features a clear structure, uniform navigation and user friendliness.
- Wizards contain a set of common pre-defined measurement methods
- User Methods allows users to save methods
- *Expert Mode*
- *AutoEvaluation* – allows for the evaluation – autonomously or at the push of a button – of unknown curves
- *Identify* – is a unique tool for automatic identification and interpretation of curves with only a single click. The database contains a NETZSCH library for typical polymers and can also be extended by adding the user's own materials.
- Automatic baseline correction
- *Purity Determination*
- *Tau-R*<sup>®</sup> mode (thermal resistance, time constant)
- Specific heat capacity ( $c_p$ )
- *c-DTA*<sup>®</sup> (calculated DTA for TGA and DIL)
- *Proteus*<sup>®</sup> *Protect* ensures data integrity and meets the requirements of 21 CFR Part 11 or EU Annex 11
- Rate-controlled mass change, *SuperRes*<sup>®</sup> (TGA), Rate-controlled sintering (DIL)
- Temperature-modulated DSC/TGA-DSC (STA)
- Context-sensitive help system
- ISO 9001 certified by BVQI





## Advanced Software\* – Extensions for Comprehensive Evaluation



### 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.

### Kinetics Neo and "Kinetics as a Service"

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.

With "Kinetics as a Service", we offer a complete package for measurements, interpretations and solutions for your process optimization.

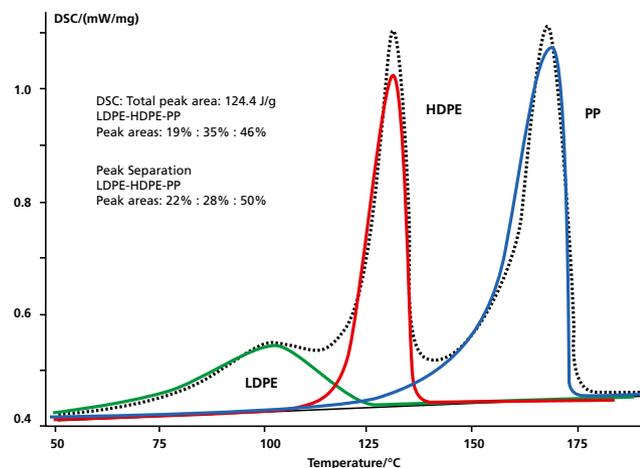
A Kinetics Neo analysis makes it possible to determine the number of reaction steps and the following values for each step:

- Reaction type
- Activation energy
- Order of reaction
- Other kinetic parameters



### 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.



The owner-managed NETZSCH Group is a leading global technology company specializing in mechanical, plant and instrument engineering.

Under the management of Erich NETZSCH B.V. & Co. Holding KG, the company consists of the three business units Analyzing & Testing, Grinding & Dispersing and Pumps & Systems, which are geared towards specific industries and products. A worldwide sales and service network has guaranteed customer proximity and competent service since 1873.

When it comes to Thermal Analysis, Calorimetry (adiabatic & reaction), the determination of Thermophysical Properties, Rheology and Fire Testing, NETZSCH has it covered. Our 60 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.

## Proven Excellence. ■

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