NETZSCH

Proven Excellence.



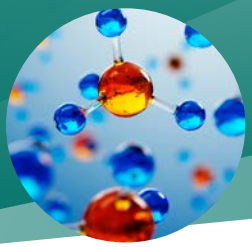



# Kinexus Prime Series

More Rheology, Less Effort.

Analyzing & Testing

# The Importance of Rheology



Phase Behavior, Microstructure, Molecular Weight



Formulation, Fillers, Additives




Kinexus Prime
Rotational Rheometer

PERFORMANCE



Product Application, Spreadability, Aesthetics, Mouthfeel, Levelling, Sag Resistance, Tack, Adhesion



In-Use Processes, Product Dispensing, Pouring, Sprayability, Curing

# Rotational and Capillary Rheology

## WITH OVER 14 DECADES OF SHEAR RATE



Processing, Extruding, Injection Moulding

Rosand
Capillary Rheometer

## THE HEART OF FORMULATION AND PRODUCTION



Product Appearance, Particle Suspending Capability, Stability, Homogeneity

## FROM FORMULATION AND PROCESSING TO END-USE PRODUCT PERFORMANCE

# NETZSCH Invites You to Join the Power of Prime

NETZSCH combines a 60 year legacy of thermal analysis with 30 years of rheometry experience to bring you the revolutionary Kinexus Prime series.

The Power of Prime offers sophisticated rheology test methods and solutions to gain unique insight into your rheological data. Unmatched ease-of-use and modularity, combined with the ultimate intuitive, flexible software.

NETZSCH are always striving to bring you the latest innovations, manufactured to German engineering standards with an unparalleled reputation for worldwide support and expertise.

An investment in a NETZSCH rheometer is an investment into your research, your product and your time. Kinexus Prime integrates innovative instrument design with a revolutionary software interface, delivering a solution that will not only enhance productivity but also elevate understanding and success.





*EasySwap* Temperature Cartridges are easily interchangeable within seconds without the need to connect tubing or control cables

- Rheological measurements **made easy** – shear stress and shear rate controlled viscometry (transient and steady-state), shear stress and shear strain controlled oscillation rheometry, creep test/ creep recovery and stress relaxation
- Unprecedented vertical travel and gapping capabilities with **ultra-responsive and highly sensitive Normal Force** for class-leading performance
- **Sophisticated software. rSpace is your space, customizable to you.** The intuitive rSpace software offers over 200 inbuilt, customizable measurement sequences in 6 languages, including supporting application notes and educational tips and tricks along the way.
- **Over 200 *EasySwap* geometries and cartridges with customizable accessories.** Rheologist designed tools for characterization of complex fluids and soft solids, including dispersions, emulsions, polymer melts, polymer and protein solutions, pastes, adhesives and gels
- **Intelligent geometry recognition** with full auto-configuration and user feedback on system status to guarantee robust data for all measurements
- **Complete sample history** from the point of loading onto the rheometer available in data file as standard – because ensuring reliable rheology data for many materials actually starts before a measurement takes place!
- **Unique plug and play** cartridge system for all environmental controllers – all mechanical, power, communication and fluid connections made in one simple action
- Multifunctional accessory design **featuring true modularity** – plate cartridges with interchangeable lower plates for a cost-effective solution addressing the widest application coverage

# *Prime Properties*
## *Engineered to be Better*

## Unprecedented Dual-Action Capabilities

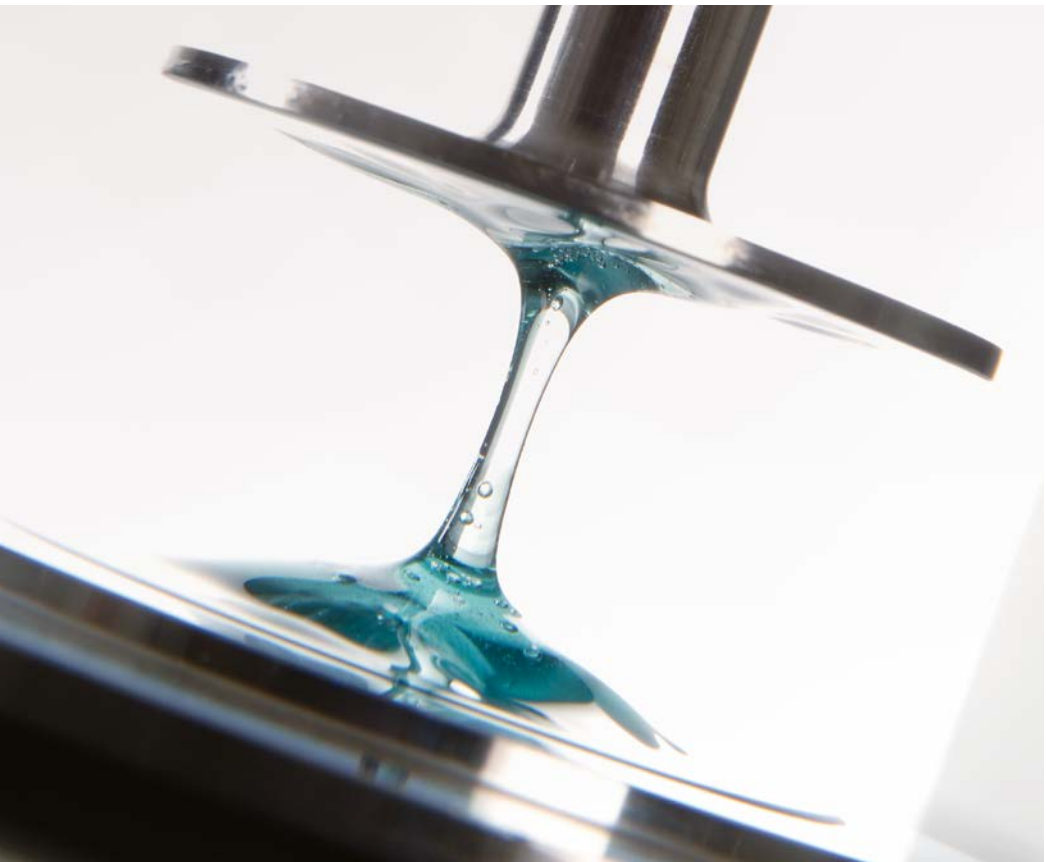
# A Revolution in Shear and Vertical (Axial) Test Control

The unique combination of Kinexus Prime hardware technology and rSpace software gives the user the ability to configure three critical rheometer functions independently:

- Rotational (shear) control: torque, speed and position
- Vertical (axial) control: gap and normal force
- Temperature control (isothermal, ramp or table)

Offering the ultimate in rheological test flexibility for both industry and academia, Kinexus Prime enables:

- All rotational shear-based testing
- Advanced vertical (axial) testing including squeeze flow and tack testing
- A combination of shear and vertical actions for revolutionary process-relevant measurements: Tangential and normal forces can be applied to the sample at the same time.



The most sensitive normal force control of any rheometer, while still robust to 50 N

Lift speed up to 35 mm/s!

Ultrafine resolution gap control to 0.1 µm

Controllable speed and/or normal force profiles over full range of vertical travel – linear, exponential and max/min limited

Ultra-fast, constant streaming data rate of 5 kHz for all raw instrument variables

# Unprecedented Dual-Action Capabilities

## Using Synchronized Torque, Displacement, Gap and Normal Force Data at Ultra-High Rates

### Gap Control

- Exceptional vertical travel range of 230 mm for maximum user access and flexibility of the test setup
- Unmatched vertical speed range from 0.1 µm/s to a maximum of 35 mm/s
- Controllable speed and normal force profiles over full range of vertical travel – linear, exponential and max/min limited
- Gap measured to a resolution of 0.1 µm over full range
- Optimal sample loading for all material types – from sensitive strain-critical structures to rapid curing systems



### Normal Force

- High sensitivity and rapid response times from a novel strain gauge design of the normal force option
- Ultra-fast, constant streaming data update rate of 5 kHz for all instrument variables, including gap and normal force – synchronized with rotational and temperature data



# *EasySwap* Temperature Cartridges

- All *EasySwap* cartridges are compatible with the complete Kinexus suite of rotational rheometers
- Exclusive *plug and play* cartridge design
- Quick, easy and robust insertion
- Featuring mechanical, power, communication and fluid connections in one action
- Automatic cartridge recognition and configuration
- Peltier-based systems provide high heating and cooling rate with excellent temperature stability
- High-accuracy temperature sensor in close proximity to the sample
- Temperature resolution to 0.01°C
- Easy-to-clean designs
- Efficient integrated solvent trap design for accurate measurement of samples with volatile components and to minimize sample drying

## Peltier-Plate Cartridge (-40°C to 200°C)



**Environmental controller for cone-plate and plate-plate measuring systems**

- Interchangeable lower plates enable optimal geometry choice, e.g. matching lower pedestal diameter for self-supporting samples, without compromising thermal performance
- *EasySwap* enables you to change the lower plate within seconds, as no screws are needed
- Disposable plate option for curing materials (see page 10)

## Peltier-Plate Cartridge with Active Hood (-40°C to 180°C)



**Environmental controller with minimized thermal gradients for cone-plate and plate-plate measuring systems**

- Applicable to the measurement of highly thermally-sensitive samples, and for temperature-critical testing where the temperature range is significantly above or below ambient
- Components with low heat capacity for high heating and cooling rates
- Inlet for inert gas feed into sample environment

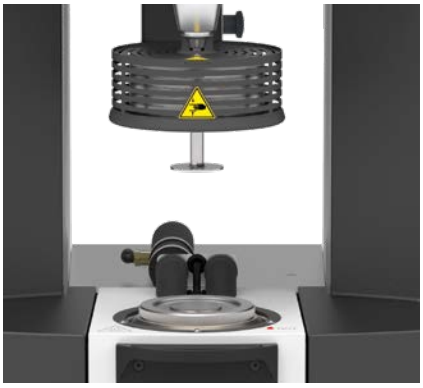
## Peltier-Cylinder Cartridge (-30°C to 200°C)



**Environmental controller with concentric cylinder-type measuring systems**

- Twin Peltier design provides rapid temperature change, quick adjustment of thermal equilibrium and minimized thermal gradients
- Interchangeable lower cups with removable base for ease of cleaning
- Cups include fill-up mark for easier sample loading
- Plate insert allows for the use of upper cone and plate geometries at the

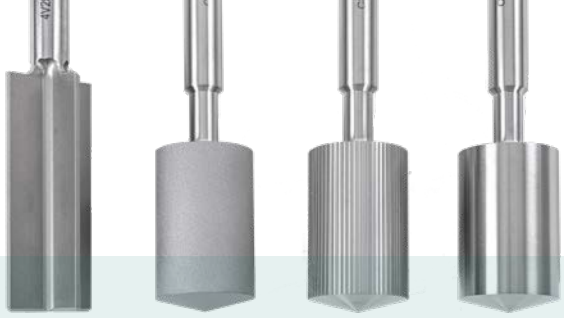
## HTC Prime Cartridge (0°C to 450°C)



**Cutting-edge temperature control in HTC Prime, inspired by thermal analysis technology**

- Boost cooling for time-efficient sample management
- Homogeneous sample temperature distribution through optimized forced convection and conductive heating
- Smart cooling air control for perfect sample temperature homogeneity
- Thermally optimized design with low thermal mass and isolation
- Active thermal management system

# Designed for Rheological Testing of Complex Fluids, Polymers and Soft Solids



## Measuring systems

- Quick-connect geometries with intelligent auto-recognition
- Geometry constants and test preferences automatically configured
- Lock-down tests to specify geometry to minimize operator errors
- Automated geometry lock via software for ease of trimming
- Various material and surface finish options
- Solvent trap compatible
- Disposable options
- Coaxial cylinders (cup and bob) to DIN standard
- Coaxial double gap geometry and vane tool options
- Geometry adapter allows use of custom geometries

See our Kinexus accessory brochure for our full range of geometries and accessories

# Accessories

## Disposable Plates

The disposable plate system is a perfect solution for studying samples that cure or set during testing such a thermosets, adhesives and paints. Both upper and lower disposable plates are available in various sizes and are easy to remove and dispose of following a measurement.

Stainless steel (316 Grade) lower plate mount and clamp designed for optimized thermal properties and mechanical alignment. The disposable plates feature quick-connect engagement and release mechanism and the lower plate includes a solvent trap cover location ring.



Disposable Plate System (KNX2155)



Disposable Lower Plates (KNX2204)

## Solvent Trap

The Kinexus solvent trap is an essential accessory when working with volatile samples prone to evaporation and drying. Providing thermal insulation from ambient conditions, the passive solvent trap KNX2513, also allows atmospheric gases to be purged across the sample via gas inlets. KNX2513 is compatible with both plate and cylinder cartridges. For measurements with an active hood cartridge the low profile KNX2514 should be used.



Lösungsmittelfalle (KNX2513)



Kinexus Prime ultra+ equipped with the UV Curing System (KNX5007)

## UV Curing System

UV-curable materials are widely used in coatings, adhesives, and dental compounds. When these materials are exposed to UV radiation, a fast cross-linking reaction occurs, typically within less than a second to a few minutes. Rheometers are used to monitor the curing process and measure the modulus change of the material.

The Kinexus Optical Cell utilizes the open base designs of the Kinexus platform and cylinder cartridge (KNX2002) enabling the required optical train to be used when shear is applied to the material.

The Kinexus UV curing system enables the rheological properties of a UV-curing material to be monitored over time during the application of UV light. The rSpace software includes an intuitive interactive guide automatically employed for when operating the UV curing accessory. UV light intensity can be controlled and programmed within the software.

## Twin Dispersion Paddle

The twin dispersion paddle is designed to be used for materials prone to sedimentation or multi-part systems requiring mixing. The upper shaft is insulated with PEEK in order to prevent heat flux during mixing at higher temperatures. In order to optimize mixing, the 22.5 paddle should be used in conjuction with a C25 DIN cup. Roughened and splined versions of these cups are also available to aid in the prevention of slippage.



# rSpace Software

## Experience the Ultimate in Test Flexibility with Sequence-Driven Rheometer Control

With its unique sequence-based rSpace software, the Kinexus Prime combines the requirements of quality assurance meeting the demands of university and industrial research with completely open programming and access to raw data. You don't need to be an expert to start generating good data with rSpace!




The rSpace software is driven by *sequences* – consisting of fundamental rheological actions (or test building blocks). These can be linked together with other test actions, such as user feedback and choices, calculate value, loops and triggers, in order to build *intelligent* tests.

### Sequence Features in Kinexus Prime

- *Drag and Drop* actions and *Import subsequence* functionality
- Sequences can be designed to include:
  - user choices
  - calculate values
  - loops
  - triggers
  - pass/fail reporting
  - specific user inputs and instructions

# Standard Operating Procedure (SOP)-Driven Tests for Reliable Rheological Measurements

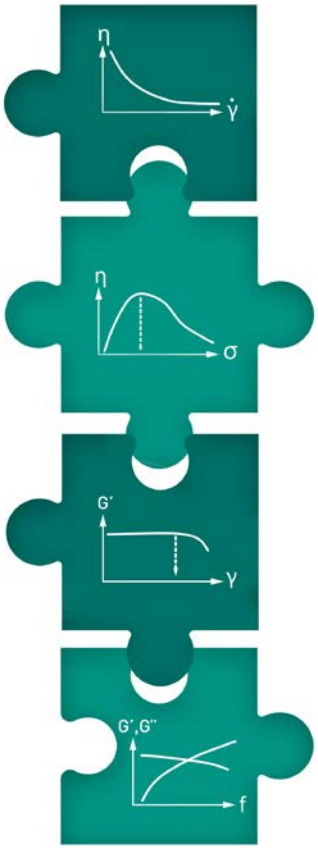



Over 200 inbuilt, customizable measurement sequences in 6 languages:

- Continuous feedback and user guidance
- Availability for use company-wide
- Consistent and reliable measurements
- Supporting application and support notes

## Rheology Toolkit

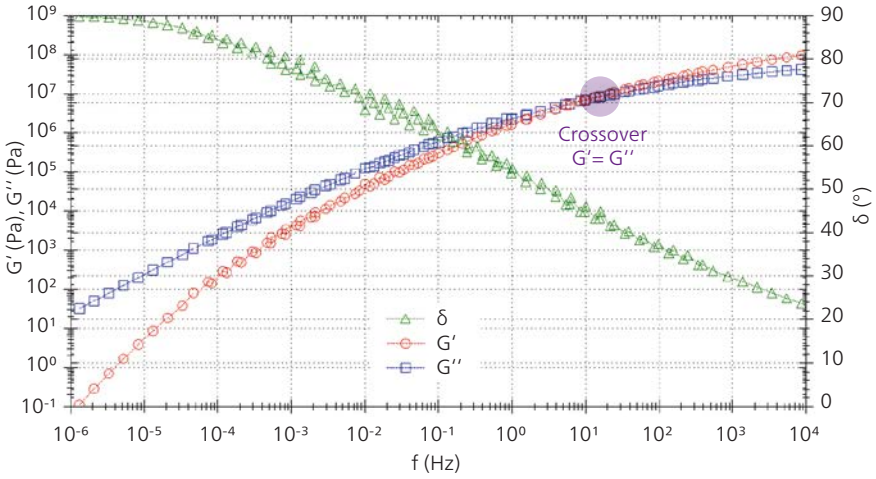
- Series of fundamental rheological tests available in rSpace at the click of a mouse
- Get started with reliable rheology testing
- Fully configured SOP-driven tests with associated test description




## Use Toolkit Tests to Solve Your Material Puzzles:

- Build up a *picture* of overall rheology of a material
- Find an answer to material formulation, application or process problems
- Targeted optimization of a key material characteristic, or implementation of a critical diagnostic test

## Prediction of the Long-Time Behavior of a Polymer Binder – Master Curves Reduce Measurement Time

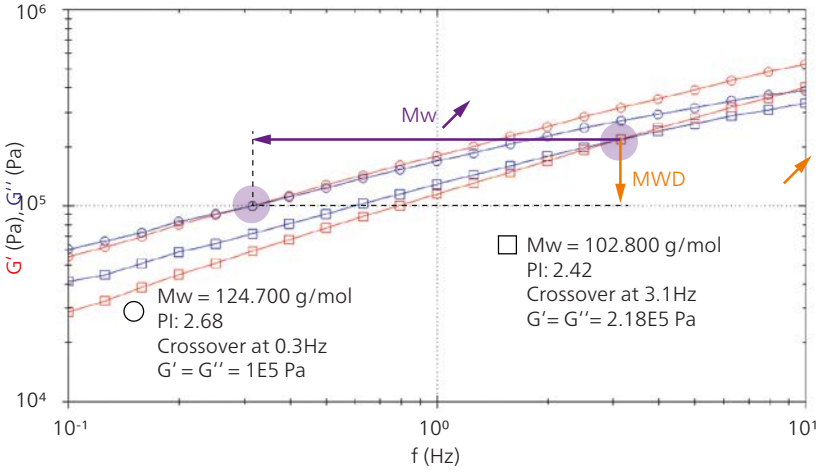



Viscoelastic spectrum of a polymeric binder showing elastic G' (red), viscous G" (blue) and phase angle (delta, green) vs. frequency (Hz)

The viscoelastic properties of polymers may change over time. Oscillation measurements at very low frequencies determine their long-time behavior. However, such analyses can be extremely time consuming. Instead of performing interminable tests, the measurements can be carried out at different temperatures over the usual frequency range and a master curve may be automatically created using time-temperature superposition (TTS).
The graph shows a master curve created with measurements on a polymer binder at 5 different temperatures. At low frequencies, the polymer reaches a phase angle of 90° (a viscoelastic liquid). Therefore, it does not exhibit a yield stress and flow will occur at any stress applied.

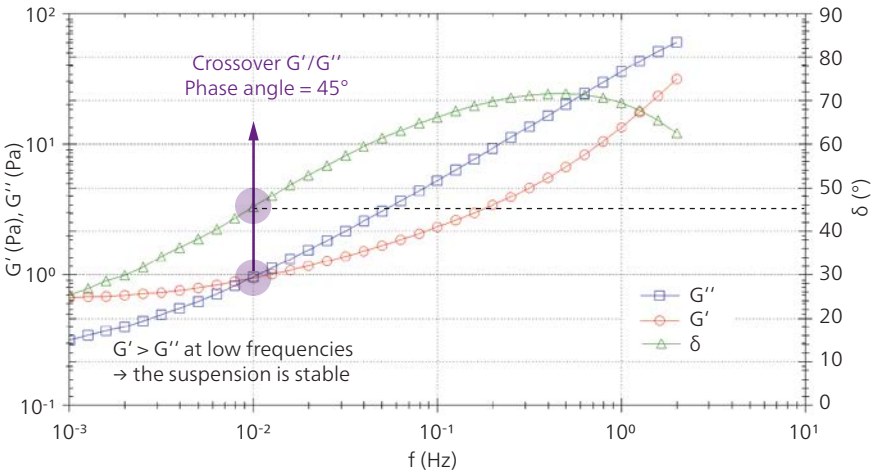
## Rheology and Molecular Weight

The molecular weight of a polymer influences its processing and the mechanical properties of the final product. It is therefore of great importance. The position of the G′/G′′ crossover obtained during a frequency sweep is indicative of the molecular weight and the molecular weight distribution of a polymer. The measurements here show two frequency sweeps carried out on PA12 materials with glass fillers differing from each other only by molecular weight. An increase of the molecular weight by 20% leads to a decrease in the crossover frequency by one decade! Moreover, a small increase of the polydispersity index (PI = $M_w/M_n$) leads to a decrease of the storage modulus detected at the crossover.

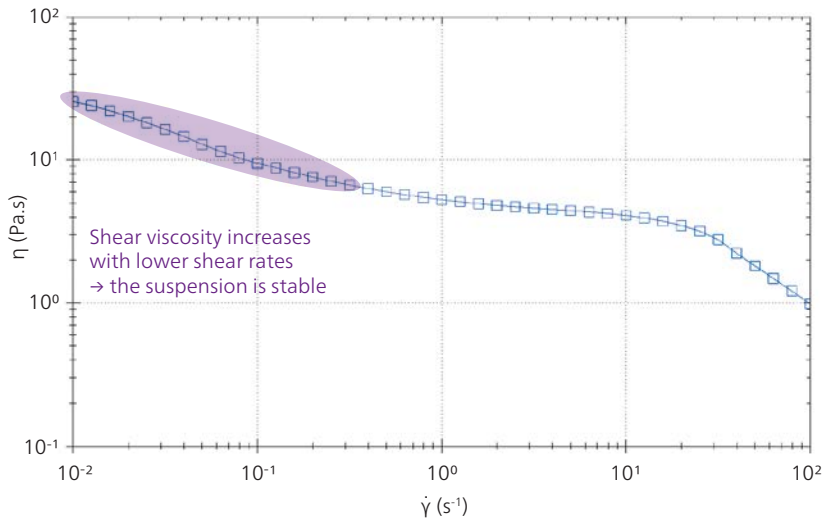



Oscillation: Frequency sweep of two polyamide samples with different MW's and glass fillers; elastic modulus (G', red); viscous modulus (G", blue) vs. frequency (Hz)

## Is my Suspension Stable?




Oscillation data of a shower gel containing particles showing elastic modulus G' (red), viscous modulus G" (blue) and phase angle (delta, green) vs. frequency (Hz); geometry was a C25 cup and bob, 2 Hz – $10^{-3}$ Hz down, 1% strain




Viscosity flow curve of a shower gel with particles; shear viscosity (Pas) vs. shear rate (1/s); geometry: cup and bob 25 mm; temperature: 25°C; shear rates: 0.01 $s^{-1}$ to 100 $s^{-1}$

Many sauces, medicines and cosmetics are in the form of a suspension, consisting of particles dispersed within a liquid medium. A challenge when formulating a suspension is to avoid sedimentation. To determine if your samples are rheologically stable, two different tests can be performed, as shown here on a shower gel containing suspended particles.

- **Oscillation (frequency sweep):**
  In the upper plot, at higher frequencies the viscous modulus is greater than the elastic modulus, indicating that the shower gel flows when vibrated or pushed quickly. However, this behavior inverts at a frequencies below 0.01 Hz, where the phase angle is below 45° and the elastic modulus is higher than the viscous modulus. This means we can determine that this shower gel is a visco-elastic solid, meaning that the "solid-like" properties will be dominant when the material is at rest. Therefore, the particles contained in the shower gel will not settle.

- **Viscosity Flow Curve:**
  This is a step up through a range of shear rates to measure the equilibrium viscosity at each rate. A higher shear viscosity at low shear rates indicates better sedimentation stability of the dispersion.

# *Applications*

# Technical Specifications

| Kinexus Prime | | | |
|---|---|---|---|
| | ultra+ | pro+ | lab+ |
| Rheometer platform | High-end rheometer for highest demands | For research and development | Quality control with SOP [4] |
| Operating modes | Direct strain control, shear rate control, shear stress control | | |
| Torque range – viscometry [1] | 1.0 nNm - 250 mNm | 5.0 nNm - 225 mNm | 10 nNm - 200 mNm |
| Torque range – oscillation [2] | 0.5 nNm - 250 mNm | 1.0 nNm - 225 mNm | 5.0 nNm - 200 mNm |
| Torque resolution | 0.05 nNm | 0.1 nNm | 0.1 nNm |
| Position resolution | < 10 nrad | < 10 nrad | < 10 nrad |
| Angular velocity range | 1 nrads$^{-1}$ to 500 rads$^{-1}$ | 1 nrads$^{-1}$ to 500 rads$^{-1}$ | 10 nrads$^{-1}$ to 325 rads$^{-1}$ |
| Step position control in strain control | < 10 ms | < 10 ms | < 10 ms |
| Frequency range | 6.28 µrads$^{-1}$ to 942 rads$^{-1}$ (1 µHz to 150 Hz) | 6.28 µrads$^{-1}$ to 942 rads$^{-1}$ (1 µHz to 150 Hz) | 6.28 µrads$^{-1}$ to 628 rads$^{-1}$ (1 µHz to 100 Hz) |
| Motor inertia | 12 µN·m.s$^2$ | 12 µN·m.s$^2$ | 12 µN·m.s$^2$ |
| Normal force range | 0.001 N - 50 N | 0.001 N - 50 N | 0.001 N - 50 N |
| Normal force resolution | 0.5 mN | 0.5 mN | 0.5 mN |
| Normal force response time | < 10 ms | < 10 ms | < 10 ms |
| Vertical lift speed | 0.1 µms$^{-1}$ to 35 mms$^{-1}$ | 0.1 µms$^{-1}$ to 35 mms$^{-1}$ | 0.1 µms$^{-1}$ to 35 mms$^{-1}$ |
| Vertical lift range (measurable) | 230 mm | 230 mm | 230 mm |
| Gap resolution[3] | 0.1 µm | 0.1 µm | 0.1 µm |
| Fully configurable vertical profiles | By speed and Normal Force | | |
| Raw instrument variables | 5 kHz constant streaming data | | |
| Complete sample history | Acquisition of raw data from loading to unloading as standard | | |
| Interface | USB2 – plug and play | | |
| rSpace software | Site-wide user license, sequence-driven user interface enabling Standard Operating Procedure (SOP)-type test functionality and fully customizable test designs | | |
| Dimensions and weights | D x W x H (weight): 485 mm x 490 mm x 680 mm (47 kg) | | |
| Power supply | 100 - 240V, 15A | | |

1) Shear rate and shear stress controlled
2) Shear strain and shear stress controlled
3) Specification of accuracy over full vertical list range
4) Standard Operating Procedures

Understanding the application under consideration, and the associated rheological test requirements, is a key factor in selecting the most appropriate rheometer system.

If you are unsure as to specifying an appropriate rheometer model for your application, we recommend contacting us for further advice and/or a sample test and evaluation report.

| Kinexus Prime | | | |
|---|---|---|---|
| | ultra+ | pro+ | lab+ |
| **Measuring geometries** | | | |
| Quick-connect geometries | Plug and Play; auto-recognition and configuration by the software | | |
| Material | Stainless Steel 316 (British Steel BS) as standard<br>Other options are available, e.g., for chemical compatibility (titanium or Hastelloy) | | |
| Plate and cone diameter | 20 mm throughout 60 mm as standardized range – other diameters on request<br>Plates with 4 mm, 8 mm and 25 mm specifically designed for asphalt testing | | |
| Cone angle | Variants with 0.5°, 1°, 2° and 4° – other angles on request | | |
| Interchangeable lower plates | Varying diameters and surface finishes (to match upper geometries) | | |
| Concentric cylinders | C14 (DIN), C25 (DIN), C34 as standard | | |
| Interchangeable cups | Quick release/engage mechanism,<br>optional with removable base and fill-up mark | | |
| Surface finish option | Smooth, sand blasted, serrated, splined or grooved | | |
| Vane tools | Type C14 and C25 | | |
| Disposable option | Upper and lower disposable plates for the investigation of curing materials | | |
| **Environmental controllers** | | | |
| Quick-Connect cartridge system | Plug and play; auto-recognition and configuration by the software | | |
| Peltier-plate cartridge | Temperature range: -40°C to 200°C<br>Maximum heating rate*: 30°C/minute<br>Maximum cooling rate*: 30°C/minute | | |
| Peltier-plate cartridge with active hood | Temperature range: -40°C to 180°C<br>Maximum heating rate*: 30°C/minute<br>Maximum cooling rate*: 20°C/minute | | |
| Peltier-cylinder cartridge | Temperature range: -30°C to 200°C<br>Maximum heating rate*: 15°C/minute<br>Maximum cooling rate*: 15°C/minute | | |
| HTC Prime | Temperature range: 0 °C** to 450 °C<br>Max. heating rate*: 30 K/min<br>Max. cooling rate*: 15 K/min<br>Max. boost cooling rate: 20 K/min | | |
| Temperature resolution | 0.01°C | | |
| Temperature stability | Better than ± 0.1°C | | |

* Temperature range dependent
** At 6 bar Vortex cooling air pressure (5 °C at 5.5 bar Vortex cooling air pressure)

NOTE: Specifications have been obtained under conditions as stated in the Installation and Site Requirements for Kinexus Prime rheometers

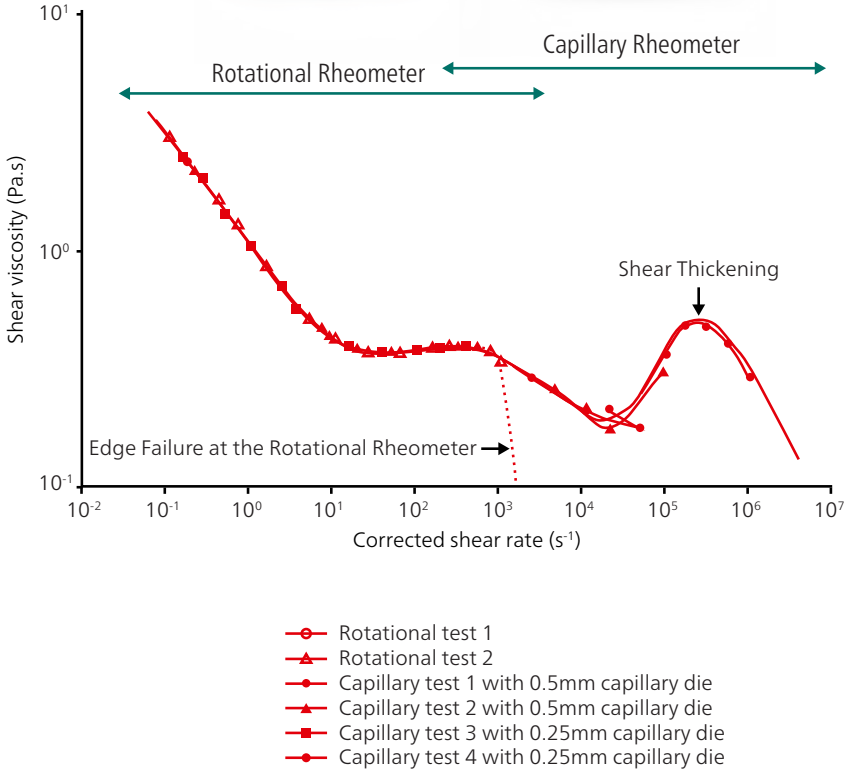
# *Unmatched Shear Rate Range with Decades of Experience*

With over 60 years experience in thermal analysis, NETZSCH uniquely offers solutions in both rotational and capillary rheometry.

In a rotational rheometer, the maximum shear rate is reached if the sample is ejected out of the gap. How to get information about flow behavior if processing requires higher shear rates, such as spraying? The solution is called: a Rosand high pressure capillary rheometer which is capable of achieving shear rates up to $10^8$ $s^{-1}$.

Here, a spray coating substance was measured with both Kinexus and Rosand. At low shear rates, the material is shear-thinning. The faster the product is poured or mixed, the less viscous it is. At the typical shear rates used for spraying (~$10^6$ $s^{-1}$), it shows a shear-thickening transition indicating this product is not suitable for spraying applications!





# Expertise in Service

## CLOSE TO OUR WORLDWIDE CUSTOMERS



### Our Expertise – Service

All over the world, the name NETZSCH stands for comprehensive support and reliable service, 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.

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

### Our Expertise – Application Laboratories

The NETZSCH Thermal Analysis applications laboratories are a proficient partner for nearly any thermal analysis and rheological issue. Our involvement in your projects begins with proper sample preparation and continues through meticulous examination and interpretation of the measurement results. Our diverse methods and over 30 different state-of-the-art measuring stations will provide ready-made solutions for all your thermal needs.

Within the realm of thermal and rheological analyses and the measurement of thermophysical properties, we offer you a comprehensive line of the most diverse analysis techniques for materials characterization.

Measurements can be carried out on samples of the most varied of geometries and configurations. You will receive high-precision measurement results and valuable interpretations from us in the shortest possible time. This will enable you to precisely characterize new materials and components before actual deployment, minimize risks of failure, and gain decisive advantages over your competitors.

### TECHNICAL SERVICE

- Maintenance and Repair
- Software Updates
- Exchange Service
- IQ/OQ Documents
- Calibration Service
- Spare Part Service
- Moving Service

### TRAINING

- Online Training Services
- Comprehensive Instrument and Method Training

### LABORATORY

- Application Service and Contract Testing

The NETZSCH Group is an owner-managed, international technology company with headquarters in Germany. The Business Units Analyzing & Testing, Grinding & Dispersing and Pumps & Systems represent customized solutions at the highest level. More than 4,000 employees in 36 countries and a worldwide sales and service network ensure customer proximity and competent service.

Our performance standards are high. We promise our customers Proven Excellence – exceptional performance in everything we do, proven time and again 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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