NETZSCH

Proven Excellence.



Kinexus Prime DSR Series

Proven Excellence in
Asphalt and Bitumen Testing

Analyzing & Testing

Characterization and Classification to Asphalt Industry

Asphalt Binder and Bitumen









Standards

Asphalt, or bitumen, is a petroleum product used in the road (pavement), roofing and construction industries. A mixture of aromatic hydrocarbons (varying with geographical source), this black viscoelastic material is considered to be a complex colloidal system.

Asphalt is used as a binder with aggregates in road (pavement) construction and as such determines performance and lifetime. Additives such as polymers, crumb rubber, oils, waxes, phosphates and pH adjusters are used to enhance mechanical properties in modified asphalt binders. Asphalt emulsions are also used as water-proofing and re-surfacing materials.

Rheological characterization by Dynamic Shear Rheometers (DSR) is the standard method of classifying asphalt binders for behavior over time and loading conditions, and in different climates.

While some still use viscosity (vis) and penetration (pen) methods for grading, the use of DSR grading methods provides a much broader range of information about the asphalt performance properties and its suitability for desired applications. This is especially the case with engineered binders; binders designed with elastomeric properties to reduce rutting, aging, thermal and fatigue cracking.

Rheological Testing with the Kinexus Prime DSR Series

- Grade testing to industry standards such as AASHTO, ASTM and EN specifications
- Full characterization of rheological behavior with Master Curves
- Formulation development and quality control metrics
- Determination of mixing and compaction temperatures
- Blend testing of warm mix, crumb rubber and Recycled Asphalt Paving (RAP)
- Solids testing for fatigue or accumulated strain
- Emulsion stability and viscosity profiling
- Benchmarking and comparison of competitive products
- Penetration, pull off and tack testing
- Tribology-friction testing
- Additive optimization and product interactions

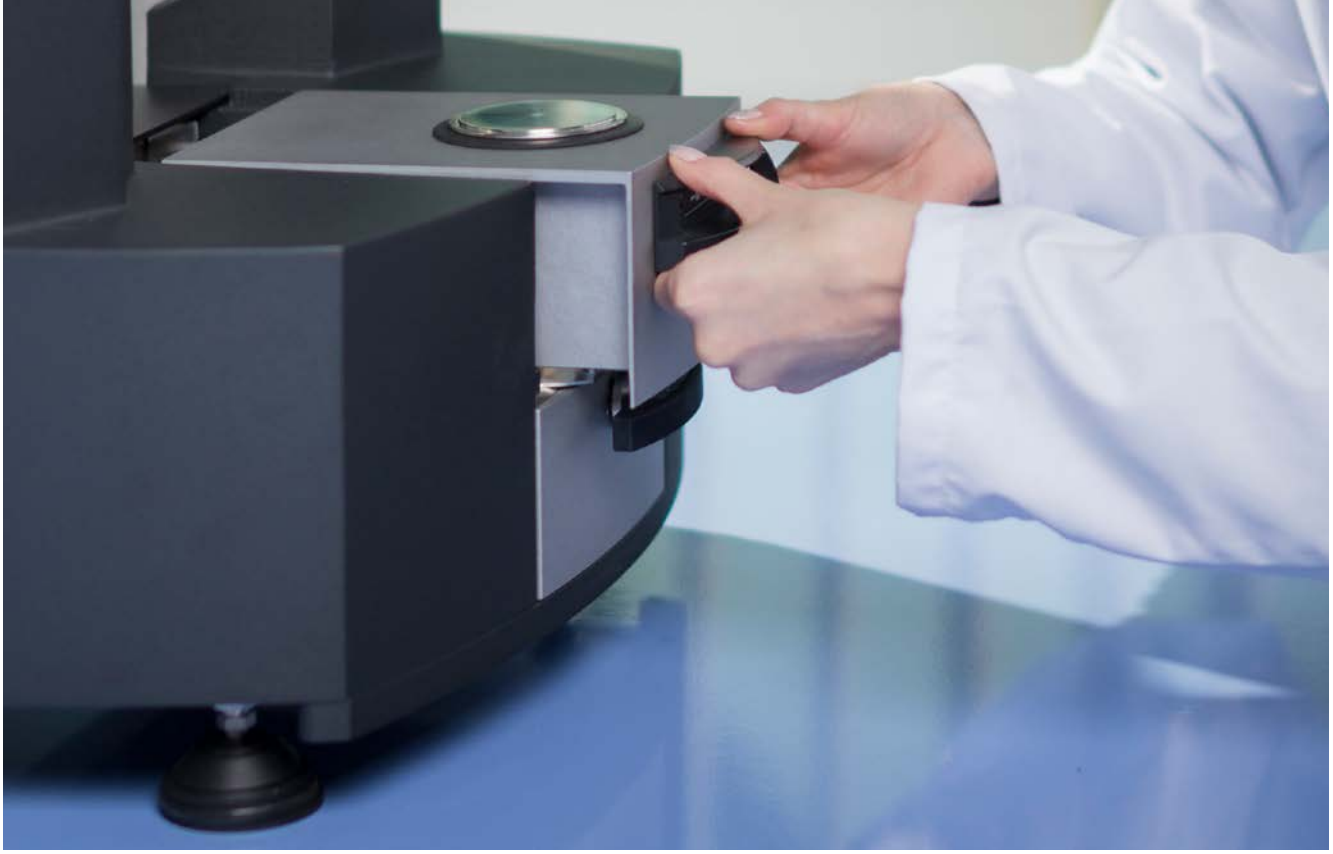
Kinexus Prime DSR Series

Redefining Rheometer Capabilities 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.

A modular rheometer with true *plug and play* functionality for all measuring systems and environmental control units – the Kinexus Prime DSR Series enables pioneering Standard Operating Procedure (SOP) based testing with a built-in comprehensive library of standard test protocols for the asphalt industry.



Environmental cartridges are easily changed or removed for service

- All modes of operation – stress, shear rate and direct strain controlled oscillation
- Exceptional vertical travel and gapping capabilities with ultra-responsive and highly sensitive Normal Force for dedicated pull-off, tack and penetration testing
- Unique rSpace software interface that offers total flexibility of test set-up, from sequence-driven Standard Operating Procedure (SOP)-type functionality to fully customizable test design
- Fully integrated materials database enables user friendly data management that can be tailored to any organization. Easily tie results by products, projects, customers, vendors, tanks, or locations. Maintain testing logs and specification limits for acceptance
- Wide variety of measurement geometries optimized for rheological characterization of liquid binders to solid asphalt cores
- Complete sample history recorded from loading to unloading, ensuring reliable and reproducible measurements
- Unique *plug and play* cartridge system for all environmental controllers – all mechanical, power, communication and fluid connections made in one simple action. Capable of fully automated calibration
- Geometry database in conjunction with RFID plate recognition ensures only the correct, in tolerance, plates are used for testing
- Fully automated Statistical Quality Control (SQC) charting with pass/fail analysis tied to any sample

Key Benefits of Kinexus Prime Rheometers

10 Features of the Kinexus Prime DSR Series

1 Inductive motor technology

Precision control of instrument torque

- Ultra low inertia, Electronically Commutated (EC), drag cup motor allows rapid change of torque and speed, as well as access to higher oscillation frequencies without the need of excessive corrections
- Wide continuous torque range facilitates measurement of low-viscosity liquids through to stiff solids without changing test conditions or measuring geometries
- Intelligent motor cooling regulates internal operating temperature according to torque and power demands

2 Precision air bearing

Provides frictionless support between moving parts

- Machined from sintered, porous carbon to provide uniform air distribution with negligible directional bias enabling operational and measurable torques below 1 nNm
- High axial and radial stiffness for increased robustness and reduced compliance

3 High precision rotational system

Accurate measurement of rotor position and speed

- Optical encoder with nanometer resolution for measuring minuscule radial displacements and speeds
- Sample response optimized by locating the sensor as close to the measurement as possible
- High speed Digital Signal Processor (DSP) provides rapid and accurate direct strain and speed control

4 Precision chuck mechanism

Connects and aligns the measuring system with the motor and bearing assembly

- Quick-connect push-fit mechanism for easy insertion and removal of measuring systems while maintaining micrometer alignment
- Auto recognition – Radio Frequency Identification (RFID) reader automatically identifies the measuring systems, calibration constants and operational settings, and ensures zero gapping prior to measurement

5 Upper measuring system

Interfaces with the sample to transfer torque or motion from the motor assembly

- Wide range of measuring systems available, including plates, cones, cylinders and vanes with different sizes, materials and surface finishes
- Precision engineered for accurate calculation of rheological parameters and designed with high shaft stiffness and low mass to minimize compliance and inertia
- Quick-connect push-fit design and integrated RFID tag (auto-detection) allows for reduced time to measurement while ensuring the correct measuring system and calibration constants are always used

6 Axial force sensors

Provides the measurement and control of normal force

- Novel strain gauge with fast transient response which is independent of air bearing rotor position and rotor speed
- Operational in all modes of instrument operation for both measurements and control
- Capable of measuring between 0.001 N and 50 N for consistent sample loading and precision control of axial testing

7 Stage drive control

Controlled vertical profiles for sample loading and axial testing

- Enables full range of vertical profiles including linear, exponential and normal force over a working range of 230 mm (0.1 µm resolution) and speed range of 0.1 µm/s to 35 mm/s for controlled sample loading or dedicated axial testing

8 Integrated electronics

Houses all electronics for controlling rheometer functionality

- All micro electronics are located as close to the measurement as possible, improving measurement quality and reliability
- Incorporates all control and measurement functions including high speed Digital Signal Processor (DSP), which provides the intelligence to the instrument

9 Environmental control cartridge/lower measuring system

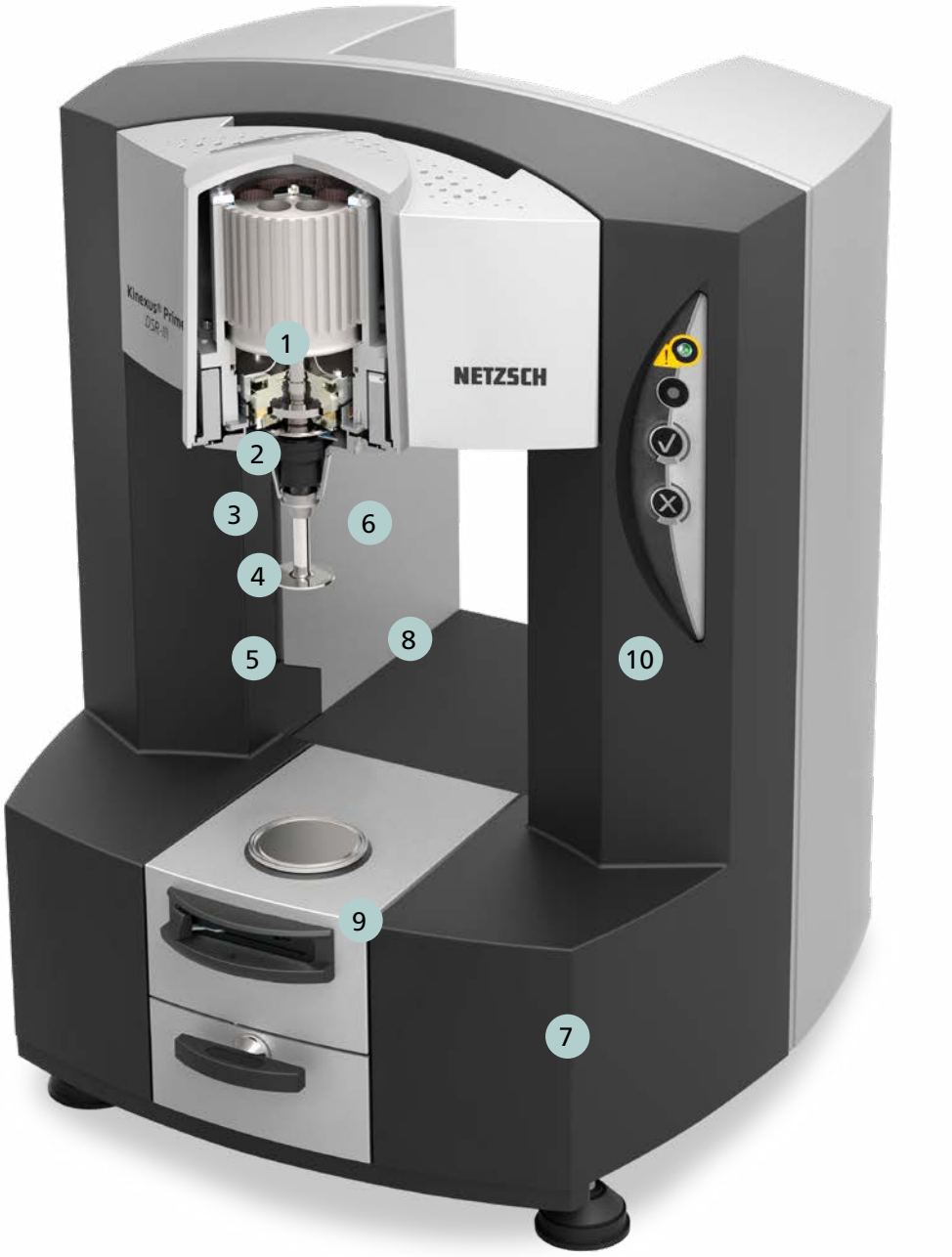
Provides fast lower geometry interchange, plus temperature and environmental control

- Unique *plug and play* cartridge system with auto-recognition All mechanical, power, communication and fluid connections made in one simple action
- Cartridge options include:
  - Asphalt Peltier Plate, active hood design
  - Universal cylinder; for cub-bob & torsion
  - High temperature; for polymer melts & curing
- Geometries available in a wide range of sizes, materials and surface finishes
- Lower measuring system can be secured and removed easily using a simple slide lock mechanism, while maintaining micrometer alignment
- Employs Peltier elements for heating/cooling of upper and lower plates working in conjunction with an intelligent heat exchanger to improve efficiency
- Optimally positioned temperature sensors (PT100s) ensure fast & accurate sample temperature reporting

10 Control panel

Allows rheometer functions to be controlled directly from the instrument

- Control panel functionality directly linked to all user instructions in test sequences so *Yes* and *No* responses to software prompts can be made without keyboard interaction
- Warning lights flag-up any rheometer faults, software communication errors or low pressure in the air bearing
- Robust design for glove operation and solvent safe for easy clean up



TAKE A CLOSER LOOK

TECHNOLOGY AT THE HEART OF KINEXUS PRIME DSR

MEASURING SYSTEMS AND ACCESSORIES



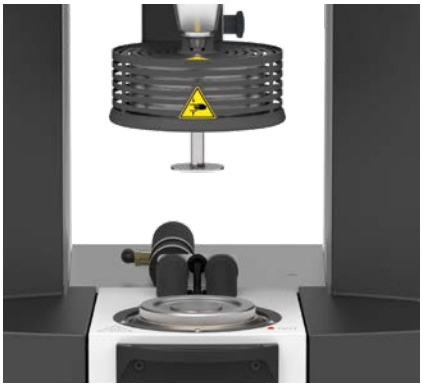
Active hood cartridge (-45°C to 225°C) environmental controller with minimized thermal gradients for plate measuring systems

- Applicable to the measurement of highly thermally-sensitive samples, and for temperature-critical testing
- Proprietary design incorporates state-of-the-art heating technology with Peltier elements to dynamically control radial and vertical thermal gradients within the sample quickly and accurately
- Conforms to AASHTO, ASTM & EN standards
- Temperature resolution 0.01 °C
- PT100 sensor located within 1 mm of asphalt sample for accurate reporting
- Low thermal mass components for rapid response
- Inlet for inert gas feed into sample chamber enables live monitoring of aging
- Easy and accurate integrated temperature calibration



Peltier cylinder cartridge (-25°C to 200°C) environmental controller for concentric cylinder-type measuring systems

- Twin Peltier design for rapid temperature changes, sample equilibration and minimal thermal gradients
- Various cup and bob sizes available – C14 (DIN), C25 (DIN) and wide diameter C34
- Interchangeable lower cups with removable base for ease of cleaning
- Plate insert provides a universal Peltier option
- Accommodates solid (torsion) fixtures for Dynamic Mechanical Analysis (DMA) testing of solid asphalt cores



HTC Prime Cartridge (0°C to 450°C) Cutting-edge temperature control in HTC Prime, inspired by thermal analysis technology

- Boost cooling for highest cooling rates
- 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

KINEXUS PRIME DSR ACCESSORY SPECIFICATIONS







Measuring systems

- Quick-connect geometries with intelligent RFID auto-recognition linked to database
- Lock-down tests to specific geometry to minimize operator error
- Standard upper plates of 4 mm, 8 mm, and 25 mm to conform to AASHTO, ASTM & EN standards, with disposable options also available
- Coaxial cylinders (cup and bob) to DIN standard with double gap and vane tool options also available
- Geometry adapter allows use of custom geometries (e.g., penetration probes)
- Automatic temperature calibration device available
- Tribology kit for friction testing, lubricity and warm mix analysis
- Torsion kit for solids testing

Solid fixtures (-20°C to 200°C dry and fluid immersed (wet)) torsion/ DMA system including sample mounting and alignment kit

- Utilizes the multifunctional design of the cylinder cartridge to allow torsional testing of a self-supporting rectangular or cylindrical solid sample (e.g., final product)
- Understand how a sample changes by temperature or time in a dry vs. wet environment
- Includes a torsional alignment jig and disposable cylindrical sample end caps
- Mounted samples can be investigated as a function of frequency, strain, stress, time and temperature to investigate solid properties
- Easy temperature calibration with sensor mounting provided

Crumb rubber kit

- Hard anodized aluminum shallow cup insert for Kinexus cylinder cartridge, designed to measure crumb rubber asphalt mixtures
- Low volume, wide gap concentric cylinder enables samples with larger particles to be measured for more accurate testing
- Optimized thermal properties and mechanical alignment
- Two piece, removable base design, and includes thermal cover and insulation kit

Unprecedented Dual-Action Capabilities

A Revolution in Shear and Vertical (Axial) Test Control



The unique combination of Kinexus Prime DSR 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

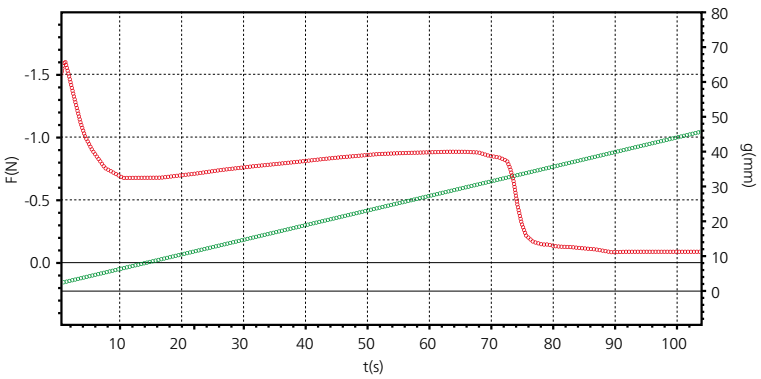
Offering the ultimate in rheological test flexibility for both industry and academia, Kinexus enables:

- 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

Significant design effort has been directed at the vertical, or axial capabilities of the Kinexus Prime DSR platform – an area that typically sees compromises on most rheometer systems.

Kinexus Prime DSR combines high speed and ultra-fine resolution gap control with high sensitivity and ultra-responsive Normal Force control for truly innovative sample loading and measurement capabilities – from sensitive structures to rapid curing systems.

Allied to *cradle to grave* data collection providing a complete sample history from loading to unloading, every aspect of rheological testing can be optimized and verified for total consistency.



Gap and normal force vs. experiment time



COMPLIANT WITH NUMEROUS STANDARDS*

AASHTO T315
AASHTO T316
AASHTO T350
AASHTO TP70
AASHTO TP101
AASHTO TP123
AASHTO TP126
AASHTO M320
AASHTO M332

ASTM D6373
ASTM D7175
ASTM D7405
ASTM D7552
ASTM D8198
ASTM D4402
(compliant up to 200°C)

EN13302
EN13307
EN14770
EN16659

FGSV 720
FGSV 721
FGSV 722
FGSV 723

ГОСТ 33137-2014
ГОСТ Р 58400.7-2019
ГОСТ Р 58400.10-2019
ГОСТ Р 58400.6-2019
ГОСТ Р 58400.9-2019

* If we are unaware of a specification doesn't mean we don't comply. By asking we learn.

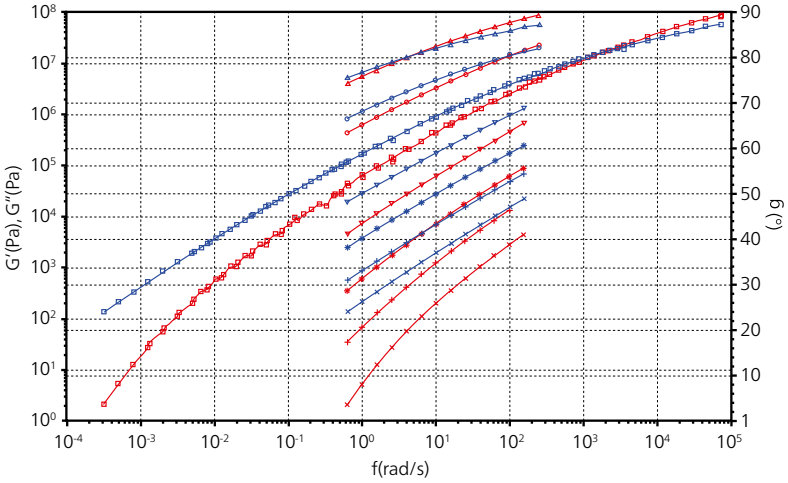
rSpace Software

Standard Operating Procedure (SOP) Driven Tests for Robust Rheological Measurements

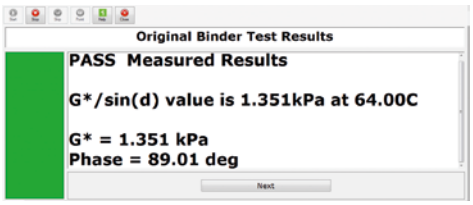
The Standard Operating Procedure (SOP) approach to material testing has been a cornerstone to all our technologies, and is now available for the first time on a rheometer system.

rSpace can be used for simple QC operation or for advanced rheological testing

- Continuous feedback and user guidance at all times
- Ensure best rheological practice
- Add specific test controls relevant to your samples
- Produce standard test methods for your samples
- Available for use company-wide
- Consistent operator-independent testing as standard
- Time-Temperature Superposition for master curve generation
- Automatically reports Pass or Fail based on the appropriate test and test criteria
- Report designer with auto print/PDF generation



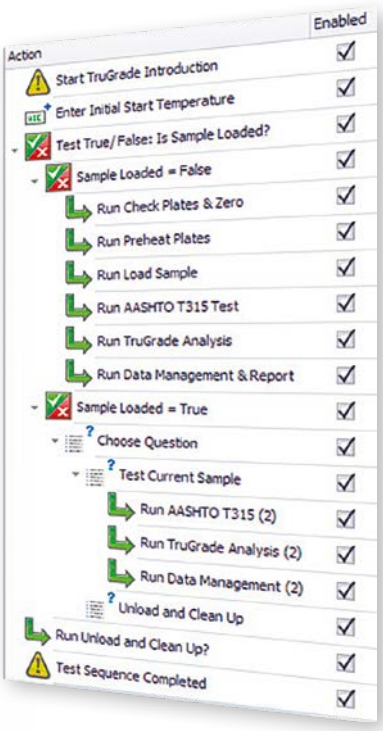
Elastic modulus, viscous modulus and phase angle vs. frequency
Automated advanced analysis available



Clear operator feedback of relevant information and visual properties







rSpace – powerful, user friendly, flexible and easily tailored

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

- Set a sequence to run only, and a user operates under SOP-type conditions with defined test instructions and feedback
- Researchers have the full design capabilities at their fingertips

What rheological test progression would you like to run?

- You think it – Kinexus can run it
- Dedicated and advanced tests exactly to your needs

Program sequence in Kinexus

- Drag and drop actions and Import subsequence functionality
- Include user choices, calculate values, loops, triggers
- Include specific user inputs and instructions as required
- Include specific analysis, acceptance criteria and what next decision making

Kinexus Prime DSR			
	DSR+	DSR	DSR-III
Rheometer Platform	Each system designed to meet the demanding needs of research, product development, comparative benchmarking, quality control and assurance required by the global asphalt / bitumen industry		
Motor control	Low inertia drag cup motor control providing absolute direct: shear strain, shear rate, shear stress for operation in steady, dynamic, and transient loading modes		
Torque range – viscometry (rate and stress control) [1)]	5 nNm – 225 mNm	10 nNm – 200 mNm	75 nNm – 165 mNm
Torque range – oscillation (strain and stress control) [1)]	1 nNm – 225 mNm	5 nNm – 200 mNm	75 nNm – 165 mNm
Torque resolution	0.1 nNm	0.1 nNm	0.1 nNm
Position resolution	< $1.8 \cdot 10^{-9}$ rad	< $1.8 \cdot 10^{-9}$ rad	< $1.8 \cdot 10^{-9}$ rad
Angular velocity range	1 $nrads^{-1}$ to 500 $rads^{-1}$	10 $nrads^{-1}$ to 325 $rads^{-1}$	10 $nrads^{-1}$ to 200 $rads^{-1}$
Step position control in strain control	< 10 ms	< 10 ms	< 10 ms
Frequency range	6.28 $\mu rads^{-1}$ to 942 $rads^{-1}$ (1 µHz to 150 Hz)	6.28 $\mu rads^{-1}$ to 628 $rads^{-1}$ (1 µHz to 100 Hz)	6.28 $\mu rads^{-1}$ to 628 $rads^{-1}$ (1 µHz to 100 Hz)
Motor inertia	12 $\mu N.m.s^2$	12 $\mu N.m.s^2$	12 $\mu N.m.s^2$
Normal force range	0.001 N – 50 N	0.001 N – 50 N	0.01 N – 20 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 20 mms^{-1}
Vertical lift range (measurable)	230 mm	230 mm	230 mm
Gap resolution (over full vertical lift range)	0.1 µm	0.1 µm	0.1 µm
Fully configurable vertical profiles	By speed and by Normal Force		
Raw instrument variables	5 kHz constant streaming data		
Complete sample history	Data available from loading to unloading as standard		
Instrument interface	USB2 – plug and play		
Dimensions	D x W x H (weight): 485 mm x 490 mm x 680 mm (47 kg)		

Kinexus Prime DSR			
	DSR+	DSR	DSR-III
rSpace software	Sequence-driven user interface enabling Standard Operating Procedure (SOP)-type test functionality and fully customizable test designs		
General rheology	✓	✓	✓
rSolution applications database	✓	✓	✓
Rheology toolkit package	✓	✓	✓
Asphalt rheology	✓	✓	✓
Rheology analysis package	✓	✓	✓
Sequence design functionality	✓	✓	✓
Interactive materials database	✓	✓	✓

1) Note the relationship between shear stress, torque and measuring geometry.

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

Technical Specifications

A range of asphalt DSR rheometer designed to meet and exceed your application requirements. If you are unsure as to specifying an appropriate rheometer model for your application or region, contact us for advice and/or a demonstration.

Kinexus Prime DSR – *EasySwap* and High Temperature Cartridges*	
Asphalt Active Hood Oven* **	
Standard temperature range (optional)	-5°C to 225°C (-45°C to 225°C)
Heating rate (controlled)	50°C/minute
Temperature resolution	0.01°C
Temperature stability	Better than ± 0.1°C
Universal Cylinder Peltier	
Standard temperature range (optional)	0°C to 200°C (-25°C to 200°C)
Heating rate (controlled)	15°C/minute
Temperature resolution	0.01°C
Temperature stability	Better than ± 0.1°C
HTC Prime	
Temperature range	0°C** to 450°C
Max. heating rate	30 K/min
Max. cooling rate	15 K/min
Max. boost cooling rate	20 K/min

Kinexus Prime DSR – Accessories

Options Available*		DSR+	DSR	DSR-III
Quick-connect upper geometries	Plug and play; auto-recognition and configuration in software	✓	✓	✓
Disposable plates option	Upper and lower disposable plate options for curing materials	✓	✓	✓
Crumb rubber kit	C14/25 – CRM C25 cup & C14 bob for use with cylinder cartridge. Other cups, bobs and vanes available	✓	✓	✓
Solids Fixtures kit	Solid fixtures for use with cylinder cartridge for testing rectangular or cylindrical solids (Asphalt cores)	✓	✓	-
Plates and Cones diameter & angle	Standard diameters range from 4 mm to 60 mm Standard angles are 0.5°, 1°, 2° and 4° – others on request	✓	✓	✓
Asphalt Plate diameter	Asphalt 4 mm, 8 mm and 25 mm plates	✓	✓	✓
Tribology – friction	Ball Tribology kit based on ISO7148 design	✓	✓	-
Temperature Calibration Kit	Fully automated and integrated NIST traceable device for easy verification and calibration of system temperature	✓	✓	✓

* Additional Environmental controllers, accessories and geometries available upon request
** at 6 bar Vortex cooling air pressure (5 °C at 5.5 bar Vortex cooling air pressure)
*** The optional temperature ranges -5°C to 225°C (-45°C to 225°C) with Asphalt Active Hood Ovens are only available for DSR+ and DSR.

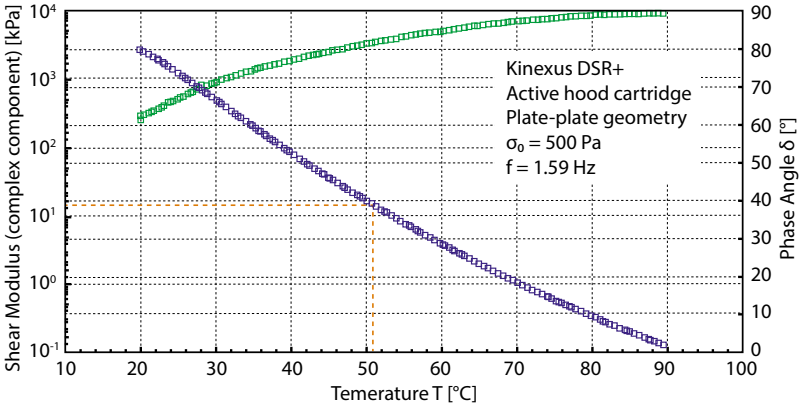
NOTE: Specifications have been obtained under conditions as stated in the Installation and Site Requirements for Kinexus Prime rheometers



APPLICATION

Bitumen

Bitumen such as pave bitumen or polymer modified bitumen and bituminous binders can be characterized according to the Bitumen-Typisierungs-Schnell-Verfahren (BTSV, German for Binder-Fast-Characterization-Test), which is based on DIN EN 14770. In this study, an un-modified bitumen sample was measured on a NETZSCH Kinexus Prime DSR, equipped with a parallel-plate geometry.
The measurement was carried out with a constant shear stress (σ_0=500 Pa) and a constant frequency (f=1.59 Hz) in stress-controlled mode. The measuring gap was 1.00 mm. The sample temperature was increased from 20°C to 90°C with a constant heating rate of 1.2 K·min^{-1}.
For evaluation of the experiment results, the complex shear modulus G* and the phase angle δ were plotted against the temperature. The temperature corresponding to the complex component of the shear modulus G*=15 kPa was analyzed and it was found to be 50.78 °C.



The rheological test on a DSR rheometer also allows for differentiation between pave bitumen and polymer modified bitumen, based on information on the elasticity of the bitumen sample

Expertise in Service

Our Expertise – Service

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.

Our Expertise – Applications Laboratories

The NETZSCH Thermal Analysis applications laboratories are a proficient partner for nearly any Thermal Analysis 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 analysis 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 Assistance
- Moving Service

TRAINING

- Basic Seminars
- NETZSCH Online Academy
- Comprehensive Instrument and Method Training

LABORATORY

- Application Service and Contract Testing

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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