KINEXUS DSR SERIES
REDEFINING RHEOMETER CAPABILITIES FOR ASPHALT BINDER AND BITUMEN TESTING
ASPHALT BINDER AND BITUMEN
Characterization and classification to asphalt industry 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 DSR Series

- Grade testing to industry standards such as AASHTO, ASTM and EN specifications (see www.malvern.com/kinexus for a full list)
- 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
The Kinexus 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 DSR Series enables pioneering Standard Operating Procedure (SOP) based testing with a built-in comprehensive library of standard test protocols for the Asphalt industry.

Key benefits of the Kinexus rheometer

- 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
UNPRECEDENTED DUAL-ACTION CAPABILITIES

A revolution in shear and vertical (axial) test control

The unique combination of Kinexus 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 DSR enables:

- All rotational shear-based testing
- Advanced vertical (axial) testing including pull-off, 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 DSR platform – an area that typically sees compromises on most rheometer systems.

Kinexus 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.
**rSpace Software**

Standard Operating Procedure (SOP) driven tests for robust rheological measurements

Malvern’s 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*

- Locked down tests including geometry and parameter set-up using standard user access control
- 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

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**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
- Set user access to ‘edit’ sequence functionality, and researchers have the full design capabilities at their fingertips

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‘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
Redefining Rheometer Capabilities

TECHNOLOGY AT THE HEART OF KINEXUS DSR

10 Features of the Kinexus 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 and 50N 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 direct 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.
Redefining Rheometer Capabilities

TAKE A CLOSER LOOK
MEASURING SYSTEMS AND ACCESSORIES

Characterization and classification to asphalt industry standards

**Active Hood Cartridge** [-40 °C to +200 °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 to better than 0.0005 °C

**Peltier Cylinder Cartridge** [-30 °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

**High Temperature Cartridge (HTC)** [0 °C to +300 °C] High temperature environmental controller for cone-plate and parallel plate measuring systems

- Extremely stable temperature control using a high accuracy PT100 sensor in close proximity to sample
- Rapid temperature changes of up to 20 °C per minute.
- Temperature resolution to better than 0.0005 °C
- Air cooling and adiabatic cooling for rapidly attaining ambient and sub-ambient temperatures

- 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
KINEXUS DSR ACCESSORY SPECIFICATIONS
Characterization and classification to asphalt industry standards

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 & 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 aluminium 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
**KINEXUS DSR 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.

<table>
<thead>
<tr>
<th>Rheometer specification</th>
<th>DSR+</th>
<th>DSR</th>
<th>DSR-E</th>
<th>DSR-III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor control</td>
<td>Electronically commutated (EC), drag cup motor control providing absolute direct: shear strain, shear rate, shear stress for operation in steady, dynamic, and transient loading modes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torque range – Viscometry (rate and stress control)</td>
<td>5 nNm – 225 mNm</td>
<td>10 nNm – 200 mNm</td>
<td>20 nNm – 200 mNm</td>
<td>100 nNm – 150 mNm</td>
</tr>
<tr>
<td>Torque range – Oscillation (strain and stress control)</td>
<td>1 nNm – 225 mNm</td>
<td>5 nNm – 200 mNm</td>
<td>10 nNm – 200 mNm</td>
<td>100 nNm – 150 mNm</td>
</tr>
<tr>
<td>Torque resolution</td>
<td>0.1 nNm</td>
<td>0.1 nNm</td>
<td>0.1 nNm</td>
<td>0.1 nNm</td>
</tr>
<tr>
<td>Position resolution</td>
<td>&lt;10 nrad</td>
<td>&lt;10 nrad</td>
<td>&lt;10 nrad</td>
<td>&lt;10 nrad</td>
</tr>
<tr>
<td>Angular velocity range</td>
<td>1 nrads⁻¹ to 500 rads⁻¹</td>
<td>10 nrads⁻¹ to 325 rads⁻¹</td>
<td>10 nrads⁻¹ to 325 rads⁻¹</td>
<td>10 nrads⁻¹ to 200 rads⁻¹</td>
</tr>
<tr>
<td>Step change in strain</td>
<td>&lt;10 ms</td>
<td>&lt;10 ms</td>
<td>&lt;10 ms</td>
<td>&lt;10 ms</td>
</tr>
<tr>
<td>Frequency range</td>
<td>6.28 μrads⁻¹ to 942 rads⁻¹ (1 μHz to 150 Hz)</td>
<td>6.28 μrads⁻¹ to 628 rads⁻¹ (1 μHz to 100 Hz)</td>
<td>6.28 μrads⁻¹ to 628 rads⁻¹ (1 μHz to 100 Hz)</td>
<td>6.28 μrads⁻¹ to 628 rads⁻¹ (1 μHz to 100 Hz)</td>
</tr>
<tr>
<td>Motor inertia</td>
<td>12 μN.m.s²</td>
<td>12 μN.m.s²</td>
<td>13 μN.m.s²</td>
<td>13 μN.m.s²</td>
</tr>
<tr>
<td>Normal Force range</td>
<td>0.001 N - 50 N</td>
<td>0.001 N - 50 N</td>
<td>0.01 N - 50 N</td>
<td>0.01 N - 20 N</td>
</tr>
<tr>
<td>Normal Force resolution</td>
<td>0.5 mN</td>
<td>0.5 mN</td>
<td>0.5 mN</td>
<td>0.5 mN</td>
</tr>
<tr>
<td>Normal Force response time</td>
<td>&lt;10 ms</td>
<td>&lt;10 ms</td>
<td>&lt;10 ms</td>
<td>&lt;10 ms</td>
</tr>
<tr>
<td>Vertical lift speed</td>
<td>0.1 μms⁻¹ to 35 mms⁻¹</td>
<td>0.1 μms⁻¹ to 35 mms⁻¹</td>
<td>0.1 μms⁻¹ to 35 mms⁻¹</td>
<td>0.1 μms⁻¹ to 20 mms⁻¹</td>
</tr>
<tr>
<td>Vertical lift range (measurable)</td>
<td>230 mm</td>
<td>230 mm</td>
<td>230 mm</td>
<td>230 mm</td>
</tr>
<tr>
<td>Gap resolution (over full vertical lift range)</td>
<td>0.1 μm</td>
<td>0.1 μm</td>
<td>0.1 μm</td>
<td>0.1 μm</td>
</tr>
<tr>
<td>Fully configurable vertical profiles</td>
<td>By speed and by Normal Force</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw instrument variables</td>
<td>5 kHz constant streaming data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete sample history</td>
<td>Data available from loading to unloading as standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrument interface</td>
<td>USB2 – plug and play</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions D x W x H (Weight)</td>
<td>485 mm x 490 mm x 680 mm (47 kg)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**rSpace software**

<table>
<thead>
<tr>
<th>rSpace package</th>
<th>Comprehensive Rheology</th>
<th>Complete Asphalt</th>
<th>Standard Asphalt</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Access Control</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>General Rheology</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>rSolution applications database</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Rheology Toolkit package</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Asphalt Rheology</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Rheology Analysis package</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sequence design functionality</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Interactive materials database</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**NOTE:** Specifications have been obtained under conditions as stated in the Installation and Site Requirements for Kinexus rheometers
Redefining Rheometer Capabilities

# KINEXUS DSR ACCESSORY SPECIFICATIONS

<table>
<thead>
<tr>
<th>Environmental controllers**</th>
<th>DSR+</th>
<th>DSR</th>
<th>DSR-E</th>
<th>DSR-III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quick-connect cartridge system</td>
<td>Plug &amp; play; auto-recognition and auto-configuration in software with all alignments and utilities in hardware</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Environmental controllers**

**DSR+**

**DSR**

**DSR-E**

**DSR-III**

| Asphalt Active Hood Oven | -5 °C to +200 °C (-40 °C to +200 °C) 30 °C/minute <0.0005 °C +/-0.003 °C <0.1 °C | -5 °C to +200 °C (-40 °C to +200 °C) 30 °C/minute <0.0005 °C +/-0.003 °C <0.1 °C | -5 °C to +150 °C (-40 °C to +200 °C) 30 °C/minute <0.0005 °C +/-0.01 °C <0.1 °C | -5 °C to +150 °C (-40 °C to +200 °C) 30 °C/minute <0.0005 °C +/-0.01 °C <0.1 °C |

**Universal Cylinder Peltier**

| -5 °C to +200 °C (-30 °C to +200 °C) 15 °C/minute <0.0005 °C +/-0.003 °C | -5 °C to +200 °C (-30 °C to +200 °C) 15 °C/minute <0.0005 °C +/-0.003 °C | -5 °C to +150 °C (-30 °C to +200 °C) 15 °C/minute <0.0005 °C +/-0.003 °C | -5 °C to +150 °C (-30 °C to +200 °C) 15 °C/minute <0.0005 °C +/-0.003 °C |

**High Temperature (HTC)**

| 0 °C to +300 °C 50 °C/minute <0.0005 °C +/-0.003 °C | 0 °C to +300 °C 50 °C/minute <0.0005 °C +/-0.003 °C | 0 °C to +300 °C 50 °C/minute <0.0005 °C +/-0.003 °C | 0 °C to +300 °C 50 °C/minute <0.0005 °C +/-0.003 °C |

* Temperature range dependent.

**Options Available**

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

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

**Additional Environmental controllers, accessories and geometries available upon request**