



Friction, Wear
and Lubrication

Unique Portfolio

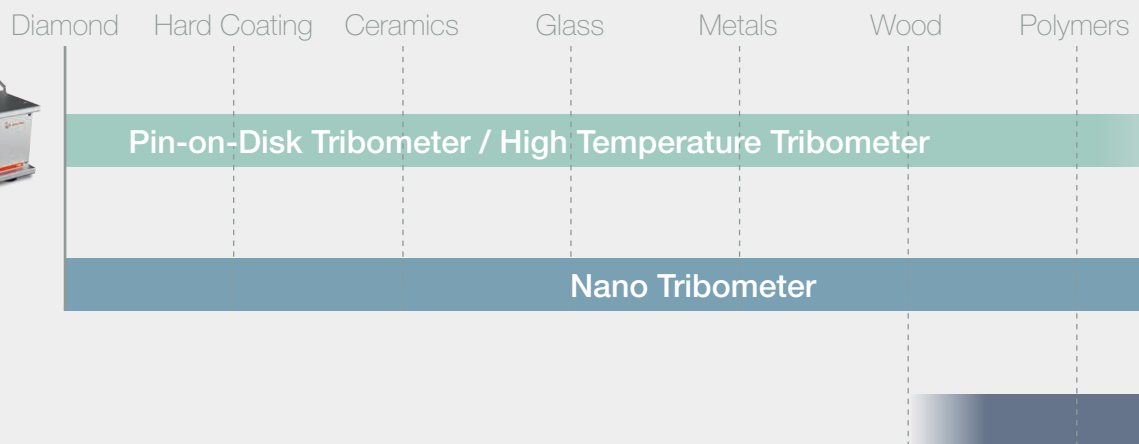
Anton Paar develops, produces, distributes and provides support for analytical instruments used in research, development and quality control worldwide.

Anton Paar's tribometer portfolio gives you the widest range of options available on the market.

Under the previous brand name CSM Instruments, Anton Paar has been designing and distributing tribometers for more than 35 years. Another high-quality choice is Anton Paar's MCR tribometers, employing the EC measuring drive based on 20 years of experience. These instruments are used in research and high-end development applications.

Tribology is the science and technology of interacting surfaces in relative motion and of related subjects and practices. Tribology involves the study of friction, wear and lubrication.

The force known as friction is defined as the resistance encountered by one body moving over another. Whenever two surfaces move against each other, wear will occur, causing damage to surfaces and progressive loss of material. In order to reduce this damage, thin layers of gas, liquids and solids are applied between two surfaces to enable easy motion. This is known as lubrication.



Biggest Influencers

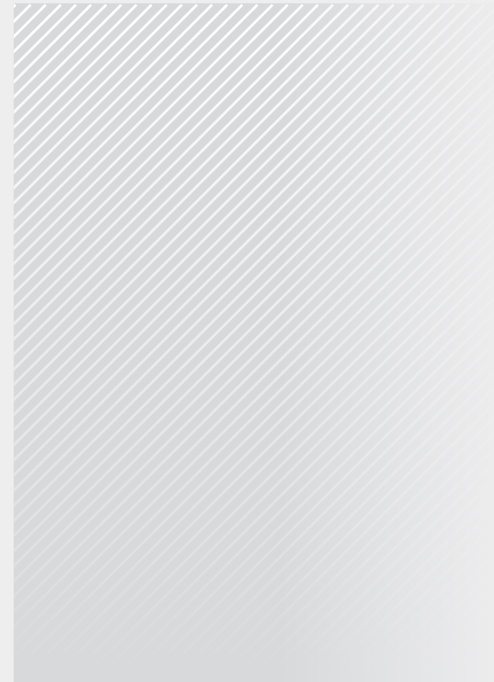
Knowledge and control of materials' tribological behavior are essential before putting them into service. It is important to conduct tribology experiments and analysis under in-service conditions, as materials' tribological properties are influenced by many external factors, such as:

- ▶ Contact pressure
- ▶ Movement mode
- ▶ Movement velocity
- ▶ Test duration
- ▶ Temperature
- ▶ Humidity
- ▶ Vacuum level
- ▶ Gaseous composition

and many more...

Anton Paar's range of tribological testing solutions covers various experimental conditions.

It includes standard pin-on-disk models as well as tribometers for high temperatures, nanomaterials, humidity and vacuum applications.



Food Cosmetics Cartilage Hydrogels Grease Oil Fuel



MCR Tribometer



Tribology on Solids

Contact Conditions

Anton Paar tribometers are unique instruments designed for high-precision measurements of friction, wear and lubrication. In a tribology test of a solid-solid contact with or without lubricant, a static partner with a sphere, pin or flat geometry is loaded onto a sample with a precisely known force. The static partner is mounted on a stiff cantilever designed as a precise frictionless force transducer. The friction force is determined by measuring the deflection of the cantilever. The wear of the sample and static partner is calculated from the materials' volume lost during the test.

Motion Mode

Anton Paar tribometers feature rotating, linear reciprocating and rotational reciprocating modes. In this way, the instruments can simulate different types of motion encountered in service. Moreover, measurement errors caused by mechanical misalignment between loading and rotating axes are cancelled out by the unique rotational reciprocating motion mode.

Environmental Conditions

Anton Paar's standard pin-on-disk tribometers are equipped with enclosures so that controlled atmospheres of varying humidity and gas compositions can be maintained during the measurement. Dedicated humidity and vacuum chambers are developed to allow for state-of-the-art environmental control. High and low temperature options are available to meet extreme testing conditions.

Customized Solutions:

Anton Paar tribometers are easily adapted to satisfy different customers' testing needs. These customized solutions range from online wear depth measurement and online profilometry to electrical contact resistance, tribo-corrosion measurements, precise heating and cooling, liquid testing, and many more.

International Standards

Anton Paar tribometers fully comply with the ASTM G99, G133 and DIN 50324 standards.

Instruments for Tribology on Solids



Nano Tribometer (NTR³)

NTR³ is designed to investigate surface interaction at extremely low contact pressure, especially where soft materials are of interest. NTR³ combines the resolution of an Atomic Force Microscope (AFM) with the stability and robustness of a dual quad-beam cantilever transducer, taking the well proven pin-on-disk tribometer testing principle to the new dimension of nano-tribology.

Unique features:

- ▶ Unique design of dual quad-beam force cantilever to minimize error signal caused by torsion
- ▶ Two independent high resolution capacitive sensors for normal and friction load measurements
- ▶ Piezo actuator to precisely control the normal force from 5 μ N to 1000 mN with extremely fast feedback loop
- ▶ Rotating, linear reciprocating and rotational reciprocating sample movement modes available
- ▶ Optional video microscope module for easy wear track failure analysis



Pin-on-Disk Tribometer (TRB)

With over 1000 installations worldwide over the last 35 years, Anton Paar pin-on-disk tribometers are the de facto standard for measurement of friction, wear and lubrication. A wide range of testing parameters, contact geometries and environmental conditions allows users to conduct tribology testing by simulating in-service condition.

Unique features:

- ▶ Independent normal load application and friction force measurement design to avoid mutual influence between different force signals
- ▶ Highly linear and precise elastic arm for friction load measurement
- ▶ Optional double friction force sensors to minimize thermal drift error on friction measurement
- ▶ Rotating, linear reciprocating and rotational reciprocating sample movement modes available
- ▶ Compliant with ASTM G99, ASTM G133 and DIN 50324 standards

Instruments for Tribology on Solids

High Temperature Tribometer (THT 800 °C)

The analysis of materials' friction and wear properties at elevated temperature is becoming increasingly important, especially for the development and quality control of cutting tools, combustion engines and power plants. To meet this demand of materials testing, Anton Paar offers its powerful high temperature tribometers, which heat the sample homogeneously, and accurately control sample temperature up to 800 °C to simulate materials' in-service condition.



Unique features:

- ▶ Dual friction force sensors to minimize thermal drift error on friction measurement
- ▶ Circular heating element and water cooling system to allow for precise and homogeneous temperature control up to 800 °C
- ▶ Independent normal load application and friction force measurement design to avoid mutual influence between different force signals
- ▶ Highly linear and precise elastic arm for friction load measurement
- ▶ Compliant with ASTM G99, ASTM G133 and DIN 50324 standards

High Temperature Tribometer (THT 1000 °C)

With its unique dual heating elements layout, THT 1000 °C brings high-temperature tribology testing to a new level of reliability and stability. Differential friction force measurement ensures negligible signal drift at extremely high temperature. Careful design of the static partner and sample holders ensures a relaxing experience for the user – even during tribology tests at 1000 °C.



Unique features:

- ▶ Dual friction force sensors to minimize thermal drift errors in friction measurement
- ▶ Top and circular heating elements combined with water cooling system to allow for precise and homogeneously temperature control up to 1000 °C
- ▶ Independent normal load application and friction force measurement design to avoid mutual influence between different force signals
- ▶ Highly linear and precise elastic arm for friction load measurement
- ▶ Compliant with ASTM G99, ASTM G133 and DIN 50324 standards



Vacuum Tribometer / Vacuum High Temperature Tribometer (V-TRB / V-THT)

Anton Paar's vacuum tribometers are designed to provide precisely controlled vacuum levels down to 10^{-7} mbar or gaseous environments for friction and wear studies, at room or high temperatures. The professional vacuum system allows the user to reach the required atmospheric condition in a well-controlled and reliable manner.

Unique features:

- ▶ Primary (10^{-2} mbar) or secondary (10^{-7} mbar) vacuum control
- ▶ Mixture of up to 3 kinds of gases ambience, with precise feedback control on pressure or on mass flow
- ▶ Independent normal load application and friction force measurement design to avoid mutual influence between different force signals
- ▶ Highly linear and precise elastic arm for friction load measurement
- ▶ Compliant with ASTM G99, ASTM G133 and DIN 50324 standards



Relative Humidity Tribometer (RH-TRB)

With the high quality relative humidity chamber, Anton Paar offers a unique solution for simulating friction and wear at different humidity and temperature, both of which are homogeneously distributed inside the chamber. Materials' tribological properties sensitive to humidity can then be studied with ease.

Unique features:

- ▶ Dual wall thermally insulated humidity chamber to guarantee homogeneous 15 % - 95 % relative humidity environment without water condensation
- ▶ Homogeneous temperature control inside the chamber between 10 °C and 40 °C
- ▶ Independent normal load application and friction force measurement design to avoid mutual influence between different force signals
- ▶ Highly linear and precise elastic arm for friction load measurement
- ▶ Compliant with ASTM G99, ASTM G133 and DIN 50324 standards

Tribology of Liquids

Explorer's Choice: The MCR Tribometer

Building on decades of experience developing and manufacturing high-precision rheometers, Anton Paar has now created the unique MCR tribometer.

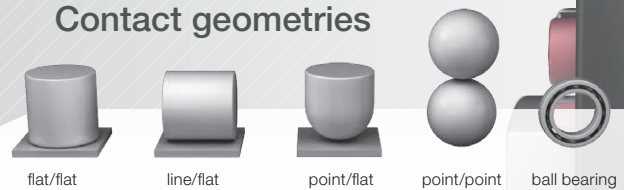
The MCR tribometer expands traditional tribological tests by opening up entirely new measuring ranges. Users can analyze friction, wear and lubrication based on previously unattainable results. Measurements are faster, more representative and more reproducible than with any other comparable system.

All relevant parameters such as speed, position, temperature, humidity, force and material can be actively preset. The MCR tribometer offers endless possibilities for exerting influence on tribological systems, detecting and depicting their reaction.

With one single MCR tribometer, you can:

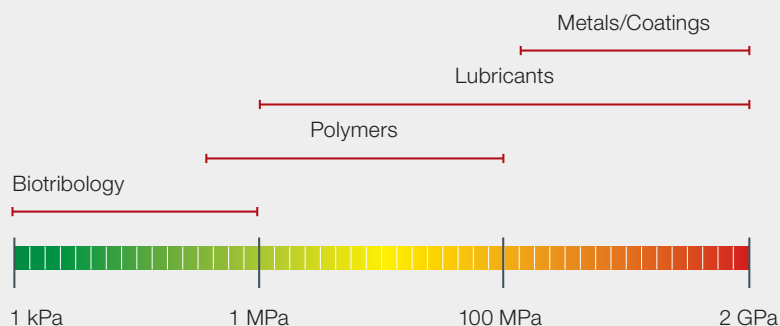
- ▶ Simulate actual tribological systems
- ▶ Classify materials and lubricants
- ▶ Investigate tribological behavior and phenomena

Contact geometries

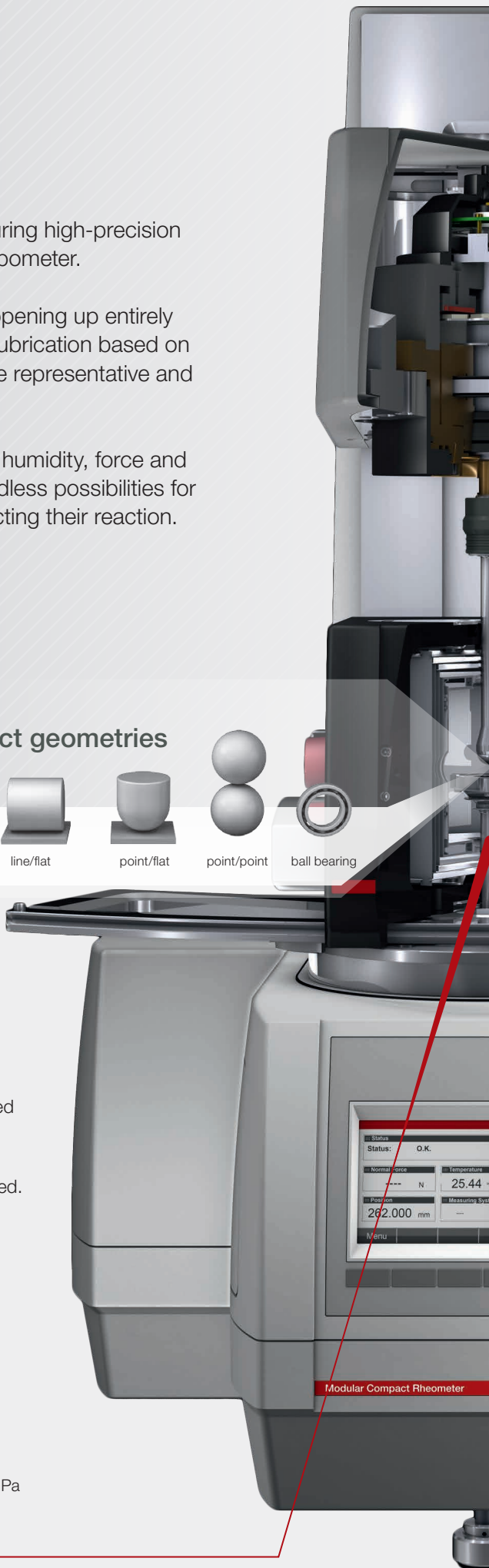


Contact Condition Control

Sample holders and measuring setups are available to customize your MCR tribometer to achieve significant and representative results for each measurement. Benefit from developments in close collaboration with research and industry partners. Measuring setups for both model tribosystems as well as components, e.g. bearings, and custom-tailored solutions are available to meet your specific needs. Test dry and lubricated systems. Even small quantities of lubricants can be tested effectively. Test point, line and flat contacts by merely exchanging a sample holder. Furthermore, options for optical and electrical investigations may be added.

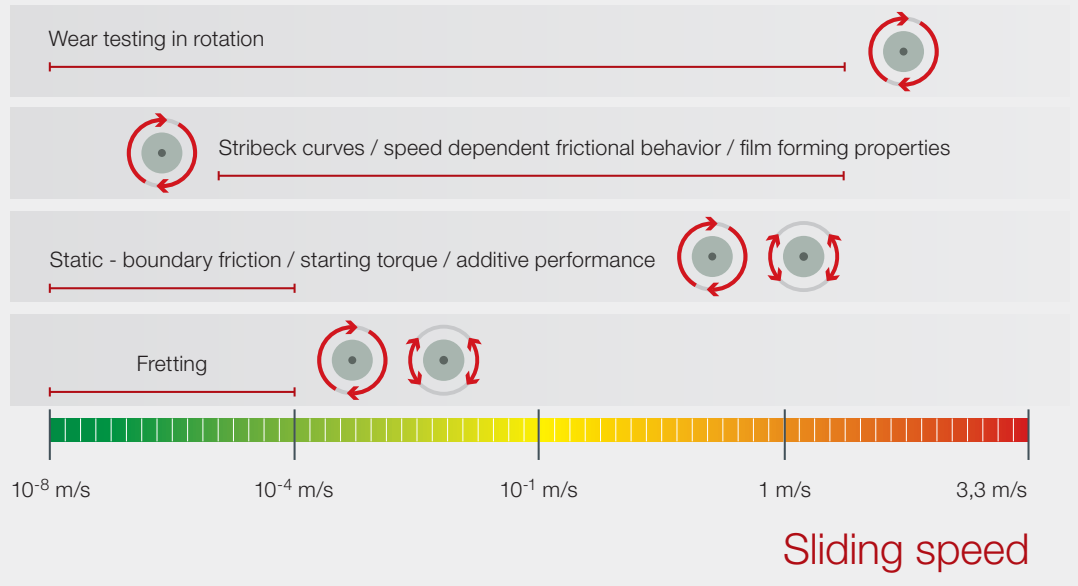


Contact pressure



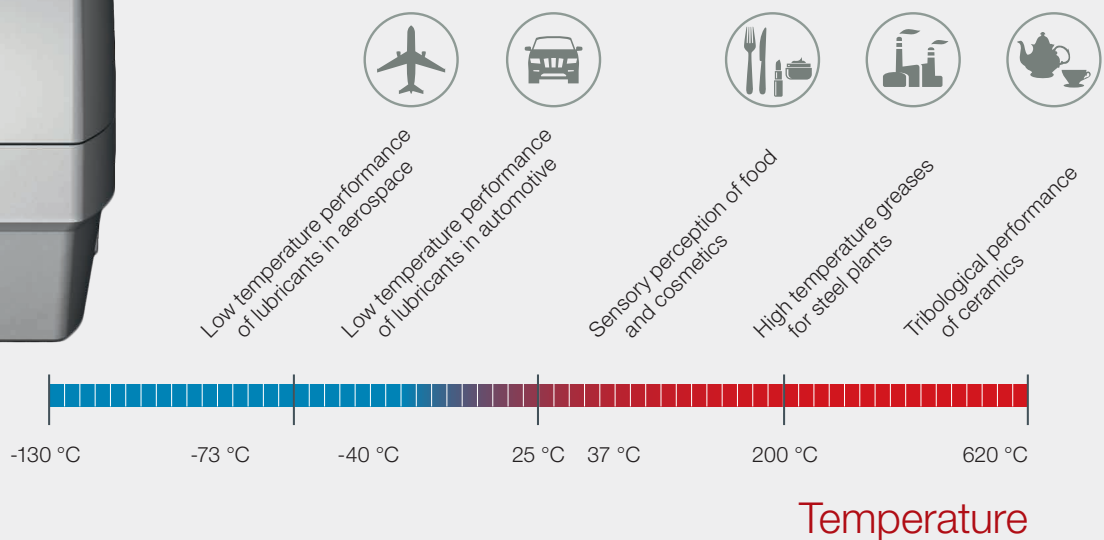
Full Flexibility Motion Control

MCR tribometer feature the broadest speed range and highest motion precision in oscillation and rotation available in the market – easily used by means of RheoCompass™ software.



Environmental Control

Quickly and accurately control temperature and relative humidity – to simulate real application conditions and ensure significant measuring results. Small headspaces combined with state-of-the-art Peltier and convection temperature devices as well as humidity generators make it possible.



Specifications: Pin-on-Disk Tribometers

	Nano Tribometer (NTR ³)	Standard Tribometer (TRB)	High Temperature Tribometer (THT)
Normal Force Range	5 μ N to 1000 mN*	up to 60 N	up to 60 N
Normal Force Resolution	0.003 μ N*	10 mN	10 mN
Friction Force Range	5 μ N to 1000 mN*	up to 10 N (20 N option)	up to 10 N (20 N option)
Friction Force Resolution	0.006 μ N*	0.03 mN	0.03 mN
Rotating Movement			
Speed	1 rpm to 200 rpm	0.3 rpm to 600 rpm (1500 rpm option)	0.3 rpm to 600 rpm (1500 rpm option)
Radius	100 μ m to 20 mm	0.5 mm to 35 mm	0.5 mm to 35 mm
Maximum Torque	-	450 mN.m	450 mN.m
Linear Reciprocating Movement¹⁾			
Stroke Length	up to 5 mm**	up to 60 mm	-
Speed	up to 26.6 mm/s**	up to 370 mm/s	-
Frequency	0.01 Hz to 10 Hz**	0.01 Hz to 10 Hz	-
Rotational Reciprocating Movement²⁾			
Speed	1 rpm to 200 rpm	0.3 rpm to 600 rpm (1500 rpm option)	0.3 rpm to 600 rpm (1500 rpm option)
Frequency	-	0.01 Hz to 7 Hz	0.01 Hz to 7 Hz
Angular Amplitude	$\pm 10^\circ$ to $\pm 150^\circ$	$\pm 10^\circ$ to $\pm 150^\circ$	$\pm 10^\circ$ to $\pm 150^\circ$
Angular Resolution	0.1°	0.1°	0.1°
Options			
Online Wear Depth	up to 250 μ m	up to 1.2 mm	up to 1.2 mm
Heating Capability	-	up to 450 °C in dry condition up to 150 °C in liquid condition	up to 1000 °C
Electrical Contact Resistance	up to 1000 Ohms	up to 1000 Ohms	up to 1000 Ohms
Vacuum Level	-	down to 10^{-7} mbar	down to 10^{-7} mbar
Relative Humidity Level	-	15 % to 95 %	15 % to 95 %

* Nano tribometer normal load and friction load specifications depend on the choices of different cantilevers (High Resolution, Standard and High Load Cantilevers)

** Nano tribometer linear reciprocating movement specifications depend on the choices of different linear stages

1) Linear reciprocating movement specifications depend on the combination of stroke length, frequency, and mass on the stage

2) Rotational reciprocating movement specifications depend on the combination of angular amplitude, frequency and mass on the stage

Software Features:

- ▶ Continuous real time data acquisition of friction signal during measurement
- ▶ Programmable incremental speed and normal force in one measurement
- ▶ User defined testing sequences in one measurement
- ▶ Adjustable data acquisition rate up to 400 Hz for recording frictional phenomena with high fidelity
- ▶ Hertzian stress modeling software: better testing parameter selection for tribological analysis
- ▶ Multi-cycle angular reciprocating mode to cancel errors due to misalignment between normal load and sample rotating axes
- ▶ Friction force and friction coefficient threshold auto-protection
- ▶ Automatic calibration procedure for friction force, rotating speed and measurement radius
- ▶ Automatic generation of reports for a set of measurements

Specifications: MCR Tribometers

MCR Tribometer Base				
Temperature Control Technology	Peltier			Electrical
Measuring Cell	T-PTD200	T-PID/44	T-BTP	
Environmental conditions				
Temperature Range	-40 °C to 200 °C	-30 °C to 190 °C	-20 °C to 180 °C	-150 °C to 450 °C
Relative Humidity Level	-	-	5 % to 95 %	-
Vacuum Level	-	-	-	-
Contact conditions				
Normal Force Range	1 N to 50 N	0.7 N to 50 N	0.1 N to 70 N	
Normal Force Resolution	0.005 N			
Contact Type	Point, Bearing	Point, Line, Flat	Point, Bearing	
Motion conditions				
Continuous rotation				
Speed Range	10 ⁻⁶ rpm to 3000 rpm	10 ⁻⁶ rpm to 1000 rpm	10 ⁻⁶ rpm to 3000 rpm	
Sliding Speed Range	10 ⁻⁸ m/s to 3.3 m/s	10 ⁻⁸ m/s to 2.3 m/s	10 ⁻⁸ m/s to 1.4 m/s	
Torque Range	1 nNm to 300 mNm			
Torque Resolution	0.1 nNm			
Friction Force Range	250 nNm to 120 N			
Friction Force Resolution	25 nNm			
Oscillatory rotation				
Frequency	10 ⁻⁷ Hz to 100 Hz			
Angular Amplitude	1 μrad to ∞ μrad			
Angular Resolution	10 nrad			
Linear Reciprocation	-	-	-	-
Additional parameters				
Min. Online Wear Depth	0.65 μm			

MCR Tribometer Software Features:

RheoCompass™ is based on the latest 64-bit technologies and developed for WIN7 and WIN8. A new test designer lets you define the test you want with optional instructions for sample preparation, post-analysis, export of data and report print-outs in PDF format. Designed for intuitive use, the client- and server-based RheoCompass™ enables post-measurement analysis, data export and report print-outs in PDF format, highly simplified data retrieval and much more. Use the Test Designer to guide you through defining your own experiment. The Test Designer provides optional text, audio and video instructions for sample preparation.

All tribologically relevant measures are available to control and evaluate your tribological measurement. In RheoCompass™ complex tribological measuring jobs are defined by clearly arranged action blocks. Combine several measurement actions with the advantage of a comfortable data structure. Each result is identified by the name of the measurement action. All measurement data are easily and quickly handled in the Microsoft SQL 2012 database.

