



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 tribometer range, 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 ideal motion. This is known as lubrication.

## Biggest Influencing Factors

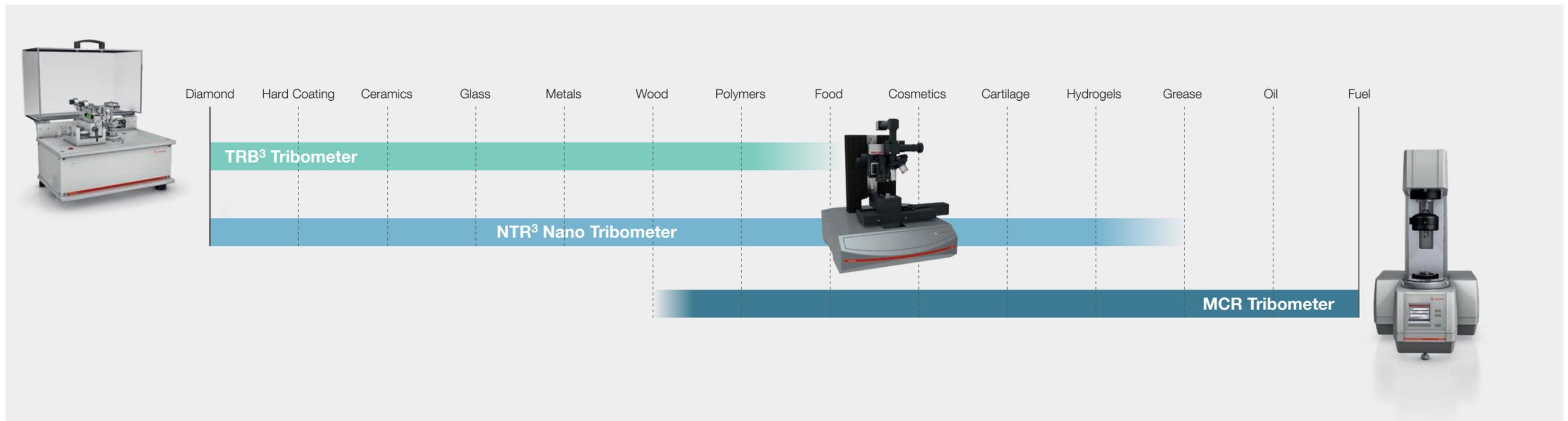
Knowledge and control of the materials' tribological behavior are essential before putting them into service. It is important to conduct tribology experiments and analyses under in-service conditions, as the materials' tribological properties are influenced by many external factors, such as:

- 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.



## Measuring principles

Anton Paar tribometers are unique instruments designed for high-precision measurements of the friction, wear, and lubrication behavior of various tribosystems. With both TRB<sup>3</sup> tribometers and MCR tribometers, measurements can be carried out in dry or lubricated mode.

In a tribology test of a solid-solid contact with a TRB<sup>3</sup> tribometer 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.

For MCR tribometers, typical contact geometries such as round-on-flat, flat-on-flat, round-on-round are available but also more complex scenarios such as the testing for roller bearings can be realized. The controlled normal force is applied by the MCR drive moving up and down. The torque is controlled and measured by an EC motor. The frictional force is calculated from the torque. The MCR tribometer, equipped with an air bearing, enables measurements over several decades of speed.

## Customized Solutions

Anton Paar tribometers are easily adapted to satisfy different customer 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.

## Motion Modes

TRB<sup>3</sup> 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. Rotational as well as oscillatory motions can be realized on an MCR tribometer. Oscillatory measurements enable the evaluation of the complex behavior of tribosystems.

## 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. MCR tribometers enable temperature control using either Peltier-based or electrical heating systems. MCR tribometers can be extended with temperature devices (accessories) to apply a certain controlled atmosphere (gas and relative humidity).

## International Standards

Anton Paar's TRB<sup>3</sup> tribometer fully complies with the ASTM G99, G133, and DIN 50324 standards.



## Nano Tribometer (NTR<sup>3</sup>)

NTR<sup>3</sup> is designed to investigate surface interaction at extremely low contact pressure, especially where soft materials are of interest. NTR<sup>3</sup> 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  $\mu$ 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<sup>3</sup>)

With over 1000 installed bases worldwide over the last 35 years, Anton Paar's pin-on-disk tribometer is the standard for measurement of friction, wear, and lubrication. Its wide range of testing parameters, contact geometries, and add-on options allows users to conduct tribology testing by simulating all in-service conditions, such as different movement modes (linear, reciprocating), contact modes, speed, lubrication, materials, high temperature, humidity, etc.

### Unique features:

- Two friction force sensors to minimize errors caused by thermal drift
- Independent normal load application and friction force measurement to avoid mutual influence between different force signals
- Integrated temperature and humidity sensors for real-time environment monitoring
- Easy friction force and rotation speed calibration
- Compliant with ASTM G99, ASTM G133, and DIN 50324 standards

# Anton Paar Tribometers



## 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 material 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 the 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 temperatures. Careful design of the static partner and sample holders ensure trouble-free measurements 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 homogeneous 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 (TRB V/ THT V)

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 three kinds of gases, 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 (TRB RH)

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

### Unique features:

- Dual wall thermally insulated humidity chamber to guarantee homogeneous 15 % to 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



# Anton Paar Tribometers



## MCR Tribometer: An evolution in tribological testing

Employ the precise motion and normal force control of MCR tribometers for your tribological measurements. Expand your traditional tribological tests by opening up entirely new measuring ranges on one single instrument. MCR tribometers come with numerous test setups and contact geometries to suit your requirements. Benefit from Anton Paar's decades of experience in precision instrumentation.

### Unique features:

- Seamlessly measure break-away forces as well as static and limiting friction of dry and lubricated contacts.
- Plot Stribeck curves over nine decades of sliding speeds – few nanometers per second to 3.3 meters per second
- Food and beverages, lubes and greases, polymers, ophthalmics, biomedicine, etc.
- All the benefits of the extended atmosphere control
- Temperature range between -160 °C and 600 °C
- Humidity control 5 % to 95 %
- In addition to the existing setups, there is always scope for customizing setups to perfectly suit your application.



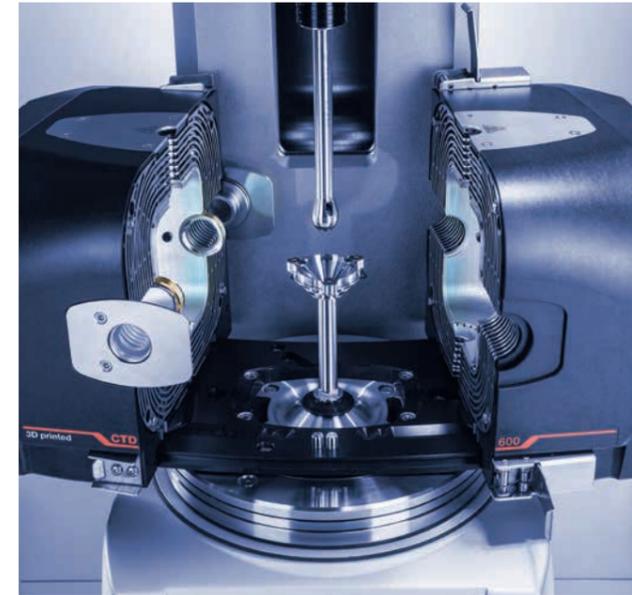
## Ball-on-three-plates: (or T-PTD200) Full motion flexibility and precision

The ball-on-three-plates setup is a well-established method for measuring both lubricated as well as dry tribological systems. Different measuring geometries (plates, cylinders) are available and can be adapted to specific sample needs.

The heart of this setup is the T-PTD 200 tribology cell which ensures precise alignment and therefore a homogeneous distribution of normal forces on the measured specimen.

### Unique features:

- Nine decades of sliding speeds – from a few nanometers per second to 3.3 meters per second
- Contact pressure of a few kPa to 1.2 GPa
- Broad range of applications – from food and beverages to lubricants and greases, metal working fluids, etc.
- Wide range of specimen and holders catering to individual applications
- The Peltier heating system allows excellent temperature control from -40 °C up to 200 °C.



## Ball-on-three-plates: (or T-BTP) Extended atmosphere control

This setup allows for measurements in a temperature range from -160 °C to 600 °C or with relative humidity between 5 % and 95 %. Normal forces as low as 0.1 N can be applied. The stiffness of the measuring system can be adjusted by the patented spring system that transfers the normal forces applied in vertical direction (Pat. No. AT514726A1).

### Unique features:

- Enjoy complete motion and force ranges of the MCR Tribometer with added low-force sensitivity.
- Employ advantages of Convection Temperature Device (CTD) for tribological measurements.
- Temperature range between -160 °C and 600 °C
- Humidity control 5 % to 95 %
- Spring stiffness adjustable in z-direction offering excellent damping characteristics



## Pin-on-disk (or T-PID/44)

The T-PID/44 allows for round-on-flat, flat-on-flat, or line contacts in dry and lubricated conditions. The spring stiffness can be adjusted in the z-direction, which enables optimal damping characteristics. Various specimen materials can be fixed in the upper and lower holder allowing a broad range of applications.

### Unique features:

- Contact geometries ranging from flat-on-flat contact to point contact, abrasive contact, line contact, etc.
- Temperature range between -30 °C and 190 °C
- Diverse applications – asphalt, lubes and greases, cosmetics, food and beverages, ice, cartilage, bio-medicine, etc.
- Make use of the flat-on-flat contact geometry for low contact pressure applications.
- Possibility to adapt the setup to accommodate a ring-on-disc test configuration

# Specifications

	Nano Tribometer (NTR <sup>3</sup> )	Standard Tribometer (TRB <sup>3</sup> )	High Temperature Tribometer (THT)
Normal Force Range	5 µN to 1000 mN*	up to 60 N	up to 60 N
Normal Force Resolution	0.003 µN*	- (dead weight)	- (dead weight)
Friction Force Range	5 µN to 1000 mN*	up to 20 N (5 N option)	up to 10 N (20 N option)
Friction Force Resolution	0.006 µN*	0.06 mN (0.015 mN option)	0.03 mN
<b>Rotating Movement</b>			
Speed	1 rpm to 200 rpm	0.2 rpm to 2000 rpm (600 rpm option)	0.3 rpm to 600 rpm (1500 rpm option)
Radius	100 µm to 20 mm	up to 40 mm	0.5 mm to 35 mm
Maximum Torque	-	450 mN.m	450 mN.m
<b>Linear Reciprocating Movement<sup>1)</sup></b>			
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	-
<b>Rotational Reciprocating Movement<sup>2)</sup></b>			
Speed	1 rpm to 200 rpm	0.2 rpm to 2000 rpm (600 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	±10° to ±150°	±5° to ±150°	±10° to ±150°
Angular Resolution	0.1°	0.1°	0.1°
<b>Options</b>			
Online Wear Depth	up to 250 µm	-2 mm to 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 <sup>-7</sup> mbar	down to 10 <sup>-7</sup> 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
- Matrix testing with the Nano Tribometer in linear reciprocating movement mode
- Statistics mode for measurement data analysis
- 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

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

<sup>1)</sup> The friction force range and the friction force resolution depend on the measuring geometry.

## MCR Tribometer Software Features:

RheoCompass™ is based on the latest 64-bit technologies and developed for WIN7 and WIN8.

- Easily set and control tribological measures such as normal force, break-away torque, speed, deflection, temperature, humidity (optional), etc.
- Enjoy the pre-loaded templates for Stribeck tests, static friction tests, wear tests, etc.
- Measurements are clearly defined in individual action blocks.
- Use the Test Designer to guide you through defining your own experiment.
- Combine several measurement actions with the advantage of comfortable data structure.
- Create multi-axis graphs to display the data the way you want.
- Run post-test analysis of data and create individual analysis routines.
- Automatically export data and reports at the end of the test.
- Measurement data is stored in a Microsoft SQL 2012 database.

