



# Multi Function Tribometer

## MFT-5000



Wear, Friction, Coefficient of Friction, Adhesion,  
Scratch Hardness & Resistance, Film Thickness,  
Step Height, Hardness, Modulus, Fretting, High  
Temperature, Cryogenic



# A Tribometer Like No Other

## All You Need In One Instrument

- Wear
- Coefficient of Friction
- Adhesion
- Scratch Hardness
- Scratch and Mar Resistance
- Film Thickness
- Step Height
- Elastic Modulus
- Fracture Toughness
- Wear Track, Volume Wear
- Radius of Curvature
- Cracks and Defects
- Chemical Properties
- Fretting
- Tensile, Compression
- High Temperature Hardness
- 4 Ball

### Industry Standard Platform

The patented (US10132733B2) state-of-the-art Rtec-Instruments Multi Function Tribometer, the MFT-5000, is globally regarded as the most versatile and technologically advanced tribometer.

The tribometer offers breakthrough technology in tribology equipment— with ultra-low resolution and negligible thermal drift force sensors, the highest speeds, the widest environmental control range, and ultra-accurate stroke control. In addition, the patented integrated 3D profilometer analyzes surface change vs. time.

### Multi ASTM, DIN, ISO Tests on the same platform

Run both standard and non-standard tests on coupons or real components and can be configured as a single-function test or multi-function

### Wide Load Range - Nano, Micro, Macro

Interchangeable load cells allow a wide range of force ranging from mN to 10,000 N

### Several Easy Test Modules To Interchange

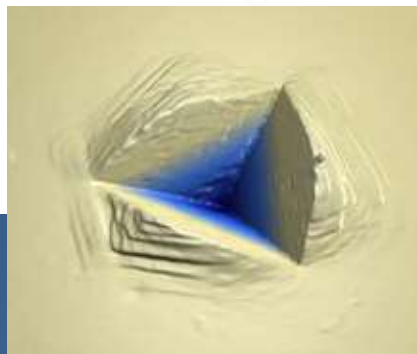
Test coatings, bulk materials, and lubricants across a wide range of testing conditions

### Integrated In-line 3D Profilometer

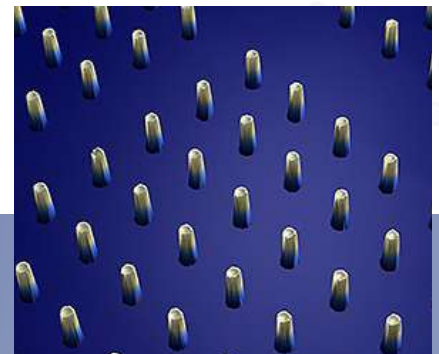
Study surface roughness, volume wear, and topography change during the test.



**Tribology**



**Mechanical Tests**



**3D Imaging**

# Patented In-line Profilometer With Automatic Stitching Technology Optimized for Tribology Testing

(US 20180024035 A1)

- **Steep Slopes**

Universal profilometer capable of imaging wear tracks with steep slopes

- **Rough, Dark, Smooth Surfaces**

The universal profilometer can scan any material (transparent, dark, corroded, flat, curved).

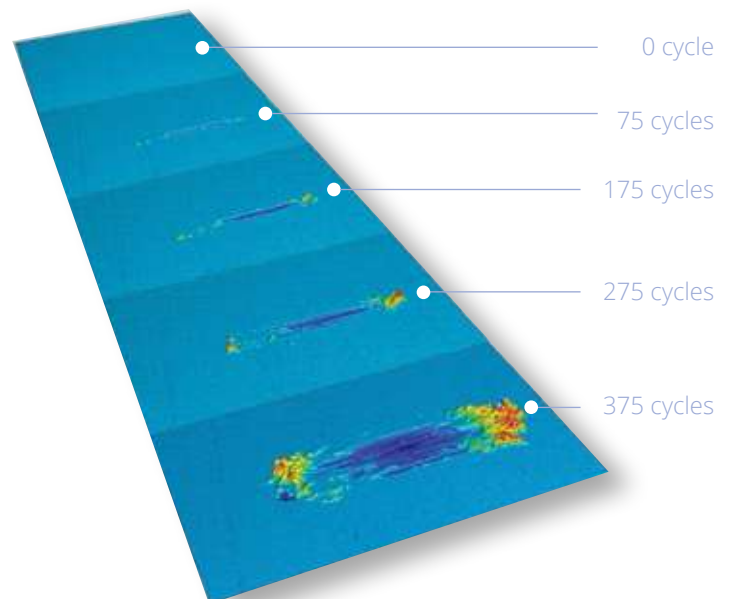
- **Auto Stitch of Entire Samples**

The high-precision XY stage allows automatic scanning and stitching of the entire wear track.

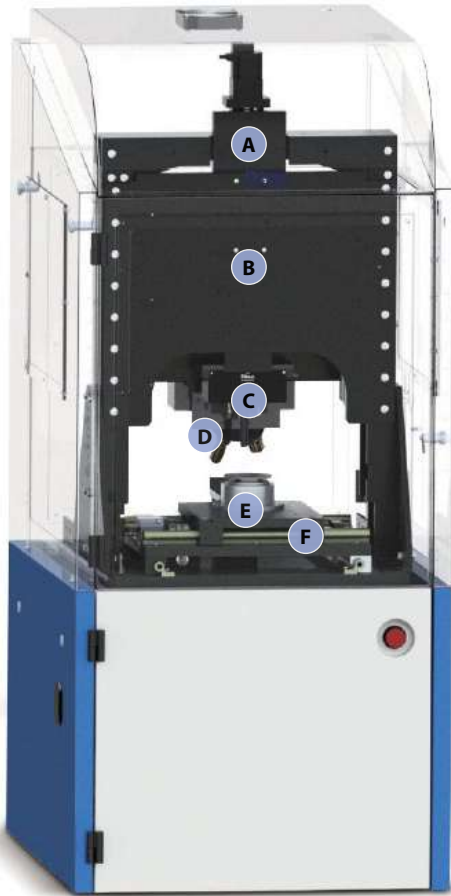
- **Image with Liquids**

Confocal microscopy can image samples under liquid media.

## Sub-nanometer 3D Image of Wear Mark Progression During Test



# Tribometer Configuration



A

## Upper Z Stage

High precision multiple Z stages to move load cell, profilometer, etc., each independently on the Z-axis.

B

## Open Platform

Universal testing machine design and high Z access provide a large working area.

C

## Force Sensor

Interchangeable load cell, spanning a wide range from mN to 12,000 N.

D

## In-line Profilometer

An in-line universal 3D profilometer is automatically synchronized with the image test area with nm resolution. The Lambda profilometer is an all-in-one profilometer with five imaging modes on the same head (Confocal, White Light Interferometer, Dark Field, Bright Field, and Focus Variation).

E

## Changeable Test Modules On Top of XY Stage

The interchangeable test modules perform several tests on the same platform (rotary, reciprocating, block on ring, fretting, scratch, etc.). The modules are mounted using fast exchange with automatic recognition on top of the XY stage.

F

## XY Stage

The 130 x 270 mm high precision XY stage moves test modules between test and imaging positions. The stage can also be used for slow-speed reciprocating tests, scratch tests, custom motion tests, and more.

# Wide Range Of Sensors With Patented Technology

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- Automatic Recognition

The tester can mount various interchangeable force sensors easily. Each sensor has an automatic recognition feature and calibration file to maintain optimized performance on testing parameters.

- Fast Exchange

Based on the application, a sensor from various types of load cells can be selected.

- Highest Resolution

- **Capacitive Load Cells -**  
Highest resolution load cells with negligible thermal drift.

- Low Floor Noise

- **Piezo Load Cells -**  
Sensors to measure data at the highest frequency.

- **Strain Gauge Load Cells -**  
Sensors with widest load range - mN to 12,000 N.



High resolution  
capacitive based sensor



Fast Piezo Sensor  
for linear reciprocating



Standard strain gauge  
sensor

## Other Available Sensors

Torque Sensors / 1D, 2D, 6D Sensors / In-line Dynamic Torque Sensors

Patent # 1017938GB2



# Modular Drives With Fast Exchange

## Modular Design For Maximum Versatility



MFT-5000 runs tests across a wide range of forces and applications using its modular concept. Various interchangeable modules can be added to the same platform based on the intended application. The modular nature of this tester allows it to test coatings, bulk materials, lubricants, real components, etc.



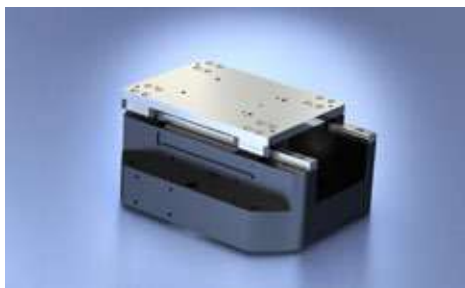
The test modules are quickly swapped. In addition, the testing modules, load cells, and lower test drives come with a fast exchange mechanism that allows the user to easily change test configurations.

The software and hardware automatically recognize the test module and easily run each test.

## Commonly Used Drives



Rotary Drive



Reciprocating Drive



Block on Ring Drive



Fretting Drive



Mini Traction Machine, EHL Drive



Upper Rotary Drive

# Environmental Chambers

-120°C to 1200°C, Tribo-Corrosion, Vacuum, High Pressure, and More

- Automatic Recognition
- Ease of Use
- Same Software
- Future Field Add-ons
- Cost Effective

The tester comes with several environmental chamber options. The chambers are typically mounted on top of room-temperature drives. Using interchangeable chambers, a wide range of -120 to 1200°C, controlled humidity, and vacuum up to  $10^{-7}$  torr are achievable. In addition, some setups allow the MFT-5000 to heat upper and lower samples separately to simulate real-life situations.

The advanced control system allows temperature measurement at multiple points simultaneously. All the chambers are closed-loop controlled, and the requested conditions are controlled automatically using the software. In addition, the PID for different ranges of chambers is automatically loaded once an option is mounted.

## Environmental Chambers



1000 °C



Salt Spray



500 °C



1200 °C



-50 °C



-120 °C

# A **Tribometer** That Comprehensively Characterizes **Surface Change vs. Time**



## Tribology Mode

Several Modules Available for Tests

**Nano Load**

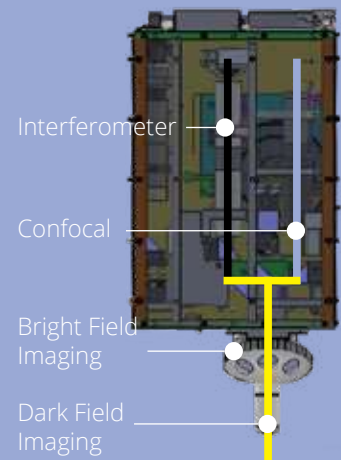
**Micro Load**

**Macro Load**

- Rotary Motion
- Linear Motion
- Horizontal Rotation Motion
- Upper Rotation
- Fretting

## Imaging Mode

Sub nm automated 3D Images of Surfaces



- Surface Roughness
- Film Thickness
- Wear Track
- Volume Wear
- Step Height
- Add on - Confocal Raman



# Oil, Lubricant Tests, and More

## Multiple ASTM, DIN, ISO, and Stribeck Curves

The Universal Tribometer is ideally suited for Industrial Tribology involving lubricants, additives, oils, metalworking fluids, and many more. The sturdy design includes various lubricant dispensing systems, speeds ranging from 0.001 rpm to 10'000 rpm, and temperature control. Because of this, the MFT-5000 precisely develops, characterizes, and provides quality control. A few of the standard tribology tests and features are described below.

- Lubricant Recirculation
- High Speed Containers
- Temperature Control
- All Regimes
- Automatic Stribeck
- Up to 10'000 N Force
- Real Components
- Low Friction
- Measurement at High Loads
- Ultra High Torque Motors
- Certified Reference Calibration Oil Samples

### HFRR

The High Frequency Reciprocating module HFRR is used to evaluate diesel fuel lubricity. The ball slides against a disk with a 1-mm stroke at a frequency of 50 Hz. ASTM D6079, D7688, CEC F-06-A-96, ISO 12156-1, IP450, BS-EC590

### Linear Oscillating/Fast Reciprocating Test, SRV Test, Piston Ring/Cylinder Liner

The standard test determines extreme pressure, friction, and wear properties of greases, solid bonded films, gear/hydraulic fluids, and lubricant oils. All tests are done in oscillation mode under controlled environmental conditions. ASTM G119, G174, G133, G203, G204, G206, D5706, D5707, D6425, D7217, D7420, D7594, D7421, DIN 51834, ASTM G181, G206, and more.

### Thrust Washer

This test assesses friction and wear parameters of self-lubricated materials in thrust washers, such as ASTM D3702.

### 4 Ball Wear, 4 Ball EP

4 ball wear module measures wear-preventing properties of lubricants and greases in sliding and rolling applications; 4 Ball EP measures lubricant extreme pressure properties. The test involves rotating one ball on three stationary balls under controlled environmental conditions. ASTM D-2266, D-4172, D-5183D-2596, D-2783, and DIN 51350, IP 239,300.

### Tapping Torque, Twist Compression

During forming and machining, the tapping torque module characterizes friction, wear, torque, etc. The test involves tapping/drilling using taps of various standard sizes on materials of choice. Twist compression is designed to measure friction and adhesion in metal forming. The test involves slowly rotating a ring on top of the material of choice.

### Block on Ring, Timken EP

The block on ring module is typically used to evaluate friction, wear of materials, or lubricant/grease where a ring/bearing/shaft is rotated under axial load. ASTM G77, D2509, D2714, D2782, D2981, D3704 and more.

### Mini Traction Machine

Study various sliding rolling ratios with upper and lower rotary motions from -200% to 200% ratio. Wide speed range to achieve -6 to 6 m/s to cover the entire lubrication regime

### Pin, Ball on Disk

The module measures friction during sliding using pin/ball on disk setup. ASTM G99, G132, DIN 50324, and more.

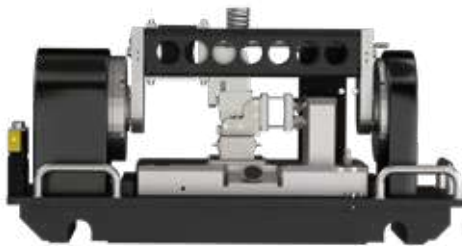
### Stribeck Curve

The Stribeck curve displays the evolution of the coefficient of friction as a function of load, velocity, and viscosity. Users can change the load and velocity to plot Stribeck Curves automatically and easily with all modules.

# Fretting With Unmatched Performance

## Voice Coil

Fretting test modules cover a wide test load range. Technology breakthrough in voice coil control, high-frequency signal processing algorithms can run fretting wear tests with less than 5  $\mu\text{m}$  stroke. The test module comprehensively characterizes fretting wear from micron to macro scale. Ultra-sensitive piezo-based load cells, combined with a robust design, high stiffness holders, and low floor noise, provide quantitative fretting wear characterization of materials, interfaces, thin films, and components.



## Real-Time Stroke Control

### The Smallest Controllable Stroke

**Less than 5  $\mu\text{m}$ , up to 2.8 mm, up to 500 Hz**

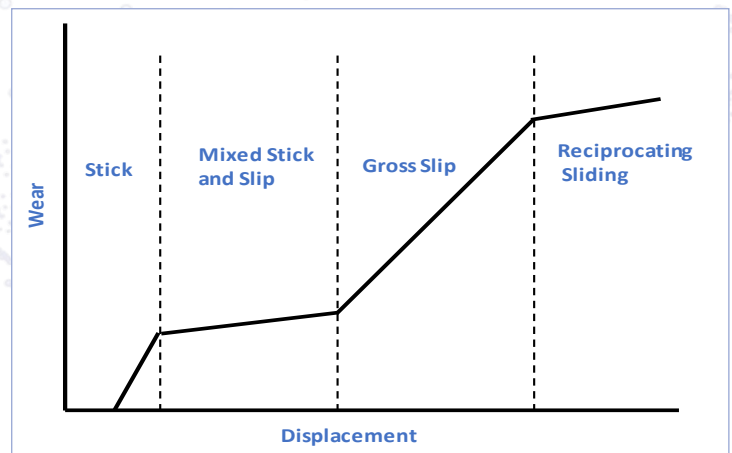
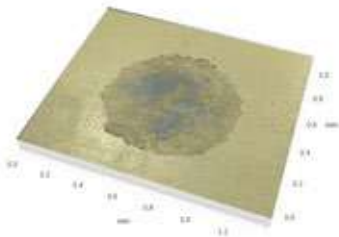
Real-time stroke, frequency monitoring, and correction using LVDT.

## High Reliability - Flexure Design

The flexural suspension guides the magnet assembly without bearings.

## High Frequency Response Force Sensors

Measure friction force with ultra-high accuracy at high frequency reciprocating tests using our Piezo-based sensors.

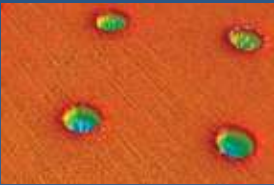


Regime Schematics

# Scratch, Hot Hardness, Adhesion



Scratch Module



Spherical Indents



Vicker's Indent



Hydrogels  
Contact Area

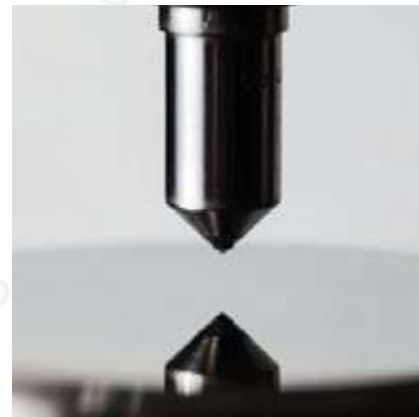


Wear Mark

## Coatings Adhesion, Scratch, and Mar Resistance

The scratch test quantifies the adhesion and scratch hardness of coatings. With the advent of new deposition methods and technologies, thinner coatings are finding their way into every aspect of our lives. Coatings are on LCDs, phones, cutting tools, gems, glass, automobiles, medical devices, etc. The quantitative coating adhesion scratch test is a simple, practical test that has existed for a long time. However, reliable, reproducible, and comprehensive tests require precise control of the test system configuration and its testing parameters.

The scratch test requires applying a load on the sample that needs to be tested with a spherical or custom tip. When applying the load, the sample is moved at a constant velocity. Several parameters, such as Friction ( $F_x$ ), Downforce ( $F_z$ ), Coefficient of friction (COF), displacement ( $Z$ ), acoustic emission (AE), temperature, etc., are measured in situ.



## Mechanical Tests - Hot Hardness, 3 - 4 Point Bending

The tribometer measures and monitors forces and displacement in all axes. The multi-axis force measurement allows it to run several standard mechanical tests such as hardness, 3-4 point bending, tensile, compression, fatigue, torsion, and fretting tests. All these tests can be done using any of the environmental chambers.

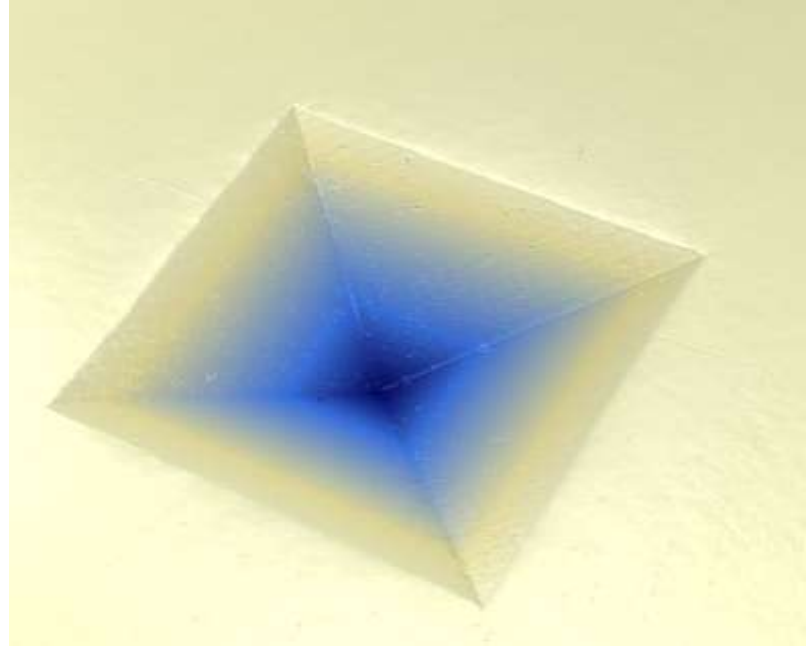
# Instrumented Indentation (IIT)

## Hardness and Elastic Modulus

Our Instrumented Indenter Testers are high-precision instruments that measure the mechanical properties of thin films, coatings, or any bulk materials.

Hardness, elastic modulus, creep, and fatigue can be determined on almost any material, from soft to hard and fragile to brittle. Using the latest actuation (piezo) and sensing technologies (capacitive sensors), the SMT quantifies the properties of surfaces from nano to micro ranges.

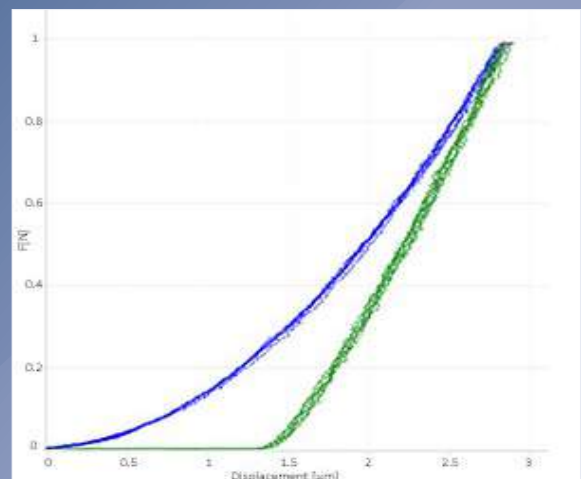
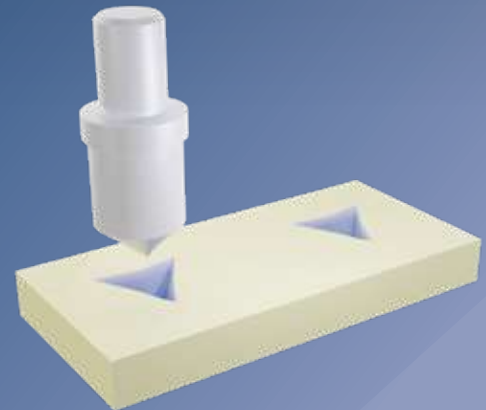
Instrumented Indentation Testing (IIT) involves pressing an indenter of known geometry into a surface while controlling and measuring the



force and displacement. The resulting load-displacement curves are used to calculate hardness and elastic modulus, among other things. Although traditional hardness measures remain available (Knoop, Rockwell, Vickers), the IIT technique adds the ability to measure the elastic modulus of the material tested.

### Key Features of Indentation Testers

- Exchangeable modules to cover multiple load ranges from mN to 200 N
- Unmatched performance with patented capacitive sensor technology
- Berkovich, Vickers, Spherical, Cube Corner, Knoop, ... indenter tip
- Handling large and heavy loads and samples (50 cm; 10 kg)
- Motorized stage 150 mm x 200 mm for automatic mapping
- Automated 3D microscopy inspection

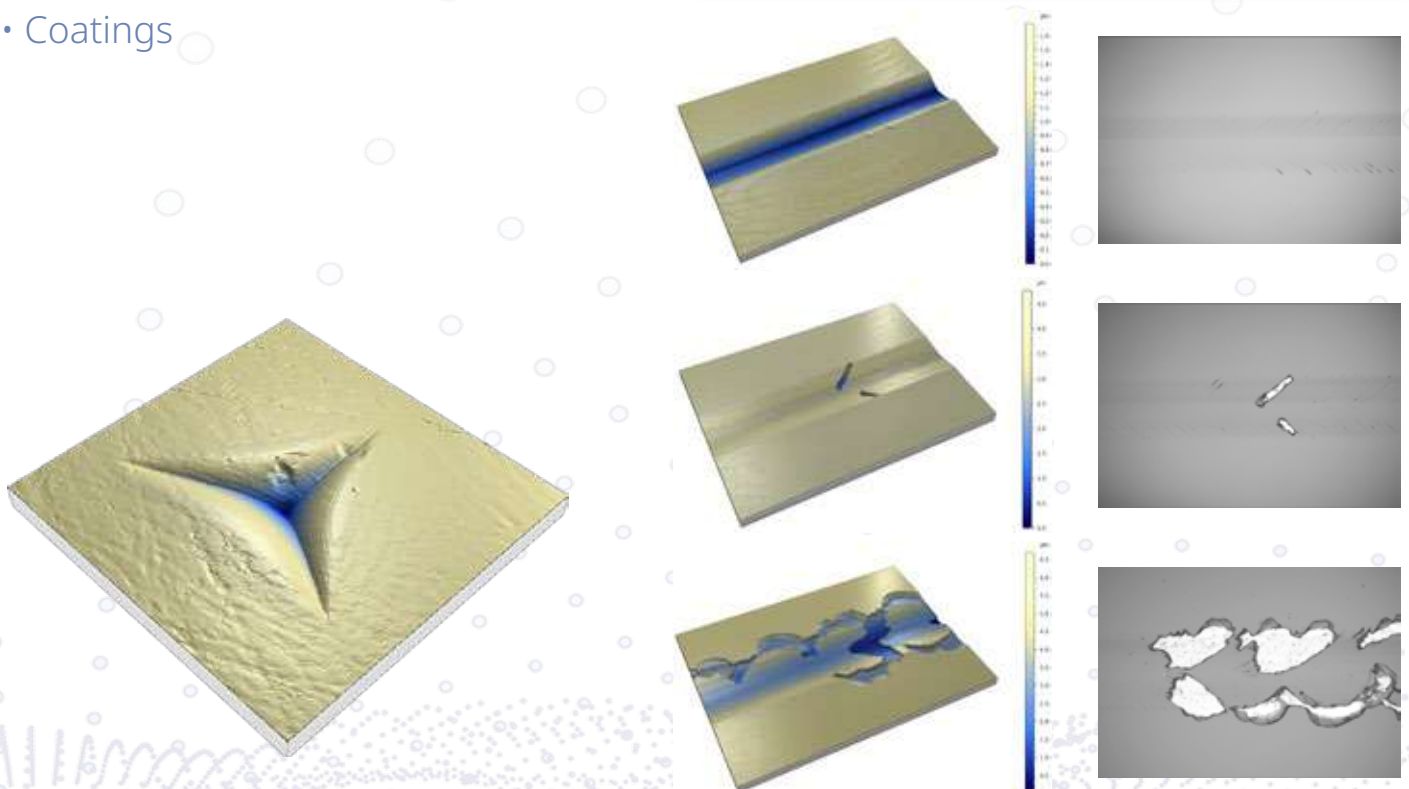
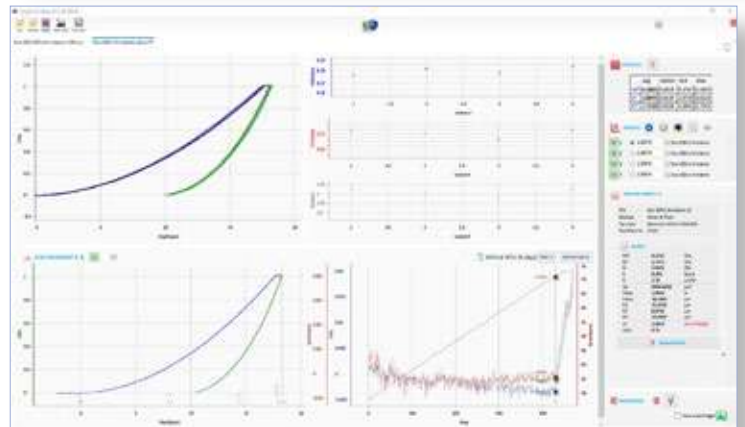
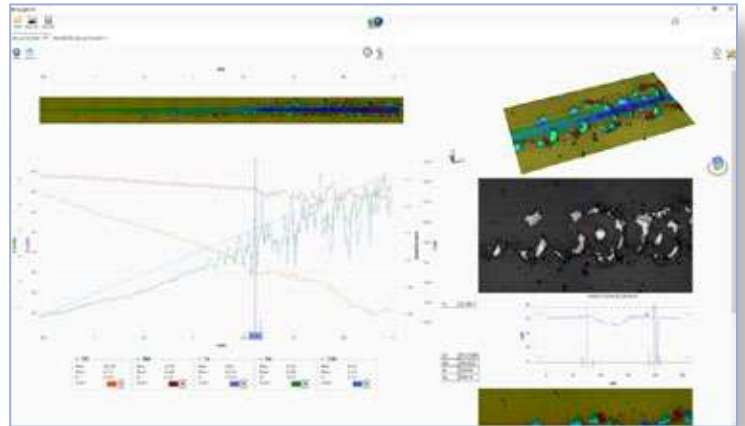




# Coatings and Materials

Scratch: from nm to mm coatings

- Hard Coatings
- Polymer Coatings
- Paints
- Soft Coatings
- Optical Lenses
- Decorative Coatings
- Real Components
- 2D Materials
- Thermal Spray
- Coatings



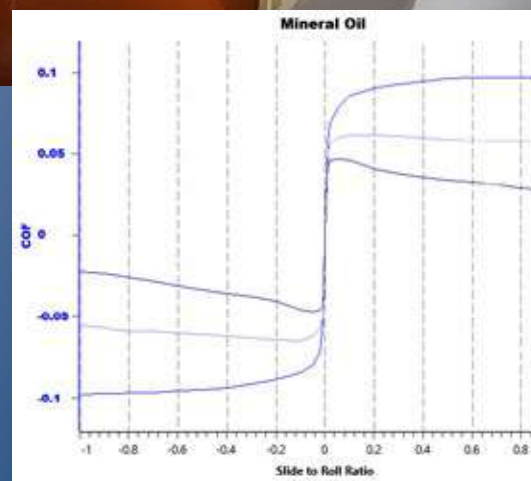




## Mini Traction Machine

The mini traction module measures the frictional properties of lubricated contacts under a wide range of sliding rolling ratios. Friction change vs. load, speed, and temperature reflect several fundamental properties valuable for assessing and comparing lubricants, greases, liquids, materials, etc.

The module can operate at a high sliding-to-rolling ratio using two independently controlled closed-loop servo drives. A wide speed range from -6 to 6 m/s allows for covering the entire lubrication regime. Standard configuration typically involves independently rotating a 19.05 mm steel ball against a rotating 46 mm steel disc. Real-time downforce, traction force, and speed data automatically create Stribeck curves across the desired temperature range.



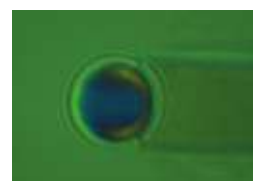
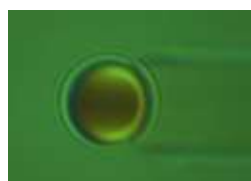
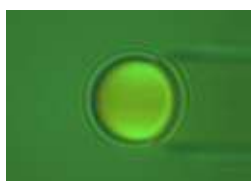
## EHL - Ultra Thin Film Measurement Module



Elastohydrodynamic Lubrication is a regime where significant elastic deformation of the surfaces takes place that alters the shape and thickness of the lubricant film in the contact.

Our fully automated EHL module allows for studying film thickness across a wide range of speeds, loads, and temperatures. In addition, high-precision interferometric optics and ease of use enable measuring the oil film thickness with nm level accuracy.

The test involves running a steel ball across coated glass disks. Real-time downforce, speed, and friction data allow for an effortless combination of film thickness and tribological information. Our software automatically calibrates the system, runs the recipes, and processes film thickness using advanced algorithms that can be traced to field pioneers.



# Precision At Best

## Superlubricity

The tribometer uses de-coupled capacitive load cells to measure friction at a COF 0.001 level, even at high down forces (1 N, 10 N, etc.). The unique design, controlled environmental conditions, and high-resolution sensors easily measure 2D materials' friction and superlubricity.

## In-situ Confocal microscopy and Raman spectroscopy

In-line confocal Raman spectroscopy can be added to the tribometer. The confocal mode allows high-resolution imaging of the chemical property of locations within the wear mark. The XY stage allows stitching of the Raman maps across the entire wear track. The test can be performed in air, inert gas, or a vacuum chamber.

## Touch Screen, Display, and Glass

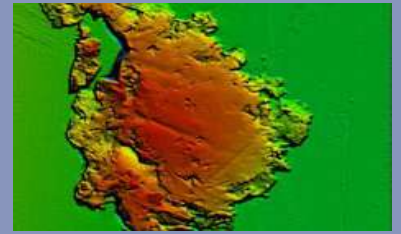
The tribometer uses a 6D sensor and closed-loop XY stage to create customized motions, such as butterfly, circular, and zig-zag, that simulate any profile. The test accurately simulates finger motion on touch screens and quantifies perception.

## Contact Area vs. Force

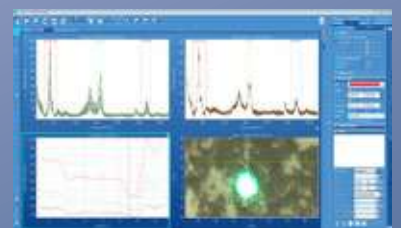
The surface adhesion module can be added to the tribometer to analyze real-time contact area vs. force using an imaging system that is placed under the sample. This calculates surface adhesion and also observes the interface in real-time.



Ball on disk setup for nanotribology agglomerated particles on a coating.



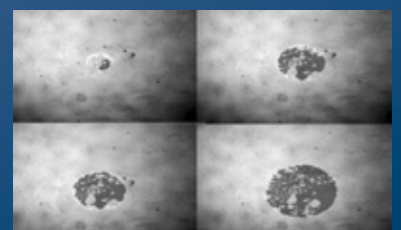
Vacuum chamber with in-line Raman and profiler Raman spectrometer data on a wear mark.



Scratch indenter in contact with a screen

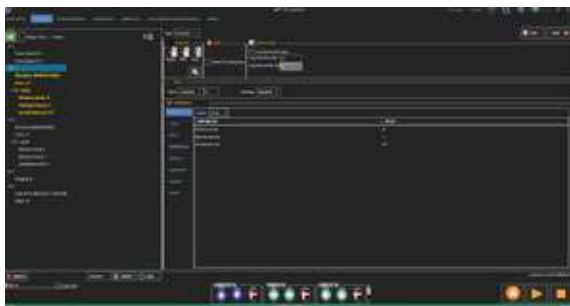


A test showing hydrogel against a coated glass slide. Real-time contact area analysis vs. force.



# Software

The tester comes with powerful operation, statistical, and image analysis software. All software is Windows-based and is very easy to learn and operate. The software runs the tool in advanced mode for experienced users or simple mode for new users or operators. The data can be saved in a proprietary format or ASCII format.



## Recipe Driven

Each test can be controlled by a series of command blocks forming a protocol or "recipe." The recipes are saved and easily drive the instrument.

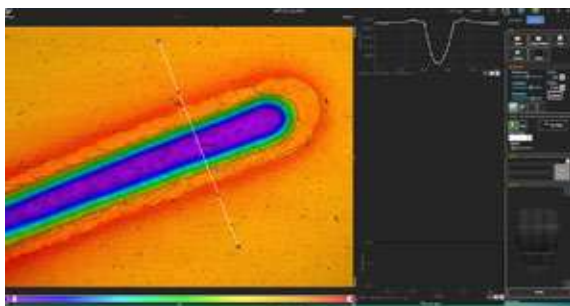


## Abort Criteria

The user's defined logical criteria can stop at each test step. All the recorded signals allowed stop conditions.

## Automatic Recognition

The testing system recognizes load cells and automatically drives the associated calibration files.



## Easy to learn

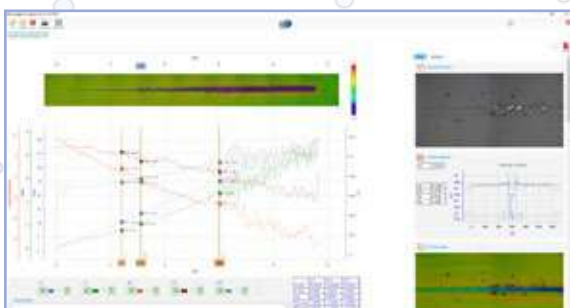
The software is intuitive and easy to learn.

## Test Library

The instrument comes with a series of test protocols that match the user's applications and can easily be modified.

## Unlimited testing conditions

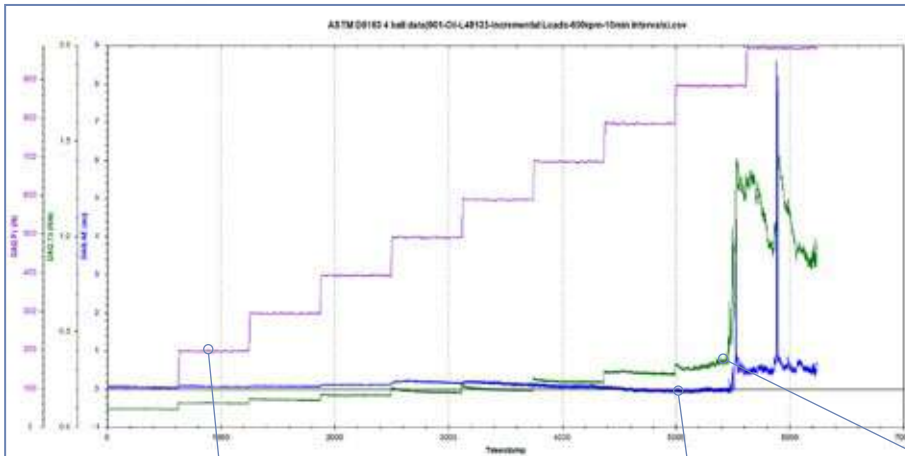
The software allows the user to control all motions in XY and Z during any test. Therefore, programming complex movements like spiral or rotary tests with lateral vibration is easy.





# Automatic Image, Tribology Data Correlation

## 4-Ball data



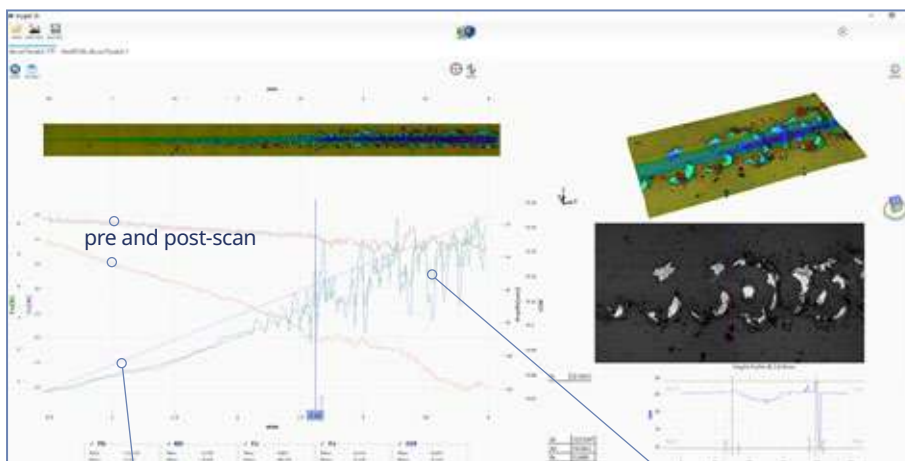
Torque, friction, acoustic emission, and applied force are recorded and displayed in real-time. As the failure starts to happen, the torque and AE jump.

Downforce is recorded and displayed in real-time. This test shows a step increase in downforce. The force can be controlled in constant, linear, or user-defined modes.

The acoustic emission signal indicates the initiation of failure at the test interface. The sensor uniquely filters out the motor and ambient noise and shows the interfacial acoustic signal.

The torque sensor measures the friction properties and when the change is happening. Here, the lubricant film is completely broken, and the contact oil/grease no longer exists.

## Scratch/Tribo data



The applied load is recorded and displayed in real-time. This test shows a progressive loading. The loading can be controlled in constant, linear, or user-defined modes.

The tangential force is recorded and used to define the friction coefficient precisely. When we start to see a variation, the tip is in contact with the substrate, and the COF changes.

All the data can be synchronized with the acquired images. Friction, wear, and depth data are associated with the cursor directly on the image. Roughness and wear volume are associated with the track.

The MFT-5000 with the scratch module allows for the pre-scan and post-scan modes to characterize the absolute penetration during the test and elastic recovery after the scratch.

# Wide Applications

The versatility of the tester allows the tribometer to play an essential role in several applications. It can be used for thin or thick films, lubricants, materials, soft materials, hydrogels, biomaterials, smooth or rough surfaces, flat or rough surfaces, transparent or opaque surfaces, nano or macro scale, coating or bulk materials, and more.

## High Temperature

- Hot Hardness Tester (up to 1200°C)
- High Temperature Tribology (up to 1200°C)

## Lubricants, Grease

- Block on Ring, Timken OK
- 4-Ball EP and Wear
- HFRR
- Twist Compression
- SRV
- Tapping Torque, Cutting, Drilling
- Piston Ring Cylinder Liner
- Mini traction machine

## Mechanical

- Hot Hardness
- 3, 4 Point Bending
- Adhesion

## Cryogenic

- Low Temperature Tribology (from -120°C)

## Corrosion Testing

- Tribo Corrosion
- Salt Spray

## High Pressure

- Compressor

## Friction Wear

- Rotary Pin on Disk Tribometer, Ball on Disk
- Reciprocating
- Brake Materials Tribology
- Fretting
- Low Friction, Nano Tribology
- Biotribology

## Coatings

- Scratch Test, Adhesion, Hardness
- 2D Materials, Low Friction Coatings
- Fretting
- Pin on Disk, Ball on Disk
- Reciprocating
- Fracture Toughness
- High Temperature Tribology up to 1200°C
- Scratch and Mar Resistance

## Industrial

- Brake Materials Screening
- Optical Lens
- Cutting Tools, Hard Coatings
- Piston Ring Cylinder Liner
- High Pressure Chamber
- Aerospace Tribology
- Textile
- Bearings
- Additive Manufacturing



Automobile



Semiconductor



Aerospace



Optical



## Platform Specification

- Floor Standing- Micro, Macro
- Bench Top- Nano, Micro
- Data Acquisition 200 kHz

### XY Stage

- Range: 130 x 270 mm
- Motion Resolution: 0.1  $\mu$ m
- Maximum Speed: 50 mm/s

### Multiple Z Stages

- Max Speed: 10 mm/s, 500  $\mu$ m/s
- Motion Resolution: 0.25  $\mu$ m, 10 nm

### Computer Console

- Latest Windows OS
- LCD monitor

### Facilities Requirement

- Power Requirements: 110 VAC/ 240 VAC /480 VAC

### Environmental Chambers (Optional)

- -120°C up to 1200°C
- 5 to 90% RH
- Vacuum
- Liquid
- Inert gas
- Corrosion
- Salt Spray
- High Pressure

## Surface Inspection

### Various Imaging Modules

- White Light interferometer
- 3D Confocal Microscope
- Variable Focus
- Raman Spectrometer
- High Mag. Microscope
- Atomic Force Microscope

### Additional Sensors

- Potentiostats
- Acoustic Emission
- Electrical Resistance
- pH Probes

## Test Modules

### Various Mechanical Heads

- Tribometer
- Indentation
- Scratch
- Mechanical

### Lower Drives

All drives are in addition to drives mentioned in platform specification

### Rotary Drive

- Range 360°
- Max Speed up to 30000 RPM
- Min Speed 0.001 RPM (low speed drive)

### Fast Reciprocating Drive

- Speed up to 80 Hz
- Stroke 0.1 mm to 30 mm

### Long Stroke Fast Reciprocating

- Speed 35 Hz
- Stroke 40 mm at 40 Hz

### Fretting Drive

- Speed up to 500 Hz
- Stroke 5  $\mu$ m to 4 mm

### Block On Ring Drive

- Range 360°
- Speed up to 7000 RPM

### Mini Traction Machine

- -200 to 200% ratio
- -6 to 6 mm/s
- Up to 180°C



Hard Coating



Decorative Coatings



Materials



Biomaterials



# Rtec instruments



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