An Introduction to the UMT-TriboLab™
Your Single Tribology Lab

May 7, 2015

Atomic Force Microscopy
3D Optical Microscopy
Tribology
Automated AFM
Stylus Profilometry
Mechanical Testing, Nanoindentation

Innovation with Integrity
Agenda

- Tribology Basics
- What is the UMT TriboLab™
- What can the TriboLab be used for: Applications
- TriboLAB™ Product Information
Tribology Basics
Mechanical design has many facets... One of those is the need to know how interacting materials and lubricants behave under various Motions, Speeds, Loads, and Environments

The result... Tribology. The study of friction, wear, and lubrication; the science of interacting surfaces in relative motion

Great Reference: Tribology 101: The Basics of Tribology, by Dr. Steve Shaffer

https://www.bruker.com/service/education-training/webinars/tribology.html

Goal is to mimic real world environments, however, we many times settle for characterization standards

<table>
<thead>
<tr>
<th>Typical Tribology Tests</th>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball/Pin-on-Disk</td>
<td><img src="image1" alt="Model" /></td>
<td>Sliding Wear and Friction Behavior Between a Static Pin (Area Contact) or Ball (Point Contact) and a Rotating Surface</td>
</tr>
<tr>
<td>Ball/Pin-on-Plate</td>
<td><img src="image2" alt="Model" /></td>
<td>Sliding Friction and Wear Behavior Between a Static Pin (Area Contact) or Ball (Point Contact) and a Linear Displacing Surface</td>
</tr>
<tr>
<td>4-Ball</td>
<td><img src="image3" alt="Model" /></td>
<td>High-Pressure Lubricant/Grease Characterization Test</td>
</tr>
<tr>
<td>Block-on-Ring</td>
<td><img src="image4" alt="Model" /></td>
<td>Sliding Wear and Friction Behavior Between a Block and a Radial Ring (Line Contact)</td>
</tr>
<tr>
<td>Disk/Ring-on-Disk</td>
<td><img src="image5" alt="Model" /></td>
<td>Sliding and/or Rolling Wear and Friction Behavior Between Two Disk or Ring Surfaces (Area Contact) Sharing the Same Axis</td>
</tr>
</tbody>
</table>
• Friction and/or Wear
  • Is generated with:
    • any motion
    • any load
    • any environment (liquid, heat, cold, humid, dry)

• Components can be exposed to changing conditions, and variances can be large between macro and micro levels.

• Will at times involve many measurements in order to characterize material behavior – COF, Wear, Acoustic Emission (AE), Electrical Contact Resistance (ECR), etc.

• We want you to have the flexibility to easily adapt your lab to your needs and objectives...
What is the UMT-TriboLAB™
UMT TriboLAB
Universal Mechanical Test System

Multiple Test Capabilities

One Platform

- Pin/ball-on-Disk
- Pin/Ball-on-Plate
- Linear Wear
  - 4-Ball
- Block-on-Ring
- Disk/Ring-on-Disk
- And More...

Multiple tests without purchasing multiple test platforms

Increased utilization, reduced training needs and fewer errors
UMT TriboLAB
Universal Mechanical Test System

The **MOST VERSATILE**
Mechanical and Tribology
Testing System!!

Now, **USER FRIENDLY**
AND EASIER TO USE!!
Easy to Install Interchangeable Lower Drives with TriboID™ Smart Chips

Tool-less Lock-Down


Self-centering, blind-mate drive coupling
Modular Environmental Chambers Available

- Standard Drive ROT-DRIVE
- Liquid Container Standard w/ ROT-DRIVE
- 400°C Chamber ROT-400
- Humidity Chamber ROT-HUMID
TriboLAB™ Product Selector Guide
Main Unit and Lower Drive Accessories
# TriboLab Base & Control Unit

## UMT-TriboLAB BASE SYSTEM Technical Specifications

**Base System**
- High density cast iron vibration dampened frame
- Integrated high speed/high torque tribology drive motor complete with motor driver and quick connect coupling
  - Max. Torque: >5Nm @100rpm, 2.5Nm @ 5,000rpm
- 8-Channel (expandable to 16-Channels), 16-bit DAS up to 200 kHz
- Load/Friction 2-Channel Signal Conditioner
- Up to 6 additional Input Channels for Advanced Sensors
- Tool-less lower drive retaining system
- TriboID™ system auto-configures software options based on hardware components
- iFast-Exchange upper assembly kit

"**X**" Lateral Positioning Motorized System with Position Encoder
- Max. Lateral Travel: 120 mm. Encoder Resolution: 0.25 micron. Speed: 0.002 to 10 mm/s.

"**Z**" Upper Specimen Motorized Vertical Positioning System with Position Encoder
- Servo-controlled precision loading, fully programmable (ramp, step, fixed)
  - Max Vertical Travel: 150 mm.; Speed: 0.002 to 10mm/s; Encoder Resolution: 0.5 micron; Accuracy: 5 microns
  - Max load 2,000N

**Built-in Temperature Controller With Front Display**
- Resolution 0.1 °C

**Software**
- Bruker UMT-TriboLab Operating Software, TriboScript™ and Data Analysis Software

**Electrical and other specifications**
- System power 220V (single phase), 15A - (transformer req'd for regions with 110V mains power)
- 15.5" (W) x 24" (D) x 30.5" (H)
- 290 lbs (132 kg)

## UMT-TriboLAB CONTROL UNIT Technical Specifications

23" Touch Screen All-In-One PC
- Windows 7 64-bit operating system
- 8GB SDRAM, 500GB HDD (or greater)
- Wireless keyboard & mouse
TriboLab Lower Drive Types
Linear & Reciprocating Drives

**Linear Drive Technical Specifications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Lateral Travel</td>
<td>120 mm</td>
</tr>
<tr>
<td>Resolution</td>
<td>1 µm</td>
</tr>
<tr>
<td>Speed</td>
<td>0.001 to 10 mm/s</td>
</tr>
<tr>
<td>Max. Load</td>
<td>2,000 N</td>
</tr>
<tr>
<td>Max. Lateral Force</td>
<td>450 N</td>
</tr>
</tbody>
</table>

**Reciprocating Drive Technical Specifications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Stroke</td>
<td>25 mm</td>
</tr>
<tr>
<td>Min. Stroke</td>
<td>0.1 mm</td>
</tr>
<tr>
<td>Position resolution</td>
<td>1 µm</td>
</tr>
<tr>
<td>Speed</td>
<td>0.1 to 60 Hz</td>
</tr>
<tr>
<td>Max. Load</td>
<td>2,000 N</td>
</tr>
<tr>
<td>Stroke vs Frequency</td>
<td>60 Hz @ 2 mm</td>
</tr>
<tr>
<td></td>
<td>20 Hz @ 25 mm</td>
</tr>
</tbody>
</table>
# TriboLab Lower Drive Types

## Rotary & Block-on-Ring Drives

### Rotary Drive Technical Specifications

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>0.1 to 5,000 rpm</td>
</tr>
<tr>
<td><strong>Max. Torque</strong></td>
<td>&gt;5 Nm @ 100 rpm, 2.5 Nm @ 5,000 rpm</td>
</tr>
<tr>
<td><strong>Max. Load</strong></td>
<td>2,000 N</td>
</tr>
</tbody>
</table>

### Block-on-Ring Drive Technical Specifications

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>0.1 to 5,000 rpm</td>
</tr>
<tr>
<td><strong>Max. Torque</strong></td>
<td>&gt;5 Nm @ 100 rpm, 2.5 Nm @ 5,000 rpm</td>
</tr>
<tr>
<td><strong>Max. Load</strong></td>
<td>2,000 N</td>
</tr>
</tbody>
</table>
Load Control & Positioning System

Load Control & Vertical Positioning System

- Precise, servo controlled motion
- Wide Range of Proprietary Force and Torque Sensors that can be exchanged in less than 10 seconds
- Closed Loop Load control with force sensor and motion control to apply and maintain various user defined loading profiles on flat and irregular surfaces

Lateral Positioning System

- Motorized lateral positioning system allows the user to perform tests at multiple sample locations automatically
“At the Advanced Research Center for Nanolithography, we have been using a Bruker UMT-1 force microscope, equipped with Bruker’s new force sensors (10mN, Gold Series) since the summer of 2014. In our experiments, this microscope is used for sensitive measurements of friction forces down to the micronewton regime. We are experienced in developing our own microscopes and we had been planning to construct one especially for this force range.

For us, Bruker’s microscope and new sensors have come precisely on time. We are impressed by the sensitivity and robustness of these sensors, which enable us to perform novel friction experiments in a largely unexplored force regime.”

Prof.dr. Joost W.M. Frenken
Director Advanced Research Center for Nanolithography (ARCNL)
Huygens-Kamerlingh Onnes Laboratory, Leiden University, The Netherlands

<table>
<thead>
<tr>
<th>MODEL/SPECS</th>
<th>Low</th>
<th>High</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVL-G</td>
<td>1 mN</td>
<td>100 mN</td>
<td>10 µN</td>
</tr>
<tr>
<td>FL-G</td>
<td>5 mN</td>
<td>500 mN</td>
<td>50 µN</td>
</tr>
<tr>
<td>DFM-0.5-G</td>
<td>0.05 N</td>
<td>5 N</td>
<td>0.25 mN</td>
</tr>
<tr>
<td>DFM-1-G</td>
<td>0.1 N</td>
<td>10 N</td>
<td>0.5 mN</td>
</tr>
<tr>
<td>DFM-2-G</td>
<td>0.2 N</td>
<td>20 N</td>
<td>1 mN</td>
</tr>
<tr>
<td>DFH-5-G</td>
<td>0.5 N</td>
<td>50 N</td>
<td>2.5 mN</td>
</tr>
<tr>
<td>DFH-10-G</td>
<td>1 N</td>
<td>100 N</td>
<td>5 mN</td>
</tr>
<tr>
<td>DFH-20-G</td>
<td>2 N</td>
<td>200 N</td>
<td>10 mN</td>
</tr>
<tr>
<td>DFH-50-G</td>
<td>5 N</td>
<td>500 N</td>
<td>25 mN</td>
</tr>
<tr>
<td>DFH-100-G</td>
<td>10 N</td>
<td>1,000 N</td>
<td>50 mN</td>
</tr>
<tr>
<td>DFH-200-G</td>
<td>20 N</td>
<td>2,000 N</td>
<td>100 mN</td>
</tr>
</tbody>
</table>
**TriboLAB™ Upper Assembly**

- A full catalog of upper specimen holders for all contact types and contact pressures

<table>
<thead>
<tr>
<th>Ball Sizes Included</th>
<th>Kit</th>
<th>(Millimeter)</th>
<th>(Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL</td>
<td>1.0</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>1/16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>1/8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>DFM</td>
<td>5.0</td>
<td>3/16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.0</td>
<td>1/4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.0</td>
<td>5/16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>3/8</td>
<td></td>
</tr>
<tr>
<td>DFH</td>
<td>6.0</td>
<td>1/4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.0</td>
<td>5/16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>3/8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.0</td>
<td>1/2</td>
<td></td>
</tr>
</tbody>
</table>
Easy to Use, Quick to Setup
Wide Range of Advanced Sensors for Environmental and Test Characterization

- Advanced sensors can be added to the TriboLab™ at any time during the life of the system.
- Advanced Sensors are user installable, and easy to configure to add increased test characterization and accuracy the TriboLab™ system.

**Advanced Sensors available include:**
- Acoustic Emission
- Electrical Contact Resistance
- Temperature
- Humidity
- Micro-Wear, Deformation

Acoustic Emission Sensor Used to Detect Coating Delamination
UMT Software
Flexible, Intuitive, Easy to Use

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NEW TriboScript™
Test Programming GUI

Display Modes
- Display Modes allow the user to define the accessibility to software capability and recipe creation
- Operator Mode for Quality Control and Manufacturing level simplicity
- Expert mode for Advanced user control and recipe creation

Recipe Window
- In the “Operator Mode” the Recipe Window allows you to manage a Recipe and its critical parameters
- By highlighting the underlying features of the Block or Test Program the user can observe or define the critical parameters for that Test

Block Library
- Blocks are predefined test programs that perform a unique test routine
- The Block Library displays these predefined blocks to allow the user to create a test recipe from these predefined blocks
- Create a Recipe by moving one or more Blocks from the library to the Recipe Window
**TriboScript**

Here is How it Works

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**Step 1: Block Selection**

- Drag a “Block” from the “Block Library” (1) into the Recipe Window (2)

**Step 2: Observing Program Sequence**

- Click on the “Block” (2) in order to “Unhide” the Sequences or Partitions (3) inside.
- Click on the Partition (3) or Sequence to display the “Properties” (4) within that program.

**Step 3: Defining the Block Properties**

- Once the “Properties” are displayed, the User can select and change the Properties values or that current Test Program
- In Operator Mode, the User will not have access to the full “Property List”, rather only critical properties.
- No changes to the process of the recipe can be made in Operator Mode

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In Expert Mode, users have full access to the software functionality, recipe and even block creation.

**Recipe Window (Expert Mode)**
- In Expert Mode, the user can create custom blocks, tests, or edit and change existing test blocks within the Recipe Window.

**Component List (Expert Mode Only)**
- Component List allows you to add Steps, Sequences, &/or Partitions to your Test to define.
- Sequences are a collection of Steps, or Test “Protocol” that will be followed sequentially.
- Partitions define the critical parameters of a block that the user will have access to in Operator Mode.

**Partition Window**
- The Partition Window will allow users the ability to define the visible parameters that can be edited in a Block in Operator Mode.

**Property List**
- The Property List contain test “Properties” or Parameters.
- The user can add Properties to a Step or Partition by dragging the desired property from the list and connecting it to the desired Partition or Sequence.
Easy to Install and Offers User Customization

- Installs with just **one USB Cable** between System and PC
- Offered with **All-in-One Dell w/ wireless Keyboard, & Mouse**
- Basic Requirements: Windows 7, 64-bit, USB 3.0, 4GB SDRAM, and i5 or better
- Additional USB Port (A) and Expanded BNC Connectivity (B) for Custom Analog Sensors
# TriboLab Product Unique Features and Benefits

<table>
<thead>
<tr>
<th>Unique Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Platform</strong></td>
<td></td>
</tr>
<tr>
<td>Universal Test Platform - rotary, reciprocating, block-on-ring and linear</td>
<td>More functionality on single platform - lower cost - less to learn</td>
</tr>
<tr>
<td>Tool-less changeover of drives</td>
<td>Speed of changeover - fewer mistakes - less potential to damage items</td>
</tr>
<tr>
<td>Auto Component ID - System recognizes which hardware is installed</td>
<td>Speed of changeover - fewer mistakes - less potential to damage items</td>
</tr>
<tr>
<td>Wide range of speed, load, torque, etc.</td>
<td>More functionality on single platform - lower cost - less to learn</td>
</tr>
<tr>
<td>High Z axis load - 2kN</td>
<td>High load testing capable</td>
</tr>
<tr>
<td>Closed Loop Servo controlled Z-axis</td>
<td>Complex motions - constant force - various loading profiles available</td>
</tr>
<tr>
<td>In-situ wear-depth monitoring</td>
<td>Increased measurement accuracy</td>
</tr>
<tr>
<td>Runs on any PC</td>
<td>Flexibility - Compliance with IT policies &amp; brand preference - lower cost</td>
</tr>
<tr>
<td>High torque quick connect couplers</td>
<td>Reliable, long-life - speed of changeover</td>
</tr>
<tr>
<td>Blind mate electrical connections</td>
<td>Speed of changeover - no cables - fewer mistakes - less potential to damage items</td>
</tr>
<tr>
<td>Removable, quick connect Environmental Chambers</td>
<td>Lower cost of ownership - simpler to configure - upgradable at any time</td>
</tr>
<tr>
<td>Single USB 3.0 connection to standard PC</td>
<td>Less cabling = tidier work area - fewer service issues - more flexibility</td>
</tr>
<tr>
<td>High-end optical microscope with three objectives and high-res digital camera</td>
<td>Better performance - clearer images - better reporting</td>
</tr>
<tr>
<td>Automatic overload protection when force sensor reaches full scale</td>
<td>Safety - lower potential for damage to system</td>
</tr>
<tr>
<td>Universal ball holder kits for each force sensor</td>
<td>Easier - simpler to configure initial purchase</td>
</tr>
<tr>
<td>USB connection on main unit for custom integration</td>
<td>Can use for webcam or imaging</td>
</tr>
<tr>
<td>BNC connections on main unit</td>
<td>Custom analog sensor integration for increased measurement capability</td>
</tr>
<tr>
<td>Fast exchange upper assembly</td>
<td>Speed of changeover - tool-less assembly - Easy to use</td>
</tr>
<tr>
<td>Expandable 16-channel plug-and-play analog sensors</td>
<td>Easy to install - can be added at any time</td>
</tr>
<tr>
<td>High density cast iron vibration dampened frame</td>
<td>Reliability - noise reduction - measurement accuracy</td>
</tr>
<tr>
<td>Built-in, software integrated temperature controller with front display</td>
<td>Easier to use - better reporting - optional environmental chambers upgradable at any time</td>
</tr>
<tr>
<td><strong>Software</strong></td>
<td></td>
</tr>
<tr>
<td>Standardized Test Library</td>
<td>Faster, simpler and better compliance to standard</td>
</tr>
<tr>
<td>Icon based scripting</td>
<td>Faster, simpler and easier to train users (and less potential to forget)</td>
</tr>
<tr>
<td>Multiple software operating modes - Basic, Expert</td>
<td>Quality control and manufacturing simplicity and full flexibility for complex programming</td>
</tr>
<tr>
<td>Built-in Calibration</td>
<td>Faster, simpler and easier</td>
</tr>
<tr>
<td>If/then programming functionality</td>
<td>Flexibility and efficiency for monitoring test behavior</td>
</tr>
<tr>
<td>Software overload protection</td>
<td>Safety - lower potential for damage to system</td>
</tr>
<tr>
<td>Menu's optimized by TriboID</td>
<td>Less potential for errors, crashes, etc.</td>
</tr>
</tbody>
</table>

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UMT TriboLab

The World’s Most Versatile Tribo Tool

The Benchmark for Tribology Testing

• Versatile
  o Multiple test modes and Environments can be configured in minutes to simulate a wide range of Tribology and Mechanical testing in real-world conditions.

• Easy to Use
  o Tool-less drive installation, modular environmental chambers, and standard fast exchange upper assembly allows users to increase productivity by eliminating tedious test setups.
  o TriboID™ smart drives eliminate user interfacing to setup and configure hardware immediately upon installation.
  o The new TriboScript™ block modeling interface allows users an easy and visual tool to program everything from the most basic to complex automated test programs.

• Better Performance
  o Speeds from 0.1 to 5,000 rpm on rotary drives and 0.1 to 60 Hz performance on our reciprocating drive allow users to cover a wide range of tests including numerous ASTM standards.
  o High torque lower drive (5 Nm) will allow users more performance capability for testing with high friction materials.
  o Significantly reduced noise offered in the gold series force sensors will allow for more accuracy during low friction testing.
What can the TriboLab be used for: Applications
Applications
Wear, Material Characterization

Block on Ring (ASTM G77)

Main Elements:
- UMT-TriboLab
- Friction/Load Sensor
- Block-on-Ring Drive
- Optional Sensors
  - Acoustic Emission
  - Temperature measurement

Benefits of the UMT:
- Platform can be reconfigured from rotary or linear testing in seconds

Possible Tests:
- Surface Coatings (DLC, etc.)
- Heat treatment effectiveness
- Lubricant comparison
- Base material comparison

Representative Data
Applications
Chains and Timing Belts

Benefits of the UMT:

- A single tool can be used for both hardness and wear testing.
- System is upgradeable through lifetime to accommodate future needs for tribology and mechanical testing.

Possible Tests:
- Wear Test
- Hardness

Cylinder-on-flat wear test
Hardness test

Main Elements:
- UMT-TriboLab
- Friction/Load Sensor
- Linear Drive (Hardness)
- Reciprocating Drive (Wear)
- Indenter
- Optional Sensors
  - Humidity & Temp. Measurement

Representative Data
Applications
Polymers

Possible Tests:
• Deformability
• Creep

Benefits of the UMT:
• Easy test exchange and software programming allow user to turn a wear generating platform to a tensile property measurement system

Tensile properties of elastomers (D412)
Rubber Property—International Hardness (D1415)
Durometer hardness of rubber (D2240)

Main Elements:
• UMT-TriboLab
• Friction/Load Sensor
• Tension Grips
• Linear Drive
• Optional Sensors
  • Temperature & Humidity

Representative Data
Applications
Coatings

Benefits of the UMT:
• Comprehensive evaluation of coatings in a single tool
• Switch between scratch, wear, and indentation in minutes

Possible Tests:
• Scratch
• Wear durability
• Fracture Toughness
• Delamination
• Friction
• Indentation test
• Bend test

Main Elements:
• UMT-TriboLab
• Friction/Load Sensor
• Linear Drive
• Indenter or Scratch Tool
• Optical Microscope

G171 (03) – Scratch Hardness Test
E2546: Instrumented Indentation Test

Representative Data
Applications
Paint

Possible Tests:
• Scratch
• Wear durability
• Friction
• Indentation test
• Bend test

Benefits of the UMT:
• Pre & Post Imaging superimposed with data for added characterization capability

D-7187 Scratch Test Paint Coatings

Main Elements:
• UMT-TriboLAB
• Friction/Load Sensor
• Linear Drive
• Indenter
• Optical Microscope

Representative Data

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Applications
Piston Rings & Cylinder Liners

Possible Tests:
Friction test of Piston ring and cylinder liner materials ASTM G181-05.

The test parameters:
• Temperature 100 ± 2°C
• Loading from 20 N to 200 N with a step of 20 N with holding time in each load is 1 min
• Unloading from 200N to 20N with 20 N step and a holding time of 1 s in each load
• Stroke of 10 mm
• Frequency of 10 Hz

ASTM G181: Friction Tests of Piston Ring and Cylinder Liner

Benefits of the UMT:
• Multi-sensing, modular design makes UMT a perfect tool for such test
• Computerized servo-control allows for easy ramping up and down of load in touch of a button

Representative Data
Applications
Lubricants

ASTM:
D2266, D2509, D2625, D2670, D2714, D2981, D3233, D3704, D4172, D5001, D5183, D5620, D5706, D5707, D6078, D6079, D6425

Benefits of the UMT:
• Run various tests in one hardware-software platform
• Controlled temperature
• Computer controlled load, speed, etc.

Possible Tests:
• Strubeck Test
• Block-on-ring
• Pin-on-disk
• Disk-on-disk
• Pin-on-vee
• 4-ball
• Twist-compression

Representative Data
New Applications

- **High Torque**
  - 5 Nm @ 100 rpm

- **Rotary cyclic testing**

- **Reciprocating testing**
  - 20Hz @ 25mm, 60Hz @ 2mm

- **Stribeck Test**
  - 7 order of magnitude capability, up to 2kN

- **Synchronized Motor Control**
  - Figure 8
  - Clover
  - Zig-zag
  - Spiral Testing

- **ASTM Standards**
  - 4-Ball ASTM D2783 (up to 2kN, weld force)
  - EP Test for Grease ASTM D5706 (up to 1200N, COF)
  - Wear Test ASTM D3704 (up to 1599N, COF)
  - HFRR Tests – ASTM D5707 & 5706
Product Information
TriboLab Product Information
Available on Web

• Product Brochure

• Application/Tech Notes
  • Glass Defects
  • High Performance Sensors
  • Hot Hardness
  • Hot Rolling
  • 3-Point Bending
  • Striebeck Curve
  www.bruker.com/tribology


• Open Resources:
  • Previously Recorded Webinars
  • Related Articles
  • Tribology 101 Webinars
  • Upcoming Events
  https://www.bruker.com/service/education-training/webinars/tribology.html
Worldwide Bruker Sales & Service Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Region</th>
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</thead>
<tbody>
<tr>
<td>Campbell, CA</td>
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<tr>
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<td>Billerica</td>
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<td>Singapore</td>
<td>APAC</td>
</tr>
</tbody>
</table>

- **Bruker Sales & Service Offices**
- **Reps & Distributors**
The Benchmark for Tribology Testing

• Versatile
  o Multiple test modes and Environments can be configured in minutes to simulate a wide range of Tribology and Mechanical testing in real-world conditions.

• Easy to Use
  o Tool-less drive installation, modular environmental chambers, and standard fast exchange upper assembly allows users to increase productivity by eliminating tedious test setups.
  o TriboID™ smart drives eliminate user interfacing to setup and configure hardware immediately upon installation.
  o The new TriboScript™ block modeling interface allows users an easy and visual tool to program everything from the most basic to complex automated test programs.

• Better Performance
  o Speeds from 0.1 to 5,000 rpm on rotary drives and 0.1 to 60 Hz performance on our reciprocating drive allow users to cover a wide range of tests including numerous ASTM standards.
  o High torque lower drive (5 Nm) will allow users more performance capability for testing with high friction materials.
  o Significantly reduced noise offered in the gold series force sensors will allow for more accuracy during low friction testing.
Web Presence

- Bruker Home Page
  www.bruker.com

- TMT Home Page
  www.bruker.com/tribology

- UMT-TriboLab™ Product Main Page

- TriboLab and Tribology Open Resource
  https://www.bruker.com/service/education-training/webinars/tribology.html
Background

- 1993 - Formed as CETR manufacturing purpose-built HDD testers
- 2000 - First UMT platform launched
- 2011 – CETR joined Bruker

- Bruker – Analytical Instrumentation
  Supplier for over 50 years
- 6,000+ Employees in over 90 countries
- Nano –to- Macro
- Mass spectrometers, Optical tools, NMR, etc.

- Largest producer of tribology test equipment
- Manufacturing in Arizona and R&D in California, USA