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Four Ball Wear and EP



K93100 Four Ball Tester

Tribology (Friction and Wear) Testing of Lubricants Friction and Wear Test Equipment

Koehler Instrument Company is pleased to offer advanced equipment for a variety of friction and wear tests. Several of the standard instruments that we offer are listed here. Please contact us to discuss your requirements for these as well as custom-designed units for tribology analysis methods. Our applications personnel will consult with you on your requirements and work with our design staff to provide solutions for your tribology testing needs.

Test Method

Determines the Wear Preventative (WP) and Extreme Pressure (EP) characteristics of lubricating oils and greases in sliding steel-on-steel applications. The test consists of rotating a steel ball under load against three stationary steel balls coated with lubricant. Measurements are taken at the rotating speeds, temperatures, and duration as specified by published standards. The load-wear index can be calculated from the weld point in EP tests, and lubricant comparisons can be made based upon scar diameters incurred from wear tests.

Four Ball Wear and EP Tester

- Conforms to ASTM D2266, D2596, IP 239, and related specifications
- Performs Wear Preventative (WP) and Extreme Pressure (EP) tests
- Displays and records normal load, frictional torque, time, and temperature
- Test speeds and temperatures are electronically controlled
- Data Acquisition Software and Card are included
- Optional CCD Camera is available for wear scar imaging
- Custom configurations are available

Four Ball Tester performs both Wear Preventative (WP) and Extreme Pressure (EP) analyses for measuring the wear and frictional properties of lubricants under sliding steel-on-steel test conditions. Tests are performed in accordance to the latest ASTM and IP published methods. Normal load on the ball assembly and frictional torque are measured through load cells. Wear scars on the steel balls are measured with a graduated-scale microscope and can be recorded with an optional CCD camera. Data is processed and stored utilizing TriboDATA, an advanced data acquisition and processing software package. Test results can be plotted and compared, as well as exported to other programs. An optional peristaltic pump, pitting detector, and ball cup with ball race are available as required for performing Fatigue Tests according to the IP 300 test method.

Specifications

Conforms to the specifications of:

ASTM D2266, D2596, D2783, D2793, D4172, D5183; IP 239, IP 300

Electrical Requirements:

220V, 60Hz, 3 phase

440V, 50Hz, 3 phase

Drive Motor: 1.5 kW

Test Speeds: 1200, 1440, 1760 rpm

Optional Test Speeds (min/max): 1000/3000, 300/3000, or 2000/10000 rpm

Maximum Axial Load: 10000 N at 3000 rpm or 12000 N at 1800 rpm

Test Duration (min/max): 1/9999 min

Test Ball diameter: 12.7 mm

Shipping Information

Shipping Weight: 1360 lbs (620 kg)

Dimensions: 45 Cu. ft.

Ordering Information

Catalog No.		Order Qty
K93100	Four Ball Tester, 220V 60 Hz	1
K93190	Four Ball Tester, 440V 50 Hz	

Included Accessories

Set of Weights	Graduated-Scale Microscope
Ball Chucks (4)	Temperature Sensor, Spare
Ball Pot	Heater Cartridges, Spare (2)
Ball Chuck Remover	Fuses, Spare (2)
Test Balls (1000)	Electrical Controller
Ball Rack	Connecting Cables (2)
Ball Clamp Ring (2)	Computer Acquisition Data Card
Ball Holder Base Disc	TriboDATA Software
Set of Hand Tools	Calibration and Test Reports
Torque Wrench	

Accessories

Catalog No.	
K93110	CCD Camera for Wear Scar Imaging
K93130	Pitting Detector
K93131	Peristaltic Pump
K93132	Running Ball Cup w/ Ball Race

Tribology Data Acquisition System

TriboDATA Data Acquisition System

- Powerful data acquisition system provides analog to digital conversion and data analysis of test results for many tribology instruments available from Koehler as well as **other tribology instrument manufacturers**
- Real-time display of critical test parameters such as normal load, friction force, temperature, and time

The Koehler TriboDATA System is designed to acquire and process analog data from the various tribology test instrumentation offered from Koehler as well as from **other tribology instrument manufacturers**. The analog-to-digital converter card is comprised of four analog inputs, and the test data is recorded and displayed in real-time. Up to four graphs can be displayed simultaneously. The data can be stored to disk for future reference or exported in an ASCII text format to other software packages. Critical test parameters are also saved with the data. With the TriboDATA hardware and software package, data acquisition of crucial test parameters such as normal load, friction load, temperature, and time can be seamlessly performed to ensure that your test results are consistent and repeatable within prescribed test conditions. As an option, a CCD camera package is available to capture wear scar images and store them on a PC for analysis.

Computer Requirements

Processor: Pentium or higher
 Processor Speed: 100 MHz or higher
 Operating System: Windows® 95/98/NT
 Memory (RAM): 16 Mb
 Required Disk Space: 10 Mb
 One Free Expansion ISA Slot

Included Accessories

Software on CD
 Acquisition Data Card
 Connection Cable
 Instruction Manual



K93900 TriboDATA Data Acquisition System

Ordering Information

Catalog No.		Order Qty
K93900	TriboDATA Data Acquisition System	1

Friction

Friction Tester

- Requires only a few drops of fluid sample or a small specimen size to test
- Measures frictional force with a piezoelectric force transducer
- Performs friction tests on a variety of lubricants, greases, cutting fluids, metals, composites, ceramics, polymers, and coatings
- Electronic control of stroke length, frequency, duration, and temperature
- TriboData Acquisition Software included to record and graph test results
- Wear characteristics can also be evaluated using a profilometer
- HFRR configuration that correlates to ASTM D6079 and other custom configurations are available

Evaluates the dynamic friction at reciprocatory contacts of dry or lubricated materials as the function of normal load, velocity, frequency, temperature, and time. A wide variety of materials including fluid lubricants, greases, cutting fluids, metals, composites, ceramics, polymers, and coatings can be tested. The test is conducted by pressing the test specimen against a ball, pin, or cylinder undergoing reciprocating linear motion, producing a sinusoidal velocity profile which allows for the monitoring of static and dynamic friction force over a wide range of linear sliding speeds. The test load, stroke, frequency, and temperature can be adjusted to simulate different conditions. The frictional force developed at the contact interface is measured by a piezoelectric force transducer equipped with a charge amplifier. The test results can be displayed and recorded on a storage oscilloscope or acquired on a PC with the TriboDATA acquisition software for evaluation. Wear analysis of the sample can also be evaluated with a profilometer.

Specifications

Normal Load: 5-50N
 Frequency: 1-50Hz
 Stroke: 0-10mm (1-10Hz)
 0-5mm (10 - 20Hz)
 0-2mm (20 - 50Hz)
 Temperature Range: ambient to 100°C
 Test Duration: 0.1-999 min

Shipping Information

Shipping Weight: 264 lbs (120 kg)
 Dimensions: 25 Cu. ft.

Included Accessories

Set of Weights
 Test Specimen Holders
 Ball Sample
 Pin Sample
 Set of Hand Tools
 Electronic Controller
 Fuses
 Connecting and Signal Cables
 Data Acquisition Card
 TriboDATA Software Package
 Calibration and Test Reports

Ordering Information

Catalog No.		Order Qty
K93400	Friction Tester, 115V 60 Hz	1
K93490	Friction Tester, 230V 50 Hz	

Accessories

K93420	Digital Storage Oscilloscope (for displaying frictional force wave form)	1
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Pin-On-Disc



K93500 Pin-On-Disc Tester

Pin-On-Disc Tester

- Conforms to ASTM G99 standard test method
- Analyzes wear and friction characteristics of sliding contacts (dry or lubricated conditions)
- Tests can be performed on a variety of materials: metals, polymers, composites, ceramics, lubricants, cutting fluids, abrasive slurries, coatings, and heat-treated samples
- TriboDATA software package varies and records pin pressure, pin temperature, sliding speed, and lubrication parameters
- Custom configurations available

The Pin-On-Disc machine is a versatile unit designed to evaluate the wear and friction characteristics a variety of materials exposed to sliding contacts in dry or lubricated environments. The sliding friction test occurs between a stationary pin stylus and a rotating disk. Normal load, rotational speed, and wear track diameter can be varied. Electronic sensors monitor wear and the tangential force of friction as a function of load, speed, lubrication, or environmental condition. These parameters as well as the acoustic emissions at the contact are measured and displayed graphically utilizing the TriboDATA software package.

Specifications

Conforms to the specifications of: ASTM G99

Sliding Speed Range: 0.26-10 m/sec
 Disc Rotation Speed: 100-2000 rpm
 Maximum Normal Load: 200 N
 Frictional Force: 0-200 N
 Wear Measurement Range: 4 mm
 Pin Size: 3-12 mm diagonal/diameter
 Disc Size: 160 mm diameter x 8 mm thick
 Wear Track Diameter: 10-140 mm

Specifications for Pin-On-Disc with Environmental Chamber & Lubricant Recirculating System

Temperature: 60°C Maximum
 Discharge Rate: 0-1 L/min
 Viscosity Range: 90 SAE Maximum
 Capacity: 3L of Lubricant

Shipping Information

Shipping Weight: 440 lbs (200 kg)
 Dimensions: 18 Cu. ft.

Included Accessories

Electrical Controller Unit
 Connecting Cables
 Spare Fuses (2)
 Data Acquisition Card
 TriboDATA Software Package
 Set of Weights
 Set of Hand Tools
 Set of Pins
 Calibration and Test Reports

Ordering Information

Catalog No.		Order Qty
K93500	Pin-On-Disc Machine, 115V 60 Hz	1
K93590	Pin-On-Disc Machine, 230V 50 Hz	

Additional Configurations

K93520	Environmental Chamber
K93530	Lubricant Recirculating System
K93540	Environmental Chamber and Lubricant Recirculating System

Bearing and Grease Noise Characteristics

Grease Noise Tester

- Quantitative evaluation of grease/bearing noise characteristics
- Peak Detection Algorithm for detection of vibration peaks
- Data Acquisition Software package to monitor, record, and evaluate data
- High quality test spindle rotating at 1800 rpm
- Pneumatic loading device for the test bearing

The Grease Noise Tester evaluates the lubrication integrity of greases, providing a quantitative assessment of the noise characteristics of the grease. The use of clean lubricants is essential for obtaining long bearing life. Many factors affect the degree of cleanliness of greases during normal operation. A clean grease for initial lubrication as well as re-lubrication are essential to ensure machine longevity. In applications where bearing fatigue life is not critical such as low operating loads, a clean grease is essential to ensure low bearing noise required for many electric motor applications.

The Grease Noise Tester measures the specific disturbances caused by the rolling of particulates called vibration peaks, and features a proprietary Peak Detection Algorithm that singles out these vibration peaks from the total bearing vibration signal. The number of vibration peaks and their intensity are analyzed to determine a quantitative value for quiet running behavior of the bearing. In addition, the "grease damping ability" can be evaluated for a direct comparison between the running of a dry bearing versus the running of a lubricated bearing. Designed for proper testing while minimizing the risk of outside contamination, the semi-automated tester utilizes computer-controlled grease dosages and peak measurements on a single test bearing of special low noise quality. The operator simply mounts the test bearing and test grease syringe into the tester, programs the test parameters into the computer, and begins the test. The test results can be monitored, recorded, and evaluated with the data acquisition software package.

Specifications

Electrical Requirements:	400-460 V, 50/60 Hz, 3 Phase
Spindle System:	Hydrodynamic oil spindle
Spindle Speed:	1800 rpm
Air Supply:	Pneumatic system, min. 5.5bar dry air
Axial Loading System:	Pneumatic, 30 N maximum

Dimensions lwxh,in.(cm)
56½x25½x70 (141x65x170)
Net Weight: 1870 lbs (850kg)



K94300 Grease Noise Tester

Ordering Information

Catalog No.		Order Qty
K94300	Grease Noise Tester, 400-460V 50/60Hz, 3 Phase	1
Accessories		
K94301	Pick-Up Sensor	2
K94302	Calibration System	1
K94303	Test Bearing	20
K94304	Seal for Test Bearing	20

Corrosion Inhibition Properties of Greases



Test Method

Measures the ability of a grease to protect a bearing against corrosion in the presence of water. Two sets of grease-coated bearings per station are partially immersed in water and rotated at a speed of 80 rpm in a sequence of running and resting periods. At the end of the test, the raceways of the bearing outer rings are inspected for rust.

Emcor Grease Testing Machine

- Conforms to IP 220, DIN 51802, and related international test methods
- Evaluates the rust preventive properties of greases and oils
- Performs both standing and dynamic testing

The Emcor Grease Testing Machine evaluates the rust preventive properties of greases on bearing components, measuring the ability of a grease to protect a bearing against corrosion in the presence of water. As bearings are normally used in environments exposed to humidity and temperature variations, condensation may form on the bearing thus promoting the onset of rust. Rust is detrimental to proper bearing operation and will compromise the longevity of the bearing. A good quality grease should be designed to protect the bearing from rust and corrosion under these conditions.

The Emcor test is performed by mounting a double-row bearing per test station for up to 8 separate test stations. The test bearings are specially-treated 1306K/236725 double row self-aligning ball bearings. The bearings are washed carefully, filled with the appropriate quantity of test grease and fitted on the shaft with the help of a nylon sleeve and nut. The seals are fitted and the specified quantity of water is introduced into the housings. The bearings are placed in the housings, and the housings are closed and sealed. The test is conducted with the bearings partially immersed in water in a sequence of running and resting over a period of one week. This also determines whether the thin oil film left in the contact zone of rollers and raceways is able to protect the bearings against corrosion while the bearings are standing. At the end of the test, the raceways of the bearing outer rings are inspected for rust. The Emcor system features test method versatility, since both greases and oils can be tested as well as variations can be made with regard to the test medium (e.g., brine instead of water). The cost for running these tests are minimal. The two test bearings are the only machined parts that have to be renewed for each test, and the polyamide material for the housing is rigid and strong and rarely ever needs replacement.

Ordering Information

Catalog No.		Order Qty
K94400	Emcor Grease Testing Machine, 115V 60Hz	1
K94490	Emcor Grease Testing Machine, 230V 50Hz	
Accessories		
K94401	Test Bearing	8
K94402	Mounting Sleeve	8
K94403	Mounting Nut	8

Specifications

Conforms to the specifications of:
IP 220; ISO 11007; DIN 51802;
NFT 60-135; SIS 155130

Electrical Requirements:
115V, 60Hz, 1 phase
230V, 50Hz, 1 phase

Dimensions l x w x h, in. (cm)

48 1/2 x 15 x 11 (123 x 38 x 28)
Net Weight: 88 lbs (40kg)

Shipping Information

Shipping Weight: 121 lbs (55 kg)
Dimensions: 8 Cu. ft.

Mechanical Stability of Greases

V2F Grease Testing Machine

- Evaluates the mechanical stability of grease under strong forces

The V2F Grease Testing Machine evaluates the mechanical stability of grease in a more stringent fashion than the penetration or roll stability tests. The machine was developed after extensive measurements on railway axleboxes and constructed such that the vibrations simulate the actual accelerative forces typical for passing over rail track joints. To conduct the test, grease is applied to the two test bearings which are mounted into the axlebox. During the first testing period of 72 hours, the bearings are run at 500rpm and the 50kg hammer strikes the axlebox with a force of 12 to 15 G every second. The test rig is calibrated using a normal accelerometer technology, and the temperature of the bearings is monitored during the test. If limited leakage is observed, then a second test is run at 1000 rpm. The amount of grease leakage through the labyrinth seal is measured and evaluated at the end of the test.

Ordering Information

Catalog No.		Order Qty
K94600	V2F Grease Testing Machine, 115V 60Hz, 1 Phase	1
K94690	V2F Grease Testing Machine, 230V 50Hz, 1 Phase	
K94695	V2F Grease Testing Machine, 400V 50Hz, 3 Phase	
Accessories		
K94601	Test Bearing	2

Dimensions l x w x h, in. (cm)
78 3/4 x 39 1/2 x 63 (200 x 100 x 160)
Net Weight: 3410 lbs (1550kg)

Shipping Information
Shipping Weight: 4268 lbs (1940kg)
Dimensions: 145 Cu. ft.

Lubricating Ability of Greases

Test Method

Measures the ability of a grease to lubricate under various speeds and at various temperatures, by recording the number of running hours before the grease ceases to lubricate and causes the bearings to fail. The maximum operating speed and temperature for any particular grease can be determined.

ROF Grease Testing Machine

- Evaluates life and temperature performance limits of lubricating greases
- Weibull Analysis Software Package for easy data calculation

The ROF Grease Testing Machine determines both the useful life and high temperature performance limits for a lubricating grease in a small, lightly-loaded deep-groove ball bearing test. The test sample is run at different temperatures and speed, and then results can be used directly for calculation of the grease life in actual lubricated-for-life DGBB applications such as in electric motors. To conduct a test, the standard 6204/C3 test bearings with separate shields are prepared and lubricated with a standard quantity of the test grease. Two bearings are properly mounted in each test station for up to five (5) stations and then slowly brought up to the test temperature. Each bearing set is individually temperature-controlled by means of a thermocouple. When the test temperature deviates by 20°C from the preset test temperature as a result of bearing failure, the particular station involved will be switched off automatically. The other stations will continue running, and a counter monitors the total number of hours each station has run. From the number of running hours, the median grease life (L_{50} , the time at which 50% of the bearings fail due to inadequate lubrication), grease life (L_{10} , the time at which 10% of the bearings fail), and the Weibull Exponent β (the measure of the spread in grease life) using the Weibull Software Package. From the results obtained, a calculation can be made how bearings will behave in practice as well as a relubrication interval. The test bearings 6204/C3 are normal production bearings and are the only component that has to be renewed for each test, keeping the overall cost at a minimum.

Dimensions l x w x h, in. (cm)

Control Unit: 25½ x 17¾ x 36½ (65 x 45 x 93)

Bearing Testing: 69 x 35½ x 10½ (175 x 90 x 27)

Net Weight: 759 lbs (345kg)



K94500 ROF Grease Testing Machine

Ordering Information

Catalog No.		Order Qty
K94500	ROF Grease Testing Machine, 400V 50Hz, 3 Phase	1
K94590	ROF Grease Testing Machine, 460V 60Hz, 3 Phase	

Accessories

K94501	Weibull Data Analysis Software	1
K94502	Test Bearing	10

Specifications

Bearing Type:	6204-2Z/C3, normal filling degree
Standard Shaft Speed:	10,000 rpm
Optional Shaft Speeds:	6,000 and 20,000 rpm
Test Temperature:	ambient to 170 °C
Radial Load:	50N / bearing
Axial Load:	100N / bearing

Shipping Information

Shipping Weight: 935 lbs (425 kg)
Dimensions: 35 Cu. ft.

Mechanical and Dynamic Behavior of Greases

R2F Grease Testing Machine

- Conforms to DIN 51806 test specifications
- Evaluates the mechanical stability properties of lubricating greases
- User variable test conditions provide enhanced system versatility

The R2F Grease Testing Machine evaluates grease performance by measuring the wear of the rollers and the cage. In this test, significant wear will only occur as a consequence of the inability of the grease to maintain a lubricant film in the rolling and sliding contact during the full test period. The grease is tested in two run-in bearings under constant radial load of 8340 N at a speed of 1500 rpm for a period of 480 hours (20 days). Over the first 24 hours, no external heat is applied. The test is then continued for a period 19 days, where heat is applied to the bearing housings at a constant temperature between 60 and 160°C. The test is stopped automatically if the bearing temperature starts to rise more than 3°C above the preset test temperature, due to increased bearing friction.

Ordering Information

Catalog No.		Order Qty
K94700	R2F Grease Testing Machine, 380V 50Hz, 3 Phase	1

Accessories

K94701	Test Bearing	2
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Dimensions l x w x h, in. (cm)
39½ x 19¼ x 39½ (100 x 50 x 100)
Net Weight: 1276 lbs (580kg)

Shipping Information

Shipping Weight: 1507 lbs (685 kg)
Dimensions: 23 Cu. ft.

Multispecimen

Multispecimen Tester

- Multiple test configuration for wear and friction monitoring in one unit
- Speeds variable to 2000 rpm and loads to 500 N
- Data acquisition system records speed of rotation, normal load, sample temperature, and frictional torque

Measures and displays a variety of friction and wear characteristics on various geometric test samples with different compositions and forms. Test configurations are easy to change on the instrument: single or multiple, sliding or rolling, point, line or area contacts are available. A wide range of materials including coatings, lubricants, plastics, metals, polymers, ceramics, and composites can be readily analyzed. The test is performed by mounting a test sample into the spindle and rotating it against a stationary counter-face test specimen. The spindle rotation speed, normal load, and interface temperature can be user-adjusted in accordance with published ASTM standards. Specimen holders are designed for standard test configurations; optional custom designed holders for customer specific applications are also available. This unit has a temperature range to 120°C, load to 500 N and speed up to 2000 rpm. Windows®-based TriboDATA data acquisition software is included, and some of the possible configurations are shown in the table to the right.

Specifications

Conforms to the specifications of:	Non-Rotating Sample
ASTM D2266, D3702, D4172	Diameter/Diagonal: up to 80 mm
Normal Load: 5-800 N	Pin Sample Diameter: up to 8 mm
Frictional Torque Measurement	Ball Diameter: 12.7 mm
Range: 0-20 Nm	Non-rotating Sample Temperature:
Shaft Speed: 200-2000 rpm	Ambient to 100°C
Wear Measurement: 0-4000 µm	

Configurations Table

Ball on flat Sliding point contact	1, 2, 3 balls can be used Dry or lubricated contact
Cylinder on flat Sliding line contact	1 or 2 pins. Dry or lubricated
Pin on flat Sliding area contact	1 or 3 pins. Dry or lubricated
Four ball wear Wear preventive properties of lubricants	ASTM D2266 ASTM D4172
Thrust washer Rotating washer against fixed washed with axial load	ASTM D3702
Slurry erosion Two test pins in sand slurry	Erosion resistance in slurry by loss of weight method

Ordering Information

Catalog No.		Order Qty
K93600	Multispecimen Tester, 115V 50/60 Hz	1
K93690	Multispecimen Tester, 220-240V 50 Hz	

Included Accessories

Electrical Controller
Electrical Cables
Data Acquisition Card
TriboDATA Software Package
Signal Cable
Set of Hand Tools
Calibration and Test Reports

Included Adapters

Ball on Flat
Cylinder on Flat
Pin on Flat
Four Ball Wear Preventative
Thrust Washer
Slurry Erosion

Shipping Information

Shipping Weight: 880 lbs (400 kg)
Dimensions: 32 Cu. ft.

Tribology Test Specimens and Other Tribology Equipment

Scratch Tester

Evaluates the scratch resistance of a sliding surface pressed against stylus as a function of normal load, sliding speed, geometry and materials such as metals, ceramics, composites, and coatings. Tangential force and level of acoustic emission at the contact are displayed graphically on a PC. Onset of scratch or adhesion failure is inferred from these graphs. Features uni- and bi-directional sliding, user-defined load, interchangeable diamond stylus, data acquisition software, and CCD camera to view and capture scratch image.

Slurry Abrasion Tester

Measures the slurry abrasive resistance of solid materials as prescribed by ASTM G105 specifications. Performs tests on metals, minerals, polymers, composites, ceramics, coatings, and heat-processed materials, for up to six (6) samples simultaneously. A rectangular test sample is rotated in a slurry cup with the temperature maintained using a water bath. The test speed, temperature, duration, sample size, and slurry composition can be varied. The differential mass of the sample before and after the test is converted to volume loss (abrasion index) for direct comparison of the tested materials.

Tapping Torque Tester

Evaluates metal working fluids and various machining operations according to ASTM D5619 for the the torque requirements of tapping operations in pre-drilled samples. Software package acquires cutting torque and rotational speed and displays them as a function of test duration or angle of tool rotation.

Air Jet Erosion Tester

Performs air jet erosion test according to ASTM G76 specifications. A test sample is bombarded by a gas containing particulates with a known velocity and concentration of particles. Comparison can be made by varying test sample composition, size, particle velocity, angle of incidence, and temperature.

Dry Abrasion Tester

Measures index of abrasive resistance to dry sand according to ASTM G65 test specifications. Test specimen is held against a rotating wheel and abraded with a grit of controlled size, composition, and flow with the proper test duration and applied force as prescribed by the ASTM test method. The differential mass of the specimen before and after the test is recorded and converted to volume loss (abrasion index) for direct comparison of tested materials.

Custom-Built Tribology Test Equipment and Test Specimens

Test specimens are available for all of the tribology instrumentation offered from Koehler. Please inquire with customer service about other custom-built tribology test equipment and test specimens. Custom-designed equipment is readily available for the following tribology test methods:

Timken (ASTM D2509, D2782)	Shear Stability (ASTM D6278)
BOCLE (ASTM D5001)	HFRR (ASTM D6079)
Grease Life Tester (ASTM D3336)	Universal Wear (ASTM G77, G99)
Pin and V-Block (ASTM D2670, D3233)	Vane Pump Wear (ASTM D2882)

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