



Herguth Laboratories, Inc.

101 CORPORATE PLACE · P.O. BOX B · VALLEJO, CA 94590

## ***DESCRIPTION OF LUBRICATING OIL TEST WITH PIN-ON-DISK TRIBOMETER***

**GENERAL COMMENTS:** The pin-on-disk tribometer is a versatile laboratory apparatus for measuring the friction and wear properties of combinations of metals and lubricants under selected conditions of load, speed and temperature. The results provide an indication of the anti-friction, anti-wear, and anti-scuff properties of an oil or an additive, in an oil. The operating conditions can be made to simulate, as far as possible, those in a practical machine. The pure sliding used in this test causes boundary lubrication, where metal-to-metal contact occurs and the chemistry of the metals and the oil control friction and wear.

The tribometer conforms to ASTM G 99-95a entitled "Standard Test Method for Wear Testing with a Pin-on-Disk Apparatus".

**DETAILS:** Tribometer as shown in Figure 1, the elements of the tribometer are a "pin" sliding on the flat face of a disk rotating in a vertical plane, with provisions for controlling load, speed and oil temperature, and for measuring friction. The test oil is contained in a cup in which the disk rotates. Oil is swept up into the contact area by the rotating disk. A photograph of the tribometer is shown in Figure 2. Friction force is measured by restraining the pin motion with a force transducer. Wear is measured by microscopic examination of the pin and the disk after the test photos shown in Figure 3.

The pin is held in a horizontal position by a collet held in a pin holder arm. The arm is "Frictionless". The arm swings freely in two directions by the use of four Bendix cross spring pivots. Bendix claims the pivots are frictionless at their null points. A known load is applied along the axis of the pin, and friction force is measured by the force transducer restraining pin motion.

The disk is mounted on the flat end of a 1.25 inch diameter shaft of a precision spindle. Disk wobble, or run out, is 0.0002 inch. The spindle shaft is rotated by belts of large rubber O-rings over special pulleys, driven by a variable speed DC motor and speed reducer worm gear box arrangement.

### ***Sliding Parts:***

**Pin** - The pin is a hemispherically (1/8 inch radius) tipped, 1/4inch diameter rod, approximately 1 inch long. The pins can be machined from any selected metal. The tip of the pins are reconditioned before every test by circular abrasion motion on 600 grit wet or dry abrasive paper.

**Disk** - The disk is a 2 inch diameter, 1/2 inch thick, flat disk of the metal of choice. The flat surface to be used is resurfaced before every run by abrasion on wet or dry 600 grit abrasive paper, ending with figure 8 motions to give a random direction finish. The sliding pin forms a circular wear track on the disk.



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**Cleanliness** - Cleanliness of pins and disks, oil cup, and adjacent parts minimizes contamination by abrasives and prevents contamination of the test oil. Pins and disks are first cleaned by wiping with laboratory tissues wet with thinner until not a trace of abrasive is detected on the tissues. Then all parts are cleaned by simultaneously wiping with laboratory tissues and ultrasonic cleaning, successively in heptane, acetone and finally pentane. Tongs and cotton gloves are used during handling to reduce contamination.

### **Operating Conditions For Oil Test**

**Preliminaries Calibrations** - The force recording system is calibrated with known weights before each set of runs. A constant of the force in grams for each small division on the friction force chart is calculated. The rotational speed of the disk is set by a speed controlling system. An example is 24 rpm which gives a sliding velocity of 5.0 cm/s or 10 ft/min.

**Assembly** - The pin is locked in its collet, and the disk is mounted on the end on the shaft. The test oil is poured into the cup to a depth to cover the bottom third of the disk. The disk is mounted on the flat end of a 1.25 inch diameter shaft of a precision spindle. Disk wobble, or run out, is 0.0002 inch. The spindle shaft is rotated by belts of large rubber O-rings over special pulleys, driven by a variable speed DC motor and speed reducer worm gear box arrangement.

**Temperature** - The oil is heated by flat Chromolox heaters contacting the bottom of the aluminum oil cup. The oil temperature is measured and controlled by a double shielded thermocouple. The temperature is controlled to (+-) 5 C (9 F).

Break-in is performed to avoid damage before anti-wear or anti-wear action can be induced. The sliding pairs are broken-in by applying lower loads for 1 minute each as the temperature of the disk increases to the desired temperature and with the disk at the desired speed. The break-in loads on the pin are usually:

grams of force	Newtons, N
199	2.0
424	4.2
573	5.6
724	7.1
799	7.8

### **Load**

Load of the pin against the disk is applied by weights on a pan hanging on a fine steel cable over a pulley and hooked to the arm. Thus the weights pull the pin towards the disk. Load of the pin is 3/4 of the total of the weights and the pan (65 grams). For example, a 500 gram weight on the pan gives a 424 gram force or 4.16 N on the pin against the disk.



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The reader is reminded that pressure is not applicable during boundary lubrication, however many users want to know anyway. The apparent pressure decreases with pin wear, as follows:

Scar on Pin		Apparent Pressure (1000g (f) Load)	
Dia.- mm	Area - mm <sup>2</sup>	N/mm <sup>2</sup>	Lbs/in <sup>2</sup>
.25	0.05	196	28307
.50	0.20	49.0	7095
1.0	0.79	12.4	1798
1.5	1.77	5.5	796

The final load, for example, 1000 grams of force (9.8 N), is then applied and run for an additional 60 minutes.

**Sliding Distance** - By running the test for 1 hour at 24 rpm, the pin will have made 1440 passes around the circular (4.2 cm or 1.65 inch diameter) wear track on the disk, and slid 190 meters or 623 feet. The arm can be lowered with shims in order to obtain two or three additional runs on the same disk. Lowering the arm gives wear circles of smaller diameter. Then the time of the run is increased slightly to give the same sliding distance of 190 m.

**Measurements and Observations Friction** - Friction is applicable to the power requirements and efficiency of a machine. It is also an indication of the efficacy of a sliding system. Lubricity is the lubricant property that reduces friction. Friction force is measured, observed, and recorded during the run.

Pin-on-disk tribometers may give a wavy friction force tracing due to non-uniform surface conditions around the wear track on the disk. In that case a range of values is recorded. A smooth and low friction force tracing is a prediction of effective lubrication. A jagged tracing is indicative of stick-slip, scuffing, distressed sliding, and lubricant failure.

The *coefficient of friction*, which is reported, is calculated from the observed friction force divided by the applied load.

**Wear:** Wear is applicable to the life of a machine's lubricated component. High wear on the tribometer would predict short component life. After the run and disassembly, the undisturbed wear scar on the tip of the pin is examined. After cleaning, the condition of the wear scar is observed microscopically. It may be smooth, polished, abraded, or scuffed. Finally, the average diameter is measured. The volume of metal removed from the pin is calculated from an equation given in the ASTM method. The results are reported as mm<sup>3</sup> X 1000.

The wear track on the disk is also examined for wear. The track may show very low wear, where only the micro peaks are worn off forming microplateaus, and most of the original grinding marks remain.



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On the other hand, a deep ragged furrow, with globs of transferred metal may have been formed. (Tracks may be so deep that regrinding of the disks at a machine shop is required).

The width of the wear track corresponds to the diameter of the scar on the pin. Disk wear is judgmental, such as very low wear or severe scuffing.

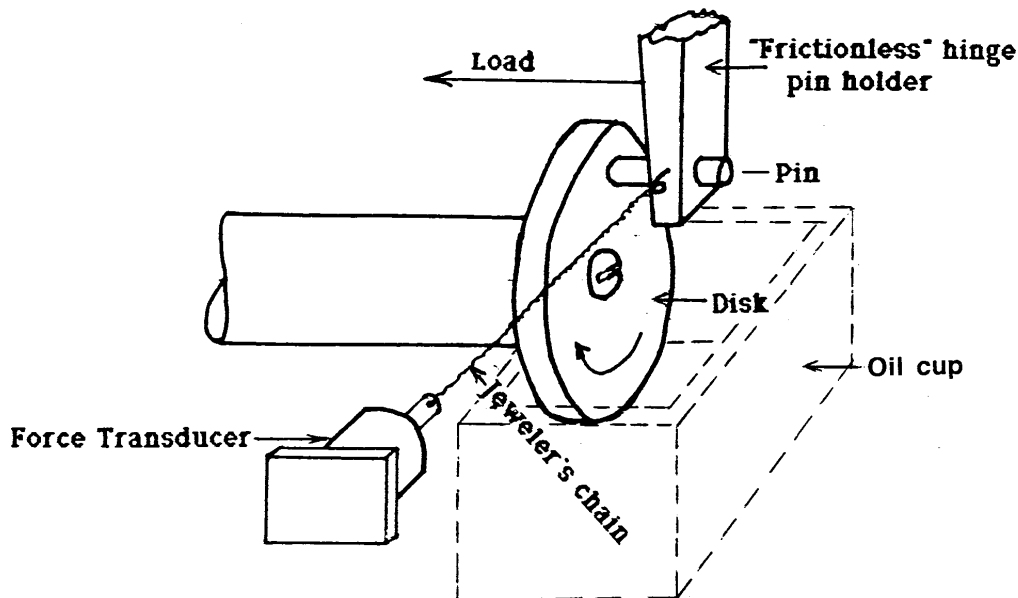
***The client will receive:***

A table showing, values of the coefficient of friction, the amount of wear on the pin and on the disk, a description of the wear scars, and comments on the boundary lubricating properties of the oil and a photo of the wear scar.

Note: Since the tribometer is versatile, other materials can be used, such as a polymer for the pin, or a coating on the disk. Also tests can be run under conditions which promote mixed boundary and hydrodynamic lubrication. The client and Herguth personnel can decide what materials and conditions to use to simulate the practical machine. 100 ml of oil is required for each tribometer run, which also provides enough for other laboratory analyses.

Figure 1

**Schematic Diagram Of Pin-On-Disk Tribometer**

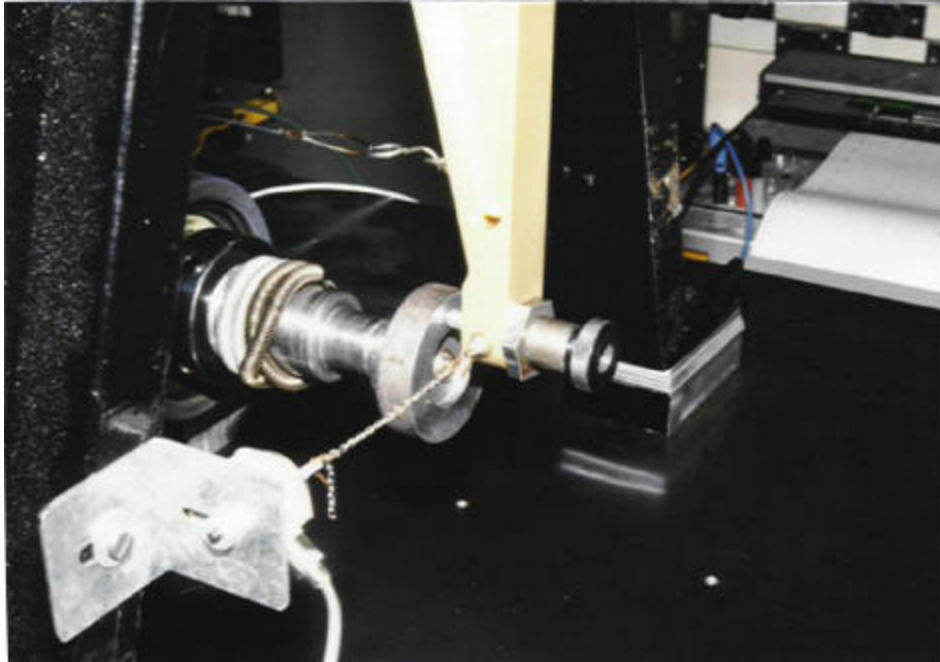




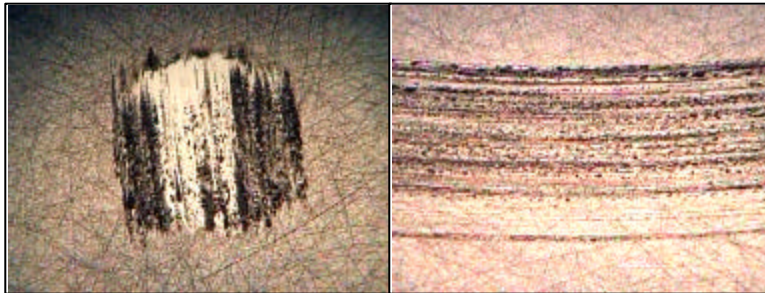
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Figure 2 Photograph of Pin On Disk Apparatus



Figures 3  
Oil "A" Results



Scar on Pin

Wear Track on disk

Oil "B" Results

