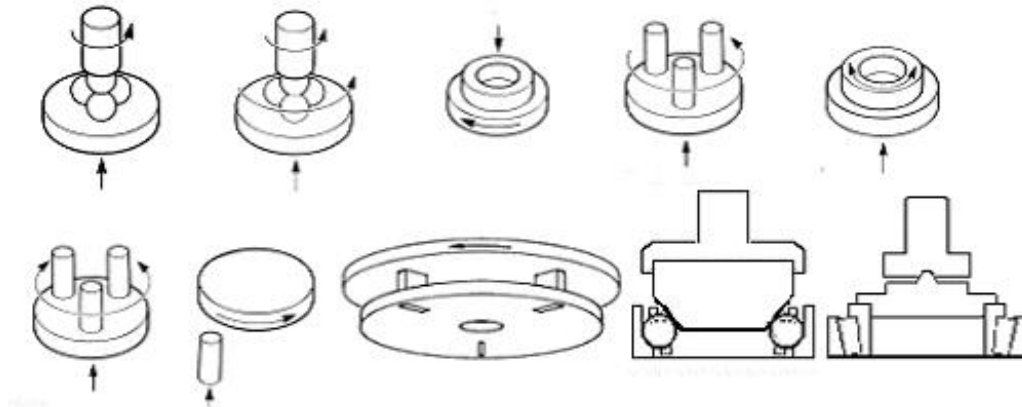


TE 92HS MICROPROCESSOR CONTROLLED ROTARY TRIBOMETER



Background:

The TE 92HS Microprocessor Controlled Rotary Tribometer is a versatile test machine for research and development work on materials and lubricants. With collinear rotating and loading axes and an open test platform the TE 92HS can accommodate a number of tribology test geometries, many relating to international test standards.

TE 92HS with TE 92/1, TE 92/2 and TE 92/3

ASTM D2266 Wear Preventive Characteristics of Lubricating Greases
ASTM D4172 Wear Preventive Characteristics of Lubricating Fluid
ASTM D2596 Extreme Pressure Properties of Lubricating Greases
ASTM D2783 Extreme Pressure Properties of Lubricating Fluid
ASTM D5183 Determination of the Coefficient of Friction of Lubricants
IP 239 Extreme Pressure Properties: Friction and Wear Test for Lubricants
DIN 51350/1-5 Testing Lubricants: Testing in the Shell Four-Ball Tester

TE 92HS with TE 92/2 and TE 92/4

IP 300 Rolling Contact Fatigue Tests for Fluids

TE 92HS with TE 92/2 and TE 92/5

DIN 51350/6 Testing of Shear Stability of Lubricating Oils Containing Polymers
CEC L-45-T-93 Viscosity Shear Stability of Transmission Lubricants (Taper Roller Bearing Rig)

TE 92HS with TE 92/6

ASTM G99 Wear Testing with a Pin-on-Disc Apparatus
DIN 50324 Measuring Friction and Wear: Model Experiments on Sliding Friction in Solids (Ball on Disc System)
ISO/DIS 7148-2 Testing of the Tribological Behaviour of Bearing Materials
ASTM D3702 Standard Test Method for Wear Rate of Materials in Self-Lubricated Rubbing Contact Using a Thrust Washer Testing Machine

Description:

The TE 92HS has servo controlled low inertia pneumatic loading with force transducer feedback, vector controlled motor speed with encoder feedback, electromagnetic clutch rapid start system, SUPERSLIM Serial Link Interface Module and [COMPEND 2000](#) Window compatible control and data acquisition software. The machine is floor-standing.

Motor and Test Spindle:

The test spindle projects downwards and runs in a housing with precision greased for life bearings. There are two drive modes for the test spindle, according to the type of tests being carried out.

For tests at speeds up to 3,000 rpm, the drive motor is connected to a pulley on the test spindle by means of a timing belt. The test spindle pulley is machined into the outer casing of an electromagnetic clutch. When the clutch is engaged the motor drives the test spindle.

This arrangement gives adjustable start-up characteristics and also provides the ability to control test duration accurately, eliminating motor inertia from the system when the clutch is disengaged. The clutch starter unit may also be used in tests with annulus adapters to enable measurements of start-up or coast-down friction.

For tests at speeds up to 10,000 rpm, the clutch is removed and the drive motor is connected directly to the drive spindle via a smooth drive belt and pulley. The motor is mounted on a sliding plate with a jacking screw to tension the drive belt.

The high-speed pulley/smooth drive ratio is 6.67:1. This means that for a motor speed of 1,500 rpm the test spindle is rotating at 10,000 rpm with available torque of 2.1 Nm.

Vector control of the motor with encoder feedback provides a variable speed turn-down ratio of 100:1. The motor is four-pole providing a constant torque of 14 Nm up to 1,500 rpm and constant power of 2.2 kW from 1,500 to 3,000 rpm. The motor is capable of providing 50% overload for 30 seconds and therefore a maximum torque of 21 Nm is available for this time. The welding limit in 4-ball EP tests is typically 12 Nm.

Location for holders for the rotating specimens is provided by a tapered hole in the end of the test spindle and the accurately machined outer diameter and end face of the spindle.

Load and Torque Measurement:

The various test adapters are mounted on an aluminium cross beam which is guided by linear bearings on the vertical machine columns. The beam is loaded from underneath by a pneumatic bellows actuator assembly which includes an in-line force transducer for measurement and feedback control of load. There are two interchangeable loading assemblies TE 92/1 and TE 92/2 providing a 500:1 turn-down ratio on load.

The test adapters are placed on a thrust bearing that permits free rotation under the influence of frictional torques generated in the contact. Each adapter includes a torque arm so that this rotational movement is resisted by a strain gauge force transducer mounted on a bracket attached to the upper plate.

Temperature Measurement:

The adapters TE 92/3, TE 92/4 are mounted on a heated block which incorporates two electrical resistance heater elements. The heated block locates on the thrust bearing of the load cross-beam. The TE 92/6 Reservoir includes integral electrical heating for tests up to 200°C. A 600°C electrical furnace TE 92/HT, completely enclosing the test pieces, is available.

Thermocouples are located in the adapters to measure the temperature of the test sample (either material or lubricant) and this measurement is used as the feedback for control. The temperature is maintained by software PID controllers.

Vibration Measurement:

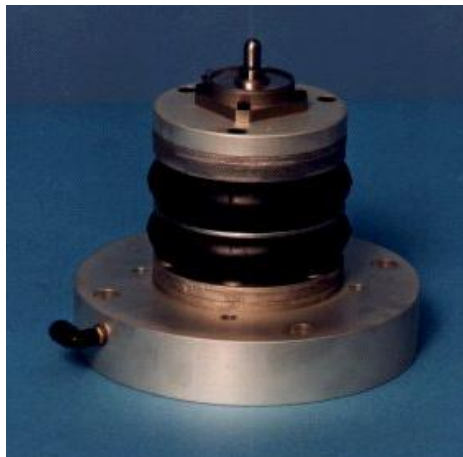
The 4-ball rolling contact fatigue tests require the machine to be shut down by detecting the onset of pitting. A piezo-electric sensor is mounted on the machine frame to detect vibration levels. The sensitivity of the detection circuit is adjustable by the operator. A sudden rise in the level of vibration, caused by the pitting damage in the test adapter, will trip the circuit and stop the motor rotating.

Control and Data Acquisition:

The TE 92HS has PC based sequence programmable control and data acquisition. This is provided by an integrated Serial Link Interface Module and [COMPEND 2000](#) software running on a host PC, operating under Windows. Data is stored to hard disc in standard spread sheet compatible file formats (.csv or .tsv).

Tests are defined by a sequence of steps, each step containing set-point, data recording rates and alarm level information. Set-points may be adjusted by step change or ramp. The test sequence is followed unless interrupted by the operator or an alarm. Set-points may also be adjusted manually using on screen toggles.

TE 92/1 Low Load Actuator Assembly:



The TE 92/1 provides a loading range of 20 to 1,000 N and this is used for pin on disc, thrust washer and 4-ball wear tests.

TE 92/2 High Load Actuator Assembly:

The TE 92/2 provides a loading range of 200 to 10,000 N and this is used for taper bearing shear stability, 4-ball EP and rolling 4-ball tests.

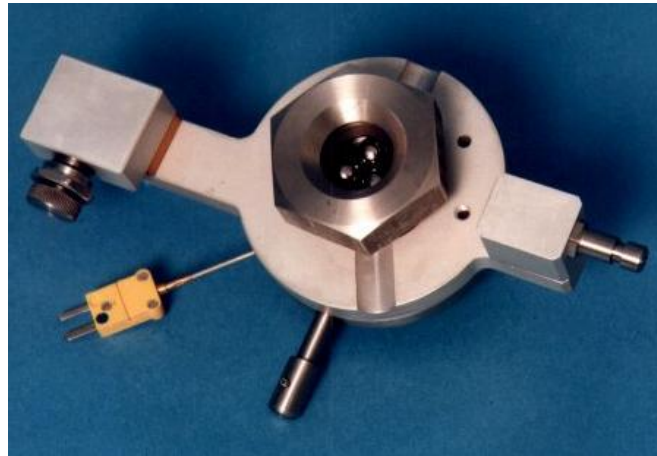
Load Range Limits:

The Load Range is dependent on the type of test being performed. Long-term high load, high speed tests would run the risk of bearing failures in the main spindle. The operating envelope of the machine is based on the L10 and L30 lives of the spindle bearing as follows:

Sliding 4-ball EP tests:	1,840 rpm @ 8 kN
Sliding 4-ball Wear tests:	1,840 rpm @ 1 kN

Rolling 4-ball tests:	1,840 rpm @ 10 kN
	3,000 rpm @ 5 kN
	10,000 rpm @ 3 kN
KRL Shear Stability test:	1,840 rpm @ 5 kN
Pin on Disc test:	1,840 rpm @ 1 kN
Thrust Washer test:	1,840 rpm @ 1kN

TE 92/3 Sliding Four Ball Test Assembly:



The TE 92/3 comprises a test reservoir, clamping nut, thrust face and clamping ring for the three test balls, integral torque arm and thermocouple sensor. The clamping ring is designed to hold the test balls at the defined contact angle for 4-ball testing. The thread of the clamping nut is designed to provide the correct clamping torque for 4-ball EP testing. The upper ball is placed in a split taper collet, which is a push fit into the spindle taper. The test assembly is also designed to locate on the TE 92/SCOPE Microscope Assembly to allow post-test measurement of wear scars.

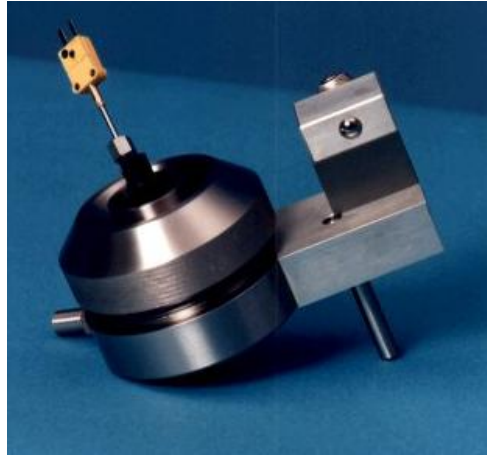
TE 92/4 Rolling Four Ball Test Assembly:



The TE 92/4 comprises a test reservoir and precision polished test race. The race is designed to permit the test balls to rotate freely maintaining a defined contact angle with the upper ball fixed in the spindle.

In this case there is no torque measurement and the rotation of the adapter is prevented by dowels in the heated pad locating in three holes in the load cross-beam. The upper ball is placed in a split taper collet, which is a push fit into the spindle taper.

TE 92/5 KRL Shear Test Adapter (DIN 51350-6):



The DIN 51350-6 and CEC test methods are for the determination of the shear stability of lubricating oils with polymer additives. For this a taper roller bearing is used to shear the fluid. The purpose of the test is to determine the permanent drop in viscosity caused by mechanical stresses under practical conditions.

The test assembly comprises a test reservoir, clamping nut, integral labyrinth for temperature control, torque arm and thermocouple sensor. The temperature of the lubricant is maintained at 60°C by means of a free-standing temperature controlled water circulating system.

TE 92/6 Shaft Hub & Heated Reservoir:

The TE 92/6 is used for pin on disc and thrust washer tests. In each case the rotating specimen clamps into a holder that mounts on the shaft hub. The shaft hub locates on the outer diameter of the test spindle and is held in place by a pin that passes through the hub and shaft.

The fixed specimen clamps into a holder that mounts in the base of the heated reservoir. The reservoir locates on the thrust bearing of the machine load cross-beam and has an integral torque arm for friction measurements. The reservoir is stainless steel and has two electrical resistance heaters in its base. A thermocouple gland is provided so that the temperature sensor can be pressed against the side of the specimen or holder located in the reservoir. Inlet and outlet pipe-fittings are also provided for fluid feed to the reservoir.

The fluid may be fed by gravity or circulated through the enclosure using the TE 92/LS or other suitable circulation system. A lid is provided for the reservoir to minimise loss of fluid by splashing or evaporation.

The following specimen adapters are included with TE 92/6:

Pin on Disc:	
Upper Specimen:	Three Rotating Pins
Lower Specimen:	Disc
Upper Specimen:	Rotating Disc
Lower Specimen:	One Pin
Upper Specimen:	Rotating Disc
Lower Specimen:	Three Pins

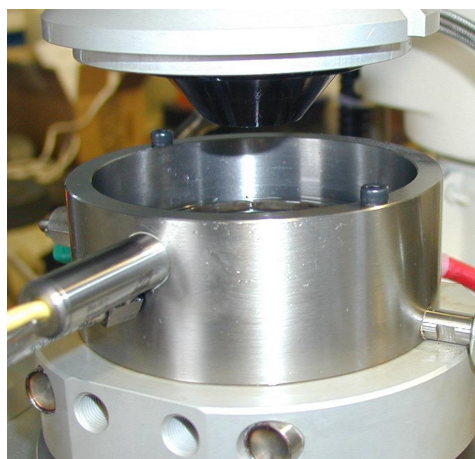
Thrust Washer:	
Upper/Lower Specimen:	ASTM D3702 (Large)
Upper/Lower Specimen:	ASTM D3702 (Small)

TE 92/6/CDS Shaft Hub & Heated Reservoir with Capacitance Displacement Sensor



The TE 92/6/CDS is identical in function to the TE 92/6 Shaft Hub & Heated Reservoir, but with a co-axially mounted capacitance displacement sensor fitted to the reservoir with a target mounted on the rotating shaft hub. As the samples wear, the sensor detects the relative displacement of the fixed specimen with reference to the rotating specimen.

TE 92/7 Rolling Contact Fatigue Adapter:

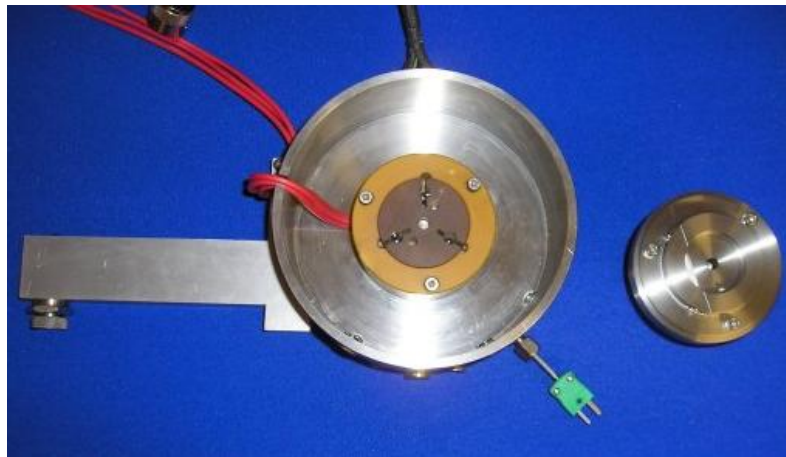


The TE 92/7 adapter uses the lower race and cage of a standard angular contact bearing (SKF 7206), with the inner race replaced by a conical specimen. The cone angle is such that the rolling contact is pure rolling with no spin. With silicon nitride balls in the bearing race, contact pressures up to 5.5 GPa can be achieved. The cone is subjected to the highest number of contacts and thus it is the rolling fatigue performance of the cone material that is investigated in this test configuration.

TE 92/9 LVFA Test Assembly:

The TE 92/9 allows small-scale LVFA friction material test samples to be mounted in a test bath of similar construction to the TE 92/6.

TE 92/10 Vane Pump Adapter:



The TE 92/10 provides mounting for a three-vane rotating specimen carrier in contact with a fixed flat disc, with the same geometry as devices produced by other manufacturers. Alternative tooling allows the same specimens to be run with the disc rotating and the vanes fixed. In this case, the vanes are independently electrically insulated allowing electrical contact potential measurements to be made between each vane and the rotating disc.

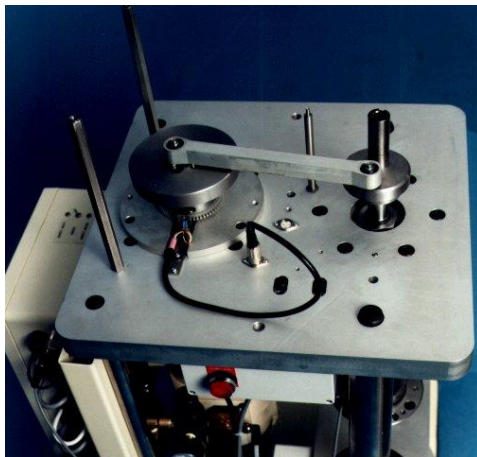
TE 92/HT 600°C Specimen Enclosure for Dry Pin on Disc Tests:



The TE 92/HT 600°C incorporates an electrically heated furnace. To ensure that heat conduction to the test spindle bearings is minimised, the TE 92HS machine must be manufactured with a longer test spindle and therefore larger frame. This option is thus not available as a retrofit item on existing standard machines and must be specified at the time of order.

The adapter is suitable for dry tests in three rotating pin on fixed disc mode only. The available track radius is less than for the TE 92/6 assemblies because of space limitations in the furnace.

TE 92/O Oscillating Drive Adapter:



The TE 92/O Oscillating Drive Adapter allows for conversion of the TE 92HS to oscillating motion instead of continuous rotation. The angle of oscillation can be set between 0 and 90° with limits on the maximum frequency at large angles. Oscillation motion is useful for wear and friction testing under pin on disc and thrust washer contact conditions. The reversal of motion can result in different wear mechanisms, particularly if wear or abrasive particles are involved.

The drive comprises a crank mechanism connecting the motor output shaft to the test spindle. The clutch and pulley assembly of the TE 92HS are removed and hubs with locations for the crank arm are mounted on the two shafts. The motor hub has a number of screwed locations for the driving pin to give a range of oscillating angles.

A clamping arrangement is provided for the torque arm on the TE 92/6 Heated Reservoir to ensure that the torque transducer monitors the bi-directional friction torques during these tests.

TE 92/LS Lubricant Re-circulating System:

The TE 92/LS uses an anodised aluminium bath with inlet, outlet and thermocouple ports. The bath is mounted on a laboratory heater/stirrer unit. A magnetic paddle is placed inside the bath to ensure that the liquid is heated evenly. The temperature of the liquid is monitored by the thermocouple mounted in the lid and the value is read from a free-standing temperature display unit. The temperature set-point is selected manually on the heater unit.

There are two integrated peristaltic pumps, one to pump liquid from the bath to a test adapter and one to scavenge the fluid from the test adapter and return it back to the bath.

TE 92/CAL Calibration System:

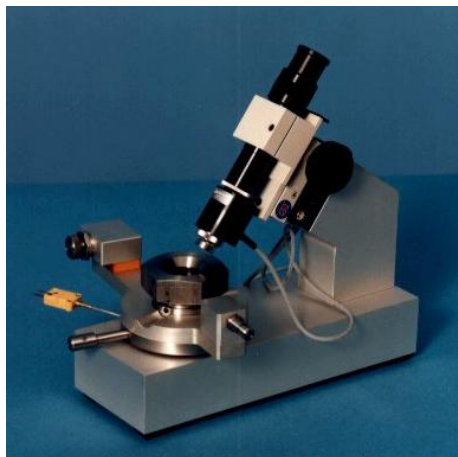
The TE 92/CAL provides facilities to calibrate Load, Torque and Temperature.

Load is calibrated by means of a calibration arm assembly that is secured to the machine base. The load force transducer is removed from the Load Actuator Assembly and mounted on the calibration assembly. Calibration masses are provided.

Torque is calibrated by removing the force transducer from its mounting and securing it to horizontal fixing locations on the machine base. Calibration masses are then applied directly to the transducer using a weight hanger.

Temperature is calibrated by placing one of the thermocouple sensors in iced water and boiling water. Means of generating ice is not provided.

TE 92/SCOPE High Resolution Microscope Assembly:



The TE 92/SCOPE enables rapid measurement of the wear scar on the test balls from a sliding four ball test (EP or Wear) without having to removing the balls from the TE 92/3 test adapter.

The sliding four-ball test adapter fits onto the base of the microscope assembly. The microscope is located on angled holder which is set to the standard contact angle of the balls in the machine. This means that the microscope is normal to the centre of the wear scar.

The microscope has a rack and pinion focusing system and the wear scar is illuminated by the internal light source. Each ball may be viewed in turn by rotating the test adapter by hand. Two interchangeable eye pieces are provided with internal gratitudes as follows:

Range 2 mm with 0.01 mm divisions

Range 4 mm with 0.02 mm divisions

The wear scar is measured in one direction and then the eyepiece is twisted 90° to read the second value

Technical Specifications:

Rotational Speed:	30 to 3,000 rpm 100 to 10,000 rpm
Spindle Bearing Load:	10,000 N @ 3,000 rpm 4,000 N @ 10,000 rpm
Torque Capacity:	14 Nm @ 30 to 1500 rpm 7 Nm @ 3,000 rpm 2.1 Nm @ 10,000 rpm
Motor:	2.2 kW ac @ 1500 rpm 50% overload available for 30 seconds
Heated Block Power:	550 W
Temperature Sensor:	k-type thermocouple
Vibration Sensor:	piezo-electric type with adjustable threshold sensitivity and cut-off time
Interface:	SUPERSLIM Serial Link Interface Module
Software:	COMPEND 2000

Controlled Parameters

- Rotational Speed
- Temperature
- Load
- Test Duration

Recorded Parameters

- Rotational Speed
- Friction Torque
- Temperatures
- Number of Revolutions
- Test Duration
- Sliding Speed
- Friction Coefficient
- Sliding Distance

TE 92/1 Low Load Actuator Assembly:

Load Range: 20 to 1,000 N

TE 92/2 High Load Actuator Assembly:

Load Range: 200 to 10,000 N

TE 92/3 Sliding Four Ball Test Assembly:

Ball Size: 12.7 mm (0.5")
Temperature Sensor: k-type thermocouple

TE 92/4 Rolling Four Ball Test Assembly:

Ball Size: 12.7 mm (0.5")
Temperature Sensor: k-type thermocouple

TE 92/5 Shear Test Adapter DIN 51350-6:

Bearing: SKF 32008 X/Q
Temperature Sensor: k-type thermocouple
Sump Capacity: 35 litres
Heater Power: 3 kW
Pump Flow: 9 litre/minute at zero head

TE 92/6 Shaft Hub & Heated Reservoir:

Reservoir Capacity: 500 ml
Heater Power: 550 W
Temperature Sensor: k-type thermocouple
Maximum Temperature: 200°C

Three Rotating Pin on Disc

Track Radius: 10 to 35 mm
Pin Size: 8 mm diameter x 15 mm long
Number of Pins: One, Two or Three
Disc Size: 75 mm diameter

Thrust Washer Test Adapters

Thrust Washer: 1.125" od according to ASTM D 3702
2" od according to ASTM D 3702

TE 92/6/CDS Shaft Hub & Heated Reservoir with Capacitance Displacement Sensor:

Reservoir Capacity: 500 ml
Heater Power: 550 kW
Temperature Sensor: k-type thermocouple
Maximum Temperature: 200°C
Resolution: 0.2 microns

TE 92/7 Rolling Contact Fatigue Adapter:

Contact Configuration:	Cone and ball race in pure rolling contact
Cone:	40 degree included angle test specimen
Rolling Bearing:	SKF 7206 cage and lower race
Balls:	silicon nitride
Maximum Contact Stress:	5.5 GPa
Maximum Speed:	3,000 rpm (TE 92) 10,000 rpm (TE 92HS)
Maximum Temperature:	200°C

TE 92/9 LVFA Adapter:

Contact Configuration:	Thrust Washer (LVFA small)
Maximum Load:	1,000 N
Heater Bath Temperature:	200 °C

TE 92/10 Vane Pump Adapter:

Contact Configuration:	Three Vane on Disc
Maximum Load:	1,000 N
Heater Bath Temperature:	200 °C

TE 92/O Oscillating Drive Adapter

Oscillating Motion:	+/-10 degrees at 25 Hz +/-15 degrees at 20 Hz +/-20 degrees at 18 Hz +/-25 degrees at 15 Hz +/-35 degrees at 10 Hz +/-45 degrees at 8 Hz
---------------------	---

TE 92/HT 600°C Specimen Enclosure:

Track Radius:	20 mm
Pin Size:	8 mm diameter x 15 mm long
Disc Size:	55 mm
Heater:	60 V ac ceramic fibre heater
Heater Power:	1 kW
Temperature Sensor:	k-type thermocouple

TE 92/LS Lubricant Re-circulating System:

Bath Volume:	1.2 litres
Peristaltic Pump Flow:	1 litre/minute (maximum)
Heating Power:	550 W
Temperature Range:	ambient to 100°C

TE 92/SCOPE High Resolution Microscope Assembly:

Magnification: x 40
Graticule: range 2 mm with 0.01 mm divisions
range 4 mm with 0.02 mm divisions

Services:

Electricity: 220/240V, single phase, 50 Hz, 7.5 kW
110/120 V, single phase, 60 Hz, 7.5 kW
Clean, dry air: 4 cfm at 8 bar (120 psi)

Installation:

Floor-standing machine: 900 mm x 600 mm deep x 2000 mm high, 250 kg
Bench-mounting cabinet: 530 mm x 420 mm x 300 mm high, 20 kg
Packing Specifications: 2.2 m³, GW 600 kg, NW 450 kg

Order As:

TE 92HS	Microprocessor Controlled Rotary Tribometer
TE92/1	Low Load Actuator Assembly
TE92/2	High Load Actuator Assembly
TE92/3	Sliding Four Ball Test Assembly
TE92/4	Rolling Four Ball Test Assembly
TE92/5	KRL Shear Test Adapter (DIN 51350-6)
TE92/6	Shaft Hub & Heated Reservoir
TE 92/6/CDS	Shaft Hub & Heated Reservoir with Capacitance Displacement Sensor
TE 92/7	Rolling Contact Fatigue Adapter
TE 92/9	LVFA Test Assembly
TE 92/10	Vane Pump Adapter
TE 92/O	Oscillating Drive Adapter
TE92/HT	600°C Specimen Enclosure
TE92/LS	Circulating Lubricant Supply
TE 92/CAL	Calibration System
TE 92/SCOPE	High Resolution Microscope Assembly
RE 92	Hydrovane Compressor

Consumables:

TE 92/CV1	Box of 600 Balls
TE 92/CV2	Ball Collet
TE 92/CV3	Five Test Races for Rolling Four Ball Tests
TE 92/CV4	Ball Clamp and Thrust Race for Sliding Four Ball Tests
TE 92/CV8	Five Precision Test Discs
TE 92/CV9	Fifty Mild Steel Test Pins