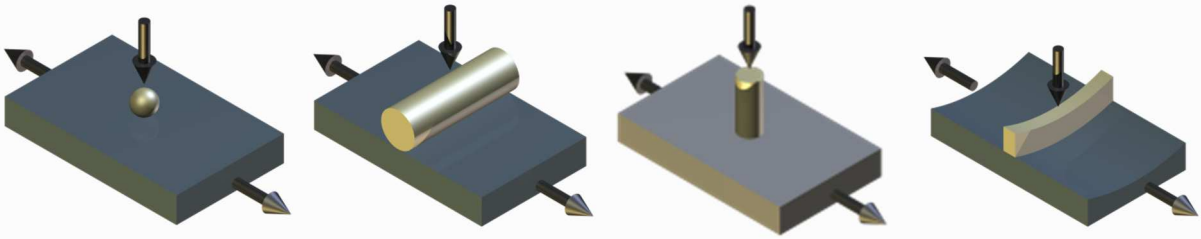
# TE 99 UNIVERSAL WEAR MACHINE

## Background

The TE 99 was formerly known as the Eyre/BICERI Universal Wear Machine and has a worldwide user base. The original machine design was made by Dr. Terry Eyre of Brunel University and Neale Consulting Engineers and it was subsequently marketed and manufactured by BICERI Limited.

The Universal Wear Machine is suited to the wear testing of materials in pin on disc or pin on plate modes. The TE 99 has a Class 1 contact configuration (pin or ball loaded vertically downwards onto a horizontally rotating disc) and may perform tests according to the guidelines laid out in ASTM G 99, DIN 50 324 and ISO/DIS 7148-2. In reciprocating mode the machine can perform tests according to ASTM F 732.

The operating ranges can be extended with options for a heated lubricant enclosure, a reciprocating plate adapter and fixtures for piston-ring/cylinder liner specimens in reciprocating mode.

# Description

The machine base frame holds the disc carrier spindle and the load/friction measurement system assembly in a fixed, accurately aligned, orientation.

The test pin is fixed in a sliding carriage clamped to the load beam. Nominally flat on flat contact is possible with a level load beam, but in practice this is difficult to achieve. Balls and pins with a radius, conical or triangular tip are recommended as these self-align when they wear.

The load beam is counter-balanced and pivots at one end on suspended roller bearings. At the other end of the beam, large weights are supported on a weight carrier that overhangs the base plate and small weights rest on the beam located by a steel peg. The wide load range achievable allows parametric studies to be made based on load. It should be noted that there can be considerable inertial effects at higher loads caused by weight bounce and this can influence the wear rates and/or mechanisms. This problem can be more acute with high hardness test materials.

The load beam pivot is trunnion mounted. When the beam is horizontal, it is restrained from transverse movement by a strain gauge force transducer. A retaining clamp maintains the beam in contact with the transducer at all times, ensuring that bi-directional forces generated in pin on disc and reciprocating contacts are measured.

The transducer output connects to a strain gauge amplifier and the output from this is passed through a true rms/dc converter and then connected to the interface to give averaged friction readings in both uni-directional and reciprocating pin on plate modes.

# Disc Carrier


The test disc is mounted on the disc carrier spindle and secured by a central bolt. The spindle is driven through a pulley belt by the vector controlled a.c. motor mounted beneath the machine. The motor has encoder feedback to ensure stable running speeds.

The track radius is set by moving the pin carriage along the beam and locking in place. This permits multiple tests to be performed on one disc specimen with a spacing of 2 mm between tracks. An integral scale on the beam is used to determine the radius set.

## Wear Measurement

An indication of wear processes going on in the contact is given by a linear potentiometer mounted on the pin carriage. This transducer measures the vertical movement of the pin relative to a fixed datum during a test (this can be due to wear, thermal expansion and wear debris generation).

## Contact Potential Measurement

The pin carriage is electrically isolated from the load beam and therefore from the disc specimen. This allows a small potential to be applied across the contact from a Lunn-Furey Contact Resistance Circuit. The connection to the disc spindle is via a slip-ring.

Variations in the voltage across the contact are indicative of the amount of contact between the pin and disc specimens provided that both are conductors of electricity. Maximum voltage (typically 40 mV) corresponds to no contact (open circuit) while zero voltage corresponds to full contact (closed circuit). The voltage signal will typically fluctuate rapidly during a test so an rms signal is used for recording purposes.

This kind of measurement is extremely useful when working with lubricants containing additives, solid lubricants and surface coatings. The contact measurement can be used to assess the formation and breakdown of high resistance chemically bonded films on the metal surfaces and the failure of coatings/films in the contact.

## Calibration

The most important parameters to calibrate on the TE 99 are the friction force and wear. Included with the machine are a pulley, cord and weights to apply a tangential force to the load beam for friction calibration and a slip gauge for wear calibration.

## Control and Data Acquisition

Control and data acquisition are implemented via host PC running COMPEND 2020 Windows compatible software, in conjunction with a Phoenix Tribology USB micro-controller interface.

Automatic control is implemented via user programmable test sequences. Manual control is implemented using on screen toggles. Data is stored to hard disc in either .csv or .tsv file formats.

## TE 99/R Reciprocating Pin on Plate Adapter

The Reciprocating Pin on Plate Adapter mounts on the machine base plate to the right of the drive spindle. The trunnion mounted load beam/friction sensing system is also moved to the right so that the test pin is located at the centre of the plate stroke.


The fixed plate specimen is located on two screw fittings in a stainless steel reservoir. The reservoir is clamped to a block that is heated by electrical resistance elements and the temperature is monitored by a thermocouple pressed against the side of the specimen or holder. The reservoir can be moved sideways on the heater block so that multiple tests can be performed on one plate specimen.

The heater block is mounted on a small base plate, restrained to move in a horizontal plane by linear bearings. This plate is reciprocated by means of a simple crank connected to the drive spindle. The crank pin position may be adjusted to provide a range of strokes.

The reciprocating adapter offers a valuable extension to the operating range of the TE 99. In particular the reciprocating contact offers a more realistic simulation of some practical contact situations (for instance reciprocating seals, piston ring and cylinder liner and other repeating contacts). The maximum operational frequency at 110 mm stroke is limited to 1 Hz for reasons of machine vibration. Higher frequencies are permissible provided that the total stroke is reduced (e.g. 5 Hz at 50 mm stroke).

The primary role of the pin on disc machine is as a tool for the analysis of the wear of materials. The reciprocating pin on plate adapter is likewise a tool for the analysis of wear. One of the chief differences is in the dynamics of wear particles. In the pin on disc, the particles are free to move away from the contact area, whereas in the reciprocating contact there is a much higher chance of the particles being involved in the contact and to contribute to the friction characteristics.

The reciprocating adapter is also more suitable to the study of abrasion than the pin on disc mode, again because of the way in which the abrasive particles will be involved in the contact region. The linear motion makes this mode suitable for studying different surface finishing techniques.

# TE 99/LE Lubricant Enclosure

The TE 99/LE is a stainless steel enclosure that mounts over the drive spindle. It is sealed against the rotating shaft and provided with a lid to permit tests to be run with the disc fully immersed in fluid. Electrical resistance heater elements are mounted in the base of the enclosure to allow the fluid temperature to be controlled up to 200°C. Thermocouples are provided to monitor the enclosure and fluid temperatures.

The fluid may be fed by gravity or circulated through the enclosure using the TE 99/LS or other suitable circulation system. The feed position is on the lid close to the in-running side of the contact and the drain is located at the base of the enclosure.

# TE 99/LS Lubricant Recirculating System

The Lubricant Recirculating System uses an anodised aluminium bath and lid 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 off 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. The scavenge pump does not have to be used if the fluid is of low viscosity (eg water) when a gravity return is sufficient.

# TE 99/HT Heating & Temperature Sensing Package

The TE 99/HT comprises a stainless steel enclosure, a method of heating and a temperature sensor. The enclosure surrounds the disc specimen and has an inlet and outlet port and a lid with access for the pin specimen and a viewing port.

The air heating system consists of a high power air blower with electrical resistance heating element. The hot jet is directed into the inlet port of the enclosure and the exhaust is directed to a chimney covering the outlet port.

The temperature of the disc specimen is measured using an optical pyrometer. The pyrometer is a non-contacting device with a focal distance of 76 mm (distance between the lens and the disc edge) with a k-type thermocouple output. The pyrometer is used to monitor and control the temperature in the enclosure.

# TE 99/LCA Line Contact Adapter

Sample holders for running tests with piston ring and cylinder liner on the TE 99/R Reciprocating Adapter. This incorporates a self-alignment mechanism to ensure face contact is maintained.

# TE 99 UNIVERSAL WEAR MACHINE

## Technical Specifications

| | |
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| Rotational Speed: | 20 to 2,000 rpm |
| Equivalent Sliding Speed: | 0.05 m/s to 8 m/s |
| Radius of Test Track: | 0 to 38 mm |
| Dead Weight Loading Range: | 5 to 2,000 N |
| Friction Force: | 0 to 50 N and<br>0 to 1,000 N |
| Wear Measurement: | Linear Potentiometer 0 to 2.5 mm<br>Resolution better than 2 µm |
| Contact Potential: | 40 mV dc signal |
| Temperature Sensing: | k-type thermocouples |
| Disc Specimen: | 75 mm diameter x 8 mm thick |
| Pin Specimen: | 8 mm diameter |
| Ball Specimen: | 6 mm diameter |
| Motor: | 2.3 kW ac vector |
| Interface: | Phoenix Tribology USB micro-controller interface |
| Software: | COMPEND 2020 |

## TE 99/R Reciprocating Plate Adapter

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| Stroke: | 0 to 110 mm (continuous variation) |
| Frequency: | 0.5 to 15 Hz<br>1 Hz max. at 110 mm stroke<br>5 Hz max. at 50 mm stroke<br>15 Hz max. at 2 mm stroke |
| Heating Power: | 800 W |
| Temperature: | ambient to 400°C |
| Plate Dimensions: | 120 mm x 40 mm x 3 mm thick |

## TE 99/HT Heating & Temperature Sensing Package

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|---|---|
| Temperature Range: | up to 400°C |
| Air Heating Power: | 2.8 kW |
| Temperature sensing: | Optical Pyrometer |

## TE 99/LE Lubricant Enclosure

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| Bath Volume: | 150 ml |

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| Heating Power: | 400 W |
| Temperature Range: | ambient to 200°C |

## TE 99/LS Lubricant Recirculating System

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

### Automatically Controlled Parameters

Rotational Speed
Temperature
Test Duration

### Manually Controlled Parameters

Load

### Measured Parameters

Rotational Speed
Wear
Friction Force
Temperatures
Contact Potential
Number of Revolutions
Test Duration
Sliding Speed
Friction Coefficient
Sliding Distance

## Services

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| Electricity: | 220/240V, single phase, 50 Hz, 7.5 kW<br>110/120 V, single phase, 60 Hz, 7.5 kW |

## Installation

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| Floor-standing: | 900 mm wide x 600 mm deep x 1,200 mm high, 250 kg |
| Control cabinet: | 530 mm x 800 mm x 300 mm high, 20 kg |