

# Electrical Contact Resistance (ECR)

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The ECR (Electrical Contact Resistance) is an add-on to the standard MTM2 system. The electrical resistance is measured between the disc and the upper specimen (ball, pin or roller).

An electrical potential is applied to the ball. When the upper specimen is fully separated from the lower specimen (disc), the ECR reading will be 100%. When direct metal-to-metal contact is made between the specimens, the contact will be a short circuit and the ECR reading will be 0%.

During a test, the lubricant between the specimens is normally non conductive, therefore the ECR signal (value between 0 and 100%) gives an indication of the surface interaction between the specimens. This is particularly useful when studying additive performance in the mixed and boundary lubrication regimes. The ECR signal has proven valuable in the study of scuffing by detecting the sudden film collapse at the onset of scuffing. Outputs electrical contact resistance between a metal ball and disc – Settings available are 10 $\Omega$ , 100 $\Omega$ , 1K $\Omega$ , 10K $\Omega$

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## Supplied Parts

Mechanical - Slip rings, connectors, brushes

Software - MTM ECR Software

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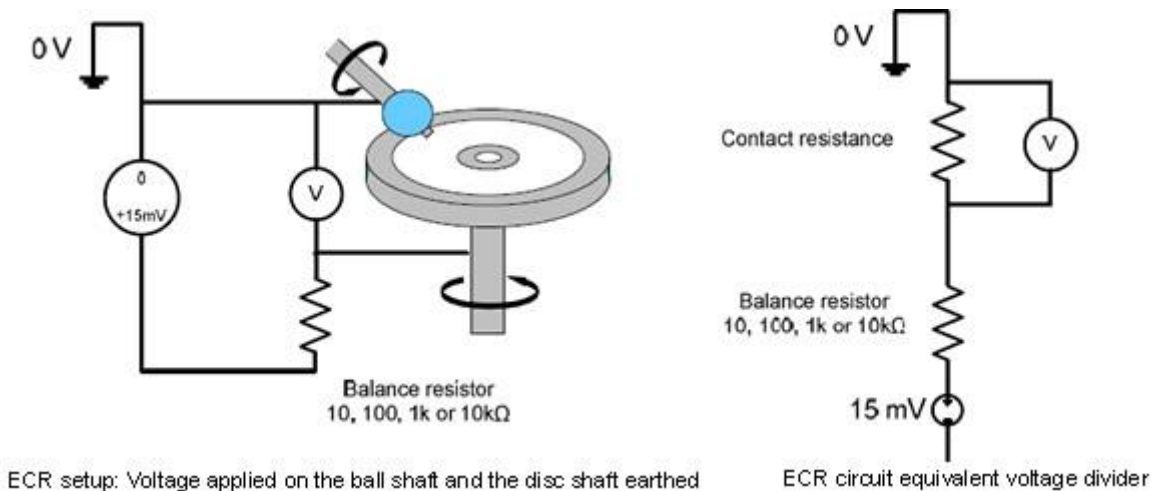
## How does the ECR option work?

A balance resistor is placed in series with the ball-disc contact and an electrical potential of approximately 15mV is applied across both. The contact resistance and balance resistor then act as a voltage divider.

When the ball and disc are fully separated, (open circuit) the voltage at the disc will be the same as the applied voltage (15mV), so the potential across the balance resistor will be 0V. This will represent 100% film.

When the ball and disc are in direct metal-to-metal contact, the voltage at the disc will be 0V, since this is a short circuit to ground. The entire voltage drop (15mV) will therefore occur across the balance resistor. This will represent 0% film.

The schematics below show the ECR set up on the MTM and the equivalent circuit:



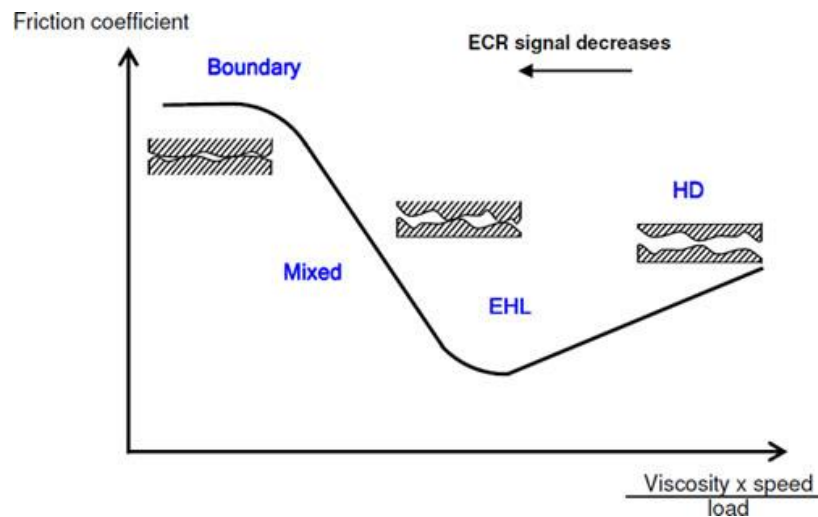
### ECR schematic for the MTM

## Contact resistance

The contact resistance is a function of:

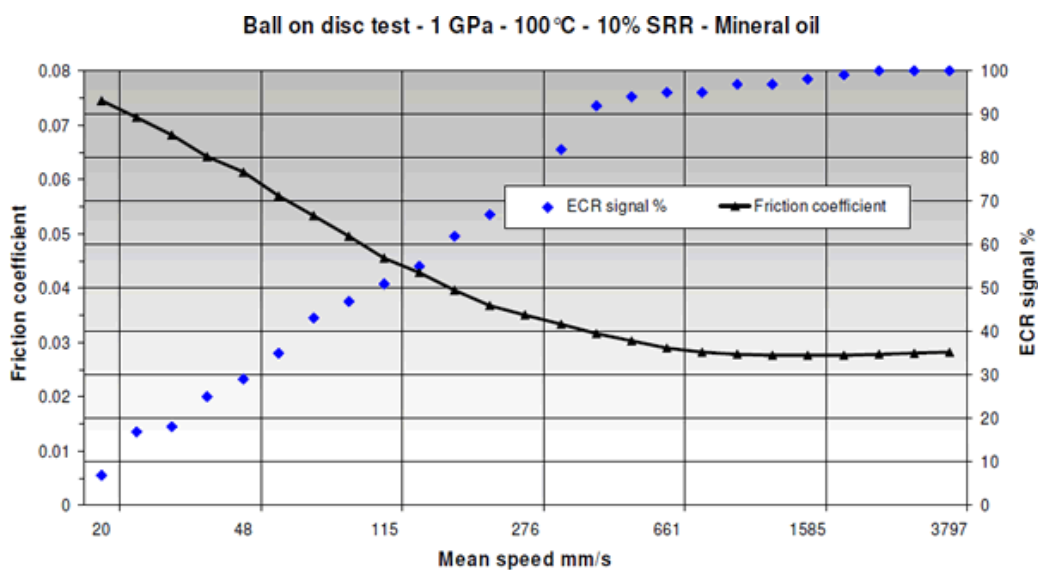
- The contact area: the smaller the area, the greater the resistance so the higher the ECR reading. The contact area is dependant on the specimens' geometry and material (Young modulus) as well as the applied load.
- The inherent electrical resistance of the materials in contact
- The inherent electrical resistance of the lubricant
- The film thickness/asperity interaction. This is directly related to the lubrication regime of the contact.

The plot below is a Stribeck curve with illustrations of the lubrication regimes. When the entrainment speed and/or viscosity are high (hydrodynamic HD and elastohydrodynamic EHL lubrication regimes), the surfaces in the contact are fully separated by the lubricant film. The ECR reading will be equal (or close) to 100%. As the speed and/or viscosity decrease, the film thickness decreases and the contact enters the mixed lubrication regime: where surfaces asperities are only separated thin surface boundary films. With increasing asperity/boundary film contact the ECR reading drops.



### Typical Stribeck curve

The graph below shows a MTM2 result for a 'Stribeck' type of test using the ECR set up.



### MTM2 result for a 'Stribeck' type of test using ECR set up

## Specimens and Applications

The standard MTM specimens are a disc and a  $\frac{3}{4}$ " ball both made of steel. However other materials and geometries are available and compatible with the ECR set up. Some compatible materials that PCS Instruments can supply are: copper, bronze, aluminium, tungsten carbide.

### Study of additives

When testing in the mixed or boundary lubrication regime, the ECR readings give an indication of asperities interactions and therefore can be used to compare the effect of different additives concentrations or packages.

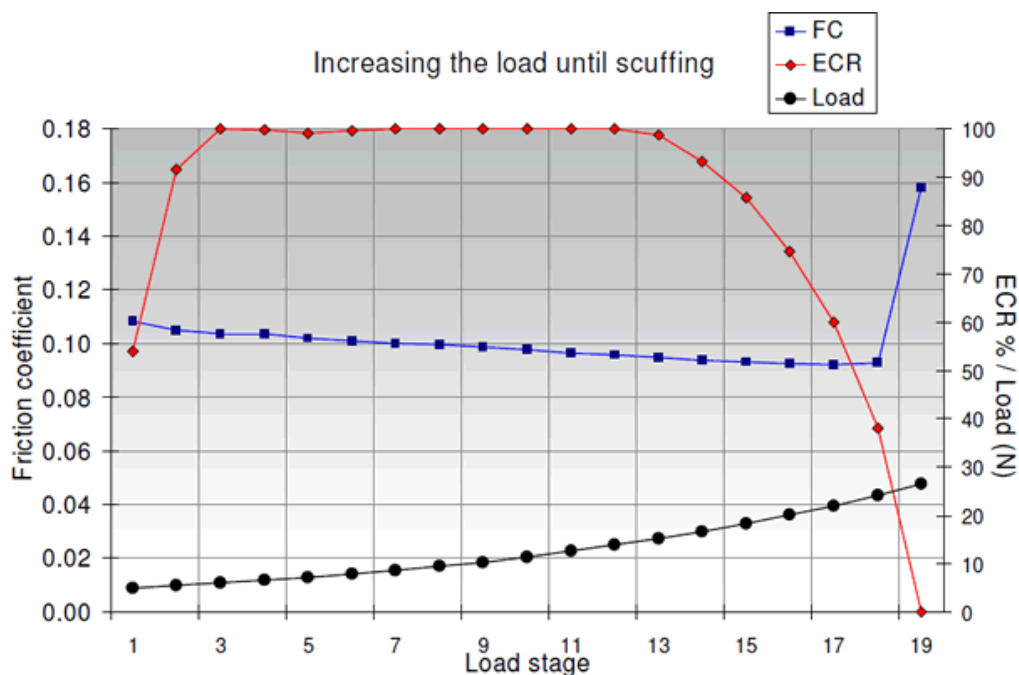
### Scuffing test / study of starvation

The ECR can be used to detect the sudden film collapse at the onset of scuffing. Scuffing can occur:

- Under high load and/or high sliding conditions for a fully flooded contact
- In a contact starved of lubricant

### Example of results

Below is an example of results obtained running a scuffing test procedure: the speeds are kept constant while the load increases in stages. The graph plots the friction coefficient (left axis) versus the load stage as well as the ECR signal (%) and load (N) on the right axis. Each point on the graph is the average value over each 1 min period. When the load reaches 20 N, the ECR signal drops dramatically until scuffing happens, as shown by the sudden increase in friction.



## MTM2 results obtained running a scuffing test procedure