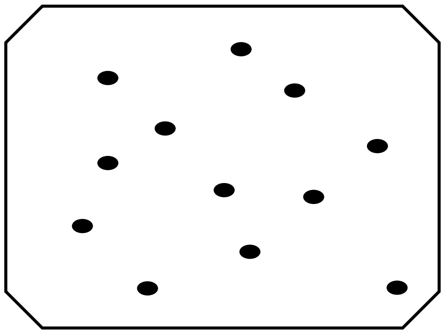
# Surface film

During operation a protective film or patina is automatically formed on the surface of the slipring which plays a very important role in conducting the current and lowering the friction reducing brush wear to the lowest possible level. The film is essential to ensure optimum operation of the brushes.

This very thin film, only about 20 Å (2 x $10^{-7}$cm) thickness consists of:

- oxide of the slipring material
- moisture (water)
- graphite



Conducting spots

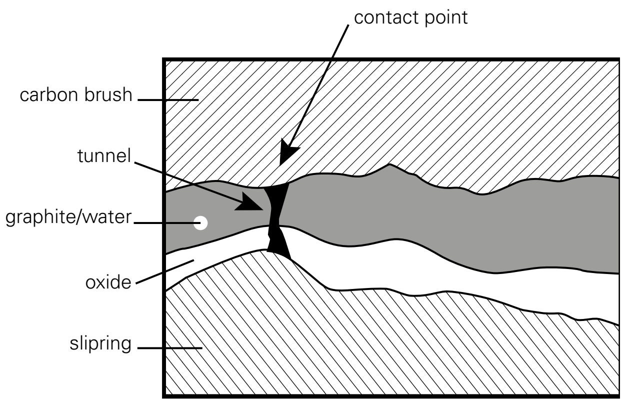
## Current flow

The flow of the current from the carbon brush to the ring is through a small number of contact points which carry the full current load. The contact points are balanced by an equilibrium between the tendency of the brush and collector surface to oxidize and the abrasion of the brush against the slipring surface.

There is a thin layer of oxide and moisture between the sliding surfaces through which current passes by means of a 'tunnel' effect arising through metallic adhesion and film breakdown. Shear forces or oxidation result in eventual breakdown of these contact points. New contact points are constantly being formed and eroded across the brush face.

Thus we can say that the current flow between a carbon brush and slipring occurs through a constantly changing, small number of contact points.

The basic elements of the film, which are oxide, water and graphite, will now be further discussed.



# Surface film (continued)

## Oxide

An oxide film on steel is more porous, more abrasive, and forms faster than on copper.

The speed of oxide formation depends on the temperature, current and specific atmospheric contaminants.

### Temperature

At a higher temperature the slipring material tends to oxidise faster than at a low temperature.

The best ring temperature during operation is 60 - 90 °C. It is also very important that the temperature is the same across the whole surface of the slipring.

Different temperatures not only cause different thickness of oxide layers, but also affects the current distribution between brushes.

Therefore the cooling air of the slipring compartment has to flow in such a way, that the same cooling properties are achieved across the slipring surface.

Sometimes air turbulence is created by obstacles in the airflow path. Because of this, part of the ring becomes less cooled than others. As a result ring wear, selective action, or even worse burnt cables can be the result.

The temperature rise of the slipring is approx. 90% caused by the friction and only 10% by electrical losses.

### Current

The ionised metal gas that conducts the current in a conducting spot transforms into a little bit of oxide. This is how in general, oxide formation is improved when the current density is higher.

On cathodic or negative brushes this effect is much stronger due to electrolysis. On positive brushes the current causes a roughening of the slipring surface.

This will be further discussed in paragraph 3, polarity effect on the film.

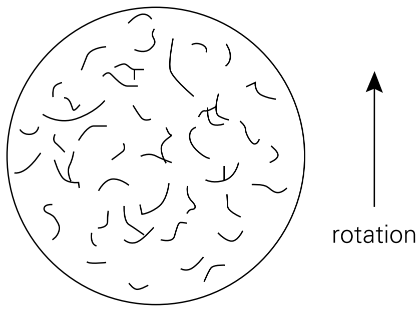
### Contaminants

The presence of oil, dirt, dust, smoke, silicones in free form or oxidising gases can reduce or increase the formation of the oxide layer. More details are given in paragraph 9, inspections and maintenance.

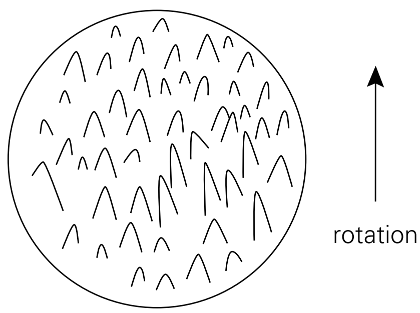
## Graphite

Studies show that the graphite layer plays the major role in reducing friction and wear in addition to improving contact.

The graphite particles fill the recesses on the slipring surface, in a layered or shingled manner. They have a random oriented structure next to the metal and a cone pointing orientation 10 – 20 degrees in the direction of sliding on the sliding surface. The layers are held together by adhesive forces which are higher than the friction force between the brush and the ring, provided that there is enough moisture on the sliding surface.




Graphite near slipring




Graphite near sliding surface

## Humidity

Another important ingredient in the film is water, which lowers friction. The humidity in the air normally provides this water which is needed to reduce the friction to an acceptable low level.

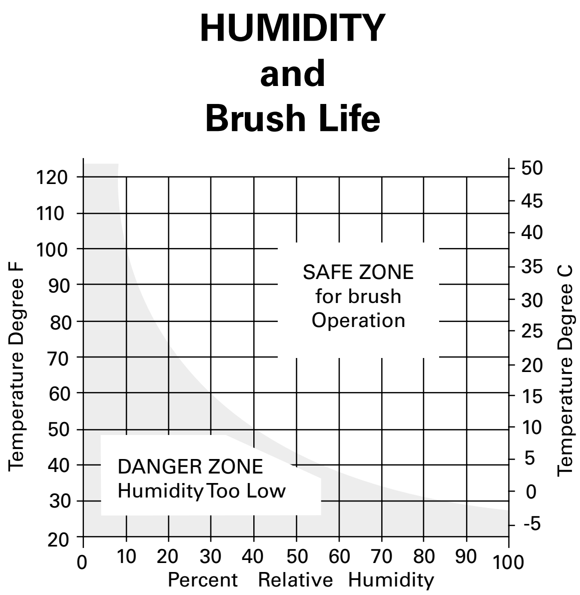
In very low temperature conditions the absolute humidity of the air will be too low.

This will cause high brush wear and increase ring temperature.

If the absolute humidity drops below 4.5 g/m3 (grams/cubic metre) friction will increase, causing severe brush problems.

If humidity exceeds 25 g/m3 over filming may occur.

The absolute humidity can be found using the following chart.




**The curved line represents 2 grains of water per cubic foot dry air or 4.6 grams per cubic meter.**

In those cases where low humidity causes problems, humidifiers are used in the cooling air intake system.