TECHNICAL DATA SHEET

PRESSURE ON CARBON BRUSHES

01 - BASIC PRINCIPLES

The **pressure exerted** should be **sufficient to ensure continuous contact** of the brush on the slip ring or commutator under all working conditions of the machine.

A poor contact between the brush and the slip ring or commutator is one cause of sparking under the brush. This sparking causes damage to the commutator or slip ring and accelerated brush wear (see TDS-14 about sparking at brush).

This basic principle leads to the following logical consequence.

The optimum brush pressure is a combination of both electrical and mechanical considerations (see also our TDS-15 on brush wear). Since the requirements of these considerations are often contradictory, the suitable pressure is, therefore, a compromise (Fig.1).

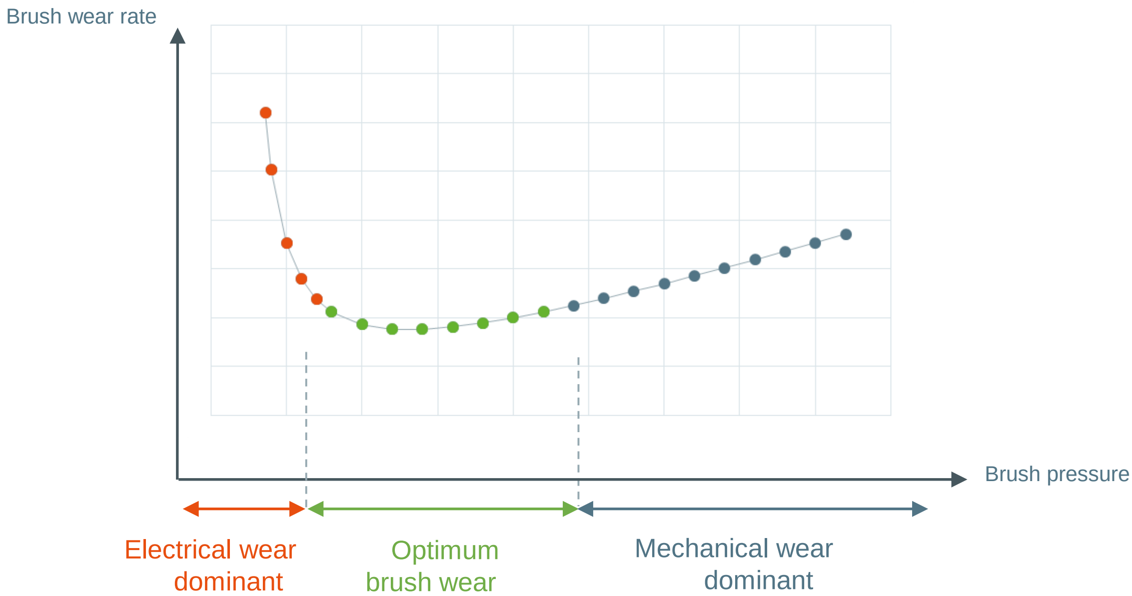


Figure 1 – Brush wear as a function of brush pressure

For machines which are:

- subject to shocks and vibrations (such as traction motors, motors for propellers, exciters, etc.),
- or machines with poor stability (unbalance, out of round),

the brush spring pressure should be increased to prevent the additional risks of interruption of contact with commutator or slip ring.

MECHANICAL CONSIDERATIONS

The **mechanical losses**, and therefore the temperature and wear of brushes, **increase** with the pressure.

The **maximum tolerable pressure** for a brush **depends on the hardness of the material**. Recommended brush pressure depending on grade family is presented in table 2.

All fragile (or soft) brushes are eliminated from applications requiring high pressure (i.e. higher than 22.5 kPa). In the group of unsuitable grades one would find particularly the natural graphite grades (LFC).

The above considerations proves the advantage of brush holders with stable pressure or at least brush pressure systems which guarantee a low variation of brush pressure during the life of the brush.

ELECTRICAL CONSIDERATIONS

The **contact voltage drop** under the brush **decreases when the pressure is increased**.

It should not be considered as insignificant. For an electrographitic brush (at 10 A/cm² and 30 m/s) it can reach 30 % when the pressure goes from 15 to 55 kPa.

Note: It shall be noted that the coefficient k_p allows to evaluate the voltage contact drop ΔU_P (in mV) for a given pressure P (in kPa) from a reference pressure P_0 (for instance 15 kPa), by following formula:

$$\Delta U_P = k_P \times \Delta U_{P0}$$

where:

ΔU_{P0} is the voltage contact drop at the reference pressure P_0 in mV.

k_p is always lower than 1 and is not a constant coefficient: its value decreases faster for lower pressures than for higher pressures. The table below gives some values of this coefficient resulting from laboratory tests carried out on an electrographitic brush at 10 A/cm².

P (kPa)	15	25	35	45	55	65	75
k_p	1	0.90	0.82	0.76	0.71	0.67	0.64

Table 1 - Values of coefficient k_p according to brush pressure for a standard EG grade at 10A/cm²

The effect is extremely important especially for commutators with large chamfers on the bar edges (increased spacing compared with the useful width of the bars), as for slip rings with helical grooves.

It shall be noted that for a DC machine, the commutating properties of the brush therefore decrease when the pressure increases.

02 - SPECIFIC SPRING PRESSURE

Specific brush pressure *p* is the force applied on brush per unit of area. It can be easily calculated from the force and brush section by the formula:

$$p = \frac{F_r}{t \times a}$$

where:

F_r is the force exerted by the pressure system, in grams (respectively cN).

t and *a* are the tangential and axial dimensions of the brush, in cm.

Specific brush pressure is given in g/cm² (respectively cN/cm²).

REMARKS

- The surface considered as the basis of calculation for the pressure indicated above does not take into account the empty space under the brush (that is to say: space between the bars of the commutator, helical grooves of slip rings, oblique saw cuts in the contact faces of the brushes for rings without groove) but only the cross section of the brush.
- It should be noted that in the case of grooved slip rings, the contact surface should be reduced by the width of the groove under the brush. The formula of specific brush pressure p becomes:

$$p = \frac{F_r}{t \times (a - k \times b)}$$

- For bevelled brushes the pressures are calculated from the cross section and the real surface of the contact face is generally not used for the base of calculation.

  Nevertheless it shall be taken into account when calculating mechanical losses (see TDS-05).
  For a brush with a contact bevel angle α (see TDS-04), *p* is given by the formula:

$$p = \frac{F_r}{t \times a \times \cos \alpha}$$

03 - RECOMMENDED SPECIFIC PRESSURE

Recommended specific pressure P for each grade family		Slip ring	Commutator	
			Stationary machines	Traction machines
Carbographitic (amorphous or hard)			18 – 20	
Electrographitic		18 – 20	18 – 20	36 - 45
Resin impregnated electrographitic		*	18 – 20	36 - 55
Soft graphitic		11 – 20*	13 – 18	
Metal-graphite	rated speed	18 – 20	*	15 – 17.5**
Metal-graphite	speed < 1m/s	25 – 27		

Table 2 - Recommended spring-pressures (in kPa) under normal operating conditions

* Please consult us
** For forklift motors

Note about units: 1 kPa = 10 cN/cm², which is approximatively 10 g/cm² (1kgF=9.81N), 1.500 PSI

04 - BRUSH PRESSURE MEASUREMENT

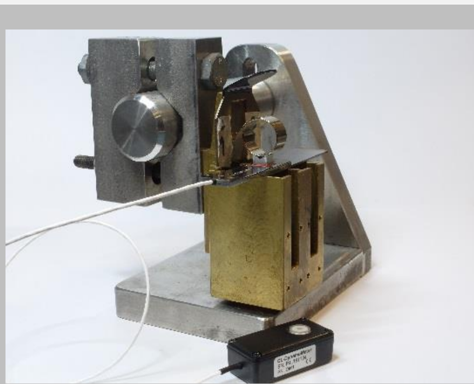
Periodic measurement of brush pressure, by a spring balance or a load-cell (dynamometer), is strongly recommended (see also our Maintenance Guide).

Different methods for measurement of the force exist, one of them is disclosed by the IEC Technical Report IEC 61015.

Pressure shall be roughly **similar for all brushes** to ensure a good current distribution. Uneven brush pressure between brushes may cause specially an uneven distribution of current on the same arm (on commutator) or same ring, and overloading on some individual brush. The result may be uneven brush wear, brush damage (over-heated flexibles, tamping failure…) with associated grooving of tracks.

A relative difference of 15% maximum is acceptable.

List of citations:
IEC 61015/TR: "Brush-holders for electrical machines – Guide to the measurement of static thrust applied to brushes“
Mersen Maintenance Guide : “How to maintain carbon brushes, brush-holders, commutators and slip rings”
TDS-03: Chamfering of commutator bar edges - Machining of ring helical grooves
TDS-04: Dimensions of carbon brushes and brush-holders
TDS-05: Losses in carbon brushes
TDS-14: Brush sparking
TDS-15: Brush wear



CL-DynamoMeter used with V-block magnetic foot

Contact: info.ptt@mersen.com