TECHNICAL GUIDE

# CARBON BRUSHES
## FOR MOTORS AND GENERATORS

MERSEN

# Contents



# What is a carbon brush?

## (also called “motor brush”)

A carbon brush is a **sliding contact** used to transmit **electrical current** from a **static to a rotating part in a motor or generator**, and, as regards DC machines, ensures a spark-free commutation.

A carbon brush can be:
- Made of one or more carbon blocks
- Equipped with one or more shunts / terminals

Five brush grade families are used for brush manufacturing. Each of them corresponds to a specif c requirement and has its own production process (see pages 9 to 17 of this guide).



## Operating parameters

The carbon brush plays an essential part in the operation of electrical machines. To enable it to fulf ll its function, we need to consider three types of parameters:
- **Mechanical**
- **Electrical**
- **Physical and chemical (environment)**

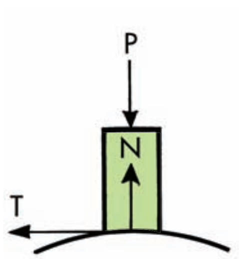
Considering those parameters, together with technical information supplied by your teams, our experts will be able to select the most suitable carbon brush grade for your application. Our teams will also advise you how to optimize the parameters of your electrical machine and to improve the maintenance operations. This joint effort between your company and Mersen will contribute to the performance and longevity of your equipment.
For more information please refer to **Technical Data Sheet AE-TDS/01*,** “Functions of a good carbon brush, what you should know”.

### Mechanical parameters

#### SLIP RING AND COMMUTATOR SURFACE CONDITIONS (ROUGHNESS)

A proper slip ring or commutator roughness will give the carbon brush an adequate seating base and will ensure a good current transmission (See **Technical Data Sheet AE-TDS/02***).
Slip ring and commutator surfaces must be neither too smooth (glossy), nor too rough to enable optimal carbon brush performance.
High mica often creates serious problems for brushes. Commutators therefore have to be carefully checked (correct mica undercutting, absence of burrs along the bar edges) and the bar edges have to be properly chamfered (See **Technical Data Sheet AE-TDS/03***).
It is also necessary to check that the commutator or slip ring run out does not exceed acceptable limits.

*More information can be obtained from our Technical data sheets, sent upon request, and also available from our web site **www.mersen.com**




$$\mu = \frac{T}{N}$$



### FRICTION COEFFICIENT (CALLED " μ ")

Carbon brush friction coeff cient "μ" has to be low and stable over time to allow the carbon brush to work without overheating.
"μ" has no f xed value. It is the result of many factors depending upon the carbon brush grade, speed, load, commutator (or slip ring) condition and environment.
For a given carbon brush grade, it is not possible to indicate a precise "μ" value, only a magnitude. This is suff cient for most machine calculations or projects.

**"μ" friction coeff cient calculation formula**
The "μ" friction coeff cient is the relationship between T (tangential force due to friction) and N (normal force)

### VIBRATION

Excessive vibration reduces the quality of the carbon brush / commutator or carbon brush / slip ring contact, and therefore the overall performance of your equipment.

Vibration can be caused by:

- Poor machine balancing, defective bearings, incorrect alignment
- Commutators in poor condition (e.g. deformed)
- External components of the machine itself (gears, coupling, drive equipment, loads)
- Very high or f uctuating friction resulting from an unsuitable carbon brush grade, polluted atmosphere, extended periods of underload, or insuff cient roughness (glazed surface)
- Moving machinery (locomotive, mine truck…)

Extreme vibration is likely to cause major brush damage as well as destruction of the brush-holder and associated commutator or slip ring.
These incidents may be minimized, if not eliminated, by proper brush design and regular maintenance of the electrical machine.

### CARBON BRUSH PRESSURE ON A SLIP RING OR COMMUTATOR

At any given machine speed, the spring pressure must be sufcient such that proper contact between the carbon brush and the slip ring / commutator is maintained. (See **Technical Data Sheet AE-TDS/11***).

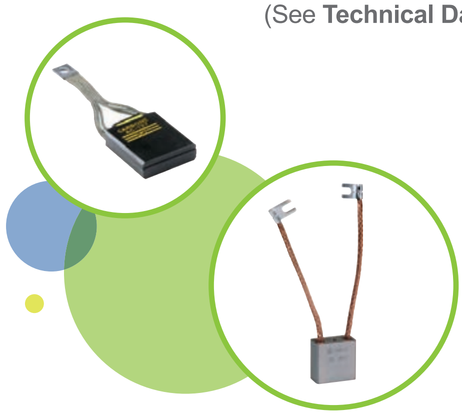
Mersen recommends:

- For stationary electrical machines: 180 - 250 g/cm² (2.56 - 3.56 psi)
- For electrical machines under heavy vibration (e.g. traction motors): 350 - 500 g/cm² (5.00 - 7.11 psi)

Equal spring pressure must be maintained for all carbon brushes to ensure a good current distribution. We therefore advise **periodic pressure measurement** with a scale or a load cell.

### BRUSH-HOLDERS

The carbon brush has to be guided by a brush-holder of suff cient height and with an adequate clearance to avoid either the brush getting stuck or the brush rattling in the holder. Tolerances and clearances are set by the International Electrotechnical Committee (I.E.C.). (See **Technical Data Sheet AE-TDS/04***).



*More information can be obtained from our Technical data sheets, sent upon request, and also available from our web site **www.mersen.com**

## Electrical parameters

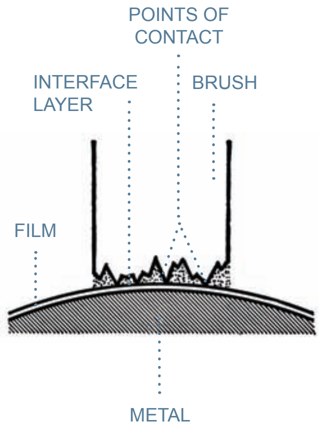
### VOLTAGE DROP (OR CONTACT DROP)

The voltage drop has to be **moderate** to avoid overheating and abnormal electrical loss which can damage the sliding contact. It also inf uences commutation and current distribution in between the carbon brushes.
This is an important characteristic which depends on the**carbon brush grade, electrical contact** and **f lm** (which is a complex mix of metal oxides, carbon, and water, deposited on the slip ring or commutator).

It is therefore to be expected that the contact drop is in f uenced by all the factors which may modify the f lm:

- Room temperature, pressure and humidity
- Environmental impurities
- Commutator / slip ring speed
- Pressure applied on the carbon brushes
- Transverse current

The contact drop data indicated for each of the Mersen carbon brush grades are **typical values obtained in specif c operating conditions**. They are grouped into f ve categories ranging from “extremely low” to “high” (see pages 13 to 15 of this guide).




### COMMUTATION (DC MACHINES)

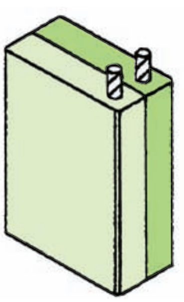
**What is Commutation?**
Commutation is the process of reversing the direction of the f ow of current in the armature coils under the brush of a DC/AC commutator motor or generator.
The **time of commutation** is the time taken for complete reversal.

Incorrect adjustment of the brush position relative to the neutral zone, or asymmetrical brush arm adjustment, can generate commutation sparking, which should not be confused with other types of sparking due to:

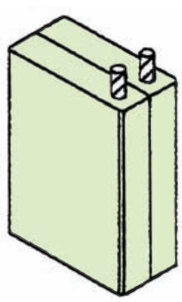
- Mechanical causes (vibration)
- Winding faults (open or short-circuit)
- Poor commutator construction
- Quality of the DC supply (ripple or spikes) from the electronic static converters…

Some solutions can help to improve commutation:

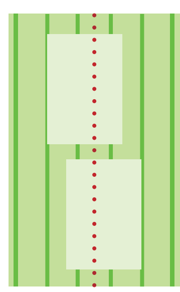
- **Multi wafer carbon brushes**
- **Dual grade composite carbon brushes** (with wafers made of different grades)
- **Sandwich brushes** (with two layers of the same grade), which limit cross currents, and have a positive inf uence on f lm control. The wafers are glued. (See **Technical Data Sheet AE-TDS/07***)
- **Staggering carbon brushes**, adapted for large slow machines (See **Technical Data Sheet AE-TDS/09***)



MULTI WAFER BRUSH



SPLIT BRUSH



STAGGERING BRUSHES
..... Neutral line

*More information can be obtained from our Technical data sheets, sent upon request, and also available from our web site **www.mersen.com**

## DISTRIBUTION OF CURRENT IN THE BRUSH CONTACT SURFACE

Current does not f ow uniformly across the whole brush contact surface. It f ows through a varying number of very small areas called contact spots. Ideally these contact spots are evenly distributed.
**This balance may be disrupted** when the contact spots concentrate and decrease in number. The f lm will then show signs of grooving, bar marking, streaking, and electrical erosion, deteriorating over time.

Various factors can cause this **imbalance:**

- External agents (dust, vapors, excessive humidity, temperature)
- Unsuitable brush grades for the operating conditions (f lm too thick, current density too high or low, poor ventilation…)
- Unequal spring pressures causing unequal current distribution between brushes of the same polarity on commutators and between brushes on the same slip ring.

## CURRENT DENSITY

**What is current density?**
This is the ratio of the current to the cross-sectional area of the brush.
Its symbol is $J_{Brush}$.

$$J_B = \frac{I}{S \times N_P}$$

I = the armature or rotor current f owing through the machine (Amps)
S = carbon brush cross-sectional area (cm² or in²)
$N_P$ = number of carbon brushes (half the number of carbon brushes for a DC machine)
or number of carbon brushes per slip ring for a slip ring machine

Current density has a major inf uence on all aspects of brush performance: wear, friction, and temperature.
The maximum current densities for each grade are those at rated speed. They can vary, however, depending on the machine's characteristics and the ventilation method.
Please note that a low current density can be more harmful to the carbon brush and commutator / slip ring than a high current density (please contact us for more information).

## RESISTIVITY

**What is resistivity?**
The **resistivity** of a material, usually symbolized by the Greek letter *rho (ρ)*, represents its resistance to the f ow of electrical current.

Higher resistivity materials increase the overall resistance in the commutation circuit, thereby improving commutation. It is a key parameter in the choice of the suitable carbon brush grade (please contact us for more information).
Multi wafer brushes, especially sandwich brushes, enable an artif cial increase of transverse resistivity and can improve commutation.

***Note***
Resistivity values for brush grades indicated in this guide are measured along the radial direction (please refer to page 18 of this guide for the def nition of the radial dimension).

## Physical and chemical parameters (environment)

### HUMIDITY

Water, the essential component of commutator or slip ring f lms, is supplied by ambient air. The f lm will form best in a humidity range of 8 to 15 g / $m^3$ (0.008 to 0.015 oz/ft3) of air (See **Technical Data Sheet AE-TDS/17***).

In **very dry air,** the f lm consists mostly of metal oxides, causing high friction and brush wear These unfavorable conditions become critical when the absolute humidity rate falls below a threshold of 2 g / m3 (0.002 oz/ft3) of air.

**This may be the case for:**

- Aerospace and space industry, where machines are likely to operate in rare f ed atmospheres at high altitudes
- Machines with brushes working in an enclosuref lled with dry gas (hydrogen or nitrogen)
- Totally enclosed motors (IP 55)
- Desert or arctic environments (for example ski lifts)

Mersen proposes carbon brushes with special treatments for these particular applications. Do not hesitate to consult us.

### CORROSIVE VAPORS OR GASES

Even when present in low concentrations, and especially in humid conditions, corrosive vapors or gases affect and destroy the contact f lm, damage the commutator (or the ring) and consequently the carbon brushes.

**Examples of corrosive vapors or gases:**

- Chlorine and its compounds (chlorate solvents)
- Ammonia
- Hydrogen sulphide
- Sulphur dioxide
- Products originating from hot distillation of silicones

Mersen's treated brushes can help mitigate these problems by creating a protective f lm on the contact surface

### OILS AND HYDROCARBONS

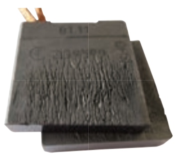
Commutators, slip rings and carbon brushes can get contaminated by oils and fats from various origins:

- Leaks from a bearing which is not properly sealed
- Tiny drops or mist carried by ventilating air
- Vapor condensation (developed at hot points)

These oily contaminations disturb the operation of carbon brushes in electrical machines, leading to the:

- Immobilization of brushes in their holders by the sticky mixture of oil and carbon dust
- Deterioration of slip rings, commutators and brush performance as a result of thick insulating f lms on the contact surfaces

*More information can be obtained from our Technical data sheets, sent upon request, and also available from our web site **www.mersen.com**



## DUST

The more abrasive the dust, the more harmful it is. Dust causes:

- Grooving of commutators and slip rings
- High brush wear
- Carbon brush side gulling (see picture opposite), with brushes sticking in their holders
- Pollution of machines

Dust grooves partly avoid these problems, but the best remedy is prevention, providing clean f ltered air to the machines.
In totally enclosed machines, where carbon dust is continuously recirculated, the same problems are likely to arise, with the possibility of polluting the machine and decreasing its insulation resistance. These machines should be cleaned regularly.

Mersen is able to design and supply a modular carbon dust collection system extracting dust at its source to refrain it from dispersing all over the machine (see box below).



## A NEW INNOVATION PATENTED BY MERSEN

**Dust extraction system integral to the brush-holder**

- No generator modif cation required
- Simple installation
- Standard product that can be customized
- A complete solution
- For original equipment or retrof t

Mersen is well aware of how vital it is to control these process parameters, and can propose maintenance services, in particular in situ diagnostics and recommendations on your machines.
See page 29 of this guide.

# Carbon brush grades

As stated in this guide's introduction, there are five main brush grade families, each with a distinct set of properties.
Some of these groups are complemented by a subgroup of impregnated brush materials (please consult us to find out more about the specific properties of those special materials).
The choice of the most suited brush grade depends on a large number of parameters linked to the machine itself as well as its environment. Choosing the brush grade that performs best for a specific application requires an in-depth knowledge of its working environment. Mersen therefore recommends contacting our experts for assistance with your specific needs.
Mersen has developed a **wide range of brush grades** able to meet even the most demanding requirements.
Hereafter, you will find a description of the manufacturing process of our main grade families, as well as a table with their material properties (see table pages 14 and 15). You will find on pages 16 and 17 a summary of the major applications together with the operating limitations of most of the grade families (based on our usual conventions reminded page 13).



## Grade families

### EG. Electrographitic brushes

**How are our electrographitic brush materials manufactured?**
Electrographitic materials are carbographitic materials that are graphitized at temperatures in excess of 2,500°C in order to transform basic amorphous carbon into artificial graphite.

#### MAIN CHARACTERISTICS

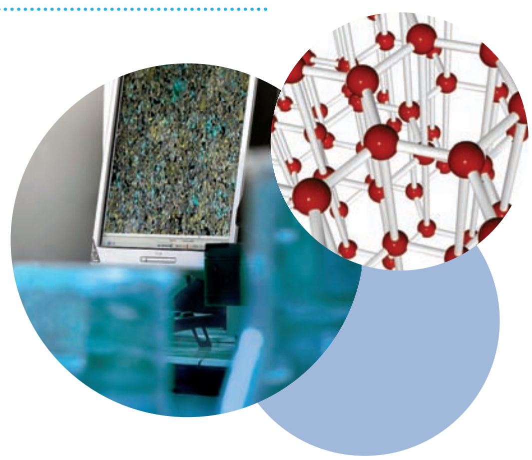
Electrographitic brushes have a medium contact drop and low to medium friction coefficient, and therefore have low electrical loss, particularly suited to high peripheral speeds (≤ 50 m/s). The graphitization process yields a high strength, low resistance material, particularly resistant to high temperatures.

#### MAIN APPLICATIONS

- All DC stationary or traction industrial machines, operating with low, medium or high voltage and constant or variable loads. They are also found on AC synchronous and asynchronous slip ring applications.

#### OPERATING LIMITATIONS

- Current density in the brushes:
  - 8 to 12 A/cm$^2$ (50 to 75 A/in$^2$) under steady conditions
  - 20 to 25 A/cm$^2$ (130 to 160 A/in$^2$) for peak loads
- Maximum peripheral speed: 50 m/s (154 ft/s).



## A. Carbographitic brushes

**How are our carbographitic brush materials manufactured?**
They are made from a mixture of coke and graphite powders, agglomerated with pitch or resin. This powder is molded into blocks which are baked at high temperature to convert the binder into coke. These materials are not graphitized.

### MAIN CHARACTERISTICS

Carbographitic brushes commutate well due to their high resistance and provide good polishing action, while maintaining moderate contact drop. As a result of their high temperature treatment, carbographitic brushes can withstand both high temperatures and variable loads.

### MAIN APPLICATIONS

- Machines with an older design, mostly characterized by a slow speed, lack of interpoles, generally operating at low voltage
- Modern small machines, operating with permanent magnets, servomotors, and universal motors
- Low voltage battery powered motors

### OPERATING LIMITATIONS

- Current density in the brushes: 8 to 16 A/cm$^2$ (50 to 100 A/in$^2$) depending on the application
- Maximum peripheral speed: 25 m/s (82 ft/s)



## LFC. Soft graphite brushes (LFC = Low Friction Coefficient)

**How are soft graphite brush materials manufactured?**
The main ingredients are purif ed natural graphite and artif cial graphite, mixed with additives, agglomerated with appropriate binders, and treated at a high temperature to carbonize the binder.

### MAIN CHARACTERISTICS

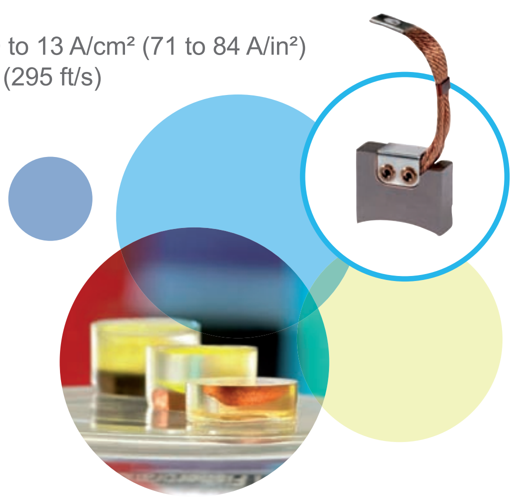
LFC brushes have a low Shore hardness with excellent shock absorbing properties. This allows them to work in applications where other materials would fail. They excel at high peripheral speeds which amplify the mechanical stresses associated with friction, vibration, air f ow, run out, and heat.

### MAIN APPLICATIONS

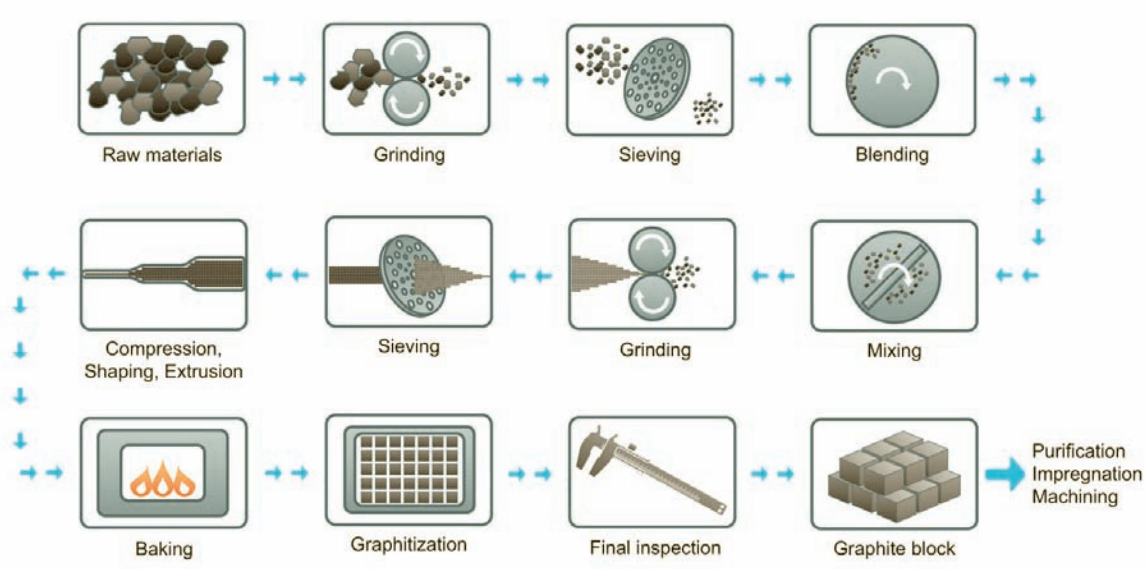
- Steel and stainless steel slip rings for synchronous machines.

### OPERATING LIMITATIONS

- Current density in the carbon brushes: 10 to 13 A/cm$^2$ (71 to 84 A/in$^2$)
- Maximum peripheral speed: up to 90 m/s (295 ft/s)



## OVERVIEW OF THE MANUFACTURE OF ELECTROGRAPHITE




## BG. Resin-bonded (bakelite graphite) brushes

**How are resin-bonded brush grades manufactured?**
Powdered natural or artif cial graphite is mixed with a thermo-setting resin.
The mix is then pressed and polymerized at a suitable temperature.

### MAIN CHARACTERISTICS

Carbon brushes with high to very high electrical resistance, contact drop, electrical loss, and mechanical strength, which have very good commutating and cleaning properties. They can also work at very low current densities.

### MAIN APPLICATIONS

- AC Schrage-type commutator motors
- Medium-speed DC machines at medium voltage

### OPERATING LIMITATIONS

- Resin-bonded grades should not be used at higher than rated current
- Admissible peripheral speed: 40 m/s (131 ft/s)

# CG-MC-CA. Metal-graphite brushes

**How are metal-graphite brush grades manufactured?**
Powdered natural or artif cial graphite is mixed with a thermo-setting resin, copper powder, and/or other metal powders. The mix is then pressed and polymerized at a suitable temperature in an inert atmosphere.

These metal-graphite materials also include EG and A carbon brushes that are metal-impregnated (see metal-impregnated brush grades on page 15).

### MAIN CHARACTERISTICS

Dense to very dense carbon brushes with low friction and very low contact drop, therefore operating with very low losses and high currents.

## (CG) Copper-based brush grades

### MAIN APPLICATIONS

- Low-speed, low voltage DC machines
- Medium-speed, highly-loaded AC asynchronous machines (wind turbine generators)
- Medium-speed AC synchronous motors slip rings
- High current collection systems (electrolytic treatment lines, wire annealers, galvanizing lines…)
- Low-voltage current collection (military, medical, paramedical, signal…)
- Special machines
- Slip ring assemblies in rotary joints

### OPERATING LIMITATIONS

- Current density:
  - 10 to 30 A/cm² (75 to 200 A/in²) under steady conditions
  - Up to 100 A/cm² (660 A/in²) for peak loads, depending on metal content
- Peripheral speed: up to 35 m/s (115 ft/s), depending on metal content

## (CA/SG) Silver-based brush grades:

Silver grades have a higher conductivity than copper grades and form a special low-resistance f lm due to the conductivity of silver oxide. Silver grades can also transfer low voltage current signals without degradation.

### MAIN APPLICATIONS

- Signal current transmission (thermocouples, thermometric sensors, regulation…)
- Pulse transmission to rotating devices (radar, prospection…)
- Tachometer generators
- Aerospace and space applications
- Shaft grounding in a dual-grade construction

### OPERATING LIMITATIONS

- Current density up to 50 A/cm² (440 A/in²).
- Peripheral speed: up to 25 m/s (82 ft/s)

# Consolidation of carbon brush grades

An increasing number of companies wish to reduce the number of brush grades and carbon brush types they currently use. Mersen will assist in meeting these expectations. For many simple applications, this is quite easy as many different brush grades will perform well.
Diff cult machines, however, will require careful preliminary examination. Mersen therefore recommends that our customers contact the Customer Technical Assistance to correctly select the brush grade to be used for each specif c case.

**Our Customer Technical Assistance Service is at your disposal for any question**

Phone: +33 (0)3 22 54 44 90 / Fax: +33 (0)3 22 54 46 08
E-mail: infos.amiens@mersen.com

Mersen is present in over 40 countries around the world; our branches are also at your disposal for local technical assistance.
You can reach our worldwide network through our website at **www.mersen.com**

## DETAILS ON CONTACT DROP AND FRICTION (SEE TABLES FOLLOWING PAGES)

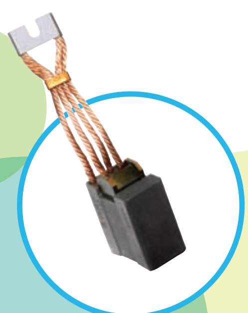
The contact drop and friction values are given in the following table:

| Symbol | Signification | Contact drop (Sum of both polarities) | Friction µ |
|---|---|---|---|
| H | High | > 3 V | µ > 0.20 |
| M | Medium | 2.3 V - 3 V | 0.12 < µ < 0.20 |
| L | Low | 1.4 V - 2.3 V | µ < 0.12 |
| VL | Very low | 0.5 V - 1.4 V | |
| EL | Extremely low | < 0.5 V | |

The contact drop and friction values were measured on a copper commutator in the following laboratory conditions:

| Elements | Contact drop | Friction µ |
|---|---|---|
| Current type | DC | DC |
| Current density | 10 A/cm² (130 A/in²) | 10 A/cm² (130 A/in²) |
| Speed | 12.5 m/s (41 ft/s) | 25 m/s (82 ft/s) |
| Spring pressure | 18 kPa (2.6 PSI) | 18 kPa (2.6 PSI) |
| Temperature | 65-70°C (149-158°F) | 65-70°C (149-158°F) |
| Brush type | radial | radial |

The current density and peripheral speed operating conditions were derived from observations on actual machines in good working order and operating in normal conditions.



## Brush grade groups main characteristics (according to IEC norm 60413)

| BRUSH GRADE GROUPS | Grades | Apparent density | Resistivity ɥΩ.cm (ɥΩ.in) | Shore hardness | Flexural strength MPa (PSI) | Contact drop | Friction | Maximum current density A/cm² (A/in²) | Upper speed limit m/s (ft/s) | Metal content % |
|---|---|---|---|---|---|---|---|---|---|---|
| EG - Electro-graphitic | EG34D | 1.60 | 1,100 (433) | 40 | 25 (3,626) | M | M | 12 (77) | 50 (164) | / |
| | EG389P | 1.49 | 1,600 (630) | 29 | 19 (2,756) | M | M | 12 (77) | 50 (164) | / |
| | L1 | 1.61 | 1,270 (500) | 35 | 21 (3,046) | M | M | 12 (77) | 60 (197) | / |
| | EG362 | 1.60 | 2,500 (984) | 35 | 21 (3,046) | M | M | 12 (77) | 50 (164) | / |
| | EG40P | 1.62 | 3,200 (1,260) | 57 | 27 (3,916) | M | M | 12 (77) | 50 (164) | / |
| | EG313 | 1.66 | 5,000 (1,968) | 50 | 21 (3,046) | M | L | 12 (77) | 50 (164) | / |
| | EG367 | 1.53 | 4,100 (1,614) | 52 | 21 (3,046) | M | M | 12 (77) | 50 (164) | / |
| | EG387 | 1.60 | 3,500 (1,378) | 60 | 31 (4,496) | M | M | 12 (77) | 50 (164) | / |
| | EG300H | 1.57 | 4,100 (1,614) | 60 | 26 (3,771) | M | L/M | 12 (77) | 50 (164) | / |
| | 2192 | 1.56 | 5,100 (2,008) | 55 | 23 (3,336) | M | M | 12 (77) | 50 (164) | / |
| | CB377 | 1.71 | 6,350 (2,500) | 75 | 29 (4,206) | H | L | 12 (77) | 40 (131) | / |
| | EG319P | 1.46 | 7,200 (2,835) | 52 | 26 (3,771) | H | M | 12 (77) | 50 (164) | / |
| | EG365 | 1.62 | 5,300 (2,087) | 40 | 15 (2,176) | M | M | 12 (77) | 50 (164) | / |
| Impregnated electro-graphitic | EG7099 | 1.72 | 1,100 (433) | 40 | 34 (4,931) | M | M | 12 (77) | 45 (148) | / |
| | EG9599 | 1.61 | 1,600 (630) | 33 | 28 (4,061) | M | M | 12 (77) | 45 (148) | / |
| | EG9117 | 1.69 | 3,300 (1,299) | 77 | 36 (5,221) | M | M | 12 (77) | 50 (164) | / |
| | EG8019 | 1.77 | 4,700 (1,850) | 77 | 31 (4,496) | M | M | 12 (77) | 45 (148) | / |
| | CB86 | 1.64 | 4,830 (1,902) | 65 | 29 (4,206) | M | M | 12 (77) | 50 (164) | / |
| | 2189 | 1.63 | 6,100 (2,401) | 60 | 32 (4,641) | M | M | 12 (77) | 50 (164) | / |
| | 510 | 1.44 | 7,100 (2,795) | 45 | 17 (2,466) | M | M | 12 (77) | 50 (164) | / |
| | 535 | 1.53 | 7,100 (2,795) | 55 | 26 (3,771) | M | M | 12 (77) | 50 (164) | / |
| | EG8067 | 1.67 | 3,900 (1,535) | 77 | 36 (5,221) | M | M | 12 (77) | 45 (148) | / |
| | AC137 | 1.72 | 5,100 (2,008) | 80 | 41 (5,947) | M | M | 12 (77) | 50 (164) | / |
| | 168 | 1.58 | 7,100 (2,795) | 65 | 36 (5,221) | M | M | 12 (77) | 50 (164) | / |
| | EG8220 | 1.82 | 5,000 (1,968) | 90 | 44 (6,382) | M | M | 12 (77) | 50 (164) | / |
| | EG7097 | 1.68 | 4,000 (1,575) | 80 | 35 (5,076) | M | M | 12 (77) | 50 (164) | / |
| | EG341 | 1.57 | 7,200 (2,835) | 74 | 34 (4,931) | H | M | 12 (77) | 50 (164) | / |
| | EG7655 | 1.70 | 5,600 (2,205) | 68 | 33 (4,786) | M | M | 12 (77) | 50 (164) | / |
| | EG6754 | 1.76 | 4,150 (1,634) | 87 | 40 (5,802) | M | M | 12 (77) | 50 (164) | / |

| BRUSH GRADE GROUPS | Grades | Apparent density | Resistivity μΩ.cm (μΩ.in) | Shore hardness | Flexural strength MPa (PSI) | Contact drop | Friction | Maximum current density A/cm² (A/in²) | Upper speed limit m/s (ft/s) | Metal content % |
|---|---|---|---|---|---|---|---|---|---|---|
| **A - Carbo-graphitic** | A121 | 1.75 | 2,250 (886) | 30 | 26 (3,771) | M | L | 12 to 20 (75 to 125) | ≤ 15 (≤ 49) | / |
| | A176 | 1.60 | 52,500 (20,669) | 40 | 20 (2,901) | H | L | 8 to 10 (50 to 65) | 30 (98) | / |
| | A252 | 1.57 | 45,000 (17,716) | 27 | 16 (2,321) | H | L | 10 to 12 (65 to 75) | ≤ 25 (≤ 82) | / |
| | M44A | 1.64 | 3,050 (1,201) | 50 | 26 (3,771) | M | M | 10 (65) | ≤ 25 (≤ 82) | / |
| **LFC - Soft graphite brushes** | LFC501 | 1.46 | 1,900 (748) | 10 | 8 (1,160) | M | L | 6 to 10 (40 to 65) | 75 (246) | / |
| | LFC554 | 1.26 | 2,000 (787) | 12 | 11 (1,595) | M | L | 11 to 13 (71 to 84) | 90 (295) | / |
| **BG - Resin-graphite** | BG412 | 1.82 | 13,800 (5,433) | / | 36 (5,221) | H | M | 8 to 10 (51 to 65) | 35 (115) | / |
| | BG469 | 1.80 | 9,450 (3,720) | / | 35 (5,076) | H | M | 6 to 8 (40 to 50) | 35 (115) | / |
| | BG348 | 1.50 | 25,500 (10,039) | / | 25 (3,626) | H | M | 8 to 10 (51 to 65) | 40 (131) | / |
| **CG - MC - Metal-graphite** COPPER AGGLOMERATED | C6958 | 2.50 | 350 (138) | / | 30 (4,351) | VL | M | 10 to 25 (65 to 220) | ≤ 32 (≤ 105) | 25 |
| | C7788 | 2.80 | 300 (118) | / | 25 (3,626) | M | M | 12 to 20 (75 to 125) | 40 (131) | 43 |
| | CG651 | 2.95 | 130 (51) | / | 30 (4,351) | VL | L | 12 to 14 (75 to 90) | 35 (115) | 49 |
| | CG626 | 2.88 | 180 (71) | / | 45 (6,527) | VL | L | 12 to 15 (75 to 100) | 30 (98) | 49 |
| | MC79P | 5.15 | 8 (3) | / | 98 (14,214) | EL | L/M | 25 to 30 (160 to 200) | 20 (66) | 83 |
| | CG657 | 4.00 | 35 (14) | / | 65 (9,427) | VL | M | 12 to 20 (75 to 125) | 30 (98) | 65 |
| | CG757 | 4.50 | 35 (14) | / | 45 (6,527) | VL | M | 16 (103) | 25 (82) | 75 |
| | CG857 | 5.65 | 7.5 (3) | / | 77,5 (11,240) | EL | M | 20 to 30 (129 to 194) | 20 (66) | 91 |
| | CG957 | 5.45 | 40 (16) | / | 110 (15,964) | EL | M | 20 to 30 (129 to 194) | 20 (66) | 87 |
| | MC877 | 5.40 | 12.5 (5) | / | 89 (12,908) | EL | M | 20 to 30 (129 to 194) | 20 (66) | 87 |
| **CA - Metal-graphite** SILVER AGGLOMERATED | CA38 | 2.55 | 250 (98) | / | 10 (1,450) | EL | M | * | 25 (82) | 33 |
| | CA26 | 3.60 | 20 (8) | / | 40 (5,802) | EL | M | * | 20 (66) | 60 |
| | CA28 | 4.00 | 40 (16) | / | 45 (6,527) | EL | M | 20 to 30 (129 to 194) | 20 (66) | 65 |
| | CA10 | 8.00 | 6.5 (3) | / | 160 (23,206) | EL | M | * | 15 (49) | 93 |
| **Metal-graphite** METAL IMPREGNATED | M609 | 2.65 | 310 (122) | 35 | 33 (4,786) | VL/EL | EL | 12 to 15 (75 to 100) | 35 (115) | 45 |
| | M673 | 1.72 | 1,180 (465) | 35 | 26 (3,771) | EL | H | 10 to 12 (65 to 75) | 40 (131) | 5.5 |
| | M9426 | 1.62 | 1,775 (699) | 24 | 20 (2,901) | VL | M | 12 to 15 (75 to 100) | 30/45 (98/148) | 9 |
| | M621 | 3.00 | 400 (157) | 34 | 35 (5,076) | EL | M | 40 (267) | 40 (131) | 44 |
| | M9020 | 1.75 | 2,700 (1,063) | 68 | 37 (5,366) | L | M | 12 to 15 (75 to 100) | 45 (148) | 5 |
| | M8295 | 1.80 | 1,775 (699) | 54 | 34 (4,931) | VL | M | 12 to 15 (75 to 100) | 30/45 (98/148) | 9 |
| | MA7696 | 3.00 | 250 (98) | / | 33 (4,786) | VL | M | 12 to 15 (75 to 100) | 35 (115) | 55 |

*Note* : 1 MPa (megapascal) = 10 daN/cm² (decanewton/cm²) and 1 kPa (kilopascal) = 10 cN/cm² (centinewton/cm²).
* Please contact us (mA low current)

# Grade selection based on application

Mersen has developed a wide range of carbon grades to meet even the most demanding applications. We recommend that our customers contact the Customer Technical Assistance to correctly select the most suitable grade for each specific application. The tables below detail brush grades most suited for different applications and operating conditions (current density peripheral speed and applied brush pressure).
For each machine group, the most common brush grades are listed.
The order of the brush grades in the table does not imply a ranking of their performance

Never mix different brush grades on a slip ring or commutator.

## "Stationary" commutator machines

| Type of current / Application | Current density A/cm² (A/in²) | Speed m/s (ft/s) | Pressure kPa (PSI) | Brush grades |
|---|---|---|---|---|
| DIRECT CURRENT | | | | |
| **Old machines without interpoles** | | | | |
| All motors | 6 (40) | 15 (49) | 18 (2.6) | EG40P - A176 - EG34D |
| **Low voltage machines (any power)** | | | | |
| Marine turbo-alternator exciters 30 to 50 V | 4 - 8 (25 - 50) | 25 (82) | 18 (2.6) | LFC3H - EG7099 - CG651 - A121 |
| Welding group generators 30 to 50 V | 0 - 20 (0 - 125) | < 20 (< 65) | 18 (2.6) | EG389P - EG367 - EG313 |
| **Industrial machines (110 - 750 V)** | | | | |
| Motors for general applications (high speeds) | 8 - 12 (51 - 77) | 20 - 45 (65 - 148) | 18 (2.6) | EG34D - EG313 - EG367 - EG389P |
| Hydro turbo-alternator exciters | 8 - 12 (51 - 77) | < 20 (< 65) | 18 (2.6) | EG34D - EG7099 - EG389P EG9599 - EG365 |
| Thermal turbo-alternator exciters | 8 - 10 (51 - 65) | 35 - 50 (115 - 164) | 18 (2.6) | EG367 - EG365 - EG9599 - EG389P |
| Pilot exciters | 2 - 5 (13 - 33) | < 35 (< 115) | 18 (2.6) | EG34D - EG389P - BG469 |
| Amplidynes | 4 - 12 (25 - 77) | 25 (82) | 18 (2.6) | EG34D - EG389P |
| Illgner and Ward Leonard generators (any speed) | 4 - 12 (25 - 77) | 20 - 35 (65 - 115) | 18 (2.6) | EG389P - EG367 - EG313 |
| Paper mill motors and generators | 4 - 12 (25 - 77) | 35 (115) | 18 (2.6) | EG34D - EG9599 - EG7099 - EG34D EG389P - BG469 - EG313 - 168 |
| Marine generators | 4 - 12 (25 - 77) | 20 - 35 (65 - 115) | 18 (2.6) | EG34D - EG389P - EG7099 - EG313 |
| Rolling mill reversing motors | 8 - 20 (51 - 125) | 0 - 15 (0 - 49) | 18 (2.6) | EG319P - EG369 - EG313 - 2192 - 535 - 510 |
| Rolling mill roughing motors | 8 - 15 (51 - 100) | 20 - 35 (65 - 115) | 18 (2.6) | EG389P - EG40P - EG319P - EG6489 EG313 - EG365 - 2192 - CB86 |
| Mine winder motors | 12 (77) | 25 (82) | 18 (2.6) | EG313 - EG365 - EG367 - CB377 |
| Totally enclosed motors | 10-12 (65 - 77) | | 18 (2.6) | EG9117 - EG8067 - EG7593 |
| ALTERNATING CURRENT | | | | |
| Single phase and repulsion motors | 8 (51) | 5 - 15 (16 - 49) | 18 (2.6) | A252 - EG367 |
| Schrage-type three-phase motors | 8 - 12 (51 - 77) | 5 - 35 (16 - 115) | 18 (2.6) | BG412 - BG469 - BG348 - EG367 |
| Schorch-type three-phase motors | 10 - 14 (65 - 90) | 5 - 35 (16 - 115) | 18 (2.6) | BG28 - BG469 - EG367 - BG348 |
| Scherbius machines | 7 - 9 (45 - 58) | 30 (98) | 18 (2.6) | EG389P - EG313 - LFC554 - EG362 |

## "Traction" commutator machines

| Type of current / Application | Current density A/cm² (A/in²) | Speed m/s (ft/s) | Pressure kPa (PSI) | Brush grades |
|---|---|---|---|---|
| **DIRECT CURRENT** | | | | |
| **Light traction** | | | | |
| All motors | 8 - 12 (51 - 77) | 40 - 50 (131 - 164) | 30 - 40 (4.4 - 5.8) | EG34D - EG7099 - EG387 - EG9599 - EG8067 |
| **Heavy traction** | | | | |
| Old motors | 10 - 12 (65 - 77) | < 45 (< 148) | < 35 (< 5) | EG34D |
| Modern motors | > 12 (> 77) | > 45 (> 148) | 35 (5) | EG300H - EG9117 - EG387 - EG8067<br>EG7097 - EG6754 - EG8220 |
| **Diesel-electric traction (locomotives and electric trucks)** | | | | |
| Generators | 10 - 14 (65 - 91) | 40 (131) | 25 (3.6) | EG389P - EG7099 - EG8067 - AC137 |
| Alternators (excitation) | 8 - 12 (51 - 77) | < 50 (< 164) | 22 (3.2) | EG34D - EG389P - L1 |
| Motors | 15 (100) | 45 (148) | 35 (5) | EG7099 - EG8067 - EG7097 - EG6754 - EG8220 |
| **Fork lift truck and hoisting motors (low voltage)** | | | | |
| Open type (handling) | 15 - 20 (100 - 130) | 10 - 25 (33 - 82) | 35 (5) | A121 - M621 - C7788 |
| **RECTIFIED CURRENT** | | | | |
| **Heavy traction** | | | | |
| Modern motors | 12 - 15 (77 - 100) | 50 (164) | 35 (5) | EG367 - EG300H - EG8067 - EG7097 - EG6754 |
| **ALTERNATING CURRENT** | | | | |
| **$16\frac{2}{3}$ and 50 Hz heavy traction** | | | | |
| Motors | 12 - 16 (77 - 104) | 45 (148) | 25 (3.6) | EG367 - E8067 - EG7097 |

## Slip ring machines

| Type of current / Application | | Slip ring material | Current density A/cm² (A/in²) | Speed m/s (ft/s) | Pressure kPa (PSI) | Brush grades |
|---|---|---|---|---|---|---|
| **Earth Return Current Units (ERCU)** | | | | | | |
| All | | Steel-Bronze | 0 - 30 (0 - 194) | 3 - 8 (10 - 26) | 35 - 40 (5 - 5.8) | MC877 - MC79P |
| **DIRECT CURRENT** | | | | | | |
| Pickling / Tinning rolls | | Bronze | 20 - 30 (125 - 194) | 3 (10) | 18 - 40 (2.6 - 5.8) | MC79P - CG957 |
| Synchronous machines (grooved or plain slip rings) | 3 000 rpm | Stainless steel | 11 - 13 (62 - 85) | ≤ 100 (≤ 328) | 13 - 18 (1.9 - 2.6) | LFC554 |
| | | Steel | 6 - 10 (39 - 65) | ≤ 70 - 80 (≤ 230 - 262) | 15 - 18 (2.2 - 2.6) | LFC501 |
| | 1 500 rpm | Steel-Bronze | 8 - 12 (51 - 77) | ≤ 40 (≤ 131) | 18 (2.6) | CG651 - CG657 (Bronze)<br>EG34D - EG389P<br>L1 (Steel) |
| | ≤ 500 rpm | Cast iron | 6 - 10 (39 - 65) | ≤ 20 (≤ 66) | 18 (2.6) | EG34D - EG389P - L1 |
| Equalizers in hydrogen | | Steel-Bronze | 5 - 8 (33 - 52) | 25 (82) | 18 (2.6) | EG34D - EG9599 - M9426 |
| **ALTERNATING CURRENT** | | | | | | |
| Asynchronous machines | Open type | Steel-Bronze | 12 - 16 (78 - 104) | 15 - 25 (49 - 82) | 18 (2.6) | CG651 - EG34D - EG389P<br>CG657 |
| | Totally enclosed type | Steel-Cupronickel | 6 - 8 (39 - 52) | 15 - 25 (49 - 82) | 18 (2.6) | EG34D |
| Motors with carbon brush lifting device | | Steel-Bronze | 25 - 30 (163 - 195) | 20 - 25 (66 - 82) | 18 (2.6) | MC79P - CG957 |
| High-speed asynchronous (pumps, ventilators) | | Bronze | 8 - 10 (52 - 65) | ≤ 50 (≤ 164) | 18 (2.6) | EG389P - EG34D - M9426 |
| Synchronous induction machines | | Bronze | 8 - 12 (51 - 77) | 15 - 40 (49 - 131) | 18 (2.6) | M673 - M9426 |
| Wind power generators | | Steel-Carbon | 12 - 15 (78 - 98) | 45 (148) | 18 (2.6) | M8295 - M9426 - CG626 |

# 03

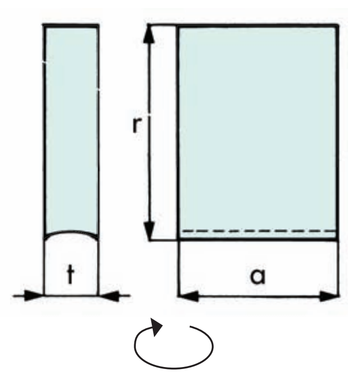
# Main carbon brush types, dimensions and hardware



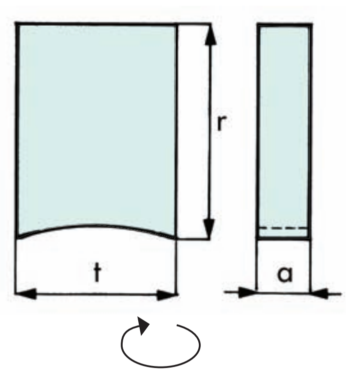
## "t", "a" and "r" dimensions

When contacting us regarding your brush requirement, please provide the following:

- Dimensions in "t" x "a" x "r" (IEC norm 60136).
  - where "t" is the tangential dimension or "thickness"
  - "a" is the axial dimension or "width"
  - and "r" is the radial dimension or "length"'.
    The "r" dimension may be for information only.
- The same rule applies whether this is a commutator or slip ring brush.
- Be careful in specifying the unit of measurement as imperial and metric units may be easily confused (1" = 25.4 mm, is not the same as 25 mm).

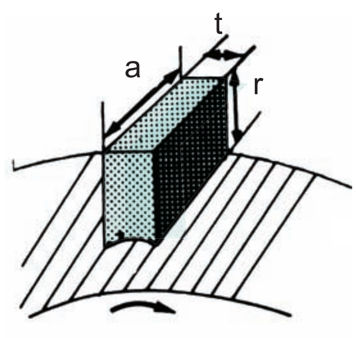



COMMUTATOR

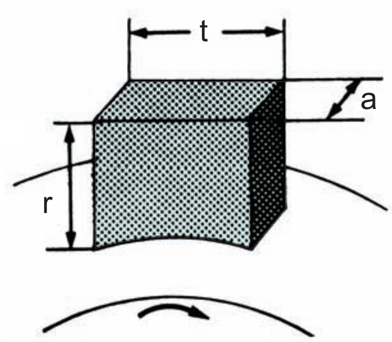



SLIP RING

## Orientation of a carbon brush on a commutator or on a slip ring




NORMAL ORIENTATION OF A CARBON BRUSH ON A COMMUTATOR

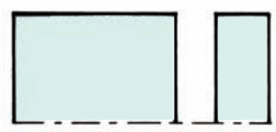



NORMAL ORIENTATION OF A CARBON BRUSH ON A SLIP RING

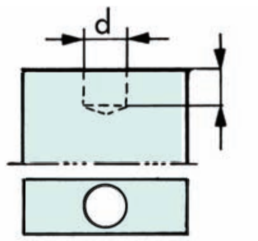
# Types of hardware

## Standard brush configurations

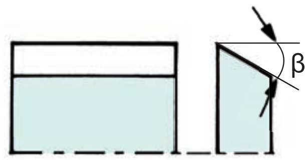
### CARBON BRUSH TOPS (COMMON SHAPES)



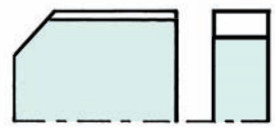
PLAIN BRUSH




GUIDING HOLE

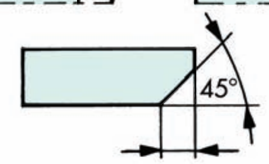



BEVELLED TOP

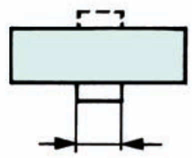


ROUNDED TOP WITH FLAT PART

### CARBON BRUSH SIDE EDGES

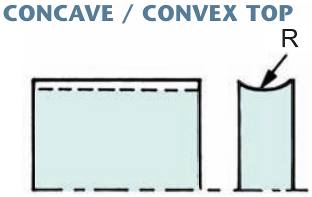



NON-REVERSING CHAMFER

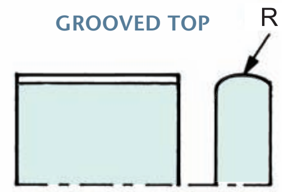


LIMIT WEAR STOP HOOK

### CONCAVE / CONVEX TOP

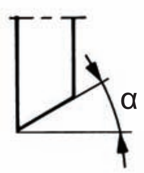



GROOVED TOP



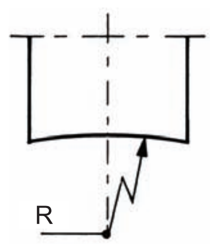

CANTILEVER TOP

### CARBON BRUSH CONTACT SURFACE

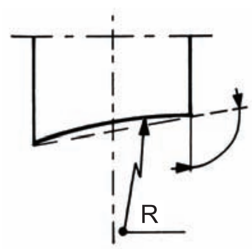



BOTTOM BEVEL

(See **Technical Data Sheet AE-TDS/16***)

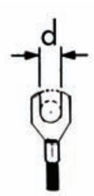



RADIUS

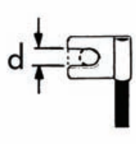



RADIUS + BEVEL

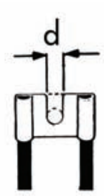
### TERMINAL TYPES AND DIMENSIONS




SPADE TERMINAL




FLAG TERMINAL

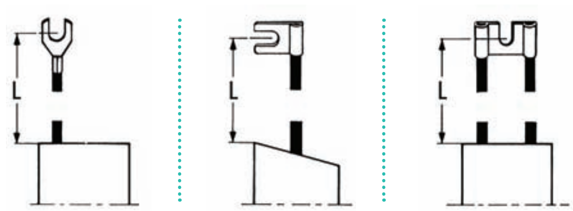



DOUBLE SHOE TERMINAL

**Slots and holes dimensions**

| bolt ø (mm) | 3 | 4 | 5 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| d (mm) | 3.4 | 4.3 | 5.2 | 6.5 | 8.5 | 10.5 |

### SHUNT LENGTH

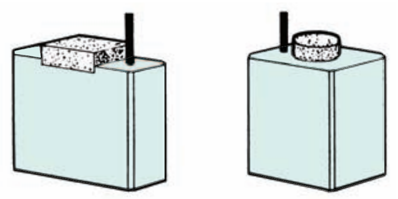



**Standardized values L (mm)**

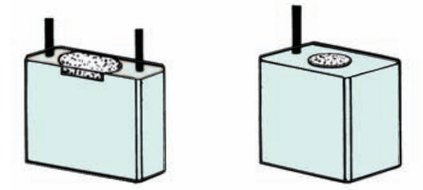
16 - 20 - 25 - 32 - 40 - 50 - 56 - 63 - 71
80 - 90 - 100 - 112 - 125 - 140 - 160

*More information can be obtained from our Technical data sheets, sent upon request, and also available from our web site **www.mersen.com**

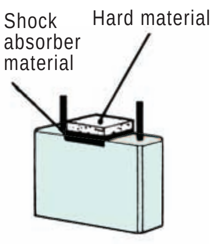
## Mounting methods



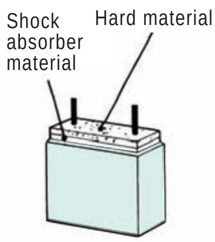
GLUED SHOCK ABSORBER



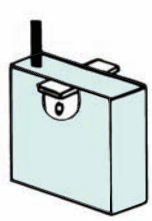
HARD INSULATING TOP
(RECESSED AND GLUED)



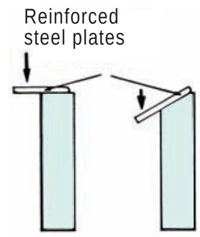

SCHOCK ABSORBER AND HARD MATERIAL FIXED PLATE SILESS



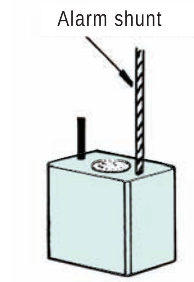

SCHOCK ABSORBER AND HARD PLATE (THE TWO PLATES ARE THREADED ON TWO FLEXIBLES AND NOT GLUED)



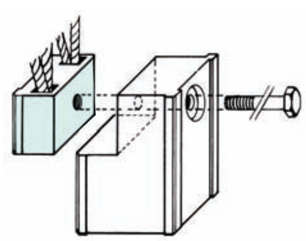
WEAR LIMITING PLASTIC CLIPS



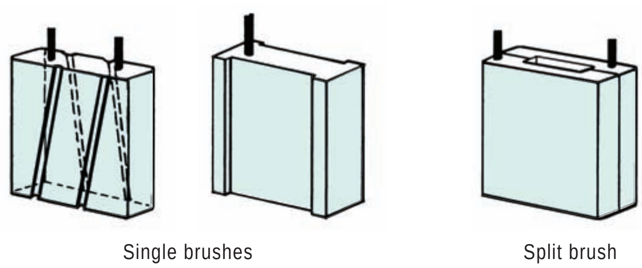

TOP PLATE FOR CANTILEVER PRESSURE DEVICE



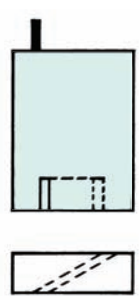

BRUSH WITH ALARM SHUNT



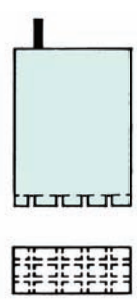
BRUSH WITH REMOVABLE TOP
FOR TINNING ROLLS



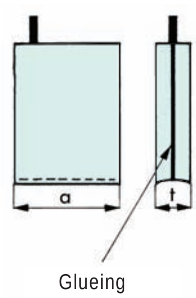

DUST GROOVES AND RECESSES



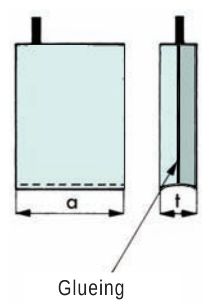
CONTACT FACE WITH SAW CUT



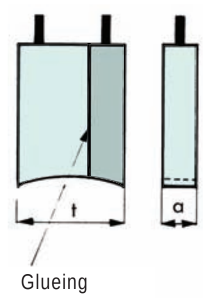
CROSS GROOVED CONTACT FACE




SANDWICH BRUSH*
(2 EG LAYERS)




GLUED BRUSH*
1 EG LAYER
1 BG LAYER




DUAL GRADE COMPOSITE BRUSH FOR SLIP RING*
1/3 EG LAYER
2/3 CG LAYER

*See Technical Data Sheet AE-TDS/07, sent upon request, and also available from our web site **www.mersen.com**

## Hardware for split brushes

### GLUED RUBBER PAD

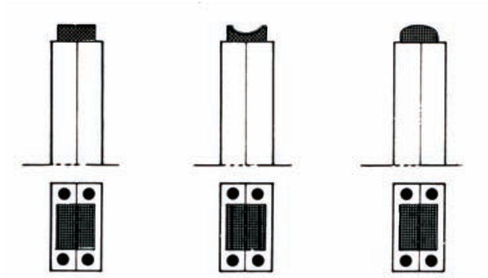


FIG. 1 FIG. 2 FIG. 3

This pad is symmetrical, allowing bi-directional rotation. However, pressure is located at the contact point of the spring. Furthermore the high friction coeff cient of the power pad keeps the spring from sliding freely on the brush top and creates lateral forces.

### SHOCK ABSORBER PLATE AND HARD TOP PLATE

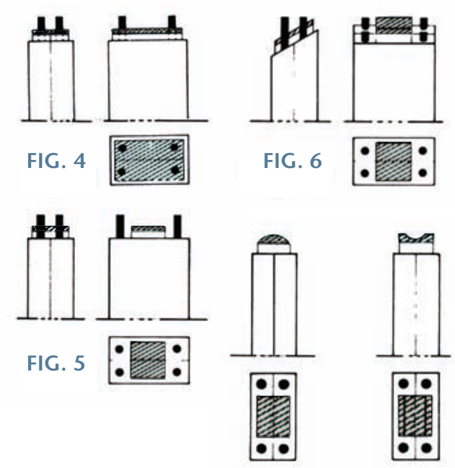


FIG. 4 FIG. 6 FIG. 5 FIG. 7 FIG. 8

This is the most common mounting type. Placed directly on the carbon brush, the shock absorber plate is topped by a hard non-metallic plate. These two elements are kept in place by threading the shunts through them. They can either be independent (Fig. 4) or glued to each other and the carbon brush (Fig. 5 and 6). Depending on the shape of the spring, the hard top plate can be machined with a convex (Fig. 7) or concave prof le (Fig. 8).

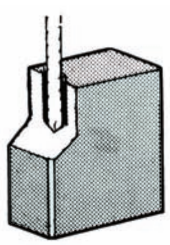
## Shunts

Shunt diameters follow the industry standard as indicated below:

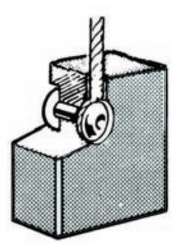
| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (mm) | 1.6 | 1.8 | 2 | 2.2 | 2.5 | 2.8 | 3.2 | 3.6 | 4 | 4.5 | 5 | 5.6 | 6.3 |
| Nominal value of current (A) | 15 | 17 | 20 | 24 | 28 | 32 | 38 | 44 | 50 | 60 | 75 | 85 | 100 |

All shunts are available with tinned wires for corrosion protection.

### MAIN SHUNT / CARBON BRUSH FASTENING METHODS



**Tamping:**
Conductive powder tamped mechanically into the hole around the shunt.



**Riveting:**
Process used for specif c applications (e.g. aviation). The shunt loop placed into the carbon brush is preformed with a tool before the riveting operation.

# 04

# Recommendations for installing carbon brushes in machines

## Carbon brushes

Our recommendations are as follows:
- Do not mix different carbon brush grades on a machine to avoid serious problems.
- Make sure to remove the existing f lm before any carbon brush grade change.
- Check that the carbon brushes slide freely in their brush-holders without excess clearance (see **Technical Data Sheet AE-TDS/04***).
- Check that the carbon brushes were not f tted (or re-f tted) in the wrong direction in the brush-holders. This is especially crucial for carbon brushes with a bevelled contact surface or split brushes with a metal plate.



## Carbon brush contact surface seating

To precisely match the carbon brush contact surface to the slip ring or commutator radius, use brush-seating stones (pumice stones) while running at low or no load. Seating stone dust rapidly erodes the brush contact surface to the right curvature.
It is of course essential to use the "M" (Medium grain) grade of grinding stone again after this operation.
When a lot of carbon brush material has to be removed, f rst rough-grind the surface using 60 or 80-grit sandpaper. To do this, just insert it with the abrasive face up between the contact surface and the commutator, and move it back and forth as shown in Fig. 1.
After brush seating thoroughly clean the contact surfaces, blowing away any abrasive material and/or carbon brush dust.

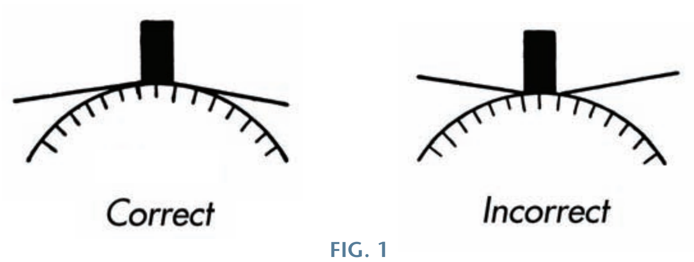



FIG. 1

## Brush-holders

- Make sure that the brush-holder is in working condition and check the interior surface condition.
- Adjust the distance between brush-holder and commutator to range from 2.5 to 3 mm (Fig. 2).
- Align the carbon brushes parallel to the commutator bars.
- Check with an appropriate gauge that the pressures are equal on all the carbon brushes.

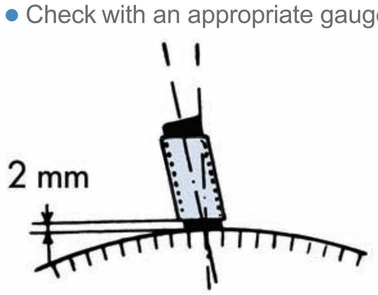



FIG. 2

*More information can be obtained from our Technical data sheets, sent upon request, and also available from our web site **www.mersen.com**

### RECOMMENDED PRESSURES IN NORMAL WORKING CONDITIONS

| Grade groups | | On slip ring kPa (PSI) | On commutator: Stationary machines kPa (PSI) | On commutator: Traction machines kPa (PSI) |
|---|---|---|---|---|
| **Electrographite** | | 18 - 20 (2.6 - 2.9) | 18 - 20 (2.6 - 2.9) | 35 - 45 (5.1 - 6.5) |
| **Resin-impregnated electrographite** | | | 18 - 25 (2.6 - 3.6) | 35 - 55 (5.1 - 8) |
| **Carbographitic & Resin-bonded** | | | 18 - 20 (2.6 - 2.9) | n/a |
| **Soft graphite** | | 11 - 20* (1.6 - 2.9) | | |
| **Metal-graphite** | **Normal speeds** | 18 - 20 (2.6 - 2.9) | | |
| | **Speeds < 1 m/s** | 25 - 27 (3.6 - 3.9) | | |

* Please consult us

***Note*** : 1 kPa = 10 cN/cm² (centinewton/cm²) = 0.145 PSI, and is close to 10 g/cm².

## Commutators and slip rings

Check that there is no out-of-round above 3 mils (75µm) or any obvious surface defect (see **Technical Data Sheet AE-TDS/02***). If needed, grind or machine using a tool support frame.
Mill or undercut the commutator slots (Fig. 1).
Chamfer the bar edges 0.2 to 0.5 mm at 45° (Fig. 2).
Clean the surface with an “M” grade of grinding stone. Avoid the use of abrasive paper or cloth. It is absolutely necessary to have suff cient roughness (1.3 to 2 µm Ra) in order to create and maintain a correct f lm.
**Our experts are at your service for any on-site diagnostic, maintenance, or refurbishment.**

FIG. 1

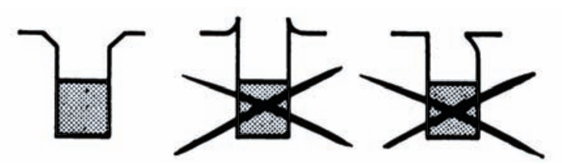


FIG. 2

## Putting the machine into service

First make sure that all carbon brushes slide freely inside the brush-holders, the shunts are correctly routed, and the terminals are properly tightened. Then start up the machine, preferably at low load, and increase progressively until full load is reached.

*More information can be obtained from our Technical data sheets, sent upon request, and also available from our web site **www.mersen.com**

# 05

# Visual guide to slip ring / commutator films

## Technical Data Sheet AE-TDS/13

The f lm is a complex mix of metal oxides, carbon and water, which is deposited on the collector / slip ring. A close look at the f lm can help in assessing the condition of your electrical rotating machine.
Below are examples of various f lm conditions and commutator / slip ring faults, as well as their causes.



## P. Film types

### SUITABLE FILMS

### COLOR INTENSITY

- **P2 - P4 - P6: Normal f lms**
  Uniform, light brown (P2) to darker brown (P6).
  The machine and the carbon brushes work well.

P2

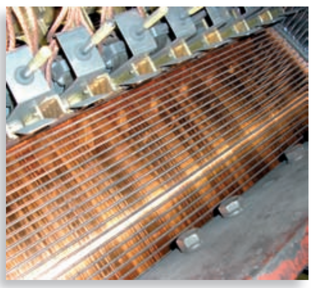
P4

P6

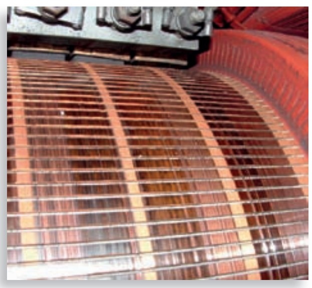
## SUSPECT FILMING REQUIRING MONITORING

### CLASSES OF FILM DEPOSIT

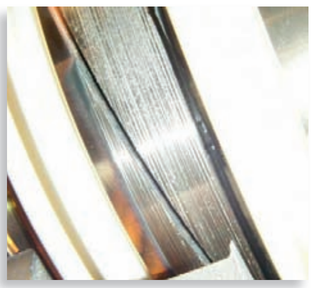
- **P12: Streaky f lm**
  Lines or bands of varying width, alternating light and dark, without copper wear.
  Most frequent causes: excess humidity, oil vapors or aggressive gases in the atmosphere, underloaded carbon brushes.
- **P14: Raw grooved f lm (P14a on commutator / P14b on slip ring)**
  Same as for P12, but with copper-colored raw grooved bands or very lightly colored bands. The metal is being attacked.
  Most frequent causes: same as for streaky f lm, but worsened or longer-lasting. Also the carbon brush grade may be unsuitable.
- **P16: Patchy f lm**
  Showing spots of various shapes, colors and dimensions, without any pattern.
  Most frequent causes: deformed or dirty commutator, out-of-round slip ring.



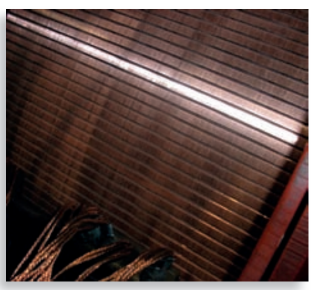
P12



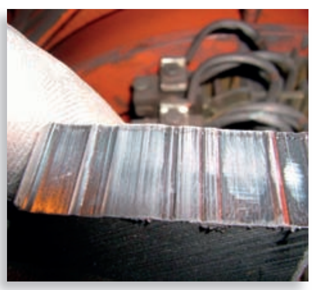
P14a



P14b

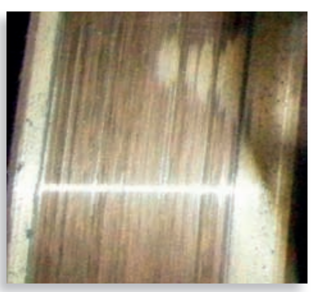


P14c



P14FF*

P16a



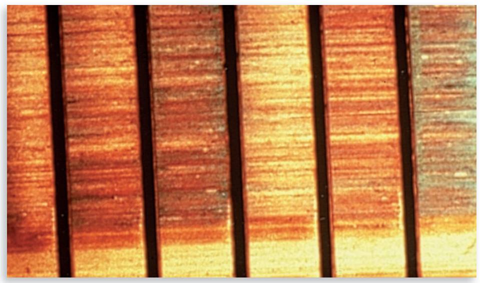
P16b

P16FF*

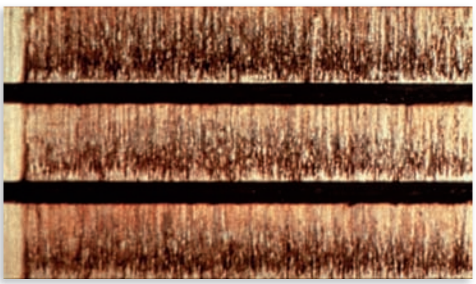
## PATCHINESS DUE TO MECHANICAL CAUSES

- **P22: Uneven f lm, “screw thread” effect**
  Most frequent cause: bad commutator machining during a maintenance operation (chattering tool).
- **P24: Dark in patches, often followed by lighter faded patches, signs of commutator deformation**
  Most frequent cause: defect affecting one bar or a group of bars, and making the carbon brush bounce. Light bars are high bars, dark bars are low bars.
- **P26 - P28: Dark patches in the middle or on the edges**
  Shading in the middle of the bars (P26) or at the two bar edges (P28).
  Most frequent cause: poor maintenance of the commutator.

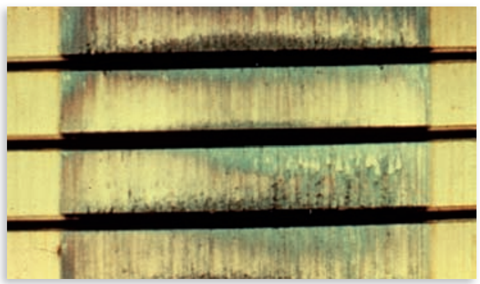
P22



P24



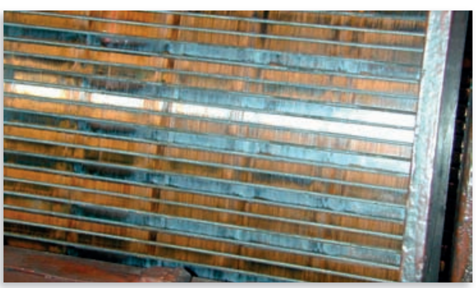
P26



P28

## BAR MARKING DUE TO ELECTRICAL CAUSES

- **P42: Alternate bars of light and dark**
  The dark bars have a polished, mat or blackened appearance. This pattern is repeated all around the whole commutator.
  The most frequent causes are of an electrical origin. They appear on armatures with more than one conductor per slot, and are linked with successive and increasingly diff cult commutation of each successive conductor in the slot.
- **P44: Pitting - Strong spark marks**
  Most frequent cause: high frequency current f ow.



P42

P44

### PATCHES DUE TO POLLUTION

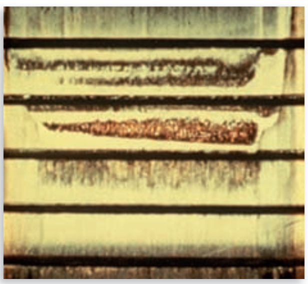
- **P62: Strong presence of deposits (oil, grease) on the f lm**
  Most frequent cause: carbon brush contaminated during maintenance operation, or environmental factors.

P62

## B. Burning

- **B6: Spark burns at bar edges**
- **B8: Burning at center of bars**
- **B10: Pitted f lm**
  Variable number of small light patches randomly spread on a normal f lmed track.
  Most frequent cause: sparking under the carbon brushes.

B6



B8

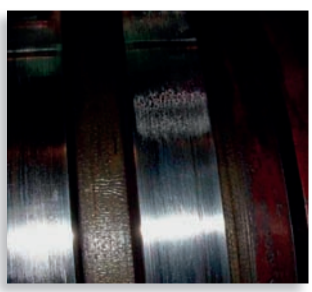
B10

## T. Marking

### PARTICULAR TYPES

- **T10: Brush image on commutator**
- **T11: Brush image on slip ring**
  Dark or black mark reproducing the carbon brush contact surface on the commutator / slip ring.
  Most frequent causes: accidental overload or electrolytic mark during a long period of stoppage.
- **T12: Dark fringe** due to high bar L2

T10

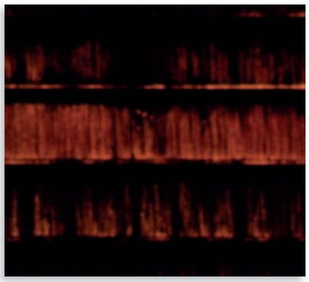


T11

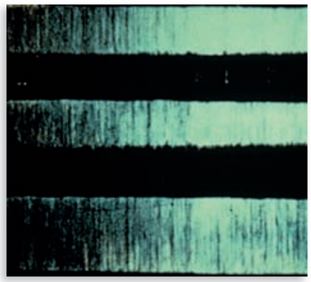
T12

### PARTICULAR TYPES (CONTINUATION)

- **T14: Dark fringe** due to low bar L4
- **T16: Dark fringes** due to high mica L6
- **T18: Dark local patches** due to burs L8



T14

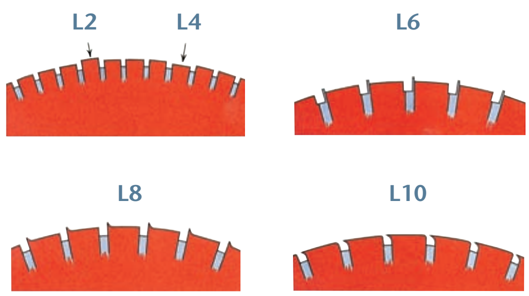


T16

T18

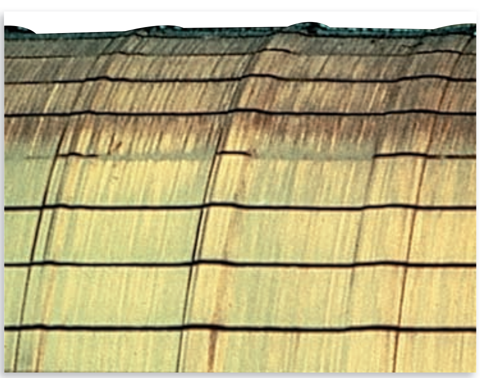
## L. Commutator bar faults

- **L2:** high bar
- **L4:** low bar
- **L6:** high mica
- **L8:** burs at bar edges
- **L10:** copper drag

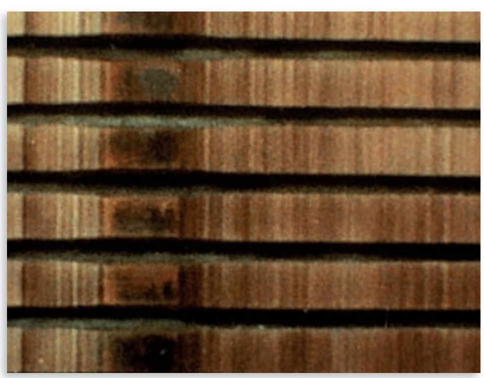



## R. Commutator bar wear

- **R2:** Commutator with axial prof le showing metal wear on each track – correct stagger. This wear may appear after a very long period of operation.
- **R4:** Commutator showing abnormal wear of the metal due to incorrect axial stagger , unsuitable carbon brush material, various pollutions...



R2



R4

# Mersen's services





## Mersen's maintenance and service offerings

For any technical expertise, maintenance or training, Mersen experts offer their extensive knowledge, years of experience and global reach.

## Expertise

- On-site practical support throughout the world
- Commutation expertise
- Measurements and diagnostics
- Support service on a daily basis
- Technical assistance by phone
- Technical documentation on-line on our website: **www.mersen.com** or upon request

## Windtracker™ services

Mersen created the Windtracker™ Service in order to support wind farm operators. Windtracker™ experts, dedicated wind engineers and technicians, bring you up tower services, diagnostic capabilities, specif c technical support and training, allowing you to optimize your wind turbine performance. They are supported by a large network of specialists in f ve continents, allowing Mersen to respond to your needs, wherever the location.


## Training

Mersen provides training courses for maintenance of electric motors.
For over twenty f ve years, more than 3,000 technicians have been undergone training, either at our facility (STAGELEC) or theirs (EXTELEC).

## Maintenance

- Diagnostics
- In situ commutator, slip ring and brush-holder refurbishment:
  - Surface re-conditioning
  - Mica undercutting (commutators)
  - Bar edge chamfering (commutators)
  - Helical groove edge chamfering (slip rings)
  - Out-of-round machining
  - Carbon brush pressure measurement
  - Proposal of suitable carbon brush grade
  - Redesign of the complete carbon brush, brush-holder and commutator / slip ring system
  - Installation of features to improve the performance of your machines (remote carbon brush wear monitoring, dust extraction solutions...)
  - Retrof t solutions
- Support services on a daily basis

## Tools and accessories

Mersen offers tools and accessories for carbon brush use and electrical rotating machine maintenance:

- **CL-Profiler:**
  - To measure commutator / slip ring profiles
  - Low speed inductive probe
  - Contact measurement
  - Ruby tip for "live" measurements
- **ComPro2000™**
  - To measure commutator profiles during operation
  - Any speed, non-contact eddy-current transducer
- **Electronic force gauges** for measuring brush-holder pressure systems
- **Tools** for maintenance of electrical rotating machine surfaces:
  - Grinding stones (abrasive cloth, brush seating stones)
  - Scrapers and slotting files
- **Mica undercutters**
- **Stroboscopes** for slip ring, commutator and carbon brushes control on rotating machines
- **Carbon brush wear indicator systems**
- **Roughness meters**
- **Complete toolkit for maintenance of slip rings and commutators** (Please consult us)
  - 0-2.5 daN force gauge for measuring spring pressure
  - Battery-operated illuminated magnifier, for monitoring films and carbon brushes
  - Thickness gauges (11 blades) for measuring carbon brush / brush-holder clearance
  - 0-200 mm caliper for measuring carbon brush wear
  - Insulated probe for assessing carbon brush vibrations
  - Grinding stones
  - Abrasive cloth

# How to order carbon brushes?

07

## Characteristics and identification

A carbon brush is clearly def ned by four characteristics:

- The part number engraved on the brush or its grade (material and possible treatments)
- Its shape and main dimensions (see on page 18)
- Additional hardware type or attachment method (see on pages 19 to 21)
- The application and motor characteristics

The part number is the best way toidentify a brush, but any additional informationwill help.

**There are also other ways to def ne a carbon brush:**

### DRAWING CATALOGUES

We can produce brush drawing catalogues containing the drawings and carbon brush model references used in our customers' plants. These catalogues make it easier for the maintenance people to identify and order spare carbon brushes. Each carbon brush is taken up by drawing and code number. To place an order you just have to quote the code mentioned in the drawing catalogue.

### IDENTIFICATION BY THE BRUSH-HOLDER

If it is a Mersen brush-holder, you just have to mention its type, the t" x a" cage dimensions, and the carbon brush grade.
For modular brush-holders (MONG, MOSPI type), it is necessary to indicate the sheath height (N, B, H ou TH), which determines the carbon brush height.
The shunt length, which depends on the brush gear arrangement on the motor, also has to be mentioned, along with the terminal bolt diameter.
For all other types, we need a carbon brush sample or a brush-holder drawing, as well as the motor type and characteristics.

### CARBON BRUSH SAMPLE

A carbon brush sample, even worn out, will generally enable us to determine the main dimensions except the brush height, which has to be selected from the list issued by the I.E.C. according to the brush-holder, and given to us separately.

### CARBON BRUSH DRAWING (OR SKETCH)

Excluding the requirements based on norms or Mersen manufacturing standards, there are few additional specif cations required to make a carbon brush drawing.
Except in very specif c cases, there is no need to specify:

- Tolerances on the main brush dimensions and on the shunt lengths
- Chamfer dimensions
- Type and thickness of materials used for attachments and connections
- Cross section and composition of shunts
- Shunt and terminal part fastening process
- Insertion depth of the shunts into the brushes
- Overall dimensions of the terminal parts

## Delivery

We can supply most of the carbon brushesf tting any motor type within one week, or even one day under certain conditions.

# CARBON BRUSH
## APPLICATION DESCRIPTION FORM
(Text conforms with IEC norm 60136)

**Company** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
**Address** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
**Date**. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

**Surname / Name** . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
**Phone Nr**. . . . . . . . . . . . . . . . **Fax Nr** . . . . . . . . . . . . . . .
**Email** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

**Questions in blue are essential information for us to determine the best brush grade appropriate to your machine**

### Information concerning the machine:

1• Machine manufacturer: ..............................................

2• Machine type: ..............................................

3• Generator: ☐ CC ☐ CA – Motor: ☐ CC ☐ CA
Direction of rotation: Reversible ☐ yes ☐ no

4• Converter: ☐ CC - CA ☐ CA - CC

| | Nominal | In service Normal | In service Max. |
|---|---|---|---|
| 5• SPEED (rpm) | | | |
| 6• VOLTAGE (V) | | | |
| 7• CURRENT (Amps) | | | |
| 8• POWER (kW) | | | |

9• Duty: ..............................................

10• Duty cycle (including no load %):
..............................................

11• Excitation : ☐ Shunt ☐ Separate ☐ Series ☐ Compound

12• Machine construction : ☐ Open ☐ Protected ☐ Closed

13• CARBON BRUSH MANUFACTURER AND GRADE ..............
..............................................

14• The slip rings are located:
☐ Between ☐ Outside the bearings

15• Are the slip rings in a closed enclosure? ☐ yes ☐ no

### Machine's environment:

16• Type of industry: ..............................................

17• Ambient temperature (°C / °F): ..............................

18• Temperature in service (°C / °F): ..............................

19• Relative humidity (%): ..............................................

20• Oil vapor: ..............................................

21• Corrosive gases - Type? ..............................................

22• Dust – Nature: ..............................................

23• Vibration? ..............................................

### Operating information:

24• Average brush life (hours): ..............................

25• DESCRIPTION OF ANY PROBLEMS (if any) ..............................................
..............................................
..............................................

| Commutator | Slip rings |
|---|---|
| DIAMETER: | DIAMETER: |
| Nr of bars: ............ | Width: ............ |
| Bar width: ............ | NUMBER: ☐ 2 ☐ 3 |
| | MATERIAL: ............ |
| Micas width: | HELICAL GROOVE: |
| NR OF TRACKS: ............ | ☐ with ☐ without |
| NR OF BRUSHES PER TRACK: ............ | NR OF BRUSHES PER RING: ............ |
| NR OF POLES: ............ | |
| BRUSH DIMENSIONS: (see Fig.1) t =........ a = ........ r = ........ | BRUSH DIMENSIONS: (see Fig.2) t =........ a = ........ r = ........ |
| BRUSH BOTTOM ANGLE (see Fig.3, 4 and 5) α =............ ° | BRUSH BOTTOM ANGLE (see Fig.3, 4 and 5) α =............ ° |
| TOP BEVEL ANGLE (see Fig.10) β =............ ° | TOP BEVEL ANGLE (see Fig.10) β =............ ° |
| SPLIT BRUSH? ☐ Fig 6 ☐ Fig 7 ☐ Fig 8 ☐ Fig 9 | Split brush? ☐ Fig 6 ☐ Fig 7 ☐ Fig 8 ☐ Fig 9 |
| The brushes on the same path are: ☐ In line ☐ Staggered | CURRENT PER RING: ............A ☐ CC ☐ CA |

26• ☐ **Commutator's** ☐ **Slip ring's condition**
☐ Good ☐ Glossy ☐ Matt
☐ Smooth ☐ Worn out ☐ Grooved
☐ Uniform ☐ Marked

Marks: ☐ Evenly distributed ☐ Unevenly distributed ☐ Burnt

Color: ☐ Light ☐ Average ☐ Dark

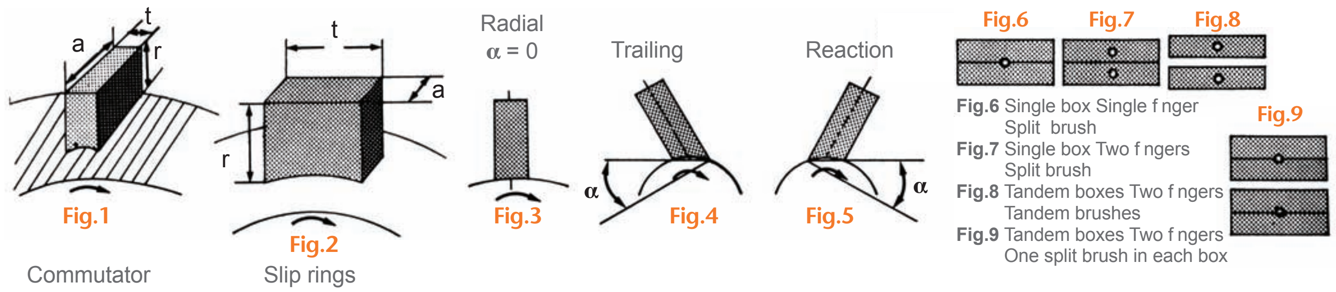



**Fig.6** Single box Single f nger Split brush
**Fig.7** Single box Two f ngers Split brush
**Fig.8** Tandem boxes Two f ngers Tandem brushes
**Fig.9** Tandem boxes Two f ngers One split brush in each box

Please f ll this form out to help us f nd the most suitable carbon brush
for your specif c application(s).

WHEN POSSIBLE PLEASE SEND US A SAMPLE OF THE CARBON BRUSH IN USE (even if worn) or a detailed sketch of the brush with its shunt and terminal (Use sketch Fig. 10 below as a guide).

## Dimensioned manual sketch of the brush in use

| | | | |
|---|---|---|---|
| l Shunt length in mm | | Diameter or width of f xing gap in mm | |

## Essential information for the manufacture of a carbon brush

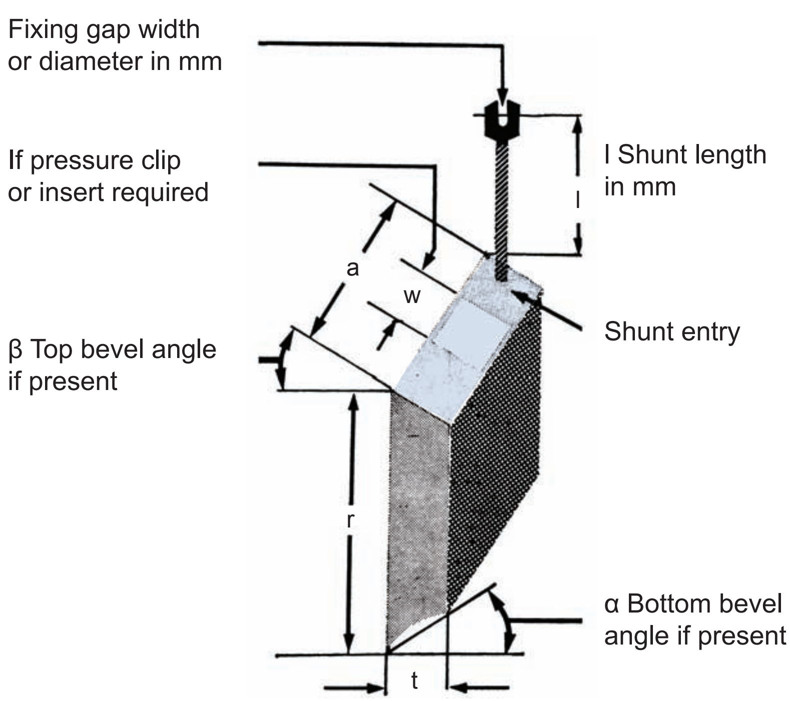
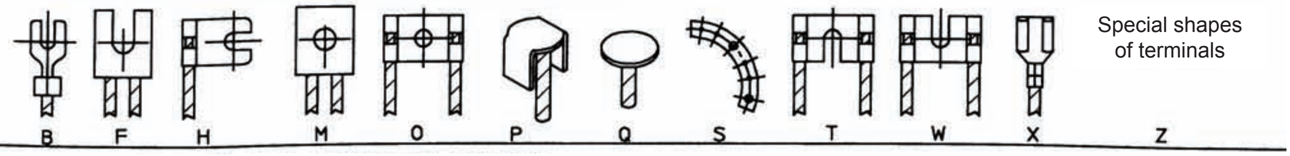


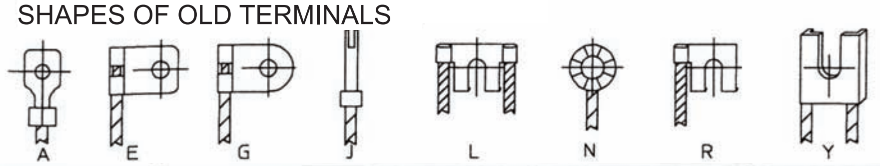

Fig.10

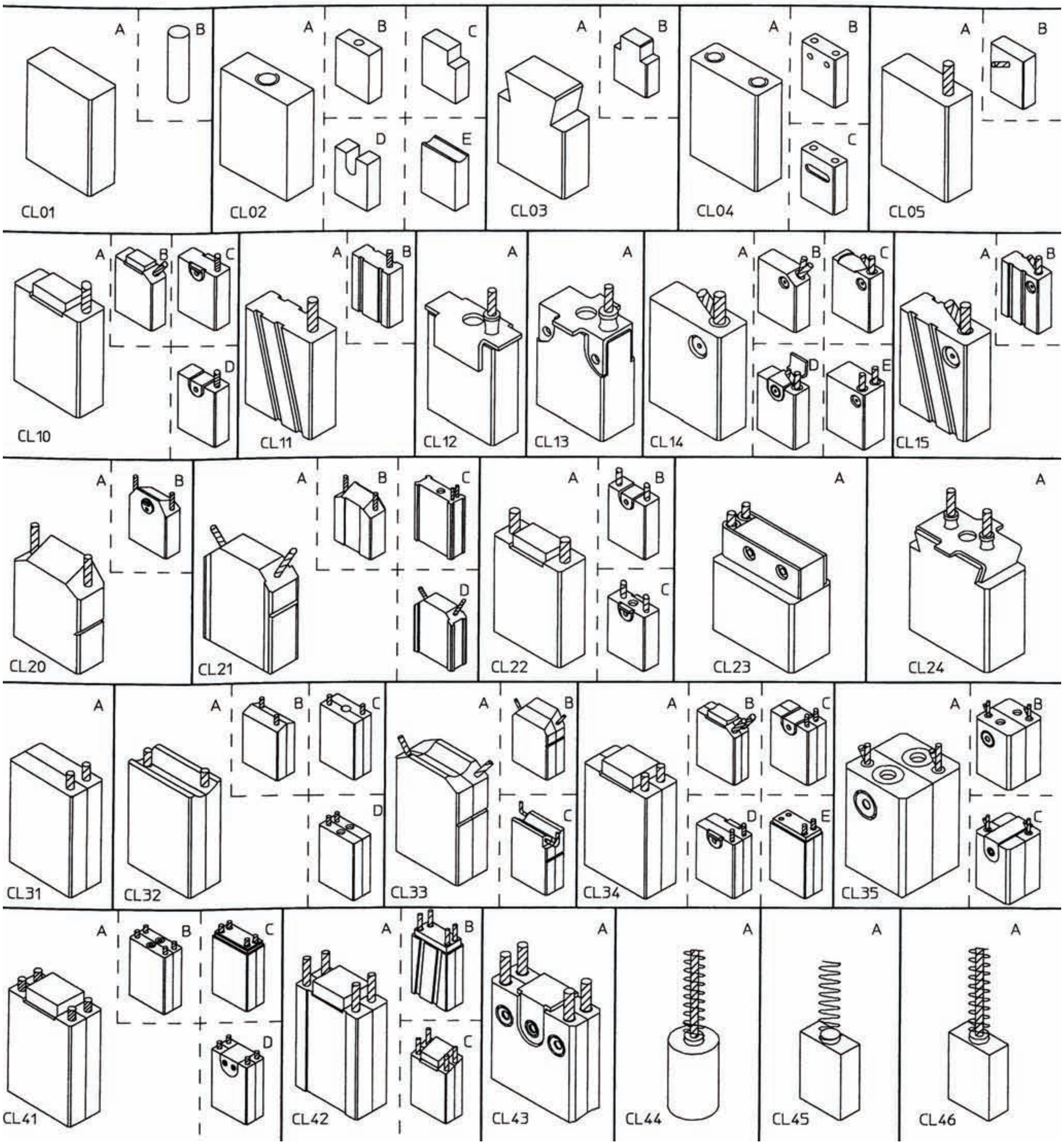
# STANDARD SHAPES

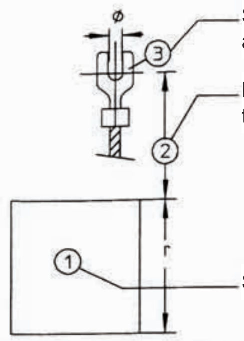
SHAPES OF NEW TERMINALS (recommended)



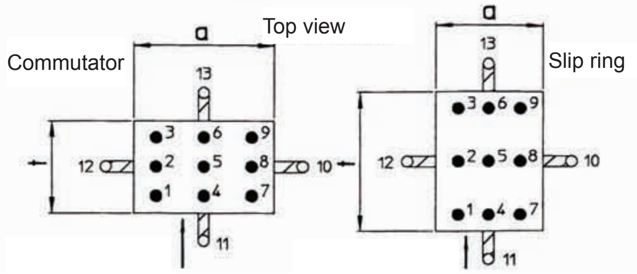

SHAPES OF OLD TERMINALS



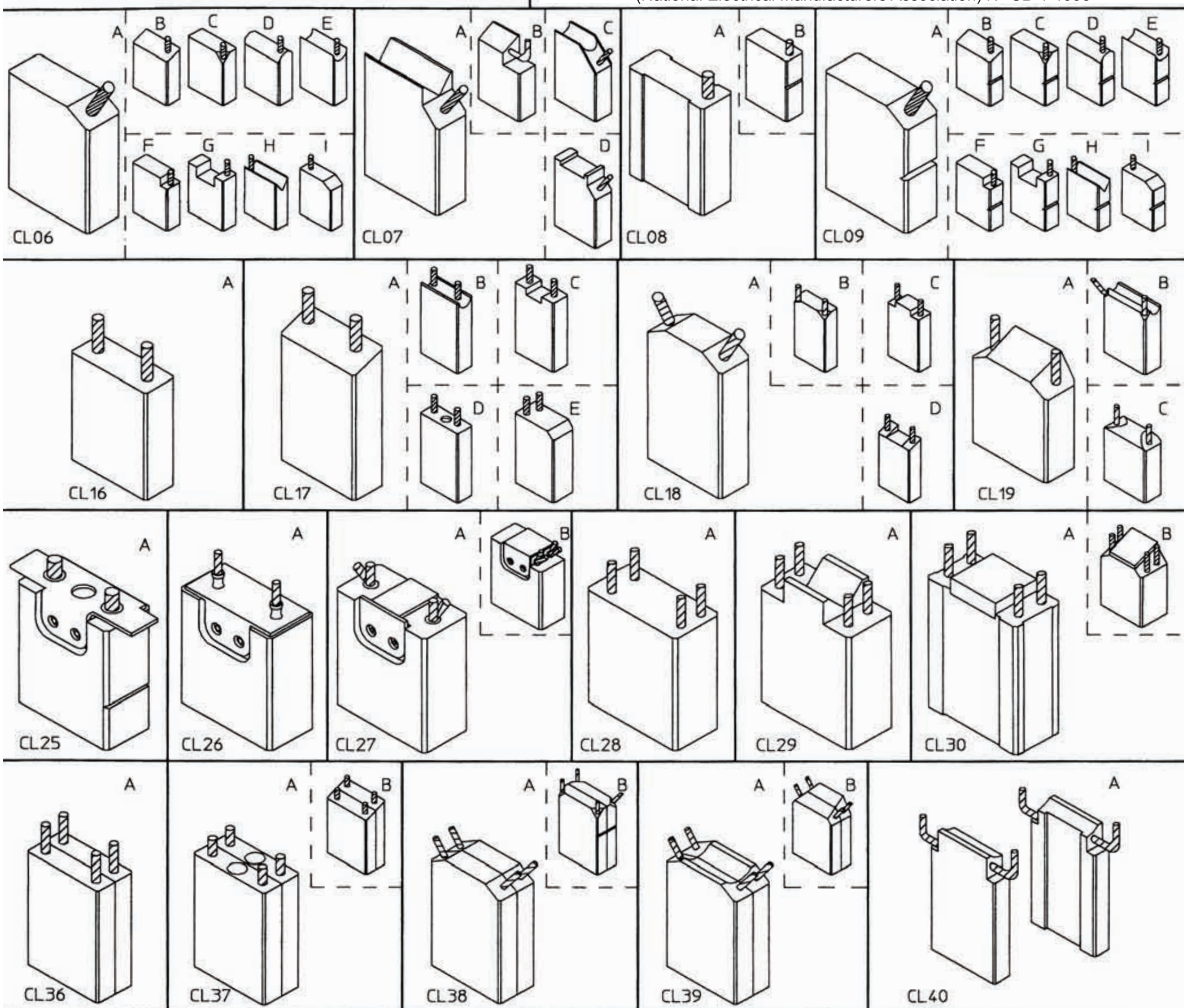






## SHUNT LOCATION




Shapes in accordance with NEMA standard
(National Electrical Manufacturers Association) N° CB-1-1995




Special
shapes

CL47

SANDWICH

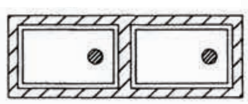
Shape above with a "S" suff x

Be careful: the number
of wafers is multiplied by 2

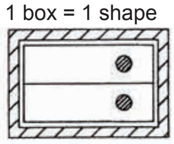
The drawings represent 1 shape per box

For example

Brush Pair
2 boxes = 2 shapes



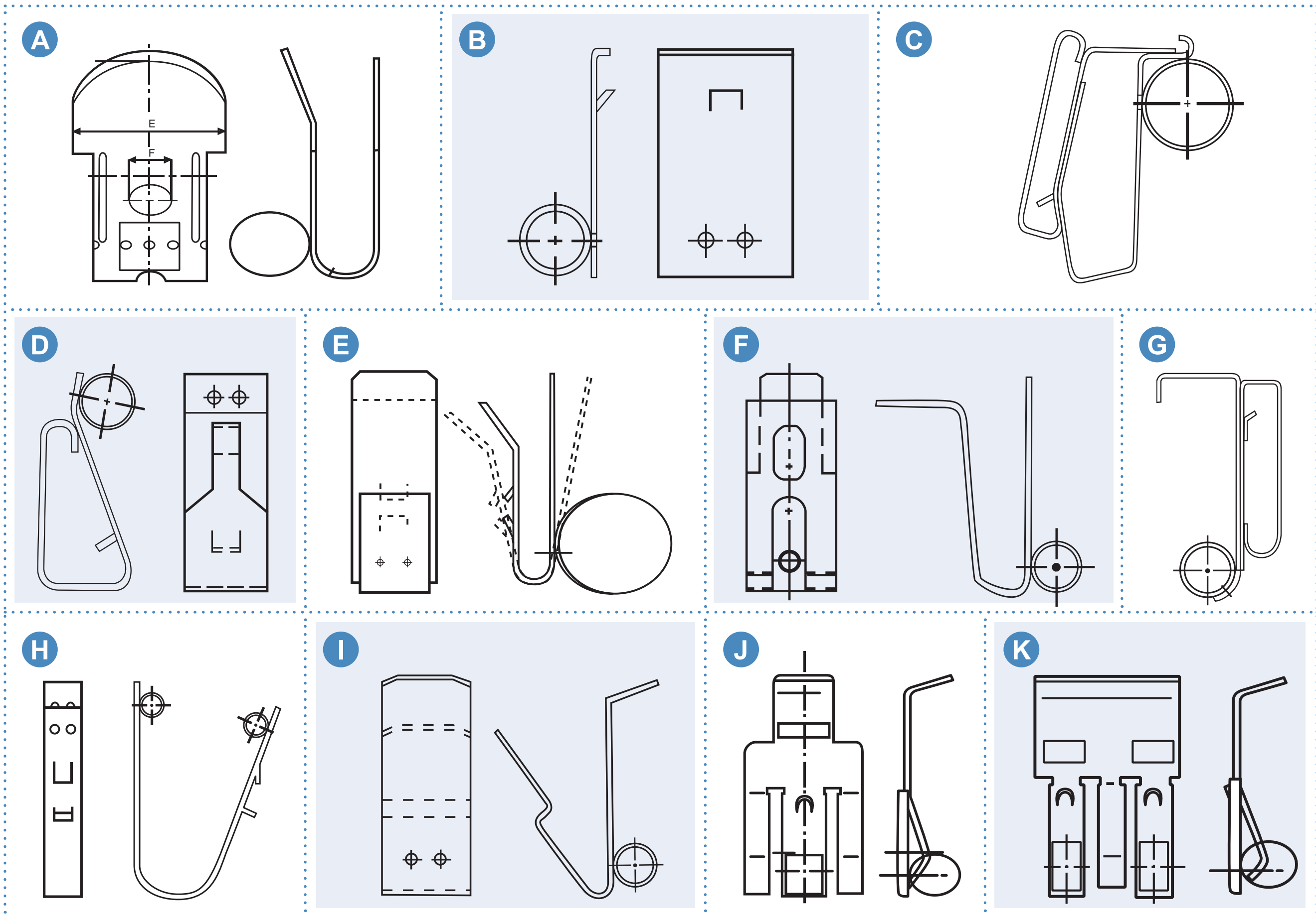
Split brush
1 box = 1 shape



# QUESTIONNAIRE
## FOR THE CHOICE OF A BRUSH-HOLDER PRESSURE SYSTEM

| | |
|---|---|
| **Company** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | **Surname / Name** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . |
| **Address** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | **Phone Nr**. . . . . . . . . . . . . . . . **Fax Nr** . . . . . . . . . . . . . . . |
| . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | **Email** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . |
| **Date**. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | |

## Identification of the spring and spring carriers for European models




### Indicate the letter corresponding to your need:

If the spring you need is not shown above, please provide a sketch on the reverse side of the form, showing front and side views or alternatively send us a sample. Minimum order quantity: 4 pieces.

### Dimensions and characteristics

| | | | |
|---|---|---|---|
| **Brush size** | t: . . . . . . . . . . . . . . . . . . . mm | a: . . . . . . . . . . . . . . . . . . . mm | r: . . . . . . . . . . . . . . . . . . . mm |
| **Spring** | Diameter:. . . . . . . . . . . . . mm | Width: . . . . . . . . . . . . . . . mm | |
| **Spring carrier** | Width: . . . . . . . . . . . . . . . mm | Height : . . . . . . . . . . . . . . mm | Thickness: . . . . . . . . . . . . mm |
| | Material: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | | Insulated:. . . . . . . . . . . . . . . |
| **Brush-holder** | Width: . . . . . . . . . . . . . . mm | Length:. . . . . . . . . . . . . . . mm | |
| | Dimension from bottom of holder to the mounting pin: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . mm | | |

### Other information

Carrier engraving: . . . . . . . . . . . . . . . . . . . . . . . . Quantity: . . . . . . . . . . . . . . . . Delivery with brushes ☐ YES ☐ NO

## Sketch for front and side views

## Special request

# Occurrence of technical terms in this guide



**In addition to present Technical Guide, other documents can be supplied upon request.**
**Do not hesitate to contact us.**

**LIST OF MERSEN'S TECHNICAL DATA SHEETS** (also available from **www.mersen.com**):

- **AE-TDS/01** Functions of a good carbon brush, what you should know
- **AE-TDS/02** Condition of the surface of commutators and slip rings - Roughness
- **AE-TDS/03** Chamfering of commutator bar edges Machining of ring helical grooves
- **AE-TDS/04** Brush and brush-holder tolerances on "t" and "a" dimensions
- **AE-TDS/05** Losses in carbon brushes
- **AE-TDS/06** Setting the neutral at rest
- **AE-TDS/07** Sandwich brushes – Composite brushes
- **AE-TDS/08** Preventive maintenance
- **AE-TDS/09** Circumferential brush stagger
- **AE-TDS/10** Threading on slip rings
- **AE-TDS/11** Brush spring pressure
- **AE-TDS/12** Ventilation
- **AE-TDS/13** Aspects of commutator / slip ring skins
- **AE-TDS/14** Brush sparking
- **AE-TDS/15** Brush wear
- **AE-TDS/16** Standardization of carbon brush dimensions
- **AE-TDS/17** Air humidity
- **AE-TDS/18** Degreasing of commutators and rings
- **AE-TDS/19** Brush seating
- **AE-TDS/20** Slip ring brushes
- **AE-TDS/21** Copper bridging of commutator bars (copper dragging)
- **AE-TDS/22** Ghost marking on synchronous machines slip rings (ghosting)
- **AE-TDS/23** Silicones
- **AE-TDS/24** Dust arising from brush wear
- **AE-TDS/25** Underloaded machines

Mersen is a global Expert in materials and solutions for extreme environments as well as in the safety and reliability of electrical equipment.

**Our markets:**

- **Energy:** • Wind • Hydro • Photovoltaic • Nuclear Power • Conventional Thermal Power • Oil & Gas
- **Transportation:** • Railways • Aerospace & Aeronautics • Ports & Marine • Electrical Vehicles
- **Electronics:** • Polysilicon • Power Electronics • Semiconductors • Compound Semiconductors • Optical Fiber Production
- **Chemicals & Pharmaceuticals:** • Organic Chemicals • Inorganic Chemicals • Fine Chemicals & Pharmaceuticals
- **Process industries:** • Metallurgy • Mining • Oil & Gas • Cement • Pulp & Paper • Rubber & Plastic • Water & Wastewater Treatment • Assembly Manufacturing • Mould Industry • Glass Industry • Sintering • Furnace Industry
- **Other Markets:** • Commercial • Residential • Data Communication • Elevators • Forklifts