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APPENDICES

The specifications or data contained in present catalogue are only given for information and do not create any undertakings whatsoever. Any copy, reproduction or translation, either partially or fully, of these information is subject to the Mersen’s prior written consent. In addition, due to the continuing improvement of techniques and change of applicable standards, Mersen is entitled to modify at any time the characteristics and specifications of its products as described in present catalogue.
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 specific 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 fulfill 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
**FRICITION COEFFICIENT (CALLED “μ”)**

Carbon brush friction coefficient “μ” has to be low and stable over time to allow the carbon brush to work without overheating.

“μ” has no fixed 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 sufficient for most machine calculations or projects.

“μ” friction coefficient calculation formula

The “μ” friction coefficient is the relationship between T (tangential force due to friction) and N (normal force)

\[ \mu = \frac{T}{N} \]

**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 fluctuating friction resulting from an unsuitable carbon brush grade, polluted atmosphere, extended periods of underload, or insufficient 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 sufficient 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 sufficient 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*).

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*More information can be obtained from our Technical data sheets, sent upon request, and also available from our web site [www.mersen.com](http://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 influences commutation and current distribution in between the carbon brushes.

This is an important characteristic which depends on the carbon brush grade, electrical contact and film (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 influenced by all the factors which may modify the film:

- 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 specific operating conditions. They are grouped into five 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 flow 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 influence on film 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*)

*More information can be obtained from our Technical data sheets, sent upon request, and also available from our web site [www.mersen.com](http://www.mersen.com)
Current density has a major influence 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 resistance of a material, usually symbolized by the Greek letter rho (ρ), represents its resistance to the flow 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 artificial 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 definition of the radial dimension).
**Physical and chemical parameters (environment)**

**HUMIDITY**

Water, the essential component of commutator or slip ring films, is supplied by ambient air. The film will form best in a humidity range of 8 to 15 g/m³ (0.008 to 0.015 oz/ft³) of air (See Technical Data Sheet AE-TDS/17*).

In very dry air, the film 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 rarefied atmospheres at high altitudes
- Machines with brushes working in an enclosure filled 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 film, 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 film 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 films 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 filtered 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 modification required
- Simple installation
- Standard product that can be customized
- A complete solution
- For original equipment or retrofit

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/cm² (50 to 75 A/in²) under steady conditions
  - 20 to 25 A/cm² (130 to 160 A/in²) for peak loads
- Maximum peripheral speed: 50 m/s (154 ft/s).
How are soft graphite brush materials manufactured?
The main ingredients are purified natural graphite and artificial graphite, mixed with additives, agglomerated with appropriate binders, and treated at a high temperature to carbonize the binder. These materials are not graphitized.

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 flow, run out, and heat.

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/cm² (50 to 100 A/in²) depending on the application
- Maximum peripheral speed: 25 m/s (82 ft/s)
OVERVIEW OF THE MANUFACTURE OF ELECTROGRAPHITE

BG. Resin-bonded (bakelite graphite) brushes

How are resin-bonded brush grades manufactured?
Powdered natural or artificial 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)
How are metal-graphite brush grades manufactured?
Powdered natural or artificial 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 film 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. Difficult 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 specific 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:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Signification</th>
<th>Contact drop (Sum of both polarities)</th>
<th>Friction μ</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>High</td>
<td>&gt; 3 V</td>
<td>μ &gt; 0.20</td>
</tr>
<tr>
<td>M</td>
<td>Medium</td>
<td>2.3 V - 3 V</td>
<td>0.12 &lt; μ &lt; 0.20</td>
</tr>
<tr>
<td>L</td>
<td>Low</td>
<td>1.4 V - 2.3 V</td>
<td>μ &lt; 0.12</td>
</tr>
<tr>
<td>VL</td>
<td>Very low</td>
<td>0.5 V - 1.4 V</td>
<td></td>
</tr>
<tr>
<td>EL</td>
<td>Extremely low</td>
<td>&lt; 0.5 V</td>
<td></td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>BRUSH GRADE GROUPS</th>
<th>Grades</th>
<th>Apparent density</th>
<th>Resistivity ρΩ.cm (ρΩ.in)</th>
<th>Shore hardness</th>
<th>Flexural strength MPa (PSI)</th>
<th>Contact drop</th>
<th>Friction</th>
<th>Maximum current density A/cm² (A/in²)</th>
<th>Upper speed limit m/s (ft/s)</th>
<th>Metal content %</th>
</tr>
</thead>
<tbody>
<tr>
<td>EG - Electro-graphitic</td>
<td>EG34D</td>
<td>1.60</td>
<td>1,100 (433)</td>
<td>40</td>
<td>25 (3,626)</td>
<td>M</td>
<td>M</td>
<td>12 (77)</td>
<td>50 (164)</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>EG389P</td>
<td>1.49</td>
<td>1,600 (630)</td>
<td>29</td>
<td>19 (2,756)</td>
<td>M</td>
<td>M</td>
<td>12 (77)</td>
<td>50 (164)</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>L1</td>
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<td>1,270 (500)</td>
<td>35</td>
<td>21 (3,046)</td>
<td>M</td>
<td>M</td>
<td>12 (77)</td>
<td>50 (164)</td>
<td>/</td>
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<tr>
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<td>EG362</td>
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<td>2,500 (984)</td>
<td>35</td>
<td>21 (3,046)</td>
<td>M</td>
<td>M</td>
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<td>50 (164)</td>
<td>/</td>
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<td></td>
<td>EG40P</td>
<td>1.62</td>
<td>3,200 (1,260)</td>
<td>57</td>
<td>27 (3,916)</td>
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<td>52</td>
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<td>50 (164)</td>
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<tr>
<td></td>
<td>EG387</td>
<td>1.60</td>
<td>3,500 (1,378)</td>
<td>60</td>
<td>31 (4,496)</td>
<td>M</td>
<td>M</td>
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<td>50 (164)</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>EG300H</td>
<td>1.57</td>
<td>4,100 (1,614)</td>
<td>60</td>
<td>26 (3,771)</td>
<td>M</td>
<td>L/M</td>
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<td>50 (164)</td>
<td>/</td>
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<tr>
<td></td>
<td>2192</td>
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<tr>
<td></td>
<td>CB377</td>
<td>1.71</td>
<td>6,350 (2,500)</td>
<td>75</td>
<td>29 (4,206)</td>
<td>H</td>
<td>L</td>
<td>12 (77)</td>
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<tr>
<td></td>
<td>EG319P</td>
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<td>52</td>
<td>26 (3,771)</td>
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<td>M</td>
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<td>50 (164)</td>
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<tr>
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<td>15 (2,176)</td>
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<td>Impregnated electro-graphitic</td>
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<td>45 (148)</td>
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<td>1,600 (630)</td>
<td>33</td>
<td>28 (4,061)</td>
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<td>50 (164)</td>
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<td>31 (4,496)</td>
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<td>535</td>
<td>1.53</td>
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<td>55</td>
<td>26 (3,771)</td>
<td>M</td>
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<td>AC137</td>
<td>1.72</td>
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<td>80</td>
<td>41 (5,947)</td>
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<td>50 (164)</td>
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<td>168</td>
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<td>36 (5,221)</td>
<td>M</td>
<td>M</td>
<td>12 (77)</td>
<td>50 (164)</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>EG8220</td>
<td>1.82</td>
<td>5,000 (1,968)</td>
<td>90</td>
<td>48 (6,962)</td>
<td>M</td>
<td>M</td>
<td>12 (77)</td>
<td>50 (164)</td>
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<tr>
<td></td>
<td>EG7097</td>
<td>1.68</td>
<td>4,000 (1,575)</td>
<td>80</td>
<td>35 (5,076)</td>
<td>M</td>
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<td>12 (77)</td>
<td>50 (164)</td>
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<tr>
<td></td>
<td>EG341</td>
<td>1.57</td>
<td>7,200 (2,835)</td>
<td>74</td>
<td>34 (4,931)</td>
<td>M</td>
<td>M</td>
<td>12 (77)</td>
<td>50 (164)</td>
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<td></td>
<td>EG7655</td>
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<td>5,600 (2,205)</td>
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<td>33 (4,786)</td>
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<td>EG6754</td>
<td>1.76</td>
<td>4,150 (1,634)</td>
<td>87</td>
<td>40 (5,802)</td>
<td>M</td>
<td>M</td>
<td>12 (77)</td>
<td>50 (164)</td>
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<tr>
<td>BRUSH GRADE GROUPS</td>
<td>Grades</td>
<td>Apparent density</td>
<td>Resistivity $\Omega\cdot\text{cm}$ ($\Omega\cdot\text{in}$)</td>
<td>Shore hardness</td>
<td>Flexural strength MPa (PSI)</td>
<td>Contact drop Friction</td>
<td>Maximum current density A/cm² (A/in²)</td>
<td>Upper speed limit m/s (ft/s)</td>
<td>Metal content %</td>
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<tr>
<td>A - Carbo-graphitic</td>
<td>A121</td>
<td>1.75</td>
<td>2,250 (886)</td>
<td>30</td>
<td>26 (3,771)</td>
<td>M L</td>
<td>12 to 20 (75 to 125) ≤ 15 (≤ 49) /</td>
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<tr>
<td>A176</td>
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<td>52,500 (20,669)</td>
<td>40</td>
<td>20</td>
<td>20 (2,901)</td>
<td>H L</td>
<td>8 to 10 (50 to 65) ≤ 25 (≤ 82) /</td>
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<td>A252</td>
<td>1.57</td>
<td>45,000 (17,716)</td>
<td>27</td>
<td>16</td>
<td>16 (2,321)</td>
<td>H L</td>
<td>10 to 12 (65 to 75) ≤ 25 (≤ 82) /</td>
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<td>M44A</td>
<td>1.64</td>
<td>3,050 (1,201)</td>
<td>50</td>
<td>26</td>
<td>26 (3,771)</td>
<td>M M</td>
<td>10 (65) ≤ 15 (≤ 49) /</td>
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<tr>
<td>LFC - Soft graphite brushes</td>
<td>LFC501</td>
<td>1.46</td>
<td>1,900 (748)</td>
<td>10</td>
<td>8 (1,160)</td>
<td>M L</td>
<td>6 to 10 (40 to 65) 75 (246) /</td>
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<td>LFC554</td>
<td>1.26</td>
<td>2,000 (787)</td>
<td>12</td>
<td>11</td>
<td>1,159 (9,367)</td>
<td>M L</td>
<td>11 to 13 (71 to 84) 90 (295) /</td>
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<td>BG - Resin-graphite</td>
<td>BG412</td>
<td>1.82</td>
<td>13,800 (5,433)</td>
<td>/</td>
<td>36 (5,221)</td>
<td>H M</td>
<td>8 to 10 (51 to 65) 35 (115) /</td>
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<tr>
<td>BG469</td>
<td>1.80</td>
<td>8,450 (3,720)</td>
<td>/</td>
<td>35</td>
<td>45 (6,527)</td>
<td>H M</td>
<td>6 to 8 (40 to 50) 35 (115) /</td>
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<tr>
<td>BG348</td>
<td>1.50</td>
<td>25,500 (10,039)</td>
<td>/</td>
<td>15</td>
<td>25 (3,626)</td>
<td>H M</td>
<td>6 to 10 (51 to 65) 130 (451) /</td>
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<td>CG - MC - Metal-graphite</td>
<td>C6958</td>
<td>2.50</td>
<td>350 (138)</td>
<td>/</td>
<td>30 (4,351)</td>
<td>VL M</td>
<td>10 to 25 (65 to 220) ≤ 32 (≤ 105) /</td>
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<td>C7788</td>
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<td>300 (118)</td>
<td>/</td>
<td>25</td>
<td>25 (3,626)</td>
<td>M M</td>
<td>12 to 20 (75 to 125) 40 (131) /</td>
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<td>CG651</td>
<td>2.95</td>
<td>130 (51)</td>
<td>/</td>
<td>30</td>
<td>45 (6,527)</td>
<td>VL L</td>
<td>12 to 14 (75 to 90) 35 (115) /</td>
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<tr>
<td>CG626</td>
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<td>180 (71)</td>
<td>/</td>
<td>45</td>
<td>45 (6,527)</td>
<td>VL L</td>
<td>12 to 15 (75 to 100) 30 (98) /</td>
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<td>MC79P</td>
<td>5.15</td>
<td>8 (3)</td>
<td>/</td>
<td>98</td>
<td>98 (14,214)</td>
<td>EL L/M</td>
<td>25 to 30 (160 to 200) 20 (66) /</td>
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<td>C6567</td>
<td>4.00</td>
<td>35 (14)</td>
<td>/</td>
<td>65</td>
<td>65 (9,427)</td>
<td>VL M</td>
<td>12 to 20 (75 to 125) 30 (98) /</td>
<td>65</td>
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<td>CG757</td>
<td>4.50</td>
<td>35 (14)</td>
<td>/</td>
<td>45</td>
<td>45 (6,527)</td>
<td>VL M</td>
<td>16 (103) 25 (82) / 75</td>
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<tr>
<td>CG857</td>
<td>5.65</td>
<td>7.5 (3)</td>
<td>/</td>
<td>7.5 (11,240)</td>
<td>EL M</td>
<td>20 to 30 (129 to 194) 20 (66) /</td>
<td>91</td>
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<td>CG957</td>
<td>5.45</td>
<td>40 (16)</td>
<td>/</td>
<td>110</td>
<td>110 (15,964)</td>
<td>EL M</td>
<td>20 to 30 (129 to 194) 20 (66) /</td>
<td>87</td>
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<tr>
<td>MC877</td>
<td>5.40</td>
<td>12.5 (5)</td>
<td>/</td>
<td>89</td>
<td>89 (12,906)</td>
<td>EL M</td>
<td>20 to 30 (129 to 194) 20 (66) /</td>
<td>87</td>
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<tr>
<td>CA - Metal-graphite</td>
<td>CA38</td>
<td>2.55</td>
<td>250 (98)</td>
<td>/</td>
<td>10 (1,450)</td>
<td>EL M</td>
<td>* 25 (82) / 33</td>
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<tr>
<td>CA26</td>
<td>3.60</td>
<td>20 (8)</td>
<td>/</td>
<td>40</td>
<td>40 (5,802)</td>
<td>EL M</td>
<td>* 20 (66) / 60</td>
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<tr>
<td>CA28</td>
<td>4.00</td>
<td>40 (16)</td>
<td>/</td>
<td>45</td>
<td>45 (6,527)</td>
<td>EL M</td>
<td>20 (66) / 65</td>
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<tr>
<td>CA10</td>
<td>8.00</td>
<td>6.5 (3)</td>
<td>/</td>
<td>160</td>
<td>160 (23,208)</td>
<td>EL M</td>
<td>* 15 (49) / 93</td>
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<td>Metal-impregnated</td>
<td>M609</td>
<td>2.65</td>
<td>310 (122)</td>
<td>35</td>
<td>33 (4,786)</td>
<td>VL/EL EL</td>
<td>12 to 15 (75 to 100) 35 (115) /</td>
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<tr>
<td>M673</td>
<td>1.72</td>
<td>1,180 (465)</td>
<td>35</td>
<td>26</td>
<td>26 (3,771)</td>
<td>EL H</td>
<td>10 to 12 (65 to 75) 40 (131) /</td>
<td>5.5</td>
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<tr>
<td>M9426</td>
<td>1.62</td>
<td>1,775 (699)</td>
<td>24</td>
<td>20</td>
<td>20 (2,901)</td>
<td>VL M</td>
<td>12 to 15 (75 to 100) 30/45 (98/148) /</td>
<td>9</td>
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<tr>
<td>M621</td>
<td>3.00</td>
<td>400 (157)</td>
<td>34</td>
<td>35</td>
<td>35 (5,076)</td>
<td>EL M</td>
<td>20 (66) / 65</td>
<td>44</td>
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<tr>
<td>M9020</td>
<td>1.75</td>
<td>2,700 (1,063)</td>
<td>68</td>
<td>37</td>
<td>37 (5,366)</td>
<td>L M</td>
<td>12 to 15 (75 to 100) 45 (148) /</td>
<td>5</td>
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<tr>
<td>M8295</td>
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<td>1,775 (699)</td>
<td>54</td>
<td>34</td>
<td>34 (4,931)</td>
<td>VL M</td>
<td>12 to 15 (75 to 100) 30/45 (98/148) /</td>
<td>9</td>
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<tr>
<td>MA7696</td>
<td>3.00</td>
<td>45,000 (10,039)</td>
<td>/</td>
<td>33</td>
<td>33 (4,786)</td>
<td>VL M</td>
<td>12 to 15 (75 to 100) 35 (115) /</td>
<td>55</td>
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</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Type of current / Application</th>
<th>Current density A/cm² (A/in²)</th>
<th>Speed m/s (ft/s)</th>
<th>Pressure kPa (PSI)</th>
<th>Brush grades</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIRECT CURRENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Old machines without interpoles</strong></td>
<td></td>
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</tr>
<tr>
<td>All motors</td>
<td>6 (40)</td>
<td>15 (49)</td>
<td>18 (2.6)</td>
<td>EG40P - A176 - EG34D</td>
</tr>
<tr>
<td><strong>Low voltage machines (any power)</strong></td>
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</tr>
<tr>
<td>Marine turbo-alternator exciters 30 to 50 V</td>
<td>4 - 8 (25 - 50)</td>
<td>25 (82)</td>
<td>18 (2.6)</td>
<td>LFC3H - EG7099 - CG651 - A121</td>
</tr>
<tr>
<td>Welding group generators 30 to 50 V</td>
<td>0 - 20 (0 - 125)</td>
<td>&lt; 20 (&lt; 65)</td>
<td>18 (2.6)</td>
<td>EG389P - EG367 - EG313</td>
</tr>
<tr>
<td><strong>Industrial machines (110 - 750 V)</strong></td>
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</tr>
<tr>
<td>Motors for general applications (high speeds)</td>
<td>8 - 12 (51 - 77)</td>
<td>20 - 45 (65 - 148)</td>
<td>18 (2.6)</td>
<td>EG34D - EG313 - EG367 - EG389P</td>
</tr>
<tr>
<td>Hydro turbo-alternator exciters</td>
<td>8 - 12 (51 - 77)</td>
<td>&lt; 20 (&lt; 65)</td>
<td>18 (2.6)</td>
<td>EG34D - EG7099 - EDG389P</td>
</tr>
<tr>
<td>Thermal turbo-alternator exciters</td>
<td>8 - 10 (51 - 65)</td>
<td>35 - 50 (115 - 164)</td>
<td>18 (2.6)</td>
<td>EG367 - EG365 - EG9599 - EG389P</td>
</tr>
<tr>
<td>Pilot exciters</td>
<td>2 - 5 (13 - 33)</td>
<td>&lt; 35 (&lt; 115)</td>
<td>18 (2.6)</td>
<td>EG34D - EG389P - BG469</td>
</tr>
<tr>
<td>Amplidynes</td>
<td>4 - 12 (25 - 77)</td>
<td>25 (82)</td>
<td>18 (2.6)</td>
<td>EG34D - EG389P</td>
</tr>
<tr>
<td>Illgner and Ward Leonard generators (any speed)</td>
<td>4 - 12 (25 - 77)</td>
<td>20 - 35 (65 - 115)</td>
<td>18 (2.6)</td>
<td>EG389P - EG367 - EG313</td>
</tr>
<tr>
<td>Paper mill motors and generators</td>
<td>4 - 12 (25 - 77)</td>
<td>35 (115)</td>
<td>18 (2.6)</td>
<td>EG34D - EG9599 - EG7099 - EG34D</td>
</tr>
<tr>
<td>Marine generators</td>
<td>4 - 12 (25 - 77)</td>
<td>20 - 45 (65 - 115)</td>
<td>18 (2.6)</td>
<td>EG34D - EG389P - EG7099 - EG313</td>
</tr>
<tr>
<td>Rolling mill reversing motors</td>
<td>8 - 20 (51 - 125)</td>
<td>0 - 15 (0 - 49)</td>
<td>18 (2.6)</td>
<td>EG319P - EG369 - EG313 - 2192 - 535 - 510</td>
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<tr>
<td>Rolling mill roughing motors</td>
<td>8 - 15 (51 - 100)</td>
<td>20 - 35 (65 - 115)</td>
<td>18 (2.6)</td>
<td>EG389P - EG40P - EG319P - EG6489</td>
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<td>Mine winder motors</td>
<td>12 (77)</td>
<td>25 (82)</td>
<td>18 (2.6)</td>
<td>EG313 - EG365 - EG367 - CB377</td>
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<tr>
<td>Totally enclosed motors</td>
<td>10-12 (65 - 77)</td>
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<td>18 (2.6)</td>
<td>EG9117 - EG8067 - EG7593</td>
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<td><strong>ALTERNATING CURRENT</strong></td>
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<tr>
<td>Single phase and repulsion motors</td>
<td>8 (51)</td>
<td>5 - 15 (16 - 49)</td>
<td>18 (2.6)</td>
<td>A252 - EG367</td>
</tr>
<tr>
<td>Schrage-type three-phase motors</td>
<td>8 - 12 (51 - 77)</td>
<td>5 - 35 (16 - 115)</td>
<td>18 (2.6)</td>
<td>BG412 - BG469 - BG348 - EG367</td>
</tr>
<tr>
<td>Schorch-type three-phase motors</td>
<td>10 - 14 (65 - 80)</td>
<td>5 - 35 (16 - 115)</td>
<td>18 (2.6)</td>
<td>BG28 - BG469 - EG367 - BG348</td>
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<tr>
<td>Scherbius machines</td>
<td>7 - 9 (45 - 58)</td>
<td>30 (98)</td>
<td>18 (2.6)</td>
<td>EG389P - EG313 - LFC554 - EG362</td>
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### "Traction" commutator machines

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

### Slip ring machines

<table>
<thead>
<tr>
<th>Type of current / Application</th>
<th>Slip ring material</th>
<th>Current density A/cm² (A/in²)</th>
<th>Speed m/s (ft/s)</th>
<th>Pressure kPa (PSI)</th>
<th>Brush grades</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Earth Return Current Units (ERCU)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>Steel-Bronze</td>
<td>0 - 30 (0 - 194)</td>
<td>3 - 8 (10 - 26)</td>
<td>35 - 40 (5 - 5.8)</td>
<td>MC877 - MC79P</td>
</tr>
<tr>
<td><strong>DIRECT CURRENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pickling / Tinning rolls</td>
<td>Bronze</td>
<td>20 - 30 (125 - 194)</td>
<td>3 (10)</td>
<td>18 - 40 (2.6 - 5.8)</td>
<td>MC79P - CG957</td>
</tr>
<tr>
<td>Synchronous machines (grooved or plain slip rings)</td>
<td>Stainless steel</td>
<td>11 - 13 (62 - 85)</td>
<td>≤ 100 (≤ 328)</td>
<td>13 - 18 (1.9 - 2.6)</td>
<td>LFC554</td>
</tr>
<tr>
<td>3 000 rpm</td>
<td>Steel</td>
<td>6 - 10 (39 - 65)</td>
<td>≤ 70 - 80 (≤ 230 - 262)</td>
<td>15 - 18 (2.2 - 2.6)</td>
<td>LFC501</td>
</tr>
<tr>
<td>1 500 rpm</td>
<td>Steel-Bronze</td>
<td>8 - 12 (51 - 77)</td>
<td>≤ 40 (≤ 131)</td>
<td>18 (2.6)</td>
<td>CG651 - CG657 (Bronze) - EG34D - EG389P - L1 (Steel)</td>
</tr>
<tr>
<td>1500 rpm</td>
<td>Cast Iron</td>
<td>6 - 10 (39 - 65)</td>
<td>≤ 20 (≤ 66)</td>
<td>18 (2.6)</td>
<td>EG34D - EG389P - L1</td>
</tr>
<tr>
<td>Equalizers in hydrogen</td>
<td>Steel-Bronze</td>
<td>5 - 8 (33 - 52)</td>
<td>25 (82)</td>
<td>18 (2.6)</td>
<td>EG34D - EG9599 - M9426</td>
</tr>
<tr>
<td><strong>ALTERNATING CURRENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asynchronous machines</td>
<td>Open type</td>
<td>Steel-Bronze</td>
<td>12 - 16 (78 - 104)</td>
<td>15 - 25 (49 - 82)</td>
<td>18 (2.6)</td>
</tr>
<tr>
<td>Totally enclosed type</td>
<td>Steel-Cupronickel</td>
<td>6 - 8 (39 - 52)</td>
<td>15 - 25 (49 - 82)</td>
<td>18 (2.6)</td>
<td>EG34D</td>
</tr>
<tr>
<td>Motors with carbon brush lifting device</td>
<td>Steel-Bronze</td>
<td>25 - 30 (163 - 195)</td>
<td>20 - 25 (66 - 82)</td>
<td>18 (2.6)</td>
<td>MC79P - CG957</td>
</tr>
<tr>
<td>High-speed asynchronous (pumps, ventilators)</td>
<td>Bronze</td>
<td>8 - 10 (52 - 65)</td>
<td>≤ 50 (≤ 164)</td>
<td>18 (2.6)</td>
<td>EG389P - EG34D - M9426</td>
</tr>
<tr>
<td>Synchronous induction machines</td>
<td>Bronze</td>
<td>8 - 12 (51 - 77)</td>
<td>15 - 40 (49 - 131)</td>
<td>18 (2.6)</td>
<td>M673 - M9426</td>
</tr>
<tr>
<td>Wind power generators</td>
<td>Steel-Carbon</td>
<td>12 - 15 (78 - 98)</td>
<td>45 (148)</td>
<td>18 (2.6)</td>
<td>M8285 - M9426 - CG626</td>
</tr>
</tbody>
</table>
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).

Orientation of a carbon brush on a commutator or 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

<table>
<thead>
<tr>
<th>Slots and holes dimensions</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>bolt ø (mm)</strong></td>
<td>3.4</td>
<td>4.3</td>
<td>5.2</td>
<td>6.5</td>
<td>8.5</td>
<td>10.5</td>
</tr>
<tr>
<td><strong>d (mm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SHUNT LENGTH**

<table>
<thead>
<tr>
<th>Standardized values L (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 - 20 - 25 - 32 - 40 - 50 - 56 - 63 - 71</td>
</tr>
<tr>
<td>80 - 90 - 100 - 112 - 125 - 140 - 160</td>
</tr>
</tbody>
</table>

*More information can be obtained from our Technical data sheets, sent upon request, and also available from our website [www.mersen.com](http://www.mersen.com)*
### Mounting methods

<table>
<thead>
<tr>
<th>GLUED SHOCK ABSORBER</th>
<th>HARD INSULATING TOP (RECESSED AND GLUED)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLUED SHOCK ABSORBER AND HARD MATERIAL FIXED PLATE SILESS</td>
<td></td>
</tr>
<tr>
<td>WEAR LIMITING PLASTIC CLIPS</td>
<td></td>
</tr>
<tr>
<td>BRUSH WITH REMOVABLE TOP FOR TINNING ROLLS</td>
<td></td>
</tr>
<tr>
<td>DUST GROOVES AND RECESES</td>
<td></td>
</tr>
<tr>
<td>CONTACT FACE WITH SAW CUT</td>
<td></td>
</tr>
<tr>
<td>CROSS GROOVED CONTACT FACE</td>
<td></td>
</tr>
<tr>
<td>SANDWICH BRUSH* (2 EG LAYERS)</td>
<td></td>
</tr>
<tr>
<td>GLUED BRUSH* 1 EG LAYER 1 BG LAYER</td>
<td></td>
</tr>
<tr>
<td>DUAL GRADE COMPOSITE BRUSH FOR SLIP RING* 1/3 EG LAYER 2/3 CG LAYER</td>
<td></td>
</tr>
</tbody>
</table>

*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**

![Images of GLUED RUBBER PAD with captions: FIG. 1, FIG. 2, FIG. 3]

This pad is symmetrical, allowing bidirectional rotation. However, pressure is located at the contact point of the spring. Furthermore, the high friction coefficient 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**

![Images of SHOCK ABSORBER PLATE AND HARD TOP PLATE with captions: FIG. 4, FIG. 6, 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 profile (Fig. 8).

**Shunts**

Shunt diameters follow the industry standard as indicated below:

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>1.6</th>
<th>1.8</th>
<th>2</th>
<th>2.2</th>
<th>2.5</th>
<th>2.8</th>
<th>3.2</th>
<th>3.6</th>
<th>4</th>
<th>4.5</th>
<th>5</th>
<th>5.6</th>
<th>6.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal value of current (A)</td>
<td>15</td>
<td>17</td>
<td>20</td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>38</td>
<td>44</td>
<td>50</td>
<td>60</td>
<td>75</td>
<td>85</td>
<td>100</td>
</tr>
</tbody>
</table>

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 specific applications (e.g. aviation). The shunt loop placed into the carbon brush is preformed with a tool before the riveting operation.
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 film 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 fitted (or re-fitted) 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, first 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.

![Correct and Incorrect](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.

![2 mm](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](http://www.mersen.com)*
### RECOMMENDED PRESSURES IN NORMAL WORKING CONDITIONS

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

**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 (75 μm) 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 sufficient roughness (1.3 to 2 μm Ra) in order to create and maintain a correct film.

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.
Visual guide to slip ring / commutator films

**Technical Data Sheet AE-TDS/13**

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

**P. Film types**

**SUITABLE FILMS**

**COLOR INTENSITY**

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

![P2](image1)

![P4](image2)

![P6](image3)
SUSPECT FILMING REQUIRING MONITORING

CLASSES OF FILM DEPOSIT

- **P12: Streaky film**
  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 film**
  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 film, but worsened or longer-lasting. Also the carbon brush grade may be unsuitable.

- **P16: Patchy film**
  Showig spots of various shapes, colors and dimensions, without any pattern.
  Most frequent causes: deformed or dirty commutator, out-of-round slip ring.
PATCHINESS DUE TO MECHANICAL CAUSES

- **P22: Uneven film, “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.

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 difficult commutation of each successive conductor in the slot.

- **P44: Pitting - Strong spark marks**
  Most frequent cause: high frequency current flow.
Patches Due to Pollution

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

B. Burning

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

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
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

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 profile 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...
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, specific technical support and training, allowing you to optimize your wind turbine performance. They are supported by a large network of specialists in five continents, allowing Mersen to respond to your needs, wherever the location.

Training

Mersen provides training courses for maintenance of electric motors. For over twenty five 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...)
  - Retrofit 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-Profilers**:
  - To measure commutator / slip ring profiles
  - Low speed inductive probe

- **ComPro2000™**:
  - To measure commutator profiles during operation
  - Any speed, non-contact eddy-current transducer
  - Contact measurement
  - Ruby tip for “live” measurements

- **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?

**Characteristics and identification**

A carbon brush is clearly defined 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 to identify a brush, but any additional information will help.

There are also other ways to define 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 specifications required to make a carbon brush drawing. Except in very specific 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 brushes fitting any motor type within one week, or even one day under certain conditions.
CARBON BRUSH
APPLICATION DESCRIPTION FORM
(Text conforms with IEC norm 60136)

<table>
<thead>
<tr>
<th>Company</th>
<th>Surname / Name</th>
<th>Address</th>
<th>Phone Nr.</th>
<th>Fax Nr.</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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  

<table>
<thead>
<tr>
<th>Element</th>
<th>Nominal</th>
<th>In service</th>
<th>Normal</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. SPEED (rpm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. VOLTAGE (V)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. CURRENT (Amps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. POWER (kW)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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:  
   - Inside  
   - 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):  

<table>
<thead>
<tr>
<th>Commutator</th>
<th>Slip rings</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIAETRER:</td>
<td></td>
</tr>
<tr>
<td>Nr of bars:</td>
<td></td>
</tr>
<tr>
<td>Bar width:</td>
<td></td>
</tr>
</tbody>
</table>

Micas width:  
- NR OF TRACKS:  
- NR OF BRUSHES  
- PER TRACK:  
- NR OF POLES:  

BRUSH DIMENSIONS:  
- (see Fig.1)  
- t = ……………. a = ………. r = ……….  

BRUSH BOTTOM ANGLE  
- (see Fig.3, 4 and 5)  
- a = …………….  

TOP BEVEL ANGLE  
- (see Fig.10)  
- β = …………….  

SPLIT BRUSH?  
- Fig 6  
- Fig 7  
- Fig 8  
- Fig 9  

The brushes on the same path are:  
- In line  
- Staggered  

<table>
<thead>
<tr>
<th>CC</th>
<th>CA</th>
</tr>
</thead>
</table>

26. Commmutator’s Slip ring’s condition  
- Good  
- Glossy  
- Matt  
- Smooth  
- Worn out  
- Grooved  
- Uniform  
- Marked  

Marks:  
- Evenly distributed  
- Unevenly distributed  
- Burnt  

Color:  
- Light  
- Average  
- Dark  

Please fill this form out to help us find the most suitable carbon brush for your specific 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

<table>
<thead>
<tr>
<th>I Shunt length in mm</th>
<th>Diameter or width of fixing gap in mm</th>
</tr>
</thead>
</table>

Essential information for the manufacture of a carbon brush

Fixing gap width or diameter in mm

If pressure clip or insert required

β Top bevel angle if present

α Bottom bevel angle if present

Fig. 10
STANDARD SHAPES

SHAPES OF NEW TERMINALS (recommended)

SHAPES OF OLD TERMINALS

Special shapes of terminals

CL01
CL02
CL03
CL04
CL05
CL10
CL11
CL12
CL13
CL14
CL15
CL20
CL21
CL22
CL23
CL24
CL31
CL32
CL33
CL34
CL35
CL41
CL42
CL43
CL44
CL45
CL46
Shape of the terminal and bolt diameter
Length of the shunt to the axis of the bolt
Shape of the brush

SHUNT LOCATION

Top view

Commutator

Slip ring

Shapes in accordance with NEMA standard
(National Electrical Manufacturers Association) No. CB-1-1995

CL06
CL07
CL08
CL09

CL10
CL17
CL18
CL19

CL25
CL26
CL27
CL28
CL29
CL30

CL36
CL37
CL38
CL39
CL40

Special shapes
Shape above with a “S” suffix
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

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

<table>
<thead>
<tr>
<th>Brush size</th>
<th>t:                   mm</th>
<th>a:                   mm</th>
<th>r:                   mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>Diameter:               mm</td>
<td>Width:                 mm</td>
<td></td>
</tr>
<tr>
<td>Spring carrier</td>
<td>Width:                   mm</td>
<td>Height:                mm</td>
<td>Thickness:            mm</td>
</tr>
<tr>
<td>Material:</td>
<td></td>
<td></td>
<td>Insulated:</td>
</tr>
<tr>
<td>Brush-holder</td>
<td>Width:                 mm</td>
<td>Length:                mm</td>
<td></td>
</tr>
<tr>
<td>Dimension from bottom of holder to the mounting pin:</td>
<td>mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other information

<table>
<thead>
<tr>
<th>Carrier engraving:</th>
<th>Quantity:</th>
<th>Delivery with brushes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>□ YES □ NO</td>
</tr>
</tbody>
</table>
Sketch for front and side views

Special request

.........................................................................................................................................................
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APPENDICES
Occurrence of technical terms in this guide

- Apparent density ................................................................. 14, 15
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- Bar edge chamfering ......................................................... 3, 29
- Carbographitic (grade) ....................................................... 10, 14, 23
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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):

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

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