

# MAINTENANCE OF CARBON BRUSHES, BRUSH-HOLDERS, COMMUTATORS AND SLIP RINGS



A major player in industry worldwide, Mersen offers you its global technical expertise based on its extensive knowledge of electrical rotating machinery gathered over a period of 120 years.

This guide is for the use of all professionals in industrial maintenance.

Preventive maintenance procedures vary depending on the type and power of machines, specific service conditions, the duration of operation and stoppage periods... This guide groups essential maintenance actions and provides check lists valid for all or part of each individual situation.

## Preventive maintenance

See Technical Data Sheet AE-TDS/08

**Preventive maintenance** ensures that machines and equipment are kept in good working condition.

Any preventive maintenance procedure not requiring the machine to be dismantled includes in chronological order:

- Inspection during operation, during slowdown and until machine stop
- Actions at standstill:
  - Cleaning
  - Electrical and mechanical controls and measurements
  - Checking before commissioning (in compliance with the specifications set by the supplier of the electrical machine)

### Inspection during operation

Classification of sparking according to the “Mersen Commutation Indicator” and “Westinghouse” spark level chart.

#### Generators and motors

Representation (axial view - carbon brush on commutator)	Mersen Commutation Indicator index	Westinghouse index	Designation
	1	1	Black
	2	1 ¼	Intermittent beads
	3	1 ½	A few beads
	4	1 ¾	Numerous beads
	5	2	Intermittent shooting sparks
	6	2 ¼	A few shooting sparks
	7	2 ½	Numerous streamers
	8	2 ¾	Heavy and continuous streamers

• Bead • Shooting Spark • Streamer

Normal acceptable limits are:

- Normal operating conditions: 1 to 3 on Mersen Commutation Indicator (1 to 1 ½ per Westinghouse).
- Peak operating conditions - Overload: 4 on Mersen Commutation Indicator (1 ¾ per Westinghouse).

If you have any questions, do not hesitate to contact our Customer Technical Assistance Service. Email: [infos.amiens@mersen.com](mailto:infos.amiens@mersen.com)

## Inspection during slowdown and until machine stop

- Watch and listen for vibration or noise which can occur at low speed
  - on the machine frame,
  - on the bearings or bearing housings,
  - or on the carbon brushes.
- Listen for any rattling at the flexible coupling.
- Using a visual mark placed on the machine's shaft, check that the rotor stops at random positions.
- As soon as the machine is stopped, measure the commutator or slip ring temperature (the temperature of each ring).

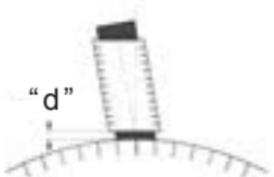
## Measurements and observations at standstill

### ELECTRICAL MACHINE

- Measure the insulation resistance of the various components and circuits before and after blowing out any dust to verify the effectiveness of the operation.
- Measure the air-gap at 4 points, 90 degrees apart (say 3, 6, 9 and 12 o'clock) with the appropriate set of feeler gauges and compare the obtained average with the original value reported by the manufacturer. The observed discrepancy will give an idea of the internal bearing clearance.

### BRUSH-HOLDERS AND CARBON BRUSHES

- Carbon brush stability (see **Technical Data Sheet AE-TDS/04**): check the clearance between the brush-holders and the carbon brushes.
- If the carbon brush does not slide properly check the brush-holder interior surface condition.



- Check that the "d" distance between the brush-holders and the rotating component (commutator or slip rings) is adjusted correctly (2.5 to 3 mm or nominal 0.125 inches for most of the machines), see figure opposite.
- Brush spring pressure (see **Technical Data Sheet AE-TDS/11**): check with a dynamometer that the pressures are equal on all the carbon brushes\* (see chart opposite).

\* A maximum of 10 to 15 % difference remains acceptable.

## RECOMMENDED PRESSURES (in kPa)

Grade groups	On slip ring	On commutator	
		Stationary machines	Traction machines
Electrographite	18 - 20	18 - 20	35 - 45
Resin-impregnated Electrographite		18 - 25	35 - 55
Carbographitic & Resin-bonded		18 - 20	n/a
Soft graphite	11-20*		
Metal-graphite	Normal speeds	18 - 20	
	Speeds < 1 m/s (3 ft/s)	25 - 27	

\* Please consult us

**Note:** 1 kPa = 10 cN/cm<sup>2</sup> (centinewton/cm<sup>2</sup>) = 0.145 PSI, and is close to 10 g/cm<sup>2</sup>.

- Make sure that the brush-holders are properly adjusted at the correct angle.
- Note if copper dust is present on the brush-holders or on the brush-holder arms. Sure signs of commutator wear.
- Measure and compare the lengths of all brushes on the same brush track to detect abnormal wear.
- **Check that the brush edges are intact**, without burn marks or chips, and that the brush sides do not show vibration (shiny surfaces), sparking or signs of sticking.
- **Check that the shunts are not discolored, oxidized, loose or frayed.**
- **Once the carbon brushes are reinstalled, check:**
  - that they slide freely inside the brush-holders with an adequate clearance to avoid either the brush getting stuck or the brush rattling in the holder
  - that the pressure devices are correctly centered on the carbon brush tops and that the shock absorber pads are in good condition
  - that the shunts are correctly located for minimal interference
- ⚠️ • **Check that the carbon brushes were not installed or reinstalled in the wrong direction in the brush-holders.** This is especially critical for carbon brushes with a beveled contact surface or split brushes with a metal plate.
- **Make sure to remove the existing film** before any carbon brush grade change.
- ⚠️ • **Do not mix different carbon brush grades or brushes from different manufacturers on a machine.**
- Carbon brush position: Axial stagger done correctly can be advantageous however one must ensure that an equal number of positive as negative brushes per track is maintained. Circumferential stagger is not recommended by Mersen as it introduces asymmetry, where circumferential stagger is deemed necessary by the OEM it is imperative that it is done correctly.
- Check that the brush arm spacing is equidistant all around the commutator.

## COMMUTATOR / SLIP RINGS

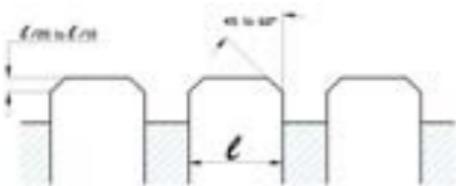
- **Degreasing (see Technical Data Sheet AE-TDS/18):**  
For slightly greasy commutators, it is advisable to thoroughly clean with a clean dry cloth. If a greasy film remains, one can use a clean cloth moistened with a dry chlorine-free solvent leaving no residues after evaporation. However make sure to remove all the carbon brushes first as they are very absorbent.
- **Run-out**  
Check the commutator / slip ring run-out with the Mersen CL-Profiler. The Total Indicated Runout (TIR) should for a new or refurbished machine be less than 30 microns or 1.2/10th of a mil. Speed dependant, please contact Mersen.
- **Surface roughness (see Technical Data Sheet AE-TDS/02)**  
Here we are talking about arithmetical roughness Ra, a roughness parameter recognized and used all over the world. Ra = Arithmetic average of the absolute values of profile variation in the entire measuring section.  
Make sure the existing skin roughness is always higher than 0.4  $\mu\text{m}$  (16 micro-inches). Otherwise roughen the surfaces, preferably with an "M" (medium grain) grade of grinding stone, or else use 80-grit sandpaper (maximum 100-grit).  
After grinding or machining we recommend the following roughness values:
  - Ra = 0.9 to 1.8  $\mu\text{m}$  (35 to 71 micro-inches) for industrial machine commutators
  - Ra = 0.5 to 1.0  $\mu\text{m}$  (20 to 39 micro-inches) for small commutators of machines less than 1 kW
  - Ra = 0.75 to 1.25  $\mu\text{m}$  (30 to 49 micro-inches) for steel or bronze slip rings



**Roughness values exceeding 2  $\mu\text{m}$  (78 micro-inches) cause high brush wear.**

The aim of the grinding operation is to obtain the correct number of 100 peaks / cm (250 peaks / inch).

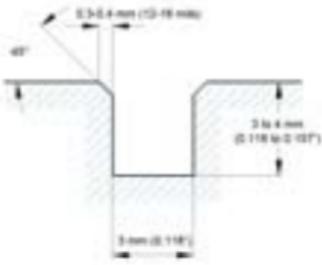
- **Control of commutator bars**
  - Check that bar edges are properly chamfered (see Technical Data Sheet AE-TDS/03).



- Make sure micas are correctly undercut and there are no burrs along the bar edges.



- Check there is no signs of pitting or dark patches on bars, or burning on bar edges (= early signs of commutation difficulties).



- Examine the slip ring helical groove edge chamfering: a sharp edge always causes quick brush wear, as well as marks or burns on metal.

- If the film seems to be a little too thick, we advise grinding the commutator / the slip rings with an “M” grade of grinding stone before commissioning.

### Cleaning

- Remove as much dust as possible with a vacuum cleaner. Blow dry air through the rotor and the stator in both directions, i.e. commutator (or slip ring) side and opposite. Best practice is to blow the dust out of the machine and not through it.

 A simple displacement of dust towards the inside of the machine can be more of a nuisance than a benefit.

- Maintain the filters on a regular basis.
- Wipe the insulators clean with a soft cloth.

### 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



### Special precautions if the machines have to be stopped for a longer period

- Protect the commutators / slip rings against dust and oil with sheets of non-porous insulating material.
- Lift all the carbon brushes, especially if the machine has to be stored in wet, salty or corrosive atmosphere, or insert a sheet of non-porous insulating material between the carbon brushes and the rotating parts (commutators / slip rings).

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

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# Maintenance tools and measuring devices

## Maintenance tools

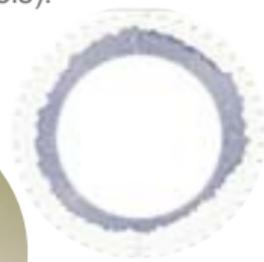
- Brush seating stones and accessories
- Grinding stones, Garnett paper
- Single and Double Handle grinding stones
- Portable mica undercutters
- Scrapers, slotting files, mica-saws
- Finishing tools
- Tool support frames (carriages designed for use with abrasive stones or cutting tools).



Set of grinding tools



CL-Profilers



Commutator profile as measured by Mersen's CL-Profilers

## Measuring devices

- CL-Profilers for commutator and slip ring profiles (standard or double Viroti probe)
- ComPro2000™ for dynamic commutator profile measurement using non-contact eddy-current transducers
- DiaMeter for the measurement of the diameter of commutators, slip ring assemblies and rolling stock wheels
- Dynamometers (Load Cell force measurement)
- Stroboscopes
- Roughness measuring devices
- Carbon brush wear monitoring devices
- Alarm boxes
- Commutation Spark Indicator to measure the spark intensity on DC electrical machines



Commutation Spark Indicator



DiaMeter, diameter measurement on commutator



DiaMeter, diameter measurement on wheel

For more information please refer to our brochure "Maintenance tools for electric machines"

# Carbon brush contact surface seating

Seating means to match the contact surface of the new carbon brush to either the slip ring or commutator radius, as well as to establish the correct surface roughness, this ensures an immediate high quality mechanical and electrical contact.

**Great care has to be taken for carbon brush contact surface seating**, particularly if:

- the commutator or slip ring's peripheral speed is high
- the commutator's radius is small – all the more so with split brushes (see fig. 1). Poor contact surface seating will make the carbon brush press on the commutator at its middle wafer only, which will then carry the whole current load. The consequences can be serious, for the commutator as well as for the carbon brush.

**Remark:** Carbon brushes are sometimes supplied with a pre-radiused contact surface, that is to say a contact surface ground to the required radius. The brush radius is only approximate and does not remove the necessity to seat the contact surface. The advantage of the preformed radius is to shorten the seating time.

## Carbon brush contact surface seating methods

① For small or medium diameter commutators or slip rings (up to around 500 mm - 19 inches), carbon brush contact surface seating can be performed by grinding wheels with a diameter equal to that of the commutator / slip rings. This is a quick, but approximate method; it is suitable for large production series of motors of the same type. During seating, the carbon brush has to be tightly held in place against the grinding wheel, not by hand, but by the means of a brush-holder mounted at a 2.5 – 3 mm (0.1 inches) distance from the grinding wheel.

 **After seating, it is necessary to blow dry air on the contact surface in order to remove residual abrasive grains.**

② Seating can most often be performed on the machine itself, several methods exist depending on the machine type and importance:

### **A - CARBON BRUSH CONTACT SURFACE SEATING WITH 80-GRIT SANDPAPER (MEDIUM)**

Adjust the sandpaper to cover all or part of the commutator as required with appropriate clips or by hand. Once the new carbon brushes are mounted into the brush-holders, press on the sandpaper, oscillate the motor back and forth until the contact surfaces are completely seated (see fig. 2).

On large machines, it is sometimes necessary to seat each path of carbon brushes by moving the sandpaper by hand (see fig. 3). Ensure the sandpaper is always in contact with the commutator or slip ring (see fig. 4), which would otherwise leave a badly seated brush surface.



Fig. 1



Fig. 2



Fig. 3



Fig. 4

## B - CARBON BRUSH CONTACT SURFACE SEATING WITH MERSEN GRINDING STONES

This method is used for larger machines operating at zero or low voltages.

Grinding stone dust operates as an abrasive and seats the carbon brush to the exact commutator profile.

This method is a good one as long as it is not used too often, because grinding stone dust wears the metal of the commutator / slip rings.

It can only be used when seating requires limited carbon brush wear. After seating, it is necessary to roughen the contact surface roughness using an “M” (medium grain) grade of grinding stone.

**⚠ After seating with sandpaper or grinding stone, it is necessary to remove the carbon brushes from the brush-holders and blow the commutator and the carbon brush contact surfaces in order to remove all of the abrasive dust and carbon brush dust.**

### Remarks

- We sometimes supply new carbon brushes with no radius but with a cross-grooved contact surface, usually used on high-speed machines. These special contact surfaces do not replace the seating operation.

**⚠ • Even if properly seated, carbon brushes are likely to vibrate upon machine start up if the commutators / slip rings were machined with a diamond tip tool, meaning they are glossy.**

We advise to roughen the glossy surfaces with an “M” grade of grinding stone or 80-grit sandpaper (maximum 100-grit) prior to commissioning, in order to facilitate graphite deposit on the sliding surfaces and therefore to speed up film creation.

- On replacing carbon brushes one by one on large machines, pre-radiused carbon brushes may be fitted without seating their contact surfaces, but only if the number of replaced carbon brushes is lower than 20% of the total number of carbon brushes, and if the new brushes are uniformly distributed around the commutator. The new carbon brushes will then self-seat in operation without disturbing the operation of the other brushes.

For more information please refer to our technical guide “Carbon brushes for motors and generators” and to our technical data sheet AE-TDS/01 (“The functions of a good brush - What you should know”).

# Visual guide to Slip ring / Commutator films

See Technical Data Sheet AE-TDS/13

Below are examples of various film conditions and commutator / slip ring faults, as well as their causes.

## P – Film types

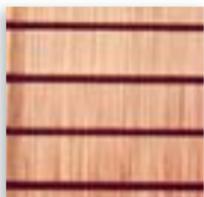
### SUITABLE FILMS

#### Color intensity

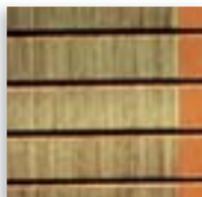
- P2 - P6: Normal films

Uniform, light brown (P2) to darker brown (P6).  
The machine and the carbon brushes work well.

Corresponding carbon brush contact surface:  
FF2 (homogeneous uniform surface).



P2



P6



FF2

### SUSPECT FILMING REQUIRING MONITORING

#### A - Classes of film deposit

- P12: Streaky film

Lines or bands of varying width, alternating light and dark, without copper wear.

**Most frequent causes:** incorrect axial stagger, excessive humidity, oil vapors or aggressive gases in the atmosphere, under-loaded carbon brushes. Slightly streaky films can also be attributed to impregnation treatments in the brushes.

- P14: Raw grooved film

P14a: on commutator / P14b: on slip rings

Same as for P12, but with copper-colored raw grooved bands or very lightly colored bands. The metal is being attacked.

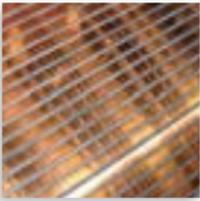
**Most frequent causes:** same as for streaky film, but worse or more severe. Also the carbon brush grade may be unsuitable.

**Corresponding carbon brush contact surface:** FF14 (streaky surface).

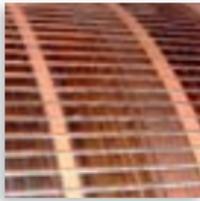
- P16: Patchy film

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



FF14



P16

## B - 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.

Corresponding carbon brush contact surface: FF24 (chipped edge).

- 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.

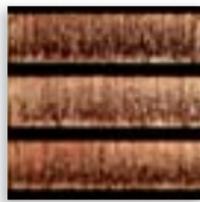
Corresponding carbon brush contact surface: FF26 (stitched surface).



P22



P24



P26



P28



FF24



FF26

## C - Bar marking due to electrical causes

- P42: The dark bars have a polished, mat or blackened appearance.

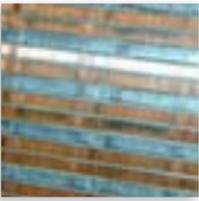
This pattern is repeated all around the whole commutator. The most frequent causes are of an electrical origin. They appear on armatures with more than one conductor per slot, and are linked with successive and increasingly difficult commutation of each successive conductor in the slot.

Incorrect brush configuration is also often the cause.

Consult Mersen Application Engineers ([infos.amiens@mersen.com](mailto:infos.amiens@mersen.com))

- P44: Pitting - Strong spark marks

Most frequent cause: high frequency current flow.



P42



P44

## D - 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.



P62

## 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.

Corresponding carbon brush contact surface: FF6 (burnt surface or edge).



B6



B8



B10



FF6

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



T10



T11



T12



T14



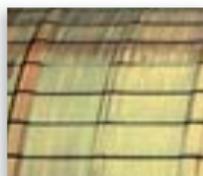
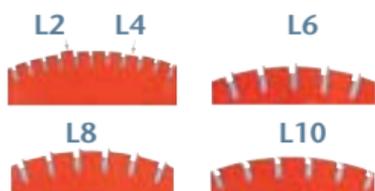
T16



T18

## L - Commutator bar faults

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



R2



R4

## 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 SERVICES, SERVICING YOUR ELECTRICAL ROTATING MACHINERY

### Motor Maintenance Service

- On-site motor inspections (application, mechanical, electrical, engineering, environment)
- *In-situ* machining of the commutators and slip rings of your electrical rotating machines (any power)
- Re-engineering and retrofit of your components, development of innovative systems)

### Training

- High quality technical training, STAGELEC inter-company, EXTELEC intra-company (in Mersen training centers or on customer's site)
- Customized training curriculum
- Technical seminars on electrical rotating machinery (any market segment)

### Technical assistance

- Permanent assistance to OEMs, users and repair companies.

## A GLOBAL PLAYER

Global Expert in electrical specialties and graphite-based materials, Mersen designs innovative solutions to address its clients' specific needs to enable them

to optimize their manufacturing process in sectors such as energy, transportation, electronics, chemical, pharmaceutical and process industries.

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