



TECHNICAL GUIDE

HOW TO MAINTAIN CARBON BRUSHES, BRUSH-HOLDERS, COMMUTATORS AND SLIP RINGS



A major player in the 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 designed 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.

01

PREVENTIVE MAINTENANCE

See Technical Data Sheet 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 the machine stops
- Actions at standstill:
 - Cleaning
 - Controlling and measuring electrical and mechanical items
 - Double-checking before restarting the machine all is in order (everything is in compliance with the specifications set by the supplier of the electrical machine)

Inspection during operation

Define the sparking according to the « Mersen Commutation Indicator » and the “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	3	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**

Inspection during slowdown and until the machine stops

- Watch and listen for vibrations or noises 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.
- Check that the rotor stops at random positions by using a visual mark placed on the machine's shaft.
- 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 any dust away 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 average with the original value reported by the manufacturer. The discrepancy will give an idea of the internal bearing clearance.

BRUSH-HOLDERS AND CARBON BRUSHES

- Carbon brush stability (**see Technical Data Sheet TDS-04**): Check the clearance between the brush-holders and the carbon brushes.



- If the carbon brush does not slide properly check the condition of the brush-holder's interior surface.
- 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 for most of the machines), see opposite figure.
- Brush spring pressure (**see Technical Data Sheet TDS-11**): Check with a dynamometer that the pressure is equal on all the carbon brushes* (see table page 3).

* 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		18-20	18-25	35-55
Carbographitic & Resin-bonded		n/a	18-20	n/a
Soft graphite		*	*	n/a
Metal-graphite	Normal speeds	18-20	*	*
	Speeds < 1 m/s	25-27	*	n/a

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

- 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, it's a sure sign 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 evidence of 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. Mersen does not recommend a circumferential stagger since it introduces asymmetry. When a 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 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 Mersen's CL-Profiler. The Total Indicated Runout (TIR) should be less than 30 microns for a new or refurbished machine. Speed dependant, please contact Mersen.

• Surface roughness (see Technical Data Sheet 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 μm . Otherwise roughen the surfaces, preferably with an "M" (medium grain) grade grinding stone.

After grinding or machining, we recommend the following roughness values:

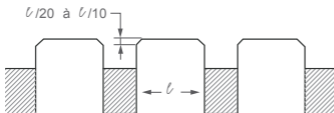
- Ra = 0.9 to 1.8 μm for industrial machine commutators
- Ra = 0.5 to 1.0 μm for small commutators of machines less than 1 kW
- Ra = 0.75 to 1.25 μm for steel or bronze slip rings

 Roughness values exceeding 2 μm cause high brush wear.

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

• Control of commutator bars

- Check that bar edges are properly chamfered (see Technical Data Sheet TDS-03)



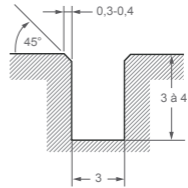
- Make sure micas are correctly undercut and there are no burrs along the bar edges.



- Check there is no sign of pitting or dark patches on bars, or burning on bar edges (= early signs of commutation difficulties).
- If the film seems to be a little too thick, we advise grinding the commutator / slip rings with an “M” grade of grinding stone before restarting the machine.

- **Control of slip ring helical groove:**

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



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.

DUSTCOLLECTOR,

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 MUST BE STOPPED FOR A LONGER PERIOD

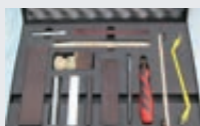
- Protect the commutators / slip rings against shocks and oil projections with sheets of non-porous insulating material.
- Lift all the carbon brushes, especially if the machine has to be stored in a wet, salty or corrosive atmosphere, and insert a sheet of non-porous insulating material between the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

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02 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-Profiler



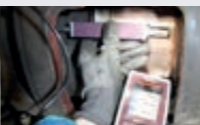
Commutator profile as measured by Mersen's CL-Profiler

MEASURING DEVICES

- CL-Profiler for commutator and slip ring profiles (standard or double Viroti probe)
- 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



CL-DynamoMeter



Roughness meter



Commutation Spark Indicator

For more information please refer to our brochure
"Tools and devices for maintenance of electrical machines"

Our Customer Technical Assistance Service is at your service for any questions

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03

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 quality mechanical and electrical contact.

Great care must be given to the 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 only press on the commutator's middle wafer, 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 cancel the necessity to seat the contact surface. The advantage of the preformed radius is to reduce the seating time.

Carbon brush contact surface seating methods

- For small or medium diameter commutators or slip rings (up to around 500 mm), 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 must be tightly held in place against the grinding wheel, not by hand, but by a brush-holder mounted at a 2.5 – 3 mm 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.



- Seating can most often be performed on the machine itself, several methods exist depending on the machine type and size.

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), lifting the sandpaper from the contact surface will lead to a reduced and uneven contact surface area under the brush.



FIG. 1



FIG. 2



FIG. 3



FIG. 4

B

CARBON BRUSH CONTACT SURFACE SEATING WITH MERSEN GRINDING STONES

This method is used for large machines, which must always be operated at zero or very low voltages.

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

This is a good method 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 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.

● When 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 TDS-01 ("The functions of a good brush - What you should know").

04

VISUAL GUIDE TO SLIP RING / COMMUTATOR FILMS

See Technical Data Sheet TDS-13

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

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).



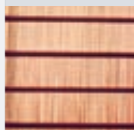
FF2

SUSPECT FILM REQUIRING MONITORING

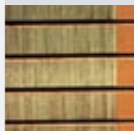
CLASSES OF FILM DEPOSIT

● P12: Streaky film

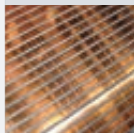
- Lines or bands of varying width, alternating light and dark, without copper wear.
- Most frequent causes: incorrect axial stagger, excessive humidity, oil vapors or aggressive gases in the atmosphere, under-loaded carbon brushes.



P2



P6



P12

● **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 more intense and longer-lasting. Also the carbon brush grade may be unsuitable. A too low spring pressure can get copper embedded in the brush face.
- Corresponding carbon brush contact surface: FF14 (streaky surface).



FF14

● **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.

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.**

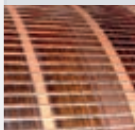
- Shading in the middle of the bars (P26) or at the two bar edges (P28).
- Most frequent cause: poor maintenance of the commutator.
- Corresponding carbon brush contact surface: FF26 (stitched surface).



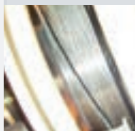
FF24



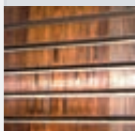
FF26



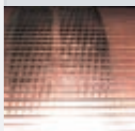
P14a



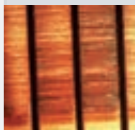
P14b



P16



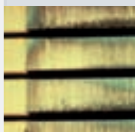
P22



P24



P26



P28

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)



P42



P44

● 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.



P62

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

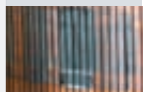


FF6

Marking

Particular types

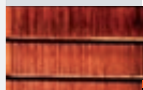
- **T10: Brush image on commutator**
- **T11: Brush image on slip ring**
 - Dark or black mark reproducing the carbon brush contact surface on the commutator / slip ring.
 - Most frequent causes: accidental overload or electrolytic mark during a long period of stoppage.
- **T12: Dark fringe due to high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



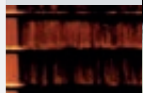
T10



T11



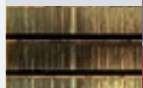
T12



T14



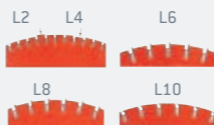
T16



T18

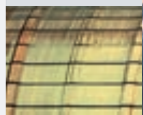
Commutator bar faults

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

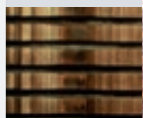


Commutator bar wear

- **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...**



R2



R4



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, inter-company or intra-company (in Mersen training centers or at 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.

MERSEN
Expertise, our source of energy

GLOBAL EXPERT IN
ELECTRICAL POWER
AND ADVANCED MATERIALS

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