

Carbon Brushes for Industry and Traction

Machine Operating Problems



When disturbances or operating difficulties concerning the running performance of carbon brushes are discussed it should be borne in mind that not all deviations from the ideal are bad.

It should be made a distinction between phenomena which represent a danger to the machine or operation, e.g. strong brush sparking; or cases where maintenance expenditure is too high, e.g. with high uneven brushwear, and instances which can more or less be regarded as “minor blemish” such as uneven patina. Such “faults” should not be overrated if otherwise the function of the machine is guaranteed.

The carbon brushes should not always be blamed for unsatisfactory running performance. It is often difficult to find the source of the problem as there are many disturbance factors that could cause poor running performance.

Some of the most common problems and the possible sources of the disturbances are discussed in the following pages.

The remedial measures necessary are apparent from the disclosure of the possible source of the problem, for instance where the wrong brush pressure must be corrected or where an out-of-round commutator must be

skimmed. Therefore, the remedial measures necessary will not be mentioned specifically.

The hints given are supplemented by illustration of typical brush and commutator surfaces (see pages 5 and 6).

We would like to achieve by means of this method that the users of our products and ourselves speak the same language regarding any queries or answers. This reduces the danger of any misunderstandings and also eases the judgement of any problems that may arise. Notwithstanding the above our application engineers are, naturally, also available to help with any problems.

Brush sparking

Brush sparking should only be objected to when it is damaging to the brush and/or collector.

Weak pin-points are harmless in nearly all cases and can be accepted even during continuous operation. If there are reddish sparks, however, then the carbon material is being attacked and discolouration of the film is apparent at the segment edges. Remedial steps are soon required if “streakers” are observed, whereas green-glowing crackling areas call for immediate action.

In order to have some means of comparison we have illustrated sparking conditions of increasing intensity on leaflet 10.36/06 and have allocated a value plus a description for each stage.

Possible sources of excessive brush sparking are:

- commutator or slipring is out-of-round
- strong vibrations
- brush pressure is too low
- carbon brush clearance in the brush holder is too large
- commutator segment insulation is not undercut enough or is protruding
- brush arm spacing is incorrect
- commutator segment coverage is too large or too small
- defective armature winding
- wrong positioning of the brush bridge
- wrongly set interpole
- machine is overloaded
- commutator or slipring is dirty
- poor connections between commutator bars and windings
- uneven current distribution, some brushes overloaded
- brushes not bedded in properly
- wrong brush grade.

Machine Operating Problems

Too high and uneven brush wear

In advance must be stated that it is very difficult to maintain, which brush wear (reduction of unit of length per time period or, more correct wear rate) can be regarded as normal without knowing the exact operating conditions.

The users of our carbon brushes require the lowest brush wear in order to achieve longer service intervals, less dust in the machine and, without saying, lower maintenance charges.

Too low brush wear can, however, in certain circumstances and after long operating times, lead to problems as smooth and dense running surfaces can build up on the carbon brush as a result of the low brush wear. These surfaces produce aerodynamic effects during high speed running which lead to a reduction in brush contact. With low peripheral speeds and smooth running surfaces the carbon brush can in certain adverse circumstances start oscillating when the sliding force is near to the static frictional force.

A minimum number of contact points are necessary for current commutation which are inevitably worn as a result of the sliding process. The extent of this wear rate depends on the operating conditions, ambient conditions and the carbon brush material.

Due to the multiplicity of influences it is difficult or even virtually impossible to give firm information about the wear rate to be expected in individual cases.

Dependent on loading, operating conditions and carbon brush material, the wear rate for stationary machines lies normally in the region of 2–7 mm/1,000 hrs. An available wear length of 20 mm, for example, gives a brush life of between 2,900 and 10,000 hours.

In traction application the wear rate is usually given in terms of wear in mm per 1,000 km. Normal wear is regarded as being in the region of 0.2 to 0.35 mm per 1,000 km.

Uneven brush wear should only be objected to if there are large differences in length after a long running time. Smaller differences in length, e. g. 10 % should be considered as normal.

The following faults can lead to high or uneven wear:

- commutator or slipring is out-of-round
- patchy commutator or slipring
- adverse influence of oil and dirt
- dusty air
- protruding mica
- vibrations
- aggressive gases and vapours in the air
- humidity too low
- bad commutation
- machine overloaded
- uneven or too low brush pressure
- uneven current distribution
- mixed brush grades
- unsuitable brush grades.

Patchiness and burns on sliprings and commutators

Patchiness and burn marks are overwhelmingly caused by mechanical disturbances of the brush running. Arcs are drawn, due to contact breaking, which lead to damage of the commutator or slipring surface.

Weak patches appear initially and these strengthen with longer running. The arced commutator or slipring material together with the brush dust form the so-called burns.

A special type of patchy formation is shown on stand still commutators or sliprings when, due to high humidity, the carbon brush/rotor forms a galvanic element. If such conditions apply, one should place insulating mats under the carbon brushes in order to avoid such markings.

Faults which could lead to patchiness and burn marks are:

- commutators or sliprings out-of-round
- protruding commutator segment insulation
- protruding or loose commutator segment
- out of balance armature
- brush pressure too low
- vibrations or oscillations at the brush holder and brush
- defective windings.

Machine Operating Problems

Grooving

There is quite a list of operating conditions and external influences which lead to attack of the commutator or slipping material and the formation of small tracks referred to as grooving. These grooves can expand in unsuitable conditions to relatively deep and wide furrows over the whole area covered by the carbon brush.

These grooves do not represent any immediate danger for the operating security of a machine. Expensive commutator copper will be worn out, however, so groove formation must be stopped by changing the operating and ambient conditions. When assessing the groove depth one should note that the strong colour or lightness difference between copper tracks and the patinated zones often looks like grooving whereas it is only a strong stripe formation of insignificant depth.

The most common causes of grooving are:

Foreign bodies

Fine, hard, dust particles carried out by the cooling air can come between the carbon brush running surface and the collector and possibly even stick into the brush. These tear the patina and lead after further running into grooving of the commutator surface.

Mineral constituents in natural graphite and carbon-graphite grades also lead to weak collector attack or grooving. This fault is now virtually eliminated as electrographite grades are nowadays predominantly used in large machines.

Light-load and copper nests in the brush running surface

If a machine is lightly loaded the collector temperature is usually very low. The same applies for excessive cooling by normal loading. The patina in all of these cases is poorly conductive so that the preferred path for the commutating current is via frit bridges. The temperature in these small frit bridges is so high that the collector metal is vaporized and deposited as fine particles in the brush running surface and in its extreme form is recognizable as so-called copper nests.

The trigger for the grooving formation are the cathodic brushes because the direction of the electric field plays a role in the copper movement. This type of grooving is practically unknown with alternating current loading. The copper particles precipitation into the carbon brush surface tear the patina and lead to grooving.

The grooving would be promoted if carbon brushes are used which lay down a patina which has a low carbon content. Grooving occurs particularly easily, if carbon brushes with direct current loading run in segregated polarity tracks. In such cases the grooving only occurs under the cathodic brushes.

High humidity

This aids the oxidation of the commutator material so that thick extraneous layers are formed. These will then be fritted locally and lead to grooving as with cold commutators.

Electrolysis also possibly plays a role in conditions of high humidity.

Grooving due to extraneous layers of oil and grease

Oil, grease and other non-conductive substances which get on to collectors form an insulating film so that the number of electrical contact points are decreased. The very high temperatures occurring locally at the remaining contact points lead to melting of the collector metal so that we get a similar effect to that obtained with fritting. In addition the oil and grease is "cracked" by the thermal conditions and very hard oil coke formed which increases the grooving.

Grooving due to gas polluted air

Chemically aggressive gases quickly build up a badly conducting layer on the collector surface.

The layers of this film are destroyed by intensive fritting and this of course leads to grooving. It is appropriate in such cases to use carbon brush materials that lay down a thick graphitic patina.

Machine Operating Problems

Brush oscillation and rattling

Brush oscillation can, dependent on intensity, lead relatively quick to damaging the brush flex as well as to step formation at the base of the brush. Similarly rattling can lead to breakage and splitting off of the brush particularly in the running surface area. Brush oscillation and especially rattling also lead to contact breakage between carbon brush and collector.

If a commutator or slipring is perfectly round and the brushes rattle then the general cause is excessive friction (out-of-roundness protruding mica, etc. naturally give rise to vibrations).

Very smooth, polished patina whose formation has been encouraged by light load or even no load running leads to the sliding of the carbon brush bordering on the limit of static friction. With other systems this creates the so-called "stickslip-effect". Carbon brushes with a correspondingly higher friction are excited into a rocking oscillation which we refer to as "rattling". The brush rattling can be reduced if the pressure

finger of the brush holder presses on the brush top such that the direction of the force on the brush top bears on the leading edge area. In this case the reaction moment at the brush becomes very small – this is of particular importance when there is variable friction. When the friction force oscillates the reaction moment has the effect of stabilizing the brush and compensates for the friction (see illus. 1 and 1a).

A large gap between brush holder and commutator is also disadvantageous as there would be a high turning moment caused by the friction force pivoted on the bottom edge of the brush box.

Carbon brushes in reaction positions tend to rattle more easily than carbon brushes in trailing positions. The rattling is not overcome by increasing the brush pressure as the frictional force would also be increased at the same time.

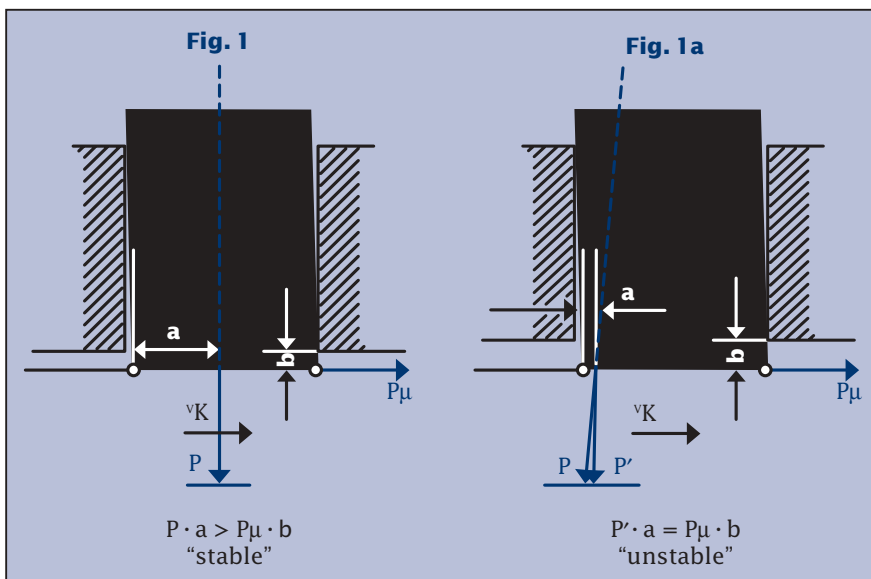
On the other hand current conduction causes micro-fine roughening of the patina as well as dust particles through brush/commutator wear and this so-called

"currentlubrication" reduces the friction. For the same reason a rattling brush-set can be quietened by lightly grinding the commutator. We should state here once again that when the commutator is reground or skimmed, the surface finish should not be too smooth (see also publication 10.32e).

Friction can also be reduced by applying a small amount of paraffin wax to the commutator or slipring by means of a cotton cloth. This process does not always have a lasting success as the paraffin tends to volatilize especially at higher temperatures.

Should there be a danger from the outset that rattling will occur due to the operating conditions then carbon brushes should be chosen which have so-called light load running abilities. The other brush requirements would naturally also have to be taken into account.

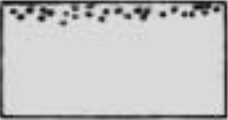
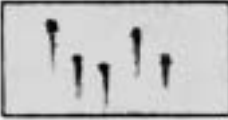
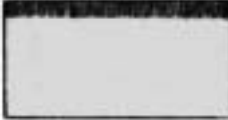
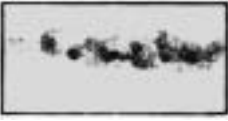
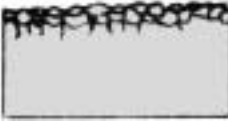
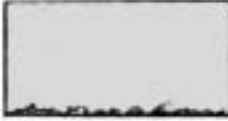



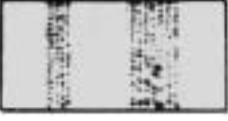

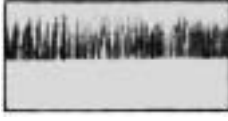



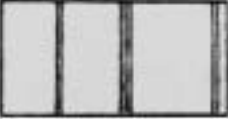
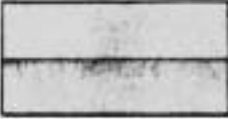
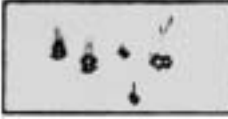
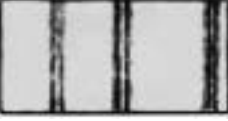
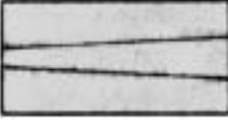

If the operating conditions are so demanding that brush rattling can not be avoided than it is helpful to lightly roughen the patina from time to time.



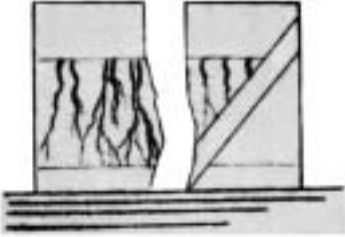

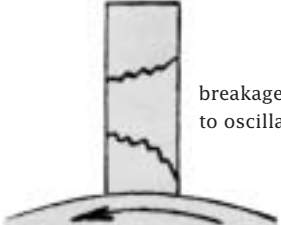
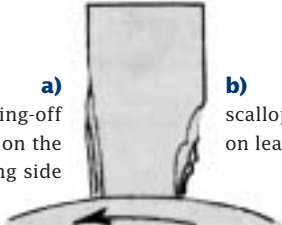
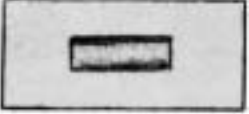

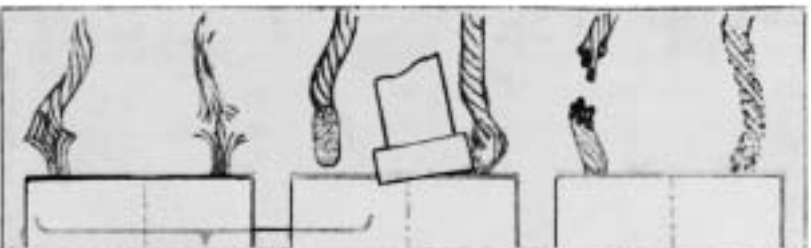
Causes of the brush oscillations and rattling are:

- commutator or slipring surface too smooth
- carbon brush underloaded
- dust, having a polishing effect, in the atmosphere
- brush holder gap too large
- excessive play in the brush box
- radial brush box is slightly in reaction position
- bent pressure finger
- commutator or slipring out-of-round
- low humidity
- protruding mica
- unsuitable brush grade.

Comparison Table of Carbon Brush Running Surfaces

Electrical causes					
1	 arcing spots on leading or trailing edge	5	 comets	9	 burn stripes due to commutator sparking at the trailing edge
2	 diffused clouding in the centre of the surface	6	 strong edge burning (trailing or leading)	10	 erosion at the leading or trailing edge
3	 burnt and cracked surface	7	 burning, from glowing, at trailing or leading edge	11	 reflection of segment spacing
4	 changes between blank, smooth and matt, open pored stripes	8	 cratering	12	 burn strips with a sharp cut off
Mechanical causes					
20	 perfect surface	23	 tacks with grooves and furrows	26	 splitting off at the leading or trailing edge
21	 hair-fine grooves	24	 double bedding	27	 copper nests
22	 fine furrows	25	 multiple bedding	28	 slightly glistening smear stripes due to oil drops

Various States of Commutator Surface

<p>30</p>  <p>a) branch formation due to extraneous dust</p> <p>b) reduced by dust grooves</p>	<p>33</p>  <p>a) step formation mechanical</p> <p>b) simultaneous breaking-up of the surface due to current flow</p> <p>side view</p>
<p>31</p>  <p>breakage due to oscillations</p>	<p>34</p>  <p>a) peeling-off in layers on the trailing side</p> <p>b) scalloping effect on leading edge</p>
<p>32 brush – top surface working in of the pressure piece</p>  <p>a) smooth through purely mechanical working in</p>  <p>b) burnt due to additional current conduction and sparking</p>	<p>Damage to Brush Flexes</p>  <p>35 bulging,</p> <p>36 due to vibration fraying,</p> <p>37 coming loose</p> <p>38 shearing off</p> <p>39 burning through</p> <p>40 gas corrosion</p>

Illustrations of Various States of Commutator Surface

Uniform patina – light brown



P 2

Uniform patina – medium brown



P 4

Uniform patina – dark brown



P 6

All of the above examples of patina are considered to be normal and represent good operating performances. The differences in color can in part be attributed to the different carbon grades used for the brushes.

Patina with strongly defined lines and tracks



P 12

This type of picture can often be found where frequent load changes take place. Without additional negative outside influences, this kind of patina may remain stable.

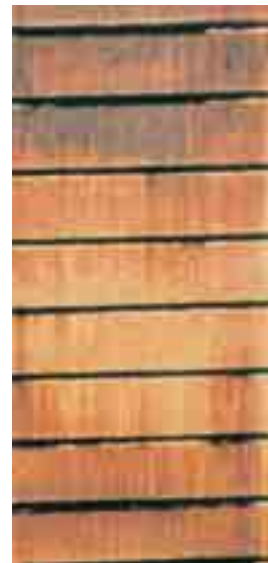
Uneven patina with light scoring



P 14

Subjected to poor environmental influences, e.g. oil vapors, dust, corrosive gases, etc., P12 may change into P14. Relief can be accomplished by improving the working conditions, or through employing a patina reducing carbon grade.

Irregular formed and spotted patina



P 16

The cause for an irregular and spotted patina may be found through using commutators out of roundness, friction vibration caused through extremely smooth commutator surfaces, vibration of the machine, etc.

Illustrations of Various States of Commutator Surface

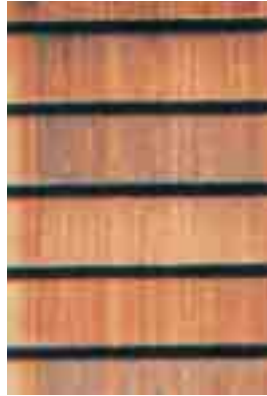
Isolated, regularly or irregularly, dispersed dark patches



P 22

Same causes as in P16, but in addition mechanical defects on the commutator.

Spotted bar face with formation of light dots



P 24

Often occurs with overly smooth commutator brush running surfaces, and little use of highly resistive graphite brush grades. Through the “dot formation”, and contact interference, arising spottiness can change into a P 22 situation.

Blurred spots or burn marks in the center of the bars, with small pools of molten metal at the bar edges



P 26

Occurs through poor commutation or flawed commutator finish. Low brush pressure, vibrations, or unsuitable brush grades could also be the cause.

Blurred shading – intensified towards the bar edge



P 28

If appearing on each bar, poor commutation may be assumed. When irregular distribution occurs, contact disruption, due to out-of-roundness on the commutator, is the cause.

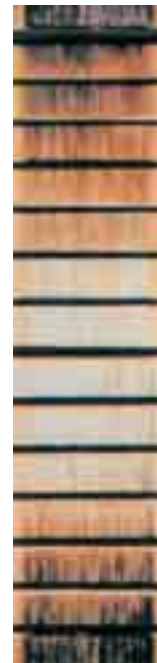
Regularly alternating light and dark commutator bars, the so-called “Zebra-Stripe Formation”



P 42

The reasons can be found in the design of the winding. Appears mostly with lap winding. Good contact carbon materials will avoid, or reduce, such situation.

Patch marks at both pole pitches of the commutator



P 46

Cause for the patch marks at both pole pitches are shortcomings in the so-called equalizing connections in the armature winding, and faulty soldering between the winding and the commutator. Idle loads can also create the same results.

Illustrations of Various States of Commutator Surface

Medium burn marks at the bar edges, no pools of molten copper are yet visible



B 2

Burn marks on trailing bar edges are due to poor reversal of current.

Stronger burn marks on one or more bars, molten copper pools are visible



B 6

The most common cause is a damaged winding of the armature, or a mechanical defect, e.g. protruded or recessed bars of the commutator, which may lead to intensive local brush sparking.

Burn marks in the center of the commutator bar



B 8

Burning of commutator bars due to poor commutation.

Flaky burn marks with distinct formation of small dots



B 10

Burning in advanced stage, due to poor reversal of current and sparking at the brush contact surface. During reversed operation, damages at the leading and trailing edges have causes as found under position B 2 and B 6.

Illustrations of Various States of Commutator Surface

Burn streaks are defined as increased patchiness and copper beading found on the commutator bars, caused by the trailing edge of the carbon brush



T 10

Faint marks on one or more commutator bar edges with slight formation of dots



T 12

Mostly a sign for localized mechanical shortcomings of the commutator (also brush tilting, variations in wear, movement of bars) that have not yet led to a brush fire.

Stronger bar scorching with flaked surface



T 14

Occurs due to vibrations and low brush pressure. Causes can also be out of roundness of the commutator.

Like T 10, but no beads due to molten copper on the trailing edge



T 16

Caused through heavy sparking, due to poor reversal of current. This in turn may have varying reasons.

Light burn marks at the trailing edge of the commutator bars of an otherwise relatively good commutator surface



T 18

Borderline commutation. Eventually replace with better commutating carbon grade.

Illustrations of Various States of Commutator Surface

Relatively strong commutator attack with build-up of wear bands and burn ridge formation



R 2

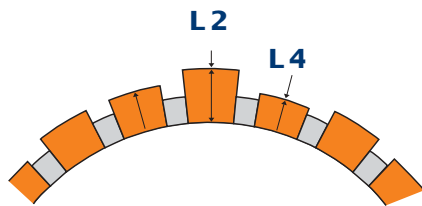
Long running conditions with unspecified load on cold commutator. Often to be found where carbon brushes with high metal content are used.

Commutator attack coupled with grooves and burn marks

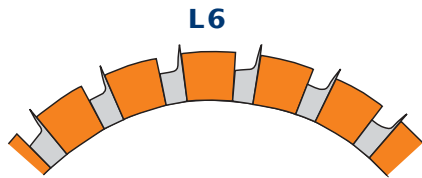


R 4

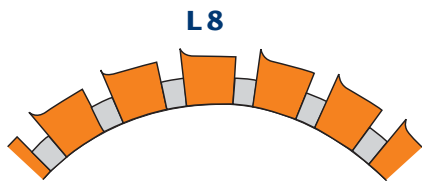
Burn stripes due to poor contact conditions (low brush pressure) and contamination.



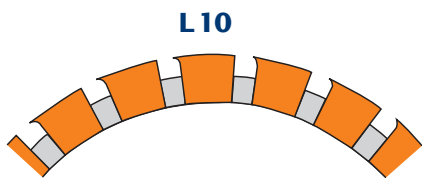
L 2
Protruding/Regressing Bars



L 6
Protruding mica insulation



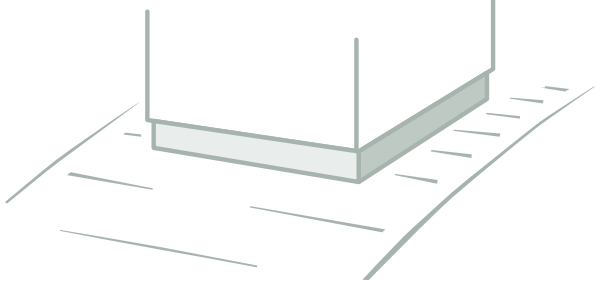
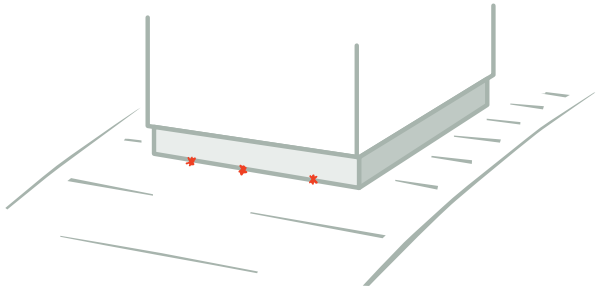
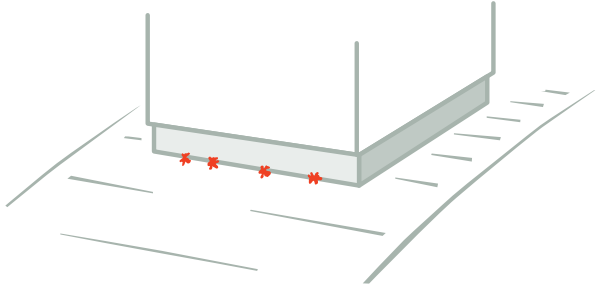
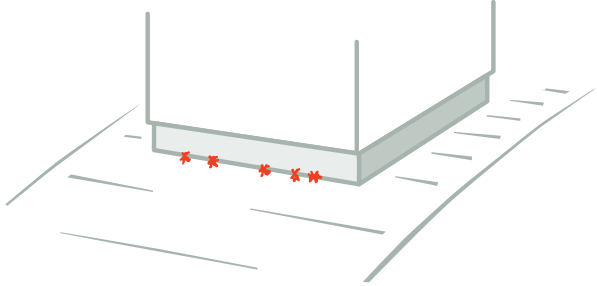
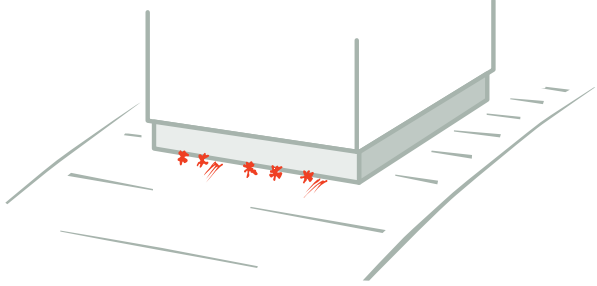
L 8
Burrs at bar edge



L 10
Copper drag

When inquiring, please use the respective problem code (P 2, P 4, etc.). This ensures that one and the same subject will be discussed.

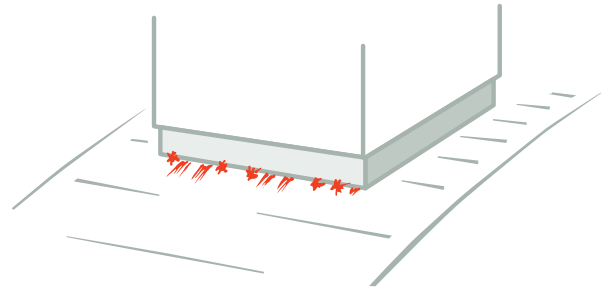
Commutation Chart

1	Spark free	
1.5	Weak, intermittent pin point sparking	
2	Weak, constant pin point sparking	
2.5	Stronger sparking with some red sparks	
3	Intensive sparking with individual streakers	

Commutation Chart

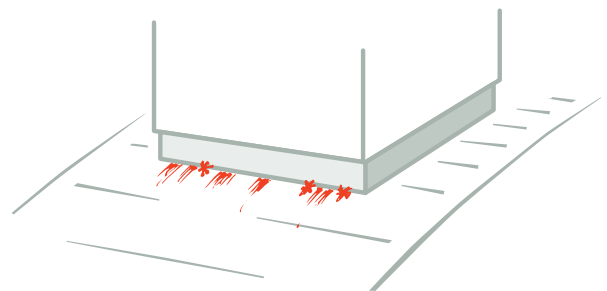
3.5

Intensive sparking with increased streakers



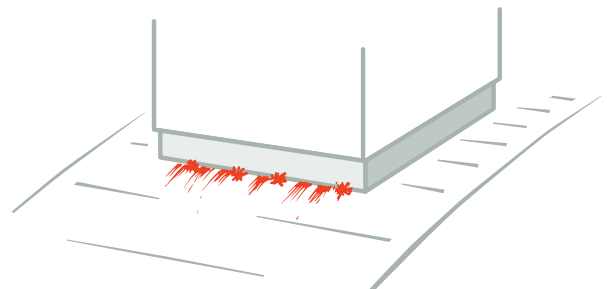
4

Strong streakers



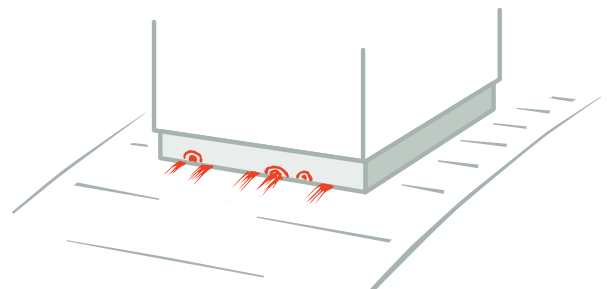
4.5

Strong streakers with some green flashes



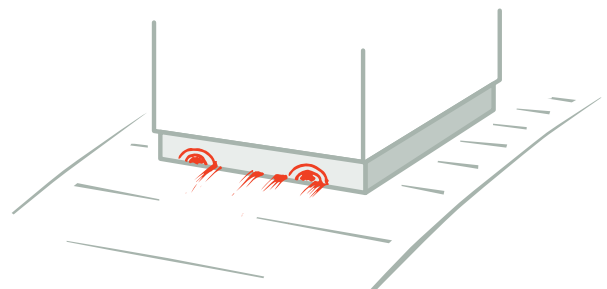
5

Individual wandering glowing spots



5.5

Strong glowing



Schunk Kohlenstofftechnik GmbH

Rodheimer Strasse 59
35452 Heuchelheim
Germany

Phone: +49 (0)641 608-0

Fax: +49 (0)641 608 1748

www.schunk-group.com

infobox@schunk-group.com

10.36e/2003

