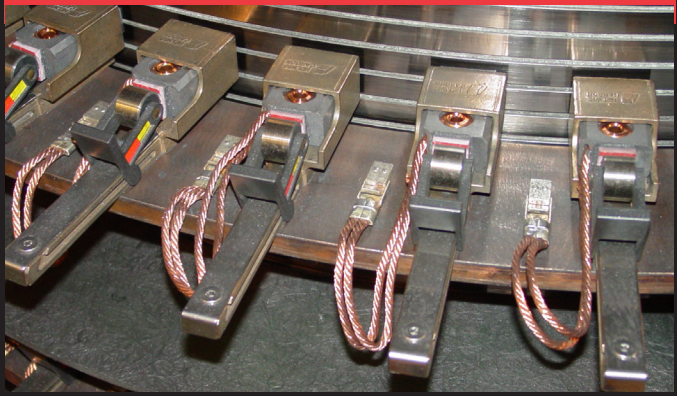
HELWIG®
CARBON
PRODUCTS, INC.

Carbon Brush Pocket Guide

From the Foremost Experts in Carbon Brushes



Specifications Installation Troubleshooting

Carbon Brushes - Essential Parts That Carry Current in Electrical Machines

Carbon brushes are used in motors and generators to conduct electricity between the stationary (armature or stator) and rotating (rotor) parts of electrical machines. This transfer of current is essential for the motor or generator to operate.

In This Guide, We Will:
1) Help you ID carbon brushes in order to buy replacements
2) Provide best practices for installation, use, and replacement of carbon brushes
3) Offer guidance to troubleshoot common problems

Helwig Carbon is a trusted expert in sliding electrical contacts, and we are ready to assist with any questions or issues you might be facing.

Contact us anytime for expert guidance.

Email: techsquad@helwigcarbon.com
Toll Free Phone: 800-962-4851
Phone: 414-354-2411
helwigcarbon.com

Selecting the Proper Brush for the Application

To select the proper brush, Helwig's carbon experts must review the application information to make a brush grade recommendation. Required information includes:

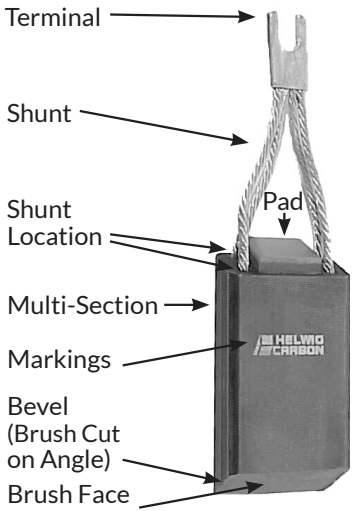
- Application
- Nameplate
- Running loads
- Environmental conditions

We also must know the dimensions of the brush, which can be provided through the following:

- OEM PN# of the brush
- Complete drawing of the brush
- A picture with dimensions
- A new or even a used brush

Providing brush pictures with several views, including brush face and nameplate data, is extremely helpful in the identification process.

Parts of an Industrial Brush



Measuring a Carbon Brush
Brush sizes are designated as: Thickness x Width x Length of the carbon.

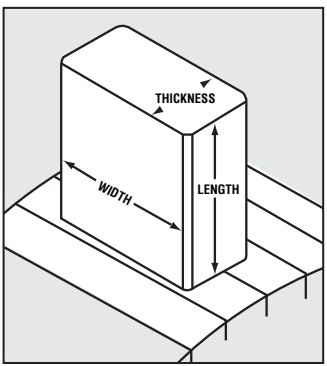
On brushes with bevels, the length is measured on the long side. If the brush design includes a Red Top, the length measurement should include the pad.

When specifying dimensions as a reference, submit information on brush length, even if it is worn length.

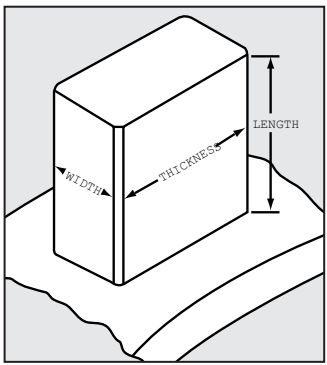
Measuring a Carbon Brush (Continued)

Some helpful measurement illustrations:

Commutator Brush



Slip Ring Brush



Primary Types of Brushes

1. Solid Brushes

The simplest type of brush used on basic machines without electrical and/or mechanical challenges.

2. Split Brushes

Split brushes are formed by assembling multiple carbon sections into one unit to create better electrical and mechanical contact conditions.

There are many other brush styles and designs.

Preparing for Brush Installation

Contact Surface Condition

The following contact surface conditions are essential for achieving optimal brush performance (See p. 24-27 for more):

- Roundness of the rotating surface
- No flat spots on the rotating surface
- No lamination protrusions (Commutator)
- A symmetrical undercutting of the commutator insulation and chamfered laminate edges (Commutator)
- Proper chamfering of helical grooves in contact surface (Slip Rings)
- Proper chamfering and leveling of split contact surface (Slip Ring)

	Peripheral Speed	
	≤ 5000 ft/min (≤ 25.4 meters/ second)	**>5000 ft/min (> 25.4 meters/ second)**
Maximum Total Indicated Runout*	0.0030” (0.076 mm)	0.0015” (0.038 mm)
Maximum Total Indicated Runout in any Quadrant*	0.0015” (0.038 mm)	0.0010” (0.025 mm)
Maximum Bar to Bar*	0.0003” (0.0076 mm)	0.0002” (0.0051 mm)
Surface Finish*	40-80 micro-inch RMS (1.02-2.03. micro-meters RMS)	

*These recommendations represent optimal conditions. Deviating from them may lead to reduced brush performance and increased wear on both the brush and the rotating surface.

Ensuring Optimal Brush Holder Performance

1) Check Spacing

The brush holders should be spaced no more than 0.125" (3.175 mm) from the commutator surface to ensure that the brushes are properly supported on the commutator. Helwig can provide Helwig Commutator Install Pad spacers to assist in brush holder installation.

Brush holder spacing around the commutator should be checked to ensure that there are an equal number of bars between each brush.

2) Check Pockets

The pockets in the holders should be checked to make sure that brushes move freely. Holders that have been overheated may become distorted and cause the brushes to jam in the holders.

3) Replace Conventional Spring Holders with Constant Force Holders

Conventional spring finger-type holders should be replaced with constant force spring holders to ensure that the pressure applied is more uniform through the usable length of the brushes. Using constant force holders will dramatically improve brush life and help **eliminate selective action.**

Selective Action
Unequal distribution of electrical current among brushes, which can result in uneven brush wear, sparking, damage, and/or reduced efficiency.

Safety

Follow all plant and electrical safety procedures and use proper PPE when working with electrical rotating equipment.

Important: Don't Mix and Match Brushes!
Do not mix brushes from different manufacturers or different grades. This can lead to selective action.

Installing New Brushes

The information below provides general guidelines. Depending on the application, some may not be relevant. Also review the DOs and DON'Ts, p. 16-21.

1. **Disconnect the power** to the machine using approved lockout procedures.
2. **Remove all old brushes from the holders and examine them**. Make note of any unusual conditions of the brushes including roughness or burning of the contact face, polished sides on the carbon, excess heat on the wires, or frayed shunt wires (See p. 22-23). These are indications of the need for maintenance on the machine
3. **Replace all brushes per set at a time**. This is always a good practice when feasible and will help in maintenance cycles for future monitoring and records.

4. **Check the rotating surface** for unusual conditions. Make note for required maintenance (See p. 24-27).
5. **Check the inside holder cavity** for dust, dirt, oil, deposits, corrosion, or burned areas and clean as needed.
6. **Check the terminal connection area** and clean as needed.
7. **Measure spring forces** to ensure there is consistent contact force at the recommended level (See p. 12-13).
8. If the new brushes are made from a different grade, then **the old film must be removed from the brush tracks**. A rubrite flexible abrasive is usually adequate for this task.
9. When brushes are installed in the holders, **ensure that the constant force springs are locked in place** to apply force on the top of the brushes.
10. **Ensure that the brushes are moving freely** in the holders.
11. **Secure all terminal connections.**
12. **Seat the brushes to the contour of the rotating surface** using non-metal bearing sandpaper or garnet paper. Do NOT use emery cloth. Medium coarse grade paper pulled under the brush face in the direction of rotation improves the quality of the brush contact and speeds the process. There should be at least 80% of the brush face seated to the contour of the contact surface prior to operating the machine. Once this level has

been achieved, the resulting dust in the machine around the brushes, holders, and rotating surface should be vacuumed out. For more information on brush seating, see p. 14-15.

13. In order to ensure complete electrical contact of the brushes, it helps to **operate the machine at no load for the final wear-in** contour of the contact surfaces, if possible.
14. **If the machine has a history of issues,** note the issues and check if they align with specific brush positions. Mark those brushes for easier tracking and data collection.
15. **If springs are to be replaced, replace all springs** at the same time to avoid selective action as old springs could be weak compared to new springs.
16. **Initially monitor operation closely.** Monitor more frequently when any change is made or on any new application. Once the brushes have been running for some time and the technician is satisfied with the performance, the PM cycle can be prolonged. This is on a case-by-case/application-specific basis. Carbon brushes or sliding electrical contacts are used in many different types of applications and operating conditions. The proper PM cycle will be left up to the end user—we just recommend making more initial checks for proper performance.
17. **Most importantly, inform your supervisor when in doubt**.

Operational Inspection

The following observations should be made and recorded while the motor or generator is under load. ***See pages 24-31 for troubleshooting information.***

Sparking

Check to see if the sparking is uniform under all brushes. The degree of sparking should be considered severe if the sparks are trailing out from under the brushes and action is required to prevent serious damage. "Furry" or light sparking may be seen at peak current loads. While light sparking should not be considered critical, it may indicate future problems.

Brush Noise

Listen for brush noise (ex. chatter or squealing), which often accompanies sparking and indicates a commutator surface problem. A high bar, low bar, high friction, flat spot, or high mica could cause the chatter. Occasionally, commutators go out of round and cause sparking and brush noise.

Contamination

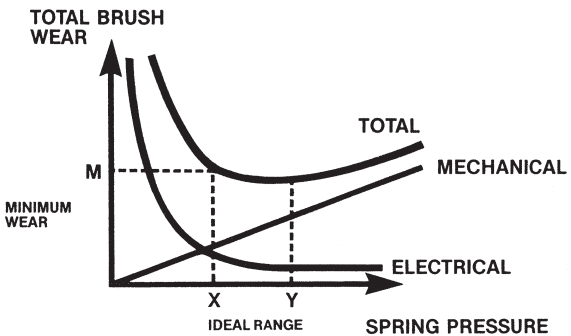
If the surface film is contaminated, this causes a high friction interface between the commutator and the brushes. This usually occurs in a chemical or particulate atmosphere.

Movement of Brushes

Excessive movement of the brushes in the holders may indicate commutator/ring imperfection, weak spring force, or high vibration.

Ensuring Proper Spring Pressure

Weak spring pressure is the single most common cause of commutator and brush problems. The brush pressure must be set to the operating conditions. There is an optimal balance point between mechanical and electrical wear as shown in the following chart.



Recommend Brush Pressure		
Industrial D.C Applications	4.0 - 6.0 P.S.I.	(280-420 g/cm2)
WRIM & Sync. Rings	3.5 - 4.5 P.S.I.	(240-310 g/cm2)
High Speed Turbine Rings Soft Graphite Grades	2.5 - 3.5 P.S.I.	(170-240 g/cm2)
Metal Graphite Brushes	4.5 - 5.5 P.S.I.	(310-390 g/cm2)
Fractional HP Brushes	4.0 - 7.0 P.S.I.	(280-490 g/cm2)
Traction Brushes	5.0 - 8.0 P.S.I.	(350-560 g/cm2)

* For brushes with top and/or bottom angles greater than 25° add an extra 0.5 - 1 P.S.I.

How to Measure Spring Force

Measure Constant Force Springs using a hanging balance scale like the Helwig DigiScale

1. Connect appropriate attachment, based on type of spring.
2. Insert roller attachment inside constant force spring or under the red handle of wear indicator, slide strap around torsion spring finger, or hook turbine-style attachment under lip of wear indicator.
3. Pull spring back to approximate new brush location.
4. SLOWLY let the spring recoil in the direction of brush travel. Observe spring force and take reading at approximately 1 outer diameter (OD) of the spring coil.
5. Be sure to check ALL springs.

Measure Helical Coil Springs using a force gauge.

1. Connect appropriate attachment or stylus.
2. Push or compress spring to approx. new brush position.
3. SLOWLY release to free length.
4. Repeat and record.

To Calculate Spring Pressure:

$$\text{Spring Pressure (P.S.I.)} = \frac{\text{Measured Force (lbs.)}}{\text{Brush Thickness (in.)} \times \text{Brush Width (in.)}}$$

Beveled brushes require additional calculation. Contact us for info.

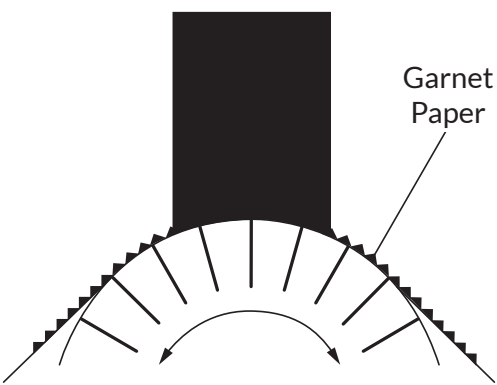
Note: If spot checking & you find some spring pressures are too light, be sure to replace ALL springs!

Seating in a Carbon Brush

Seating carbon brushes is essential to minimize arcing, heat, and premature wear. This process improves the electrical contact between the brush face and the rotating surface, allowing for a lower resistance path for current flow. Below is a step-by-step guide to seat carbon brushes.

1. Initial Seating with Garnet Paper

Place the brushes in their holders with springs engaged to apply pressure. Insert a strip of abrasive linen—preferably garnet paper with 80-100 grit—between the brush and the rotating surface. Move the paper tangentially under the brush. Once the brush begins to conform to the surface, draw the paper in the direction of machine rotation to finish shaping. Lift the brushes before removing the paper.



2. Wrapping
Wrap a strip of garnet paper around the rotating surface and secure it with adhesive tape. Insert the brushes into their holders and again make sure the springs are engaged and applying pressure. Rotate the machine's rotor in its operating direction. If the motor runs in both directions, choose one. Once the process is complete, remove the paper. If this step can't be performed, ensure step 1 is done thoroughly, as more seating time may be required.

3. Final Seating
With all brushes installed and **any remaining garnet paper removed** run the machine at idle or reduced speed. Gently press a pumice or cleaning stone in front of the brushes. The resulting dust will help polish and contour the brushes further. This method is useful for large DC machines and may not be necessary for all motors.

When 75–80% of the brush face is contoured, the process is complete. Remove the brushes and vacuum out any dust. Avoid letting dust reach coils or bearings. Reinsert each brush into its original holder.

DOs and DON'Ts

SAFETY FIRST—Don't use any shortcuts on safety precautions for handling electric machines.

DOs & DONT's - Cleaning Procedures

- **Use proper PPE** (Personal Protective Equipment) such as gloves, face masks, isopropyl alcohol wipes, rags, etc., as needed to avoid possible irritation to skin and eyes.
- **Vacuum** to remove the dust.
- **Clean the specific sensitive areas** such as around risers for commutators and between the phases on insulators for the rings **with wipes and rags** as much as possible.
- **Use compressed air as the last option** for hard-to-reach areas (it can have drawbacks so only use it if you must). Please note that metal dust is more detrimental than carbon dust to cause flashovers.
- If the slots of the commutator bars are filled with dust, **clean the slots without damaging the insulating mica underneath**.
- **Don't leave any traces of oil**, which will attract dust and contaminants.

DOs - Checking Conditions While Removing Old Brushes

- **Ensure you know how the machine or equipment is used for load**, especially current, speed, and voltage. Compare this to rating of the machine by OEM.
- **If there is a pattern on the brush face** such as arcing, bouncing, chipping, or if the wire is showing discoloration, **take close up pictures,** typically of brush face and back, **or send sample representative brushes** to Helwig Carbon. We are in the best position to help you.
- **Take pictures of the contact surface** showing brush tracks before repair. If anything unusual is found on contact surface such as contamination, photographing/ghosting, burn spots, bar marking, edge burn, threading, grooving, etc., send pictures to Helwig Carbon. The contact surface tells the story of operating conditions. **Refer to commutator charts on p. 24-27 for possible root causes.**
- **If there are localized burn spots or photographing, it is always good practice to mark the spots** with a permanent marker, typically on the side for identification radially on large diameter contact surfaces. If the cleaning and machining cut is not enough, the spot may reappear in the same location.

DOs - Checking Conditions While Removing Old Brushes (Continued)

- **Remove the old film after taking pictures.** Poor film will build up and burn spots add to the resistance and heat.
- **Machine the contact surface** if the damage is severe. Stone cleaning may not be enough and burn spots may reappear.
- **Troubleshoot potential root cause** of problems. Brush condition will help you identify most, but not all, operating issues (See p. 22-31).
- **If the machine was flashed over and the brushes and/or holders are damaged, you must locate and address the root cause of the flash or the unit will flash again,** even with new brushes and holders.
- **If the contact surface is a commutator that has been machined,** clean the slots by chamfering the slot bars.
- **If you must hammer out metal brushes that are stuck in holder (avoid if at all possible)**, check for squareness of holders after removing the brushes.
- **Remove deposits, if any, in the holder** as they can restrict the brush movement.
- **If there is field weakening and higher speed is desired for more output**, adjust neutral for the load. Please note that the field weakening shifts the neutral, potentially causing more arcing.

DOs -
Installing Brushes

- **Order the brushes with precut radius** to match the contact surface diameter.
- **If there is contamination or low humidity**, work with Helwig Carbon for proper carbon grade for the operating conditions given.
- **Ensure the mica insulation is below the contact surface**.
- **Use Helwig Commutator Install Pad** for proper distance between brush holder and contact surface.
- **Ensure the brushes are in neutral** on the commutator.
- **Check brush spacing** and if any arms are bent.
- **If brushes have top and bottom bevel angles or different size chamfers,** check the proper orientation of the brushes to match the holders.
- **For slip rings**, ensure each ring has the same number of brushes.

Questions? Contact us anytime for expert guidance.

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DON'Ts - IDing & Fixing Problems and Brush Replacement Timing

Identifying Problems

- **Don't run with high arcing and sparking—**these are warning signs before potential flashover.
- **Don't run the machine if the drive or supply gives spikes or ripples that cause the brushes to arc**. Please remember brushes will just show you the operating conditions and symptoms. Most of the time they are not the root cause.
- **Don't throw away used brushes.** They can be good reference if there are previous issues with the equipment. At least keep some that represent the majority.

Addressing Problems

- **Don't expect brushes to round the contact surface**, they will only clean and polish it.
- **Don't expect brushes to resolve drive spikes or ripples**. They will only help reduce the arcing with better commutating ability to minimize the damage but cannot resolve it completely.

Knowing When to Replace Brushes

- **Don't run the brushes to the wire or rivet.** Replace them in advance otherwise the contact surface can be damaged. It can also cause a flashover in some severe cases due to loss of brushes or lack of contact area to transfer the current.

DON'Ts - Brush & Holder Replacement, Use & Care

- **Don't mix different grades**. The selective action will result in uneven wear.
- **Don't add a sleeve on the brush unless you have to.** Contact Helwig Carbon for potential issues with sleeves.
- **Don't try to modify brushes for one holder to make them fit and work with another holder**. The compatibility of brush in the holder is very important.
- **Don't put impact on brushes—handle them carefully.** Most carbon grades will chip on impact.
- **Don't spray any lubricant or any other chemical on contact surface**. It is not needed; the brushes are self-lubricating due to graphite content.
- **Don't use silicone-based lubricants on any sealers for covers**. The silicone vapors (overheating) are proven to cause rapid wear on brushes.
- **Don't mix different holder types.** Most likely the spring force at the brush face will be different causing selective action and misleading results.
- **Don't hammer the brushes out of the box.** The holder squareness could be compromised for the next set of brushes.
- **Don't keep excess holder mounting height.** Please see Helwig Commutator Pad for proper height.
- **Don't put full load on machine without seating the brushes**. Allow the brushes enough time to have more contact area to carry current.

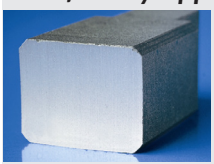
Assessing the Performance of Carbon Brushes

1) Check Front and Back of the Brush

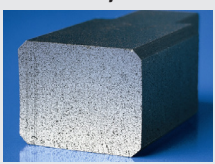
Inspect the brush for shiny rail marks on both the front and back surfaces. These marks indicate movement of the brush within its holder. While some movement is normal, highly polished or worn rail marks on the carbon brush suggest excessive movement. The most common cause of this is contact surface imperfections.

2) Check Brush Sliding Face

Satisfactory Appearance of the Brush Sliding Face



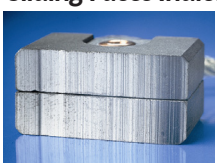
Dense, shiny sliding face - Normal Operation



Slight porous sliding face - Normal Operation

Fine hairlining Normal Operation, slight dust interference

Sliding Faces Indicating Mechanical or Electrical Problems:

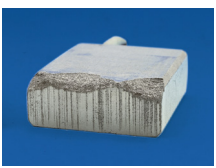


Hairlining. Causes: Underload, influence of dust, oil, or grease, weak spring pressure

Tracking with hairlining and grooves. Causes: Same as hairlining (left), but stronger

Eroded brush face. Causes: Electrical overload, interruption of contact

Burning edge of the leaving or trailing edge. Causes: Difficult commutation, heavy sparking, interruption of contact due to out-of-round commutator or insufficient brush holder spring pressure.



Broken edges. Causes: High raised lamination, commutator seriously out of round, brush chatter by low load and idle running

NOTE: The face of the brush will reflect the condition of the commutator surface.
For example, if the commutator surface is threaded or rutted, the brush face will likewise be threaded or rutted.

3) Check the Shunts for Fraying

Windage or movement of brushes in the holders may cause fraying. Frayed shunts will often limit the life of the brushes, regardless of the remaining brush length. If fraying is present, contact Helwig Carbon to discuss solutions.

Questions? Send Your Brush Pictures to Us
Email: techsquad@helwigcarbon.com

The patina/film is of equal importance to the physical appearance of the commutator.

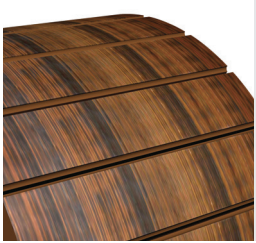
Normal Patina/Film Formation

When a machine runs well, the patina/film on a commutator will be even, slightly shiny, and coppery brown to black in color (there may be grayish, bluish, and reddish hues, but the important factor is evenness of the patina/film formation and not its color).

The following are examples of normal patina/film:

Patina/Film Indicating Problems

Streaking

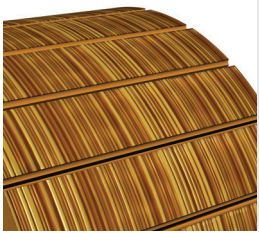


Causes

- Low spring pressure
- Low current loads
- Contaminated atmosphere
- High humidity
- Copper particle pickup from commutator

Patina/Film
Indicating Problems (Continued)

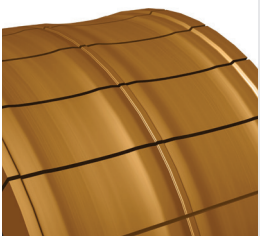
Threading



Cause

- Commutator damage from long-term streaking conditions
- Low spring pressure
- Low current loads
- Contaminated atmosphere
- High humidity

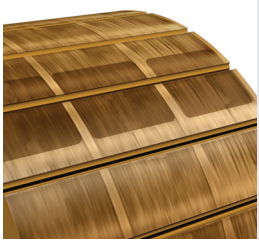
Grooving



Causes

- Arcing due to low spring pressure
- Abrasive brush grades
- Vibration
- Contaminated atmosphere
- Low humidity and temperature

Photographing

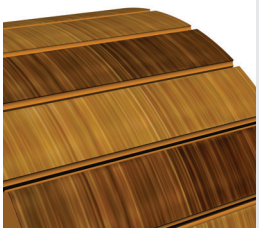


Causes

- Condensation under brush face from extended shut-down time
- A jolt on the brushes and interruption of contact or electrical spike at the same point in rotation

Patina/Film
Indicating Problems (Continued)

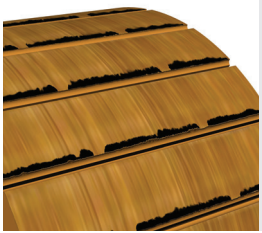
Slot Bar Marking



Causes

- Uneven current distribution in armature windings
- Unequal number of windings in adjacent slots
- Inconsistency in armature windings related to number of coils, slots, and commutator bars

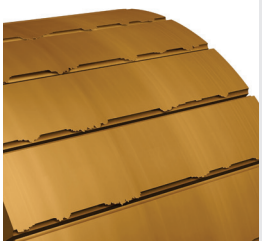
Bar Edge Burning



Causes

- Incorrect brush alignment/ off neutral
- Incorrect interpole strength
- Inappropriate brush grade
- Low spring pressure
- Sparking caused by commutation problems

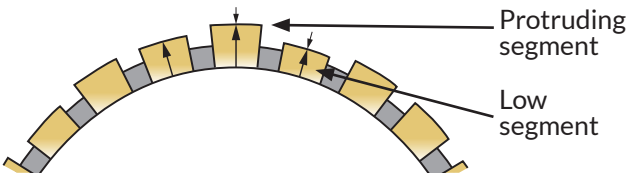
Copper Drag

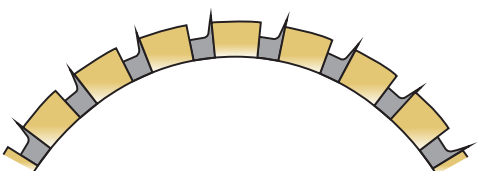


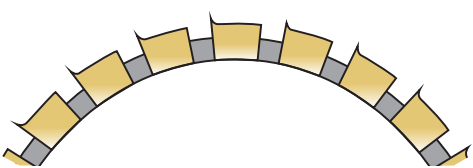
Causes

- Overheating and softening of the commutator
- Low spring pressure
- High friction brush grades
- Excessive vibration

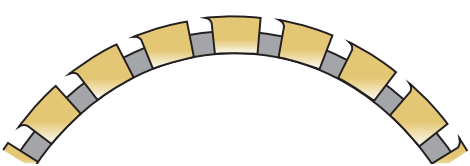
Other Contact Surface Issues







Causes: Faulty commutator segments



Causes: Bumps or vibrations with various causes

Strong Brush Sparking

Cause	Corrective Measures
Out of round commutator or slipring	Turning or grinding
Insufficient brush pressure	Increase brush pressure (see recommendations for brush pressure, page 12)
Carbon brushes are stuck in holder	Carefully remove foreign bodies and dust from brush holder. Dust grooves are recommended
Oil or dirt between segments	Clean segments, filter cooling air, and possibly seal bearings
Carbon brushes (not seated in)	Repeat the seating in process
Brush holder too far from the commutator or slipring	Adjust distance between holder and commutator to no more than 0.125” (3.175 mm)
Protruding insulation segments	Undercut insulation and chamfer segments
Machine vibrating or chattering	If it is not possible to reduce the vibration of the machine, increase brush pressures or use a brush design fitted with fiber and rubber top

Strong Brush Sparking (Continued)

Cause	Corrective Measures
Wrong positioning of brush bridge	Establish neutral position and adjust brush arms accordingly
Faulty installation of brush arms	Adjust brush arms correctly
Interpole too strong or too weak	Machine manufacturer to correct fault, or install another brush grade to compensate
Incorrect brush grade	Please contact the Helwig Tech Squad

Uneven Brush Wear

Cause	Corrective Measures
Uneven current distribution	Adjust brush pressure to correct level
Bad connection of wire to brush	Change carbon brushes
Mixed brush grades	Use only one brush grade
Brushes stuck in holder	Clean holder and brushes, check tolerances, and use dust grooves eventually

Patches or Burn Marks

Cause	Corrective Measures
Protruding or low segments	Retighten and turn the commutator
Raised mica insulation	Turning the commutator, undercut mica and possibly retighten commutator
Out of round commutator or sliprings, i.e., badly out of balance	Rebalance and/or remachine commutator or slipring
Bad soldering of risers	Resolder risers
Electrolytic deposit from brush to steel on stationary steel sliprings (galv. element)	In case of long standstill periods, insert insulating strip under the carbon brush

Excessive Wear of Commutator and Sliprings

Cause	Corrective Measures
Overload on brush track due to uneven current distribution	Adjust brush pressures to the correct level. Possibly use brushes with a higher polishing effect
Dusty environment	Blow in clean air by installing a filter

Excessive Wear of Commutator and Sliprings (Continued)

Cause	Corrective Measures
Aggressive gases or vapors	Blow in clean air and use brushes with a stronger polishing effect
Grooving caused by low electrical load on brushes	Reduce number of brushes per pole or change brush grade
Grooving caused by oil film on commutator or sliprings	Seal bearings and avoid oil vapor
Material loss by anodic when using sliprings with DC current	Change polarity of sliprings from time to time
Copper drag	Because of the complex nature of potential causes, please contact the Helwig Tech Squad
Development of flat spots	Install starting current limits

Questions? Contact us anytime for expert guidance.

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