Morgan
Advanced Materials

NATIONAL® TECHNOLOGY BRAND

1 How to Select Carbon Brushes for Motors and Generators

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Contents

Brush Grades Families

Brush grades are usually classified according to the manufacturing processes and the types of carbons and other ingredients used. The four main brush grade families are:

Carbon Graphites
Electrographites
Graphites
Metal Graphites

Carbon Graphite Brushes

Carbon graphite brushes made their entrance early in the brush industry. They are high-strength materials with a pronounced cleaning action. Carbon graphite brushes are generally limited to lower current densities 45 amps/in² (7 amps/cm^2) and are used on older, slower speed machines that reach maximum surface speeds of approximately 4000 feet/minute (20.3 m/sec). The high friction generated with this type of material also makes it unattractive for present day use on commutators, but does have use as contacts and as a base for metal impregnated grades.

Electrographitic Brushes

Electrographitic brushes are baked at temperatures in excess of 2400°C that changes the material physically to a more graphitic structure. Apparent density, strength, hardness, and resistivity can be closely controlled through raw material composition and processing to achieve superior commutating ability while providing long life.

The high processing temperature volatizes impurities which makes electrographitic brushes generally free from abrasive ash. Therefore, commutators must have undercut mica since very little mechanical wear results.

Electrographitic materials in general are fairly porous which permits treatment with various organic resins or inorganic materials. The treatments increase strength and lubricating ability which generally increases brush life significantly at high operating temperatures and at lower humidity.

Treatments can also permit electrographitic materials to operate satisfactorily in a variety of contaminated atmospheric environments.

Friction characteristics with electrographitic materials can be controlled through raw material combinations before graphitization and also by treating the finished product with organic resins. Brush face temperature is a primary influence in determining the coefficient of friction as shown by the typical curve of coefficient of friction vs. temp chart.

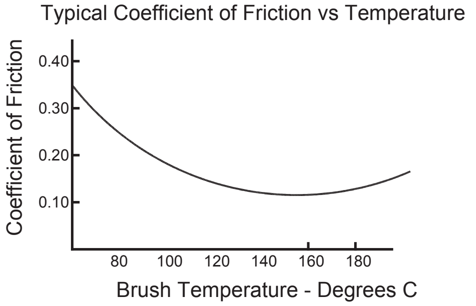

Figure 1

Electrographitic brushes are generally capable of continuous operation at 80 amps/in² (12.4 amps/cm^2) and surface speed of 7000 feet/minute (35.6 m/sec). Intermittent operation at higher values is not uncommon. They are widely used in the industrial, transportation, mining and aerospace industries on both AC and DC machinery.

Grade Characteristic Definitions

Graphite Brushes

Graphite brushes are composed of natural or artificial graphite bonded with resin or pitch to form a layered brush material. Natural graphite usually contains ash which gives the brushes an abrasive or cleaning action. Artificial graphite generally does not contain ash nor does it have the flaky structure of natural graphite.

Graphite brushes are characterized by their controlled filming and excellent riding qualities on both commutators and slip rings at brush current densities 45 to 65 amps/in² (7 to 10 amps/cm²). They are not capable of sustained operation at higher current densities like electrographitic materials; however, higher surface speeds are often permitted with some type of graphite materials.

The fast filming properties of graphite brushes is very beneficial in protecting the commutator or slip ring during operation in contaminated atmospheres such as those seen in paper mills. Their low porosity and higher density are valuable in reducing commutator threading often encountered in contaminated environments.

Metal Graphite Brushes

Metal graphite brushes are generally made from natural graphite and fine metal powders. Copper is the most common metallic constituent, but silver, tin, lead and other metals are sometimes used.

Metal graphites are ideal for a variety of applications because of their low resistivity. Metal graphites are used on commutators of plating generators where low voltage and high brush current densities are encountered. They operate on rings of wound rotor induction motors where high brush current densities are also common. Metal graphites are used for grounding brushes because of their low contact drop.

The following table describes some general applications where metal graphite brushes are used.

Metal Content (Percent)	Application
50% or Less	Forklift and battery truck motors rated 24 – 72 volts Battery charging and welding generators rated 24 – 72 volts Slip rings at brush current densities 100 amps/in² (15.5 amps/cm²) or less
65 to 85%	Plating generators rated 6 – 24 volts Slip rings at brush current densities less than 125 amps/in² (19.4 amps/cm²)
75% and Above	DC machines rated less than 6 volts. Slip rings at brush current densities 150 amps/in² (23.3 amps/cm²) or less Grounding brushes

The characteristics of the most widely used brush grades are shown in the tables on pages 6 - 10. The following definitions and explanations will help you to interpret these tables.

Specific Resistance

Unless otherwise specified, specific resistance (or resistivity) in ohm-inches (micro ohm-meters) is equal to the resistance that a specific volume of brush material offers to the passage of current. Specific resistance is measured in the length direction of the brush, since resistance in the direction of width or thickness may be considerably different. Specific resistance is calculated from measurements on a test sample as follows:

R = (E x W x T) / (I x L) (English)

R = (E x W x T x 10^{-3}) / (I x L) (Metric)

Where R = the specific resistance in ohm-inches (micro ohm-meters)

E = voltage drop over length "L"

I = amps of current passed through the sample

W = width of sample in inches (millimeters)

T = thickness on sample in inches (millimeters)

L = that portion of the length, in inches (millimeters), over which the voltage drop "E" is measured

Apparent Density

For a brush material, the apparent density (also known as bulk density) is equivalent to its weight in grams divided by its volume in cubic centimeters. Density must be considered jointly with other brush characteristics in estimating brush quality.

Abrasiveness

The ability of the brush to prevent excessive build up of film usually caused by corrosive or oily atmospheres is called the abrasiveness or "polishing action". The abrasiveness of a brush may be influenced by its hardness, grain structure and ash content. The brushes are classified according to abrasiveness as follows: "Low" indicates very little abrasiveness (commonly referred to as "non-abrasive" by the trade), "Medium" indicates some polishing action, "High" indicates pronounced polishing action which is usually obtained by using a material with high ash content or by the addition of a polishing agent.

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Contact Drop

Contact voltage drop for the brushes listed in this brochure are approximate values only and represent the total voltage drop (positive plus negative) obtained on a copper ring at 50 amps/in^2 (7.75 amps/cm^2) while rotating at 2500 f/m (12.7 m/sec).

They are classified as follows:

Contact Drop	Volts
Very High	1.7 and above
High	1.2 to 1.7
Medium	0.6 to 1.2
Low	Below 0.6

Current Carrying Capacity

The actual current carrying capacity of a brush is widely influenced by operating conditions such as type of ventilation, continuous or intermittent duty, speed and other factors. The brush grade current ratings are conservative, some allowance having been made for overloads. Brushes have been run at currents considerably above those listed in the grades table. Metal graphites, for example, have been operated at 180 amps/in² (27.9 amps/cm^2) on certain high current generators. Electrographitic brushes have been operated at 100 amps/in² (15.5 amps/cm^2) on similar equipment with reasonably good results.

The current carrying capacity of a brush depends on the operating temperature. On well ventilated machines, having small brushes, with large surface area in proportion to their volume, and where brushes cover only a small percentage of the commutator or ring surface, conventional current densities can usually be doubled for short periods without seriously jeopardizing the performance. However, increasing current density without making provisions for maintaining a low brush temperature may severely reduce brush life.

To calculate the current density you need to know or measure: the operating current in amps, the number of brushes and the brush thickness and width. Brush T x W = the cross sectional area. Brushes that contact the commutator at an angle do have more contact area than the product if their T x W, but it is usually not a significant difference so the easier to calculate cross sectional area is used.

Maximum Speed

The highest peripheral or surface speed in feet per minute (meters per second) recommended for the collector or commutator on which the brush is to ride is referred to as the maximum speed. The maximum speed depends not only upon the characteristics of the brush material, but also upon the spring force, current density, type of brush holder, brush angle, condition of the ring or commutator, atmospheric conditions, etc. Consequently, the maximum speed, conventionally listed as a brush characteristic, is only an approximation.

Friction Coefficients

Brush friction is influenced by many variables including brush temperature, spring force, current, atmospheric conditions, mechanical conditions, ring or commutator materials, surface films, speed and other factors. The slip ring/commutator surface even under favorable conditions is continually undergoing changes caused by oxidation, abrasion and moisture.

Friction chatter, noise and associated brush wear can be accelerated with certain brush holder configurations. This is especially true under conditions of light loads and lower brush temperatures when the coefficient of friction is relatively high (refer to Fig. 1). Specific brush grades are used to lessen the severity of friction chatter under these conditions. Friction between the brush and rotating surface can be a major source of heat generation that causes serious temperature related problems. Commutators can distort, slip rings can move, and brush wear can become excessive when the coefficient of friction becomes too high.

The brushes are classified as follows:

Friction Classification	Friction Coefficient
High	0.40 and above
Medium	0.22 to 0.40
Low	Below 0.22

Inches

$$\text{Current Density (DC Motor)} = \frac{\text{Amps}}{1/2\ \#\ B\ R \times T \times W}$$

$$\text{Current Density (Slip Ring)} = \frac{\text{Amps}}{\#\ B\ R \times T \times W}$$

Example: 125HP DC Motor rated 500 Volts, 201 amps and has 8 brushes

$$\text{Current Density} = \frac{201}{1/2\ (8) \times 6.25 \times 1.250} = 64.3\ \text{amps/in}^2$$

Metric

$$\text{Current Density (DC Motor)} = \frac{\text{Amps} \times 100}{1/2\ \#\ B\ R \times T \times W}$$

$$\text{Current Density (Slip Ring)} = \frac{\text{Amps} \times 100}{\#\ B\ R \times T \times W}$$

Example: 100KW DC Motor rated 500 Volts 217 amps and has 8 brushes

$$\text{Current Density} = \frac{217 \times 100}{1/2\ (8)\ 16\ \text{mm} \times 32\ \text{mm}} = 10.5\ \text{amps/cm}^2$$

Transverse Strength

The standard sample is supported near the ends on two knife edges as shown in Figure 2. A third knife edge presses on the top of the sample midway below the two supporting edges. The force is increased on the top knife edge until the sample breaks. The transverse strength is computed by using the beam formula, also called 3 Point Method:

$S_t = 3 \times P \times L / (2 \times W \times T^2)$

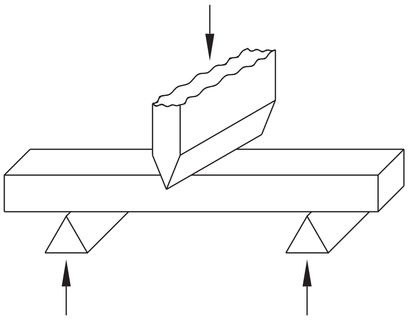
S_t = transverse strength in PSI (Kgf/cm^2)

P = the total force in pounds (Kgf) applied at the upper knife edge

L = distance between supports in inches (cm)

W = width of sample in inches (cm)

T = thickness of sample in inches (cm)



Details of transverse strength test

Figure 2

Special Brush Types

Laminated Brushes

There are times when a laminated design brush is desired. The laminated "L" series has been developed to help the designer and ultimate user to obtain more effective performance from his commutator-type machine (where conditions warrant a laminated brush).

There are two types of laminated brushes. The first laminated style brush is a composite assembly of two or more grades of electrographite/graphite materials that provide a slight polishing action to combat contaminated environments. These brushes improve commutation, reduce commutator wear and provide better brush life, where contamination is a concern. Brief application descriptions are listed in Table I.

Brush Grade	Description and Application Recommended for:
L932	A good commutating grade with slight polishing action operational range is 50 to 75 APSI (7.75 APSC to 11.6 APSC).
L944	Treated grade for improved life.
L963	A good commutating grade with slight polishing action, also treated for low humidity protection.
L964	Stronger base material for improved life.
L966	Similar to L932, provides improved filming vs. L932.
L983	Low friction base material, with slight polishing action used in stubbing/leading (brush holder) configurations.

Table I

The second laminated style brush is a composite assembly of two or more grades of electrographitic materials that are of varying resistance. These brushes improve commutation, reduce commutator temperatures, and reduce commutator erosion.

Reduction of the resistivity of the various parts will reduce the commutating ability slightly, but will increase brush life. Therefore, several combinations are listed in table II. Other variations in material can be made on request. Contact the Morgan AM&T Application Engineering team for assistance.

Brush Grade	Description and Application
L351	A high commutating brush with low (contact) drop.
L352	Stronger base material for improved life.
L357	Similar to L352 but lower friction. Less subject to chatter

Table II

Fluted Brushes

Many larger machines in operation are equipped with a fluted brush face to reduce the running time necessary to get a good brush fit and commutator film.

When replacement brushes are installed a few at a time, the fluted brush does not have to be sanded in. Using a fluted brush for replacements will decrease the possibility of damaging or stripping the commutator film surface when brushes are replaced and not sanded to fit the commutator surface. On critical threading conditions, it is recommended that fluted brushes be used, as the brush allows for a quick brush fit and a more even film.

It is not necessary to remove the brush after the fluted portion is worn away, but can be operated to the normal minimum wear length.

Pre-Radius Brushes

An alternate method to form the brush to the surface of the commutator is to machine a radius (pre-radius) in the brush face. This machining applies a radius that is equal to or slightly larger than the commutator. Adding a pre-radius does not remove the need to sand in a brush, but it does significantly decreases the time needed to match the contact surface.

Rubber Hardtop Brushes

Morgan Advanced Materials manufactures a full line of rubber hardtop brushes, also known as pads, designed to soften the impact from a rough commutator, giving longer brush life and reducing brush breakage. However, rubber hard top brushes are not a “cure-all” solution. For more information on rubber hard top brushes, refer to the technical data sheet on Rubber Hardtop Brush Applications.

Surface Cleaning Brushes

The surface cleaning brush (SCB) is a preventative maintenance tool designed to give the best possible performance in rotating equipment exposed to severe contamination. The SCB fits in the brush holder of the motor or generator and cleans the commutator and/or collector ring during operation. The SCB does not limit the apparatus output. For less aggressive cleaning, please refer to the laminated grades listed previously. For more information on SCB’s, refer to the technical data sheet on Surface Cleaning Brushes.

Surface Rounding Brushes

The surface rounding brush (SRB) is another preventative maintenance tool designed to give the best possible performance in rotating equipment (that has a rough riding surface). The SRB fits in the brush holder of the motor or generator and smooths the commutator and/or collector ring to a specific roundness as the machine operates. The SRB does not limit the apparatus output since it is made of the material compatible with the other brushes. SRB’s will remove metal as they slowly grind off the high areas. For more information on SRB’s, refer to the technical data sheet on Surface Rounding Brushes.

Electrographitic

Brush Grade	Spec. Res. Ω-in. (µΩ-m)	Dens. g/cm³	Trans. Strength lbf/in² (kgf/cm²)	Con-tact Drop	Fric-tion	Surface Speed ft/min (m/sec)	Normal Current Density A/in² (A/cm²)	Description and Application Recommended for:
234	0.0020 (51)	1.48	3700 (260)	VH	L	6000 (30)	80 (12.5)	A variety of industrial and FHP machines. Good general purpose grade.
258	0.00075 (19)	1.60	2700 (191)	H	L	6000 (30)	80 (12.5)	Copper alloy slip rings with current density up to 75 APSI and speeds up to 6000 ft/min. Also used on lightly loaded machines.
561	0.0030 (76)	1.54	1700 (120)	VH	M	8000 (41)	80 (12.5)	Where excellent commutating ability is of primary importance.
569	0.0029 (74)	1.53	1600 (113)	VH	M	8000 (41)	80 (12.5)	Contaminated atmospheres where slight polishing action is necessary.
571	0.0027 (66)	1.57	2400 (169)	VH	M	7000 (36)	80 (12.5)	Industrial and transit applications.
581	0.0022 (56)	1.61	3200 (225)	VH	M	6000 (30)	80 (12.5)	Mill-type motors and generators where normal commutation is needed.
590	0.0024 (61)	1.62	3700 (260)	VH	M	6000 (30)	80 (12.5)	Where high strength and superior commutating ability is needed.
591	0.0020 (51)	1.66	4000 (282)	VH	M	6000 (30)	80 (12.5)	Where severe mechanical conditions require a high strength grade..
A451	0.0026 (66)	1.50	1400 (99)	VH	L	8000 (41)	80 (12.5)	Where humidity is low or where filming conditions are difficult.

Electrographic *(continued)*

Brush Grade	Spec. Res. Ω-in. (μΩ-m)	Dens. g/cm³	Trans. Strength lbf/in² (kgf/cm²)	Con-tact Drop	Fric-tion	Surface Speed ft/min (m/sec)	Normal Current Density A/in² (A/cm²)	Description and Application Recommended for:
AY	0.0004 (10)	1.68	3000 (211)	H	M	4000 (20)	80 (12.5)	Steel or bronze field rings of synchronous motors and wound rotor motor rings up to 100 APSI and up to 4000 ft/min.
B344	0.0008 (20)	1.65	3700 (260)	H	M	6000 (30)	80 (12.5)	Low voltage battery lift trucks where low contact drop is required.
D	0.0005 (13)	1.65	4200 (296)	H	M	5000 (25)	80 (12.5)	Steel and cast iron slip rings.
DE2	0.0021 (53)	1.64	3700 (260)	VH	L	8000 (41)	80 (12.5)	Smaller diesel-electric locomotive main generators and auxiliary equipment motors and generators.
DE25	0.0025 (64)	1.69	4200 (296)	VH	L	10000 (51)	80 (12.5)	Traction and hoist motors operating under severe conditions of temperature and low humidity.
DE3	0.0020 (51)	1.62	4500 (317)	VH	L	8000 (41)	80 (12.5)	Transit traction motors.
DE7	0.0025 (58)	1.67	4400 (310)	VH	L	10000 (51)	80 (12.5)	Traction motors and wheel motors in off highway vehicles where high loads and low humidity are present. Also suitable for motors in transit applications.
DE7000	0.0020 (51)	1.67	5500 (387)	VH	L	10000 (51)	80 (12.5)	Diesel-electric traction motors providing good commutation and long life.
DE8	0.0020 (51)	1.70	5000 (352)	VH	L	8000 (41)	80 (12.5)	Larger diesel-electric locomotive main generators, and other auxiliary equipment motors and exciters.
DE869	0.0013 (36)	1.71	4000 (282)	H	M	6000 (30)	70 (11)	Brass collector rings, also used for medium commutating service.
DE9000	0.0020 (51)	1.68	5500 (387)	VH	L	10000 (51)	80 (12.5)	High speed locomotive traction motor applications.
F799	0.0035 (76)	1.65	2800 (197)	VH	M	7000 (36)	70 (11)	Applications where friction chatter is encountered.
G	0.0013 (36)	1.65	3300 (232)	VH	M	6000 (30)	70 (11)	Medium-duty commutating service.
N19	0.0025 (58)	1.61	2800 (197)	VH	L	8000 (41)	75 (12)	Medium to low current density applications with normal commutation requirements.
N38	0.0020 (51)	1.70	5000 (352)	VH	L	8000 (41)	80 (12.5)	Industrial generators and exciters where long life is necessary . Exceptional ability to maintain film under lightly loaded conditions.
N39	0.00075 (19)	1.77	4700 (331)	VH	L	10000 (51)	80 (12.5)	Slip rings where a stabilized film is critical and long life is necessary.
N44	0.0024 (61)	1.50	1500 (106)	VH	L	10000 (51)	80 (12.5)	High commutating applications from large heavy duty motors and generators to less critical applications.
N48	0.0028 (71)	1.58	2000 (141)	VH	L	10000 (51)	80 (12.5)	Where excellent commutation is required and sustained high loads are present.
N6000	0.0026 (66)	1.55	2800 (197)	VH	L	8000 (41)	80 (12.5)	Low or variable humidity conditions and where long periods of light loading are a factor. Slight polishing action, also controls film in heavily loaded applications.

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Electrographitic *(continued)*

Brush Grade	Spec. Res. Ω-in. (μΩ-m)	Dens. g/cm³	Trans. Strength lbf/in² (kgf/cm²)	Con-tact Drop	Fric-tion	Surface Speed ft/min (m/sec)	Normal Current Density A/in² (A/cm²)	Description and Application Recommended for:
N66	0.0026 (66)	1.62	2800 (197)	VH	L	8000 (41)	80 (12.5)	Where a slight polishing action may be required for controlling commutator bar marking or other contaminants.
N964	0.0021 (53)	1.60	3400 (239)	VH	M	8000 (41)	80 (12.5)	Low/variable humidity conditions and where long periods of light loading are a factor.
R20X1	0.0004 (10)	1.70	3000 (211)	H	M	4000 (20)	80 (12.5)	Slip rings of wound rotor or synchronous machines used in low humidity or difficult filming conditions.
SA35	0.0021 (53)	1.54	2400 (169)	VH	L	8000 (41)	80 (12.5)	Where intermediate commutating ability is required.
SA45	0.0026 (66)	1.49	1450 (102)	VH	L	10000 (51)	80 (12.5)	Where excellent commutating ability is required. Used widely on industrial motors and generators.
SA4542	0.0026 (66)	1.51	1525 (107)	VH	M	8000 (41)	80 (12.5)	Where severe operating conditions such as transient overloads and improper machine adjustment are present and a slight polishing action is needed.
SA4548	0.0025 (64)	1.50	1500 (106)	VH	L	8000 (41)	80 (12.5)	Applications where SA45 would normally be used but where increased filming ability is required.
SA50	0.0028 (71)	1.49	1000 (70)	VH	L	10000 (51)	80 (12.5)	Machines where superior commutation is the primary requirement.
T300	0.0008 (20)	1.72	4000 (282)	H	M	7000 (36)	80 (12.5)	24 to 80 volt DC machines where low humidity and high loads are present.
T416	0.0030 (76)	1.62	3200 (225)	VH	M	8000 (41)	80 (12.5)	Where excellent commutating and riding properties are required. Applied on high-voltage machines used in steel mills, paper mills, dragline generators, etc.
T500	0.0030 (76)	1.57	2000 (141)	VH	M	8000 (41)	80 (12.5)	Heavily loaded, difficult to commutate machines. Long life at lower humidity.
T508	0.0022 (56)	1.68	4300 (303)	VH	M	8000 (41)	80 (12.5)	General industrial and transportation applications. Requiring low humidity protection.
T550	0.0029 (74)	1.63	3900 (275)	VH	M	8000 (41)	80 (12.5)	The plastics industry where good filming and excellent commutation is necessary.
T563	0.0030 (76)	1.58	2400 (169)	VH	M	8000 (41)	80 (12.5)	Wide variety of industrial applications where excellent commutation is necessary.
T566	0.0030 (76)	1.62	2500 (176)	VH	M	8000 (41)	70 (11)	Contaminated atmospheres seen in paper mills and where load requirements are high.
T573	0.0027 (66)	1.62	3100 (218)	VH	M	7000 (36)	80 (12.5)	Wide variety of industrial applications.
T583	0.0022 (56)	1.67	4100 (289)	VH	M	6000 (30)	80 (12.5)	Medium duty industrial and general traction motor application.
T606	0.0035 (76)	1.73	3600 (253)	VH	M	7000 (36)	70 (11)	Where threading is a concern in contaminated atmospheres and to minimize friction chatter.
T652	0.0030 (76)	1.62	3200 (225)	VH	M	8000 (41)	80 (12.5)	Where low humidity and selelctivity are concerns.
T659	0.0030 (76)	1.63	4000 (282)	VH	M	8000 (41)	80 (12.5)	Low friction and good commutation are primary concerns.
T758	0.0027 (66)	1.68	4700 (331)	VH	M	8000 (41)	80 (12.5)	High-speed transit car motors.

Electrographitic *(continued)*

Brush Grade	Spec. Res. Ω-in. (μΩ-m)	Dens. g/cm³	Trans. Strength lbf/in² (kgf/cm²)	Con-tact Drop	Fric-tion	Surface Speed ft/min (m/sec)	Normal Current Density A/in² (A/cm²)	Description and Application Recommended for:
T825	0.0025 (58)	1.69	4200 (296)	VH	L	10000 (51)	80 (12.5)	Off highway vehicle traction motors under severe conditions of high temperature, low humidity, and heavy loads.
T869	0.0013 (36)	1.71	4000 (282)	VH	M	6000 (30)	70 (11)	Brass collector rings and medium-duty commutating service.
T900	0.0020 (51)	1.68	4500 (317)	VH	M	8000 (41)	80 (12.5)	Where excellent low humidity and high brush temperature are primary concerns. Used extensively in traction motor service.
T959	0.0024 (61)	1.68	4200 (296)	VH	M	8000 (41)	80 (12.5)	Traction motors which require superior commutation and low friction under various duty cycles and low humidity conditions.

Graphite

Brush Grade	Spec. Res. Ω-in. (μΩ-m)	Dens. g/cm³	Trans. Strength lbf/in² (kgf/cm²	Con-tact Drop	Fric-tion	Surface Speed ft/min (m/sec)	Normal Current Density A/in² (A/cm²)	Abra sive ness	Description and Application Recommended for:
634	0.0007 (18)	1.28	750 (53)	VH	L	16000 (81)	65 (10)	M	High-speed slip rings on turbo alternators around the world.
H100-USA	0.0010 (28)	1.36	1300 (92)	VH	M	12000 (61)	55 (8.5)	M	High-speed service where scrubbing action required.
H100-USA	0.0010 (28)	1.82	3450	M	L	8000 (41)	80 (12.5)	L	Low voltage motors and generators where low humidity protection is needed.
K816	0.00036 (13)	1.83	2900 (204)	M	M	8000 (41)	65 (10)	M	Contaminated atmospheres for light loads and low-voltage machines.
PH	0.0400 (1016)	1.61	3300 (232)	VH	L	6000 (30)	40 (6.2)	L	Where a very high contact drop is primary consideration. Recommended for FHP motors with difficult commutating characteristics.
R310	0.0022 (76)	1.75	3600 (253)	VH	M	5000 (25)	45 (7)	L	Where exceptional riding and commutating ability is required. Successful on 3600 RPM turbo exciters up to 60 kw size, motors and generators in paper mill, steel mill service.
R312	0.0020 (51)	1.73	2400 (169)	VH	M	6000 (30)	55 (8.5)	L	Similar to R310 but with greater load capacity.
R318	0.0007 (25)	1.75	3200 (225)	H	M	10000 (51)	65 (10)	M	Steel slip rings of alternators and synchronous motors.
R320	0.0013 (33)	1.35	1000 (70)	H	M	12000 (61)	65 (10)	M	Where selectivity is primary concern. This grade has a very low coefficient of friction for high-speed service.
R884	0.0220 (762)	1.62	3000 (211)	VH	M	6000 (30)	55 (8.5)	M	Small, difficult to commutate machines such as amplidynes and non-commutating pole motors used with SCR packages.
T341	0.0020 (51)	1.79	4500 (317)	VH	M	6000 (30)	55 (8.5)	L	Contaminated environments to reduce threading and improve brush life.
T990	0.0025 (64)	1.83	3700 (260)	VH	M	8000 (41)	80 (12.5)	M	Battery truck motors where superior commutating ability is required.

Metal Graphite

Brush Grade	Spec. Res. Ω-in. (μΩ-m)	Dens. g/cm³	Trans. Strength lbf/in² (kgf/cm²	Con-tact Drop	Fric-tion	Surface Speed ft/min (m/sec)	Normal Current Density A/in² (A/cm²)	Abra siven ess	% Met al	Description and Application Recommended for:
537	0.0003 (8)	2.77	3200 (225)	VH	M	6000 (30)	100 (15.5)	L	48	24 – 50 volt DC motors and AC motor collector rings where low humidity protection is required.
AJT	0.00016 (4)	3.00	4700 (331)	L	L	6000 (30)	100 (15.5)	L	40	High current/low voltage motors exposed to high altitudes.
ANK	0.000006 (0.2)	4.95	3500 (246)	L	L	6000 (30)	150 (23.3)	M	75	Where high copper content and low humidity protection is needed.
AYK	0.000044 (1.1)	2.64	5000 (352)	M	M	4000 (20)	100 (15.5)	L	40	Applications of wound rotor motor rings up to 100 APSI.
F83	0.0450 (1143)	2.02	2300 (162)	VH	L	4000 (20)	40 (6.2)	L	25	Appliance motors and other FHP applications and suitable for low current densities.
L4	0.000014 (0.38)	4.57	3100 (218)	L	H	5000 (25)	125 (19.4)	M	75	Low-voltage motors, particularly switch and signal equipment. Also used on plating generators up to 15 volt and on brass slip rings of induction motors.
M2650	0.000125 (2.79)	2.80	3500 (246)	L	L	7000 (36)	100 (15.5)	L	50	Slip rings and low voltage motors (24 – 72 volts).
M2665	0.000025 (0.76)	3.50	3800 (268)	L	VL	6000 (30)	110 (17)	L	65	Slip rings and low voltage motors (6 – 24 volts).
M2675	0.000008 (0.23)	4.25	3200 (225)	L	L	6000 (30)	125 (19.4)	M	75	Slip rings and low voltage motors (6 – 24 volts). Also can be used on slip ring applications when higher current density is needed.
M2688	0.000015 (0.38)	5.40	8000 (563)	L	L	6000 (30)	150 (23.3)	M	88	Plating generators up to 15 volts and conductor rolls.
M407	0.000008 (0.2)	5.10	2400 (169)	L	M	4500 (23)	150 (23.3)	L	75	Where very low contact drop, and low friction are required. Also used on controllers and control equipment.
M540	0.000015 (0.38)	5.40	8300 (584)	L	H	5000 (25)	140 (21.7)	M	85	Low-voltage machines and grounding brushes.
M5N	0.000012 (0.3)	5.91	6000 (422)	L	M	4000 (20)	150 (23.3)	M	96	Low voltage, high current applications where long brush life and minimum collector wear is desired.
M785	0.00027 (7)	3.20	3000 (211)	L	H	6000 (30)	100 (15.5)	L	50	Low-voltage DC motors and generators in the 24 to 72 volt range and on brass slip rings of induction motors.

Grade Properties Tabulation Disclaimer

The information contained in this tabulation of material properties is based on experimental and / or historical trends and indicates guidelines for typical lots of materials. Choosing the correct grade for a particular application should not be based solely on physical properties. No guarantee of these properties is given or implied.

Brush Request Form

Six Steps to Identify a Carbon Brush

Morgan Advanced Materials
251 Forrester Dr.
Greenville, SC 29607

NATIONAL

1 Identification and Nameplate Information

☐ Motor ☐ Generator ☐ Slip Ring

Stamping / Part # ____________________

Manufacturer ____________________

Model #_________________ Serial # ___________

Total # Brushes _____ HP/KW ______ RPM ________

Volts_____ Amps _____ Actual Running Amps ______

2 Describe The Application

Commutator Diameter ________ (inches)

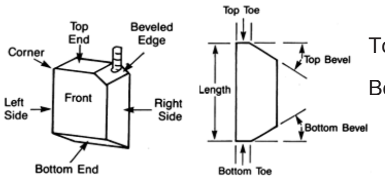
Slip Ring ☐ Synchronous ☐ Wound Rotor ☐ Steel Ring ☐ Bronze Ring

Diameter ________ (inches)

Application
☐ General Industrial
☐ Papermill
☐ Mining
☐ Other ___________
☐ Steel Mill
☐ Elevator
☐ Power Gen

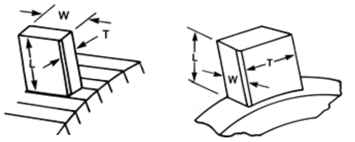
3 Describe The Brush

Circle Any Special Features



Top Bevel _______

Bot Bevel _______



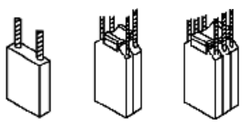
Commutator **Slip Ring**

Use calipers to measure (T), (W), and (L). Notice differences in SR and Comm style brushes

Thickness (T) ______

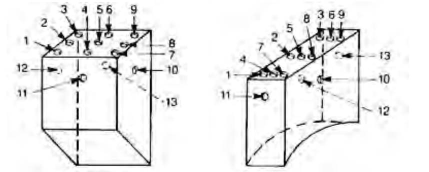
Width (W) _________

Length (L) _________



Solid ☐
Plytek ☐
Triply ☐

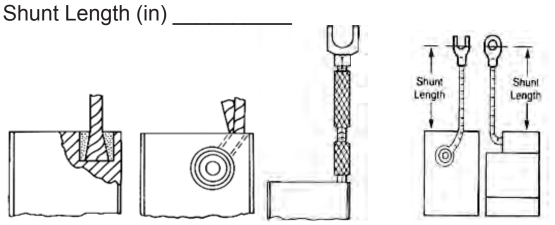
4 Describe The Shunt



Commutator **Slip Ring**

Shunt Location(s) __________

Shunt Length (in) __________



☐ **Tamed** ☐ **Rivet** ☐ **Insulated** **Measuring Length**

5 Describe The Brush Top

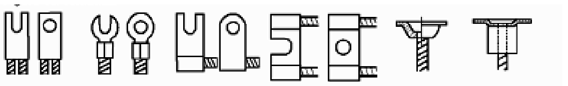
☐ ☐ ☐ ☐ ☐ ☐

Pad **Clip**

Other (for example: no pad or clip, convex, channel, etc.)

Describe ___________________________________

6 Describe The Terminal



Tube Crimped Flag Yoke Button Eared

Circle Terminal and Measure
I.D. of Hole or Fork (in) ___________

Quick Disconnect EZ Terminal

Fill out the form and fax to 205.252.6300. Then call a Customer Service Representative at 800.543.6322.

Advanced Materials & Technology
www.morganadvancedmaterials.com

		Electrographite Grades 40 to 80 APSI																								
Applications		234	AY	D	DE8	DE25	DE7000	DE9000	L932	L944	L966	N19	N39	N44	N48	N6000	N66	N964	SA35	SA45	SA4542	SA4548	SA50	T300	T416	T500
Paper Mills	light load											●														
	moderate load											●			●						●					
	heavy loads													●	●		●				●		●		●	
	contamination								●	●	●						●				●				●	
Steel Mills	auxilary motors											●		●			●								●	
	collector rolls																									
	dc cranes	●															●									
	generators													●						●					●	
	looper motors													●						●						
	low voltage generators																									
	rolling mill motors														●		●				●				●	
	contamination								●	●	●															
Mining	excavator generators														●	●		●							●	
	excavator motors															●				●						●
Elevators	generators											●				●						●				
	hoist motors																●									
Power Generation	exciter generators											●														
	hydroelectric		●	●																						
	steam turbine slip rings																									
	wind generators																									
Industrial	light loads											●														
	moderate load	●											●		●		●		●	●		●				
	heavy loads														●		●						●			●
	contamination								●	●	●						●				●					
Railroad	alternator		●		●								●													
	grid blower motor																									
	light rail																									
	traction motor						●	●																		
Off Highway	alternators																									
	grid blowers																									
	wheelmotors					●																				
Misc	annealers																									
	container cranes																			●						
	electric vehicle pump																							●		
	electric vehicle traction																							●		
	grounding																									
	plastics															●										
	rotary conversion																									
	shears (hi inrush)														●								●			
	ski lifts															●									●	
	slip rings - bronze		●																							
	slip rings - steel		●	●																						
	wound rotor motors		●	●																						

Application / Grade Matrix Disclaimer

The applications of brushes to all types of electrical machines is numerous and varied. This grade / application matrix is intended to give general recommendation guidelines for many of those applications. These recommendations are the product of intensive research, development, and experience of our Application Engineers in both the laboratory and in the field and cover a wide range of service conditions. This process is a continuous development program and we are always striving to recommend the best grade for each application.

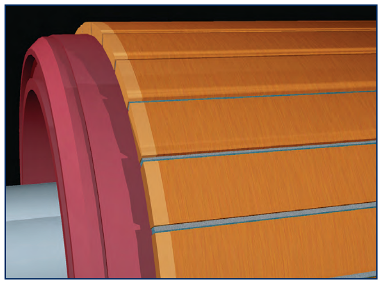
													Graphite Grades 5 to 65 APSI							Metal Graphite Grades 80 to 150 APSI									
T508	T550	T563	T566	T573	T583	T606	T652	T758	T825	T869	T900	T959	634	R310	R312	R318	R320	T341	T990	537	L4	M2650	M2665	M2675	M2688	M407	M5N	**Applications**	
						●								●	●			●	●									light load	Paper Mills
			●																									moderate load	Paper Mills
			●	●																								heavy loads	Paper Mills
																												contamination	Paper Mills
		●		●	●																							auxilary motors	Steel Mills
		●																			●				●		●	collector rolls	Steel Mills
		●		●	●																							dc cranes	Steel Mills
																												generators	Steel Mills
																					●							looper motors	Steel Mills
																					●	●	●					low voltage generators	Steel Mills
		●		●	●																							rolling mill motors	Steel Mills
																												contamination	Steel Mills
							●																					excavator generators	Mining
																												excavator motors	Mining
															●			●										generators	Elevators
																												hoist motors	Elevators
																												exciter generators	Power Generation
													●			●												hydroelectric	Power Generation
													●			●	●											steam turbine slip rings	Power Generation
																				●				●				wind generators	Power Generation
						●								●	●			●										light loads	Industrial
		●																										moderate load	Industrial
				●	●																							heavy loads	Industrial
	●																											contamination	Industrial
																●												alternator	Railroad
●								●																				grid blower motor	Railroad
								●																				light rail	Railroad
											●	●																traction motor	Railroad
																●	●											alternators	Off Highway
●					●																							grid blowers	Off Highway
●									●																			wheelmotors	Off Highway
																								●	●		●	annealers	Misc
		●			●																							container cranes	Misc
																			●									electric vehicle pump	Misc
																				●		●						electric vehicle traction	Misc
																					●			●		●	●	grounding	Misc
	●																											plastics	Misc
																						●	●			●		rotary conversion	Misc
																												shears (hi inrush)	Misc
																												ski lifts	Misc
										●										●								slip rings - bronze	Misc
										●						●				●								slip rings - steel	Misc
										●						●				●	●	●	●	●				wound rotor motors	Misc

There is a total cost consideration of commutators / slip rings and brushes when making decisions to apply a brush material. A balance between good brush life versus commutator or slip ring wear that must be calculated and should be the final basis for grade selection.

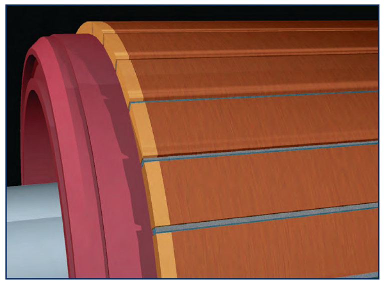
There is no guarantee given or implied in these recommendations.

COMMUTATOR SURFACE CONDITIONS

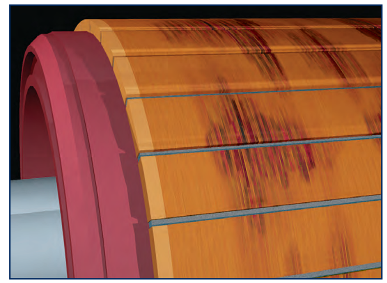
Satisfactory Conditions



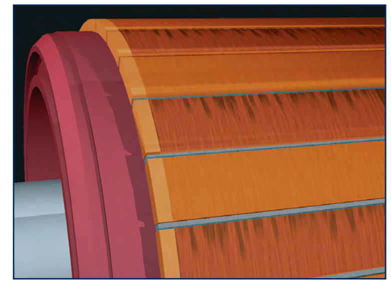
Light Film - over the entire commutator surface is one of the many normal conditions often seen on a well functioning machine. Film tone is dependent on the brush grade and current density.



Dark Film - if uniform over the entire commutator surface is acceptable. This condition can be the result of a high filming brush grade, higher current densities or the presence of chemical vapor contamination.

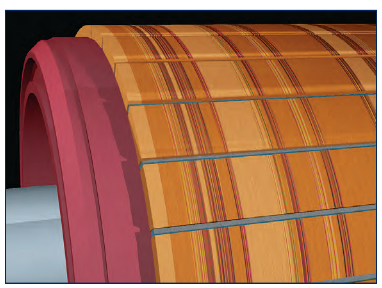


Blotchy Film - this nonuniform filming condition is the most common appearance. The accumulated tolerances in the machine such as commutator roundness, brush contact pressure, unequal magnetic fields and chemical vapors all contribute to this type of film development.

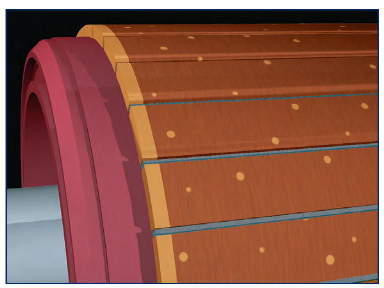


Slot Bar Filming - repeating light and dark filming patterns related to the number of armature coils per slot. This pattern is dependent on the machine design and usually not a function of the brush grade.

Concerned Conditions

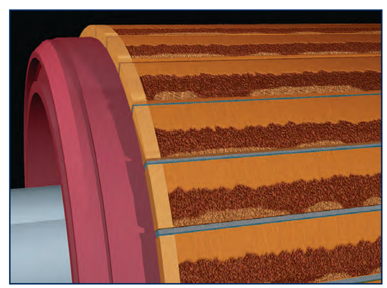


Streaking - of only the film is not detrimental to the commutator. Brush and commutator life are not at risk in this condition. If metal transfer develops, this condition will progress into threading. This type of filming can be dependent on current density or brush grade.

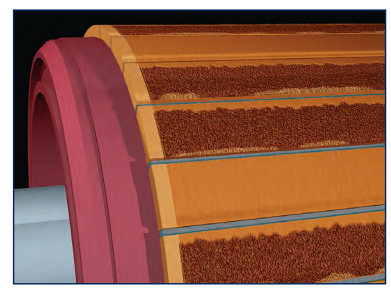


Bright Spots - a freckled appearance of the film usually caused by machines that are subjected to frequent overload cycles. If the bright spots disturb only the film, a machine can operate for long periods of time with this condition. If severe metal transfer begins, the bright spots could progress to dangerous bar burning or film stripping.

Unsatisfactory Conditions

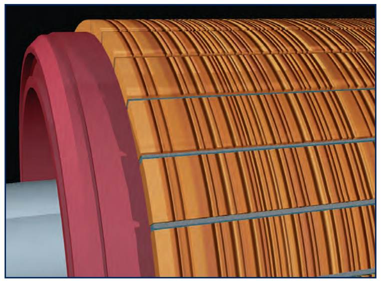


Bar Burning - is the erosion of the trailing edge of the commutator bar. Failed machine components, maladjusted electrical symmetry of the machine or a poor commutating brush can result in bar burning. If not corrected, this condition can cause severe commutator damage or a flashover.

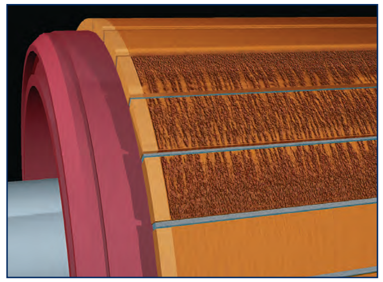


Slot Bar Burning - results in commutator erosion of every second, third, or fourth bar depending on the winding design of the armature. Improper brush material, brush design or electrical adjustment of the machine can cause this condition. This condition severely damages the commutator and reduces brush life.

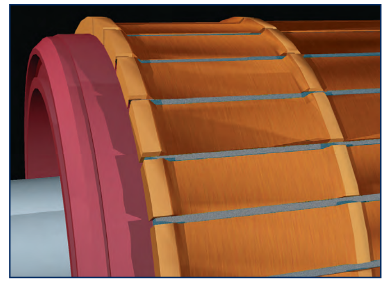
Unsatisfactory Conditions



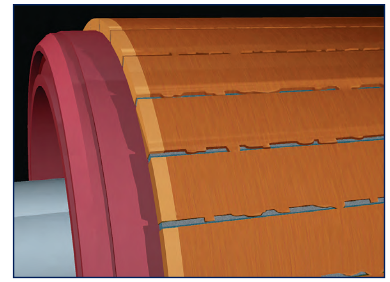
Threading - is machining of the commutator by copper particles in the brush face. The excessive copper transfer occurrs due to low spring pressure, light loading or contamination. These particles are trapped in the porous carbon brush and work harden, creating a tool that machines or gauls the commutator surface. The machine can operate for long periods of time with this condition, but reduced commutator and brush life will be experienced.



Pitch Bar Burning - results in commutator bars being eroded in a pattern related to 1/2 the number of brush arms, progressing into a pattern equal to the number of brush arms. This condition is caused by a cyclic mechanical or electrical disturbance such as an unbalanced armature, misaligned shafts, bent shaft, bad bearings, weak foundation, failed equalizers or a poor riser connection. If not corrected this condition will result in a flashover.



Grooving - is the uniform circumferential wear, the width of the brush, that is exhibited on the commutator. Excessive abrasive dust in the atmosphere or an abrasive brush can cause this condition. Extreme light spring pressure (below 1.5 psi) can also cause this condition. Proper brush applications and filtering the air on force ventilated motors can reduce the commutator wear. Some people call this "Ridging" because of the resulting ridges on each side of the groove.



Copper Drag - occurs when high energy transfers copper in a molten state. These particles become coated by contaminants from the surrounding environment or the brush treatment and do not oxidize properly to form the film on the commutator surface. These particles accumulate at the edge of the bar, eventually shorting across the insulating mica. This condition needs to be addressed immediately when discovered or serious damage may occur. Chamfering the commutator bar edges is necessary to stop the progression of this condition.

Call our Application Engineering Dept.
if you would like help improving your
Commutator Condition or Brush Performance.
864-458-7777 or 1-800-543-6322

NAT SCP 4/08 INDEXX

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