The Perfect Drive

by Theodor Helmle

Learning Objectives
After reading this article, you should have learned about:
- the comparison of planetary and gearless elevator drives.
- the use of synchronous motor and planetary gearing in elevator hoist machines.
- the duty cycle in elevator machine application.
- the effect of inverter clock frequency on elevator ride quality.
- the use of planetary drive machines for machine-room-less elevators.

Experience gathered in the manufacture of high-quality servo drives destined for use in mechanical engineering, aviation, medical technology and other industries has been successfully applied in devising new system technology for elevators. The central component in this development by Alpha Getriebebau GmbH is a low-play planetary drive distinguished by superb dynamics, torque transmission and precision.

Taking a look at the advantages offered here (in comparison with a gearless drive) is certainly worthwhile. The efficiency level achieved by a high-quality gearless drive is the equivalent of that for a planetary elevator drive. The disadvantage of gearless drives is found, however, in the fact that they have only a 35% duty cycle. Modern lift equipment should, however, achieve a 60% duty cycle. The high-quality planetary-gear systems engineered by Alpha Getriebebau are persuasive due to their overall efficiency of more than 90% and their capacity for up to 240 motor starts per hour.

Developing economical elevator technology is just as much in line with current trends as are other energy-saving measures. That's hardly a surprise since, due to drastic price increases in the energy sector, greater emphasis is being placed on the total efficiency of elevator systems.

A High-Torque Featherweight

The idea behind this innovative lift technology is as simple as it is effective. The combination of a synchronous motor and two-stage planetary gearing gives the elevator drive high torque that cannot be achieved by a comparable gearless drive. The compact design of the planetary gear means the drive (without the drive sheave) for an elevator generating 630 kilograms of lifting power weighs less than 100 kilograms. A comparable gearless drive will weigh 600-680 kilograms.

$$\text{Moment-to-weight factor} \left[\frac{\text{Nm}}{\text{kg}}\right] = \frac{\text{Moment}}{\text{Empty weight}}$$

$$\text{Payload factor} = \frac{\text{Payload}}{\text{Empty weight}}$$

Both the moment-to-weight factor and the payload factor in a high-quality geared drive unit are considerably higher than for a gearless drive.

The gearless drives available on the market today have a duty cycle of about 35%. It has been demonstrated in practical testing that these drives can move the cars within the hoistway for a maximum of 21 minutes in continuous duty. If a gearless drive with a higher duty cycle (at the same lifting load) is required, a larger gearless drive with the appropriate output data, power consumption and purchase costs will have to be used.

Continued

This article and **"Get the Lead Out!"** on page 77 combined equal a continuing-education value of:

1 contact hour

These articles are part of ELEVATOR WORLD's Continuing Education program. Elevator-industry personnel required to obtain continuing-education credits can receive one hour of credit by reading these articles and completing the assessment examination questions found on page 97.
For this article and more continuing-education opportunities, visit www.elevatorbooks.com.

Approved by NAEC for CET®

Approved by NAESAI for QEI

Efficiency in Continuous Duty

In short: The limited duty cycle of the gearless drive, when compared to a planetary drive using a synchronous drive, results from the drive's high heat-generation level. One of the results of this heating is that the motor's inductance changes and, if the inverter is not large enough, this can lead to unsatisfactory ride quality. Elevator machinery with planetary drives is engineered for 240 motor starts per hour and has no limits on output in continuous operation – something often required in hospitals, for instance.

ECD – The economical elevator drive that rides along with the car

The ECD unit travels along with the car.

Quieter, Faster, More Reliable

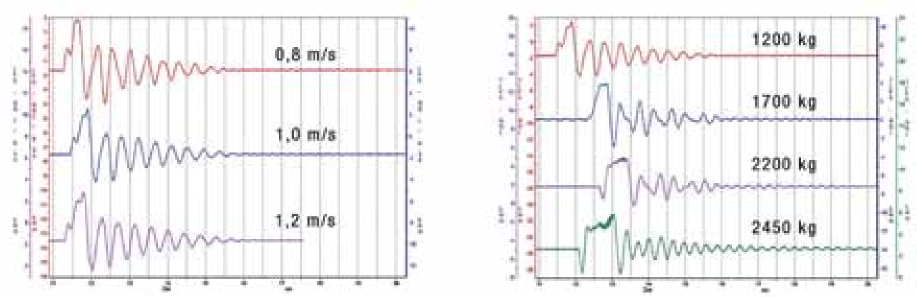
The customers' understandable desire for the quietest possible drive is also achieved with a high-quality combination of motor and gearing, provided that maximum manufacturing precision is paired with good engineering design. Ride quality can be further enhanced by using inverters with a clock frequency of 16 kHz at the output. In order to shave costs, a clock rate of 12 kHz or even less is often used so as to be able to use smaller insulated gate bipolar transistors (IGBTs), modules and less-expensive heat sinks. But regulators which use a clock rate of 12 kHz or less generate – in conjunction with the drive – noises that are perceived by the human ear as unpleasant.

Testing

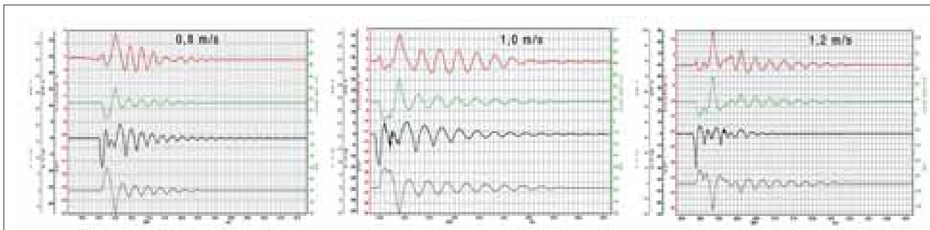
To examine its own quality achievement, the company has had quality testing carried out at the Central Technical College for Elevator Technology at Rosswein. Among the tests carried out were emergency stop trials in which loads and stresses were generated far beyond normal requirements in elevator engineering:

- Test 1: Emergency stop tests/power outage simulation.
- Test 2: Emergency stop testing/loading tests when the safeties engage during an overspeed condition. During these tests, acceleration values >6g were achieved. After several trials, the drive was still 100% functional.
- Test 3: Bouncing counterweight: car traveling to contact with various bumper systems to generate counterweight bounce at differing loading states and car speeds.
- Test 4: Determining system stiffness: varying stiffness by removing the sprung suspension at the car and the counterweight.

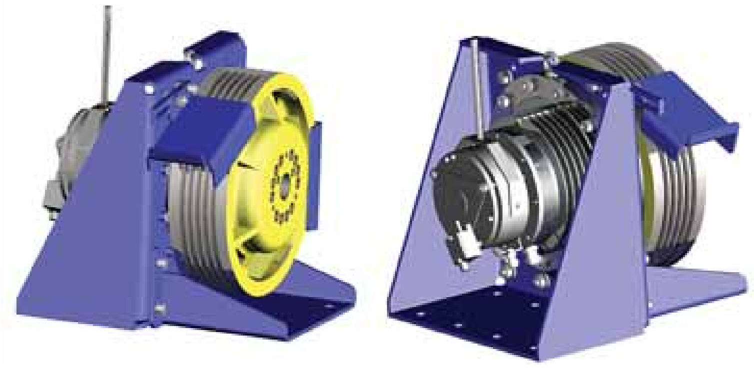
Changing system stiffness, i.e., removing the spring elements at the car and counterweight, makes it possible to determine the frequency change to be expected but with no increase in the moments that might occur. The spring elements or spring buffers have no influence on the forces or acceleration that appear.



Power outage simulation: The progress of the moment curve shows no significant differences at various travel speeds. The torques are on about the same order of magnitude as the moment of acceleration, are limited by the braking moment and are dependent upon the inertia of the motor and the traction power of the ropes at the drive sheave. The development of moment will be shifted according to the loading status. Pulsating and (at balanced loading states) alternating loads will occur. Whenever there is a change in system stiffness, i.e., elimination of the springing elements at the car and counterweight suspension systems, the expected change in frequency can be determined but without increase in the moments that arise.



During the measurements, the reaction moment, the force at the counterweight and the acceleration of the car and the counterweight were registered. Due to the bouncing, counterweight-excessive forces could appear in the ropes at the counterweight at about three to four times the weight.



The ECD elevator equipment can be broken down into its major components: the motor system, drive sheave and frame components.

Result

The test results have demonstrated convincingly that the planetary gearing used in the drive can withstand the load levels encountered in lifts to an above-average extent.

Utilization Options

The combination of compactness and lightness opens up entirely new solution options for the engineer. On the one hand, it is possible to realize a machine-room-less system for new installations in which the machine can ride on the car without creating any problems. This gives the engineer the option of building a self-propelled car featuring an integral drive unit. In order to complete integration, the manufacturer is also offering a suitably modified control and regulation package. On the other hand, the ECD machinery offers new options for rehabilitation work. It has low weight and compact dimensions.

In Summary

The product description, augmented by testing and the installation options which derive from that prove that this "perfect" drive is absolutely uncompromising in its quality and utility.

*Reprinted from **Lift-Report***

Theodor Helmle is the executive director of Alpha Mechatronics. Helmle spent 12 years as head of the Elevator Business Unit of Alpha Getriebebau GmbH and has experience as a developing engineer and in plant design engineering.

Learning-Reinforcement Questions

Use the below learning-reinforcement questions to study for the Continuing Education Assessment Exam available online at www.elevatorbooks.com or on page 97 of this issue.

- What is the duty cycle of a gearless drive?
- What are the approximate weights of a 630-kilogram capacity elevator gearless and planetary-drive machines?
- What are some of the best applications of planetary-drive elevators? Why?
- What effect does the clock-drive frequency have on an elevator drive?
- What are the features of planetary-drive machines that make them suitable for use in machine-room-less elevators?

Get the Lead Out!

Carbon Brushes in Elevator Applications

by Keith Challenger and Nick O'Dell

Learning Objectives

After reading this article, you should have learned about:

- the composition of carbon brushes.
- the factors that can adversely affect commutator film.
- why the film is important.
- the causes of shortened brush life.
- how to measure current density.
- the characteristics of brush materials.

Recent Developments

The past quarter century has presented new challenges, both to the elevator service industry and the brush manufacturer. The typical age of elevator traction equipment in cities like New York and Chicago, with some of the earliest high-rise buildings, averages around the half century mark. A substantial number of these elevators date back to the 1920s and even earlier. In many cases, the route and amount of equipment for which the elevator mechanic is responsible is increasing. Labor costs are soaring while competition for service contracts has stiffened and building management is less tolerant of car downtime.

Replacement of motors and generators with new units is rare. In fact, most electrical equipment manufacturers no longer make generators. Each passing year, the equipment the service mechanic is charged with maintaining gets older, insulation becomes more brittle and electrical faults more common. In addition, mechanical tolerances increase, and critical factors like commutator surface condition and brush holder to commutator gap become harder to keep within specifications. These problems also have a negative effect on brush operation and life span.

Around the 1980s, elevator service personnel began to report unfavorable changes in brush performance, particularly in respect to dusting and brush life. Even with the acknowledged degradation of motors and generators through age, the question has been posed whether changes in brush construction or composition, possibly mandated by federal environmental regulations, may have contributed to these problems. This may have led to the much-repeated rumor that brush manufacturers had discontinued using lead or other toxic substances in their carbon recipes, or grades, hence the title of this article.

Was the Lead Ever in?

In the infancy of carbon brush development, the material used as the base for the few different grades in existence was the mineral graphite, known since antiquity as *plumbago*, or "black lead" from the fact that it was confused with the ore from which metallic lead is extracted. The word graphite comes from the Greek "to write," and the same confusion continues to this day as the mineral is used in what are still called *lead pencils*.

Perhaps this misunderstanding of "lead" was the basis for another confusion, so at this point let us attempt to finally lay to rest the oft-repeated legends of the use of arsenic, asbestos and lead. Neither arsenic nor asbestos has any conceivable application in brushes; in fact asbestos is an insulator, and any brush containing more than a trace amount would pass no

Continued

This article and **"The Perfect Drive"** on page 57 combined equal a continuing-education value of:

1 contact hour

These articles are part of ELEVATOR WORLD's Continuing Education program. Elevator-industry personnel required to obtain continuing-education credits can receive one hour of credit by reading these articles and completing the assessment examination questions found on page 97.

For this article and more continuing-education opportunities, visit www.elevatorbooks.com.

Approved by NAEC for CET®

Approved by NAESAI for QEI

electric current! Lead, as the metal or its salts, has been used in a few industrial applications, but *we have no knowledge of any form of lead ever having been used in elevator brushes*.

Empirical vs. Material Technology

In the early years, brush development was very much a trial-and-error process. It is no pun on the undeniable color of graphite to describe the development of what came to be called *carbon brushes* as a "black art." Little was understood about such subjects as commutation and voltage drop, or the importance of current density, film formation or spring pressure. If a brush made from a certain grade worked, few cared why or how. If it didn't, a different one was tried.

This empirical approach worked reasonably well when steam engines powered most of industry and all of railroading, and the few industrial electrical machines were generally made in the same style, massively over-engineered and lightly loaded. With the increasing demands on the motors and generators that made possible the Second Industrial Revolution, a scientific approach to brush development and improvement became essential, using the relatively new discipline of material technology.

Morgan Crucible Co. originated in the U.K. in the 19th century manufacturing graphite crucibles for the steel industry. Today, it is a global enterprise applying scientific research and materials technology to such diverse fields as advanced ceramics, fuel cells, carbon fiber composites and carbon brushes. Operations in the United States began with the opening of Morganite Inc. in Long Island City, New York, in 1907. Today, the divisions of Morganite, now located in Dunn, N.C., and National Electrical Carbon Industries, based in Greenville, S.C., are leading suppliers of brushes to all industries, offering a wealth of experience and capability in meeting the special challenges posed by traction elevators and especially their generators.

The Unique Elevator Generator

Unmatched among industrial operations, especially in a high-risk, people-moving application, the direct-current (DC) elevator generator stands alone in its unusual characteristics and the demands made on it. It may operate in wide extremes of temperature and humidity, and not infrequently be subject to noxious atmospheric contaminants. It must be able to operate unsupervised for very long periods, run off-load (which is harmful both to brush and commutator) for an appreciable proportion of its duty cycle and then instantly supply current at precise voltages to accommodate the widely varying loads and demands of the traction motor.

All these requirements make developing a carbon grade to meet the special needs of the elevator generator one of the brush industry's greatest challenges. It must be able to commutate well under widely varying circumstances, resist as far as possible the detrimental effects of long periods running off-load, accommodate large variations in current, protect the commutator and at the same time offer a reasonable life-span. National Electrical Carbon Products, Inc., is one of the few companies with the resources to conduct research and field testing, develop its own unique elevator carbon grades and control the entire manufacturing process from raw materials to the finished brush.

Why Is the Film Important?

A typical generator armature rotates at some 30 revolutions per second. A 12-inch diameter commutator is therefore moving past the brushes at approximately 60mph. To put this in perspective, if a carbon brush were placed in contact with the ground, in six months it would completely circle the earth – some 24,000 miles – 10 times! The brush must remain firmly pressed against the commutator in order to conduct operating current, maintain the correct commutation and contact voltage drop and eliminate sparking as far as is possible. If there were actual physical contact, with the commutator rubbing directly on the brushes, they would destroy each other by frictional heat in the first few miles, not even one time around the earth.

A protective conducting layer (see Figure 1, Commutator Surface Film) must be interposed between brush and commutator surface; this is the purpose and function of the film (sometimes known as glaze or skin). Although only a few microns thick (a

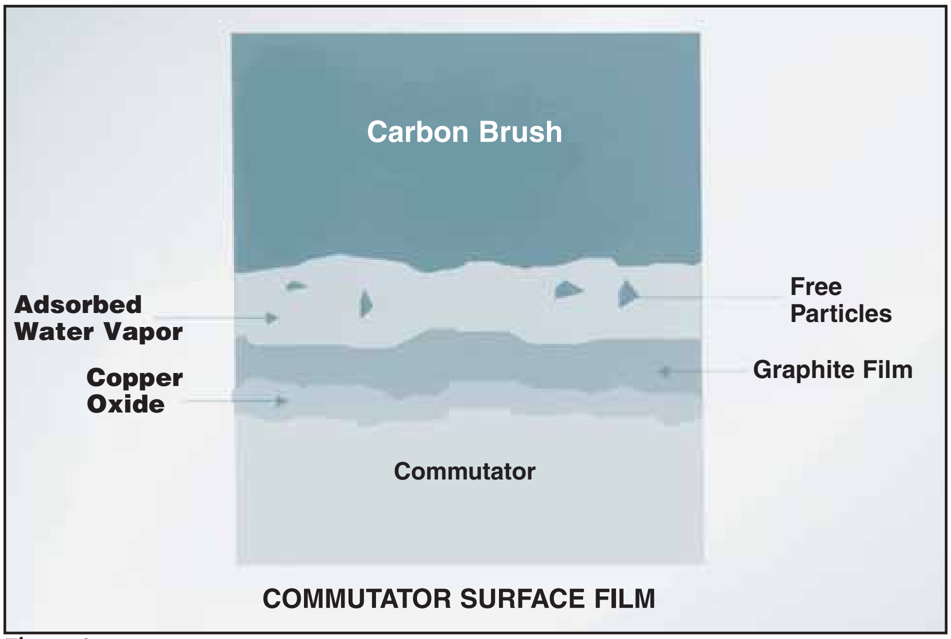


Figure 1

human hair, for comparison, is about 57 microns), a properly-formed film covering the entire width of the brush path, will make the difference between an undamaged commutator and nine or 12 months brush life – or a grooved commutator, a few weeks of brush life, copious carbon dust, repeated out-of-service time and expensive repair work. The film also plays an essential part in the voltage drop at its junction with the brush, which in turn affects proper elevator operation, especially car leveling.

Causes of Short Brush Life and Dusting

Most brush and commutator problems (and the two are almost always related) can be divided into **Mechanical** and **Electrical** in origin.

Mechanical Causes

Let us deal with this simplest group first. A generator brush can tolerate a maximum of about five-thousandths of an inch (0.005 inches) of total indicated commutator runout **(TIR),** or eccentricity. Excessive runout can cause brush instability, rapid wear, shunt looseness and sparking.

A more critical parameter is the maximum allowable bar-to-bar difference **(MBTB),** i.e. the worst case on the commutator surface of a height differential in adjacent bars. MBTB much in excess of about half of one thousandth of an inch (0.0005 inches) will turn the commutator surface into an effective milling machine, quickly wearing down the brush and producing excessive dust. (Hoist motors, especially the gearless type, are more tolerant of these departures from the ideal, due to their slower rotational speeds.)

A grossly excessive MBTB condition on one pair of bars may be due to a loose bar having moved radially by centrifugal force. This is often accompanied by sparking at the trailing edge of the brush, characteristically resulting in the bar *following* the high bar, in the direction of rotation, being badly burned, followed by a series of bars with steadily diminishing burning.

Continued

Factors that Can Adversely Affect Commutator Film

◆ **Brush Grade.** A grade unsuitable for the application can result in sparse, or absent, film. A common but harmful practice is mixing brushes of different grades or using motor brushes in generators. Brushes can look exactly the same but have widely different characteristics, particularly in resistivity. For this reason they must always be installed in complete sets, and replaced by exactly the same ones, as identified by their manufacturer's logo and part number.

◆ **Current Density.** Film is largely formed by an electrophoretic process by the anodic brushes, roughly proportional to the current density in amps per square inch averaged over the entire duty cycle of the generator. Friction by the cathodic brushes tends to oppose this formation, resulting in an equilibrium at a certain film depth. Generators tend to be over-brushed, being designed with a brush area (brush width x thickness x number of brushes per set) able to accept the maximum rated current stated on the data plate. Unfortunately, except in rare cases, the actual current load is often closer to half this value, leading to a low current density and poor filming.

◆ **Spring Pressure.** Weak spring pressure is a common problem, as springs weaken steadily throughout equipment life (and very rapidly if overheated). The pressure should be measured every year or two, and, on adjustable brush holders, set at the top end of the equipment manufacturer's recommended range. Pressure cannot be easily measured on constant-force springs (commonly known as "roll-up" or "money clip"), so if there is any doubt as to their having weakened they should be replaced. Do not intentionally reduce spring pressure in an attempt to reduce brush or commutator wear. The result will almost always be to *increase* the rate of wear.

◆ **Ambient Air Humidity.** As will be seen in the diagram, absorbed moisture is an essential component of film. Where the ambient relative humidity is very low (e.g., during winter in northern states, in non-humidified motor rooms), the result can be inadequate film formation. The solution, in such cases, is to artificially humidify the motor room, or use brushes with a grade specially designed for low humidity conditions.

◆ **Atmospheric Contaminants.** Several agents in the ambient air can cause film problems. Abrasives, like airborne grit and building site dust, can cause long-term trouble, and if this is unavoidable, intake air filtration may be required. Even the microscopic fibers given off when new carpet is installed in the building may cause the same trouble in the short term. Fumes from the exhaust stack of a building incinerator are also occasionally implicated. Special care should be taken to avoid the use of silicone-based lubricants, and *uncured* silicone caulks and sealant (sometimes called "RTV") in the vicinity of DC motors and generators. Suitable substitutes, such as butyl rubber, are available. Silicone lubricant splash, or mist, or the vapor from uncured silicone sealants, combine with atmospheric oxygen at the brush/ commutator interface to produce *silica*. Silica is better known as quartz, and is the main component of sand. This highly abrasive substance will rapidly wear away both brush and commutator.

Two critical mechanical parameters also affect the brush holder. For brush stability, the distance between the bottom of the brush box and the commutator surface should not exceed 1/8 inch, although 3/32 inch (the thickness of a nickel) is preferable. In addition, the brush holder angle, whether leading, radial or trailing, should be within 5 degrees of the manufacturer's specification, or screeching and vibration can occur, which can lead to brush fracture and loose shunts. Finally, the brush box must not be worn to the point of allowing excessive lateral brush movement, and the spring pressure, as previously noted, must be within specification.

Even when the TIR and MBTB fall within the acceptable range, general commutator roughness can be sufficient to cause premature brush wear and excessive dusting by its "grindstone" effect. As equipment ages it becomes harder to conform to these mechanical criteria, the result in many cases being short brush life, sparking and excessive dust. The solution, ideally, is a shop overhaul, or replacement, as needed; real world economics, however, especially if generator replacement by SCR drives is imminent, may dictate that the mechanic must do the best with what he has.

Flush mica is a common cause of rapid brush wear, and one easily rectified. This condition is sometimes referred to as "high mica," which is a misnomer. The mica does not grow, rather the copper alloy of the commutator bars wears down – slowly over a long period, or rapidly with the use of abrasive brushes or where atmospheric contamination is present – until the mica is exposed. Mica is considerably harder than brushes and will mill them down rapidly. Cutting back the mica is usually performed on site; the only problem that is sometimes encountered is using a slotting tool that does not completely fill the gap, leaving thin "fins" of mica next to the bars. These will continue to wear the brushes.

Electrical Causes

1. Low Current Density. Most generators are over-brushed in elevator applications. To avoid brush and shunt overheating and overload-provoked sparking, the manufacturer equips them with sufficient total brush area (width x thickness x number) to be able to handle the maximum continuous rated current output listed on the data plate. However, in actual use the true operating current of a car, properly balanced by the counterweight, even taking accelerating and braking peaks into account, is almost always well below this value – often closer to 60%.

The frequent result is a current density (amps per square inch) too low to afford the electrical energy needed to form and maintain proper film. The usual symptom is either zero or sparse film, or alternating circumferential bands of adequate, thin and no film.

The solution? First, a true current density (see sidebar below) must be obtained.

Versatile brushes, such as National's Grade SA35 and 45, can tolerate a wide range of APSI, but when it falls much below about 20, trouble can be expected.

On larger, multi-track machines (at least three brush tracks), a low APSI can often be corrected by removing an *entire circumferential track* (ring) of brushes. All the brushes in the track must be removed to avoid electrical unbalance. On the three-track example, the current density will be increased by 50%. Removing a track of brushes on one of the rare four-track generators will result in a 33% APSI increase.

On machines with only one or two brush tracks, it may be necessary to substitute brushes with a carbon grade designed for low APSI applications. Consult your brush supplier for advice.

It should be emphasized once more that removing brushes, or changing grades, should only be undertaken with the advice and technical field assistance of a major brush manufacturer.

2. Winding Faults. An open circuit, or high resistance, to a commutator riser can result in a bar being electrically dead and its neighbors carrying an overload. As the commutator can be regarded in many ways as a rotating DC switch, the breaking of the contact as the overloaded bar leaves the brush trailing edge will cause arcing. The clue is that the bar *following* the dead one, in the direction of rotation, will be burned. Often it is difficult to differentiate between this fault and the high-bar problem discussed under "mechanical causes." Resistance testing will identify the

Don't Mix Carbon Brush Grades!

Each brush grade produces a film which is chemically and electrically unique. This is one more reason why brushes must never be mixed. On the rare occasions when it is necessary to change brush grades - which should only be done on the recommendation, and under the supervision, of a major brush manufacturer - the existing film should be removed with a mild abrasive and the new brushes properly seated before use. The car should then be run limit to limit for at least 30 minutes before being placed back in service. The operating current will allow the beginning of film formation before any generator off-load situation is encountered (remember, film is dependent on current density). Car time-out periods should be checked and monitored to reduce off-load generator running to the minimum practicable.

Measuring Current Density

A clamp-on DC amp meter is placed around a main armature conductor and the empty car operated from limit to limit, observing the current during car running and averaging the "up" and "down" readings. On express cars, a small allowance should be added for the acceleration and braking peaks; on local cars, the allowance should be higher. Next, measure the effective brush area: the thickness x width of a brush in inches, multiplied by *half* the number of brushes (since the current enters through the anodic and leaves through the cathodic ones). The effective brush area is then divided by the operating current, and the result noted in amps per square inch, or APSI.

affected bar. Left uncorrected, this situation will have a cascading effect, destroying the film and causing damage to commutator and brush gear.

3. Bad Brush Holder Contact. Where the brush shunt terminal connection to the brush holder is loose or corroded, the current will take the path of least resistance, often through the brush holder spring, which will become overheated and lose its force. This may result in sparking, which is destructive to the commutator, brush and brush gear.

These are the three most common electrical faults which can cause problems with the film, although there are rarer and more exotic ones, which we do not have space to discuss here.

Natural Graphite vs. Electrographite

We discussed at the beginning of this article the discovery of the natural graphite ore, which was the basis for all early carbon brush grades. On cursory examination this material, with its slick, greasy texture, would appear to be ideal for electrical brushes. Unfortunately, like almost all naturally occurring substances (gold is one of the very few exceptions!), graphite is mixed by nature with hard minerals, principally the same abrasive silica as was mentioned earlier. It is impractical to remove these substances – collectively called "ash" as they remain after graphite is burned in the lab – on a commercial scale. Natural graphite, then, belies its slick texture by being quite abrasive on commutators. It does find a use today in certain grades where very low APSI conditions are met, and particularly on low-speed gearless motors.

It was discovered many years ago that any form of carbon – natural graphite, lampblack, petroleum coke, charcoal (even diamond!) – heated to some 3000 degrees F undergoes a crystalline change to a unique kind of graphite not found in nature. With this knowledge, brush manufacturers who produce their own grades (most don't) have been able to develop artificially graphitic grades. The process used to heat carbon to such high temperatures is usually performed in an electric furnace, hence the resulting materials are usually referred to as electrographites. These materials are often infused with chemical treatments and additives in a vacuum-pressure impregnation process to produce unique properties, which allow them to meet a wide variety of operating conditions and problems.

Characteristics of Brush Materials

Natural Graphite

These brushes, the present-day successors to the original brushes of a century ago, have largely been superseded by the electrographite kind, but still have a limited use. They are constructed from natural mineral graphite with various binders such as resins or pitch.

These brushes have certain disadvantages. Their current density operating limits are narrow, and they are able to handle only light electrical loads. As previously noted, they promote more commutator wear. They are also more brittle and less able to handle mechanical shocks.

However, in some applications they are still the preferred choice. National's grade IM9101, for example, has proved outstandingly successful in Otis equipment.

Electrographite

Not being limited to what nature provides, man-made electrographite brushes can be designed for a wide variety of conditions. Over the years, several hundred grades have been evolved by the various manufactur-

Continued

"Hard" Vs. "Soft" Brushes

When premature commutator wear is encountered, there is a natural tendency to suspect that the brushes are too hard, and substitute some containing preponderantly natural graphite, which are perceived to be "soft," and thus kinder to the commutator.

To the brush manufacturer, "hard" and "soft" are terms with no scientific basis. In actual fact, natural graphite, with its included abrasive component, will generally cause substantially more wear than an electrographite grade properly matched to the equipment and operating with an established commutator film, despite the perception that this material is harder.

TEST	CARBON GRADE	TREATMENT	EXPECTATION
1	SA3538	Filming additive	This is a versatile base material with superior filming ability. Adding a further filming treatment should give this grade superb light load capabilities.
2	SA3538	Friction reducer	Same versatile base material but with a classic friction reducer which also promotes filming in a slightly different way. Expect nice looking film and good brush life.
3	SA35	Friction reducer	Same as the above combination, but with a slightly less filming base material in case the SA3538 version causes a little *too much* film.
4	SA40	Film enhancer	Less dense carbon grade. Should give good brush life although lightly loaded geneerators might need a little help in filming, hence the treatment.

ers. Unlike natural graphite, they can be, and usually are, impregnated with different additives to modify strength, resistivity, friction, film-forming and commutation characteristics, and to meet difficult operating conditions, such as low humidity.

Generally, electrographite brushes are able to meet a wide variety of electrical loads and current densities, cause minimal commutator wear and are more resistant to mechanical abuse.

One Size Fits All?

Present-day elevator service industry realities make it difficult for service personnel to devote their increasingly hectic schedule to the classic practice of selecting from the multitude of carbon grades and applying different ones to different motors and generators. The small number of remaining manufacturers of carbon brush grades are constantly conducting research into evolving a "one-size-fits-all" grade that will offer satisfactory operating characteristics in all parameters.

To develop such a grade, research at National is following this model:

1. A new grade is made in a small trial batch and initial testing conducted on standard bench generators and motors under tightly controlled laboratory conditions. Most experimental grades are discarded at this point as they either offer no noticeable improvement over existing ones, or are actually found to be inferior.
2. A promising grade is then field tested against a standard grade in side-by-side generators, which have been checked to eliminate mechanical or electrical faults that would skew the results. Parameters, such as spring pressure and brush holder alignment, are also checked and standardized. Finally, the operating temperature and humidity of the motor room are checked to ensure that they fall within acceptable limits. After careful seating, the brush lengths are accurately measured.
3. Equipment performance and freedom from sparking or overheating, excessive brush noise or vibration, and any other signs of mechanical or electrical distress are monitored at startup and for the next few hours.
4. The condition of the commutators, film and brushes, and the brush lengths are checked at regular intervals as experience dictates. Any positive or negative observations by service personnel about equipment performance are noted. The equipment is also checked for any signs of excessive dusting. After three months, it is generally possible to predict long-term performance and brush life, and those showing inferior performance are discarded.

5. The best grades are tested in a similar fashion on a wider selection of conditions, including those with adverse characteristics such as low current densities, long generator idling periods, frequent overloads and atmospheric contamination. Tests are even conducted on equipment in less-than-ideal mechanical condition, to reflect the practical realities faced by the service company.

National will report the results of these tests in a forthcoming article. Meanwhile, any elevator service company willing and able to cooperate in onsite testing as outlined above is invited to contact National Electrical Carbon Products, Inc. at 1-800-395-7776 ext. 100.

The Demise of the Carbon Brush

Some years ago, with the advent of solid-state sources of DC supply and the evolution of variable-speed AC motors, it was predicted that the carbon brush in elevator applications would disappear into the history books in a few years. A quarter of a century later, although reduced in number, there are still around 125,000 DC traction motors, and some 54,000 generators, in operation.

As Mark Twain remarked, on seeing his obituary erroneously printed in a newspaper, "The reports of my death have been greatly exaggerated." Certainly, brush-type elevator traction equipment will be around for many years, and National Electrical Carbon Products, Inc., will be at the forefront of research into carbon brushes that offer superior economics, reduced labor costs and protection of elevator capital equipment, for the foreseeable future.

Keith Challenger is Business Development Manager at National Electrical Carbon Products in Greenville, South Carolina. He has an Electrical Engineering degree and extensive field experience with the development and application of carbon brushes in the elevator industry.

Nick O'Dell is Managing Partner of Grubstreet LLC, a technical writing company. Prior to this, he spent 15 years as a technical representative in the carbon brush industry. Born and raised in England, he currently resides in Philadelphia, Pennsylvania.

Learning-Reinforcement Questions

Use the below learning-reinforcement questions to study for the Continuing Education Assessment Exam are available online at www.elevatorbooks .com or and page 97 of this issue.

- Is lead ever used in elevator brushes?
- Why is a film or skin on a commutator surface important?
- What type of wire should be used for control and signal circuit leads?
- What is the maximum allowable bar-to-bar height differential in adjacent bars?
- Why should asbestos never be used as a base material in any brush?

ELEVATOR WORLD Continuing Education Assessment Examination Questions

Instructions:

- Read the articles **"The Perfect Drive"** (page 57) and **"Get the Lead Out!"** (page 77) and study the learning-reinforcement questions at the end of each article.
- To receive **one hour** of continuing-education credit, answer the assessment examination questions found below online at www.elevatorbooks.com or fill out the ELEVATOR WORLD Continuing Education Reporting Form found overleaf and submit by mail with payment.
- Approved for Continuing Education by **NAEC for CET® and NAESAI for QEI**.

Questions from "The Perfect Drive"

1. The duty cycle of gearless elevator drives has been found to be:
   a. 15%.
   b. 35%.
   c. 50%.
   d. 85%.

2. A planetary-gear drive for a 630-kilogram-capacity elevator will weigh:
   a. 600-680 kilograms.
   b. Less than it looks.
   c. Two times the lifting capacity of the elevator.
   d. None of the above.

3. Elevator machinery with planetary drives is suitable for application in hospital elevators because they are:
   a. Designed for large lifting capacity.
   b. Able to be repaired quickly.
   c. Engineered for a high number of motor starts.
   d. Able to be operated manually.

4. Regulators that use a clock drive of 12kHz or less generate noises that are perceived as:
   a. Far from the motor.
   b. Being only in the machine room.
   c. Unpleasant to the human ear.
   d. Over a two-way radio or cell phone.

5. Planetary-drive machines are suitable for use as self-propelled elevator cars because they are:
   a. Easy to re-rope.
   b. Provided with sound isolation.
   c. Compact and lightweight.
   d. None of the above.

Questions from "Get the Lead Out"

6. What substance was used as a base in early carbon brushes?
   a. Lead.
   b. Graphite.
   c. Coal.
   d. Arsenic.

7. Why should asbestos never be used as a base material in any brush?
   a. It is too heavy and doesn't wear well.
   b. It would expose elevator technicians to dangerous health concerns.
   c. It is an insulator and would prevent the flow of current.
   d. It is too fragile for brush base material.

8. What is the protective conducting layer of a carbon brush called?
   a. Outer strata.
   b. Conductor edge.
   c. Conductor face.
   d. Commuter surface film.

9. What is the maximum allowable bar-to-bar height differential in adjacent bars?
   a. 0.0015 inches.
   b. 0.0025 inches.
   c. 0.0005 inches.
   d. 0.0050 inches.

10. What problem may occur when a bar following a dead one is burned?
    a. Low current density.
    b. A winding fault.
    c. A bad brush-holder contact.
    d. High-current density.

ELEVATOR WORLD
Continuing Education Reporting Form

Article titles: **"The Perfect Drive"** (EW, December 2007, page 57) and **"Get the Lead Out!"**. (EW, December 2007, page 77)

Continuing-education credit: These articles will earn you **one contact hour** of elevator-industry continuing-education credit.

Directions: Select one answer for each question in the exam. Completely circle the appropriate letter. A minimum score of 80% is required to earn credit. You can also take this test online at website: www.elevatorbooks.com.

Last name: ____________________

First name: ____________________ Middle initial: ________

CET®, CAT® or QEI number: ____________________

Company name: ____________________

Address: ____________________ City: ____________________

State: ____________________ ZIP code: ____________________

Telephone: ____________________ Fax: ____________________

E-mail: ____________________

These articles, "The Perfect Drive," and "Get the Lead Out!", combined are rated for one contact hour of continuing-education credit. Certification regulations require that we verify actual study time with all program participants. Please answer the below question.

How many hours did you spend reading the article and studying the learning-reinforcement questions?

hours ____________ minutes ____________

Circle correct answer

1.	a	b	c	d	6.	a	b	c	d
2.	a	b	c	d	7.	a	b	c	d
3.	a	b	c	d	8.	a	b	c	d
4.	a	b	c	d	9.	a	b	c	d
5.	a	b	c	d	10.	a	b	c	d

Signature: ______________________________

Payment options:

Check one:
- ❏ $30.00 – Non-subscriber course fee
- ❏ $25.50 – ELEVATOR WORLD subscriber course fee

Subscriber #: ___ ___ ___ ___ ___ ___
(6 digit number on your print label or in your digital confirmation.)

- ❏ Payment enclosed (check payable to Elevator World, Inc.)

Charge to my:
- ❏ VISA
- ❏ MasterCard
- ❏ American Express

Card number: ______________________________

Expiration date: ____________

Signature: ______________________________

To receive your certificate of completion using the mail-in option: Send the completed form with questions answered and payment information included to: Elevator World, Inc., P.O. Box 6507, Mobile, AL 36660.

To receive your certificate of completion online, visit website: www.elevatorbooks.com and follow the instructions provided for online testing.