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**TESTS OF COMMUTATING BRUSHES
FOR USE IN D.C. MOTORS OPERATING IN
A DRY ARGON ATMOSPHERE**

by

**M. A. Slaweki, G. J. Bernstein,
and L. F. Coleman**

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Chemical Engineering Division

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INTRODUCTION

Operation of d.c. motors in a dry, low-oxygen atmosphere can cause rapid wear of the commutating brushes. Operation of manipulators using d.c. drives in the Argon Cell of the Fuel Cycle Facility* have presented commutation problems requiring extensive tests of brush materials. These tests were performed by operating d.c. motors, of the type used in the manipulators, in an enclosure containing a high-purity argon atmosphere. A gas-purification system was used to control the moisture and oxygen content of the enclosure atmosphere. Brushes were provided by Stackpole Carbon Company, Superior Carbon Company, and Carbon Products Division of Union Carbide, based on their brush-grade recommendations for use in dry atmospheres. The initial purpose of the tests was to find as quickly as possible the best brush grade to use since brush failures were seriously hampering operation in the Argon Cell. As testing progressed, the possibility of determining minimum impurity concentrations in argon (primarily moisture with some emphasis on oxygen) conducive to good brush wear became apparent. Tests were performed on one brush grade by varying moisture concentrations in the range from less than 5 to 100 ppm, and this report summarizes the results. Data scatter in the test results is discussed as a function of oxygen and nitrogen concentrations and as a function of other variables inherent in brush wear on a sliding surface. Specific applications of the most promising brush material tested are cited aside from the use for which the tests were originally performed.

COMMUTATION BRUSH WEAR

When the manipulators¹ were being designed for the Argon Cell of the Fuel Cycle Facility, brush wear on commutating d.c. motors operating in very dry atmospheres was recognized as a problem. The problem of rapid brush wear at high altitudes, which closely matches the dry environment of the Argon Cell, had been solved through the introduction of various

*Part of the Experimental Breeder Reactor II (EBR-II) project located at the AEC National Reactor Testing Station in Idaho.

ingredients into the brush. Both organic and inorganic ingredients had been used with a fair measure of success. Metallic halides proved successful. Among the halides, lead iodide has been preferred and applied in service on military aircraft equipment. It was found that lead-iodide-treated brushes were able to maintain a perfect film even in the most adverse conditions. It is presumed that in service the lead iodide is changed to an intermediate compound, cuprous iodide, which, being extremely unstable, is readily oxidized to cuprous oxide even in an atmosphere where the normal oxidation of copper would not take place. Thus a copper oxide film is maintained. Barium fluoride was also used in brushes to preserve this oxide film. The barium fluoride treatment was discovered during the work on heavy metal halides originally carried out by Elsey.²

In the early stages of operation in the Argon Cell of the Fuel Cycle Facility, various leak tests were made prior to its being filled with argon. Included in these tests was the filling of the cell with nitrogen and operation of the purification system to reduce the oxygen and moisture contents.

At the conclusion of the 9-week period during which the Argon Cell was filled with nitrogen, the drive motors (d.c.; 1/4 hp) for the manipulator grips were examined. An extremely high rate of brush wear was discovered. Although the total running time of these motors in the high-purity nitrogen atmosphere (as low as 5 ppm water and 8 ppm oxygen) was an hour or less, brushes were worn more than 0.218 in., which was the maximum allowable wear. These brushes (Stackpole Grade 56) are made of electrolytic graphite and are treated with barium fluoride for high-altitude use. The results of earlier brush tests^{3,4,5} in an argon atmosphere indicated that the wear rate of these brushes should have been much less than that found. The earlier tests, however, were conducted in a small-volume test chamber in which it was difficult to maintain an atmosphere of low moisture content for long periods of time. Apparently, the slow drying of the brushes in the Argon Cell during the extended period of exposure to the dry nitrogen atmosphere created the condition for rapid brush wear. A rush test program was initiated to find a suitable brush material.

Since it was evident that halide additives did not improve brush wear in low-impurity argon or nitrogen atmospheres, some form of "immediate-filming" brush material was necessary. The most suitable material found was molybdenum disulfide, which has been used as a dry lubricant for many years. Therefore, the brush materials selected for immediate testing were commercially available grades containing molybdenum disulfide, which has become established as the most generally applied material for obtaining high-altitude protection without prefilming. Other brushes without molybdenum disulfide were tested for comparison and also because they were recommended by the brush manufacturers.

Although the differences in properties, such as dielectric strength and heat-transfer characteristics, between nitrogen and argon are considerable and may affect the rate of brush wear, the primary cause of the high rate of brush wear in either atmosphere is believed to be low moisture content with some effect due to low oxygen content. If dielectric strength and heat-transfer characteristics of the atmosphere have a significant deleterious effect upon the wear rate of the brushes, operation in argon should cause greater rates of brush wear than operation in nitrogen. Also, since the cell would eventually be filled with argon, it was considered desirable to conduct the tests in an argon atmosphere.

TEST APPARATUS

Environment

The tests were performed in a gloved vacuum enclosure filled with argon gas. The gas was continually recirculated through a purification system consisting of a Molecular Sieve* dryer for removal of moisture and a palladium wire catalyst for removal of oxygen. Bypass valves in the system made it possible to control water concentration by allowing more or less gas to pass through the dryer. For faster addition of water to the gas, argon was added to the box after bubbling through a heated-water bath. Oxygen removal was controlled by the addition of hydrogen to the circulating gas stream so that the catalytic reaction of oxygen and hydrogen on palladium would produce H_2O , which could then be removed on the dryer bed. The amount of hydrogen added determined the degree of oxygen removal. Oxygen was added by injecting a measured amount into the system using a hypodermic syringe. The concentrations of water and oxygen were measured with MEECO** electrolytic moisture and oxygen analyzers. Figure 1 is a diagram of the system used for atmosphere control. The atmosphere could be changed very quickly by evacuating the chamber and associated piping, and refilling, if this was deemed necessary. Toward the end of the tests, this method had to be used for oxygen control since the palladium catalyst had lost its effectiveness, possibly because of the buildup of carbon on the palladium wire.

Brush Test Apparatus

The brushes were tested in a pair of self-excited, shunt-wound, d.c. motors, which were coupled together so that one motor drove the second one, which acted as a generator. The load on the generator was adjusted to impose a controlled load on the driving motor. The motors used

*Product of Linde Company, Division of Union Carbide Corporation.

**Manufacturers Engineering and Equipment Company, Warrington, Pennsylvania.

are rated for reversing duty and were identical to those used in the Argon Cell manipulator (1/4-hp, d.c. EEMCO* motor, Model No. C-743-C, and 1/4-hp, d.c. Master Motor,** Model No. Gr 2730) (see Figs. 2 and 3). The EEMCO motor was used in most of the tests. The power supply consisted of two full-wave rectifiers. The unfiltered output of one rectifier was a constant voltage fed to the fields of the motor and generator combination, while the output of the other rectifier was a variable voltage supply to the motor armature. Meters were used to monitor both motor and generator voltage and current. Maximum motor voltage was 100 V, approximately the maximum voltage on the motors in the manipulator. This voltage limitation was based on earlier brush tests and may not be necessary with the new brushes, but since the units and electrical equipment are sized for this voltage, tests were performed under these conditions. Reversing switches were included so that the motor could be operated in either direction.

Fig. 1. Argon Purification System

Fig. 2

1/4-hp EEMCO Motor Used
on Manipulator Grip

108-9604

*Electrical Engineering and Manufacturing Corporation, Los Angeles, California.

**Reliance Electric and Engineering Company, Cleveland, Ohio.

Fig. 3

1/4-hp Master Motor Used on Manipulator Carriage, Bridge, and Rotation Motions

108-9603

A variable resistance was used to load the generator. Figure 4 is a block diagram of the system used. The input power for the motor and the output power from the generator were brought through the enclosure wall by use of a sealed connector. Brush lengths were measured and recorded before transfer to the enclosure through a vacuum lock. Subsequent measurements were made within the enclosure after each run.

Fig. 4

Brush Test Power Supply, Block Diagram

BRUSH MATERIALS TESTED

The brush materials tested were recommended by various brush manufacturers for possible use in the dry argon atmosphere. Table I lists the composition and manufacturer of each brush tested.

TABLE I. Brush Materials

Grade	Manufacturer	Composition	Treatment
56	Stackpole Carbon Co.	Electrolytic Graphite	BaF ₂
316	Stackpole Carbon Co.	Resin-bonded Carbon-Graphite	None
505	Stackpole Carbon Co.	Carbon-Graphite	MoS ₂
660	Stackpole Carbon Co.	Resin-bonded Carbon-Graphite	MoS ₂
687	Stackpole Carbon Co.	Graphite	None
25B	Superior Carbon Co.	Electro-Graphite	C ₂ Compound
82B	Superior Carbon Co.	Graphite	None
35A	Superior Carbon Co.	Carbon-Graphite	MoS ₂
B54-27	Superior Carbon Co.	Graphite-20 to 25% Silver	Unknown
NAA	Union Carbide-Carbon Prod.	Carbon Graphite	MoS ₂

The tests were divided into three sets. The initial set consisted of tests of brush materials made in an attempt to obtain the best replacement brushes in the shortest possible time. A second set of more extensive tests was made on the best brush material found in the initial tests. The last set of tests was performed on materials received near the end of the testing program. Since the new brush material for the Argon Cell manipulator motors had already been selected at that time, the last set of tests was performed only to supply information for possible future applications.

There are now a multitude of brush materials manufactured by the companies shown or by other companies that would probably perform as well as those tested. However, because of the nature of the testing program, only those recommended by manufacturers at the time of the tests were tried.

TESTS RESULTS

Initial Tests

In the initial set of tests, Grades 316, 505, 660, 687, 25B, and 82B were used to determine which of these grades could replace the Grade 56

brush then being used in the Argon Cell. Table II shows the results of these initial tests.

TABLE II. Brush Wear Rates
during Initial Tests

Brush Grade	H ₂ O Concentration Range, ppm	Average Wear Rate, in./hr
56	9.7-11.4	0.296
316	15.6	0.0325
505	8.2-10.8	0.124
660	1.7-21	0.0184
687	2.8-20	0.0303
25B	3.0-8.1	0.550
82B	2.0-9.0	0.102

The above tests were performed by cycling the motor-generator set in the following sequence: 5 sec on in CW direction, 5 sec off, 5 sec on in CCW direction, and 5 sec off. This cycling test was chosen to approximate the performance of the grip motor on the manipulator; however, this cycling, as compared to steady operation in one direction, had no detectable effect on wear characteristics and was not used on later

tests. The moisture concentration is shown as a range of values since precise control was not undertaken. Water content could be held within 5 ppm if necessary.

During these early tests oxygen content was not measured since the instrument used in later tests was not available. It is believed, however, that oxygen content was less than 50 ppm.

The Stackpole Grade 56 brushes were tested at moisture levels between 9.7 and 11.4 ppm and oxygen levels of less than 50 ppm in order to verify that low levels of moisture and oxygen were indeed the cause of the rapid brush wear in the nitrogen atmosphere of the Argon Cell. A high rate of wear of 0.296 in./hr was found under these experimental conditions.

The lowest wear rate was obtained with a resin-bonded carbon-graphite brush containing 5% molybdenum disulfide (Stackpole Grade 660). In atmospheres containing 1.7 to 21 ppm moisture and less than 50 ppm oxygen, the highest wear rate for this grade brush was 0.0189 in./hr.

Grade 660 Brush Tests

On the basis of the results of the initial tests, the Grade 660 brush was chosen for the second set of tests in which the concentrations of oxygen and moisture (in the range of 0-100 ppm) would be varied in an attempt to determine brush wear rate at various concentrations. Figure 5 is a plot of brush wear rate versus moisture concentration for the Grade 660 brush used in an EEMCO motor. The curve seems to have a sharp break in the region somewhere between 40 and 50 ppm moisture. Above this region, brush wear rate is not significantly affected by changes in moisture concentration; below this region, there is a large change in wear rate with moisture concentration. Oxygen content was not held constant, but in all tests was less than 100 ppm and in 80% of the tests was less than 50 ppm.

Fig. 5. D.C. Motor Brush Wear in a Low-moisture-content Argon Atmosphere

Moberly and Johnson⁶ tested brushes of this type in a high-altitude environment where moisture contents of less than 1 ppm were attainable. The brush wear rate for a brush of this type was much less in their tests, but the oxygen content was very much higher since an air environment was used. The lowest oxygen content obtained in their tests was two to three orders of magnitude higher than the oxygen content in the tests reported here. Shobert⁷ points out that oxygen, which can support the oxide film on the commutator, cannot prevent dusting under very dry conditions. However, this holds true for ordinary carbon and graphite brushes, while the brushes used in these tests and in Moberly's tests were specifically treated with molybdenum disulfide to improve wear. What effect oxygen has on these brushes is not too clear in the tests performed, but it would seem that some effect is present. There is also the possibility of nitrogen affecting wear rates in some manner similar to oxygen. The amount of nitrogen in our test environment was not

known but was estimated to be less than 100 ppm, since the enclosure, in addition to being evacuated and refilled periodically, was operated at a slightly positive pressure to minimize air in-leakage. The point scatter in Fig. 5 could be due to the effects of the presence of oxygen and nitrogen.

Additional variables that could influence brush wear rate, such as motor load and speed, were kept constant during the tests made to obtain the data for Fig. 5. However, separate tests were performed to detect whether motor-load changes would affect brush wear. No detectable difference in brush wear was noted with varying motor loads from about 30 to 75% of full load. (Operating with an armature voltage of 100 V, the maximum load was 75% of nameplate full load.) Motor speed was not changed, and it is believed that motor speed will influence brush wear. The brushes on the other motors (Master Motors) in the Argon Cell manipulators showed no wear after more than 100 hr of service, a portion of which was in dry argon. The brush material (Stackpole 687) used in these motors is a low-friction graphite with no special treatment. The rated speed for the Master Motors is 1725 rpm, which is much lower than that (6000 rpm) for the EEMCO motors used in the grip drives. (Commutator peripheral speeds are about 1000 ft/min for the Master Motors and 1800 ft/min for the EEMCO motors.)

The Master Motors are provided with interpoles and are physically larger though of the same horsepower rating as the EEMCO motors. Interpoles may reduce brush wear; however, interpoles improve commutation electrically and may not be significant in reducing brush wear in low-moisture-content atmospheres in which brush wear seems to be primarily a friction phenomenon. Lower peripheral speed and larger brush-contacting surface could contribute more to the lower rate of brush wear. The Master Motor was operated in the test apparatus under manipulator-operating conditions using Grade 660 brushes. Tests were made with the interpoles both connected and disconnected, and no detectable difference in wear rate was found in either case. Moisture and oxygen contents were less than 10 ppm in both cases. It would seem therefore that operation of d.c. motors in low-impurity argon atmospheres could be improved by the use of good-quality motors containing interpoles and operating at low speeds. The additional use of molybdenum-disulfide-treated brush materials, such as the Grade 660, would further enhance brush life.

It should be stressed that the results shown are based on the use of the Grade 660 brush in an EEMCO motor. Care must be taken in substituting brushes in other types of motors so that brush resistivity, composition, hardness, etc., compare favorably with the motor manufacturer's specifications.

As a result of the tests performed, Grade 660 brushes were placed in all Argon Cell manipulator grip motors and in other motors on manipulator auxiliary attachments with excellent results to date. Cell moisture and oxygen concentrations have been held at 20-60 ppm. Only one problem has occurred as a consequence of using the molybdenum-disulfide-treated brushes. A cell manipulator grip motor was removed for inspection because of erratic performance after 30 hr of operation using Grade 660 brushes. Tests of the motor revealed a high armature resistance caused by a glazed coating on the commutator. Apparently the molybdenum disulfide (an insulator by itself) in the brushes had coated the commutator to some extent causing the glazed surface. Cleaning the commutator with fine sandpaper corrected the problem. There was no measurable wear of the brushes. It is too early to tell if this problem will occur again since only one motor has been affected. Other grip motors have operated close to 50 hr with no evidence of this condition. The 50 hr of motor running time corresponds to about $1\frac{1}{2}$ years of facility operation.

Miscellaneous Tests

Additional brush materials received toward the end of the test program were tested and merit attention here. The last three materials listed in Table I were tested with the following results: A maximum wear rate of 6 mils/hr with a moisture content of approximately 2 to 3 ppm was found for Grade 35A. The Grade NAA wear rate was 10.5 mils/hr, with approximately the same atmosphere moisture content. The Grade B5427 exhibited wear rates of between 0.5 to 5.5 mils/hr in atmospheres containing 2 to 7 ppm of moisture. This latter grade is treated with a compound that the manufacturer would not identify. However, according to the manufacturer, the compound decreases the frictional characteristics of the material.

The tests made with these last three brush grades were of a short-term nature. If it is deemed desirable to use these materials, further testing will be performed.

CONCLUSIONS AND RECOMMENDATIONS

Tests of various brush materials for use on d.c. motors in dry argon atmospheres have resulted in the selection of a brush material (Stackpole Grade 660) that is being used successfully on manipulator drive motors in the Argon Cell of the Fuel Cycle Facility. Brushes made of this material have also been installed on other d.c. motors used on processing equipment undergoing tests in argon atmospheres at Argonne National Laboratory. The same brush material has been installed in universal motors used in vacuum cleaners and hand drill units employed in argon atmospheres. This latter use has greatly increased the life of universal motors.

whose commutator peripheral speeds approach 5000 ft/min. One such vacuum-cleaner motor operating in a dry argon atmosphere ran about 15 min using the brushes provided with the unit. By this time the brushes had worn completely down and caused short-circuiting of the motor armature commutator. An identical unit has now been in heavy use for about 1 year in a dry argon atmosphere after the original brushes were replaced with Grade 660 brushes. The brushes will still wear faster than if operated in normal-humidity atmospheres, but wear occurs at a reasonable rate, which can be tolerated. Based upon limited tests, other brush grades show promise for use in low-impurity atmospheres.

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REFERENCES

1. Graae, J. E. A., et al., A Radiation Stable Heavy Duty Electromechanical Manipulator, TID-7599, 8th Conference on Hot Labs and Equipment, San Francisco (Dec. 13-15, 1960).
2. Elsey, H. M., Treatment of High Altitude Brushes by Application of Metallic Halides, AIEE Paper No. TP45-108 (June 1945), pp. 1-10 and 128, 135, and 203.
3. Lawroski, S., Rodger, W. A., Vogel, R. C., and Munnecke, V. H., Chemical Engineering Division Summary Report, April, May, June 1959, ANL-6029, p. 21.
4. Lawroski, S., Rodger, W. A., Vogel, R. C., and Munnecke, V. H., Chemical Engineering Division Summary Report, July, August, September 1959, ANL-6068, p. 25.
5. Lawroski, S., Rodger, W. A., Vogel, R. C., and Munnecke, V. H., Chemical Engineering Division Summary Report, October, November, December 1959, ANL-6101, p. 23.
6. Moberly, L. E., and Johnson, J. L., Effect of Variable High Altitude Humidity on Wear of Nondusting Brushes, Applications and Industry, AIEE Trans., No. 44:263 (Sept 1959), pp. 263-267.
7. Shobert, E. I., II, Carbon Brushes--The Physics and Chemistry of Sliding Contacts, Chemical Publishing Company, Inc., New York (1965), p. 134.