Double Insulated Drill Tests

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CONTENTS

ILLUSTRATIONS

DOUBLE INSULATED DRILL TESTS

by

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ABSTRACT

This report examines the double insulation system as an alternative to frame grounding and the hazards which could possibly occur when using the drills in a mining environment. The purpose of this examination is to determine the integrity of the double insulation system when subjected to conditions found in coal mines.

INTRODUCTION

Periodically, the question comes up concerning the use of a separate grounding conductor for the exposed, noncurrent carrying metal parts of double insulated drills. Coal and metal and nonmetal mine health and safety regulations (75.702, 77.702, 55, 56, and 57.12-25, 30 CFR) allow the Secretary or his authorized representative to permit grounding methods other than frame grounding if such methods provide no less effective protection.

In order to determine the effectiveness of double insulation systems, the Mining Enforcement and Safety Administration in Coal Mine Health and Safety Activity requested the Mine Electrical Systems Branch, Pittsburgh Technical Support Center, to evaluate the Underwriters Laboratories (UL) standards for double insulated drills as well as the adequacy of double insulation protection under the adverse conditions present in underground coal mines.

Using UL's UL45 standard for portable electric tools as a reference, a detailed set of four tests was arrived at for examining double insulated drills for mine use. These tests are more rigorous than UL's UL45 standard and require the drill to be tested under more adverse conditions. Testing guildelines for tests 1 through 4 are listed in appendixes A through D, respectively.

Two sets of tests 1 through 4 were run. The first set was run on drills direct from the factory (unconditioned drills); the second set, on drills conditioned with a water and coal dust mixture (coal-conditioned drills).

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The 3/8-inch drills tested were all Ingersoll-Rand's[3] model 8020, 115-125 volts, 1,000 rpm no load, 3 amp.

UNCONDITIONED DRILL TESTS

The following four tests were made on drills taken from factory sealed boxes. These drills had no prior conditioning. For identification purposes in this section, the drills will be referred to as drill A and drill B.

Test 1--Dielectric Withstand Test, March 2, 1976

The purpose of this test was to determine if the drill's insulation system could withstand a high voltage after the drill had reached full load operating temperature. In order to obtain the full load operating temperature, the drill was loaded to full load and its temperature monitored until it had stabilized.

Before the dielectric withstand test was run, drill A was brought up to operating temperature by being mounted in the drill test jig and loaded to full load current. The procedure, test equipment, and drill test jig are listed and shown in detail in appendix A. The actual setup is shown in figure G-1. For the location of drill parts, see appendix F.

The temperature probes were mounted as follows:

T1--Chuck end of drill on metal case.

T2--Right side of drill as viewed from commutator end in the exhaust ports of the commutator.

T3--Left side of drill as viewed from the commutator and in the exhaust ports of the commutator.

The test was started at 8:30 a.m. The following is a list of the temperature probe readings as a function of time:

Time	Temperature, ° F		
	T1	T2	T3
9:03 a.m.	81.2	83.1	78.2
9:15 a.m.	80.9	83.3	77.7
9:25 a.m.	81.1	83.9	77.8
10:12 a.m.	81.3	84.1	79.0
10:25 a.m.	82.4	84.5	78.4
10:30 a.m.	82.1	84.8	78.2

Figure G-2 shows the drill undergoing the dielectric withstand test.

[3]Reference to specific brands of equipment in this report is made to facilitate understanding and does not imply endorsement by the Mining Enforcement and Safety Administration.

The following is a list of the results of the dielectric withstand test:

	Volts
Between metal case of drill and prong 1 of male power connector	3,750
Between metal case of drill A and prong 2 of male power connector	3,750
Between metal case of drill A and foil wrapped tightly around the insulated case	3,750
Between foil wrapped tightly around the insulated case and prong 1 of male power connector	3,750
Between foil wrapped tightly around the insulated case and prong 2 of male power connector	3,750

The above readings indicate that the insulation system on the new drills is very good. At the above voltages, the insulation system did not break down. The breakdown voltage was not determined since this would have destroyed the insulation of the drills.

Test 2--Leakage Current Test, March 11, 1976

The leakage current test was performed on drill A to determine the leakage current a man could be subjected to while using this type of drill. The drill was conditioned for the test by running it with no load for approximately 200 hours. After conditioning drill A, the insulated case was tightly wrapped with metal foil to provide a means for measuring leakage current from the nonmetal handle.

The conditioning of drill A was started at 11:15 a.m., March 2, 1976. Sometime between 4:30 p.m., March 8, 1976, and 8:00 a.m., March 9, 1976, the drill stopped running. The brushes were replaced on March 9, 1976, and at 9:00 a.m., the drill was started again. One brush wore out again on March 10, 1976; this was replaced and the drill started again. On March 11, 1976, at 3:15 p.m., the drill was stopped and the leakage current test was performed. Appendix B illustrates the test and lists the test equipment used; figure G-3 shows the actual test setup. For the location of drill parts, see appendix F.

The temperature probes for the following test were located as follows:

T1--Chuck end of drill on metal case.

T2--Right side of drill as viewed from commutator end in the exhaust ports of the commutator.

T3--Left side of drill as viewed from the commutator end in the exhaust ports of the commutator.

A 0.15-microfarad capacitor and a 1,500-ohm resistor connected in parallel were used to simulate a human body. The voltage across this resistor capacitor combination should not exceed 0.6 volt to keep the current the human body would be subjected to under 0.5 milliampere.

The following is a list of the time, temperature, and voltage readings taken:

Time	Temperature, ° F			Voltage to metal case, polarity switch S_2		Voltage to foil, polarity switch S_2	
	T1	T2	T3	Position 1	Position 2	Position 1	Position 2
3:35 p.m....	82.0	82.6	82.7	0.006	0.0055	0.004	0.003
3:45 p.m....	83.2	77.9	78.3	.0059	.0054	.0037	.0025
3:55 p.m....	86.7	82.4	82.0	.0059	.0052	.0037	.0025
4:05 p.m....	89.0	84.3	83.9	.0062	.0056	.0032	.0026

It can be calculated from the above data that the maximum current a man would be subjected to while operating a typical drill is 0.0052 milliampere. This amount of current cannot be felt by a man and is a safe exposure level.

Test 3--Insulation Resistance Test, April 13, 1976

The purpose of this test is to determine the effects of storing a double insulated tool in a humid environment. The value of the insulation resistance over a time period of 10 seconds is measured for this determination. As insulation resistance is adversely affected by heat and humidity, the drill was placed in a humid environment for 6 days. This allowed the drill's insulation system to thoroughly absorb moisture. By conditioning the drill in this manner, insulation resistance values are obtained which represent a drill which has been stored in a humid environment. Drill A was used in this test since it had been run for an extended period of time which allowed heat, the other factor that deteriorates insulation, to have its effect.

On April 7, 1976, drill A was placed in a humidity chamber at 95 percent humidity and a temperature of 70° F (fig. G-9). On April 13, 1976, the drill was then given the insulation resistance test. A 1,000-volt megohmmeter was used to measure the resistance of the drill's insulation system (fig. G-4). A detailed list of the equipment used is contained in appendix C.

The following is a list of the results of the insulation resistance test:

	Results
Insulation resistance:	
Between metal foil wrapped tightly around insulated case and metal case.	Infinity.
Between metal foil wrapped tightly around insulated case and prong 1 of power cord.	Infinity.
Between metal foil wrapped tightly around insulated case and prong 2 of power cord.	Infinity.

As can be seen from the above test results, the drill's insulation system integrity was not adversely affected by heat and humidity.

Test 4--Overload Test, March 3, 1976

After extended usage and constant overloading of a drill, the motor will eventually fail. The failure of the motor, especially under overload conditions, usually results in smoking, heating, and burning of the drill. The purpose of this test is to determine the dielectric strength of the drill's insulation system after an overload failure of the drill has occurred. In this test, a drill was constantly overloaded until it burst into flame and was no longer able to operate electrically.

A new factory boxed drill, drill B, was placed in the drill loading test jig as shown in figure G-1. The drill was loaded in the following manner at the times indicated.

Time	Drill loading
8:05 a.m........	Started running, no load.
8:20 a.m........	Full load, 3 amps.
8:35 a.m........	Loaded drill to 3.25 amps.
9:05 a.m........	Loaded drill to 3.6 amps.
9:35 a.m........	Loaded drill to 3.9 amps.
9:40 a.m........	Drill B burned out and burst into flame.

After drill B had time to cool, a dielectric withstand test was performed as shown in figure G-2. A detailed list of the equipment used for the test is given in appendix D. The following is a list of the results of the dielectric withstand test:

	Volts
From the metal case to each prong of the male power connector..	1,000
From metal foil wrapped tightly around the insulated case and each prong of the male connector..................	1,000
From metal foil wrapped tightly around the cord strain relief and each prong of the male power connector...........	1,000
From metal foil wrapped tightly around the insulated case and the metal case..................................	1,000

Drill B was next disassembled as shown in figure G-5. The field coil and armature were then given a dielectric withstand test. The test results are given below:

	Volts
Dielectric strength from each coil lead and the frame of the coil...	1,000
Dielectric strength between the commutator and the shaft.....	3,500

The above results indicate that the drill's insulation system has good dielectric properties even though the drill was overloaded until it burst into flame.

COAL-CONDITIONED DRILL TESTS

The following four tests were conducted on drills that were subjected to conditions as might be found in the coal mines. A mixture of 650 milliliters -200 mesh coal dust and 2-1/2 gallons of water was prepared. Two new factory boxed drills were placed in the solution and allowed to soak for 3 hours. This is illustrated in figure G-14. The drills were then allowed to air-dry at room temperature for 48 hours. These drills are referred to in the following four tests as coal-conditioned drills C and D.

Test 1--Dielectric Withstand Test, March 11, 1976

The purpose of this test was to determine the dielectric properties of drill C, which had been subjected to an adverse environment. The coal-conditioned drill was loaded to full load and its temperature monitored until it had stabilized.

The drill was mounted in the drill test jig and loaded to full load at rated current. The procedure, test equipment, and drill test jig are listed and illustrated in appendix A. The actual setup is shown in figure G-6. For the location of drill parts, see appendix F.

The temperature probes were placed on the drill at the following locations:

T1--Right side of drill as viewed from the commutator and between the insulated case and the metal case.

T2--Left side of drill as viewed from the commutator and between the insulated case and the metal case.

T3--Left side of drill as viewed from the commutator and in the commutator exhaust ports.

The test was started at 1:15 p.m. at a constant load of 3 amps. The following is a list of the temperature probe readings as a function of time:

Time	Temperature, ° F		
	T1	T2	T3
1:25 p.m.	125.4	87.6	87.5
1:35 p.m.	122.5	99.8	86.3
1:45 p.m.	119.4	99.1	82.7
1:55 p.m.	123.3	100.7	87.1
2:05 p.m.	121.0	100.0	83.4

Figure G-7 shows the drill undergoing the dielectric withstand test.

The following is a list of the results of the dielectric withstand test:

	Volts
Between metal case of drill and prong 1 of male power connector	3,750
Between metal case of drill and prong 2 of male power connector	3,750
Between metal case of drill and foil wrapped tightly around insulated case	3,750
Between foil wrapped tightly around the insulated case and prong 1 of male power connector	3,750
Between foil wrapped tightly around the insulated case and prong 2 of male power connector	3,750

As the above readings indicate, the insulation system on drill C, which had been subjected to water and coal dust, has good dielectric properties. The above voltages are not breakdown voltages but are the voltages which the insulation system of the drill withstood.

Test 2--Leakage Current Test, April 2, 1976

The purpose of this test was to determine the current a man could be subjected to when using a drill which had been conditioned with coal dust and water. Insulation systems are adversely affected by heat, dirt, and humidity. Drill C, which was previously conditioned with water and coal dust, was then run at no load for approximately 500 hours. By conditioning the drill in this manner, it gave these three factors time to deteriorate the insulation systems. The insulated case of the drill was then tightly wrapped with metal foil to provide a means for measuring leakage current to the insulated case.

Drill C, which was used in the dielectric withstand test, began approximately 500 hours of run time on March 11, 1976, at 2:30 p.m. Between 6:00 p.m., March 16, 1976, and 8:00 a.m., March 17, 1976, the drill stopped running. The brushes were replaced and the drill started. The drill stopped again sometime between 4:00 p.m., March 23, 1976, and 4:00 p.m., March 24, 1976. The brushes were again replaced and the drill restarted. On April 2, 1976, at 12:45 p.m., the drill was stopped and the leakage current test was performed. Appendix B illustrates the test and lists the test equipment used; figure G-8 shows the actual test setup. For the location of drill parts, see appendix F.

The temperature probes for the leakage current test were located as follows:

T1--Chuck end of drill on metal case.

T2--Right side of drill as viewed from the commutator end in the commutator exhaust ports.

T3--Left side of drill as viewed from the commutator end in the commutator exhaust ports.

A 0.15-microfarad capacitor and a 1,500-ohm resistor connected in parallel were used to simulate a human body. The voltage across this resistor capacitor combination should not exceed 0.6 volt to keep the current the human body would be subjected to under 0.5 milliampere.

Listed below are the time, temperature, and voltage readings taken:

Time	Temperature, ° F			Voltage to metal case, polarity switch S_2		Voltage to foil, polarity switch S_2	
	T1	T2	T3	Position 1	Position 2	Position 1	Position 2
1:00 p.m...	106.9	78.9	79.2	0.004	0.0044	0.0026	0.0038
1:10 p.m...	107.0	78.7	83.1	.0042	.0044	.0027	.0039
1:20 p.m...	106.3	77.9	78.9	.004	.0043	.0027	.004
1:30 p.m...	105.8	78.0	77.8	.0038	.0044	.0027	.004
1:40 p.m...	106.0	77.7	77.1	.0038	.0042	.0027	.004
1:50 p.m...	105.4	76.9	76.8	.0042	.0044	.0028	.004
2:00 p.m...	104.8	76.4	76.4	.0042	.0045	.0027	.004

It can be calculated from the above data that the maximum current a man would be subjected to while operating a typical drill is 0.00375 milliampere. This amount of current cannot be felt by a man and is considered a safe exposure level.

Test 3--Insulation Resistance Test, April 13, 1976

The purpose of this test is to determine the insulation resistance over a period of 10 seconds. Since the drill was conditioned with coal dust and water, and ran for approximately 500 hours, the value of insulation resistance determined by this test should represent a drill which had been used for a long period of time. Prior to the insulation resistance test, the drill was placed in a humid environment for 6 days. This allowed the insulation system of the drill to absorb moisture.

On April 7, 1976, drill C, which had run at no load for more than 500 hours and was used in the leakage current test, was placed in a humidity chamber at 95 percent humidity and a temperature of 70° F (fig. G-9). The drill was then given the insulation resistance test. A 1,000-volt megohmmeter was used to measure the resistance of the drill's insulation system (fig. G-4). A detailed list of the equipment used is contained in appendix C.

The following is a list of the results of the insulation resistance test:

	Results
Insulation resistance:	
Between metal foil wrapped tightly around insulated case and metal case.	Infinity.
Between metal foil wrapped tightly around insulated case and prong 1 of power cord.	Infinity.
Between metal foil wrapped tightly around insulated case and prong 2 of power cord.	Infinity.

As can be seen from the above test results, the drill's insulation system was not adversely affected by coal dust, heat, and humidity.

Test 4--Overload Test, March 15, 1976

After extended usage and constant overloading of the drill, the motor will eventually fail. The failure of the motor, especially under overload conditions, usually results in smoking, heating, and burning of the drill. Since the drill used in this test had been conditioned with coal dust and water, the overloading and burnout of the drill in the test should also result in some tracking on the insulation system of the drill. The purpose of this test was to determine the dielectric strength of the drill's insulation system after an overload failure of the drill had occurred. The drill was constantly overloaded until it burst into flame and was no longer able to operate electrically.

Another coal-conditioned drill, drill D, was placed in the drill test jig and the overload test performed (figs. G-10--G-12). Drill D was loaded in the following manner at the times indicated.

Time	Drill loading
9:24 a.m.	Started running, no load.
9:50 a.m.	Full load, 3 amps.
10:05 a.m.	Loaded drill to 3.3 amps.
10:35 a.m.	Loaded drill to 3.6 amps.
11:05 a.m.	Loaded drill to 3.9 amps.
11:13 a.m.	Drill D burned out and burst into flame.

After the drill had cooled, a dielectric withstand test was performed on the drill as shown in figure G-13. For a detailed list of the equipment used in this test, see appendix D. Listed below are the results of the dielectric withstand test:

	Volts
From the metal case to each prong of the male power connector	1,500
From metal foil wrapped tightly around the insulated case and each prong of the male power connector	1,500
From metal foil wrapped tightly around the insulated case and the metal case	1,500
From metal foil wrapped tightly around the cord strain relief and each prong of the male power connector	1,500

Drill D was disassembled as shown in figure G-15. The field coil and armature were then given a dielectric withstand test. The test results are given below:

Dielectric strength from coil lead one and the frame of the coil broke down at 600 volts;

Dielectric strength from coil lead two and the frame of the coil broke down at 800 volts; and

Dielectric strength between the commutator and the shaft was taken to 3,000 volts, and showed no breakdown.

The above results indicate that the drill's insulation system has good dielectric properties even though the drill was overloaded and burst into flame. The insulation of the coil leads and frame of the coil did break down at 600 and 800 volts. For the same test on the unconditioned drill, the leads did not break down and the voltage was taken to 1,000 volts. The breakdown of the insulation at 600 and 800 volts is still acceptable since the maximum voltage the drill's insulation system will have on it will be approximately 200 volts.

CONDITIONED WET DRILL TESTS

The two leakage current tests explained in this section were made on two separate drills that were conditioned with coal dust and water and tested wet, simulating very severe conditions that are present in the mines. The two drills are referred to as (1) drill E, a new drill that was taken from a factory sealed box, and (2) drill C, a coal-conditioned drill previously used in tests 1, 2, and 3 (see section on Coal Conditioned Drill Tests). After soaking in the coal dust/water mixture for a period of time, the two wet drills were taken out of the solution and each given the leakage current test.

Leakage Current Test--New, Wet Drill, April 26, 1976

The purpose of this test was to determine the leakage current a man would be subjected to when using a wet, coal-conditioned drill. Testing a drill in this manner simulates the effects of a man dropping a dirty drill into water, then drying the outside of it off and using it again. Drill E was placed in a solution of 650 milliliters of -200 mesh coal dust and 2-1/2 gallons of water at 8:00 a.m., April 26, 1976. The drill was taken from the solution 7 hours later at 3:00 p.m.

After allowing the water to run out of the drill, the outside of the drill was wiped with a rag. The insulated case of drill E was then tightly wrapped with metal foil. Appendix B illustrates the leakage current test and lists the test equipment used; figure G-16 shows the actual test setup. For the location of drill parts, refer to appendix F.

The temperature probes for this test were located as follows:

T1--Chuck end of drill between metal case and insulated case.

T2--Right side of drill as viewed from the commutator end in the exhaust ports of the commutator.

Readings were taken across a 0.15-microfarad capacitor in parallel with a 1,500-ohm resistor. The voltage across the resistor capacitor combination should not exceed 0.6 volt to keep the current the human body would be subjected to under 0.5 milliampere. A current above 0.5 milliampere is considered to be unsafe.

Listed below are the time, temperature, and voltage readings taken:

Time	Temperature, ° F		Voltage to metal case, polarity switch S_2		Voltage to foil, polarity switch S_2	
	T1	T2	Position 1	Position 2	Position 1	Position 2
3:20 p.m.	75.4	88.4	0.22	0.18	0.032	0.063
3:30 p.m.	76.1	89.0	.205	.185	.033	.060
3:40 p.m.	76.0	89.1	.18	.17	.055	.048
3:50 p.m.	76.1	89.8	.51	.05	.033	.04
4:00 p.m.	75.6	87.9	.15	.13	.028	.038

It can be calculated from the above data that the current a man would be subjected to when holding the metal case of the drill after it was pulled out of the water and coal dust solution is approximately 0.43 milliampere. This is considered to be a safe amount of current and would not hurt the drill operator.

Leakage Current Test--Coal-Conditioned Wet Drill, April 3, 1976

The purpose of this test is to determine the leakage current available from a drill which had been used for a long period of time and subjected to coal dust and water. Testing the wet drill simulates the condition where a man drops a drill into water then dries the outside and uses it.

On April 3, 1976, drill C was placed in a solution of 650 milliliters of -200 mesh coal dust and 2-1/2 gallons of water at 8:30 a.m. After 6-1/2 hours of soaking, the drill was taken from the solution. The water was allowed to run out of the drill and the outside was wiped with a rag. The insulated case of the drill was tightly wrapped with metal foil. For a further illustration of this test and the equipment used, see appendix B.

Temperature probes were placed on drill C at the following locations:

T1--Chuck end of drill between the metal case and the insulated case on the left side of the drill as viewed from the commutator end.

T2--Chuck end of drill between the metal case and the insulated case on the right side of the drill as viewed from the commutator end.

Voltage readings were taken across a 0.15-microfarad capacitor in parallel with a 1,500-ohm resistor. The voltage across this resistor capacitor combination should not exceed 0.6 volt to keep the current the human body would be subjected to under 0.5 milliampere. A current above 0.5 milliampere is considered to be unsafe.

Listed below are the time, temperature, and voltage readings taken:

Time	Temperature, ° F		Voltage to metal case, polarity switch S_2		Voltage to foil, polarity switch S_2	
	T1	T2	Position 1	Position 2	Position 1	Position 2
3:30 p.m........	88.2	82.1	1.5	0.45	8.8	2.2
3:40 p.m........	112.1	93.8	.68	.78	.0053	.0045
3:50 p.m........	109.0	97.9	.06	.055	.0047	.0035
4:00 p.m........	105.2	98.5	.055	.05	.0045	.0034
4:10 p.m........	104.5	98.9	.04	.045	.0045	.0033
4:20 p.m........	107.5	96.8	.04	.04	.0045	.0033

It can be calculated from the above data that the current a man would be subjected to when holding the insulated case after the drill is first pulled out of the water is approximately 75 milliamperes. This is in the range of currents that could be fatal to the drill operator.

CONCLUSIONS

As can be seen from the tests which were conducted on the drills, the double insulation system held up under very adverse testing. Of the leakage current tests made on the different drills, the coal-conditioned wet drill test of drill C on page 11 was the only failure. This failure was expected as the drill was dripping wet when it was energized. The hazardous leakage current levels of this test decreased to a safe level after 10 minutes of running time.

The tests proved double insulation protection to be very effective in providing electrical shock protection for hand-held tools. The protection performed very well even under adverse wet conditions. However, as with the standard frame grounded handtool, the double insulated handtool should not be used while wet or in situations where a man is in contact with wet surfaces.

We recommend the double insulated system be accepted under Sections 75.702 and 77.702 and in nonmetallic mines under Sections 55, 56, and 57.12-25, when it has been listed by Underwriters Laboratories. On those few occasions when double insulated or standard handtools must be used in wet areas, it is highly recommended that the tool be kept dry and a ground fault interrupter be used with it.

APPENDIX A.--DIELECTRIC WITHSTAND TEST

Conditions Prior To Testing

The drill was loaded by a 3-hp, dc motor until the current input of the drill equaled the rated current input of the tool (fig. A-1). The drill was continuously operated under full load until the temperature of the drill became constant. At this time the following test was conducted.

Test

The tool shall withstand for 1 minute, without breakdown, the application of a dc potential, as illustrated in figure A-2, in accordance with the following:

1. Between accessible dead metal parts and live parts: 3,500 volts plus twice the rated voltage of the tool.

2. Between foil wrapped tightly around insulated enclosure and live metal parts: 3,500 volts plus twice the rated voltage of the tool.

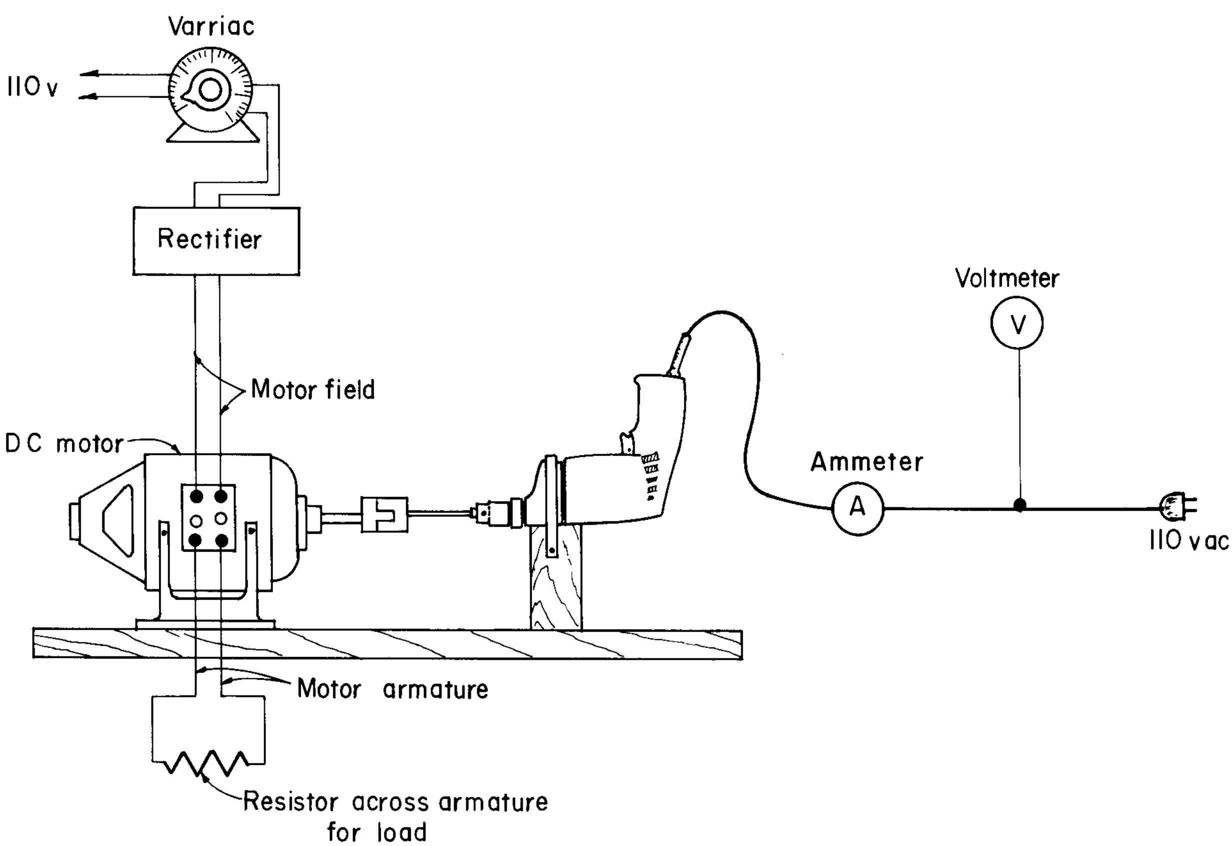

FIGURE A-1. - Drill loading test.

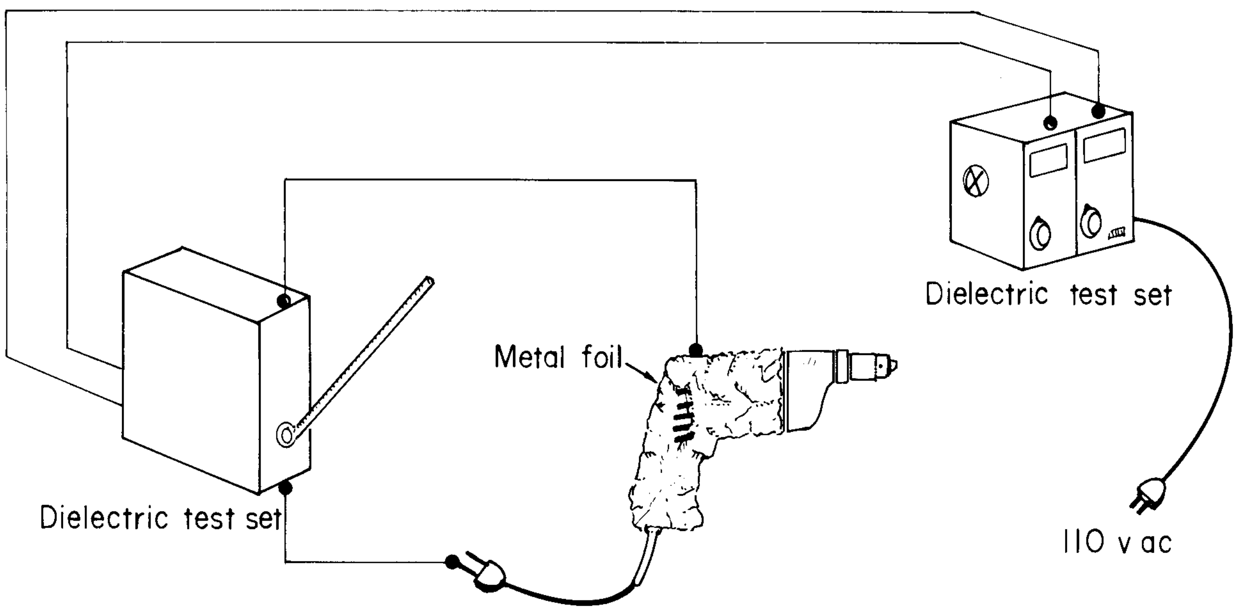

FIGURE A-2. - Dielectric withstand test.

3. Between accessible dead metal parts and metal coil wrapped around the power supply cord, the inlet bushings cord guards, strain relief clamps, and the like: 3,500 volts plus twice the rated voltage of the tool.

Equipment Used

Motor--Westinghouse, dc marine motor; 2 hp; compound wound; 115 volts; 15.7 amps; 1.750 rpm; frame F225; style 4B7968.

Rectifier--15 amps; 0-350 volts dc.

Resistor--Ohmite; 270225P-46, No. D900C; 1 ohm; 225 watts.

Varriac--Power stat; type 3PN136B; 120 input volts; 0-140 output volts; amps, 22 kva (3.1).

Voltmeter--RCA, powerline monitor WU-120B; ac; rms voltage.

Ammeter--Weston Model 433; No. 178076; 0-1 amp; 0-5 amps; 0-10 amps; 25-500 cycles.

Temperature meters--Tektronix TM 503; DM501; digital multimeter.

Dielectric tester--Biddle; stabilized dielectric test set; Biddle Catalog No. 222-060, James G. Biddle Co.

APPENDIX B.--LEAKAGE CURRENT TEST

Conditions Prior To Testing

Prior to measurement of the leakage current, the tool is to be operated at no load, but with normal airflow through the tool, for 100 or more hours, or until the brushes wear out if the latter condition occurs in less than 100 or more than 25 hours of operation. If the brushes wear out in less than 25 hours of operation, they are to be replaced and operation is to be continued until the tool has operated for a total of 25 hours.

Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between dead metal parts of a tool and ground or other dead metal parts of a tool. All dead metal parts are to be tested for leakage currents. The leakage currents from these parts are to be measured to the grounded supply conductor individually as well as collectively and from one part to another.

The leakage current is to be measured using a metal foil wrapped tightly around the nonmetal part of the tool. The metal foil is not to remain in place long enough to affect the temperature of the tool.

The measurement circuit for leakage current is to be as shown in figure B-1. Unless the meter is being used to measure leakage from one part of

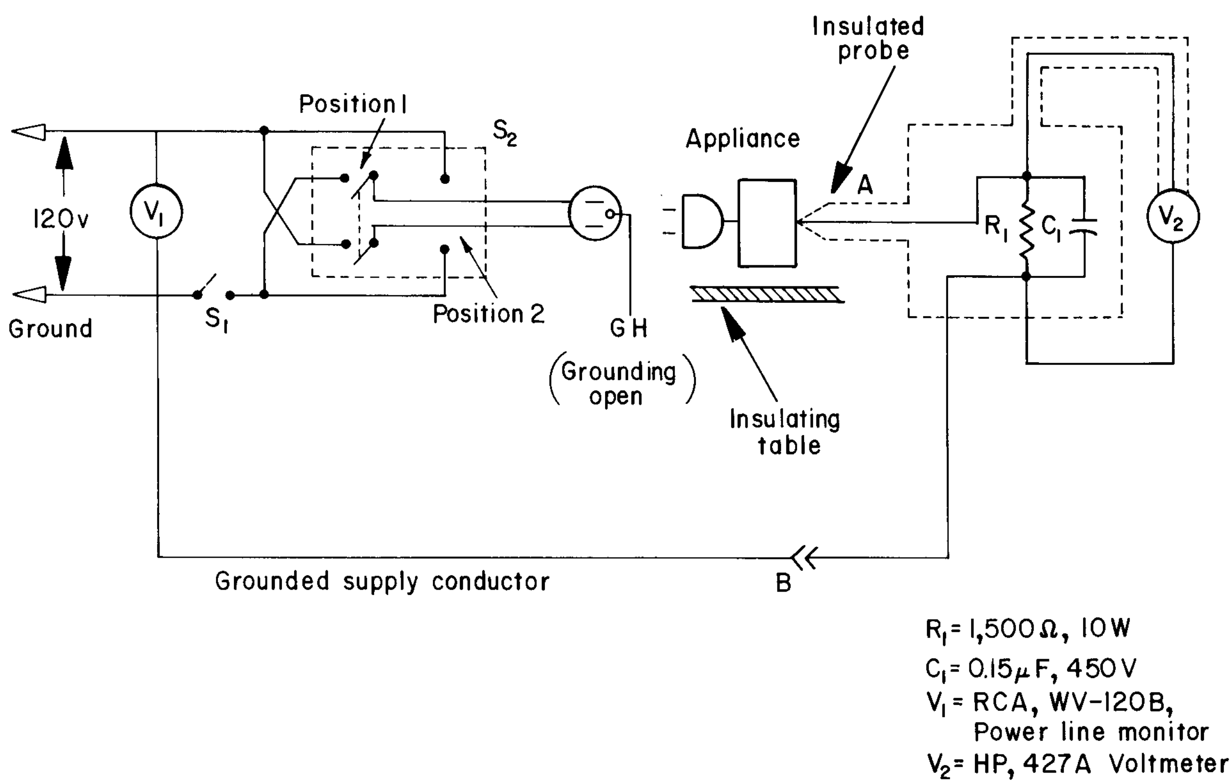

FIGURE B-1. - Schematic of leakage current test.

a tool to another, the meter is to be connected between the dead metal parts and the ground supply conductor (fig. B-2).

Test

A sample of a tool is to be tested for leakage current after the conditioning described previously. The supply voltage is to be adjusted to 120 volts. The test sequence, with reference to the measurement circuit (fig. B-1), is to be as follows:

1. With switch S1 open, the tool is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the tool switching devices in all of their normal operating positions.

2. Switch S1 is then closed energizing the tool, and with a period of 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the tool switching devices in all their normal operating positions.

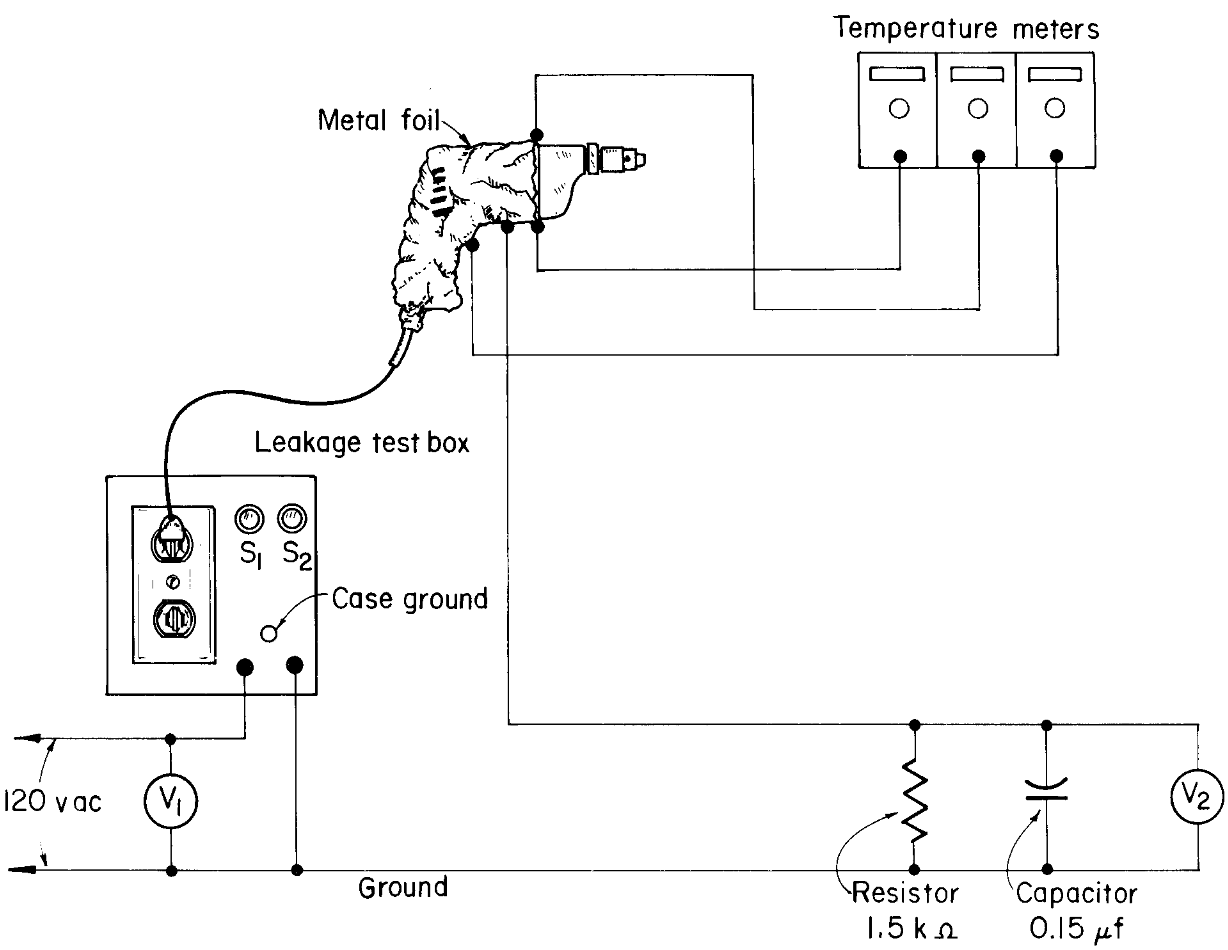

FIGURE B-2. - Leakage current test.

3. The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is considered to be obtained, when the temperature of the drill becomes constant.

An individual measurement is to be made of the leakage current to each dead metal part that is insulated from other dead metal parts. Leakage current, as measured in this test, includes current resulting from any distributed capacitance as well as current through leakage resistance.

The leakage currents of a tool when tested shall not be more than 0.5 milliampere.

Equipment Used

Voltmeters--(1) Simpson 260, volt ohm milliammeter, series 6P.
(2) Hewlett-Packard 427A voltmeter, rms voltmeter.

Temperature meters--Tektronix, TM503; DM501; digital multimeter.

APPENDIX C.--INSULATION RESISTANCE TEST

Conditions Prior To Testing

The insulation resistance test is to be conducted on the sample that was used for the current leakage test unless it is necessary to modify the sample or introduce extraneous conditions in measuring the currents to inaccessible parts. If a different sample must be used, it is to be conditioned in the same manner as for the current leakage test. In preparation for the test, the tool is to be kept in an enclosure for 48 hours or more at room temperature and at a relative humidity of 90 to 95 percent. The measurements of insulation resistance are to be made immediately after the tool has been removed from the conditioning chamber (fig. C-1).

Test

For a tool, the outer enclosure of which consists wholly or partly of insulating material, the term dead metal parts signifies metal foil tightly wrapped around the exterior of the enclosure.

In the determinations of insulating resistance, a dc potential of 1,000 volts is to be employed, and the value of the insulation resistance is to be determined 10 seconds after the application of the test potential. An

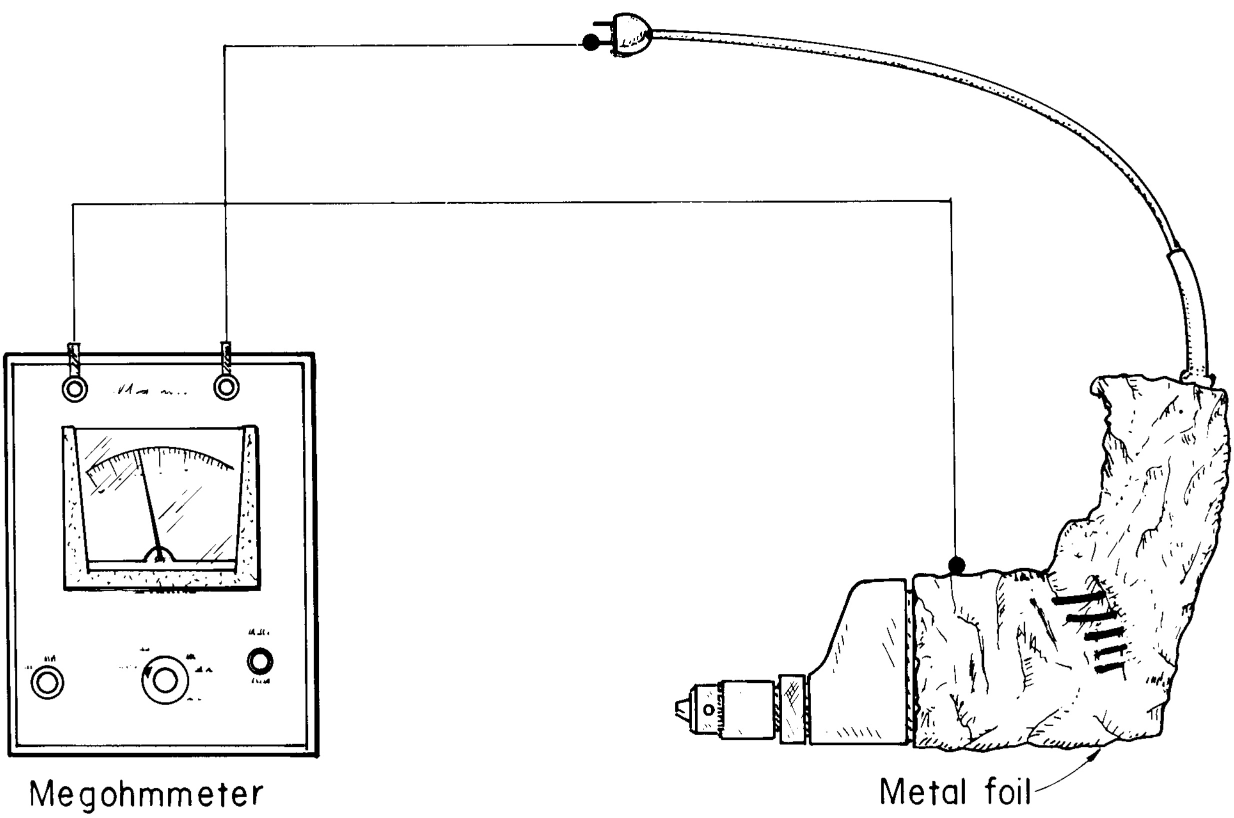

FIGURE C-1. - Insulation resistance test.

appropriate megohmmeter may be used for conducting the insulation resistance test, or other suitable means may be employed. The tool is not to be running during this test. Between live parts and dead metal parts the insulation resistance shall be at least 2 megohms.

Equipment Used

Megohmmeter--Associated Research Model 2204; Serial No. 1773; megohms at 1,000 volts dc.

APPENDIX D.--OVERLOAD TEST

Conditions Prior To Testing

If the tool can be subjected to a running overload, each of three samples of the complete tool is to be subjected to operation at no load for 15 minutes, immediately followed by operation at full load (rated load for a general use tool) for 15 minutes. Directly following this, the load is to be increased in steps of 10 percent of the rated current for each of four successive 30-minute periods, followed by two 15-minute periods, followed by nine 10-minute periods, then followed by additional periods of 5 minutes each, as necessary, to produce breakdown of the functional insulation. (See fig. D-1.)

Breakdown of the functional insulation is considered to have occurred when (1) flame appears, (2) the winding burns open, or (3) the tool stalls under no load condition.

During the running overload operation, any protective device provided with the tool is to be short-circuited, and the branch circuit protection is to be of high enough capacity to withstand the test currents without opening

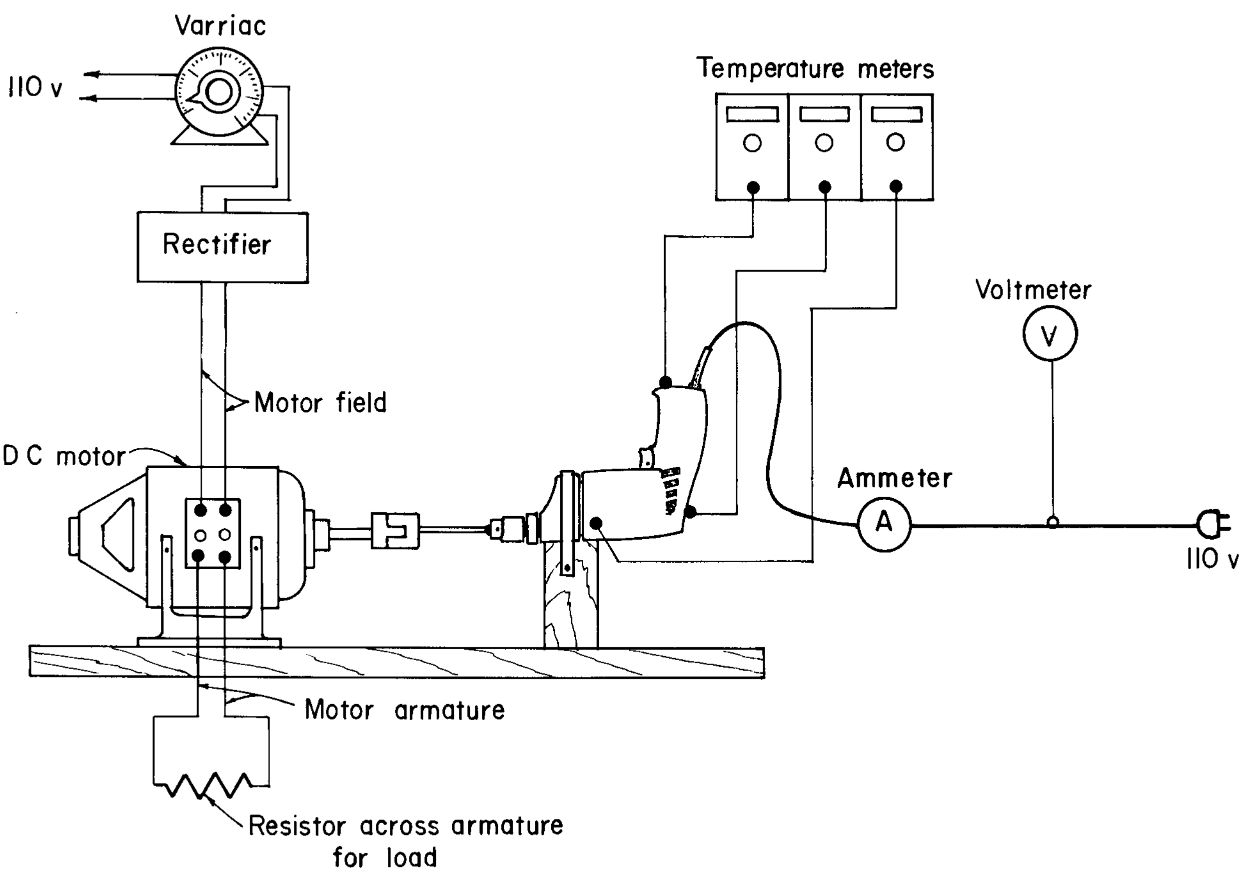

FIGURE D-1. - Drill overload test.

the circuit. The objective of the test is to determine the ingenuity of the tool insulation and not the effectiveness of a protective device.

Operation of the tool under conditions of extreme overload shall not affect the insulation to the extent that live parts are exposed. The tool must also withstand for 1 minute the application between live parts and dead metal parts (or the foil), a dc potential of 1,000 volts plus twice the rated voltage without breakdown.

Equipment Used

Motor--Westinghouse, dc marine motor; 2 hp; compound wound; 115 volts; 15.7 amps; 1,750 rpm; frame F225; style 4B7968.

Rectifier--15 amps; 0-350 volts dc.

Resistor--Ohmite; 270225P-46, No. D900C; 1 ohm; 225 watts.

Varriac--Power stat; type 3PN136B; 120 input volts; 0-140 out volts; amps, 22 kva (3.1).

Voltmeter--RCA, powerline monitor WU-120B; ac; rms voltage.

Ammeter--Weston Model 433; No. 178076; 0-1 amp; 0-5 amps; 0-10 amps; 25-500 cycles.

APPENDIX E.--INSULATION SYSTEM USED IN MODEL 8020 INGERSOLL-RAND DRILL

Functional Insulation

A. Armature

1. Magnet wire.................. Film insulation on wire is Nytherm[1]--a dual coating of modified polyester and nylon overcoat.

2. Slot liner.................... Slot liner is 0.007-inch rag paper with 0.002-inch mylar surface.

3. Slot wedge.................... Slot wedge is Armite Peerless insulation.

4. End lamination................ End lamination is vulcanized fiber.

5. Commutator bars to slot....... The bars are molded into an MM2020 molding compound. Over the surface spacing is over 1/2 inch. (5/16 inch is considered safe by UL--this is "reinforced" insulation.) Distance from bars to shaft through compound is 0.080 inch.

6. Varnish...................... Varnish sealer is a solventless polyester, Sterling Y0543, developed for high-speed tool armatures.

B. Field

1. Magnet wire.................. Same as armature.

2. Liners....................... Epoxy coating 3M No. 270, 0.006-inch min. on corners.

3. End insulation................ Epoxy coating 3M No. 270, 0.006-inch min. on corners.

Protective Insulation

A. Armature

1. Laminations to shaft.......... Aluminum oxide coating on shaft 0.040 inch thick. (UL specifies 0.020 inch thick.)

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[1]Reference to specific brand names is made to facilitate understanding and does not imply endorsement by the Mining Enforcement and Safety Administration.

2. Commutator.................... Commutator is "reinforced" insulation, covered by IA5.

B. Field

1. Outer sleeve.................. None required.

APPENDIX F.--DIAGRAM OF DOUBLE INSULATED DRILL

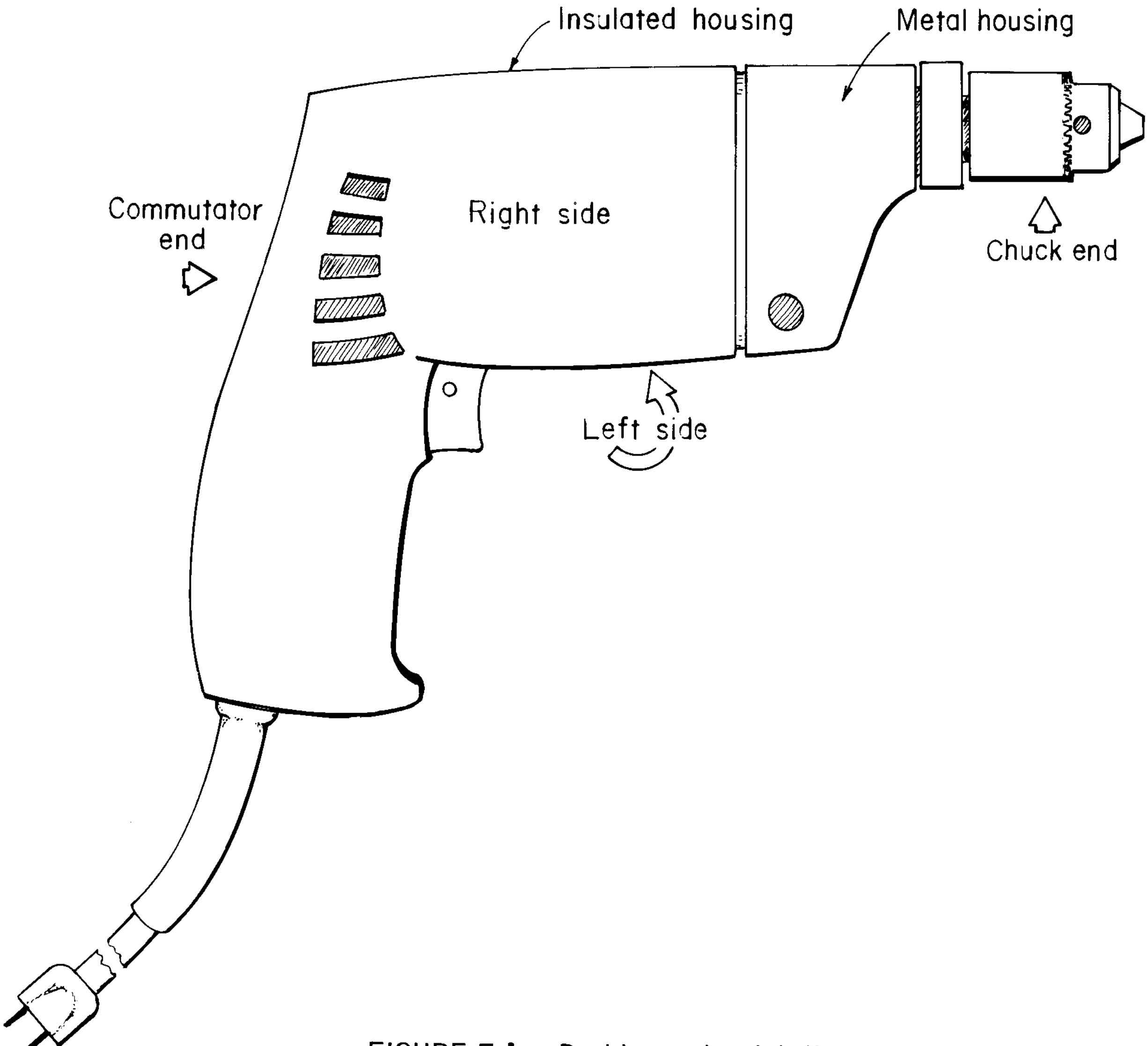

FIGURE F-1. - Double insulated drill parts.

APPENDIX G.--ILLUSTRATIONS

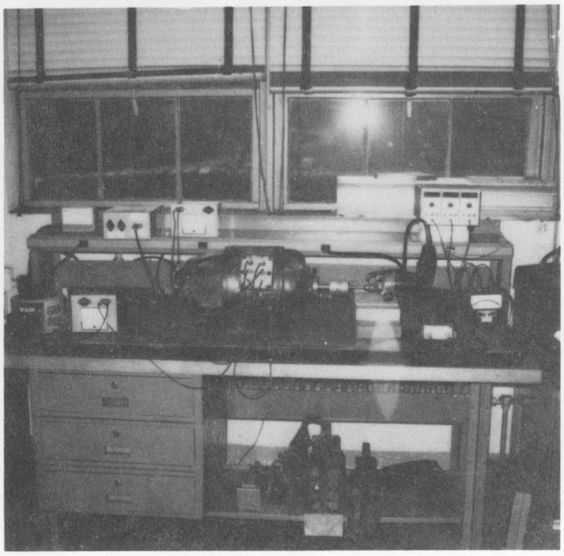

FIGURE G-1. - Drill loading test jig, 3-2-76.

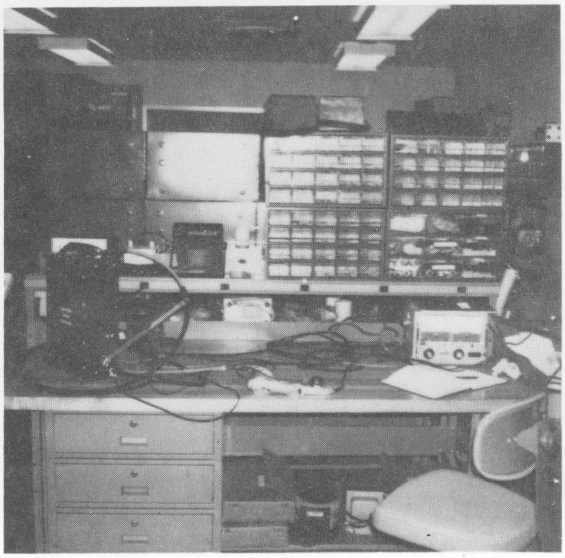

FIGURE G-2. - Dielectric withstand test, 3-2-76.

FIGURE G-3. - Leakage current test, 3-11-76.

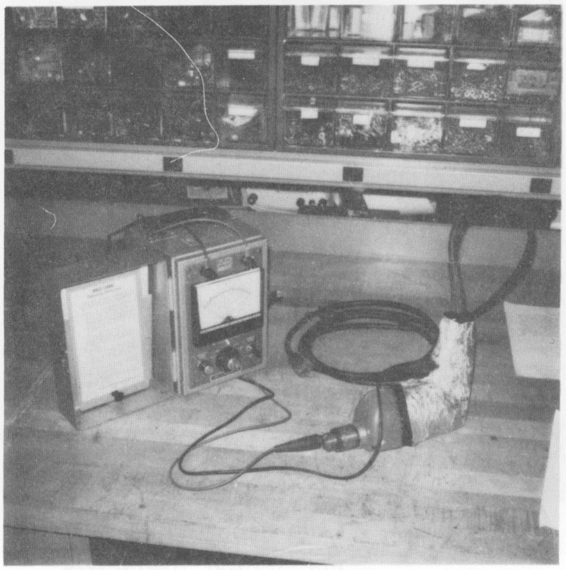

FIGURE G-4. - Insulation resistance test, 4-13-76.

FIGURE G-5. - Overloaded disassembled drill, 3-3-76.

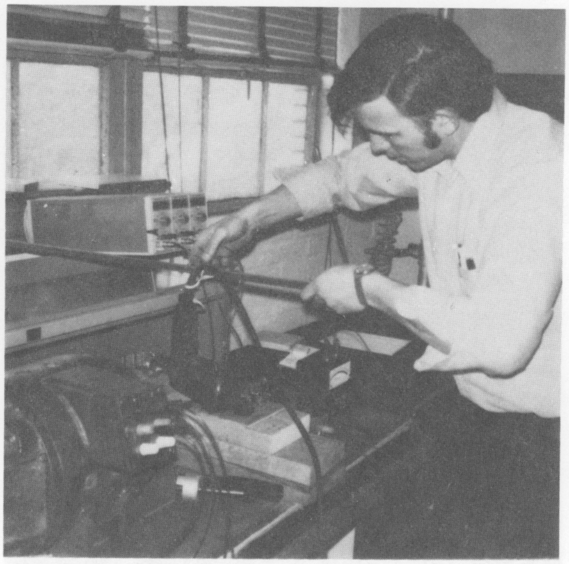

FIGURE G-6. - Loading of coal-conditioned drill, 3-11-76.

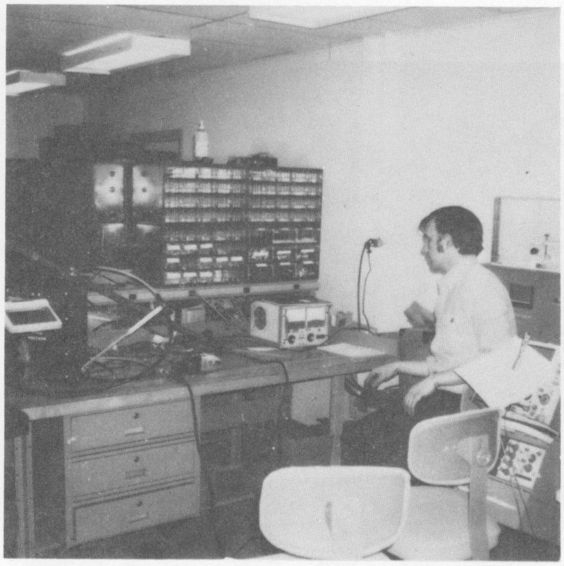

FIGURE G-7. - Coal-conditioned drill undergoing dielectric withstand, 3-11-76.

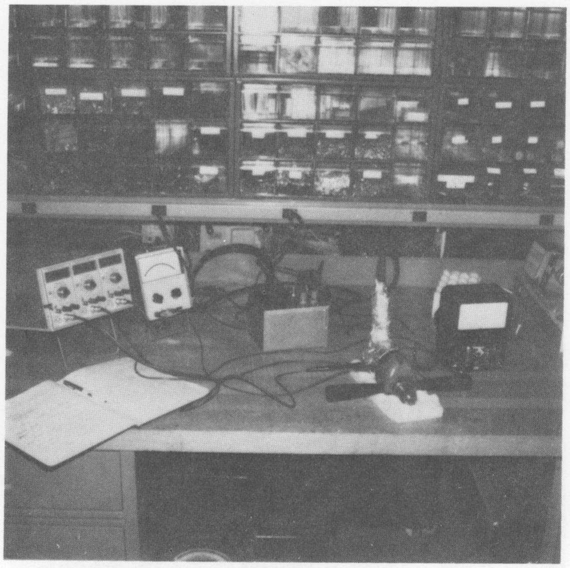

FIGURE G-8. - Leakage test on coal-conditioned drill, 4-2-76.

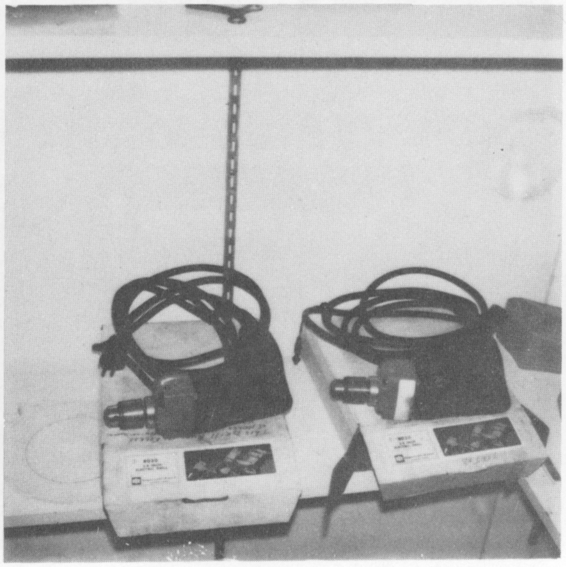

FIGURE G-9. - Drill in environmental chamber, 4-13-76.

FIGURE G-10. - Beginning of overload test on coal-conditioned drill, 3-15-76.

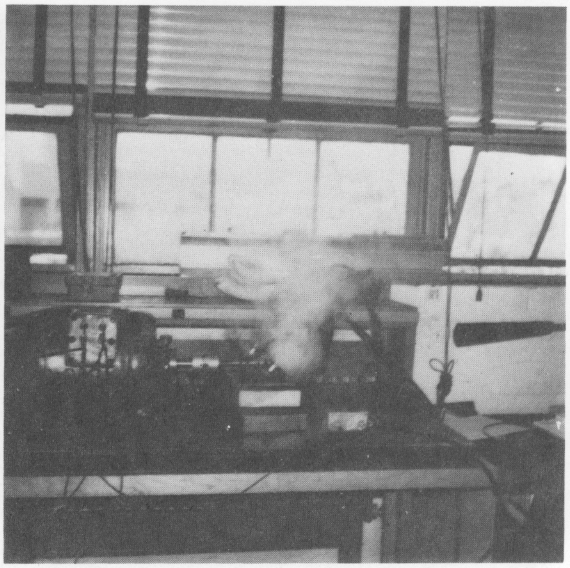

FIGURE G-11. - Drill smoking when loaded to 3.6 amps, 3-15-76.

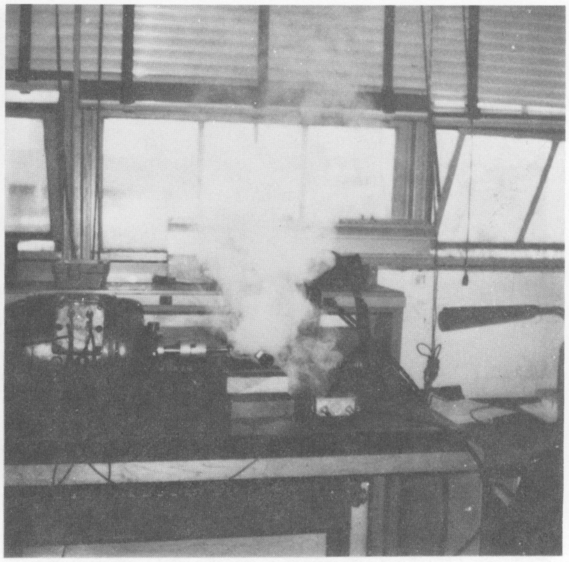

FIGURE G-12. - Drill burning out when loaded to 3.9 amps, 3-15-76.

FIGURE G-13. - Dielectric withstand test on coal-conditioned drill, 3-15-76.

FIGURE G-14. - Drill soaked in coal dust and water, 3-11-76.

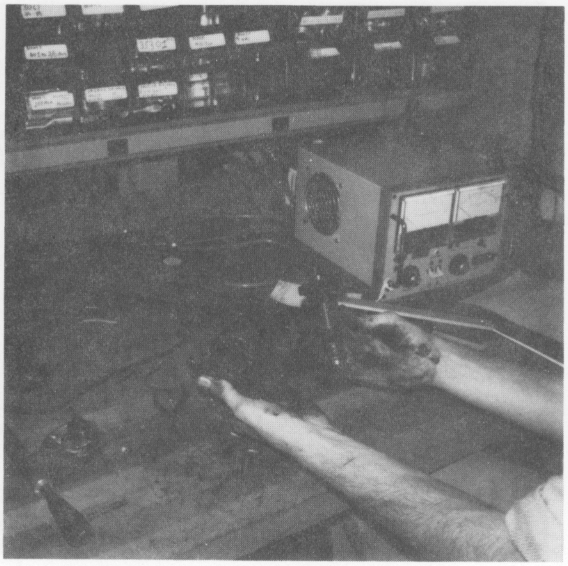

FIGURE G-15. - Disassembled, overloaded coal-conditioned drill, 3-15-76.

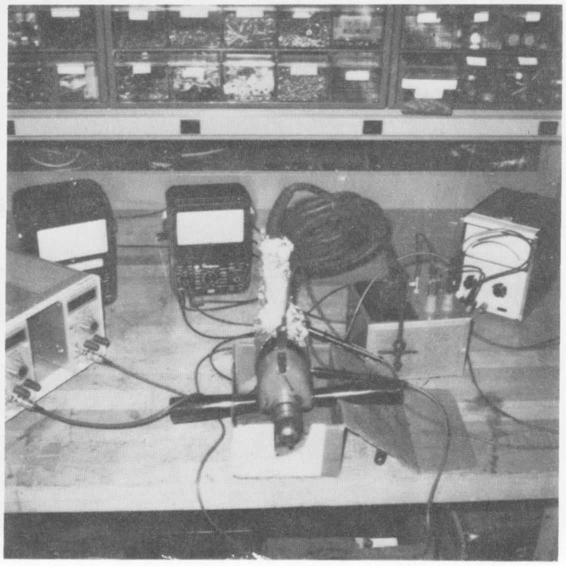

FIGURE G-16. - Leakage test of wet drill, 4-26-76.

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