Standard Test Method for Determining Current Carrying Capacity of a Conductor as Part of a Membrane Switch Circuit[1]

This standard is issued under the fixed designation F 1681; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the current carrying capacity of a conductor as part of a membrane switch.

1.2 This test method may be used to test a circuit to destruction, that is, to determine its maximum current carrying capacity, or it may be used to test the ability of a circuit to withstand a desired current level.

1.3 This test method applies only to static conditions, and does not apply to contact closure cycling of a membrane switch under current load (test method forthcoming).

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

F 1680 Test Method for Determining the Circuit Resistance of a Membrane Switch

3. Terminology

3.1 *Definitions:*

3.1.1 *conductor resistance*—the measured electrical resistance through a circuit loop between two test points.

3.1.2 *Discussion*—When a switch is included in that loop, it shall be ′′closed" in accordance with Test Method F 1680.

3.1.3 *current carrying capacity (CCC)*—the maximum level of electrical current that a circuit can conduct without sustaining damage.

3.1.4 *membrane switch*—a momentary switching device in which at least one contact is on, or made of, a flexible substrate.

3.1.5 *power capacity*—electrical power is defined as current × voltage = V × I (watts).

3.1.6 *test points*—two preselected conductive points in a circuit loop, possibly including a switch.

4. Significance and Use

4.1 Current carrying capacity is used by designers and manufacturers of electronic interface circuitry to ensure that the membrane switch can reliably handle the loads occurring in normal use and under extreme circumstances. A thorough understanding of CCC allows manufacturers to take it into account when developing design rules for membrane switches.

4.2 Failures due to exceeding the CCC of a circuit may take the form of a significant change in conductor resistance, insulation breakdown (shorts), or conductor breakdown (opens).

4.3 Since a number of design parameters, such as trace width, ink film thickness, etc. affect the final test results, any conclusions should only be applied to specific designs, rather than to a general combination of materials.

4.4 Current carrying capacity tests may be destructive and units that have been tested should be considered unreliable for future use.

4.5 Current carrying capacity may be significantly different for static loads and dynamic (that is, cycling) loads. Failure modes are also generally different.

5. Interferences

5.1 The following parameters may affect the results of this test:

5.1.1 Temperature,

5.1.2 Relative humidity, and

5.1.3 Barometric pressure.

6. Apparatus

6.1 *Suitable Device*, providing a controlled voltage, capable of supplying sufficient current for the range in question.

6.2 *Suitable Meter(s)*, capable of measuring current and resistance (with range appropriate to the test). Do not apply a voltage greater than the intended operating range of the circuit under test.

6.3 *Discreet Resistors*, sufficient to provide at least 2 times the current range desired for the test (at the preselected voltage level) if the power supply current cannot be limited and measured directly. At the specified test voltage, the smallest

[1] This test method is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.18 on Membrane Switches.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

resistor should correspond to twice the maximum current level to be tested, or the anticipated failure range (if testing to destruction).

NOTE 1—A standardized selection of resistors may be used. To determine resistor values, see examples in Section 10.

NOTE 2—The resistors must be of sufficient wattage to handle the anticipated current/power loads.

6.4 *Suitable Device*, to apply a predetermined, repeatable force in accordance with Test Method F 1680 to close the switch (if a switch is part of the conductor circuit being tested).

7. Procedure

7.1 *Pre-Test Setup*:

DISCREET RESISTOR METHOD

7.1.1 Measure and record the initial circuit resistance R_i of the circuit to be tested (if the circuit includes a switch, in accordance with Test Method F 1680).

7.1.2 Based on the initial resistance R_i, the known resistors values R_x, and the desired test voltage level, calculate and record in advance, the predicted current levels I_x for each test resistance R_x (see Section 8, Calculations).

7.1.3 Connect the circuit and ammeter in series to the power supply, allowing two leads for attaching the discreet resistors R_x(see Fig. 1).

7.1.4 If the circuit includes a switch, close it in the same manner used to measure the initial resistance (see 7.1.3).

7.1.5 Set the power supply voltage to the desired level.

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7.1.6 Measure and record the initial circuit resistance R_i of the circuit to be tested (if the circuit includes a switch, in accordance with Test Method F 1680).

7.1.7 Connect the circuit to the power.

7.1.7.1 If the circuit includes a switch, close it in the same manner used to measure the initial resistance.

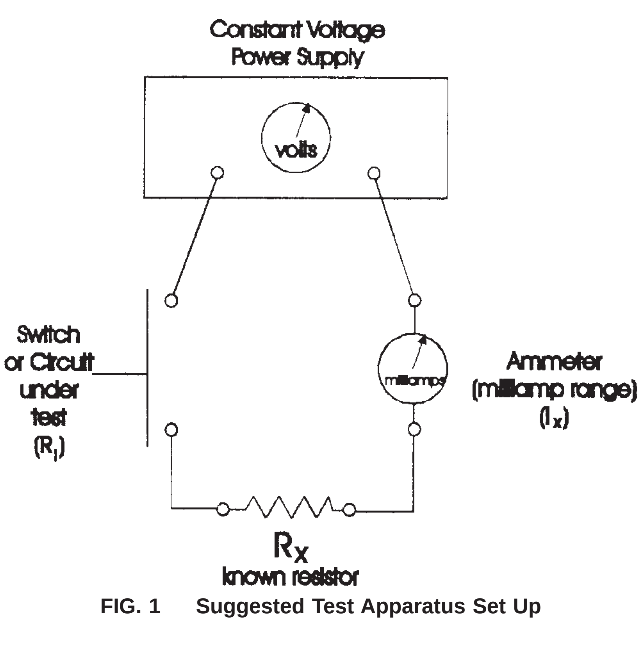

FIG. 1 Suggested Test Apparatus Set Up

7.1.7.2 Set the power supply voltage to the desired level, and the current to the initial test level.

7.2 *In Process Test*:

DISCREET RESISTOR METHOD

7.2.1 Starting with largest resistor value (corresponding to the lowest current level), insert the known resistor R_x into the circuit.

7.2.2 Turn on the power supply.

7.2.3 Measure and record the actual current I_{xa} through the circuit.

7.2.4 After either a predetermined time has passed, or when the current has stabilized, turn off the power supply.

7.2.5 Record the length of time T_x for which power was applied.

7.2.6 Compare the actual current level I_{xa} to the predicted I_x. If the two levels are significantly different, disconnect the circuit, measure and record its resistance. Significant changes in resistance or observable degradation, such as burning or discoloration of conductors, insulators or substrates are all forms of degradation occurring in the circuit, and therefore indicate that the CCC has been reached or exceeded.

7.2.7 Repeat 7.2.1 to 7.2.6 with the next lower value resistor R_x, until either degradation is noted, or the desired current test range has been completed.

7.2.8 If the test is intended to go to destruction, and no degradation occurs at the maximum current/minimum resistor level (that is, $R_x = 0$), the test may be repeated using a higher voltage level to achieve higher current levels.

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7.2.9 Starting with the lowest current level, turn on the power supply.

7.2.10 Measure and record the actual current I_{xa} through the circuit.

7.2.11 After either a predetermined time has passed, and when the current has stabilized, turn off the power supply.

7.2.12 Record the length of time T_x for which power was applied.

7.2.13 Measure and record the circuit conductor resistance. Significant changes in resistance or observable degradation, such as burning or discoloration of conductors, insulators or substrates are all forms of degradation occurring in the circuit, and therefore indicate that the CCC (that is, maximum) has been reached or exceeded.

7.2.14 Repeat 7.2.9 to 7.2.14 with the next higher current value, until either degradation is noted, or the desired current test range has been completed.

7.2.15 If the test is intended to go to destruction, and no degradation occurs at the maximum level, the test may be repeated using a higher voltage level to achieve higher power levels.

8. Calculations

8.1 To achieve desired test current values I_x, use test resistor values as follows:

$$R_x = (V / I_x) - R_i$$

.

8.2 Or, using available resistors $R_x$will result in test current values as follows:

$$I_x = V / (R_x + R_i)$$

.

8.3 Calculate power capacity (in watts) from CCC and test voltage V as follows:

$$P = CCC \times V$$

.

9. Report

9.1 Report the following information:

9.1.1 Description and specifications of all apparatus,

9.1.2 Date of test,

9.1.3 Person performing test,

9.1.4 Temperature,

9.1.5 Relative humidity,

9.1.6 Barometric pressure,

9.1.7 Test voltage (dc, ac, ac-r/min, etc.),

9.1.8 Test type (destructive or specified range),

9.1.9 Part number, revision level and description of part under test,

9.1.10 Description of test points and connection,

9.1.11 Description of device and method used to close switch (if applicable),

9.1.12 Initial circuit resistance R_i,

9.1.13 For each test cycle at a different current level, report the following:

9.1.13.1 Test resistor value R_x (if using discreet resistor method),

9.1.13.2 Predicted current value I_x (if using discreet resistor method),

9.1.13.3 Actual current value I_{xa},

9.1.13.4 Duration of time T_x for which power was applied, and

9.1.13.5 Description of any visual or resistance changes observed.

9.1.14 At the conclusion of the test, report either the CCC (that is, the maximum) or whether the circuit passed or failed at the desired voltage and current level.

10. Examples

10.1 *To Calculate the Resistances* R_x *Needed To Achieve Desired Current Values* I_x:

10.1.1 For a test voltage of 20 volts, and desired current test range of 100 mA, and an initial switch resistance R_i = 30 Ω.

10.1.2 To get test current values I_x = 50, 100, and 250 milliamps, use test resistor values R_x as follows:

$$R_1 = V / I_1 - R_i \ldots = 20/0.050 - 30 = 370\ \Omega$$

$$R_2 = V / I_2 - R_i \ldots = 20/0.100 - 30 = 170\ \Omega$$

$$R_3 = V / I_3 - R_i \ldots = 20/0.250 - 30 = 50\ \Omega$$

10.2 *To Calculate the Current Values* I_x *Corresponding to Available Resistor Values* $R_{x:}$:

10.2.1 For a test voltage of 20 volts, and desired current test range of 100 mA, and an initial switch resistance R_i = 30 Ω ...

10.2.2 Using available resistor values R_x = 350, 150, 75 Ω, and R_{min} = 0 Ω, will result in test current values I_x as follows:

I_1	=	$V/(R_1 + R_i)$	=	20/(350 + 30)	=	0.053 A =53 mA
I_2	=	$V/(R_2 + R_i)$	=	20/(150 + 30)	=	111 mA
I_3	=	$V/(R_3 + R_i)$	=	20/(75 + 30)	=	190 mA
I_{max}	=	$V/(R_{min} + R_i)$	=	20/(0 + 30)	=	667 mA

NOTE 3—R_{min} = 0 Ω corresponds to the highest possible test current, I_{max}, at that voltage level.

11. Precision and Bias

11.1 The precision and bias of this test method are under investigation.

12. Keywords

12.1 circuit resistance; current carrying capacity; membrane switch; power capacity