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LAW ENFORCEMENT STANDARDS PROGRAM

MAGNETIC SWITCHES FOR BURGLAR ALARM SYSTEMS

U.S. DEPARTMENT OF JUSTICE
Law Enforcement Assistance Administration
National Institute of Law Enforcement and Criminal Justice

LAW ENFORCEMENT STANDARDS PROGRAM

NILECJ STANDARD FOR

MAGNETIC SWITCHES FOR BURGLAR ALARM SYSTEMS

A Voluntary National Standard Promulgated by the National Institute of Law Enforcement and Criminal Justice

MARCH 1974

U.S. DEPARTMENT OF JUSTICE

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NILECJ Standard
for
Magnetic Switches for Burglar Alarm Systems

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FOREWORD

Following a Congressional mandate [1] to develop new and improved techniques, systems, and equipment to strengthen law enforcement and criminal justice, the National Institute of Law Enforcement and Criminal Justice (NILECJ) has established the Law Enforcement Standards Laboratory (LESL) at the National Bureau of Standards. LESL's function is to conduct research that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

In response to priorities established by NILECJ, LESL is (1) subjecting existing equipment to laboratory testing and evaluation and (2) conducting research leading to the development of several series of documents, including national voluntary equipment standards, user guidelines, state-of-the-art surveys and other reports.

This document, NILECJ–STD–0301.00, *Magnetic Switches for Burglar Alarm Systems,* is a law enforcement equipment standard developed by LESL and approved and issued by NILECJ. Additional standards as well as other documents will be issued under the LESL program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, investigative aids, vehicles, and clothing.

This equipment standard is a technical document, consisting of performance and other requirements together with a description of test methods. Equipment which can meet these requirements is of superior quality and is suited to the needs of law enforcement agencies. Purchasing agents can use the test methods described in this standard to determine firsthand whether a particular equipment item meets the requirements of the standard, or they may have the tests conducted on their behalf by a qualified testing laboratory. Law enforcement personnel may also reference this standard in purchase documents and require that any equipment offered for purchase meet its requirements and that this compliance be either quaranteed by the vendor or attested to by an independent testing laboratory.

The necessarily technical nature of this NILECJ standard, and its special focus as a procurement aid, make it of limited use to those who seek general guidance concerning magnetic switches for burglar alarms. The NILECJ Guideline Series is designed to fill that need. We plan to issue guidelines to this as well as other law enforcement equipment as soon as possible, within the constraints of available funding and the overall NILECJ program.

The guideline documents to be issued are highly readable and tutorial in nature in contrast to the standards, which are highly technical, and intended for laboratory use by technical personnel. The guidelines will provide, in non-technical language, information for Purchasing Agents and other interested persons concerning the capabilities of equipment currently available. They may then select equipment appropriate to the performance required by that agency. Recommendations for the development of particular guidelines should be sent to us. A list of the documents already completed under the Law Enforcement Standards Program will be found on the inside back cover of this document.

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[1] Section 402(b) of the Omnibus Crime Control and Safe Streets Act of 1968, as amended.

NILECJ Standards are subjected to continuing review. Technical comments and recommended revisions are invited from all interested parties. Suggestions should be addressed to the Program Manager for Standards, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, D.C. 20530.

Gerald M. Caplan, *Director,*
National Institute of Law Enforcement and Criminal Justice

NILECJ STANDARD
for
MAGNETIC SWITCHES FOR BURGLAR ALARM SYSTEMS

1. PURPOSE AND SCOPE

This standard establishes performance criteria for magnetically-actuated electrical switches intended for use in protective intrusion alarm circuits to monitor the position of doors, windows, etc. These devices cause the initiation of an signal to a police panel, central station, or local audible alarm device. Included are requirements and test methods for performance, electrical properties and materials. The performance characteristics addressed are those that affect the reliability of the device with emphasis on those characteristics which affect its false alarm susceptibility. This standard does not provide performance criteria for the ability of these devices to resist attempts to defeat them through physical or surreptitious attack.

2. CLASSIFICATION

Switches covered by this standard are classified into four types based on their intended operating environment and tamper resistance features. Switches with one or both of the following tamper resistance features are classified as types III or IV: a tamper switch, or a fixed resistor for electrical balancing. When submitting switches for testing, the manufacturer shall specify the switch type.

2.1 Type I

Switches intended for indoor use only, and having neither of the specified tamper resistance features.

2.2 Type II

Switches intended for outdoor use, and having neither of the specific tamper resistance features.

2.3 Type III

Switches intended for indoor use only, and having one or both of the specified tamper resistance features.

2.4 Type IV

Switches intended for outdoor use, and having one or both of the specified tamper resistance features.

3. DEFINITIONS

3.1 Alarm State of Switch

The switch state which causes the control box in the secure mode to signal an alarm (compare with secure state of switch).

3.2 Deactuation Distance

The distance between the magnet's normal position and the magnet's position at which the switch first changes to its alarm state. The second position is determined by moving the magnet away from the switch.

3.3 Electrically-Balanced Switch Circuit

A switch circuit that will go to the alarm state on sensing an increase or decrease in the current through the circuit. This change in current may result from a change in the resistance of the switch or connecting wiring or the addition of an external voltage source to the circuit.

3.4 Magnetically-Balanced Switch

A magnetic switch that will go to the alarm state on sensing a magnetic field larger or smaller than that which maintains the switch in its secure state.

3.5 Normal Position of Magnet

The magnet's position when mounted symmetrically opposite the switch on a flush door or window and with the separation recommended by the manufacturer.

3.6 Parallel and Perpendicular Motion

Movement of the switch along a path parallel to an imaginary line passing through the poles of the magnet is called parallel motion and movement of the switch along a path perpendicular to this line is called perpendicular motion.

3.7 Secure Mode of Alarm System

Alarm system operation mode during which opening of the protected port causes an alarm.

3.8 Secure State of Switch

The switch state which does not cause the control box in the secure mode to signal an alarm (compare with alarm state of switch).

3.9 Simple Magnetic Switch

A magnetic switch which is not magnetically balanced.

3.10 Switch Terminals

The points at which a switch is connected to the switch circuit. If a switch has integral cables, the switch terminals are the wires at the end of the cable away from the switch.

3.11 Tamper Switch

A switch which monitors the position of the switch assembly cover. It signals an alarm if the cover is removed.

4. REQUIREMENTS

4.1 Acceptance Criteria

The switch meets the requirements of this standard if none of the switch specimens fail any of the required tests or only one switch fails one test and the spare switch (see par. 5.3) is substituted in the test sequence and passes the failed test and all remaining tests.

4.2 Common Requirements

All switches shall meet the requirements of this section.

4.2.1 Switch Specifications

The following information items shall be among those supplied to the user by the manufacturer or distributor.

(a) Switch current range—both upper and lower limits

(b) Switch voltage range—both upper and lower limits

(c) Allowable switch/magnet motions—parallel, perpendicular, or both

(d) Minimum mounting distance from magnetic material for surface mounted switch or whether or not a recess mounted switch will operate correctly in steel doors

(e) Switch mounting location—on floor or not on floor

(f) Nominal closed resistance if greater than 0.5 ohms

(g) Nominal open resistance if less than 100 kilohms

(h) Nominal resistance of other states, if any

(i) Switch-to-magnet mounting separation—either a range or nominal separation

(j) Classification (see sec. 2)

(k) Tamper resistance features for types III and IV

(l) Type of material for all components necessary to show compliance with paragraph 4.2.2

4.2.2 Material and Configuration

The material, parts, and components of the product shall conform to the requirements of Underwriters' Laboratories, Inc. (UL) UL 634-second edition, Connectors and Switches for Use with Burglar Alarm Systems, sections 3 through 12 [1].

4.2.3 Deactuation Distance

Surface mounted switches shall meet the deactuation distance requirements while mounted on both nonmagnetic material (par. 4.2.3.1) and magnetic material (par. 4.2.3.2). Recess mounted switches shall meet these requirements while mounted in both nonmagnetic and magnetic material (pars. 4.2.3.1 and 4.2.3.2) unless the switch instructions specify it cannot be mounted in steel doors, in which case only the nonmagnetic requirements apply.

4.2.3.1 Nonmagnetic Materials

The switch-to-magnet deactuation distance of each switch specimen when measured in accordance with paragraph 5.5.2 shall be within the limits given in table 1. The switch and magnet shall meet these requirements for both perpendicular motion, as can result when mounted on a door and parallel motion, as can result when mounted on a window (see par. 5.5.2), unless the switch's installation instructions specify only one type of motion is allowed, in which case only those requirements apply (see par. 4.2.1).

TABLE 1.—*Deactuation distance limits*

Switch type	Deactuation distance			
	Minimum		Maximum	
	centimeters	(inch)	centimeters	(inch)
Simple	2.0	(0.79)	5.0	(1.97)
Magnetically-balanced	1.3	(0.51)	5.0	(1.97)

4.2.3.2 Magnetic Material

While mounted on a test steel door or window, the switch-to-magnet deactuation distance of each switch specimen measured in accordance with paragraph 5.5.2 shall be within the limits given in table 1. The switch and magnet shall meet those requirements for both perpendicular and parallel motion, unless the switch's installation instructions specify only one type of motion is allowed, in which case only those requirements apply (see par. 4.2.1).

4.2.4 Endurance

4.2.4.1 Normal Current

Each switch specimen tested for endurance at normal current in accordance with paragraph 5.5.3.1 shall complete a minimum of 100,000 operations with no failures. The test currents (or current) used are dependent upon the manufacturer's specified current range (par. 4.2.1). The switch specimens shall be tested at each "current region" (first column of table 2) which overlaps the manufacturer's specified current range. If the manufacturer specifies only one current as opposed to a range of currents, then that current shall be used. The open circuit voltage shall be 6 volts dc, unless the manufacturer specifies a single voltage or a voltage range not including 6 volts, in which case the single voltage or the minimum voltage specified shall be used. The failure criteria listed in table 2 are dependent upon the initial open and closed resistances (R_{io} and R_{ic}) of the switch measured at the switch terminals prior to the test.

4.2.4.2 High Current

Each switch specimen tested for endurance at high current in accordance with paragraph 5.5.3.2 shall complete a minimum of 50 operations with no failures. The current or power used depends on the initial closed resistance of the switch. Table 3 gives the test conditions. The failure criteria to be used are listed in the first row in table 2 for currents greater than 10 milliamperes.

TABLE 2.—*Endurance test contact requirements*

Switch current Rating region	Test current	Failure criteria—resistance or voltage limits			
		Closed ($R_{ic} \leq 0.45\ \Omega$)	Closed ($R_{ic} > 0.45\ \Omega$)	Open ($R_{io} < 110\ K\Omega$)	Open ($R_{io} \geq 110\ K\Omega$)
Upper limit > 10 mA............	Upper limit	$> 0.5\ \Omega$	$> 1.1 \times R_{ic}$ or $< 0.9 \times R_{ic}$	$> 1.1 \times R_{io}$ or $< 0.9 \times R_{io}$	$< 100\ K\Omega$
1 mA to 10 mA	10 mA............	> 5 mv	$> 1.1 \times R_{ic}$ or $< 0.9 \times R_{ic}$	$> 1.1 \times R_{io}$ or $< 0.9 \times R_{io}$	$< 100\ K\Omega$
Lower limit < 1 mA.............	Lower limit	> 1 mv	$> 1.1 \times R_{ic}$ or $< 0.9 \times R_{ic}$	$> 1.1 \times R_{io}$ or $< 0.9 \times R_{io}$	< 4.8 V

TABLE 3.—*High current endurance test conditions*

Closed resistance	Closed contact Test current	Power dissipated by switch	Open contact Source voltage
$R_c \leq 8\ \Omega$	500 mA	....	130 V DC
$R_c > 8\ \Omega$	....	2 watts	130 V DC

4.2.5 Temperature

Type I and III switch specimens tested for temperature sensitivity in accordance with paragraph 5.5.4 shall operate properly without readjustment when subjected to temperatures varying between 65 °C (149 °F) and − 18 °C (− 0.4 °F) in accordance with paragraphs 5.5.4.1 and 5.5.4.2. Type II and IV switch specimens shall meet the temperature requirements of paragraph 4.3.5.

4.2.6 Hydrogen Sulfide

The switch specimens tested for hydrogen sulfide corrosion sensitivity in accordance with paragraph 5.5.4 shall meet the contact resistance requirements of paragraph 4.2.4.1 after being exposed for 10 days to a corrosive atmosphere in accordance with paragraph 5.5.4.3. The switches shall show no visual evidence of corrosion on any electrical or operating parts.

4.2.7 Sulfur Dioxide and Carbon Dioxide

The switch specimens tested for sulfur dioxide and carbon dioxide corrosion sensitivity in accordance with paragraph 5.5.4 shall meet the contact resistance requirements of paragraph 4.2.4.1 after being exposed for 10 days to a corrosive atmosphere in accordance with paragraph 5.5.4.4. The switches shall show no visual evidence of corrosion on any electrical or operating parts.

4.2.8 Shock

The switch specimens tested for shock sensitivity in accordance with paragraph 5.5.4 shall meet the contact resistance requirements of paragraph 4.2.4.1 after being subjected to 18 shock pulses in accordance with paragraph 5.5.4.5.

4.2.9 Dielectric Strength

The switch specimens tested for dielectric strength in accordance with paragraph 5.5.5 shall withstand a 60 hertz test voltage between the switch circuit and the metallic mounting surface for a minimum of 1 minute without breakdown. Breakdown is defined as any current in excess of 1 milliampere RMS. The test voltage shall be the appropriate voltage given in table 4. As indicated by the test schedule, table 6, this test shall be performed after the hydrogen sulfide and shock tests for indoor switches but during the rain test for outdoor switches.

TABLE 4.—*Dielectric strength test voltages*

Voltage rating	Test voltage (RMS)*
50 V or less	500 V.
Above 50 V	1000 V plus twice rated voltage.

*60 Hz essentially sinusoidal.

4.2.10 Vibration

The switch specimens tested for vibration sensitivity shall give no false contact closures or openings when tested in accordance with paragraph 5.5.6.

4.3 Outdoor Switches

Type II and type IV switches intended for use outdoors shall meet all the requirements of this section.

4.3.1 Configuration

The switch shall have a watertight cover over all electrical terminals and waterproof insulation on all exposed electrical conductors.

4.3.2 Rain

The switch specimens tested for rain sensitivity shall not admit water to any electrical or operating parts when subjected for 1 hour to a simulated beating rain applied to the top and sides in accordance with paragraph 5.6.2. After the exposure the switch specimens shall still meet the dielectric strength requirement of paragraph 4.2.9. The switch specimens shall show no visual evidence of water in the area of any electrical or operating parts of the switch.

4.3.3 Dust

The switch specimens tested for dust sensitivity shall show no visual evidence of dust in the area of any electrical or operating parts when subjected for 1 hour to a dusty atmosphere in accordance with paragraph 5.6.3.

4.3.4 Salt Spray Corrosion

The switch specimens tested for salt spray sensitivity shall meet the contact resistance requirements of paragraph 4.2.4.1 after being exposed to a salt spray for 48 hours in accordance with paragraph 5.6.4. The switch specimens shall show no visual evidence of corrosion on any electrical or operating parts.

4.3.5 Temperature

The switch specimens tested for temperature sensitivity shall operate properly without readjustment when subjected to temperatures varying between 65 °C (149 °F) and − 35 °C (− 31 °F) in accordance with paragraphs 5.5.4.1 and 5.6.5.

4.4 Tamper Resistance Features

Switches having either of the tamper resistance features described in this section and thus classified as type III or IV shall meet the requirements of the applicable paragraph(s) below.

4.4.1 Tamper Switch

The switch specimens tested for tamper switch operation shall not trigger an alarm until the cover has moved at least 1.5 millimeters (0.06 in) in accordance with paragraph 5.7.1. The switch shall trigger an alarm before the cover has moved 6.0 millimeters (0.24 in).

4.4.2 Electrical-Balance

The switch specimens with internal resistors tested for electrically-balanced operation shall meet the following requirement: over the specified temperature range [− 18 °C (− 0.4 °F) to 65 °C (149 °F) for type III switches and − 35 °C (− 31 °F) to 65 °C (149 °F) for type IV switches] the resistance variation measured at the switch terminals shall be less than 10 percent of the maximum resistance measured when measured in accordance with paragraph 5.7.2.

4.5 Floor Switches

Switches intended for floor mounting shall meet the requirements of this section.

4.5.1 Rough Usage and Immersion

The floor switch specimens subjected to the rough usage test (par. 5.8.1) followed by the immersion test (par. 5.8.3) shall, while still immersed in the salt water, meet the open resistance criteria given in table 2.

4.5.2 Impact and Immersion

The floor switch specimens subjected to the impact test (par. 5.8.2) followed by the immersion test (par. 5.8.3) shall, while still immersed in the salt water, meet the open resistance criteria given in table 2.

5. TEST METHODS

5.1 Sampling

A sample of either 8 or 10 switch specimens shall be selected at random for test, depending on the number of switches to be tested for endurance. The number shall be eight if the switch is to be tested at one or two currents, and ten if the switch is to be tested at three currents.

5.2 Ambient Conditions

Unless otherwise specified, all the tests shall be performed at laboratory ambient conditions. These shall be maintained at 23 ± 10 °C (73 ± 18 °F) temperature and from 20 to 80 percent relative humidity.

5.3 Test Schedule

The switches shall be randomly assigned numbers from 1 to 8 or 10. This is used to assign the switches to test groups according to table 5. The three test currents to be used in the endurance tests are also designated in table 5 as "a," "b," and "c." Switches designated "a" are tested at the single current or the lowest current. Switches designated "b" are tested at the higher current if tests are made at two currents and the middle current if tests are made at three currents. Switches designated "c" are tested at the highest current if tests are made at three currents. Table 6 gives the sequence of tests for each group.

TABLE 5.—*Switch group assignment and endurance test current assignment*

Switch Number	1	2	3	4	5	6	7	8	9	10
Group Number	4	3	3	3	2	2	2	1	1	1
Endurance test for:										
one current					a	a	a	a		
two currents					a	b	a	b		
three currents					a	b	c	a	b	c

TABLE 6.—*Test schedule*

Test (Number of switches)	Req. para.	Test para.	Sample group number 1 (1 or 3)	2 (3)	3 (3)	4 (1) (spare)
Common Tests (All Switches):						
Material and Configuration	4.2.2	5.5.1	1	1	1	
Deactuation Distance	4.2.3	5.5.2	2	2	2	1
Endurance	4.2.4	5.5.3				
Normal Current	4.2.4.1	5.5.3.1	3	3		
High Current	4.2.4.2	5.5.3.2	4	4		
High Temperature	4.2.5	5.5.4.1			3	
Low Temperature—indoor	4.2.5	5.5.4.2			4	
Hydrogen Sulfide	4.2.6	5.5.4.3			5	
Sulfur Dioxide and Carbon Dioxide	4.2.7	5.5.4.4		5		
Shock	4.2.8	5.5.4.5			6	
Dielectric Strength	4.2.9	5.5.5			9	
Vibration	4.2.10	5.5.6		6		
Outdoor Tests (Types II and IV):						
Configuration	4.3.1	5.6.1		7	7	
Rain	4.3.2	5.6.2			8	
Dust	4.3.3	5.6.3			10	
Salt Spray Corrosion	4.3.4	5.6.4		8		
Low Temperature—outdoor	4.3.5	5.6.5			4	
Tamper Resistance Features (Types III & IV):						
Tamper Switch	4.4.1	5.7.1		9		
Electrical Balance	4.4.2	5.7.2		10		
Floor Switch Tests:						
Rough Usage and Immersion	4.5.1	5.8.1 5.8.3		11		
Impact and Immersion	4.5.2	5.8.2 5.8.3		12		

The numbers under each group give the order in which the tests are to be run. For example, the switches in group 1 shall be first examined for compliance with the material and configuration requirements, then tested for deactuation distance, normal current endurance, and finally, high current endurance. Group 4 is the spare switch to be used if another switch fails a test.

5.4 Test Equipment

5.4.1 The dc power supply outputs shall have a voltage which varies less than 1 percent from full load to no load and has less than 0.1 percent or 0.5 millivolts ripple, whichever is less.

5.4.2 The ac power supply outputs shall have an RMS voltage which varies less than 1 percent from full load to no load and has less than 1 percent distortion from a sinewave.

5.4.3 Voltmeters shall have an impedance at least 100 times that of the circuit to be measured and shall be capable of measuring 1 millivolt to 60 volts dc and 1 volt to 1500 volts ac with an accuracy as defined in ASTM Recommended Practice E 177 [2] of at least ± 3 percent (LE%).

5.4.4 Ammeters shall have a voltage drop less than 200 millivolts on full scale readings and shall be capable of measuring 1 microampere to 1 ampere dc and 1 milliampere to 1 ampere ac with an accuracy as defined in ASTM Recommended Practice E 177 [2] of at least ± 3 percent (LE%).

5.4.5 Voltage level detectors (voltage comparators) shall be capable of indicating when a sensed voltage crosses a threshold voltage with a resolution better than ± 5 millivolts. The threshold voltage shall be adjustable from zero to the open circuit voltage. Each detector shall include a counter. The open detector shall count the number of times the sensed voltage rises above its threshold voltage. The closure detector shall count the number of times the sensed voltage drops below its threshold voltage. The input impedance of each detector shall be at least 10 times the impedance of the sensed voltage source but not less than 1 megohm. These detectors shall be insensitive to voltage changes lasting 1 millisecond or less.

5.4.6 The switch actuator shall either move magnets past the switch or simulate a magnet moving past the switch. The switch actuator shall meet the timing requirements of paragraph 5.5.3.1. Some means shall be provided to register the number of times the switch actuator has operated during a test.

5.4.7 The test window and test door shall have a means to indicate the door and window movement to an accuracy of ± 1.0 millimeter (± 0.04 in). The door shall be sturdy enough to prevent twisting and other unwanted motions of the magnet. The door shall be 85 to 95 centimeters (33.5 to 37.4 in) wide and constructed of nonmagnetic material. The magnet-to-switch clearance shall be maintained to an accuracy of ± 1.0 millimeter (± 0.04 in) on both test fixtures (see par. 5.5.2).

5.4.8 The dust chamber shall meet the requirements of MIL-STD-202D [3] dated April 14, 1969, method 110, test condition B, except that temperature control of 25 ± 5 °C (77 ± 9 °F) shall be considered adequate.

5.4.9 The contact-break indicator shall be used to positively indicate when the switch contact is broken. The input impedance of each indicator shall be at least 10 times the impedance of the sensed voltage source but not less than 1 megohm. The indicator shall be sensitive to all voltage changes lasting 1 millisecond or more. Once a break in contact has been registered (as shown, for example, by a signal light) the indicator design shall be such as to require manual resetting, even if the switch contact is closed again. A suitable circuit for such an indicator is shown in figure 8-8 of Engineers' Relay Handbook [4]. The indicator may be designed so as to serve as the source of test current for the switch. In this case it shall meet the requirements of paragraph 5.4.1.

5.4.10 The electrodynamic vibration exciter shall be capable of producing a sinusoidal acceleration over the frequency range of 5 hertz to 500 hertz with wave shape distortion not to exceed 5 percent. The vibration exciter shall have a force output of 22 newtons (5 pound-force approximately) or greater.

5.4.11 The electrodynamic vibration exciter shall either be equipped with a built-in monitoring accelerometer, or a suitable monitoring accelerometer shall be mounted on the vibrating table top in close proximity to the switch being tested. The monitoring accelerometer system shall contain a suitable signal conditioner and output indicator to permit measurement of the amplitude of the test vibrational acceleration with an accuracy as defined in ASTM Recommended Practice E 177 [2] of at least ± 5 percent (LE%).

5.5 Common Tests

5.5.1 Material and Configuration

The switch shall be examined to determine that it conforms to sections 3 through 12 of the Underwriters' Laboratory Standard UL 634, Connectors and Switches for Use with Burglar Alarm Systems [1].

5.5.2 Deactuation Distance

The method of measuring the deactuation distance depends on the alignment relationship of the switch and magnet in their normal secure position. Using a line through the poles of the magnet as the axis of the magnet, the switch may be on-axis or off-axis. Figure 1 shows some examples of possible alignments. In the following procedures and figures

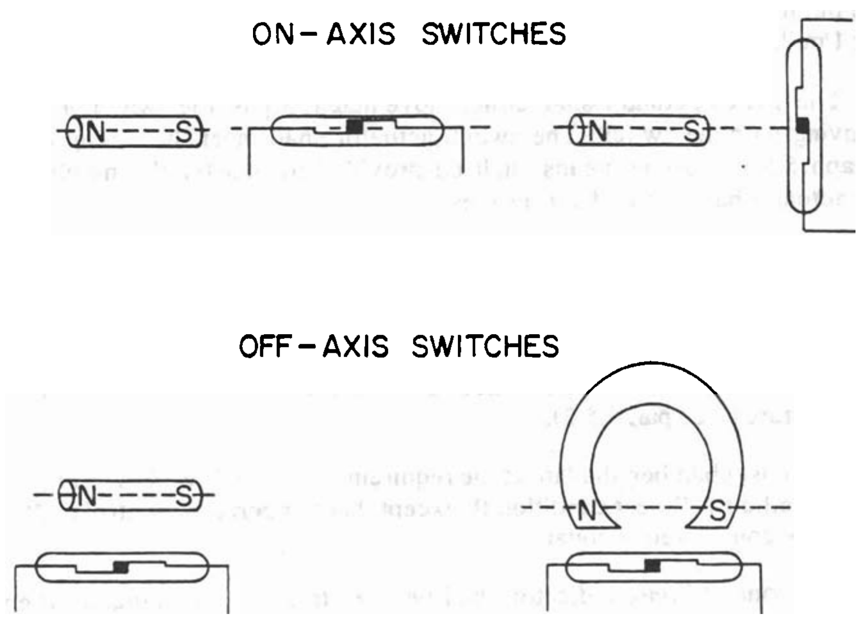

FIGURE 1. *Examples of on-axis and off-axis magnetic switches.*

the off-axis switch will be shown as a surface-mounted switch and the on-axis switch will be shown as a recess-mounted switch. For an on-axis surface-mounted switch or an off-axis recess-mounted switch, the mountings will differ from the figure but all measurements will be made as described in the procedures.

5.5.2.1 Nonmagnetic Material — Off-Axis Switch

Conformance with the perpendicular motion requirements for off-axis switches shall be determined by mounting the devices on a test door (see par. 5.4.7) 5.0±0.5 centimeters (2.0±0.2 in) from the door edge opposite the hinge (see fig. 2). The switch-to-magnet separation shall be measured at the point of closest approach (B in fig. 2.b) and shall be the separation specified by the manufacturer. No magnetic material shall be located within 25 centimeters (9.8 in) of the devices. The door movement shall be measured at the edge opposite the hinge (A in fig. 2.a). The deactuation distance shall be determined by swinging the door open thus moving the magnet away from the switch.

Conformance with the parallel motion requirements for off-axis switches shall be determined by mounting the devices on a test window. The switch-to-magnet separation shall be measured at the point of closest approach (B in fig. 3.a) and shall be the separation

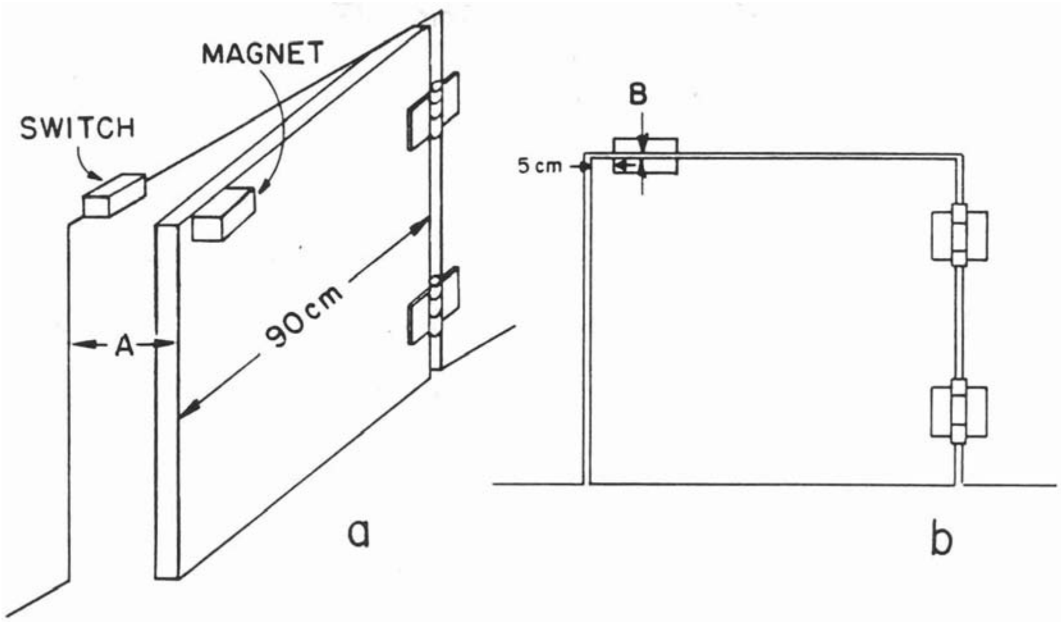

FIGURE 2. *Test door for surface-mounted off-axis magnetic switch on nonmagnetic material.*

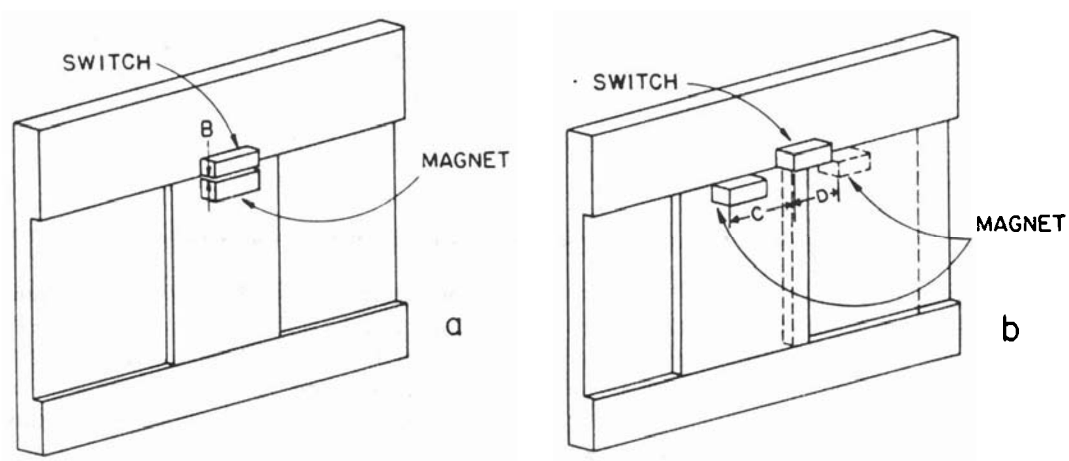

FIGURE 3. *Test window for surface-mounted off-axis switch on nonmagnetic material.*

specified by the manufacturer. No magnetic material shall be located within 25 centimeters (9.8 in) of the devices. The window movement shall be measured for both right and left movements. Both measurements shall meet the requirements (see C and D in fig. 3.b). The deactuation distances shall be determined by moving the magnet away from the switch to the left and right.

5.5.2.2 Nonmagnetic Material — On-Axis Switch

Conformance with the perpendicular motion requirements for on-axis switches shall be determined by mounting the devices in two blocks of nonmagnetic material mounted on the test door (par. 5.4.7). One block shall be fastened to the door and the other on the frame adjacent to the first (see fig. 4). The devices shall be mounted in the blocks 5.0 ± 0.5

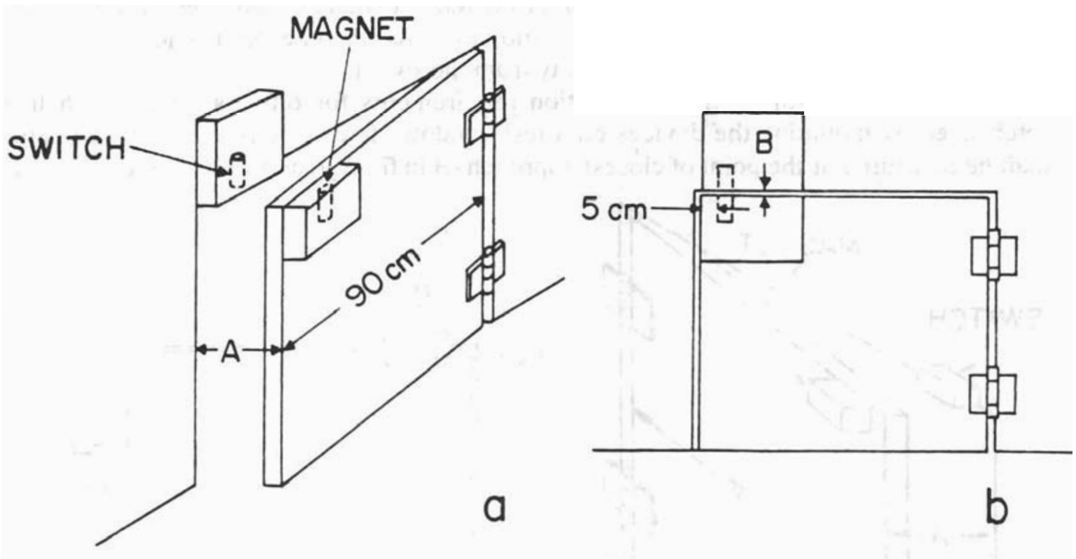

FIGURE 4. *Test door for recess-mounted on-axis magnetic switch on nonmagnetic material.*

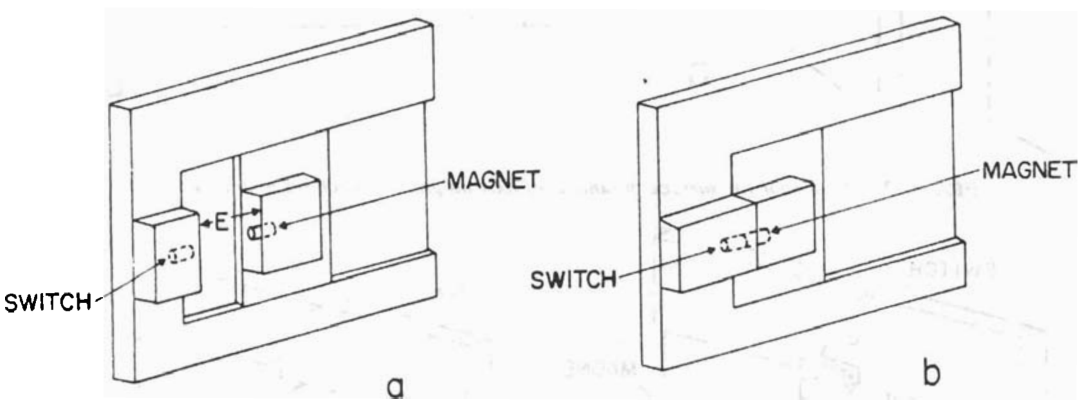

FIGURE 5. *Test window for recess-mounted on-axis magnetic switch on nonmagnetic material.*

centimeters (2.0 ± 0.2 in) from the door edge opposite the hinge. The switch-to-magnet separation shall be measured at the point of closest approach (B in fig. 4.b) and shall be the separation specified by the manufacturer. No magnetic material shall be located within 25 centimeters (9.8 in) of the devices. The door movement shall be measured at the edge opposite the hinge (A in fig. 4.a). The deactuation distance shall be determined by swinging the door open thus moving the magnet away from the switch.

Conformance with the parallel motion requirements for on-axis switches shall be determined by mounting the devices in two blocks of nonmagnetic material mounted on the test window (par. 5.4.7). One block shall be fastened to the moving part ("window") and the other adjacent on the frame (see fig. 5). The devices shall be mounted such that when the "window" is in the extreme left position, the switch and magnet touch. The window movement shall be measured as the separation of the switch and magnet (E in fig. 5.a). The deactuation distance shall be determined by moving the "window" to the right away from the switch.

5.5.2.3 Magnetic Material—Off-Axis Switch

Conformance with the perpendicular motion requirements for off-axis switches shall be determined by measurements made on a test steel door (par. 5.4.7). Two 25-centimeter by 25-centimeter by 0.6-centimeter (9.8-in by 9.8-in by 0.24-in) steel plates, which have a relative permeability greater than 100,* shall be used to simulate the steel door. One shall be mounted in the corner of the door and the other adjacent on the frame (see fig. 6). With the door closed, the plates shall be separated by less than 0.25 centimeter (0.1 in). The mounting separation from switch to plate (F in fig. 6) shall be measured at the point of closest approach. The mounting bracket or separators shall be made of nonmagnetic material. The door movement shall be measured at the edge opposite the hinge (A in fig. 6.a). The deactuation distance shall be determined by swinging the door open thus moving the magnet away from the switch.

Conformance with the parallel motion requirements for off-axis switches shall be determined by measurements made on a test steel window. Two 25-centimeter by 25-centimeter by 0.6-centimeter (9.8-in by 9.8-in by 0.24-in) steel plates, which have a relative permeability greater than 100, shall be used to simulate the steel window. One shall be mounted on the window and the other on the frame (see fig. 7) with 0.25 centimeter (0.1 in) clearance. The mounting separation from switch to plate shall be measured at the point of closest approach (F in fig. 7). The mounting bracket or separators shall be made of nonmagnetic material. The window movement shall be measured for both right and left movements. Both measurements shall meet the requirements. The deactuation distances shall be determined by moving the magnet away from the switch to the left and right.

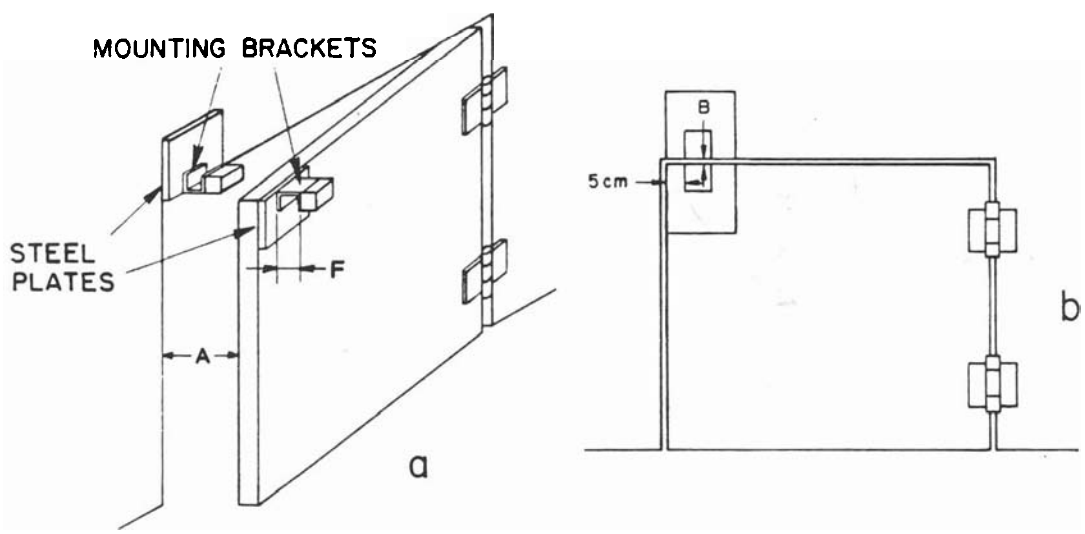

FIGURE 6. *Test door for surface-mounted off-axis magnetic switch on magnetic material.*

*Carbon steels such as AISI C1010-1020 are acceptable.

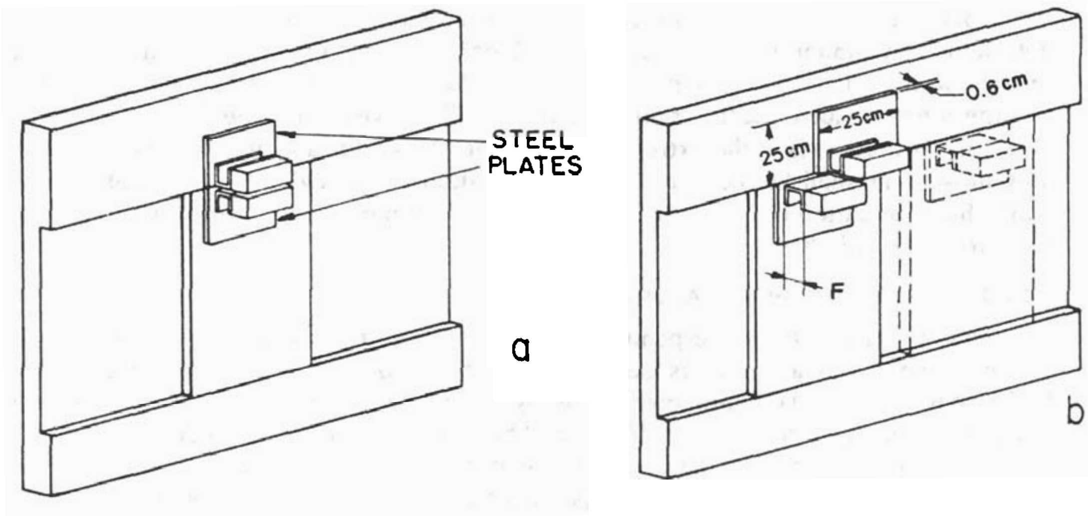

FIGURE 7. *Test window for surface-mounted off-axis magnetic switch on magnetic material.*

5.5.2.4 Magnetic Material—On-Axis Switch

Conformance with the perpendicular motion requirements for on-axis switches shall be determined by mounting the devices in two 25-centimeter by 25-centimeter by 3.8-centimeter (9.8-in by 9.8-in by 1.5-in) blocks of nonmagnetic material clad on both sides with 0.3 ± 0.05 centimeter (0.12 ± 0.02 in) steel plates with a relative permeability greater than 100 and mounted on the test door (par. 5.4.7). One block shall be fastened to the door and the other on the frame adjacent to the first (see fig. 8). The devices shall be mounted in the blocks 5 centimeters (2 in) from the door edge opposite the hinge. The switch-to-magnetic separation shall be measured at the point of closest approach (B in fig. 8.b) and shall be the separation specified by the manufacturer, if this is specified, otherwise, less than 0.25 centimeter (0.1 in). The door movement shall be measured at the edge opposite the hinge (A in fig. 8.a). The deactuation distance shall be determined by swinging the door open thus moving the magnet away from the switch.

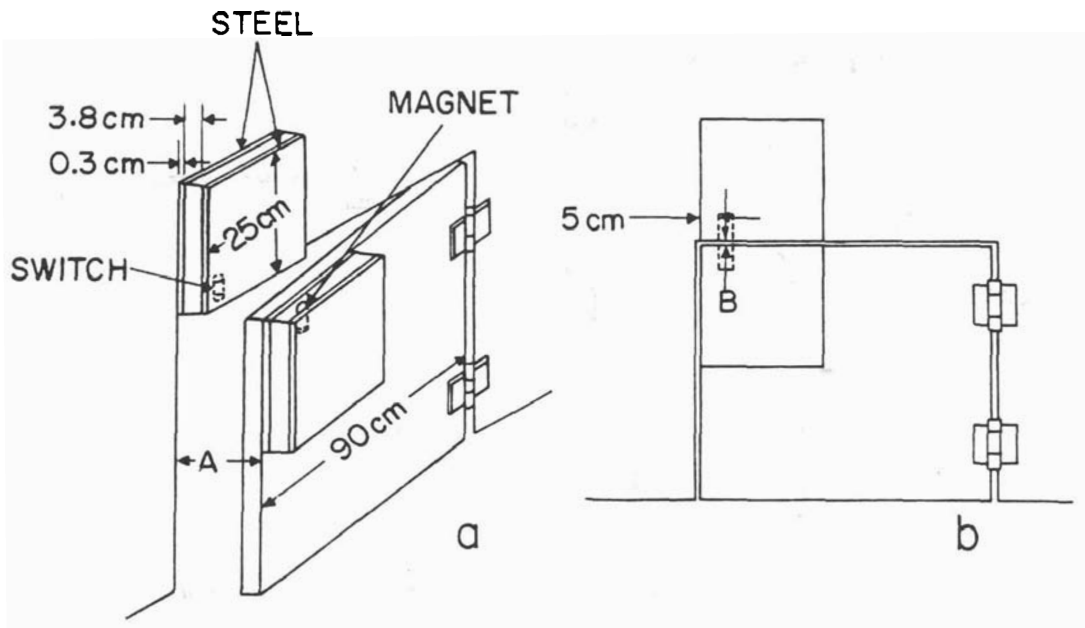

FIGURE 8. *Test door for recess-mounted on-axis magnetic switch on magnetic material.*

Conformance with the parallel motion requirements for on-axis switches shall be determined by mounting the devices in two 25-centimeter by 25-centimeter by 3.8-centimeter (9.8-in by 9.8-in by 1.5-in) blocks of nonmagnetic material clad on both sides with 0.3 ± 0.05 centimeters (0.12 in ± 0.02 in) steel plates with a relative permeability greater than 100 and mounted on the test window (par. 5.4.7). One block shall be fastened to the moving part ("window") and the other adjacent on the frame (see fig. 9). The devices shall be mounted such that when the "window" is in the extreme left position, the switch and magnet touch. The deactuation distance shall be determined by moving the "window" to the right away from the switch.

5.5.3 Endurance Tests

5.5.3.1 Normal Current Test

Cycle the switch on and off with the switch actuator (see par. 5.4.6) while switching the normal test current. The on-off cycle time shall be greater than 0.8 seconds during which the switch shall be closed for at least 0.3 seconds and open for at least 0.3 seconds. If the switch has more than one set of contacts, each set shall be tested. All contacts in a switch assembly shall be tested simultaneously. The open and closed resistances of each set of contacts shall be checked prior to the endurance testing and after the following number of operations: 5,000; 10,000; 25,000; 50,000; 75,000; 100,000. Each check shall consist of five open resistance measurements, and five closed resistance measurements, during five successive switch operation cycles. The resistance measurements shall be made at the test current and test voltage using the circuit shown and formulas given in figure 10. V_s and A shall be used to determine the closed contact resistance, R_c, and the open resistance, R_o. Also, during each cycle of the endurance test, the switch contacts shall be monitored by open and closure detectors (see par. 5.4.5). The threshold voltage for these detectors shall be set to within 5 millivolts of the levels given in table 7. The switch will have failed the test if either the open detector counter or closure detector counter does not agree with the actuator counter.

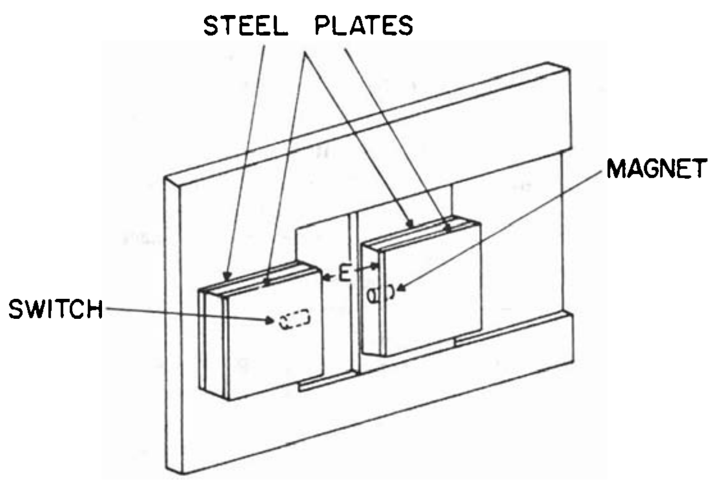

FIGURE 9. *Test window for recess-mounted on-axis magnetic switch on magnetic material.*

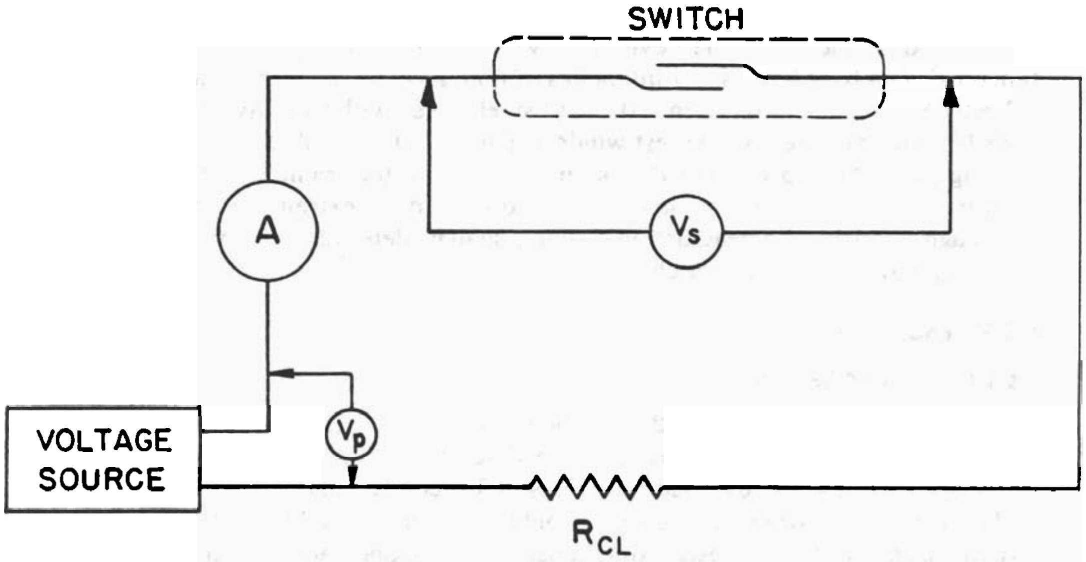

FIGURE 10. *Circuit for making contact resistance measurements. A is an ammeter with readings I_c with the switch closed and I_o with the switch open. V_s is the switch voltmeter with readings V_{so} with the switch open and V_{sc} with the switch closed. V_p is the source voltmeter with readings V_{po} with the switch open and V_{pc} with the switch closed. R_{cl} is the current limiting resistor. The switch-closed contact resistance, R_c, is given by $R_c = \frac{V_{sc}}{I_c}$ and the switch-open contact resistance, R_o, is given by $R_o = \frac{V_{po} - R_{cl}}{I_o}$.*

5.5.3.2 High Current Test

Cycle the switch on and off with the switch actuator 50 times while switching the high test current. The on-off cycle time shall be greater than 0.8 seconds during which the switch shall be closed for at least 0.3 seconds and open for at least 0.3 seconds. If the switch assembly has more than one set of contacts, each set shall be tested. The open and closed resistance of each set of contacts shall be checked prior to and after the test. Each check shall consist of five open resistance measurements and five closed resistance measurements during five successive switch operation cycles. The measurements shall be made with a 6 ± 0.3 volt dc source voltage and 10 ± 0.5 milliamperes test current using the circuit shown and the formulas given in figure 10. During each cycle of this test, the switch contacts shall be monitored by an open detector and a closure detector (see par. 5.4.5). The threshold voltage for these detectors shall be set to within 5 millivolts of the levels given in table 7. The switch will have failed the test if either the open or closure detector counters do not agree with the actuator counter.

TABLE 7.—*Switch contact failure criteria*

Test current (I_c)	Threshold for voltage level detectors			
	Closure detectors		Open detectors	
	($R_{ic} \leq 0.45\ \Omega$)	($R_{ic} > 0.45\ \Omega$)	($R_{io} < 110\ K\Omega$)	($R_{io} \geq 110\ K\Omega$)
Over 10 mA	$(I_c \times 0.45\ \Omega) + 15$ mV	$I_c \times R_c + 15$ mV	$V_{so} - 100$ mV	$V_{so} - 100$ mV
10 mA	20 mV	$I_c \times R_c + 15$ mV	$V_{so} - 100$ mV	$V_{so} - 100$ mV
Under 1 mA	15 mV	$I_c \times R_c + 15$ mV	$V_{so} - 100$ mV	$V_{so} - 100$ mV
High Current	$(I_c \times 0.45\ \Omega) + 15$ mV	$I_c \times R_c + 15$ mV	$V_{so} - 100$ mV	$V_{so} - 100$ mV

$$V_{so} = \frac{R_o \times V_{po}}{R_o - R_c + (V_{po}/I_c)}$$

Where: I_c = test current in closed position, R_c = switch-closed resistance
R_o = switch-open resistance, V_{po} = open circuit source voltage
V_{so} = voltage across the open switch, R_{ic} = initial switch-closed resistance
R_{io} = initial switch-open resistance

5.5.4 Environmental Tests

The ability of the switches to operate properly in severe environments shall be checked with the following procedures. Prior to each test the open and closed resistances shall be measured for five successive operation cycles, then the switch shall be cycled 25 times and the resistances again measured for five successive operation cycles. Each measurement shall be performed with the equipment, using the procedures and the requirements described in paragraph 5.5.3.1. These measurements shall be repeated during the environmental test, if called for, with the switch in the environmental chamber and immediately following the test at laboratory ambient conditions.

5.5.4.1 High Temperature Test

The switch shall be placed in a test chamber and the temperature raised to 65 ± 2 °C (149 ± 3.6 °F). This temperature shall be maintained for 4 hours. Before the test, during the final hour of the test, and after the test at laboratory ambient conditions, the switch shall be tested for proper operation as described in paragraph 5.5.4.

5.5.4.2 Low Temperature Test—Indoor Switch

The switch shall be placed in a low temperature test chamber and the temperature lowered to -18 ± 2 °C (-0.4 ± 3.6 °F). This temperature shall be maintained for 4 hours. Before the test, during the final hour of the test, and after the test at laboratory ambient conditions, the switch shall be tested for proper operation as described in paragraph 5.5.4.

5.5.4.3 Hydrogen Sulfide Test

The switch shall be exposed for 10 days at laboratory ambient temperature to an atmosphere containing 0.5 to 1.5 percent hydrogen sulfide by volume in air saturated with water vapor. The air in the chamber shall be circulated and care taken to assure that the switches do not touch each other and that condensate does not drip onto them. Before and after the exposure the switch shall be wiped dry, then checked for proper operation as described in paragraph 5.5.4. Following this the switch shall be disassembled and inspected for corrosion.

5.5.4.4 Sulfur Dioxide and Carbon Dioxide Test

The switch shall be exposed for 10 days at laboratory ambient temperature to an atmosphere containing 0.5 to 1.5 percent sulfur dioxide and 0.5 to 1.5 percent carbon dioxide by volume in air saturated with water vapor. The air in the chamber shall be circulated and care taken to assure that the switches do not touch each other and that condensate does not drip onto them. Before and after the exposure the switch shall be wiped dry, then checked for proper operation as described in paragraph 5.5.4. Following this the switch shall be disassembled and inspected for corrosion.

5.5.4.5 Shock Test

Use MIL-STD-202D [3] dated April 14, 1969, method 213A, test condition G. A sawtooth shock pulse with peak value of 490 meters per second squared (50.0 g_n) and 11 milliseconds duration shall be used three times in each direction along each of the three mutually perpendicular axes of the switch (total of 18 shocks). Following the test the switch shall be tested for proper operation as described in paragraph 5.5.4.

5.5.5 Dielectric Strength Test

Mount the switch on a metallic surface and apply the appropriate voltage. The voltage shall be increased gradually from 0 at a rate not to exceed 100 volts RMS per second. A series resistor shall be used to limit a breakdown current to approximately 100 milliamperes RMS when full voltage has been applied. The voltage and current shall be monitored and the test stopped if the current ever exceeds 1 milliampere RMS. For indoor switches this test shall be performed after the shock test, but for outdoor switches, it shall be performed as part of the rain test (par. 5.6.2).

5.5.6 Vibration Test

The switch shall be mounted on a vibration exciter (par. 5.4.10) so the direction of acceleration is perpendicular to the mounting plane. Two slow linear sweeps (approximately 3 minutes each) shall be made from 5 hertz to 500 hertz with an amplitude of 0.25 ± 0.03 centimeter peak to peak from 5 to 17 hertz and 14.7 ± 1.0 meters per second squared (1.5 ± 0.1 g_n) peak to peak from 17 to 500 hertz (see fig. 11). One sweep shall be made with the switch actuated and the other sweep shall be made with the switch deactuated. During both sweeps the contacts shall be monitored with a contact-break indicator (par. 5.4.9).

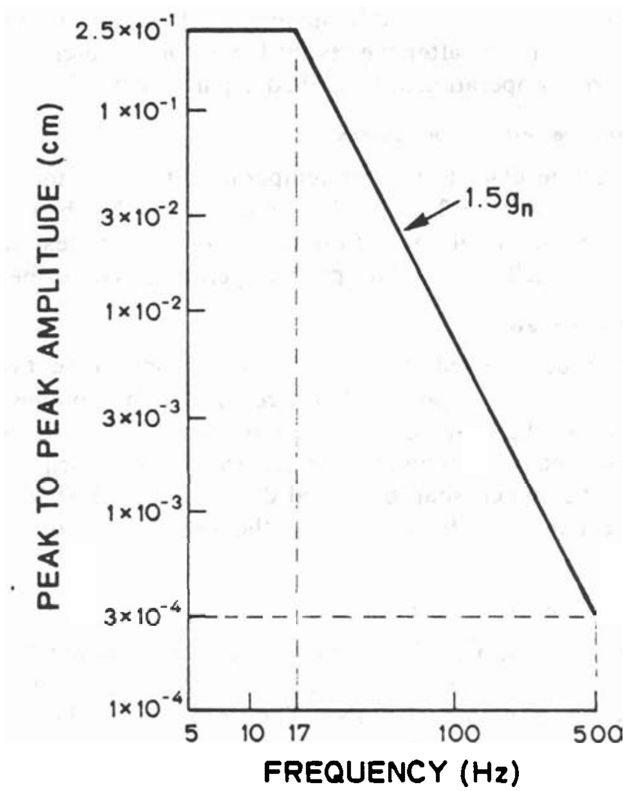

FIGURE 11. *Vibration test amplitude versus frequency.*

5.6 Outdoor Tests

5.6.1 Configuration

The switch shall be examined to determine that all electrical terminals are under a watertight cover and exposed electrical conductors have waterproof insulation.

5.6.2 Rain Test

The switch shall be placed in the rain test chamber. The procedures given in Underwriters' Laboratories Standard UL1023, Household Burglar-Alarm System Units [5] paragraphs 26.1 and 26.2 shall be used. Following exposure the dielectric strength test shall be performed in accordance with paragraph 5.5.5. Following that test the switch shall be wiped dry, then disassembled and inspected for water penetration.

5.6.3 Dust Test

The switch shall be placed in the dust chamber (see par. 5.4.8) and tested according to MIL-STD-202D [3], dated April 14, 1969, method 110, test condition B, except the duration shall be at least 1 hour, not the 6 hours called for in method 110. Following the test, the switch shall be wiped clean and disassembled and inspected for dust penetration.

5.6.4 Salt Spray Corrosion Test

The switch shall be subjected to salt spray in accordance with MIL-STD-202D [3], dated April 14, 1969, method 101C, test condition B. A 5 percent salt solution shall be used, the chamber temperature shall be 35 ± 2 °C (95 ± 3.6 °F) and the exposure shall be for 48 hours. Before and after the exposure the switch shall be tested for proper operation as described in paragraph 5.5.4. Following this the switch shall be disassembled and inspected for corrosion.

5.6.5 Low Temperature Test — Outdoor Switch

The switch shall be placed in a test chamber and the temperature lowered to −35 ± 2 °C (−31 ± 3.6 °F). This temperature shall be maintained for 4 hours. Before the test, during the fina hour of the test, and after the test, the switch shall be tested for proper operation as described in paragraph 5.5.4.

5.7 Tamper Resistance Tests

5.7.1 Tamper Switch Test

The cover on a switch with a hinged cover shall be swung open until the tamper switch first actuates. The movement of the cover opposite the hinge shall be measured. The cover on a switch with a nonhinged cover shall be lifted uniformly on all sides until the tamper switch first operates. The cover movement shall be measured on four sides to show it was lifted uniformly.

5.7.2 Electrically-Balanced Test

The switch shall be placed in a test chamber and the temperature lowered to the appropriate temperature [−35 ± 2 °C (−31 ± 3.6 °F) for type II and IV switches or −18 ± 2 °C (− 0.4 ± 3.6 °F) for type I and III switches]. The temperature of the switch shall be monitored with a thermocouple or similar device. The resistance of each state of the switch shall be measured. Then the temperature of the switch shall be raised to 0 ± 2 °C (32 ± 3.6 °F), then to 25 ± 2 °C (77 ± 3.6 °F), and finally 65 ± 2 °C (149 ± 3.6 °F). At each temperature a measurement of the resistance of each state of the switch shall be made.

5.8 Floor Switch Tests

5.8.1 Rough Usage Test

The switch shall be mounted as recommended by the manufacturer. If the recommended mounting method requires the switch to be epoxied, grouted or similarly permanently sealed into a concrete floor, the switch shall be mounted into a concrete slab such that later the slab can be immersed into a salt-water solution for the immersion test (5.8.3). One wheel of a two-wheel hand truck with solid rubber tires, loaded to provide a total force of 900 newtons (200 pounds-force approximately), shall be rolled over the switch 1200 times. The hand truck shall have smooth 3.5- to 5.0-cemtimeter (1.4- to 2.0-in) wide solid rubber tires. Following this test the immersion test (5.8.3) shall be performed.

5.8.2 Impact Test

The switch shall be mounted on a concrete floor as recommended by the manufacturer. If the recommended mounting method requires the switch to be epoxied or grouted or similarly permanently sealed into a concrete floor, the switch shall be mounted into a concrete slab such that later the slab can be immersed into a salt-water solution for the immersion test (5.8.3). Then a steel sphere with a diameter of 5.0±0.2 centimeter (2.0±0.1 in) and a mass of 0.54±0.02 kilograms (1.18±0.04 lb) all be dropped from a height above the switch of 1.29±0.01 meters (51.0±0.5 in) onto the switch once.

5.8.3 Immersion Test

The switch shall be completely immersed in a 20 percent (by weight) salt-water solution at laboratory ambient conditions for 24 hours. While the switch is still in the salt-water solution, the switch shall be tested for water leaks by measuring its open contact resistance as described in paragraph 5.5.4.

Appendix A—REFERENCES

[1] Underwriters' Laboratory Standard UL 634, second edition, September 8, 1972, "Connectors and Switches for Use with Burglar Alarm Systems," Underwriters' Laboratories, Inc., 333 Pfingsten Road, Northbrook, Ill. 60062.

[2] ASTM Recommended Practice E 177. American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

[3] MIL-STD-202D, dated April 14, 1969. Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pa. 19120.

[4] Engineers' Relay Handbook, second edition, (Hayden Book Co., Inc., New York, N.Y., 1969).

[5] Underwriters' Laboratories Standard UL 1023-1972, "Household Burglar-Alarm System Units."

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