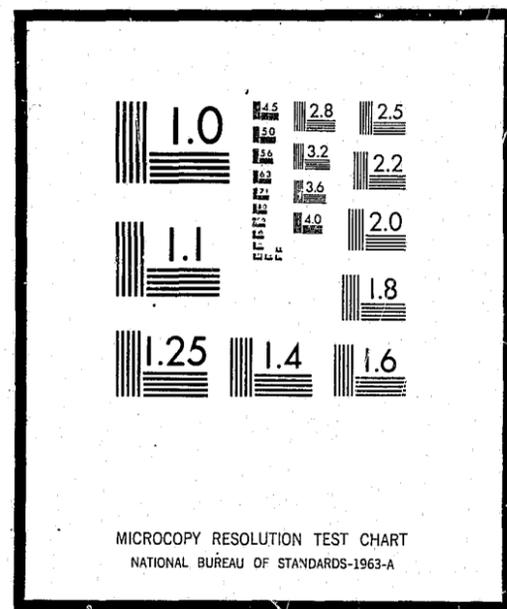


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LAW ENFORCEMENT ASSISTANCE ADMINISTRATION  
NATIONAL CRIMINAL JUSTICE REFERENCE SERVICE  
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## LAW ENFORCEMENT STANDARDS PROGRAM

### NILECJ STANDARD FOR MECHANICALLY ACTUATED SWITCHES FOR BURGLAR ALARM SYSTEMS

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

MAY 1974

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LAW ENFORCEMENT ASSISTANCE  
ADMINISTRATION

Donald E. Santarelli, *Administrator*  
Richard W. Velde, *Deputy Administrator*  
Charles R. Work, *Deputy Administrator*

**NATIONAL INSTITUTE OF LAW ENFORCEMENT  
AND CRIMINAL JUSTICE**

Gerald M. Caplan, *Director*

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This standard was formulated by the Law Enforcement Standards Laboratory of the National Bureau of Standards under the direction of Marshall A. Isler, Manager, Security Systems Program and Jacob J. Diamond, Chief of LESL. Technical research was performed by Martin L. Kite of the NBS Electronic Technology Division under the supervision of Gerald N. Stenbakken. Linda K. Smith assisted in editing.

**NILECJ Standard  
for Mechanically Actuated  
Switches for Burglar Alarm Systems**

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## FOREWORD

Following a Congressional mandate\* 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-0302.00, Mechanically Actuated 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 tests 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 guaranteed by the vendor or attested to by an independent testing laboratory.

The necessary 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 mechanically actuated 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 nontechnical 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 their agency. Recommendations for the development of particular guidelines should be sent to us.

**Lester D. Shubin, Manager  
Standards Program**

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\*Section 402(b) of the Omnibus Crime Control and Safe Streets Act of 1968, as amended.

**NILECJ STANDARD**  
**for**  
**MECHANICALLY ACTUATED SWITCHES FOR**  
**BURGLAR ALARM SYSTEMS**

**1. PURPOSE AND SCOPE**

This standard establishes performance criteria for mechanically-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 alarm 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 their 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.

**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 specified 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 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.

#### 3.3 Maximum Operation Force

The maximum force required to move the switch plunger slowly up to the switch operation stop.

#### 3.4 Operation Stop

The switch plunger position at which the force required for further movement increases sharply.

#### 3.5 Secure Mode of Alarm System

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

#### 3.6 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).

#### 3.7 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 ends of the cables away from the switch.

#### 3.8 Tamper Switch

An auxiliary switch which monitors the position of the mechanically actuated 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 (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) Nominal closed resistance if greater than 0.5 ohms
- (d) Nominal open resistance if less than 100 kilohms
- (e) Classification (see sec. 2)
- (f) Tamper resistance features for types III and IV
- (g) Type of material for all components necessary to show compliance with paragraph 4.2.2
- (h) Switch mounting location—on floor or not on floor

#### 4.2.2 Material and Configuration

The material, parts, and components of the product shall conform to the requirements of Underwriters' Laboratories, Inc. (UL), UL634, second edition, Connectors and Switches for Use with Burglar Alarm Systems, sections 3 through 12 [1].

#### 4.2.3 Operation Force Variation

The maximum operation force of each switch specimen when measured in accordance with paragraph 5.5.2 prior to the endurance test shall be within 50 percent of the average of the maximum operation forces of all the switch specimens, or within 1 newton (102 gram-force or 3.6 ounce-force), whichever is greater. During and following the endurance test, the maximum operation force of each switch tested for endurance in accordance with paragraph 5.5.3 shall remain within 50 percent of the average of the maximum operation forces of all the switch specimens determined above, or 1 newton (102 gram-force or 3.6 ounce-force), whichever is greater. Table 1 gives the limits of acceptable force variation. For both the pre- and post-endurance operation force tests, the switch specimens tested shall meet the above requirements on each of five successive measurements.

TABLE 1.—Operation force variation limits

Average operation force, F, in newtons (gram-force, ounce-force)	Lower force limit	Upper force limit
Greater than 2.0 (204, 7.2).....	0.5 × F	1.5 × F
Less than or equal to 2.0 (204, 7.2).....	F - 1 (102, 3.6)	F + 1 (102, 3.6)

#### 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 manu-

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 contact resistance requirements are listed in table 2. They are dependent upon the initial open and closed resistances ( $R_{io}$  and  $R_{ic}$ ) of the switch, which are measured at the switch terminals prior to the test.

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 ( $R_{io} < 110 \text{ K}\Omega$ )	Open ( $R_{io} \geq 110 \text{ K}\Omega$ )
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 $\text{K}\Omega$
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 $\text{K}\Omega$
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

#### 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 3.—High current endurance test conditions

Closed resistance	Closed contact Test current	Power dissipated by switch	Open contact Source voltage
$R_{ic} \leq 8 \Omega$	500 mA	.....	130 V DC
$R_{ic} > 8 \Omega$	.....	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 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 min without permitting any current in excess of 1 milliamperes 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 after the rain exposure 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 h 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 h 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 h 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), when tested 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 and after being removed from the salt water the switches shall meet the operation force variation requirements of paragraph 4.2.3.

##### 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 and after being removed from the salt water the switches shall meet the operation force variation requirements of paragraph 4.2.3.

## 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 8 if the switch is to be tested at 1 or 2 currents, and 10 if the switch is to be tested at 3 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. These are used to assign switches to the test groups according to table 5. The 3 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 2 currents and the middle current if tests are made at 3 currents. Switches designated "c" are tested at the highest current if tests are made at 3 currents. Table 6 gives the sequence of tests for each group. 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 operation force variation, 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 millivolt ripple, whichever is less.

5.4.2 The ac power supply outputs shall have less than 5 percent distortion from a sine wave and have no spikes greater than 1 percent of the RMS voltage.

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 of at least ± 3 percent.

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 of at least ± 3 percent.

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 switches tested at										
one current.....						a	a	a	a	
two currents.....						a	b	a	b	
three currents.....						a	b	c	a	b

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)
<b>Common Tests (All Switches):</b>						
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		
<b>Outdoor Tests (Types II and IV):</b>						
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	
<b>Tamper Resistance Features (Types III &amp; IV):</b>						
Tamper Switch.....	4.4.1	5.7.1		9		
Electrical Balance.....	4.4.2	5.7.2		10		
<b>Floor Switch Tests:</b>						
Rough Usage and Immersion.....	4.5.1	5.8.1		11		
		5.8.3				
Impact and Immersion.....	4.5.2	5.8.2		12		
		5.8.3				

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  $\pm 5$  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 provide the mechanical motion necessary to operate the switch. The switch actuator shall meet the timing requirements of paragraph 5.5.3.1. A counter shall be provided to indicate the number of times the switch actuator has operated during a test.

5.4.7 The dust chamber shall meet the requirements of MIL-STD-202D [2] dated April 14, 1969, method 110, test condition B, except that temperature control of  $25 \pm 5^\circ\text{C}$  ( $77 \pm 9^\circ\text{F}$ ) shall be considered adequate.

5.4.8 The contact-break and contact-closure indicators shall be used to positively indicate when the switch contact is broken or closed. 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 indicators shall be sensitive to voltage changes lasting 1 millisecond or more. Once a break (or closure) in contact has been registered (as shown, for example, by a signal light) the indicator designs shall be such as to require manual resetting, even if the switch contact is closed (or opened) again. A suitable circuit for such a contact-break and contact-closure indicator is shown in figure 8-8, Engineers' Relay Handbook [3]. The indicators may be designed so as to serve as the source of test current for the switch. In this case they shall meet the requirements of paragraph 5.4.1.

5.4.9 The electrodynamic vibration exciter shall be capable of producing a sinusoidal acceleration over the frequency range of 5 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.

5.4.10 The electrodynamic vibration exciter (par. 5.4.9) 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 of at least  $\pm 5$  percent.

5.4.11 The series of force gages shall have dial indicators that maintain the maximum force readings until reset manually. They shall be capable of measuring 0.01 newtons (1.0 gram-force approximately) to 30 newtons (3000 gram-force approximately) with an accuracy of at least  $\pm 5$  percent.

## 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' Laboratories Standard UL634, Connectors and Switches for Use with Burglar Alarm Systems [1].

### 5.5.2 Operation Force Variation Test

Make five maximum operation force measurements on each of the 8 or 10 switches obtained for testing (see par. 5.1). The maximum operation force shall be measured with the appropriate force gage (see par. 5.4.11) taking care that the switch plungers are depressed up to but not past the operation stop. The values of all these force measurements for all the switches (8 or 10) shall be averaged to give the average pre-endurance test maximum operation force.

### 5.5.3 Endurance Tests

#### 5.5.3.1 Normal Current Test

Cycle the switch on and off with the switch actuator (par. 5.4.6) while switching the normal test current. The on-off cycle time shall be greater than 0.8 sec, during which the switch shall be closed for at least 0.3 sec and open for at least 0.3 sec. 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 and the switch operation force 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, five closed resistance measurements, and five maximum operation force 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 1. Voltmeter  $V_s$  and ammeter A shall be used to determine the closed contact resistance,  $R_c$  and the open resistance,  $R_o$ . The operation force measurements shall be made as described in paragraph 5.5.2. Also, during each cycle of the endurance test, the switch contacts shall be monitored by open and closure detectors (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.

TABLE 7.—Switch contact failure criteria

Test current ( $I_c$ )	Threshold for voltage level detectors		
	Closure detectors		Open detectors
	$(R_{ic} \leq 0.45 \Omega)$	$(R_{ic} > 0.45 \Omega)$	
Over 10 mA.....	$(I_c \times 0.45 \Omega) + 15 \text{ mV}$	$I_c \times R_{ic} + 15 \text{ mV}$	$V_{so} - 100 \text{ mV}$
10 mA.....	20 mV	$I_c \times R_{ic} + 15 \text{ mV}$	$V_{so} - 100 \text{ mV}$
Under 1 mA.....	15 mV	$I_c \times R_{ic} + 15 \text{ mV}$	$V_f - 100 \text{ mV}$

$$V_{so} = \frac{R_{io} \times V_{po}}{R_{io} - R_{ic} + (V_{po}/I_c)}$$

Where:  $I_c$  = test current in closed position,  $R_c$  = switch-closed 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

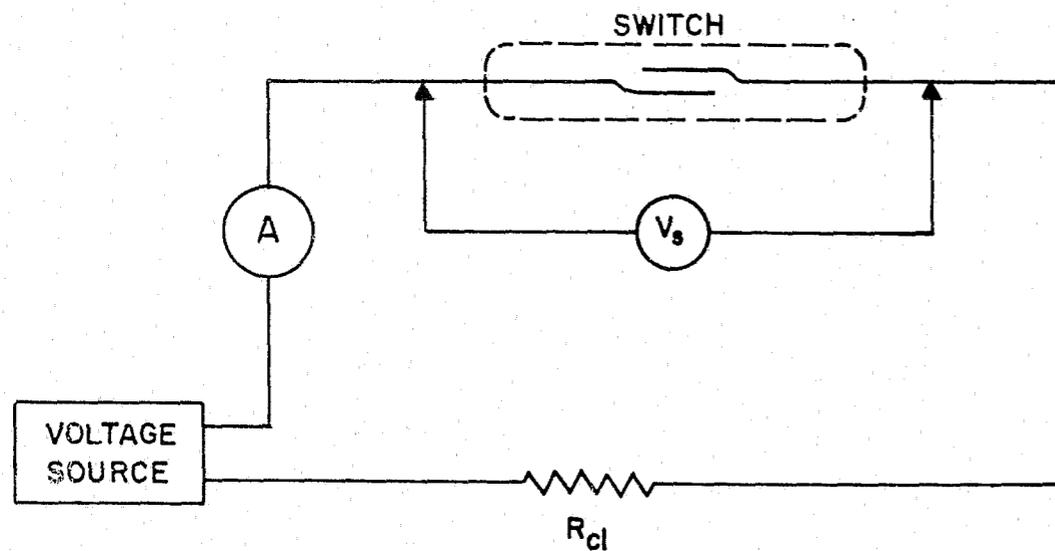


FIGURE 1. Circuit for making contact resistance measurements. A is an ammeter which reads  $I_c$  with the switch closed and  $I_o$  with the switch open.  $V_s$  is the switch voltmeter which reads  $V_{so}$  with the switch open and  $V_{sc}$  with the switch closed.  $R_{cl}$  is the current limiting 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  $R_o = \frac{V_{so}}{I_o}$ .

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 sec, during which the switch shall be closed for at least 0.3 sec and open for at least 0.3 sec. 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  $6 \pm 0.3$  volt dc source voltage and  $10 \pm 0.5$  milliamperes test current using the circuit shown and the formulas given in figure 1. During each cycle of this test, the switch contacts shall be monitored by an open detector and a closure detector (par. 5.4.5). The threshold voltage for these detectors shall be set to within 5 millivolts of the levels given in the first row of table 7. The switch will have failed the test if either the open or closure detector counters do not agree with the actuator counter.

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. Each measurement shall be performed with the equipment and using the procedures 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  $65 \pm 2 \text{ }^\circ\text{C}$  ( $149 \pm 3.6 \text{ }^\circ\text{F}$ ). This temperature shall be maintained for 4 h. 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  $-18 \pm 2 \text{ }^\circ\text{C}$  ( $-0.4 \pm 3.6 \text{ }^\circ\text{F}$ ). This temperature shall be maintained for 4 h. 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 [2] dated April 14, 1969, method 213A, test condition G. A sawtooth shock pulse with peak value of 490 meters per second squared ( $50 g_n$ ) and 11

milliseconds duration shall be applied 3 times in each direction along each of the three mutually perpendicular axis 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 zero 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 after the rain exposure (par. 5.6.2).

#### 5.5.6 Vibration Test

The switch shall be mounted on a vibration exciter (par. 5.4.9) so the direction of acceleration is perpendicular to the mounting plane. Two slow linear sweeps (approximately 3 min each) shall be made from 5 to 500 hertz with an amplitude of  $0.25 \pm 0.03$  centimeter peak to peak from 5 to 17 hertz and  $14.7 \pm 1.0$  meters per second squared ( $1.5 \pm 0.1 g_n$ ) peak to peak from 17 to 500 hertz (see fig. 2). 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 or contact-closure indicator (par. 5.4.8).

### 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 UL 1023, Household Burglar-Alarm System Units [4] 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 the 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. 5.4.7) and tested according to MIL-STD-202D [2] dated April 14, 1969, method 110, test condition B, except the duration shall be at least 1 h, not the 6 h 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 [2] dated April 14, 1969, method 101C, test condition B. A 5 percent salt solution shall be used, the chamber temperature shall be  $35 \pm 2$  °C ( $95 \pm 3.6$  °F) and the exposure shall be for 48 h. Before and after the exposure, the switch shall be wiped dry then tested for proper operation as described in paragraph 5.5.4. Following this, the switch shall be disassembled and inspected for corrosion.

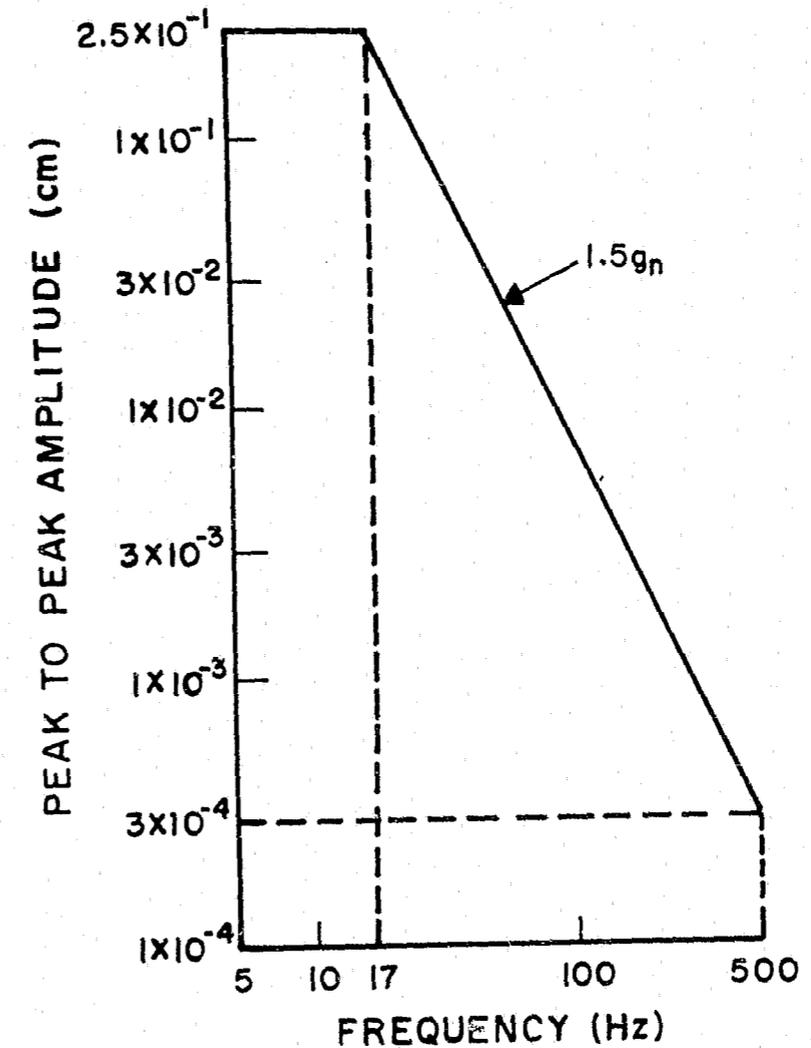


FIGURE 2. Vibration test amplitude versus frequency.

#### 5.6.5 Low Temperature Test-Outdoor Switch

The switch shall be placed in a test chamber and the temperature lowered to  $-35 \pm 2$  °C ( $-31 \pm 3.6$  °F). This temperature shall be maintained for 4 h. Before the test, during the final 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 Electrical Balance Test

The switch shall be placed in a test chamber and the temperature lowered to the appropriate temperature [ $-35 \pm 2$  °C ( $-31 \pm 3.6$  °F) for types II and IV switches or  $-18 \pm 2$  °C ( $0.4 \pm 3.6$  °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  $0 \pm 2$  °C ( $32 \pm 3.6$  °F), then to  $25 \pm 2$  °C ( $77 \pm 3.6$  °F), and finally to  $65 \pm 2$  °C ( $149 \pm 3.6$  °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 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-centimeter (1.4- to 2.0-in) wide solid rubber tires.

#### 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, 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  $5.0 \pm 0.2$  centimeter ( $2.0 \pm 0.1$  in) and a mass of  $0.54 \pm 0.02$  kilograms ( $1.18 \pm 0.04$  pounds) shall be dropped from a height above the switch of  $1.29 \pm 0.01$  meters ( $51.0 \pm 0.5$  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 h. 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. Following this the switch shall be removed from the salt-water solution and tested for operation force variation as described in paragraph 5.5.2.

### Appendix A—References

- [1] Underwriters' Laboratory Standard UL634, second edition, Sept. 8, 1972, "Connectors and Switches for Use with Burglar Alarm Systems," Underwriters' Laboratories, Inc., 333 Pfingsten Road, Northbrook, Ill. 60062.
- [2] MIL-STD-202D, dated Apr. 14, 1969. Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pa. 19120.
- [3] Engineers' Relay Handbook, second edition, (Hayden Book Co., Inc., New York, N.Y., 1969).
- [4] Underwriters' Laboratory Standard UL1023, first edition, March 15, 1972, "Household Burglar-Alarm System Units," Underwriters' Laboratories, Inc., 333 Pfingsten Road, Northbrook, Ill. 60062.

**END**