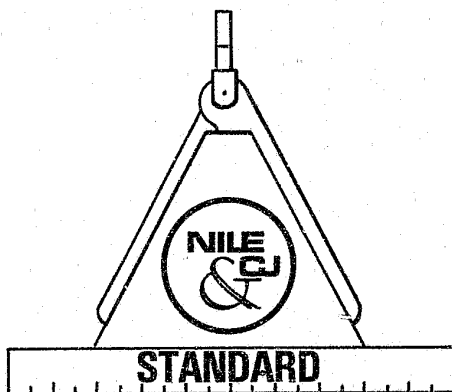


NILECJ-STD-0303.00
MAY 1974

LAW ENFORCEMENT STANDARDS PROGRAM

MERCURY SWITCHES FOR BURGLAR ALARM SYSTEMS



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

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LAW ENFORCEMENT STANDARDS PROGRAM

**NILECJ STANDARD
FOR**

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

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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 and Lawrence K. Eliason, Managers, Security Systems Program, and Jacob J. Diamond, Chief of LESL. Technical research was performed by Vincent A. Martino of the NBS Technical Analysis Division and Martin L. Kite of the Electronic Technology Division, under the supervision of Gerald N. Stenbakken.

NILECJ Standard for Mercury 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-0303.00, Mercury 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 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 mercury 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.

*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.

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

NILECJ STANDARD for MERCURY SWITCHES FOR BURGLAR ALARM SYSTEMS

1. PURPOSE AND SCOPE

This standard establishes performance requirements and methods of test for mercury switches used in protective intrusion alarm circuits to monitor the tilt position of horizontally hinged doors, windows, etc. These devices cause the initiation of an alarm signal to a police panel, central station, or local audible alarm device. The characteristics addressed are those which affect the reliability of the device, with emphasis on those which affect its false alarm susceptibility. This standard does not address 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 to protect the mercury switch enclosure, or a fixed resistor to provide line security by 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 Actuation Angle

Angle of the mounting plane with respect to the vertical at which the switch changes "off" to "on."

3.2 Alarm State of Switch

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

3.3 Deactuation Angle

Angle of the mounting plane with respect to the vertical at which the switch changes from "on" to "off."

3.4 Electrical Balance Switch Circuit

A switch circuit which 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.

3.5 Non-Alarm 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).

3.6 Secure Mode of Alarm System

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

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 mercury 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 (paragraph 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 (dc with resistive load)—both upper and lower limits
- (b) Switch voltage range (dc)—both upper and lower limits
- (c) Classification (see Section 2)
- (d) Tamper resistance features for types III and IV
- (e) Type of material for all components necessary to show compliance with paragraph 4.2.2
- (f) Actuation and deactuation angles for nonadjustable switches or ranges of actuation and deactuation angles for adjustable switches

4.2.2 Material and Configuration

The materials, parts, and components of the switch shall conform to the requirements of Underwriters Laboratories Standard UL 634, Second Edition, Connectors and Switches for Use with Burglar Alarm Systems, sections 3 through 12 [1].

4.2.3 Actuation and Deactuation Angles

The actuation and deactuation angles of each nonadjustable switch specimen measured in accordance with paragraph 5.5.2 shall be within $\pm 1.0^\circ$ of that specified by the manufacturer (paragraph 4.2.1 f). The ranges of actuation and deactuation angles shall extend to at least the limits specified by the manufacturer (paragraph 4.2.1 f). The fixed actuation and deactuation angles of each nonadjustable switch specimen, or a mid-range setting for each adjustable switch specimen, shall remain within $\pm 2.0^\circ$ of the preendurance test values after the normal current endurance test (paragraph 4.2.4.1) and after the shock test (paragraph 4.2.8) or vibration test (paragraph 4.2.9), in accordance with the test schedule (table 5).

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, paragraph 4.2.1). The switch specimens shall be tested at each "current region" (first column of table 1) which overlaps the manufacturer's specified current range. If the manufacturer specified only one current, then that current shall be used. The open circuit voltage shall be six volts dc, unless the manufacturer specifies a single voltage or a voltage range not including six volts, in which case the single voltage or the minimum voltage specified shall be used. The contact resistance requirements are listed in table 1. 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.

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 2 gives the test conditions. The failure criteria to be used are listed in the first row of table 1 for currents greater than 10 milliamperes.

TABLE 1.—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 $> 10 \text{ mA}$	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.....	$> 5 \text{ mV}$	$> 1.1 \times R_{ic}$ or $< 0.9 \times R_{ic}$	$> 1.1 \times R_{io}$ or $< 0.9 \times R_{io}$	$< 100 \text{ k}\Omega$
Lower limit $< 1 \text{ mA}$	Lower limit	$> 1 \text{ mV}$	$> 1.1 \times R_{ic}$ or $< 0.9 \times R_{ic}$	$> 1.1 \times R_{io}$ or $< 0.9 \times R_{io}$	$< 4.8 \text{ V}$

TABLE 2.—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 $+18^\circ \text{C}$ (-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 visible 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 visible 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 and the actuation and deactuation angle requirements of paragraph 4.2.3 after being subjected to 18 shock pulses, in accordance with paragraph 5.5.4.5.

4.2.9 Vibration

The switch specimens tested for vibration sensitivity shall give no false contact closures or openings and shall meet the actuation and deactuation angle requirements of paragraph 4.2.3, when tested in accordance with paragraph 5.5.4.6.

4.2.10 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 one minute, without permitting any current in excess of one milliamperere RMS. The test voltage shall be the appropriate voltage given in table 3. As indicated by the test schedule, table 5, this test shall be performed after the hydrogen sulfide and shock tests for indoor switches, but after the rain exposure for outdoor switches.

TABLE 3. -- *Dielectric strength test voltages*

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

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 rain applied to the top and sides in accordance with paragraph 5.6.2. After the exposure, the switch specimens shall meet the dielectric strength requirement of paragraph 4.2.10.

4.3.3 Dust Penetration

The switch specimens tested for dust penetration shall show no visible 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 visible 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 inch) 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 inch).

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.

5. TEST METHODS

5.1. Sampling

A sample of either 8 or 10 switch specimens shall be selected at random for test, dependent 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.

5.3 Test Schedule

The switches shall be randomly assigned numbers from 1 to 8 or 10. These are used to assign the switches to test groups according to table 4. The three test currents to be used in the endurance tests are also designated in table 4 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 5 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 actuation and deactuation angles, 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.

TABLE 4.—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 5.—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	1
Actuation and deactuation angles.....	4.2.3	5.5.2	2	2	2	
Endurance						
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 switch.....	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	
Vibration.....	4.2.9	5.5.4.6		6		
Dielectric strength.....	4.2.10	5.5.5			9	
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 switch.....	4.3.5	5.6.5			4	
Tamper resistance features (Types III and IV):						
Tamper switch.....	4.4.1	5.7.1		9		
Electrical balance.....	4.4.2	5.7.2		10		

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.

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, consisting of a mounting plate with a shaft for pivoting the plate and switch, shall provide the tilting 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 shall be controlled to $25 \pm 5^\circ \text{C}$ ($77 \pm 9^\circ \text{F}$).

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 indicator is shown in Figure 8-8, Engineers' Relay Handbook, [3]. With the addition of an inverter to the input, this same circuit may be used as the contact-closure indicator. 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 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.

5.4.10 The electrodynamic vibration exciter (paragraph 5.4.9) shall either be equipped with a built-in monitoring accelerometer, or a suitable monitoring accelerometer shall be mounted on the vibration 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 ± 5 percent.

5.5 Common Tests

5.5.1 Material and Configuration

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

5.5.2 Actuation and Deactuation Angle Test

Adjust the actuation angle of the adjustable switch specimens to the midrange angle. For both the adjustable and nonadjustable specimens, make five measurements of the angle at which the switch changes from "off" to "on" and five measurements of the angle at which the switch changes from "on" to "off." If the switch has more than one

*set of contacts, the actuation and deactuation angles for each set shall be measured. Each angular measurement shall be made to a precision of $\pm .5^\circ$ or better. The average of the first five measurements is the preendurance test actuation angle, and the average of the second five measurements is the preendurance test deactuation angle. Following the endurance test, and following the shock test or vibration test (as indicated in the test schedule), the actuation and deactuation angles shall be measured by making five measurements of each angle and averaging the results for each.

5.5.3 Endurance Tests

5.5.3.1 Normal Current Test

Cycle the switch on and off with the switch actuator (paragraph 5.4.6), while switching the normal test current. The on-off cycle time shall be greater than 0.8 second, during which the switch shall be closed for at least 0.3 second, and open for at least 0.3 second. If the switch has more than one set of contacts, each set shall be tested simultaneously. The open and closed resistances (see below) of each set of contacts and the actuation and deactuation angles (paragraph 5.5.2) shall be checked prior to the endurance testing and after 100,000 operations. Each check shall consist of five open resistance and five closed resistance measurements, and five actuation and five deactuation angle measurements, during five successive switch operation cycles. The resistance measurements shall be made at the test current and test voltage using a circuit connected as shown in figure 1. 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 (paragraph 5.4.5). The threshold voltage for these detectors shall be set to within 5 millivolts of the levels given in table 6. The switch will have failed the test if either the open detector counter or closure detector counter does not agree with the actuator counter.

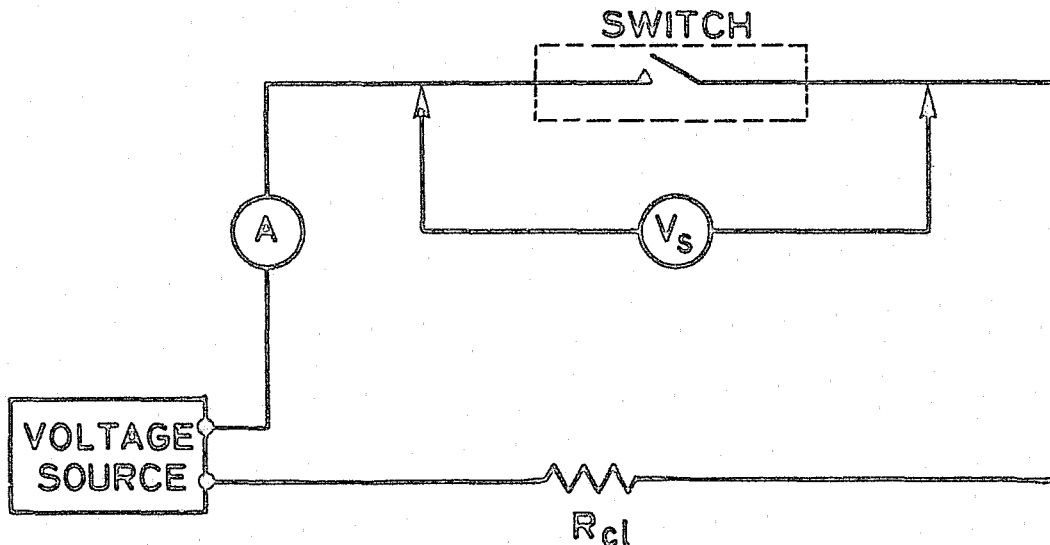


FIGURE 1. Circuit for making contact resistance measurements. A is an ammeter which reads I_c with the switch closed and I_o with the switch open. V_s is the switch voltmeter which reads V_{so} with the switch open and V_{sc} with the switch closed. R_{cl} is the current limiting resistor. The switch-closed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

TABLE 6.—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	$I_c \times R_{ic} + 15 \text{ mV}$	$V_{so} - 100 \text{ mV}$

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

Where: I_c = test current in closed position
 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

5.5.3.2 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 second, during which the switch shall be closed for at least 0.3 second and open for at least 0.3 second. 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 1. During each cycle of this test, the switch contacts shall be monitored by an open detector and a closure detector (paragraph 5.4.5). The threshold voltage for these detectors shall be set to within 5 millivolts of the over 10 milliamperes levels given in table 6. 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 using the equipment and test method for resistance 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. Between environmental tests, this measurement need be made only once.

5.5.4.1 High Temperature Test

The switch shall be placed in a test chamber and the temperature raised to $65 \pm 2^\circ \text{C}$ ($149 \pm 3.6^\circ \text{F}$). 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 $-18 \pm 2^\circ \text{C}$ ($-0.4 \pm 3.6^\circ \text{F}$). 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

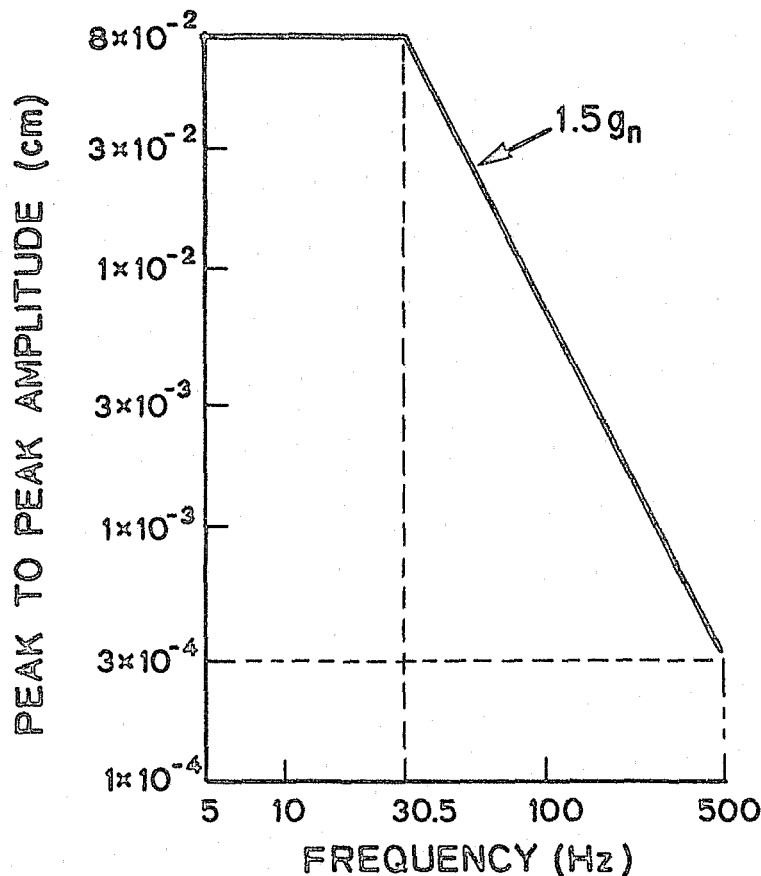
Use NIL-STD-202D [2], dated April 14, 1969, method 213A, test condition G. A sawtooth shock pulse with peak value of 490 meters per second squared ($50 g_n$) and 11 milliseconds duration shall be applied three times in each direction along each of the three mutually perpendicular axes of the switch (total of 18 shocks). Following the test, the switch shall be tested for proper operation as described in paragraph 5.5.4, and the actuation and deactuation angles shall be measured as described in paragraph 5.5.2.

5.5.4.6 Vibration Test

The switch shall be mounted on a vibration exciter (paragraph 5.4.9), so the direction of acceleration is perpendicular to the mounting plane. Two slow linear frequency sweeps (approximately 3 minutes each) shall be made from 5 hertz to 500 hertz with an amplitude of 0.080 ± 0.005 centimeter peak-to-peak, from 5 to 30.5 hertz and 14.7 ± 1.0 meters per second squared ($1.5 \pm 0.1 g_n$) peak-to-peak from 30.5 to 500 hertz (see figure 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 (paragraph 5.4.8). After this, the actuation and deactuation angles shall be measured as described in paragraph 5.5.2.

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 10 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 (paragraph 5.6.2).



VIBRATION TEST AMPLITUDE vs FREQUENCY

FIGURE 2

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 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 (paragraph 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 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 [2], dated April 14, 1969, method 101C, test condition B. A 5 percent salt solution shall be used, the chamber temperature shall be $35 \pm 2^\circ \text{C}$ ($95 \pm 3.6^\circ \text{F}$), and the exposure shall be for 48 hours. 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.

5.6.5 Low Temperature Test—Outdoor Switch

The switch shall be placed in a test chamber and the temperature lowered to $-35 \pm 2^\circ \text{C}$ ($-31 \pm 3.6^\circ \text{F}$). This temperature shall be maintained for 4 hours. 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 [$-35 \pm 2^\circ \text{C}$ ($-31 \pm 3.6^\circ \text{F}$) for type II and IV switches, or $-18 \pm 2^\circ \text{C}$ ($-0.4 \pm 3.6^\circ \text{F}$) 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 $0 \pm 2^\circ \text{C}$ ($32 \pm 3.6^\circ \text{F}$), then to $25 \pm 2^\circ \text{C}$ ($77 \pm 3.6^\circ \text{F}$), and finally to $65 \pm 2^\circ \text{C}$ ($149 \pm 3.6^\circ \text{F}$). At each temperature, a measurement of the resistance of each state of the switch shall be made.

Appendix A—REFERENCES

- [1] Underwriters Laboratories 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] MIL-STD-202D, dated April 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 Laboratories Standard UL 1023-1972, "Household Burglar-Alarm System Units."