

**ULC
STANDARD**

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**STANDARD FOR BURGLARY RESISTANT ELECTRONIC
COMBINATION LOCKS**

Prepared and Published by:



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COMBINATION LOCKS

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CAN/CSA-C22.2 No. 0.17-92, Evaluation of Properties of Polymeric Materials
C22.1-94, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations
C22.2 No. 1-94, Audio, Video, and Similar Electronic Equipment

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ULC-S318-96, Power Supplies for Burglar Alarm Systems
ULC/ORD-C887-1998, Timelocks
ULC-S337-98, Standard for Delayed-Action Timelocks

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ASTM D412-92, Test Methods for Vulcanized Rubber and Plastic Rubbers and Plastic Elastomers - Tension

STANDARD FOR BURGLARY RESISTANT ELECTRONIC COMBINATION LOCKS

PREFACE

This is the Reaffirmation of the First Edition of the Standard for Burglary Resistant Electronic combination Locks, ULC-S334.

This Edition of the Standard has been formally approved by the ULC Standards Committee on Physical Security Equipment.

This Standard has been developed in compliance with the requirements of SCC for accreditation of a Standards Development Organization.

Only metric SI units of measurement are used in this Standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

This First Edition National Standard of Canada has been reaffirmed.

Attention is drawn to the possibility that some of the elements of this Canadian standard may be the subject of patents rights. ULC Standards shall not be held responsible for identifying any or all such patents rights.

Requests for interpretation of this Standard should be sent to ULC Standards. The requests should be worded in such a manner as to permit a “yes” or “no” answer based on the literal text of the requirement concerned.

The review and action to revise or reaffirm this Standard will not exceed 5 years from the date of publication, unless the Standard is identified as fitting within a stabilized category, whereby the review will commence within the appropriate time frame set out by ULC Standards.

This Standard is intended to be used for conformity assessment.

1. SCOPE

1.1 These requirements cover burglary resistant electronic combination locks designed for attachment on doors of safes, chests, vaults, automated banking machines, depository units, and the like, to provide a means of locking the boltwork against unauthorized opening.

1.2 These requirements are intended to test the ability of burglary resistant electronic combination locks to resist unauthorized opening for a limited period of time. Electronic combination locks covered by these requirements may or may not have integral protection against entry by force.

1.3 These requirements cover burglary resistant electronic combination locks powered by electrical circuits, or they generate their own power as a function of their operation. A power supply that is used to energize a burglary resistant electronic combination lock shall comply with the requirements of the Standard for Power Supplies for Burglar Alarm Systems, ULC-S318.

1.4 If a burglary resistant electronic combination lock has a timelock feature, it shall comply with ULC-ORD-C887, Timelocks.

1.5 If a burglary resistant electronic combination lock has a time delay feature in any user mode, it shall comply with ULC-S337, Standard for Delayed-Action Timelocks.

1.6 The requirements of this Standard do not apply to components and systems external to the burglary resistant electronic combination lock which are required for the administration and operation of the locking system.

2. GLOSSARY

Note: For the purpose of this Standard, the definitions in *italic print* shall apply.

AUDIT TRAIL - Minimum number of events retained by the burglary resistant electronic combination lock to specifically include date, time, all types of events, and identification.

DUAL CUSTODY - Two persons with two different combinations.

ELECTRONIC OVERRIDE - A unique combination allowing entry into the lock, which may be provided by the manufacturer.

EXTRA-LOW VOLTAGE - Any voltage up to and including 30 V.

FIRMWARE - Basic operating program which is inherent to the system and is not field programmable.

HIGH VOLTAGE - Any voltage above 750 V.

LOW VOLTAGE - Any voltage from 31 to 750 V inclusive.

OVERVIEW - Technique/method of obtaining the combination of a burglary resistant electronic combination lock by unauthorized viewing while the combination is being dialled by the custodian.

MANIPULATION - Unauthorized opening of the burglary resistant electronic combination lock by methods such as sense, sight, touch, hearing, or by electromechanical devices.

PRIMARY BATTERY - Any battery which, by construction, is not intended to be recharged.

SECONDARY BATTERY - A battery that is capable of multiple charge/discharge cycles.

SINGLE CUSTODY - One person with one combination.

SOFTWARE - A program, or set of programs and associated data, procedures, rules, documentation, and materials concerned with the use, operation, and maintenance of an automated information or message processing system or computing system.

STANDBY CONDITION - The ready-to-operate condition which exists prior to being operated to unlock.

WORKING HOURS - A time period which may include one person working 'X' hours, two persons working together one-half 'X' hours, or the like (e.g. one person working 20 h, two persons working together 10 h, etc.). This time limit is not to include the time spent on review and examination of samples.

3. INSTALLATION AND OPERATING INSTRUCTIONS

3.1 A copy of the operating and installation instructions together with related schematic wiring diagrams and installation drawings intended to accompany the burglary resistant electronic combination lock are to be furnished with the sample submitted for investigation. These items are to be used as a guide in the examination and test of the burglary resistant electronic combination lock.

3.2 The instructions and drawings shall include at least the following:

- A** Typical installation instructions and drawings and complete representative installation wiring diagram(s) for the burglary resistant electronic combination lock(s) indicating recommended wiring methods;
- B** A concise description of the operation, testing, and maintenance procedures for the burglary resistant electronic combination lock(s), and recommended testing frequency;
- C** User replacement parts, such as lamps or batteries, identified in the instructions by a part number, manufacturer's model number, or the equivalent;
- D** A description of the conditions which might be anticipated as resulting in impaired operation of the burglary resistant electronic combination lock; and
- E** A description of any features provided which reduce the risk of fire or electric shock, and a warning against bypassing such features.

3.3 Operating and installation instructions shall be provided with each burglary resistant electronic combination lock.

4. CONSTRUCTION

4.1 GENERAL

4.1.1 A burglary resistant electronic combination lock shall permit a choice of codes or combinations as specified in Table 1 excluding any command sequence up to a maximum of ten. If the lock allows for the use of multiple users, each with their own code or combination, the possible number of codes or combinations shall be as specified in Table 1.

4.1.2 A burglary resistant electronic combination lock shall have *audit trail* capability as specified in Table 1 with the records safeguarded from unauthorized removal.

4.1.3 A burglary resistant electronic combination lock shall permit *single custody* or *dual custody* as specified in Table 1.

4.1.4 A burglary resistant electronic combination lock may have an *electronic override* code as outlined in Table 1.

4.2 ENCLOSURE

4.2.1 General

4.2.1.1 A burglary resistant electronic combination lock shall resist the abuses to which it is likely to be subjected without adversely affecting its performance and without increasing its fire and shock hazard due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

4.2.1.2 Electrical parts of a burglary resistant electronic combination lock shall be located or enclosed to provide protection against accidental contact with uninsulated *low voltage* live parts.

4.2.1.3 Operating parts, such as gear mechanisms, light-duty relays, and similar devices, shall be protected against fouling by dust or other material which may adversely affect their normal operation.

4.2.1.4 An enclosure containing other than power limited circuits shall be constructed to minimize the possibility of emission of flame, molten metal, flaming or glowing particles, or flaming drops. See Abnormal Operation Test, Subsection 5.28.

4.2.1.5 Enclosures shall be in accordance with Subsection 4.2.2, Cast Metal Enclosures; Subsection 4.2.3, Nonmetallic Enclosure; or Subsection 4.2.4, Sheet Metal Enclosures.

4.2.2 Cast Metal Enclosure

4.2.2.1 The thickness of cast metal used for an enclosure shall be as indicated in Table 2.

4.2.2.2 Cast metal of lesser thickness may be employed if, upon investigation, consideration being given to the shape, size, and function of the enclosure, it is found to have equivalent mechanical strength. See Mechanical Strength Tests for Enclosures, Subsection 5.26.

4.2.3 Nonmetallic Enclosure

4.2.3.1 Among the factors to be taken into consideration when judging the acceptability of a nonmetallic enclosure with respect to aging are: mechanical strength; resistance to impact; moisture-absorption; flammability and resistance to ignition from electrical sources, dielectric strength insulation resistance; resistance to arc tracking; and resistance to distortion and creeping at temperatures to which the material may be subjected under any condition of use. See Tests on Plastic Materials, Subsection 5.25, and Mechanical Strength Tests for Enclosures, Subsection 5.26.

4.2.4 Sheet Metal Enclosure

4.2.4.1 The thickness of sheet metal employed for the enclosure of a burglary resistant electronic combination lock shall be not less than that indicated in Table 3 and in Table 4.

EXCEPTION: Sheet metal of lesser thickness may be employed if, consideration being given to the shape, size and function of the enclosure, it provides equivalent mechanical strength.

4.2.4.2 A plate or plug closure for an unused conduit opening or other hole in the enclosure shall have a thickness not less than:

- A** 0.36 mm for steel or 0.48 mm for nonferrous metal for a hole having a maximum dimension of 6.4 mm; or
- B** 0.69 mm for steel or 0.81 mm for nonferrous metal for a hole having a maximum dimension of 35 mm.

4.2.4.3 A hole larger than 35 mm diameter shall have a closure whose thickness is not less than that required for the enclosure of the product or shall have a standard knockout seal. Such plates or plugs shall be securely mounted.

4.2.4.4 A knockout in a sheet metal enclosure shall be secured but shall be capable of being removed without undue deformation of the enclosure.

4.2.4.5 A knockout shall be provided with a surrounding surface area of sufficient size to permit seating of a conduit bushing, and shall be so located that a bushing employed at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those indicated under Subsection 4.18, Spacings.

4.2.4.6 An enclosure intended for recessed mounting and whose front panel is to be flush with the surface of the wall shall have no openings that vent into concealed spaces of a building structure, such as into hollow spaces in the wall, when the product is mounted as intended.

4.2.4.7 The requirement in Clause 4.2.4.6 does not apply to an opening for a mounting screw or nail or for a manufacturing operation, such as paint drainage, provided:

- A** No such opening has a dimension greater than 7 mm or an area greater than 35 mm²; and

- B** Where more than four mounting screws are required additional mounting holes shall be not more than 300 mm apart.

4.2.4.8 A sheet metal member to which a wiring system is to be connected in the field shall have a thickness not less than 0.81 mm if of uncoated steel, of not less than 0.86 mm if of galvanized steel, and of not less than 1.14 mm if of nonferrous metal.

4.3 ASSEMBLY

4.3.1 The burglary resistant electronic combination lock shall be factory-built as a complete assembly and shall include all the essential components, except batteries, necessary for its intended function when initially installed (used) as intended.

4.4 CORROSION PROTECTION

4.4.1 Iron and steel parts, other than bearings, and the like where such protection is impracticable, shall be protected against corrosion by enamelling, galvanizing, sherardizing, plating, or other equivalent means. Bearing surfaces shall be of such materials and construction as to resist binding due to corrosion.

4.4.2 The requirement specified in Clause 4.4.1 applies to all enclosures of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation may depend.

EXCEPTION No. 1: This requirement does not apply to parts such as washers, screws, bolts, and the like, if corrosion of such unprotected parts would not be likely to impair the operation of the lock.

EXCEPTION NO. 2: Parts made of stainless steel, polished or treated, if necessary, do not require additional protection against corrosion.

4.4.3 Metals used in a burglary resistant electronic combination lock shall be galvanically compatible.

EXCEPTION: If galvanic action does not result in impaired operation this requirement does not apply.

4.4.4 Hinges and other attachments shall be resistant to corrosion.

4.5 FIELD WIRING CONNECTIONS

4.5.1 General

4.5.1.1 Wiring terminals or leads shall be provided for connection of conductors of at least the size required by the Canadian Electrical Code, Part I.

4.5.2 Field Wiring Compartment

4.5.2.1 The field wiring compartment in which connections are to be made shall be of acceptable size for completing all wiring connections as specified by the installation wiring diagram.

4.5.2.2 Internal components in the wiring area and wire insulation shall be protected from sharp edges by insulating or metal barriers having smooth, rounded edges.

4.5.2.3 The field wiring compartment of a burglary resistant electronic combination lock using Class 1 wiring methods as defined in C22.1, Canadian Electrical Code, Part I, shall have provision for the connection of armoured cable or conduit.

4.5.3 Terminals (General Application)

4.5.3.1 A wiring terminal shall be prevented from turning.

4.5.3.2 Any of the following terminal configurations may be employed on all circuits to which field wiring connections are made:

- A** Connectors and Lugs: Non-ferrous soldering lugs or solderless (pressure) wire connectors shall be used for No. 8 AWG and larger wires. If the connectors or lugs are secured to a plate, the plate thickness shall be not less than 1.3 mm thick. Securing screws may be plated steel; and
- B** Terminal Plates With Wire Binding Screws (for No. 10 AWG and Smaller Wires): A terminal plate tapped for a wire binding screw shall be of a non-ferrous metal not less than 1.3 mm in thickness for a No. 8 or larger screw, and not less than 0.76 mm in thickness for a No. 6 screw. The plate shall have not less than two full threads in the metal (the terminal plate metal may be extruded to provide the two full threads) and shall have upturned lugs, clamps, or the equivalent to hold the wires in position. If a wire binding screw is employed at a wiring terminal, the screw shall be not smaller than a No. 8 except that a No. 6 screw may be employed for the connection of a No. 14 AWG or smaller conductor and a No. 4 screw may be used for No. 19 AWG or smaller conductor. The screws may be plated steel. Other constructions may be employed if they provide equivalent thread security of the wire binding screw. If two or more conductors are intended to be connected by wrapping under the same screw, a non-ferrous intervening metal washer shall be employed for each additional conductor. A separate washer is not required if two conductors are separated and intended to be secured under a common clamping plate. If the wires protrude above terminal barriers, the non-ferrous separator shall include means, such as upturned tabs, or sides to retain the wire.

4.5.4 Terminals (Qualified Application)

4.5.4.1 Any of the following terminal configurations may be employed for connection of field wiring provided all of the conditions in Clause 4.5.4.2 are met. See Tests on Special Terminal Assemblies, Subsection 5.27:

- A Telephone Type Terminals: Non-ferrous terminal plates employing a narrow V-shaped slot for securing of a conductor in a special post design. Requires special tool for wire connection;
- B Solderless Wrapped Terminals: Solderless wrapped non-ferrous terminals which require a special tool and terminal post design;
- C Quick Connect Terminals: Non-ferrous quick-connect (push type) terminals consisting of male posts permanently secured to the device and provided with compatible female connectors for connection to field wiring. Requires special tool for crimping of field wires. Mating terminals shall be shipped with the product with instructions for their installation;
- D Push-In Terminals: Non-ferrous (screwless) push-in terminals of the type employed on some switches and receptacles. Solid conductors are pushed into slots containing spring type contacts. The leads can be removed by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals are not considered acceptable for use with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used;
- E Solder Terminals: Conventional non-ferrous solder terminals; and
- F Other Terminal connections may be employed if found to be equivalent to items A through E of this clause and limited to the same restrictions.

4.5.4.2 Any of the terminal configuration listed in Clause 4.5.4.1 may be employed for connection of field wiring provided all of the following indicated conditions are met:

- A If a special tool is required for connection, its use shall be indicated on the installation wiring diagram by name of manufacturer and model number or equivalent, along with information as to where the tool may be obtained;
- B The range of wire sizes shall be indicated on the installation wiring diagram;
- C The wire size to be employed shall have the current-carrying capacity of the circuit application; and
- D If a lead is to be disconnected for testing or routine servicing it shall comply with the requirements of Subsection 5.27.2, Disconnection and Reconnection.

4.5.5 Leads

4.5.5.1 If leads are provided in lieu of wiring terminals, they shall be:

- A Stranded copper;
- B Not less than 150 mm long provided with strain relief;
- C Not smaller than No. 22 AWG or not smaller than No. 18 AWG for connection of a line-voltage source; and

- D Provided with insulation, if of rubber or plastic, not less than 0.79 mm in thickness.

4.5.5.2 Leads may be less than 150 mm in length if it is evident that the use of longer leads may result in a hazard.

4.6 POLARITY IDENTIFICATION

4.6.1 In a burglary resistant electronic combination lock intended to be connected to a grounded circuit, one terminal or lead shall be identified for the connection of the grounded conductor. The identified terminal or lead shall be the one which is connected to screw shells of lampholders and to which no primary overcurrent protective devices of the single pole type are connected.

4.6.2 A terminal intended for the connection of a grounded supply conductor shall be of, or plated with, metal that is substantially white in colour and shall be readily distinguishable from the other terminals; or proper identification of the terminal shall be clearly shown in some other manner, such as on an attached wiring diagram. A lead intended for the connection of a grounded power supply conductor shall be finished to show a white or natural grey colour and shall be readily distinguishable from the other leads.

4.7 INTERNAL WIRING

4.7.1 The internal wiring of a burglary resistant electronic combination lock shall consist of conductors having insulation rated for the potential involved and the temperatures to which it may be subjected and having adequate mechanical strength and current-carrying capacity for the service. The wiring shall be routed away from moving parts and sharp projections and held in place with clamps, string, ties, or equivalent, unless of sufficient rigidity to retain a shaped form.

4.7.2 Leads or a cable assembly, connected to parts mounted on a hinged cover, shall be of sufficient length to permit the full opening of the cover without applying stress to the leads or their connections. The leads shall be secured or equivalently arranged to prevent abrasion of insulation and jamming between parts of the enclosure.

4.7.3 Insulation, such as coated fabric and extruded tubing, shall not be affected physically or electrically by the temperature or other environmental conditions to which it may be subjected in actual use.

4.7.4 Wireways shall be smooth and entirely free from sharp edges, burrs, fins, moving parts, and the like, which may cause abrasion of the conductor insulation. Holes in sheet-metal walls through which insulated wires pass shall be provided with a bushing if the wall is 1.07 mm or less in thickness. Holes in walls thicker than 1.07 mm shall have smooth, well-rounded edges.

4.7.5 All splices and connections shall be mechanically secured and bonded electrically.

4.7.6 Stranded conductors clamped under wire-binding screws or similar parts shall have the individual strands soldered together or equivalently arranged to insure reliable connections.

4.7.7 A splice shall be provided with insulation equivalent to that of the wires involved if permanence of required electrical spacing between the splice and uninsulated metal parts is not assured.

4.7.8 A printed wiring assembly employing insulating coatings or encapsulation shall be tested for dielectric voltage withstand before and after being treated. If it is impractical to use untreated samples, finished samples shall be subjected to the Dielectric Voltage Withstand Test, Subsection 5.22, after they are subjected to the Humidity Test, Subsection 5.15; Temperature Test, Subsection 5.21; and other applicable tests described in this Standard. Electrical connections between circuits under test shall be disconnected prior to testing.

4.8 SEPARATION OF CIRCUITS

4.8.1 Internal wiring of circuits which operate at different potentials shall be separated by barriers, clamps, routing, or other equivalent means, unless all conductors are provided with insulation which is rated for the highest potential involved.

4.8.2 If a barrier is used to provide separation between the wiring of different circuits, it shall be of metal or of insulating material. A barrier of insulating material shall be not less than 0.8 mm in thickness. Any clearances between the edge of a barrier and a compartment wall shall be not less than 1.6 mm.

4.9 BONDING FOR GROUNDING

4.9.1 An exposed (see Clause 4.9.2) non-current-carrying metal part, which is liable to become energized, of a burglary resistant electronic combination lock operating at more than 30 V or of a burglary resistant electronic combination lock equipped with auxiliary function contacts rated at more than 30 V shall be reliably bonded to the point of connection of the field-equipment grounding terminal or lead, if provided or required, and to the metal surrounding the knockout, hole, or bushing provided for field power supply connections.

4.9.2 Except as indicated in Clause 4.9.3, uninsulated metal parts of electrical enclosures, capacitors, and other electrical components are to be bonded for grounding if they may be contacted by the user or by a serviceman in servicing the equipment.

4.9.3 The following metal parts need not comply with the requirement of Clause 4.9.2:

- A** Adhesive attached metal foil markings, screws, handles, and the like which are located on the unsecured side of the burglary resistant electronic combination lock enclosure and isolated from electrical components or wiring by grounded metal parts so that they are not liable to become energized;
- B** Isolated metal parts, such as small assembly screws, and the like which are positively separated from wiring and uninsulated live parts;
- C** Panels and covers which do not enclose uninsulated live parts if wiring is positively separated from the panel or cover so that it is not liable to become energized; and

- D Panels and covers which are insulated from electrical components and wiring by an insulated barrier of vulcanized fibre, varnished cloth, phenolic composition, or similar material not less than 0.8 mm thick and reliably secured in place.

4.9.4 A bonding conductor shall be of material suitable for use as an electrical conductor. If of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The conductor shall be not smaller than the maximum size wire employed in the circuit wiring of the component or part. A separate bonding conductor or strap shall be installed in such a manner that it is protected from mechanical damage.

4.9.5 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, brazing, or welding. The bonding connection shall reliably penetrate nonconductive coatings such as paint. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material.

NOTE 1: A bolted or screwed connection that incorporates a star washer under the screw head is considered acceptable for penetrating nonconductive coatings.

NOTE 2: Where the bonding means depends upon screw threads, two or more screws or two full threads of a single screw engaging metal are considered acceptable.

NOTE 3: Metal-to-metal hinge-bearing members for doors or covers may be considered as a means for bonding the door or cover for grounding providing that a multiple bearing, pin-type hinge is employed.

4.9.6 Splices shall not be employed in conductors used to bond electrical enclosures or components. On an equipment grounding terminal, a wire binding screw intended for the connection of an equipment grounding conductor shall have a green coloured head that is hexagonal, slotted, or both.

4.9.7 The surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be green, with or without one or more yellow stripes. No other lead shall be so identified.

4.10 INSULATING MATERIALS

4.10.1 A base for the support of live-metal parts shall be of a strong, noncombustible, moisture-resistant insulating material, such as porcelain, phenolic or cold-molded composition, or the equivalent.

4.10.2 A base mounted on a metal surface which may be grounded shall be provided with an insulating barrier between the mounting surface and all live-metal parts on the underside of the base which are not staked, upset, sealed, or equivalently prevented from loosening so as to prevent such parts and the ends of replaceable terminal screws from coming in contact with the supporting surface.

4.10.3 Ordinary vulcanized fibre may be used for insulating bushings, washers, separators, and barriers, but not for the sole support of live-metal parts where shrinkage, current leakage, or warping of the fibre may introduce an electric shock or risk of fire.

4.10.4 A countersunk sealed live part shall be covered with a waterproof insulating compound which will not melt at a temperature 15°C higher than the maximum normal operating temperature of the assembly, and at not less than 65°C in any case. The depth or thickness of scaling compound shall be not less than 3.2 mm.

4.10.5 The thickness of a flat sheet of insulating material, such as phenolic composition, or the equivalent, employed for panel mounting of parts shall be not less than that indicated in Table 5.

4.11 MOUNTING OF PARTS

4.11.1 All parts shall be securely mounted in position and prevented from loosening or turning if such motion may affect the normal performance of the equipment or introduce an electric shock or risk of fire.

4.11.2 A switch, lampholder, attachment-plug receptacle, plug connector, or similar electrical component, shall be mounted securely and except as noted in Clause 4.11.3, shall be prevented from turning.

4.11.3 The requirement that a switch be prevented from turning may be waived if all four of the following conditions are met:

- A** The switch is to be of a plunger or other type that does not tend to rotate when operated;
- B** The means for mounting the switch makes it unlikely that the operation of the switch will loosen it;
- C** The spacings are not to be reduced below the minimum required values if the switch rotates; and
- D** The normal operation of the switch is to be by mechanical means rather than by direct contact by persons.

NOTE: A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a non-removable jewel, need not be prevented from turning if rotation cannot reduce spacings below the minimum required values.

4.11.4 Uninsulated live-metal parts shall be secured to their supporting surfaces so that they will be prevented from turning or shifting in position if such motion may result in a reduction of spacings to less than those indicated in Subsection 4.18, Spacings.

4.11.5 Friction between surfaces is not acceptable as a means to prevent turning, loosening, or shifting of a part as required in Clauses 4.11.1 and 4.11.4, but a lock washer that provides both spring take-up and an interference lock or equivalent means may be accepted.

4.12 CURRENT-CARRYING PARTS

4.12.1 A current-carrying part shall be of gold, silver, copper, or a copper alloy or equivalent.

4.12.2 Bearings, hinges, and the like, are not acceptable for use as carrying current parts.

4.13 BUSHINGS

4.13.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent which shall provide a smoothly rounded surface against which the cord may bear.

4.13.2 If the cord hole is in phenolic composition or other suitable nonconducting material, or in metal not less than 1.07 mm in thickness, a smooth, rounded surface is considered to be the equivalent of a bushing.

4.13.3 Ceramic materials and some molded compositions are considered to be acceptable for insulating bushings, but bushings of wood and of hot-molded shellac are not acceptable.

4.13.4 Fibre may be employed where it will not be subjected to a temperature higher than 90°C under normal operating conditions if the bushing is not less than 1.2 mm in thickness and if it is so formed and secured in place that it will not be affected by conditions of ordinary moisture.

4.13.5 If a soft-rubber bushing is employed in a hole in metal, the hole shall be free from sharp edges, burrs, projections, and the like, which would be liable to cut into the rubber.

4.13.6 An insulating metal grommet may be considered to be acceptable in lieu of an insulating bushing, provided that the insulating material used is not less than 0.8 mm in thickness and fills completely the space between the grommet and the metal in which it is mounted.

4.14 TRANSFORMERS, COILS AND RELAYS

4.14.1 Except as noted in Clause 4.14.2, a transformer shall be of the two-coil or insulated type.

4.14.2 An autotransformer may be employed provided that the terminal or lead connected to the autotransformer winding which is common to both input and output circuits is identified and the output circuits are located only within the enclosure containing the autotransformer. See Clause 4.6.1.

4.14.3 Coils shall be treated with an insulating varnish and baked, or otherwise impregnated, to exclude moisture.

4.14.4 Film-coated wire is not required to be given additional treatment to prevent moisture absorption.

4.15 SWITCHES

4.15.1 A switch provided as part of the burglary resistant electronic combination lock shall have a current and voltage rating not less than that of the circuit which it controls when the

burglary resistant electronic combination lock is operated under any condition of intended service. If the circuit controlled has a power factor less than 75%, the switch shall have a horsepower rating (judged on the basis of the ampere equivalent) or a rating of not less than 200% of the maximum load current.

4.16 OVERCURRENT PROTECTION

4.16.1 If a primary circuit breaker or fuses are provided, their rating shall be in accordance with the maximum input to the burglary resistant electronic combination lock.

4.17 SEMICONDUCTORS

4.17.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they may be exposed in service.

4.18 SPACINGS

4.18.1 Spacings between uninsulated live parts and between uninsulated live parts and dead-metal parts shall be not less than those indicated in Clauses 4.18.2 through 4.18.10.

4.18.2 The spacing between an uninsulated live part and a wall or cover of a metal enclosure, a fitting for conduit or metal-clad cable, and a metal piece attached to a metal enclosure, where deformation of the enclosure is liable to reduce spacings, shall be not less than that indicated in Table 6 .

4.18.3 The spacings between an uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded dead metal part other than the enclosure, and exposed dead-metal part which is isolated (insulated) shall be not less than those indicated in Table 6.

4.18.4 If a short circuit between uninsulated live parts of the same polarity would prevent the normal operation of the burglary resistant electronic combination lock without simultaneously producing an audible signal, the spacings between such parts shall be not less than those indicated for "Other Parts" in Table 6.

4.18.5 The through-air and over-surface spacings at an individual component part shall be judged on the basis of the volt-amperes used and controlled by the individual component. However, the spacing from one component to another, and from any component to the enclosure or to other uninsulated dead metal parts excluding the component mounting surface, shall be judged on the basis of the maximum voltage and total volt-ampere rating of all components in the enclosure.

4.18.6 The spacing requirements in Table 6 shall not apply to the inherent spacings of a component which is provided as part of the burglary resistant electronic combination lock, except at wiring terminals. Such spacings shall be judged on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete device, including clearances to dead metal or enclosures, shall be those indicated in Table 6.