UL 294

STANDARD FOR SAFETY

Access Control System Units

UL Standard for Safety for Access Control System Units, UL 294

Eighth Edition, Dated May 24, 2023

Summary of Topics

This new edition of ANSI/UL 294 dated May 24, 2023, includes updates, clarifications, and revisions throughout including the following:

- ***Power over communication cable equipment updates***
- ***Remote Access requirements***
- ***Software/Firmware Upgrades***
- ***Egress Control Systems Requirements***
- ***Key Management System Requirements***
- ***Overload and Endurance Test (power supply) updates***
- ***Destructive Attack Test updates***

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated July 29, 2022 and February 17, 2023.

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Standard for Access Control System Units

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May 24, 2023

This ANSI/UL Standard for Safety consists of the Eighth Edition.

The most recent designation of ANSI/UL 294 as an American National Standard (ANSI) occurred on May 24, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in ULSE's Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements apply to the construction, performance, and operation of physical access control equipment and/or systems intended to regulate or control:

a) Entry into and/or exit from a controlled area, protected area or a restricted area or

b) Access to or the use of a device(s) by electrical, electronic or mechanical means.

1.2 The extent of control of entry/exit may include the reporting and recording of related activity. The accuracy of the logged data is not evaluated by this standard.

1.3 This standard defines the minimum requirements as they apply to the construction, performance and operation of such systems, equipment and/or computer equipment as well as tiered characteristics to meet four levels of security performance with Level I (lowest level security equipment) to Level IV (highest level security equipment).

1.4 Where an access control equipment and/or system incorporates the features and functions of a burglar alarm control unit, the requirements of the Standard for Proprietary Burglar Alarm Units and Systems, UL 1076, or the applicable section of the Standard for Commercial Premises Security Alarm Units and Systems, UL 2610, shall also apply.

1.5 These requirements apply to computer equipment that, when used in conjunction with the main control unit, is necessary to support the operation (granting (authorized) or denying (unauthorized) access) of the access control system. This Standard does not apply to supplementary computer equipment that is not necessary for operation of the access control system if electrical transients or single opens, earth ground faults or wire-to-wire shorts on the circuit connection from the computer to the access control system does not inhibit intended operation or provide unauthorized entry.

2 General Information

2.1 For equipment utilizing power over communications cables, refer to 35.7, Power over communications cable equipment. Compliance with IEEE 802.3 (at or af) specifications shall not be verified as part of these requirements.

2.2 Biometric equipment parameters such as False Acceptance Rate (FAR), False Rejection Rates (FRR), Failure to Enroll, Failure to Acquire, and other biometric quality parameters, are not specifically evaluated as part of this standard. See Section 68, Biometric Test.

2.3 Access control systems that include duress signaling features are additionally evaluated per UL 636, or the applicable section of UL 2610.

2.4 Products intended for use in air-handling spaces in Accordance with Section 300.22, (C) of NFPA 70, are additionally investigated to the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043.

2.5 Products that utilize input, output and/or control devices that are not interconnected by a solid medium, such as cable, optical fiber, or the like, but provide signaling by means of low power radio frequency (RF) defined by the Code of Federal Regulations (CFR), Title 47, Part 15, shall comply with the Short-Range Radio Frequency (RF) Tests in UL 2610, as applicable. The following tests are not considered necessary for access control products:

a) Clash Error;

b) Interference Protection;

c) Tamper Protection; and

d) Time to Report Alarm.

Exception No. 1: Wireless access control credentials (i.e. cards, tokens, electronic devices) are not subject to the RF requirements noted.

Exception No. 2: Egress control systems (i.e. Infant Protection/Patient Wandering systems; see 35.9) are subject to all RF tests noted in UL 2610 (Short-Range Radio Frequency (RF) Tests). When the tag or credential of an egress control system is an active element of the intended two-way RF transmission functionality, the tag/credential is also subject to the RF tests noted above as applicable.

2.6 Unless otherwise specified, the fundamental compliance criteria of this Standard indicates that the access control system and its components shall not inhibit intended operation, or provide unauthorized entry, when subject to the tests and requirements documented within.

2.7 Electromechanical or electromagnetic door locking devices are typically evaluated in accordance with UL 1034.

2.8 Systems and components may also be utilized in accordance with NFPA 101, International Building Code and the like.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Annex A for a list of Standards covering components generally used in the products covered by this standard.

3.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

3.3 A component shall be used in accordance with its rating established for the intended conditions of use.

3.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3.5 Compliance of laser products with the Code of Federal Regulations (CFR), Title 21, Part 1040, shall be determined by:

a) Determining the Class of the laser product and the Class of the radiation emitted by the laser product (as defined in the CFR) from the manufacturer's Center for Devices and Radiological Health (CDRH) product report;

b) Verifying that the manufacturer’s markings and labels having the information specified in the CFR are affixed on the laser product (as defined in the CFR);

c) Determining that the corresponding construction features, such as protective housing, interlocks, and similar features, are provided in accordance with the CFR;

d) Determining that the resulting construction complies with the construction requirements of this standard; and

e) Verifying that the manufacturer's safety instructions required by the CFR are provided with the laser product (as defined in the CFR).

4 Units of Measurement

4.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4.2 Unless otherwise indicated, all voltage and current values mentioned in this standard are root-mean-square (rms).

5 Referenced Publications

5.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

5.2 The following publications are referenced in this Standard:

ANSI C80.1, *Specifications for Zinc-Coated Rigid Steel Conduit*

ANSI S12.31, *Precision Methods for the Determination of Sound Power Levels of Broad Band Noise Sources in Reverberation Rooms*

ANSI S12.32, *Precision Methods for the Determination of Sound Power Levels of Discrete Frequency and Narrow Band Noise Sources in Reverberation Rooms*

ASTM A653/A653M, *Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM A90/A90M, *Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM D396, *Standard Specification for Fuel Oils*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers – Tension*

ASTM E230/E230M, *Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples*

47 CFR Part 15, *Radio Frequency Devices*

FIPS 46-3, *Federal Information Processing Standard, Data Encryption Standard*

FIPS 140-2, *Security Requirements for Cryptographic Modules*

FIPS 180-4, *Secure Hash Standard (SHS)*

FIPS 185, *Escrowed Encryption Standard*

FIPS 186-4, *Digital Signature Standard (DSS)*

FIPS 198-1, *The Keyed-Hash Message Authentication Code (HMAC)*

FIPS 197, *Federal Information Processing Standard, Advanced Encryption Standard*

IEEE 802.3, *Standard for Ethernet*

IEC 61000-4-5, *Surge Tests per Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEEE 1394, *Standard for a High-Performance Serial Bus*

IEEE C62.41, *IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits*

MIL-STD-338, *Cleaning and Treatment of Aluminum Parts Prior to Painting*

MIL-STD-750F, *Test Methods for Semiconductor Devices*

MIL-STD-883H, *Department of Defense Test Method Standard: Microcircuits*

NFPA 70, *National Electrical Code*

NFPA 101, *Life Safety Code*

NIST SP 800-38B, *Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication*

NIST SP 800-38C, *Recommendation for Block Cipher Modes of Operation: The CCM Mode for Authentication and Confidentiality*

NIST SP 800-38D, *Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC*

NIST SP 800-67, *Recommendation for the Triple Data Encryption Algorithm (TDEA) Block Cipher*

TIA-568-C.2, *Balanced Twisted-Pair Telecommunications Cabling and Components*

UL 50, *Enclosures for Electrical Equipment, Non-Environmental Considerations*

UL 305, *Panic Hardware*

UL 310, *Electrical Quick-Connect Terminals*

UL 437, *Key Locks*

UL 486A-486B, *Wire Connectors*

UL 486E, *Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors*

UL 497A, *Secondary Protectors for Communications Circuits*

UL 497B, *Protectors for Data Communications and Fire-Alarm Circuits*

UL 636, *Hold Up Units and Alarm Systems*

UL 746C, *Polymeric Materials – Use in Electrical Evaluations*

UL 796, *Printed Wiring Boards*

UL 827, *Central-Station Alarm Services*

UL 969, *Marking and Labeling Systems*

UL 1034, *Burglary-Resistant Electric Locking Mechanisms*

UL 1059, *Terminal Blocks*

UL 1076, *Proprietary Burglar Alarm Units and Systems*

UL 1449, *Surge Protective Devices*

UL 1481, *Power Supplies for Fire-Protective Signaling Systems*

UL 1642, *Lithium Batteries*

UL 1778, *Uninterruptible Power Systems*

UL 1863, *Communications-Circuit Accessories*

UL 1977, *Component Connectors for Use in Data, Signal, Control and Power Applications*

UL 2043, *Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces*

UL 2610, *Commercial Premises Security Alarm Units and Systems*

UL 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

UL 62368-1, *Audio/Video Information and Communication Technology Equipment – Part 1: Safety Requirements*

6 Glossary

6.1 For the purpose of this standard the following definitions apply.

6.2 The term "product" as used in this standard refers to all types of access control equipment or systems of equipment.

6.3 ACCESS CONTROL – A means and/or measure to regulate or control physical access control that may consist of:

a) Entry and/or exit to/from a controlled area, protected area or a restricted area; or

b) Physical access to or the use of a device(s) by electrical, electronic or mechanical means.

6.4 ACCESS CONTROL DESTRUCTIVE ATTACK LEVEL I _ An access control product intended for, but not limited to, a controlled area that is not required to meet the destructive Attack Test.

6.5 ACCESS CONTROL DESTRUCTIVE ATTACK LEVEL II – An access control product intended for, but not limited to, a protected area that can withstand the destructive Attack Test for 2 minutes.

6.6 ACCESS CONTROL DESTRUCTIVE ATTACK LEVEL III – An access control product intended for, but not limited to, a restricted area that can withstand the destructive Attack Test for 5 minutes, or 2 minutes if an alarm is activated during the test.

6.7 ACCESS CONTROL DESTRUCTIVE ATTACK LEVEL IV – An access control product intended for, but not limited to, a restricted area that can withstand the destructive attack test for 5 minutes, generate an alarm signal in 2 minutes and the alarm cannot be silenced until acknowledged by the operator for 2 minutes.

6.8 ACCESS CONTROL ENDURANCE LEVEL I – An access control product shall operate as intended at rated voltage and current for 1,000 cycles of intended operation.

6.9 ACCESS CONTROL ENDURANCE LEVEL II – An access control product shall operate as intended at rated voltage and current for 25,000 cycles of intended operation.

6.10 ACCESS CONTROL ENDURANCE LEVEL III – An access control product shall operate as intended at rated voltage and current for 50,000 cycles of intended operation.

6.11 ACCESS CONTROL ENDURANCE LEVEL IV – An access control product shall operate as intended at rated voltage and current for 100,000 cycles of intended operation.

6.12 ACCESS CONTROL LINE SECURITY – Equipment incorporates refinement in electric apparatus and circuit arrangement to guard against an attempt to compromise the connecting line or communication channel between two access control products or equipment.

6.13 ACCESS CONTROL LINE SECURITY LEVEL I – An access control product with no communication line security.

6.14 ACCESS CONTROL LINE SECURITY LEVEL II – An access control product provided with standard communication line security. See 67.2.

6.15 ACCESS CONTROL LINE SECURITY LEVEL III – An access control product provided with 128-bit encryption. See 67.3.

6.16 ACCESS CONTROL LINE SECURITY LEVEL IV – An access control product provided with 256 bit encryption. See 67.4.

6.17 ACCESS CONTROL STANDBY POWER LEVEL I – An access control product designed with no secondary power source.

6.18 ACCESS CONTROL STANDBY POWER LEVEL II – An access control product that operates as intended with a loss of primary power for 30 minutes while the product is operated every minute.

6.19 ACCESS CONTROL STANDBY POWER LEVEL III - An access control product that operates as intended with a loss of primary power for 2 hours while the product is operated every minute.

6.20 ACCESS CONTROL STANDBY POWER LEVEL IV – An access control product that operates as intended, and with a loss of primary power for 4 hours while the product is operated every minute.

6.21 ACCESS CONTROL SYSTEM – A collection of means, measures and specific practices that when combined, form or compose a systematic approach, which enables an authority to control access to areas and resources in a given physical facility. An access control system, within the field of physical security, is generally seen as the second layer in the security of a physical structure.

6.22 ACCESS CONTROL UNIT – A part of the access control system that interfaces with readers, locking devices and sensing devices, making a decision to grant or deny access.

6.23 ACCESS CONTROL UNIT ACCESSORY – Any device or component of an access control system other than the access control unit that is employed to assure intended operation of the system. Examples of access control unit accessories include: readers, keypads, request-to-exit devices, input/output interfaces, and the like.

6.24 AIR-HANDLING SPACE – Space not specifically fabricated for environmental air-handling purposes but used for air handling purposes as a plenum. (The space above a hung ceiling used for environmental air-handling is an example.)

6.25 ALARM – A condition requiring human assessment or intervention.

6.26 ALARM SIGNAL – A transmission of an alarm condition or alarm report.

6.27 BIOMETRIC(S) – Any measurable, unique physiological characteristic or personal trait that is used as a credential to recognize and verify the identity of an individual. (e.g. fingerprint, hand or face geometry, retinal/eye, face, voice, signature or keyboarding dynamics).

6.28 CIRCUITS, ELECTRICAL:

a) High-Voltage – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage power limited circuit.

b) Low-Voltage – A circuit involving a potential of not more than 30 volts alternating current (AC), 42.4 volts direct current (DC) or AC peak.

c) Power Limited / Class 2/3 Circuit – A circuit wherein the power is limited as specified in Table 40.1 and Table 40.2.

d) Power over Communications Cable – A limited energy circuit that meets the requirements of 35.7.

e) Risk of Electric Shock – A risk of electric shock is determined to exist within a circuit unless that circuit meets one of the following criteria (1 and 2, or 3):

1) The circuit is supplied by an isolating source such that the maximum open-circuit voltage potential available to the circuit is not more than 30 V AC rms, 42.4 V DC, or 42.4 V peak, and

2) The circuit is supplied by an isolating source such that the current available through a 1500-ohm resistor connected across any potential in the circuit (including to ground) does not exceed 0.5 mA; or

3) A limited energy power over communications circuit that meets the requirements of 35.7, Power over communications cable equipment.

f) Risk of Fire – A risk of fire is considered to exist at any two points in a circuit where:

1) The open circuit voltage is more than 30 V AC rms, 42.4 V DC, or 42.4 V peak, and the energy available to the circuit under any condition of load including short circuit, results in a current of 8 A or more after 1 minute of operation, or

2) A power of more than 15 watts can be delivered into an external resistor connected between the two points.

Exception: The product meets all of the requirements of 35.7, Power over communications cable equipment, for equipment utilizing power over communications cables.

6.29 CONTROLLED AREA – A room, office, building, facility, premises, or grounds to which access is monitored, limited, or controlled.

6.30 CONTROLLED EGRESS EQUIPMENT AND SYSTEMS – A door-latching assembly incorporating a device such as an electric or electromagnetic locking mechanism that controls the releases latch on an egress door.

6.31 CORD-CONNECTED UNIT – A unit intended for connection to the power source by means of a supply cord. Such a unit is intended to be moved for reasons of interchange or realignment of the units of a system.

6.32 CREDENTIAL – Any token, card, memorized or stored information, biometric image, or electronic means used to identify an individual to an access control system in order to verify user access rights.

6.33 CRITICAL COMPONENT – A critical component is one whose malfunctioning will impair the normal operation of the product, grants unauthorized access or creates a risk of fire or electrical shock.

6.34 DELAYED EGRESS EQUIPMENT AND SYSTEMS – A door-latching assembly incorporating a time-delay feature that controls the release latch on an egress door upon the application of a force in the direction of egress travel.

6.35 EGRESS CONTROL SYSTEM - A system that is used to control the unauthorized egress of patients and/or infants from secured areas within a hospital or other healthcare facility. See 35.9.

6.36 ENDSPAN – A device that is typically a network switch capable of supplying power over a communications circuit.

6.37 EQUIPMENT – Any part of an electronic access control system, such as access control units, readers, reader interface modules, access point actuators, access point sensors, keypads, and the like.

6.38 ESSENTIAL COMPUTER EQUIPMENT – Computer equipment connected to the access control system either on or off premises that is relied upon, or can perform, access control operations.

6.39 ETHERNET CABLING – A structured cabling system using 4 pair unshielded or shielded twisted pair cable, meeting Category 5e performance or higher and conforming to TIA-568C.2 requirements. The

extent of the cabling is taken to be the channel that connects the appropriate port of the network switch to the powered device.

6.40 FAIL SAFE – A condition under which the product ceases to operate in such a way as to automatically allow access or egress.

6.41 FAIL SECURE – A condition under which the product ceases to operate in such a way as to not allow unauthorized access or unauthorized egress.

6.42 FIRMWARE – A software program or set of instructions programmed on a hardware device (e.g. Flash ROM, EPROM).

6.43 HARDWARE – Physical equipment that constitutes the components of an access control system.

6.44 HVAC SYSTEM – Heating, Ventilating, and Air-Conditioning system.

6.45 KEY MANAGEMENT SYSTEM – Key management systems provide a means of regulating or controlling keys by electrical, electronic and/or mechanical means, and allow authorized users access to keys upon verification of appropriate credentials. See 35.10.

6.46 LINE-VOLTAGE – The voltage (commonly 115, 208, and 230 volts) at any field-connected source of supply, nominally 50 – 60 hertz (Hz).

6.47 MIDSPAN – A midspan device is Power Sourcing Equipment (PSE) that injects power onto communications cable. It is located between the network switch and the Powered Device (PD).

6.48 NETWORK SWITCH – Active electronic equipment that selects a path or circuit for sending a unit of data to its next destination.

6.49 NORMAL STANDBY CONDITION – The ready-to-operate condition that exists prior to being operated.

6.50 POWER INJECTOR (Alternative terms – Injector or Power Brick) – Power Sourcing Equipment (PSE) similar to a midspan device, comprising three ports. These are:

a) Data in, typically from the network switch,

b) Data and power – nominal 48 or 53 VDC out, and

c) Line voltage from a utility supply.

6.51 POWER OVER COMMUNICATIONS CABLES – A means to supply DC power to a network device over communications cabling. The power supplied to the device may or may not be on the same conductors supporting data. Typical technologies include PoE (see Annex B) and USB.

6.52 POWER SOURCING EQUIPMENT (PSE) – The power supply that provides DC power to the powered device (PD) through the communications cabling. It may be an endspan device, such as an enabled network switch, or a midspan device that is located in between the network switch and the powered device.

6.53 POWERED DEVICE (PD) – A device that receives DC power from the power sourcing equipment (PSE) through communications cabling. Also referred to as the load.

6.54 PRIMARY BATTERY – Any battery which by design or construction is not intended to be recharged.

6.55 PROTECTED AREA – A room, office, building, facility, premises or grounds to which access is monitored, and limited and/or controlled, whereby the authorized person of the Access Control System may grant access to non-authorized persons.

6.56 RESTRICTED AREA – A room, office, building, facility, premises, or grounds to which access is monitored, limited and strictly controlled, whereby only the administrator of the Access Control System shall issue credentials that will lead to access.

6.57 SECONDARY BATTERY – Any battery that is intended to be recharged.

6.58 SECURED AREA – Any Controlled, Protected, or Restricted Area.

6.59 SINGLE POINT LOCK – An autonomous access control solution, residing locally to the access point, where during primary operation, authorizations are stored, access decisions are made, and access is physically granted or denied within a single stand-alone product.

6.60 SOFTWARE – Instructions that are temporarily or permanently stored in the computer's memory and used to provide function and control of the computer's components.

6.61 STAND-ALONE SYSTEM/MODE – An access control solution or mode of operation which does not rely upon communication between the access control unit and/or the computer (monitoring) equipment for access control operations.

6.62 STANDBY POWER / SECONDARY POWER SOURCE – Provides power when the primary power source fails.

6.63 SYSTEM DATABASE – Information entered into the computer by authorized personnel including items such as names, security information for system users, emergency phone numbers, and graphics.

7 Performance Level Definitions For Access Control

7.1 The access control features identified in Table 7.1 shall be identified for the product or equipment by the Level specified by the manufacturer for that feature.

Table 7.1
Summarized Levels of Access Control Components

Feature	Level I	Level II	Level III	Level IV
Destructive attack	No attack test	Withstand attack test for 2 minutes	Withstand attack test for 5 minutes or generate an audible alarm in 2 minutes	Withstand attack test for 5 minutes, generate an audible alarm in 2 minutes which cannot be silenced for 2 minutes
Line security	No line security	Standard line security	Encrypted line security 128 bit	Encrypted line security 256 bit
Endurance	1000 cycles	25,000 cycles	50,000 cycles	100,000 cycles

Table 7.1 Continued on Next Page

Table 7.1 Continued

Feature	Level I	Level II	Level III	Level IV
Standby power	No secondary power source	Can maintain normal operation for a minimum of 30 minutes (see 6.18)	Can maintain normal operation for a minimum of 2 hours (see 6.19)	Can maintain normal operation for a minimum of 4 hours (see 6.20)
Single Point Locking Device with Key Locks (see 35.2.2)	No attack test on key lock	Picking, Lock Bumping and Impression tests for key locks from Attack Resistance Test Time table of UL 437	All key lock attack resistance tests from Attack Resistance Test Time table of UL 437	N/A

7.2 When a product or equipment provides standby power, the manufacturer shall specify the amount of time the product or equipment can operate normally under the specified load conditions, while on standby power. See 72.14.

7.3 The level of the access control feature may be marked on the product or equipment.

7.4 The level of access control feature shall be specified in the product or equipment documentation that is provided.

7.5 Features that exceed the levels specified for endurance and standby power shall be verified by tests and may be indicated in the product or equipment documentation. The level of access control feature shall be indicated to the highest tiered level achieved through tests.

8 Information Required for Assessment

8.1 The following documentation shall be required as applicable to determine compliance, and shall be furnished with the sample(s) submitted for investigation:

a) Installation and operating instructions intended to accompany each product or component as produced (see Section 91);

b) Schematic diagrams of all circuits;

c) Printed wiring board construction drawings (e.g. component layouts, foil patterns);

d) Bill of Materials (BOM)/parts list (including manufacturer name and part number for critical components);

e) Mechanical drawings; and

f) Markings to be applied to the product as required in MARKINGS, Details, Sections 72 and 90.

9 Version Number

9.1 If reprogrammable, an access control product or equipment shall provide some method to identify the current version of programming logic code / software being used. Subversions that are used to identify non-critical logic changes are not required to be identified. This information shall also appear in the product installation instructions.

CONSTRUCTION

ASSEMBLY

10 General

10.1 Specific product requirements

10.1.1 Products that currently meet all the requirements of UL 60950-1 or UL 62368-1, fulfill the requirements of:

a) 10.3 (Electrical Protection);

b) Section 11 (Protection of Service Personnel);

c) 12.1, 12.3 – 12.7 (Enclosure);

d) Section 13 (Electric Shock);

e) Section 14 (Corrosion Protection);

f) Section 15 (Field Wiring Connection, General);

g) Section 16 (Cord Connected Products);

h) 17.6 (Polarity Identification);

i) Section 18 (Grounding);

j) Section 19 (Internal Wiring, General);

k) Section 22 (Bonding for Grounding);

l) Section 23 (Mounting of Components);

m) Section 24 (Insulating Materials);

n) Section 25 (Fuseholders and Current-Carrying Parts);

o) Section 28 (Switches);

p) Section 29 (Transformers and Coils); and

q) Section 33 (Spacings, General).

10.2 Product assembly

10.2.1 An access control product shall not impair the intended operation of panic hardware used in conjunction with it.

10.2.2 The product shall be factory-built as a complete assembly and shall include all the essential components necessary for its intended function when installed (used) as intended. The product may be shipped from the factory as two or more major subassemblies.

10.2.3 If the product is not assembled by the manufacturer as a complete unit, it shall be arranged in major subassemblies. Each subassembly shall be capable of being incorporated into a final assembly without requiring alteration, cutting, drilling, threading, welding, or similar tasks by the installer. Two or

more subassemblies shall be arranged and constructed to permit them to be incorporated into the complete assembly only in the intended relationship with each other, where this is necessary, without need for alteration or alignment. Otherwise, such subassemblies shall be assembled, tested, and shipped from the factory as one element.

10.3 Electrical protection

10.3.1 Louvers and other openings in the enclosure shall be constructed and located to reduce the risk of contact by persons with uninsulated high-voltage live parts. In determining compliance with this requirement, parts such as covers, panels, and grilles used as part of the enclosure are to be removed unless tools are required for their removal or an interlock is provided.

10.3.2 Uninsulated high-voltage live parts shall be located, guarded, or enclosed as indicated in 10.3.3 and 10.3.4.

10.3.3 Openings directly over uninsulated high-voltage live parts shall not exceed 0.187 inch (4.75 mm) in any dimension unless the configuration is arranged to reduce the risk of unintentional contact by persons with uninsulated high-voltage live parts. See Figure 12.2 for examples of top cover constructions which may be used.

10.3.4 An opening in an electrical enclosure that does not permit entrance of a 1-inch (25.4-mm) diameter rod shall be sized and arranged so that a probe, as illustrated in Figure 10.1, cannot be made to contact any uninsulated live high-voltage electrical part when inserted through the opening in a straight or articulated position.

10.3.5 An opening that permits entrance of a 1-inch (25.4-mm) diameter rod may be used under the conditions described in Figure 10.2.

Figure 10.1

Articulate Probe

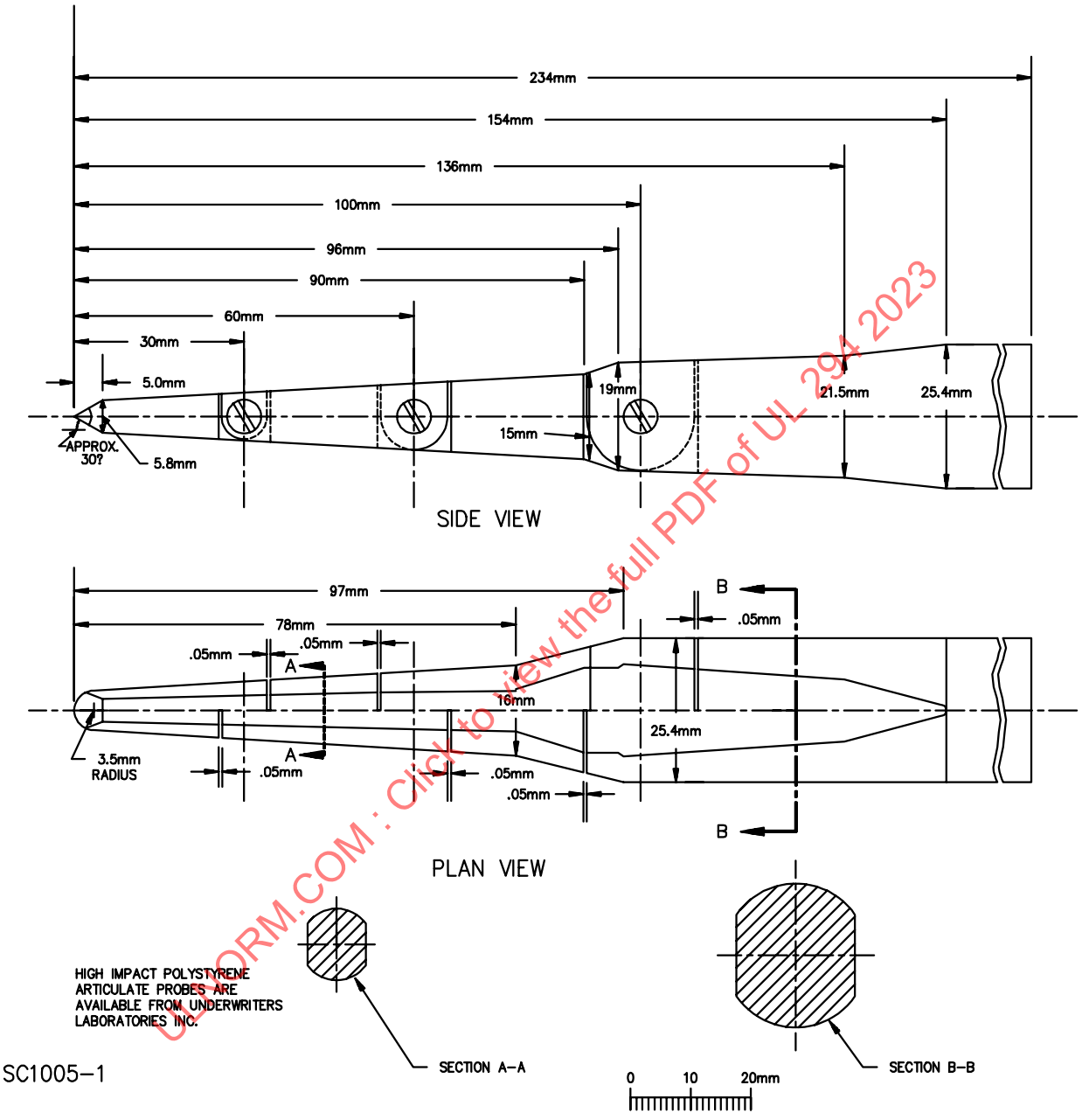
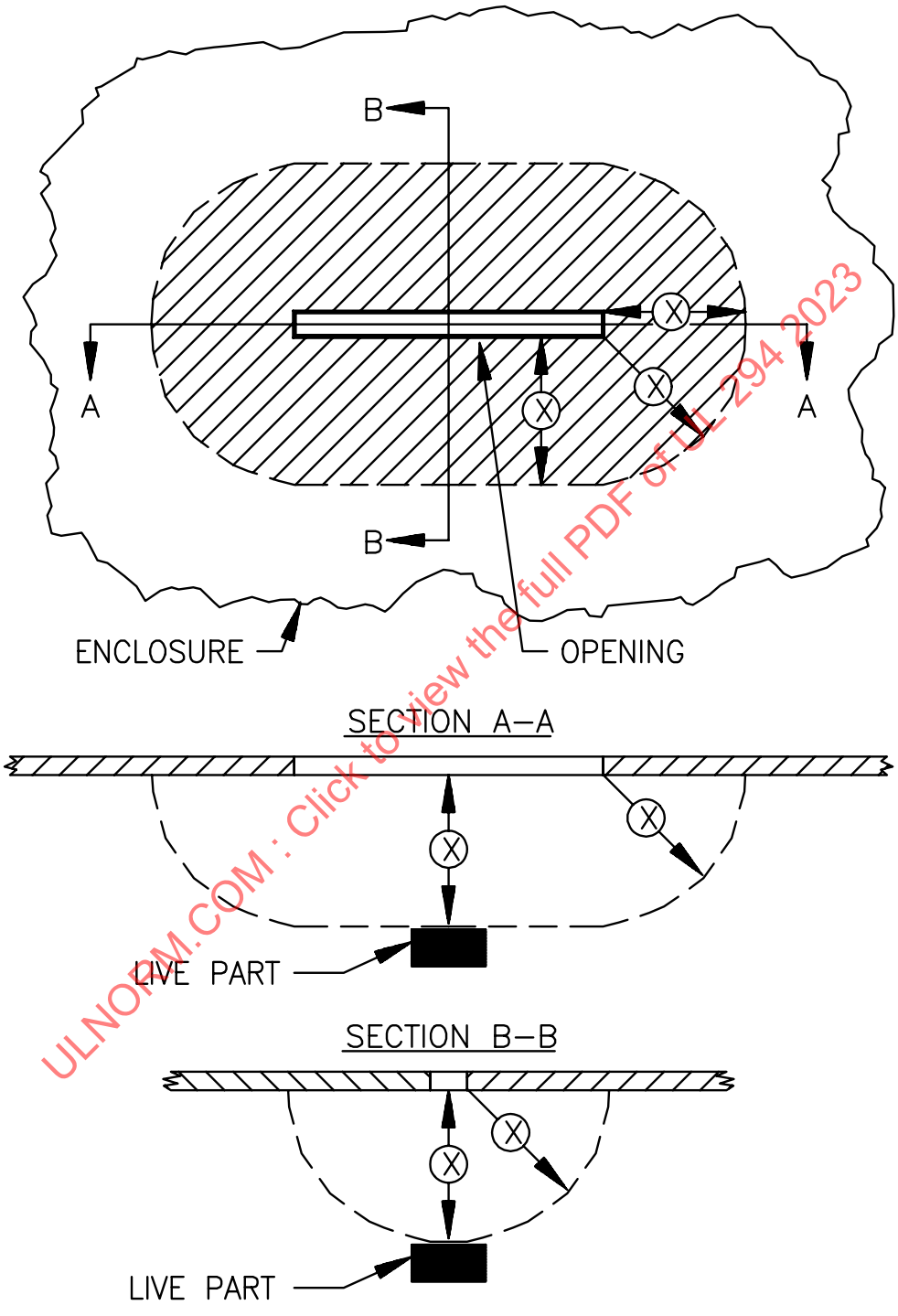


Figure 10.2

Opening in Enclosure



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NOTE – The opening may be used if, within the enclosure, there is no uninsulated live part or film-insulated wire less than X inches (mm) from the perimeter of the opening, as well as within the volume generated by projecting the perimeter X inches (mm) normal to its plane. X equals five times the diameter of the largest diameter rod that can be inserted through the opening, but not less than 6-1/4 inches (154 mm).

11 Protection of Service Personnel

11.1 An uninsulated live part of a high-voltage circuit within the enclosure shall be located, guarded, or enclosed so as to reduce the risk of unintentional contact by persons performing service functions while the equipment is energized.

11.2 The requirements specified in 11.1 are not satisfied by a part of the enclosure that may be removed:

a) To allow access by a user making intended operating adjustments; or

b) Without the use of tools.

11.3 An electrical component that may require examination, replacement, adjustment, servicing, or maintenance while the product is energized shall be located and mounted with respect to other components and with regard to grounded metal so that it is accessible for such service without subjecting the serviceman to the risk of electric shock from adjacent uninsulated high-voltage live parts.

11.4 The following are not considered to be uninsulated live parts:

a) Coils of relays and solenoids, and transformer windings, if the coils and windings are provided with insulating overwraps rated for the potentials encountered;

b) Terminals and splices with insulation rated for the potential encountered; and

c) Insulated wire.

12 Enclosure

12.1 General

12.1.1 The enclosure of a product shall have the strength and rigidity to resist total or partial collapse and attendant reduction of spacings, loosening or displacement of parts, or other defects. See the Mechanical Strength Tests for Enclosures, Section 63.

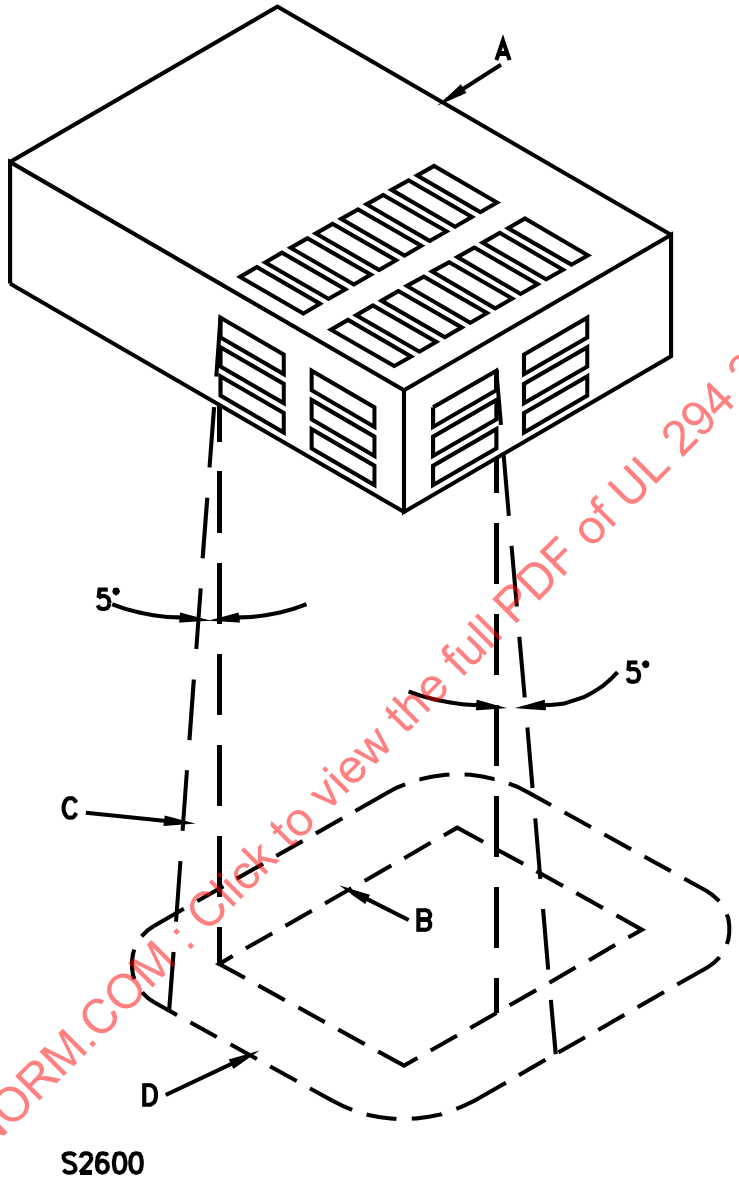
12.1.2 Operating parts, such as gear mechanisms, light-duty relays, and similar devices, shall be enclosed to protect against malfunction from dust or from other material that may impair their intended operation.

12.1.3 An enclosure containing other than power-limited or Class 2 or Class 3 circuits shall be constructed to reduce the risk of emission of flame, molten metal, flaming or glowing particles, or flaming drops. See the Tests for Ignition Through Bottom-Panel Openings, Section 62.

12.1.4 The requirement specified in 12.1.3 requires either a nonflammable bottom in accordance with 12.3.2, or a protective barrier as illustrated in Figure 12.1 under all areas containing combustible materials. However, openings in the bottom of an enclosure that comply with the requirements of 12.6 may be used.

Figure 12.1

Enclosure Bottom



A – The entire component under which an enclosure (flat or dished with or without a lip or other raised edge) of noncombustible material is to be provided. The sketch is of an enclosed component with ventilation openings showing that the enclosure is required only for those openings through which flaming parts are to be emitted. When the component or assembly does not have its own noncombustible enclosure, the area to be protected is the entire area occupied by the component or assembly.

B – Projection of the outline of the area of A that requires a bottom enclosure vertically downward onto the horizontal plane of the lowest point on the outer edge D of the enclosure.

C – Inclined line that traces out an area D on the horizontal plane of the enclosure. Moving around the perimeter of the area B that requires a bottom enclosure, this line projects at a 5° angle from the line extending vertically at every point around the perimeter of A and is oriented to trace out the largest area; except that the angle shall be less than 5 degrees when the enclosure bottom contacts a vertical enclosure or side panel, or when the horizontal extension of the enclosure B to D exceeds 6 inches (152 mm).

D – Minimum outline of the enclosure, except that the extension B to D is not required to exceed 6 inches (152 mm), flat or dished with or without a tip or other raised edge. The bottom shall either be flat or formed in any manner when every point of area D is at or below the lowest point on the outer edge of the enclosure.

12.1.5 A construction using an individual barrier under a component, group of components, or an assembly, as specified in Figure 12.1, shall comply with the requirement specified in 12.1.3.

12.2 Doors and covers

12.2.1 An enclosure cover shall be hinged, sliding, or similarly attached to secure it against removal if:

a) Displacing the cover gives access to fuses or any other overcurrent protective device, the intended functioning of which requires renewal; or

b) Opening the cover is required as part of the intended operation of the unit.

Exception: If the enclosure cover position is supervised by an electrical contact intended to disable the product or activate an audible or visual warning, an enclosure cover need not comply with the requirements of this paragraph. See also 41.1.2.

12.2.2 Fasteners requiring the use of a tool or key shall be used for all enclosures if access is not required for operation of the product.

12.3 Enclosure openings – general

12.3.1 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.

Exception: Products supplied solely from power-limited sources and controlling only power-limited loads.

12.3.2 The requirement in 12.3.1 does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage) when:

a) An opening for non-mounting purposes does not have a dimension greater than 17/64 inch (6.75 mm) or an area greater than 0.055 square inch (35.5 mm^2); and

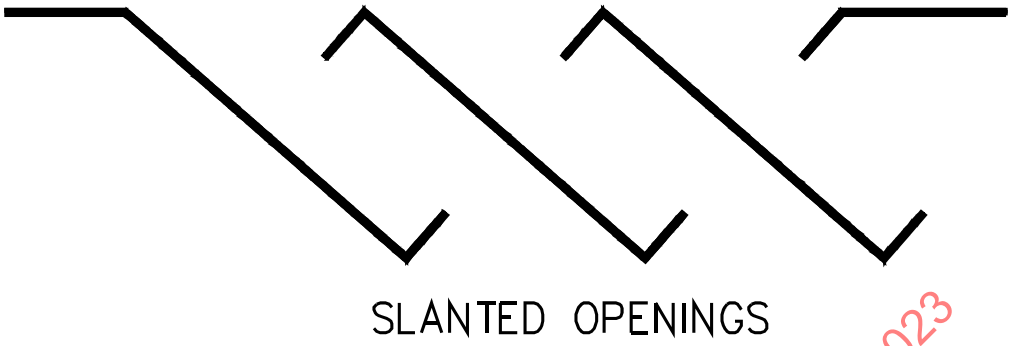
b) An opening for mounting does not have a dimension greater than 0.75 inches (19.05 mm) or an area greater than 0.7 $inches^2$ (430 mm^2) and there are no more holes than are needed to mount the product.

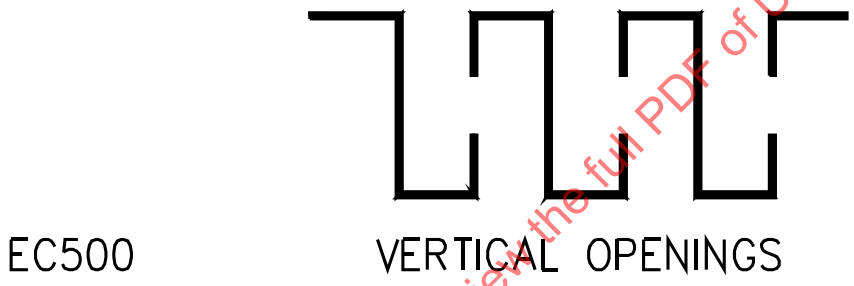
12.4 Enclosure top openings

12.4.1 An opening directly over an uninsulated live part involving a risk of fire, electric shock, or electrical-energy/high-current levels, shall not exceed 0.20 inch (5.0 mm) in any dimension unless the configuration is such that a vertically falling object cannot fall into the unit and contact an uninsulated live part. See Figure 12.2 for examples of top-cover designs complying with the intent of the requirement.

Figure 12.2

Top Cover Designs





12.5 Enclosure side openings

12.5.1 An opening in the side of the enclosure shall:

a) Not exceed 0.19 inch (4.8 mm) in any dimension;

b) Be provided with louvers shaped to deflect an external falling object outward (see Figure 12.3 for examples of louver designs complying with the requirement); or

c) Be located and sized so that objects which are present cannot drop into the unit and fall (with no horizontal velocity) onto uninsulated live parts involving a risk of fire, electric shock, or electrical-energy/high-current levels, or parts involving injury to persons (see Figure 12.4).

Figure 12.3

Louver Designs

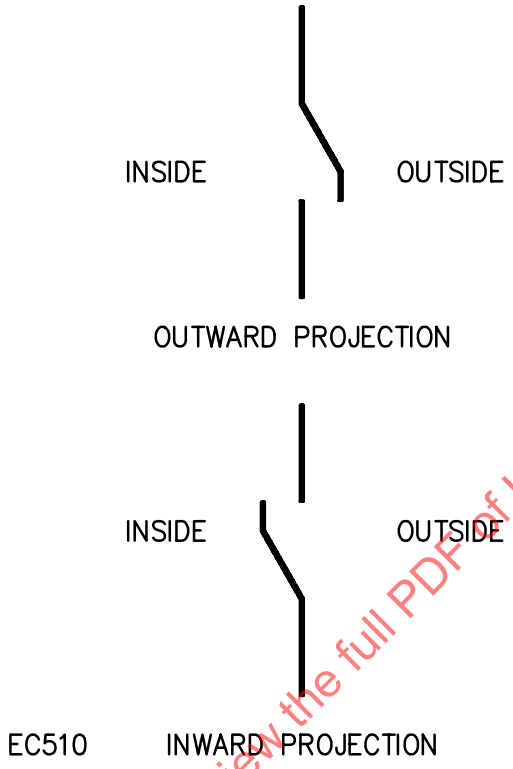
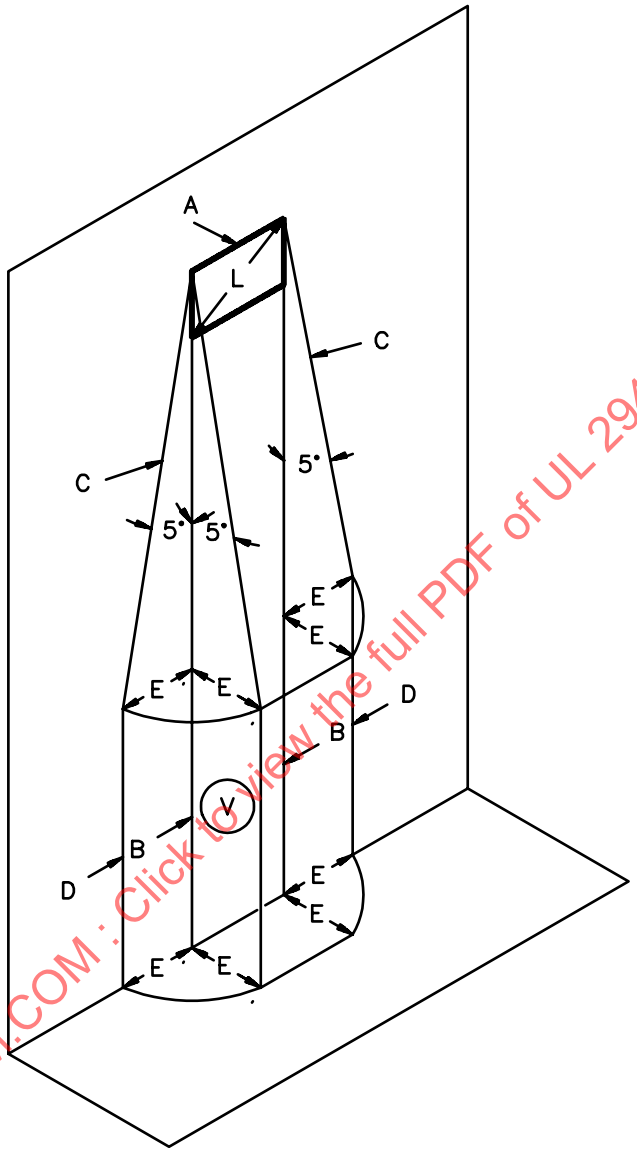


Figure 12.4

Example of Enclosure Side Opening



A – Enclosure side opening.

B – Vertical projection of the outer edges of the side opening.

C – Inclined lines that project at a 5° angle from the edges of the side opening to point located E distance from B.

D – Line which is projected straight downward in the same plane as the enclosure side wall.

E – Projection of the opening (not to be greater than L).

L – Maximum dimension of the enclosure side opening.

V – Volume in which bare parts at uninsulated live parts are not located.

12.5.2 When a portion of a side panel falls within the area traced out by the 5° angle in Figure 12.1, that portion of the side panel shall be investigated as a bottom enclosure in accordance with 12.6.1 – 12.6.3.

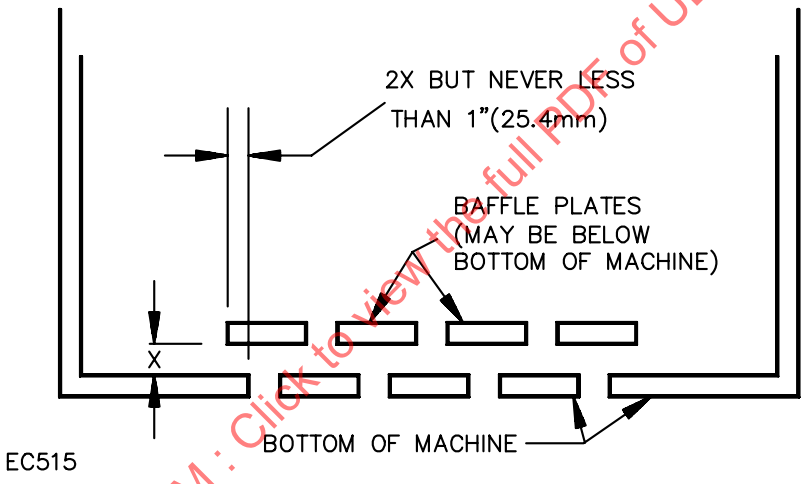
12.6 Enclosure bottom openings

12.6.1 The bottom of an enclosure shall consist of a complete or partial bottom enclosure under a component, groups of components, or assemblies, as shown in Figure 12.5, that complies with the ventilation opening requirements in 12.6.2 and 12.6.3 unless a test demonstrates that the bottom enclosure provided contains flames, glowing particles or similar burning debris when all combustible material in the interior is ignited.

Exception: Openings without limitations on their size and number are permitted in areas that contain only wires, cables, plugs, receptacles, and impedance- and thermally-protected motors.

Figure 12.5

Baffle



12.6.2 Ventilation openings provided in the bottom of an enclosure under materials that are not rated V-1 or less flammable meet the intent of the requirements when the openings are constructed so that materials do not fall directly from the interior of the unit. Other bottom-opening constructions that comply with the intent of the requirements are those that incorporate a perforated metal plate as described in Table 12.1, or a galvanized or stainless-steel screen having a 14 by 14 mesh per 1 inch (25.4 mm) constructed of wire with a minimum diameter of 1/64 inch (0.4 mm). Other constructions are to be used only when they comply with the Tests for Ignition Through Bottom-Panel Openings, Section 62.

Table 12.1
Perforated Metal Plates

Minimum thickness		Maximum diameter of holes		Minimum spacing of holes, center-to-center	
inch	(mm)	inch	(mm)	inch	(mm)
0.026	(0.66)	0.045	(1.14)	0.067	(1.70)
–	–	–	–	[233 holes per inch^2]	([36 holes per cm^2])
0.026	(0.66)	0.047	(1.19)	0.093	(2.36)
0.032	(0.81)	0.075	(1.91)	0.125	(3.18)
–	–	–	–	[72 holes per inch^2]	([11 holes per cm^2])
0.036	(0.91)	0.063	(1.60)	0.109	(2.77)
0.036	(0.91)	0.078	(1.98)	0.125	(3.18)

12.6.3 The bottom of the enclosure under areas containing only materials rated V-1 or less flammable shall have openings no larger than 1/16 inch^2 (40 mm^2).

12.7 Screens and expanded metal

12.7.1 A screen or mesh of expanded metal used as a guard, enclosure or part of an enclosure shall comply with the requirements of 12.7.2 – 12.7.4 and with the Mechanical Strength Tests for Enclosures, Section 63.

12.7.2 Perforated sheet steel or sheet steel used for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) in thickness [0.045 inch (1.17 mm) if zinc coated] if the mesh openings or perforations are 1/2 square inch (323 mm^2) or less in area. For larger openings, the steel shall not be less than 0.080 inch (2.03 mm) in thickness [0.084 inch (2.13 mm) if zinc coated]. The largest dimension shall not exceed 4 inches (102 mm).

12.7.3 With reference to the requirements in 12.7.2, expanded steel mesh or perforated sheet steel that is 0.020 inch (0.53 mm) thick [0.023 inch (0.58 mm) thick if zinc coated] may be used if the indentation of a guard or the enclosure will not alter the clearance between uninsulated live parts and grounded metal so as to impair performance or reduce spacings below the minimum required values (see Spacings, General, Section 33). If this is the case, then either:

a) The exposed mesh on any one side or surface of the product so protected shall have an area of not more than 72 square inches (464 cm^2) and no dimension greater than 12 inches (305 mm); or

b) The width of an opening so protected shall not be greater than 3-1/2 inches (89 mm).

12.7.4 The wires of a screen shall not be less than 16 AWG (1.29 mm diameter) steel if the screen openings are 1/2 square inch (323 mm^2) or less in area and shall not be less than 12 AWG (2.05 mm diameter) steel for larger screen openings.

12.8 Cast metal

12.8.1 The thickness of cast metal for an enclosure shall be as specified in Table 12.2. However, cast metal of lesser thickness may be used if, consideration being given to the shape, size, and function of the enclosure, the cast metal has been determined to provide the same level of mechanical strength. See the Drop Test, Section 60, and the Mechanical Strength Tests for Enclosures, Section 63.

Table 12.2
Cast-Metal Enclosures

Use, or dimensions of area involved[a]	Minimum thickness			
	Die-cast metal		Cast metal of other type than the die-cast type	
	inch	(mm)	inch	(mm)
Area of 24 square inches (155 mm^2) or less and having no dimension greater than 6 inches (152 mm)	1/16	(1.6)	1/8	(3.2)
Area greater than 24 square inches or having any dimension greater than 6 inches	3/32	(2.4)	1/8	(3.2)
At a threaded conduit hole	1/4	(6.4)	1/4	(6.4)
At an unthreaded conduit hole	1/8	(3.2)	1/8	(3.2)

[a] The area limitation for metal 1/16 inch (1.6 mm) thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

12.8.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, there shall not be less than 3-1/2 nor more than 5 threads in the metal, and the construction shall allow a standard conduit bushing to be attached as intended.

12.8.3 If threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall not be less than 3-1/2 threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors that has been determined to provide the same level of protection to the conductors as that of a standard conduit bushing.

12.9 Sheet metal

12.9.1 The thickness of sheet metal for an enclosure shall not be less than that specified in Table 12.3 or Table 12.4, whichever applies.

Exception: Sheet metal of lesser thickness may be used if, consideration being given to the shape, size, and function of the enclosure, the sheet metal has been determined to provide the same level of mechanical strength. See the Drop Test, Section 60, and the Mechanical Strength Tests for Enclosures, Section 63.

Table 12.3
Minimum Thickness of Sheet Metal for Electrical Enclosures Carbon Steel or Stainless Steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	Uncoated [MSG]	Metal coated [GSG]
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020 (0.51) [24]	0.023 (0.58) [24]
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)		
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026 (0.66) [22]	0.029 (0.74) [22]
7.0	(17.8)	11.5	(22.2)	10.0	(25.4)	12.5	(31.8)		
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032 (0.81) [20]	0.034 (0.86) [20]
9.0	(22.9)	18.0	(45.7)	13.0	(33.0)	16.0	(40.6)		
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042 (1.07) [18]	0.045 (1.14) [18]
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)		
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053 (1.35) [16]	0.056 (1.42) [16]
20.0	(50.8(	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)		
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060 (1.52) [15]	0.063 (1.60) [15]
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)		
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067 (1.70) [14]	0.070 (1.78) [14]
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)		
33.0	(83.3)	Not limited		51.0	(129.5)	Not limited		0.080 (2.03) [13]	0.084 (2.13) [13]
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)		
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093 (2.36) [12]	0.097 (2.46) [12]
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)		
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108 (2.74) [11]	0.111 (2.82) [11]
60.0	(152.4)	74.0	(188.0)	84.0	(231.4)	103.0	(261.6)		
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123 (3.12) [10]	0.126 (3.20) [10]
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)		

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1) A single sheet with single formed flanges (formed edges),

2) A single sheet which is corrugated or ribbed, and

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

Table 12.4
Minimum Thickness of Sheet Metal for Electrical Enclosures Aluminum, Copper, or Brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches	(mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited			
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	0.023	(0.58)
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited			
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	12.5	(34.3)	0.029	(0.74)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited			
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	0.036	(0.91)
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited			
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	0.045	(1.14)
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited			
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	0.058	(1.47)
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited			
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)	0.075	(1.91)
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited			
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	0.095	(2.41)
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited			
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	0.122	(3.10)
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited			
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	0.153	(3.89)

[a] a A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1) A single sheet with single formed flanges (formed edges),

2) A single sheet which is corrugated or ribbed, and

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

12.9.2 A sheet metal member to which a wiring system is to be connected in the field shall have a thickness of not less than:

a) 0.032 inch (0.81 mm) if of uncoated steel;

b) 0.034 inch (0.86 mm) if of galvanized steel; or

c) 0.045 inch (1.14 mm) if of nonferrous metal.

12.9.3 For a hole having a maximum diameter of 1-3/8 inches (34.9 mm), a plate or plug closure for an unused conduit opening or other hole in the enclosure shall not be less than:

a) 0.027 inch (0.69 mm) thick if of ferrous metal; or

b) 0.032 inch (0.81 mm) thick if of nonferrous metal.

12.9.4 A closure for a hole larger than 1-3/8 inch (34.9 mm) diameter shall have a thickness equal to that required in 12.9.1 for the enclosure of the device. Otherwise, a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

12.9.5 A knockout in a sheet metal enclosure shall be removable without undue deformation of the enclosure.

12.9.6 A knockout shall be provided with a surrounding surface that can seat a conduit bushing as intended. The knockout shall be located so that installation of a bushing 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 in Spacings, General, Section 33.

12.10 Product enclosure mounting

12.10.1 An enclosure shall have means for mounting that shall be accessible without disassembly of any operating part of the product. Removal of a completely assembled panel to mount the enclosure is not considered to be disassembly of an operating part.

12.11 Polymeric materials

12.11.1 Among the factors taken into consideration when judging the acceptability of a nonmetallic enclosure are:

a) The mechanical strength;

b) Resistance to impact;

c) Moisture-absorption properties;

d) Flammability and resistance to ignition from electrical sources;

e) Dielectric strength, insulation resistance, and resistance to arc tracking; and

f) Resistance to distortion and creeping at temperatures to which the material may be subjected under any conditions of use.

12.11.2 All the factors in 12.11.1 are considered with regard to aging in accordance with the Polymeric Materials Test, Section 58, and the Mechanical Strength Tests for Enclosures, Section 63.

12.11.3 A polymeric enclosure intended for connection to a rigid metallic or nonmetallic conduit system shall comply with the applicable requirements for polymeric enclosure conduit connections in UL 50.

12.11.4 The continuity of a conduit system shall be provided by metal-to-metal contact and not rely on a polymeric material. It shall also comply with the requirements for polymeric enclosure bonding in UL 50.

13 Electric Shock

13.1 Any part that is exposed during operator servicing shall not present the risk of electric shock. See the Electric Shock Current Test, Section 48.

13.2 Each terminal provided for the connection of an external antenna shall be conductively connected to the supply circuit grounded conductor. The conductive connection shall have a maximum resistance of

5.2 megohms, a minimum wattage rating of 1/2 watt, and shall be effective with the power switch in either the on or off position.

Exception: The conductive connection need not be provided if:

a) Such a connection is established in the event of electrical breakdown of the antenna isolating means;

b) The breakdown does not result in a risk of electric shock; and

c) In a construction using an isolating power transformer, the resistance of the conductive connection between the supply circuit and chassis does not exceed 5.2 megohms.

13.3 The maximum value of 5.2 megohms mentioned in 13.2 is to include the maximum tolerance of the resistor value used; that is, a resistor rated 4.2 megohms with 20 % tolerance or a resistor rated 4.7 megohms with a 10 % tolerance may be used. A component comprised of a capacitor with a built-in shunt resistor that complies with the requirements for antenna isolating capacitors may be rated a minimum of 1/4 watt.

13.4 The insertion in any socket of any vacuum tube or its glass or metal equivalent of like designation used in the product shall not result in a risk of electric shock.

14 Corrosion Protection

14.1 Iron and steel parts, other than bearings, and the like, where such protection is impracticable, shall be protected against corrosion by enameling, galvanizing, vapor plating, plating, or other means providing such protection. Bearing surfaces shall resist binding due to corrosion.

14.2 The requirement specified in 14.1 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 the unprotected parts would not impair the operation of the unit or create a risk of fire, electric shock, or unintentional contact with moving parts that can cause injury to persons.

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

14.3 Metal used in cabinets and enclosures shall be used in combinations that are galvanically compatible. However, this requirement does not apply if galvanic action does not result in impaired operation of the product, risk of fire, electric shock, or unintentional contact with moving parts that can cause injury to persons.

14.4 Hinges and other attachments shall be resistant to corrosion.

FIELD WIRING CONNECTIONS

15 General

15.1 Wiring terminals or leads that are of at least the size required by NFPA 70, shall be provided for connection of conductors.

16 Cord Connected Products

16.1 A portable product that is intended to be connected to high voltage or line voltage shall be provided with not less than 6 feet (1.8 m) of flexible cord and a two-prong attachment plug or three-prong grounding-type attachment plug rated for connection to the required supply circuit.

Exception: The cord may be less than 6 feet (1.8 m) in length if the use of the longer cord:

a) May result in damage to the cord or product;

b) May result in a risk of fire, electric shock, or injury to persons;

c) May impair the intended operation of the product; or

d) Is not required for the intended operation of the product.

16.2 A flexible cord may be used with a stationary product.

16.3 The flexible cord shall be of Type SJ, SJT, or other types determined to be equivalent, minimum 18 AWG (0.82 mm^2). It shall be rated for use at the voltage and current rating of the product.

16.4 The power supply cord shall be provided with strain relief means so that a stress on the cord will not be transmitted to terminals, splices, or internal wiring. See the Strain Relief Test, Section 61.

16.5 If a knot in a flexible cord serves as strain relief, a surface against which the knot may bear or with which it may come in contact shall be free from projections, sharp edges, burrs, fins, and the like which may cause abrasion of the insulation on the conductors.

16.6 Clamps of any material (metal or otherwise) may be used on cords and supply leads without varnished-cloth insulating tubing or the equivalent under the clamp, unless the tubing or the equivalent is necessary to prevent the clamp from damaging the cord or supply leads.

16.7 The supply cord or supply leads shall be prevented from being pushed into the product through the cord-entry hole if such displacement is likely to:

a) Subject the cord or supply leads to mechanical damage or exposure to a temperature higher than for which the cord or supply leads are rated;

b) Reduce spacings (such as to a metal strain-relief clamp) below the minimum intended values; or

c) Damage internal connections or components.

17 Permanently Connected Products

17.1 General

17.1.1 A fixed product shall have provision for connection of one of the applicable wiring systems in accordance with NFPA 70.

17.1.2 A knockout provided for connection of a field-wiring system to a field-wiring compartment shall accommodate conduit of the trade size determined by applying Table 17.1.

Table 17.1
Trade Size of Conduit in inches (mm OD)

Wire size		Number of wires[a]									
AWG	(mm^2)	2		3		4		5		6	
14	(2.1)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)
12	(3.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
10	(5.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
8	(8.4)	3/4	(26.7)	3/4	(26.7)	1	(33.4)	1	(33.4)	1-1/4	(42.3)
6	(13.3)	3/4	(26.7)	1	(33.4)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)

NOTE – Trade size per ANSI C80.1.

[a] This table is based on the assumption that all conductors are of the same size and there will be no more than six conductors in the conduit. If more than six conductors are involved or if all of them are not of the same size, the cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of Type THW wire.

17.1.3 A terminal box or compartment in which power supply connections are to be made shall be located so that the connections are accessible without removal of parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made.

17.1.4 A terminal compartment intended for the connection of a supply raceway shall be secured against turning or shifting in position.

17.1.5 The product shall be provided with field-wiring terminals or leads for the connection of conductors having an ampacity not less than that required by the product. It is assumed that branch circuit conductors rated for not less than 60 °C (140 °F) will be used.

17.2 Power Limited/Class 2 or 3 circuits

17.2.1 When the design of the product is such that the product either requires or permits Class 2 or 3 circuit conductors to occupy the same enclosure as electric light, power, Class 1, or non-Class 2 or 3 signaling-circuit conductors, or medium-power network-powered broadband communications-circuit conductors, both of the conditions in (a) and (b) shall be met:

a) The enclosure shall provide one or more cable openings into the enclosure. When a single opening is provided, a continuous and firmly fixed nonconductor, such as flexible tubing, shall be provided. This is required so that the Class 2 or 3 conductors are segregated from electric light, power, Class 1 conductors, non-Class 2 or 3 signaling conductors, and medium-power network-powered broadband communications-circuit conductors. The installation document of the product shall completely detail cable entry routing of all conductors into the product.

b) The product shall be constructed so that, with all field-installed wiring connected to the product, either:

1) A minimum 1/4 inch (6.4 mm) is provided between all Class 2 or 3 conductors and all electric light, power, Class 1 conductors, non-Class 2 or 3 signaling conductors, or medium-power network-powered broadband communications-circuit conductors, or

2) For circuit conductors operating at 150 volts or less to ground where the Class 2 or 3 conductors are installed, a minimum 1/4-inch (6.4 mm) separation is provided between these Class 2 or 3 cable conductors extending beyond the jacket and all electric light, power, Class 1 conductors, non-Class 2 or 3 signaling conductors, and medium-power network-powered broadband communications-circuit conductors.

17.2.2 Compliance with 17.2.1 shall be achieved by specific wire routing configurations that are detailed in the installation document, or when a wire routing scheme will not maintain the required separation, barriers, or nonconductive sleeving shall be used to provide separation.

17.3 Field-wiring terminals

17.3.1 As used in these requirements, a field-wiring terminal is a terminal to which power supply (including equipment grounding) or control connections will be made in the field when the product is installed.

17.3.2 A field wiring terminal shall comply with:

a) 17.3.4 – 17.3.8; or

b) The field-wiring requirements in UL 310; or

c) UL 486A-486B; or

d) UL 486E; or

e) The field-wiring requirements (Code 2 application) in UL 1059 and also suitable for the voltage, current, wire range, and wire type intended.

The current-carrying parts shall be silver, copper, a copper alloy, or a similar nonferrous conductive material. Securing screws and similar parts of plated steel are not prohibited. Equipment provided with quick-connect terminals intended for field termination of electrical conductors to the equipment and complying with UL 310 shall be provided with strain relief, and the installation instructions shall include instructions for effecting the strain relief and references to the specific connectors to be used.

17.3.3 A field-wiring terminal shall be secured against turning or shifting in position. This may be accomplished by such means as:

a) Two screws or rivets;

b) Square shoulders or mortices;

c) A dowel pin, lug, or offset; or

d) A connecting strap or clip fitted into an adjacent part.

17.3.4 Friction between surfaces shall not be used for preventing movement of the terminals.

17.3.5 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used with 8 AWG (8.4 mm^2) and larger wires. If the connectors or lugs are secured to a plate, the plate thickness shall not be less than 0.050 inch (1.3 mm). Securing screws may be of plated steel.

17.3.6 A wire binding screw intended for connection of the power-supply (line-voltage) source shall not be smaller than No. 10 (4.8 mm diameter). The screw may be of plated steel.

Exception: A No. 8 (4.2 mm diameter) screw may be used for the connection of one 14 AWG (2.1 mm^2) and a No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) conductor.

17.3.7 For connection of other than power-supply (line-voltage) circuits using 10 AWG (5.3 mm^2) and smaller wires, a wire binding screw shall not be smaller than No. 8 (4.2 mm diameter). However, a No. 6

(3.5 mm diameter) screw may be used for the connection of a 14 AWG (2.1 mm^2) or smaller conductor. Also, a No. 4 (2.8 mm diameter) screw may be used as a 19 AWG (0.65 mm^2) or smaller conductor.

17.3.8 A terminal plate tapped for wire binding screws shall:

a) 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. Other constructions may be used if they provide thread security equivalent to that of the wire binding screw.

b) Be of a nonferrous metal not less than 0.050 inch (1.3 mm) in thickness for a No. 8 (4.2 mm diameter) or larger screw, and not less than 0.030 inch (0.076 mm) in thickness for a No. 6 (3.5 mm diameter) or smaller screw.

17.3.9 If two or more conductors are intended to be connected by wrapping under the same screw, a nonferrous intervening metal washer shall be used for each additional conductor. A separator washer is not required if two conductors are separated before being secured under a common clamping plate. If the wires protrude above terminal barriers, the nonferrous separator shall include means, such as upturned tabs or sides, to retain the wire.

17.4 Qualified application

17.4.1 Any of the following terminal configurations may be used for connection of field wiring, if they also comply with the requirements in 17.4.2:

a) Push-In Terminals – Nonferrous (screwless) push-in terminals of the type used 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 may not be used with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used.

b) Quick Connect Terminals – Nonferrous (push-type) terminals consisting of male posts permanently secured to the device and provided with compatible female connectors for connection to field wiring. A special tool for crimping of field wires is required. Mating terminals shall be shipped with the product with instructions for their installation.

c) Solder Terminals – Conventional nonferrous solder terminals.

d) Solderless Wrapped Terminals – Solderless wrapped nonferrous terminals that require a special tool and terminal post construction.

e) Telephone-Type Terminals – Nonferrous terminal plates employing a narrow V-shaped slot for securing of a conductor in a special post design. A special tool for wire connection is required.

f) Communication Terminals – For Ethernet, USB, FireWire (IEEE 1394), and the like data transmission, employing connectors complying with the requirements of UL 1863, or UL 1977.

Exception: In the case where power is supplied to the access control unit from a power over communications cable source that has been tested and is in compliance with 35.7, Power over communications cable equipment, then the field wiring terminal shall typically be an RJ-45 style jack that complies with the requirements of UL 1863.

g) Other Terminals – Other terminal connections may be used if determined to be equivalent to terminals described in (a) – (f). They are subject to the same restrictions.

17.4.2 Any of the terminal configurations listed in 17.4.1 may be used for connection of field wiring if they with all of the

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 permissible wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size to be used shall not be less than 26 AWG (0.13 mm^2).

c) The wire size to be used shall have the current-carrying capacity appropriate to the circuit application.

d) The terminal configurations shall comply with the requirements of the Special Terminal Assemblies Tests, Section 64.

Exception: Terminals complying with the requirements in any of the standards specified in 17.3.2 (b) – (e) are not required to be subjected to the Special Terminal Assemblies Tests, Section 64.

17.5 Field wiring leads

17.5.1 If leads are provided in lieu of wiring terminals, they shall not be less than 6 inches (152 mm) long, and shall not be smaller than 22 AWG (0.32 mm^2). See 17.5.2.

Exception No. 1: A lead may be less than 6 inches in length if it is evident that the use of a longer lead:

a) May result in damage to the lead, lead insulation, or product;

b) May result in a risk of fire, electric shock, or injury to persons;

c) May impair the intended operation of the product; or

d) Is not required for the intended operation of the product.

Exception No. 2: Copper leads as small as 26 AWG (0.13 mm^2) may be used if:

a) The current does not exceed 1 ampere for lengths up to 2 feet (61 cm) and the current does not exceed 0.4 ampere for lengths up to 10 feet (3.05 m);

b) There are two or more conductors and they are covered by a common jacket or the equivalent;

c) The assembled conductors comply with the requirement of 61.2.1 for strain relief; and

d) The installation instructions indicate that the lead shall not be spliced to a conductor larger than 18 AWG (0.82 mm^2).

Exception No. 3: In the case where power is supplied to the access control unit from a power over communications cable source that has been tested and is in compliance with 35.7, Power over communications cable equipment, then the field wiring minimum permissible wire size to be used shall not be less than 26 AWG for patch cords; 24 AWG for horizontal or riser cable.

17.5.2 For connection of a line voltage source, the leads shall not be smaller than 18 AWG (0.82 mm^2).

17.5.3 Leads intended for connection to an external circuit shall be provided with a strain relief if stress on the lead may be transmitted to terminals, splices, or internal wiring. See the Strain Relief Test, Section 61.

17.6 Polarity identification

17.6.1 In a product 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 the screw shells of lampholders and to which no primary overcurrent-protective devices or other switching devices of the single-pole type are connected.

17.6.2 A terminal intended for the connection of a grounded supply conductor shall be composed of or plated with metal that is substantially white in color and shall be distinguishable from the other terminals. Otherwise, identification of the terminal shall be clearly shown in an alternative 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 gray color and shall be distinguishable from the other leads.

18 Grounding

18.1 A grounding means shall be provided for all equipment containing parts that require grounding. See Bonding for Grounding, Section 22.

18.2 The following are considered to constitute means for grounding:

a) In a product intended to be permanently connected by a metal enclosed wiring system, a knockout or equivalent opening in the metal enclosure of the product.

b) In a product intended to be permanently connected by a nonmetal enclosed wiring system, such as nonmetallic-sheathed cable, an equipment grounding terminal or lead.

c) In a cord-connected product, an equipment grounding conductor in the cord.

18.3 On a permanently-connected product, a terminal intended solely for the connection of an equipment grounding conductor shall be capable of securing a conductor sized in accordance with NFPA 70.

18.4 A soldering lug, a push-in connector, a screwless connector, or a quick-connect or similar friction-fit connector shall not be used either as the grounding terminal intended for the connection of field supply connections or as the grounding wire in a supply cord.

18.5 On a permanently-connected product, a wire binding screw intended for the connection of an equipment grounding conductor shall have a green head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified such as by being marked "G," "GR," "GROUND," or "GROUNDING," or the like, or by a marking on a wiring diagram provided on the product. See also 18.7.

18.6 The wire binding screw or pressure wire connector specified in 18.5 shall be secured to the frame or enclosure of the product and shall be located so that it is unlikely to be removed during service operations, such as replacing fuses, resetting manual-reset devices, or the like.

18.7 If a pressure wire connector intended for grounding is located where it would be mistaken for a neutral conductor of a grounded supply, it shall be identified by a marking "EQUIPMENT GROUND" or by a green color identification or by both of these.

18.8 On a permanently connected product, the surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be finished in a continuous green, or a green with one or more yellow stripes. No other lead shall be so identified.

18.9 On a cord-connected product, the grounding conductor of the flexible cord shall be finished in a continuous green or in a green with one or more yellow stripes. No other conductor shall be so identified.

18.10 With reference to 18.9, the grounding conductor shall be secured to the frame or enclosure of the product by a positive means (see Bonding for Grounding, Section 22) that is not likely to be removed during any servicing operation not involving the power-supply cord. The grounding conductor shall be connected to the grounding blade of the attachment plug.

INTERNAL WIRING

19 General

19.1 The wiring and connections between parts of a product shall be protected or enclosed, or they shall be in a cord or cable that has been evaluated and determined to be rated for the application.

19.2 Internal wiring shall have thermoplastic or rubber insulation not less than 1/64 inch (0.4 mm) thick for 0 – 300 volt applications if power is less than 375 volt-amperes, current is less than 5 amperes, and the wiring is not subject to flexing or mechanical abuse. Otherwise, thermoplastic or rubber insulation not less than 1/32 inch (0.8 mm) thick and rated 600 volts, or appropriately rated supplementary insulation applied to the internal wiring, shall be used.

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

19.4 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 intended use.

19.5 Internal wiring shall be evaluated and determined to be rated for the application, with respect to temperature, voltage, ampacity, and exposure to oil, grease, solvents, acids, and other conditions of service to which the wiring is subjected.

19.6 When it is possible that internal wiring is to be exposed to moisture, including any condensation resulting from operation of the product, the wiring shall be evaluated and determined to be rated for such exposure. See Outdoor Use Equipment, Sections 74 – 86.

19.7 Vibration, impact, flexing, or other movement of wires during intended use, including user servicing, shall not reduce the wire insulation or the wire termination integrity.

19.8 Wireways shall be smooth and entirely free from sharp edges, burrs, fins, moving parts, and the like, that can 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 0.042 inch (1.07 mm) or less in thickness. Holes in walls thicker than 0.042 inch shall have smooth, rounded edges.

20 Wiring Methods

20.1 All splices and connections shall be mechanically secure and electrically bonded. Consideration shall be given to vibration when investigating electrical connections. Pressure-wire connectors have been determined to comply with the requirements.

20.2 Stranded conductors clamped under wire-binding screws or similar parts shall have the individual strands soldered together or equivalently arranged.

20.3 A splice shall be provided with insulation equivalent to that of the wires involved.

20.4 In determining whether or not splice insulation consisting of coated-fabric, thermoplastic, or another type of tape or tubing complies with the aforementioned requirements, a comparison is to be made of factors such as mechanical strength, dielectric properties, and heat- and moisture-resistant characteristics. Thermoplastic tape wrapped over sharp edges does not comply with the intent of this requirement.

20.5 When stranded internal wiring is connected to a wire-binding screw, there shall not be loose strands of wire that contact other uninsulated live parts or dead-metal parts. This shall be accomplished by use of pressure-terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other means that have been determined to be equivalent.

20.6 A printed wiring assembly shall comply with UL 796.

20.7 A printed-wiring assembly using insulated 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, Section 52, after they are subjected to the Humidity Test, Section 46; the Temperature Test, Section 53; and other applicable tests described in this Standard.

20.8 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 smooth, rounded surface against which the cord may bear.

20.9 If the cord hole is in phenolic composition or other nonconducting material, or in metal not less than 0.042 inch (1.07 mm) thick, a smooth, rounded surface is considered to be the equivalent of a bushing.

20.10 Ceramic materials and some molded compositions may be used for insulating bushings if they have been investigated and found acceptable for the purpose.

20.11 Fiber may be employed where it will not be subjected to temperatures higher than 90 °C (194 °F) under intended operating conditions if the bushing is not less than 3/64 inch (1.2 mm) thick and if it will not be exposed to moisture.

20.12 A soft rubber bushing may be employed in the frame of a motor if the bushing is not less than 3/64 inch (1.2 mm) thick and if the bushing is located so that it will not be exposed to oil, grease, oily vapor, or other substance which may have a deleterious effect on rubber. 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 likely to cut into the rubber.

20.13 An insulating-metal grommet is acceptable in lieu of an insulating bushing, when the insulating material used is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

21 Separation of Circuits

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

21.2 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 not be less than 0.028 inch (0.71 mm) thick.

Any clearance between the edge of a barrier and a compartment wall shall not be more than 1/16 inch (1.6 mm).

22 Bonding for Grounding

22.1 Except as specified in 22.3, in a high-voltage product, provision shall be made for the grounding of all exposed or accessible noncurrent-carrying metal parts that are likely to become energized and that may be contacted by the user or by service personnel during service operations likely to be performed when the product is energized.

22.2 Uninsulated metal parts, such as cabinets, electrical enclosures, capacitors and other electrical components, shall be bonded for grounding if they may be contacted by the user or serviceman except as specified in 22.3.

22.3 A metal part described in (a) – (d) need not be grounded:

a) An adhesive-attached metal-foil marking, screw, handle, or the like that is located on the outside of an enclosure or cabinet and isolated from electrical components or wiring by grounded metal parts so that it is not likely to become energized.

b) An isolated metal part, such as a small assembly screw, that is positively separated from wiring and uninsulated live parts.

c) A cabinet, panel, or cover that does not enclose uninsulated live parts and that is separated from wiring that can energize it.

d) A panel or cover that is secured in place and insulated from electrical components and wiring by an insulating barrier or vulcanized fiber, varnished cloth, phenolic composition, or similar materials not less than 0.028 inch (0.71 mm) thick. If material having a lesser thickness is used, consideration is to be given to such factors as its electrical, mechanical, and flammability properties when compared with materials of thicknesses specified above.

22.4 The metal enclosure of a product having a slide-out chassis is considered to be grounded if the resistance between the point of connection of the equipment-grounding means and the enclosure does not exceed 0.1 ohm. Unless a separate grounding conductor is used, this will require that all coatings between the enclosure and equipment grounding means be penetrated when the chassis is inserted in the enclosure. In such cases, metal-to-metal contact shall be maintained at any point of insertion or withdrawal of the chassis.

22.5 Metal-to-metal hinge bearing members for a door or cover are considered to be means for bonding a door or cover for grounding if a minimum of two pin-type hinges, with a minimum of three knuckles each, are used.

22.6 A separate component bonding conductor shall be of copper, a copper alloy or other material intended for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by metallic or nonmetallic coatings, such as enameling, galvanizing, or plating. A separate bonding conductor or strap shall:

a) Be protected from mechanical damage or be located within the confines of the outer enclosure or frame; and

b) Not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

22.7 Except as specified in 22.10, the bonding shall be by such means as clamping, riveting, bolted or screwed connection, or welding, soldering, or brazing of materials having a softening or melting point greater than 445 °C (833 °F). The bonding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel. Bonding around a resilient mount shall not depend on the clamping action of rubber or other nonmetallic material.

22.8 A bolted or screwed connection that incorporates a star washer under the screwhead, or a serrated screwhead may be used for penetrating nonconductive coatings. If the bonding means depends upon screw threads, two or more screws or two full threads of a single screw shall engage the metal.

22.9 An internal connection intended to bond internal parts to the enclosure for grounding, but not intended for use with a field installed grounding conductor or the grounding wire in a supply cord, may use a quick-connect terminal of the specified dimensions if the connector is not likely to be displaced and the component is limited to use on a circuit having a branch circuit protective device, rated as follows:

Terminal dimensions, inches	Terminal dimensions, (mm)	Rating of protective device, amperes
0.020 by 0.187 by 0.250	(0.51 by 4.75 by 6.4)	20 or less
0.032 by 0.187 by 0.250	(0.81 by 4.75 by 6.4)	20 or less
0.032 by 0.205 by 0.250	(0.81 by 5.2 by 6.4)	20 or less
0.032 by 0.250 by 0.312	(0.81 by 6.4 by 7.9)	60 or less

22.10 A connection that depends upon the clamping action exerted by rubber or other nonmetallic material may be used if:

a) It complies with 22.12 under the compression permitted by a variable clamping device; and

b) It functions as intended after exposure to the effects of oil, grease, moisture, and thermal degradation that may occur in service.

Also, the effect of assembling and disassembling such a clamping device for maintenance purposes is to be considered, with particular emphasis on the likelihood of the clamping device being reassembled in its intended fashion.

22.11 On a permanently connected product, the size of a conductor used to bond an electrical enclosure shall be based on the rating of the branch circuit overcurrent device to which the equipment will be connected. The size of the conductor or strap shall be in accordance with Table 22.1.

Table 22.1
Bonding Wire Conductor Size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum Wire	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)
40	10	(5.3)	8	(8.4)

Table 22.1 Continued on Next Page

Table 22.1 Continued

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum Wire	
	AWG	(mm^2)	AWG	(mm^2)
60	10	(5.3)	8	(8.4)
100	8	(8.4)	6	(13.3)
200	6	(13.3)	4	(21.2)

[a] Or equivalent cross-sectional area

22.12 A conductor, such as a clamp or strap, used in place of a separate wire conductor to bond an electrical enclosure shall have a minimum cross-sectional conducting area equivalent to that of the wire sizes indicated in Table 22.1.

22.13 On a cord-connected product, a bonding conductor or strap shall have a cross-sectional area not less than that of the grounding conductor of the supply cord. See 22.14 and 22.15 for exceptions to this requirement.

22.14 A bonding conductor to an electrical component need not be larger than the size of the conductors supplying the component.

22.15 Splices shall not be used in wire conductors used to bond electrical enclosures or other electrical components.

22.16 If branch-circuit overcurrent protective devices of more than one size are involved, the size of the bonding conductor is to be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor. For example, if a component is individually protected by a branch circuit overcurrent device smaller than other overcurrent devices used with the equipment, a bonding conductor for that component is sized on the basis of the overcurrent device intended for ground-fault protection of the component.

22.17 The continuity of the grounding system of the product shall not rely on the dimensional stability of nonmetallic material.

COMPONENTS, ELECTRICAL

23 Mounting of Components

23.1 A switch, lampholder, attachment-plug, connector base, or similar electrical component, shall be secured in position and, except as noted in this section, shall be secured against turning.

23.2 The tension of a screw or other fastening used to mount or support small, fragile insulating parts shall be adjusted so that the expansion or contraction of the screw will not cause weakening or cracking of the insulating parts.

23.3 The requirement that a switch be secured against turning may be waived if all four of the following conditions are met:

a) The switch is of the plunger type or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during intended operation of the switch.

b) The means for mounting the switch makes it unlikely that the operation of the switch will loosen it.

c) Spacings are not reduced below the minimum required values if the switch rotates.

d) The switch is operated mechanically rather than by direct contact by persons.

23.4 A lampholder of the type in which the lamp cannot be replaced need not be secured against turning if rotation will not reduce spacings below the minimum required values. A neon pilot light or an indicator light in which the lamp is sealed in a nonrenewable jewel exemplifies such lampholders.

23.5 Uninsulated live parts shall be secured to the base or mounting surface so that they will not turn or shift in position, if such motion may reduce spacings below the intended values. (The security of contact assemblies shall provide for the continued alignment of contacts.)

23.6 The means to prevent turning shall be provided by more than friction between surfaces.

23.7 A lock washer that provides both spring take-up and an interference lock may be used as a means to secure a small stem-mounted switch or other device having a single-hole mounting means.

23.8 A flush plate for outlet box mounting shall be of:

a) 0.030 inch (0.76 mm) or thicker ferrous metal;

b) 0.040 inch (1.01 mm) or thicker nonferrous metal; or

c) 0.100 inch (25.4 mm) or thicker nonconductive material.

23.9 A yoke or strap or the mounting ears of a part intended to be mounted on a standard outlet box or box with a similar back shall be of 0.040 inch (1.01 mm) or thicker steel. If a nonferrous metal is used, it shall be of thickness sufficient to provide mechanical strength and rigidity not less than that of steel 0.040 inch thick.

24 Insulating Materials

24.1 Insulating materials used in a base for the support of live parts shall be nonflammable and moisture-resistant. Porcelain and phenolic or cold-molded composition are examples of such insulating materials.

24.2 A base mounted on a metal surface shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base that are not staked, upset, sealed, or secured in an equivalent manner. The insulating barrier shall prevent the live parts and the ends of replaceable terminal screws from coming in contact with the supporting surface.

24.3 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not for the sole support of live parts where shrinkage, current leakage, or warping of the fiber may introduce a risk of fire or electric shock.

24.4 A countersunk sealed live part shall be covered with a waterproof insulating compound that will not melt at a temperature of 15 °C (27 °F) higher than the maximum intended operating temperature of the assembly, and at not less than 65 °C (149 °F) in any case. The depth or thickness of sealing compound shall not be less than 1/8 inch (3.2 mm).

24.5 The thickness of a flat sheet of insulating material, such as phenolic composition or the equivalent, used for panel-mounting of parts shall not be less than that indicated in Table 24.1.

Table 24.1
Thickness of Flat Sheets of Insulating Material

Maximum dimensions				Minimum thickness[a]	
Length or width		Area			
inch	(cm)	inch^2	(cm^2)	inch	(mm)
24	(60.9)	360	(2323)	3/8	(9.5)
48	(122.0)	1152	(7423)	1/2	(12.7)
48	(122.0)	1728	(11,148)	5/8	(15.9)
over 48	(122.0)	over 1728	(11,148)	3/4	(19.1)

[a] Material less than 3/8 inch (9.5 mm) but not less than 1/8 inch (3.2 mm) in thickness may be used for a panel if the panel is adequately supported or reinforced to provide rigidity not less than that of a 3/8 inch sheet. Material less than 3/16 inch (4.8 mm) may be employed for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

25 Fuseholders and Current-Carrying Parts

25.1 A fuseholder shall be installed or protected so that adjacent uninsulated high-voltage live parts, other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. A separation of less than 4 inches (102 mm) is considered to be adjacent.

25.2 All current-carrying parts shall be of silver, copper, a copper alloy, or other material determined to be acceptable for use as an electrical conductor. However, multimetallic thermal elements and heater elements of a thermal protector need not comply with this requirement.

25.3 Bearings, hinges, and the like shall not be used as current-carrying parts.

26 Overcurrent Protection

26.1 If a primary circuit breaker or fuse is provided, its rating shall be in accordance with the maximum input to the product.

27 Semiconductors

27.1 A semiconductor shall be rated for the intended application under all environmental conditions to which it may be exposed in service. See Performance Tests, Sections 35 – 69, 79 – 85.

28 Switches

28.1 A switch provided as part of the product shall have a current and voltage rating not less than that of the circuit that it controls when the product is operated under any condition of intended service. If the circuit controlled has a power factor of less than 75 %, the switch shall have a horsepower rating (evaluated on the basis of the ampere equivalent), or a current rating of not less than 200 % of the maximum load current.

29 Transformers and Coils

29.1 A transformer shall be of the two-coil or insulated type. However, an autotransformer may be used, if the terminal or lead common to both input and output circuits is identified and the output circuits are located only within the enclosure containing the autotransformer. See 17.6.2 for identification requirements.

29.2 A coil shall be treated with an insulating varnish and baked or otherwise impregnated to exclude moisture.

29.3 Film-coated wire is not required to be given additional treatment to exclude moisture.

30 Rechargeable Storage-Type Batteries Used as a Secondary Power Source

30.1 A storage battery shall have sealed cells, or cells with spray trap vents, and shall be maintained in the charged state.

30.2 Batteries shall be located and mounted so that terminals of cells are prevented from coming into contact with terminals of adjacent cells or with metal parts of the battery enclosure as a result of shifting of the batteries.

30.3 The mounting arrangement for the batteries shall permit access to the cells for testing and maintenance, or the product shall provide integral meters or readily accessible terminal facilities for the connection of meters for determining battery voltage and charging current.

30.4 A conditioning charge shall be limited so that, with the maximum rate of charge that can be obtained, the battery gases do not adversely affect any part of the product. The trickle and fast charge rates of a battery shall not exceed the battery manufacturer's recommended rates.

30.5 The battery shall be protected against excessive loading or charging current by a fuse or other overcurrent protective device.

31 Nonrechargeable (Primary) Dry-Cell Batteries

31.1 When a battery or set of batteries is used as the main source, or the non-rechargeable standby source of power of a product, it shall meet the requirements noted below.

31.2 Batteries shall be located and mounted to reduce the risk of terminals of cells coming in contact with uninsulated live parts, terminals or adjacent cells, or metal parts of the enclosure as a result of shifting.

31.3 Ready access shall be available to the battery compartment to facilitate battery replacement, without damage to the product components or disassembly of any part of the product, except for a cover or similar parts.

31.4 Removal of the product from a mounting support to replace a battery shall be permitted only where the connected wiring is not subjected to flexing or stress and the mounting of the product is supervised.

31.5 Lead or terminal connections to batteries shall be identified with the proper polarity (plus or minus signs), and strain relief provided for any leads.

31.6 Connections to battery terminals shall be either by a lead terminating in a positive snap-action type clip, a fixed butt-type connection, or another connection means that has been determined to be equivalent. The connection shall consist of an unplated or plated metal that is resistant to the corrosive action of the electrolyte.

31.7 Each lead of a clip lead assembly used as part of a battery operated product shall be suited for the intended application, shall be minimum 26 AWG (0.13 mm^2) stranded wire size with minimum 1/64 inch (0.4 mm) insulation and provided with strain relief.

32 Lithium Batteries

32.1 Lithium batteries shall comply with the requirements in UL 1642.

32.2 A lithium battery shall be protected from abnormal charging currents during use as required in UL 1642.

Exception: A circuit that obtains power solely from a lithium battery (for example, a circuit in which the lithium battery serves as the sole power source as opposed to serving as a standby power source) is not required to be subjected to the abnormal charging current requirements in UL 1642.

SPACINGS

33 General

33.1 Except as specified in 34.2, spacings between uninsulated live parts or between uninsulated live parts and dead-metal parts shall not be less than those indicated in 33.2 – 33.5.

33.2 Where deformation of the enclosure is likely to reduce spacings, the spacings between an uninsulated live part and:

a) A wall or cover of a metal enclosure;

b) A fitting for conduit or metal-clad cable; and

c) A metal piece attached to a metal enclosure, where deformation of the enclosure is likely to reduce spacings,

shall not be less than those indicated in Table 33.1. Also see Figure 33.1.

Table 33.1
Minimum Spacings

Point of application	Voltage range volts	Minimum spacings[a, b] Through air, inches	(mm)	Over surface, inches	(mm)
To walls of enclosure:					
Cast metal enclosures	0 – 300	1/4	(6.4)	1/4	(6.4)
Sheet metal enclosures	0 – 50	1/4	(6.4)	1/4	(6.4)
	51 – 300	1/2	(12.7)	1/2	(12.7)
Installation wiring terminals:					
With barriers	0 – 30	1/8	(3.2)	3/16	(4.8)
	31 – 150	1/8	(3.2)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)
Without barriers	0 – 30	3/16	(4.8)	3/16	(4.8)
	31 – 150	1/4	(6.4)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)
Rigidly clamped assemblies[c]:					

Table 33.1 Continued on Next Page

Table 33.1 Continued

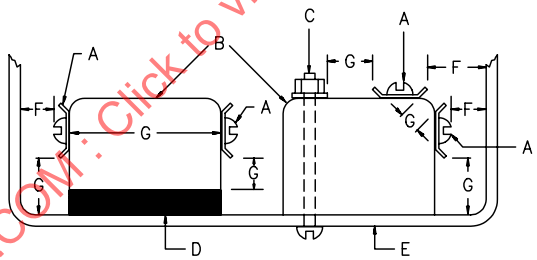
Point of application	Voltage range volts	Minimum spacings[a, b]			
		Through air,		Over surface,	
		inches	(mm)	inches	(mm)
Class 2, Power-Limited	0 – 30	–	–	–	–
Class 2 or 3, Power-Limited	Over 30	3/64	(1.2)	3/64	(1.2)
Non Class 2, Power-Limited	0 – 30	3/64	(1.2)	3/64	(1.2)
	31 – 150	1/16	(1.6)	1/16	(1.6)
	151 – 300	3/32	(2.4)	3/32	(2.4)
Other parts	0 – 30	1/16	(1.6)	1/8	(3.2)
	31 – 150	1/8	(3.2)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)

[a] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material used where spacings would otherwise be insufficient, shall not be less than 0.028 inch (0.71 mm) thick; except that a liner or barrier not less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of not less than one-half of the through-air spacing required. The liner shall be located so that it will not be affected adversely by arcing. Insulating material having a thickness less than that specified may be used if it is suitable for the particular application.

[b] Measurements are to be made with solid wire of adequate ampacity for the applied load connected to each terminal. The wire shall not be smaller than 18 AWG (0.82 mm^2).

[c] Rigidly clamped assemblies include such parts as contact springs on relays or cam switches, printed wiring boards, and the like.

Figure 33.1
Component Spacings



SM100

A – Uninsulated live parts of a component.

B – Insulating materials of a component.

C – Mounting screw of a component.

D – Dead metal part of a component.

E – Dead metal part of the product.

F – Spacings to which the requirements of this standard apply unless specifically noted otherwise.

G – Spacings to which the requirements in this standard may not apply.

33.3 The spacings between an uninsulated live part and:

a) An uninsulated live part of opposite polarity;

b) An uninsulated grounded dead-metal part other than the enclosure; and

c) An exposed dead-metal part that is isolated (insulated),

shall not be less than those indicated in Table 33.1. See 34.1 – 34.4 for exceptions to this requirement.

33.4 If a short circuit between uninsulated live parts of the same polarity would prevent the intended operation of the product, the spacings between the uninsulated live parts shall not be less than those indicated for "Other parts" in Table 33.1.

33.5 Film-coated wire is considered an uninsulated live part in determining compliance of a product with the spacing requirements, but film coating may be used as turn-to-turn insulation in coils.

34 Components

34.1 A component in which the spacings do not comply with 33.2 may be used if, upon investigation, the component is determined to comply with the performance requirements of this Standard.

34.2 Where minimum values of spacings cannot be measured, such as those present on multi-layered printed wiring boards, the spacings shall be such that the circuit(s) will comply with the requirements in the Dielectric Voltage-Withstand Test, Section 52.

34.3 The spacing requirements in Table 33.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component which is provided as part of the control unit. Such spacings are determined 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 as specified in Table 33.1.

34.4 The "To-walls-of-enclosure" spacings indicated in Table 33.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

34.5 The spacings within snap switches and similar wiring devices supplied as part of the unit are investigated on the basis of the requirements for such devices.

PERFORMANCE – ALL UNITS

35 General

35.1 General information

35.1.1 Products that currently meet all the requirements of UL 60950-1 or UL 62368-1, fulfill the following requirements:

a) Leakage Current Tests for Cord-Connected Products, Section 47;

b) Electric Shock Current Test, Section 48;

c) Dielectric Voltage-Withstand Test, Section 52;

d) Abnormal Operation Test, Section 54;

e) Polymeric Materials Test, Section 58;

f) Strain Relief Test, 61;

g) Tests for Ignition Through Bottom-Panel Openings, Section 62;

h) Mechanical Strength Tests for Enclosures, Section 63;

i) Special Terminal Assemblies Tests, Section 64;

j) Production Line Dielectric Voltage-Withstand Test for High-Voltage Products, Section 70; and

k) Production Line Grounding Continuity Test, Section 71.

35.1.2 In addition to the above, products that currently meet all the Limited Power Source (LPS) requirements of UL 60950-1 , or UL 62368-1, also fulfill the requirements of the Power Limited/Class 2 and 3 Circuits Test, Section 40.

35.2 Single point locking devices

35.2.1 Single point locking devices shall be subjected to the following tests as applicable:

a) Normal Operation Test, Section 36;

b) Input Measurement Test, Section 38;

c) Output Measurement Test, Section 39;

d) Electrical Supervision Test, Section 41;

e) Standby Power, Section 42;

f) Undervoltage Operation Test, Section 43;

g) Overvoltage Operation Test, Section 44;

h) Variable Ambient Test, Section 45;

i) Humidity Test, Section 46;

j) Endurance Test, Section 50;

k) Jarring Test, Section 51;

l) Dielectric Voltage-Withstand Test, Section 52;

m) Temperature Test, Section 53;

n) Abnormal Operation Test, Section 54;

o) Electrical Transient Tests, Section 55;

p) Polymeric Materials Test, Section 58;

q) Battery Replacement Test, Section 59;

r) Strain Relief Test, Section 61;

s) Impact Test, 63.2;

t) Special Terminal Assemblies Tests, Section 64;

u) Destructive Attack Test, Section 65; and

v) Access Control Line Security, Section 67.

35.2.2 Single point locking devices that incorporate key locks for Levels II, III, and IV, as described in Table 7.1, shall be subject to the applicable requirements of UL 437.

35.3 Test units and data

35.3.1 Access control equipment units that are fully representative of production units are to be used for each of the following tests unless otherwise specified.

35.3.2 The devices used for testing are to be those specified by the wiring diagram of the product, except that substitute devices may be used if they produce functions and load conditions equivalent to those obtained with the accessories intended to be used with the product in service.

35.4 Test samples and miscellaneous data

35.4.1 The following samples are to be provided for testing:

a) Two or more complete access control equipment units. However, a single sample may be provided if the size and complexity of the product would make it impracticable to provide more than one sample. The single sample shall be fully representative of the product.

b) One or more samples of each encapsulated or sealed assembly shall be provided in the unencapsulated or unsealed condition.

c) Installation and operating instructions as specified in Section 91, Installation and Operating Instructions.

35.4.2 One of the following configurations shall be provided for testing:

a) Samples described in 35.4.1 with associated access control equipment for testing. The equipment submitted for test shall include the product under test, and any associated equipment to provide a complete access control system for test. All equipment submitted shall be tested without requiring any simulator or other equipment that can emulate any sub-system of the access control system.

b) Samples described in 35.4.1 with associated simulator or other equipment that can emulate a specific sub-system of the access control system.

1) Any simulator provided shall simulate an interface connection to the product under test.

2) Any simulator provided shall completely provide the necessary communication protocols for a published public interface listed in Table 35.1.

3) Testing shall utilize all parameters of the communications protocols listed in (2).

4) The simulator shall not be tested but its implementation of the communications protocols listed in (2) shall be verified.

5) Test voltages and transient tests for the product shall still comply.

Table 35.1
Test interfaces

Interface description
SIA AC-01-1996.10 – Access Control Standard Protocol for the 26-bitWiegand Reader Interface
SIA Open Supervised Device Protocol (OSDP), v2.1.5 or later

35.5 Test voltages

35.5.1 Unless specifically noted otherwise, the test voltage for each test of a product is to be as follows, at rated frequency:

Rated voltage nameplate,	Test voltage
110 to 120	120
220 to 240	240
Other	Marked rating

35.6 Essential computer equipment

35.6.1 This section describes test methods for the evaluation of essential computer equipment meeting the conditions specified in 35.6.2 and 1.5. This section does not apply to equipment such as the main access control system unit (dedicated control panel) and card readers.

35.6.2 Essential computer equipment meeting all the conditions specified in (a) – (j) need not be subjected to Sections 38 – 40, 42 – 61, and 68 – 69.

a) Data processing equipment and office appliance/business equipment used as computer equipment shall comply with UL 60950-1 or UL 62368-1.

b) The manufacturer specifies the minimum system configuration consisting of the following:

1) Operating system class, minimum revision levels/or kernel type and revision level.

2) Microprocessor type, minimum revision level and minimum clock speed.

3) Minimum disk storage.

4) Minimum memory requirements.

5) Access Control Monitoring software revision level.

c) A product meeting, but not exceeding the specifications of (b), shall be submitted for compliance with the following tests:

1) Normal Operation;

2) Electrical Supervision;

3) Destructive Attack Test.

Exception: The Destructive Attack Test is not applicable when the essential computer equipment is located within the controlled/protected/restricted area as indicated in the installation instructions.

d) The installation instructions shall specify supply line transient protection complying with UL 1449, with a maximum marked rating of 330 V.

e) The installation instructions shall specify signal line transient protection complying with the requirements for UL 497B, with the maximum marked rating of 50 V.

f) The installation instructions shall specify that communication circuits and network components connected to the telecommunications network shall be protected by secondary protectors for

communication circuits. These protectors shall comply with UL 497A. These protectors shall be used only in the protected side of the telecommunications network.

g) The installation instructions shall indicate that equipment be installed in a temperature controlled environment. A temperature controlled environment is defined as one that can be maintained between 13 – 35 °C (55 – 95 °F) by the HVAC system. Twenty-four hours of standby power shall be provided for the HVAC system. The standby power system for the HVAC system may be supplied by an engine driven generator alone. A standby battery is not required to be used.

h) A failure of the computer equipment such as a loss of the system program, system lockup or total failure, shall not allow unauthorized access. A loss of operation is acceptable if the system fails secure.

i) The installation instructions shall specify that in addition to the main power supply and secondary power supply that are required to be provided at the central supervisory station, the system shall be provided with an uninterruptable power supply (UPS) with sufficient capacity to operate the computer equipment for a minimum of 15 minutes. If more than 15 minutes is required for the secondary power supply to supply the UPS input power, the UPS shall be capable of providing input power for at least that amount of time.

35.7 Power over communications cable equipment

35.7.1 General

35.7.1.1 This section provides requirements for the evaluation of power over communications cable devices for access control systems and equipment. Power sources may be provided integral with the access control equipment or as a separate device supplying power.

35.7.1.2 The equipment is intended to comply with the following sections of NFPA 70:

a) Where the power supplied over a communications cable is less than or equal to 60 watts: Article 725.121, Power Sources for Class 2 and Class 3 Circuits;

b) Where the power supplied over a communications cable is greater than 60 watts: Article 725.144, Transmission of Power and Data.

35.7.1.3 The power sourcing equipment (PSE) shall comply with UL 60950-1 and/or UL 62368-1, as well as meet the requirements of 10.1.1, 35.1.1, 35.1.2, the requirements of this Section (35.7), and all other applicable requirements of this Standard. Powered Devices (PD) shall comply with this Section (35.7), as well as all other applicable requirements of this Standard.

35.7.1.4 These requirements apply to all connected equipment and interconnections necessary to ensure normal operation of the network powered access control system.

35.7.1.5 A power over communications circuit must be power-limited and shall not exceed 60 V DC, 8.0 amperes, and/or 100 watts. Products shall be evaluated at the marked input/output circuit ratings.

35.7.1.6 For equipment covered by this section that is intended to be located in an outdoor environment, the requirements noted in Outdoor Use Equipment, Sections 74 – 86, are to be applied as applicable. In addition, any equipment installed in outdoor use applications shall employ NEC Class 3 wiring methods, as indicated in the product installation instructions.

35.7.2 Installation and operation

35.7.2.1 Communications circuits

35.7.2.1.1 Where a product has provisions for connection to a telephone, or outside wiring as covered by Article 800 in NFPA 70, the product shall comply with the requirements for Protection Against Overvoltage From Power Line Crosses described in UL 60950-1 or UL 62368-1.

35.7.2.1.2 Where the product is intended to, or under normal use conditions can come in contact with the equipment users, the product shall comply with requirements for Protection of Equipment Users From Overvoltages on Telecommunication Networks, described in UL 60950-1 or UL 62368-1.

35.7.2.2 Location of midspan PSE or power injector

35.7.2.2.1 The midspan PSE or power injector can be located at any point within the defined structured cabling channel compliant to TIA-568-C.2, between the network switch and the powered device (PD).

35.7.2.3 Cabling requirements

35.7.2.3.1 Category 5e cabling is the minimum performance category recommended. The performance category utilized should match the transmission speed required at the installation site.

35.7.2.3.2 The minimum conductor gauge permitted to connect between the PSE or power injector and the PD shall be 26 AWG (0.13 mm^2) for patch cords; 24 AWG (0.21 mm^2) for horizontal or riser cable.

35.7.2.4 Additional requirements

35.7.2.4.1 Products that utilize power over communications cable are typically connected through standard eight-pin RJ-45 connectors. The connector configuration shall be supplied in the product documentation with the power over communications equipment.

35.7.2.4.2 The equipment shall be provided with information concerning the power sourcing equipment (PSE) connector configuration (for example, Alternative A or Alternative B or both), and the maximum power class supported by the PSE.

35.7.2.4.3 Power sourcing equipment and powered devices that meet the requirements of this standard shall specify the UL 294 compliant network powered access control system and equipment with which it is compatible with.

35.7.3 Markings

35.7.3.1 PoE equipment for access control systems that complies with the requirements of Section 40, Power Limited/Class 2 and 3 Circuit Test, shall be marked to specifically identify all Power Limited/Class 2 and Class 3 circuits by terminal designation. This marking may be on a separate installation wiring diagram if so referenced on the product.

35.7.3.2 The maximum voltage and current for each power over communications circuit shall be marked in accordance with 72.1(d).

35.7.3.3 In addition to “Security Equipment”, power over communications cable equipment shall be identified as "UL 60950", "UL 60950-1", "Information Technology Equipment" (or "Info. Tech. Equip." or "I.T.E."), “UL 62368”, “UL 62368-1”, or “Audio/Video, Information and Communication Technology Equipment”, as applicable.

35.7.4 Installation and operating instructions

35.7.4.1 In addition to the information noted in Section 91, Installation and Operating Instructions, the following paragraphs contain essential information that shall be provided in the product installation instructions of the power over communications cable equipment:

a) 2.1, IEEE statement;

b) 35.7.1.2, NEC statement;

c) 35.7.1.6, outdoor use applications;

d) 35.7.2.1.1, outside wiring;

e) 35.7.2.3.1, Cat 5e cabling;

f) 35.7.2.3.2, min. conductor gauge; and

g) 35.7.2.4.1, 35.7.2.4.2, connector configurations.

35.8 Remote access

35.8.1 General

35.8.1.1 A remotely accessible system is a system that is able to be accessed with a device other than that located at the protected premises. The device can take the form of a smart phone/tablet, an internet-connected device, or any other means of accessing an access control system that is not using the control unit's human interface, albeit a wired and/or wireless keypad, card reader, or other user-accessible interface device located at the protected property.

35.8.1.2 The requirements of 35.8 are optional and when equipped with remote access features, the requirements of 35.8 apply. When equipment complies with the requirements in 35.8, the system shall be identified for Remote Access. Also see 35.8.1.12.

35.8.1.3 The access control system components and the software used in network-connected and/or smart environments are within the scope of this standard[a]. The requirements for remote communication, remote operation, and software downloading and installation are given in 35.8.1 – 35.8.10. These requirements specifically address the operation of remote controlled control units that are intended to operate access control equipment located within the protected area(s) that may be physically unattended by the user.

[a] Also referred to as “control unit”. Generally these include the access control unit, accessories, and/or it's supporting system platform such as a monitoring station, as applicable.

35.8.1.4 Validation of the user, performed through the remote device/connection, shall comply with the minimum security measures as detailed in 35.8.2.

35.8.1.5 The system, when being accessed remotely, shall operate as it would if it were being accessed from a control unit's human interface device located within the protected area. As such, all other applicable operational requirements of this Standard shall also be applied to any remotely accessible functions.

Exception: Any action initiated by the control unit via a direct (trusted physical) path shall always take precedence over a remote action. See 35.8.1.9.

35.8.1.6 The use of remote access shall not compromise the integrity, change the intended use, or impair the operation of the access control system.

35.8.1.7 The manufacturer's intended remote access operation shall be defined in the product's installation and operating instructions.

35.8.1.8 A control unit shall be locally programmed or remotely programmed and securely configured per 35.8.1 – 35.8.3 for remote operation before remote access is to be permitted.

35.8.1.9 Any actions or control activity initiated by the control unit via a direct (trusted physical) path takes precedence and priority over a remotely actuated action.

35.8.1.10 When remote access features are employed, the manufacturer shall specify the minimum configuration consisting of the following:

a) Transmission technology employed (e.g. GSM, CDMA, HSPA, LTE), along with protocol name and version number if applicable;

b) Remote device operating system(s) and revision level, along with kernel version (if applicable);

c) Remote device application software and build revision levels. The application software shall be specifically developed by the manufacturer or its subsidiary and be proven compatible with specific control units/equipment;

d) The access control system shall have the means to distinguish between the type of command/control information received from the local interface device versus that received from a remote device, via code or description. This user information, along with date/time stamp, shall be transmitted to the monitoring station (as applicable) so it is known which user (local vs. remote) has performed a specific system command; and

e) All items above shall be documented in the product installation instructions.

35.8.1.11 The access control system shall allow the connection of a user under the following conditions:

a) As defined in the product installation instructions, a timeout feature, after a period specified by the manufacturer of no communication activity and/or no user connection, shall be implemented if the remote connection is lost, broken, or ended. The communication session shall be automatically terminated if it is idle for a maximum of 15 minutes;

b) There can be multiple remote connections per system at a time for monitoring/communication purposes only. Remote operation, remote service/maintenance, and/or software/firmware deployment must be performed first-in, first-out (FIFO);

c) Access levels that are configured to provide specific functionality on the access control system shall then provide that functionality on the systems that the user is permissioned to execute; and

d) Means shall be provided to detect repeated attempts to gain access not recognized as valid by the control unit. There shall be a mechanism to lockout the system or an individual user from future validation after a maximum of 5 unsuccessful attempts within a 10-minute period, as specified by the manufacturer in the product installation instructions. Further attempts during this time period shall be automatically disabled.

35.8.1.12 When remote access features have been evaluated, the product installation instructions shall contain verbiage specifying “Evaluated for Remote Access”, or the like.

35.8.2 Validation of remote access credential

35.8.2.1 User validation – All remote access communications for the purpose of remote operation to the control unit shall comply with the authentication requirements detailed in this section.

a) There shall be an assigned “administrator” that has the rights to perform a software/firmware upgrade if this is allowable on the control unit. The administrator shall have priority over commands accessed by remote users.

b) All remote connections shall require defined users. The manufacturer of the control unit shall document any default users (such as factory authorized installers) in the product's installation instructions or manuals. Any special "Undocumented users" (such as system administrators) defined for debugging or test purposes shall follow the rules of this entire section and shall ensure there is no security risk or unintended use of the control unit with an "Undocumented user".

35.8.2.2 There shall be a means to validate the identity of the user. This means shall be a user-name and credential that authenticates the validity of the identity of the user. A credential can be a password, PIN, biometrics, token, cryptographic mechanism, or key.

35.8.2.3 The validation means shall have a factory default or installation default that comes with the control unit at installation, for example a default PIN or password, with no biometrics or keys as a default.

35.8.2.4 The validation means shall have a way to reset or return to the factory or installation default.

35.8.2.5 The user validation means may be a combination of numbers, letters, and symbols. It shall be no less than 6 characters.

35.8.2.6 The user validation means shall have a way to modify or change the factory default credential during installation and setup.

35.8.2.7 A user validation mechanism as described in this section shall be used to modify or change any existing or new user validation data and shall be considered a remote operation if performed via a remote connection.

35.8.2.8 The transmission of the user validation mechanism or credential from a remote device via a remote connection to a control unit covered in this section shall be encrypted. (See Communication Data Integrity Standards, 35.8.4.)

35.8.2.9 When provided on the control unit, the storage of the validation mechanism or credential shall not be in plain text and shall be protected from unauthorized disclosure or modification.

35.8.3 Communication

35.8.3.1 All remote access connections shall be required to be authenticated and meet the requirements of 35.8.2.

35.8.3.2 Any remotely accessible features for maintenance and diagnostic testing shall either be disabled by default or when enabled, shall meet the requirements of this section, as well as 35.8.9 and 35.8.10.

35.8.3.3 Remote connection(s) from different sources shall not degrade the intended operation of the system at the protected premises and shall not cause any security compromise. A minimum of three different sources shall be used (e.g. Web server, smart phone, tablet, etc.).

35.8.3.4 The remote connection to a control unit shall be capable of withstanding a compromise attempt by the way of corruption of data, message alteration, spoofing, or replay between the sender and the receiver.

35.8.3.5 Invalid or incorrect data received by the control unit shall not impair the operation of the access control system or cause a security compromise.

35.8.3.6 Session termination (either intended or unintended) shall not impair the operation of the access control system or create a security compromise.

35.8.3.7 Evidence of compliance for the validation of approved communication security functions shall be provided. Compliance shall be from the National Institute of Standards and Technologies (NIST) cryptographic algorithm validation program (CAVP) and shall be a current valid certificate for the security function used by the system and security function. (See Communication Data Integrity Standards, 35.8.4.)

35.8.4 Communication data integrity standards

35.8.4.1 Examples of standardized communication data integrity protection mechanisms are defined in the following:

a) Symmetric Algorithms and techniques:

1) NIST SP 800-67, Recommendation for the Triple Data Encryption Algorithm (TDEA) Block Cipher; and

2) FIPS PUB 197, Advanced Encryption Standard.

b) Asymmetric algorithms and techniques:

1) FIPS PUB 186-4, Digital Signature Standard (DSS).

c) Message authentication codes and techniques:

1) FIPS PUB 198-1, The Keyed-Hash Message Authentication Code (HMAC).

d) Hash functions:

1) FIPS 180-4, Secure Hash Standard (SHS); and

2) FIPS 198-1, The Keyed-Hash Message Authentication Code (HMAC).

e) Authentication Encryption:

1) NIST SP 800-38B, Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication;

2) NIST SP 800-38C, Recommendation for Block Cipher Modes of Operation: The CCM Mode for Authentication and Confidentiality; and

3) NIST SP 800-38D, Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC.

35.8.5 Software/Firmware upgrade

35.8.5.1 If the product covered in this standard allows for software or firmware to be modified outside of the manufacturer's facilities, then the product shall comply with this section. These requirements describe

the testable criteria for established software/firmware deliverables onto the control unit and its evaluated/compatible system devices.

35.8.5.2 The software and firmware components described in this section shall include the following:

a) The software or firmware operating system of the product;

b) The application components of the product;

c) Any apps, applications or binary deliverables required to operate the product for its intended use of this standard; and

d) Any apps, applications or binary deliverables required to add non-safety features and functionalities to the product that are separate from the safety or performance features of the equipment.

35.8.5.3 The software and firmware components of this product shall use a mechanism of configuration management that is defined by the manufacturer. The configuration management mechanism shall maintain a version control and labelling policy to track and record different versions of software/firmware components.

35.8.5.4 The software and firmware components of this product shall be clearly documented in the product installation instructions and traceable by versions.

35.8.5.5 The product shall be able to easily display or demonstrate the version of the currently installed software and firmware components. Also see Version Number, Section 9.

35.8.5.6 The software and firmware components of the product shall be created and delivered such that it protects the previous operable code and all executable code from modification and disclosure from an unauthorized source.

35.8.5.7 Remote panel programming or configuration access shall require the use of a valid password, the panel's account or network address, and a unique credential or hardware key device to enable a remote programming mode. If an internet connection is used, the data shall be encrypted (see 35.8.5.9) and an audit trail shall be created in the control unit and/or the monitoring station.

35.8.5.8 There shall be an acceptable integrity mechanism, to ensure that software and firmware installed remotely is not corrupted.

35.8.5.9 Evidence of compliance for the validation of approved communication security functions shall be provided. Compliance shall be from the National Institute of Standards and Technologies (NIST) cryptographic algorithm validation program (CAVP) and shall be a current valid certificate for the security function used by the system and security function. (See Data Integrity Standards, 35.8.6.)

35.8.6 Data integrity standards

35.8.6.1 Examples of standardized data integrity protection mechanisms are defined in the following:

a) Asymmetric algorithms and techniques:

1) FIPS 186-4.

b) Message authentication codes:

1) FIPS 140-2; and

2) FIPS 185.

c) Hash functions:

1) FIPS 180-4; and

2) FIPS 198-1.

35.8.7 Software/Firmware deployment process

35.8.7.1 The new software and firmware components shall be created with an approved software integrity mechanism to generate a factory code or signature for the binary. (See Data Integrity Standards, 35.8.6.)

35.8.7.2 Deployment of the software/firmware components to the control unit/system shall begin with the download of the software/firmware components which can be via a remote connection or direct physical connection.

35.8.7.3 If upgrade of the software/firmware components to the control unit/system interrupts the continued operation of the system, it shall be annunciated at the protected property and the monitoring station.

35.8.7.4 After upgrade of the software component, a system integrity confirmation shall be performed, and meet the following conditions:

a) Upon successful completion of the re-programming, the integrity confirmation requires the control unit/system to generate a new integrity value in accordance with the standards noted in 35.8.6;

b) The integrity confirmation performs a comparison of the factory generated code or signature validated against the integrity value in (a). If the comparison fails, the integrity confirmation fails;

c) If the integrity confirmation fails and the access control system becomes inoperable, a trouble signal shall be annunciated locally and at the monitoring station (if applicable);

d) If the integrity confirmation fails and the control unit/system can fully recover, it shall revert back to a previous known and functional state;

e) The comparison of the integrity mechanism shall only occur when the control unit/system has the complete software binary. It shall not be done prior to upgrade; and

f) The factory code or signature shall be included in the software binary and shall not be downloaded separately.

35.8.8 Event log

35.8.8.1 If a manufacturer incorporates an event-log, within their control unit, it shall be configured as follows:

a) Loss of power shall have no effect upon the event log;

b) The log shall be remotely accessible;

c) If a remote session is terminated unexpectedly and without proper sign-off, it shall be recorded; and

d) The manufacturer shall specify the period of time in which the log shall be preserved.

35.8.8.2 Each event logged shall, at a minimum contain:

a) Date of the event, or equivalent means to determine date;

b) The time of the event, or equivalent means to determine date;

c) An event identifier; and

d) The identification of the user who initiated the event.

35.8.9 Remote diagnostics connection

35.8.9.1 If a manufacturer allows access for the purpose of remote diagnostics, the requirements in 35.8.3 and 35.8.5 shall apply.

35.8.9.2 Multiple remote access connections to the access control system for the purpose of diagnostics shall be allowed.

35.8.9.3 An access control system providing the option to acquire information by a remote device shall implement machine to machine authentication using signed SSL Certificates.

35.8.9.4 Remote diagnostics shall not impair or interrupt the normal operation of the access control system.

35.8.10 Remote service and maintenance

35.8.10.1 If a manufacturer allows access for the purpose of remotely updating system software, configurations, and/or servicing of the access control system, the requirements in 35.8.3, 35.8.5 and 35.8.7 shall apply.

35.8.10.2 Remote access to the access control system shall be restricted to a single user per system at a time during remote service/maintenance.

35.8.10.3 Remote control is permitted during remote servicing/maintenance where a maximum time out of 4 hours is provided.

35.9 Egress control systems

35.9.1 Egress control systems that utilize low power radio frequency (RF) technology are subject to all RF tests noted in the Short-Range Radio Frequency (RF) Tests, in UL 2610, as applicable. The associated tags/credentials used for the egress control system are also subject to the RF tests noted, as applicable. Also see 2.5, Exception No. 2.

35.10 Key management systems

35.10.1 Key management systems provide a means of regulating or controlling keys by electrical, electronic and/or mechanical means. Key management systems allow authorized users access to keys upon verification of appropriate credentials.

35.10.2 Key management systems shall meet all necessary requirements of this Standard and shall be subject to the following tests as applicable:

a) Normal Operation Test, Section 36;

b) Electronic Authentication, Section 37;

c) Input Measurement Test, Section 38;

d) Undervoltage Operation Test, Section 43;

e) Overvoltage Operation Test, Section 44;

f) Variable Ambient Test, Sections 45 and 81;

g) Humidity Test, Section 46;

h) Endurance Test, Section 50; and

i) Destructive Attack Test, Section 65.

35.10.3 In addition to those tests noted above, key management system units shall undergo the operational tests of Central-Station Service – Handling of Subscriber's Keys of UL 827.

35.10.4 Software-based equipment shall meet all applicable requirements in 35.6, Essential Computer Equipment.

35.10.5 Key management systems that communicate with a monitoring station located outside the protected area shall also comply with the following tests:

a) Electrical Supervision Test, Section 41;

b) Standby Power Test, Section 42;

c) Electrical Transient Tests, Section 55;

d) AC Induction Test, Section 56;

e) Communication Circuits, Section 57; and

f) Battery Replacement Test, Section 59.

35.10.6 High voltage products shall additionally undergo the following safety tests as applicable:

a) Leakage Current Tests for Cord-Connected Products, Section 47;

b) Electric Shock Current Test, Section 48;

c) Dielectric Voltage-Withstand Test, Section 52;

d) Temperature Test, Section 53;

e) Abnormal Operation Test, Section 54;

f) Polymeric Materials Test, Section 58;

g) Drop Test, Section 60;

h) Strain Relief Test, 61.1;

i) Tests for Ignition Through Bottom-Panel Openings, Section 62;

j) Mechanical Strength Tests for Enclosures, Section 63; and

k) Special Terminal Assemblies Tests, Section 64.

36 Normal Operation Test

36.1 A unit shall perform its intended function when installed in accordance with the product installation instructions and 36.2 – 36.4.

36.2 The unit is to be mounted in the intended manner and its terminals connected to circuits of related equipment, or its wireless connectivity configured with compatible devices, as indicated by the installation-wiring diagram so as to represent a typical system combination or simulators that can simulate a typical system combination.

36.3 If equipment is to be mounted in a definite position in order to function as intended, it shall be tested in that position.

36.4 Power-input supply terminals are to be connected to supply circuits of rated voltage and frequency. A product under test is to be in the intended circuit condition and ready for normal operation when it is connected to related products and circuits as specified in 36.2 and 36.3.

36.5 Each credential type and transmission technology employed (e.g. Wiegand, Clock and Data, RS-232, RS-485, OSDP, UART) shall be verified for normal functional operation between the reader/user interface and the control unit.

36.6 As indicated in 35.4.2(b)(2), simulators can only be used for the communication protocols documented in Table 35.1. All other credential formats and bit lengths shall be verified as applicable in 36.5.

36.7 The functions specified in 91.5(f) shall be verified as applicable.

37 Electronic Authentication

37.1 For systems using a wireless electronic device as a credential (e.g. smartphones, tablets, wearables, etc.), the manufacturer shall specify the minimum configuration consisting of the following:

a) Electronic credential transmission technology (e.g. Bluetooth, Near Field Communication (NFC), WiFi, IR (Infrared), RFID), along with protocol name and version number if applicable;

b) Wireless electronic device operating system and revision level, along with kernel version (if applicable);

c) Wireless electronic credential device application software and build revision level;

d) User Verification: a means of verification shall be employed by the user to enable access to the wireless electronic device such as a PIN or biometric feature, which subsequently provides access to the credential application software present on the wireless electronic device;

e) The access control system shall have the means to distinguish between the type of credential used via code or description (e.g. authentication/digital signature keys received from a physical card vs. authentication/digital signature keys received from a wireless electronic credential);

f) When provided, minimum data encryption/authentication techniques shall be employed in accordance with 67.3.2; and

g) All items above shall be documented in the product installation instructions with the exception of (f).

37.2 The wireless electronic credential shall only be used as an alternate means for transmitting the user data typically found on a physical credential to the reader interface. As indicated in the product installation instructions, the wireless electronic device shall not be capable of command, control, programming, or any other system manipulation.

37.3 As indicated in the product installation instructions, the wireless electronic device shall only be used in the same manner as a physical credential, transmitting user data to the reader interface within close proximity, as indicated by the manufacturer.

38 Input Measurement Test

38.1 The input of a product shall not exceed the marked current, power, or volt-ampere rating by more than 10 % when the product is operated under all conditions of use while connected to a source of supply in accordance with the requirements in 38.2.

38.2 The test voltage for this test is to be the maximum rated voltage for the product. For a product having a single voltage rating, such as 115 volts, maximum rated voltage is to be that single voltage. If the voltage is given in terms of a range of voltages, such as 110 – 120 volts, the maximum rated voltage is the highest value of the range.

39 Output Measurement Test

39.1 The measured voltage of all output circuits shall be within 85 and 110 % of their marked rating under the following conditions:

a) With primary power connected and varied from 85 % to 110 % of rated voltage. If a standby battery is used, a fully charged battery shall be connected; and

b) With primary power connected and varied from 85 % to 110 % of rated voltage. If a standby battery is used, it shall be disconnected.

39.2 Measurements shall be made with no load or with the minimum load that is specified by the manufacturer. If more than one output circuit is provided, all circuits shall have no load connected to the minimum load that is specified by the manufacturer connected to each circuit.

39.3 Upon completion of 39.2, measurements shall then be made with the maximum load connected to the output circuit. If more than one output circuit is provided, all circuits shall have the maximum load connected. If connecting the maximum load to each output circuit will exceed the total output capacity of the product, the output circuit to be measured shall be loaded to its maximum rating and the other output circuits shall have their load adjusted so that the maximum total output capacity of the product is reached. This shall be repeated for each test.

39.4 Rated load is that value of resistive load which causes the rated current to flow when the load is connected to the output circuit and the input voltage to the product is adjusted to its rated voltage.

39.5 The measured voltages at the output circuits, with the minimum and maximum rated loads applied in turn, shall be compatible with the rating of the product intended to be connected to the circuit.

39.6 An output circuit that has a voltage deviation greater than permitted in 39.1 shall be identified in the product installation instructions as “special application”. In addition, the product installation instructions shall describe the manufacturer's name and model designation of the specific device(s) intended to be powered by the non-regulated circuit that have been proven to be compatible at that same marked voltage rating or range.

40 Power-Limited/Class 2 and Class 3 Circuits Test

40.1 General

40.1.1 All field-wiring circuits that derive energy from power sources connected to a control unit shall be classified as Power-Limited/Class 2 or 3 or non-power-limited circuit. A circuit shall be considered non-power-limited unless otherwise identified in the installation documentation and marking on the product. See 17.2.1 and 72.15.

40.1.2 The power source (or sources) supplying a Power-Limited/Class 2 or 3 circuit shall be either inherently limited requiring no overcurrent protection, or limited by a combination of a power source and overcurrent protection devices such that a Power-Limited/Class 2 or 3 circuit has electrical characteristics as described in Table 40.1 for AC circuits or Table 40.2 for DC circuits.

Table 40.1
Power Source Limitations for Alternating-Current, Power-Limited/Class 2 and Class 3 Circuit

Circuit		Inherently limited power source (overcurrent protection not required)				Not inherently limited power source (overcurrent protection required)			
		Class 2			Class 3	Class 2		Class 3	
Circuit voltage V_{max} (volts)[a]		0 – 20	over 20 – 30	over 30 – 150	over 30 – 100	0 – 20	over 20 – 30	over 30 – 100	over 100 – 150
Power limitations $(VA)_{max}$ (volt-amps)[a]		–	–	–	–	250[b]	250	250	NA
Current limitations I_{max} (amps)[b]		8.0	8.0	0.005	150/V_{max}	1000/V_{max}	1000/V_{max}	1000/V_{max}	1.0
Maximum overcurrent protection (amps)		–	–	–	–	5.0	100/V_{max}	100/V_{max}	1.0
Power source maximum nameplate ratings	VA (volt-amps)	5.0 × V_{max}	100	0.005 × V_{max}	100	5.0 × V_{max}	100	100	100
	Current (amps)	5.0	100/V_{max}	0.005	100/V_{max}	5.0	100/V_{max}	100/V_{max}	100/V_{max}

Voltage ranges shown are for sinusoidal AC in indoor locations or where wet contact is not probable. For non-sinusoidal or wet contact conditions, see note c.

[a] V_{max}: Maximum output voltage regardless of load with rated input applied.

I_{max}: Maximum output current under any noncapacitive load, including short-circuit, and with overcurrent protection bypassed, when used. When a transformer limits the output current, I_{max} limits apply after one minute of operation. Where a current-limiting impedance, listed for the purpose, or as part of a listed product, is used in combination with a nonpower-limited transformer or a stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after 5 seconds.

VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed, when used. Current-limiting impedance shall not be bypassed when determining I_{max} and VA_{max}.

[b] When the power source is a transformer, VA_{max} is 350 or less where V_{max} is 15 or less.

[c] For non-sinusoidal AC, Vmax shall not be greater than 42.4 volts peak. Where wet contact (immersion not included) is probable, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 15 volts for sinusoidal AC and 21.2 volts peak for non-sinusoidal AC.

Table 40.2
Power Source Limitations for Direct-Current, Power-Limited/Class 2 and Class 3 Circuits

Circuit		Inherently limited power source[a] (overcurrent protection not required)					Not inherently limited power source (overcurrent protection required)			
		Class 2				Class 3	Class 2		Class 3	
Circuit voltage V_{max} (volts)[b]		0 – 20	over 20 – 30	over 30 – 60	over 60 – 150	over 60 – 100	0 – 20	over 20 – 60	over 60 – 100	over 100 – 150
Power limitations $(VA)_{max}$ (volt-amps)[b]		–	–	–	–	–	250[c]	250	250	NA
Current limitations I_{max} (amps)[b]		8.0	8.0	$150/V_{max}$	0.005	$150/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	1.0
Maximum overcurrent protection (amps)		–	–	–	–	–	5.0	$100/V_{max}$	$100/V_{max}$	1.0
Power source maximum name plate ratings	VA (volt-amps)	$5.0 \times V_{max}$	100	100	$0.005 \times V_{max}$	100	$5.0 \times V_{max}$	100	100	100
	Current (amps)	5.0	$100/V_{max}$	$100/V_{max}$	0.005	$100/V_{max}$	5.0	$100/V_{max}$	$100/V_{max}$	$100/V_{max}$

Voltage ranges shown are for continuous DC in indoor locations or where wet contact is not probable. For interrupted DC or wet-contact conditions, see note d.

[a] A dry-cell battery shall be considered an inherently limited power source, provided the voltage is 30 volts or less and the capacity is equal to or less than that available from series connected No. 6 carbon zinc cells.

[b] V_{max}: Maximum output voltage regardless of load with rated input applied.

I_{max}: Maximum output current under any noncapacitive load, including short-circuit, and with overcurrent protection bypassed, when used. When a transformer limits the output current, I_{max} limits apply after 1 minute of operation. Where a current-limiting impedance, listed for the purpose or as part of a listed product, is used in combination with a nonpower-limited transformer or stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after 5 seconds.

VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed, when used. Current-limited impedance shall not be bypassed when determining I_{max} and VA_{max}.

[c] When the power source is a transformer, $(VA)_{max}$ is 350 or less where V_{max} is 15 or less.

[d] For DC interrupted at a rate of 10 to 200 Hz, V_{max} shall not be greater than 24.8 volts. Where wet contact (immersion not included) is probable, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 30 volts for continuous DC and 12.4 volts for DC that is interrupted at a rate of 10 to 200 Hz.

40.1.3 Relative to 40.1.2, acceptable means for current limiting include:

a) Transformer winding impedance,

b) Thermal link embedded within the winding overwrap of a transformer,

c) Circuit components (resistors, regulators, transistors, and similar devices) which comply with the temperature test under I_{max} condition, and

d) Suitable current-limiting impedances (positive temperature coefficient varistor, and the like).

40.1.4 Relative to 40.1.2, the following are not acceptable means of current-limiting:

a) Circuit component burnout;

b) Permanent or replaceable fuses;

c) Opening of conductors on printed-wiring boards; and

d) Opening of internal wiring conductors.

40.1.5 The overcurrent protection device specified in 40.1.2 shall be of the non-interchangeable type such that it cannot be renewed in the field with an overcurrent device having a higher current rating.

40.1.6 When conducting I_{max} and VA_{max} measurements, all overcurrent protection devices of the control unit are to be short-circuited. However, current-limiting devices are not to be bypassed and are to be allowed to remain functional.

40.1.7 Where the product contains a float battery charger, V_{max}, I_{max}, and VA_{max} measurements are to be conducted with both AC and battery connected to the product. If the product contains a battery transfer relay or contains a trickle charge battery circuit, measurements of V_{max}, I_{max}, and VA_{max} are to be conducted with the product first energized only from the AC power source and then repeated with the product energized solely from the battery. The battery used during these measurements is to have the largest capacity as specified in the manufacturer's installation document.

40.1.8 The loads referenced in 40.2.1 – 40.4.1 shall be resistive.

40.2 Maximum voltage

40.2.1 With the product energized only from its rated primary power source, the output voltage of the circuit under test is to be measured while the circuit is connected to full rated load and under open circuit conditions. The maximum voltage recorded under these two conditions is to be considered V_{max}. Where the product incorporates a secondary source of supply, the test is to be repeated with the product energized solely from the secondary power source and with the primary power source disconnected. The V_{max} value obtained from each power source is to be considered separately when applying the requirements of Table 40.1 or Table 40.2.

40.3 Maximum current

40.3.1 In order to determine compliance with the I_{max} limitation, a variable load resistor initially set to draw rated current is to be connected across the circuit. The current through the load resistor is to be noted and the load removed. The resistance of the load shall then be incrementally decreased, momentarily reconnected across the circuit while noting the current, and then removed. The method is to be repeated until a short-circuit condition is obtained. The load resistor is then to be readjusted to a value capable of producing and maintaining a current equal to the maximum permitted in Table 40.1 and Table 40.2. The load resistor is then to be connected to the circuit and the current through the load resistor measured after 1 minute or after 5 seconds as determined from Table 40.1 or Table 40.2.

40.3.2 The maximum current measurement is to be the rms value for circuits that are constantly energized and the peak value for circuits that pulse the output. The measurement of the time period starts when the output is initially energized with the load specified in 40.3.1, and continues until the current is continuously below the I_{max} value indicated in Table 40.1 or Table 40.2. The time period is to include any momentary period where the output current temporarily drops below the required I_{max} value limit.

40.3.3 Where a transformer limits the value of I_{max}, and when I_{max} cannot be maintained for 1 minute due to transformer burnout, a plot of current versus time is to be generated and the graph extrapolated to 1 minute. The results satisfy the requirement of the test when the extrapolated value of I_{max} at 1 minute does not exceed the Imax limitations as indicated in Table 40.1 or Table 40.2.

40.3.4 Where a transformer does not limit the current of I_{max}, and when the maximum current through the load resistor cannot be maintained for 5 seconds due to current-limiting devices (opening of thermal link power supply foldback, PTC varistor effect, and similar devices) the current load resistor shall be adjusted to a value which will produce a current just above the I_{max} value indicated in Table 40.1 or Table 40.2. The results are in compliance when the I_{max} value stated in Table 40.1 or Table 40.2 cannot be maintained for more than 5 seconds.

40.4 VA_{max} (not inherently limited circuits only)

40.4.1 In order to determine VA_{max}, the product is to be energized from a rated source of supply and the circuit under test open-circuited. A variable load resistor, initially set to draw rated circuit current, is then to be connected across the circuit, the circuit voltage and current recorded, and the load removed. The resistance of the load is then to be incrementally decreased, momentarily reconnected across the circuit while recording the voltage and current, and then removed. This procedure is to be repeated until the load resistance has been reduced to a short circuit. Using the recorded voltage and current, the volt-ampere output under each load condition is to be calculated. The load resistor is then to be adjusted to that value which produced the maximum volt-ampere calculated and then connected to the circuit. After 1 minute, the voltage and current are again to be measured. The results of this test are acceptable if the calculated volt-ampere output of the circuit after 1 minute does not exceed the value specified in Table 40.1 or Table 40.2, as appropriate.

41 Electrical Supervision Test

41.1 General

41.1.1 Open circuit, short circuit, ground fault, and/or wire pair reversal conditions applied to wires connected to any components of an access control system installed outside its controlled/protected/restricted area, or accessible from outside its controlled/protected/restricted area, shall not result in the operation of the access point actuator device allowing access to the secured area.

Exception No. 1: This requirement can be waived if the product is provided with enclosure cover and rear tamper supervision as described in 41.1.2.

Exception No. 2: This requirement can be waived for products rated Destructive Attack Level I.

41.1.2 Any cover, door, panel, or mounting means shall be electrically supervised if it gives access to any relays, terminals, controls, or related components that might be subject to tampering outside of a secured area. When a cover, door, panel, or mounting means is opened or removed, either an alarm signal shall activate, or the access function shall not operate.

Exception: Tamper protection need not be provided for a request-to-exit device intended to render free exit from inside the secured area if tampering with the device cannot cause the device's field of view to extend beyond the secured area.

41.1.3 A malfunction or loss of primary power shall be shown by de-energization of an "AC power on" indicator, visible from the exterior of the product. The location and function of the indicator must be described in the product installation instructions and the component shall be marked in accordance with 72.1(k).

41.2 Power interruption

41.2.1 The interruption and restoration of the electrical supply shall not result in false operation of the product.

42 Standby Power

42.1 Products that provide a secondary power source shall be able to operate without primary power based on the level tests in 42.3 – 42.6.

42.2 All products will be tested to the minimum performance level parameters of Table 7.1. Products that perform beyond the minimum back up requirements are tested to confirm the manufacturers performance claims.

42.3 Level I – No Secondary Power Source.

42.4 Level II Test – Shall continue to operate as intended at full load for a minimum of 30 minutes while the product operates a minimum of one cycle of its intended function every minute.

42.5 Level III Test – Shall continue to operate as intended at full load for a minimum of 2 hours while the product operates a minimum of one cycle of its intended function every minute.

42.6 Level IV Test – Shall continue to operate as intended at full load for a minimum of 4 hours while the product operates a minimum of one cycle of its intended function every minute.

42.7 Instructions for the replacement of batteries shall be on the product, and the polarity shall be indicated.

43 Undervoltage Operation Test

43.1 An access control product shall operate as intended while energized at 85 % of its rated voltage.

43.2 A product which uses rechargeable (secondary) batteries for standby power shall be tested for operation at 85 % of nominal battery voltage while operating from standby power.

43.3 Maximum load shall be applied to the product when performing this test.

44 Overvoltage Operation Test

44.1 An access control product shall withstand 110 % of its rated supply voltage continuously without damage during the standby condition and shall operate as intended at the increased voltage.

44.2 This test shall be performed with no load connected to the product.

45 Variable Ambient Test

45.1 With the unit energized from rated voltage and connected to maximum rated load, an access control product intended for indoor use shall function as intended at the test voltage with its related equipment at ambient temperatures of 0 °C and 49 °C (32 °F and 120 °F).

45.2 The exposure to each of the above temperatures shall be 4 hours or more.

46 Humidity Test

46.1 With the unit energized from rated voltage and connected to maximum rated load, an access control product shall function as intended during and after an exposure of 24 hours to air having a relative humidity of 85 ±5 % and a temperature of 30 ±2 °C (86 ± 3 °F).

46.2 Cord-connected products powered from a high-voltage source shall comply with the requirements in the Leakage Current Tests for Cord-Connected Products, Section 47, following exposure to high humidity.

47 Leakage Current Test for Cord-Connected Products

47.1 Where a cord-connected product is powered by a source greater than 42.4 V peak, the leakage current at any exposed surface, or between any accessible part and earth ground, or any other accessible part with an open potential of greater than 42.4 V peak shall not be more than the values shown in Table 47.1 when tested in accordance with 47.2 – 47.8, immediately after exposure to the Humidity Test, Section 46.

Table 47.1
Maximum Leakage Current

Type of product[a]	Maximum leakage current[b], (mA)
Two-wire cord-connected portable or stationary product	0.50
Three-wire (including grounding conductor) cord-connected, portable product	0.50
Three-wire (including grounding conductor) cord-connected, stationary or fixed product	0.75

[a] Products which incorporate a loss-of-ground detector which dependably opens the live conductors are exempted from the requirements of this table.

[b] If an electromagnetic radiation suppression filter is necessary for the equipment to function as intended, the leakage current shall not be more than 2.5 mA if the equipment complies with the following conditions:

1) The equipment is provided with grounding means in accordance with the applicable requirements for cord-connected equipment in Section 16.

2) With the filter removed from the equipment, the leakage current does not exceed the limits specified in this table, as applicable.

3) The equipment is marked in accordance with 72.12.

47.2 With regard to the requirements in 47.1, leakage current refers to all currents, including capacitively coupled currents that are capable of being conveyed between exposed conductive surfaces of the equipment and ground, or between exposed conductive surfaces of the equipment.

47.3 Leakage currents from all exposed surfaces are to be measured to the grounded supply conductor individually as well as collectively where exposed surfaces are simultaneously accessible, and from one exposed surface to another where the exposed surfaces are simultaneously accessible. A part is considered to be an exposed surface unless it is guarded by an enclosure determined to protect against the risk of electric shock. Surfaces that can be readily contacted by one or both hands of a person at the same time are determined to be simultaneously accessible. For the purpose of these requirements, one hand is determined to be able to contact parts simultaneously when the parts are within a 4 by 8 inches (102 by 203 mm) rectangle, and two hands of a person are determined to be able to contact parts simultaneously when the parts are no more than 6 feet (1.8 m) apart.

47.4 Where a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil having dimensions of 3.94 by 7.88 inches (10 by 20 cm) in contact with the surface. Where the surface is less than 3.94 by 7.88 inches (10 by 20 cm), the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the product.

47.5 The measurement circuit for the leakage current test is to be as illustrated in Figure 47.1. The measurement instrument is defined in (a) – (c). The meter used for a measurement need only indicate the same numerical value for the particular measurement as would the defined instrument. The meter is not required to have all of the attributes of the defined instrument.

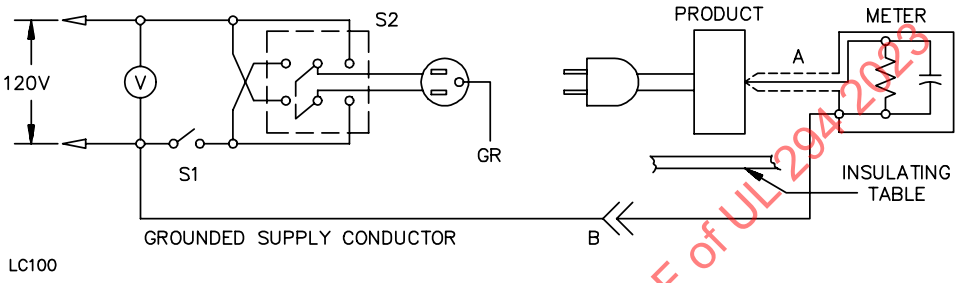
a) The meter is to have an input impedance of 1500 W resistive shunted by a capacitance of 0.15

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor;

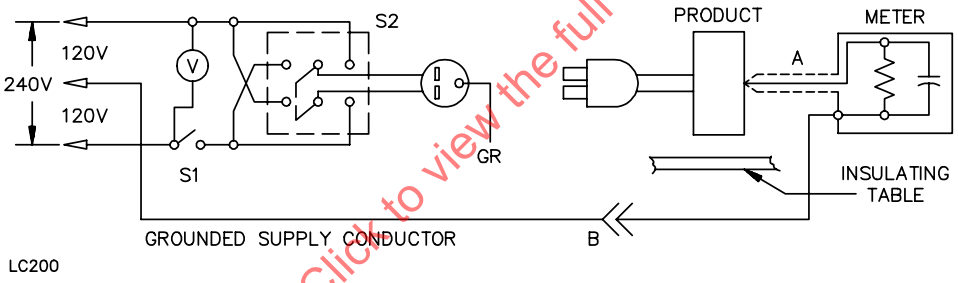
c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-W resistor shunted by a 0.15 µF capacitor to 1500 W. At an indication of 0.5 or 0.75 mA, the measurement is to have an error of not more than 5 % at 60 Hz.

Figure 47.1

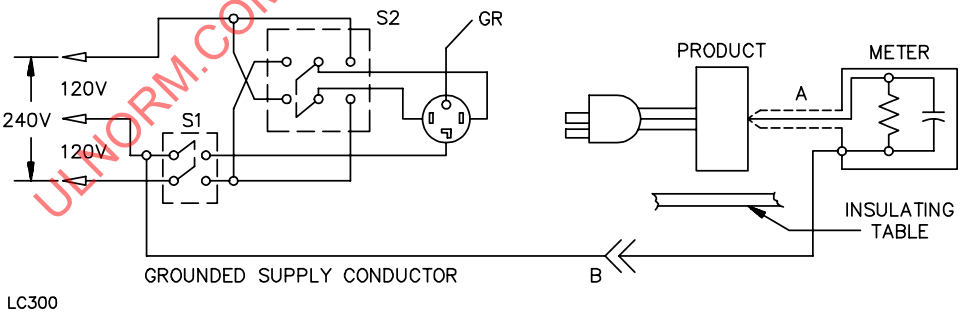
Leakage current measurement circuits



Circuit A: Product intended for connection to a 120- or 208-volt power supply.



Circuit B: 240- or 208-volt product intended for connection to a 3-wire, grounded neutral power supply.



Circuit C: 240- or 208-volt product intended for connection to a 3-wire, grounded neutral power supply.

A – Probe with shielded lead. Under some circumstances where higher frequency components are present, shielding of measuring instrument and its leads may be necessary.

B – Separated and used as clip when measuring currents from one part of a product to another.

47.6 Unless the meter is being used to measure the leakage current from one part of a product to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

47.7 Systems of interconnected equipment with individual connections to primary power shall have each piece of equipment tested separately. Systems of interconnected equipment with one common connection to primary power shall be treated as a single piece of equipment. Equipment designed for multiple (redundant) supplies shall be tested with only one supply connected.

47.8 A sample of the product is to be tested in the as-received condition initially with all switches indicated below closed, but with its grounding conductor, when provided, open at the attachment plug. A product that has not been energized for a minimum of 48 hr prior to the test, and that is at room temperature, is determined to be in the as-received condition. The supply voltage is to be the maximum voltage marked on the product, in accordance with 35.5.1, but not less than 120 or 240 V. The test sequence (with regard to Figure 47.1) is to be as follows:

a) With switch S1 open, the product is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the product switching devices in all of their normal operating positions;

b) Switch S1 is then to be closed, energizing the product, and within 5 s the leakage current is to be measured using both positions of switch S2 and with the product switching devices in all their normal operating positions; and

c) Leakage current is to be monitored until thermal stabilization occurs. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation of the product as in the Temperature Test, Section 53.

48 Electric Shock Current Test

48.1 If the open circuit potential between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part exceeds 42.4 volts peak, the part shall comply with the requirements of 48.2, 48.3, and 48.4, as applicable.

48.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 48.1 when the resistor is connected between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part.

Table 48.1
Maximum Current During Operator Servicing

Frequency, hertz[a]	Maximum current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000	19.6
5000	22.0
6000	25.1
7000 or more	27.5

[a] Linear interpolation between adjacent values may be used to determine the maximum current corresponding to frequencies not shown. The table applies to repetitive nonsinusoidal waveforms.

48.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 48.2 shall not exceed:

a) The value determined by the following equation:

$$T \leq \left(\frac{20\sqrt{2}}{I} \right)^{1.43}$$

in which:

T is the interval, in seconds, between the time that the instantaneous value of the current first exceeds 7.1 milliamperes and the time that the current falls below 7.1 milliamperes for the last time; and

I is the peak current in milliamperes; and

b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. Typical calculated values of maximum transient current duration are shown in Table 48.2.

Table 48.2
Maximum Transient Current Duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.26 seconds
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	919 milliseconds
40.0	609
50.0	443
60.0	341
70.0	274
80.0	226
90.0	191
100.0	164
150.0	92
200.0	61
250.0	44
300.0	34
350.0	27

Table 48.2 Continued on Next Page

Table 48.2 Continued

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
400.0	23
450.0	19
500.0	16
600.0	12
700.0	10
809.0	8.3

48.4 The maximum capacitance between the terminals of a capacitor that is accessible during operator servicing shall comply with the following equations:

$$C = \frac{88{,}400}{E^{1.43}(In\ E - 1.26)} \quad for\ 42.4 \le E \le 400$$

$$C = 35{,}288E^{-1.5364} \quad for\ 400 \le E \le 1000$$

in which:

C is the maximum capacitance of the capacitor in microfarads and

E is the potential in volts across the capacitor prior to discharge.

E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or the like. Typical calculated values of maximum capacitance are shown in Table 48.3.

Table 48.3
Electric Shock – Stored Energy

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27

Table 48.3 Continued on Next Page

Table 48.3 Continued

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.6
100	36.5
90	43.5
80	53.8
70	68.0
60	89.4
50	124.0
45	150.0
42.4	169.0

48.5 With reference to the requirements in 48.2 and 48.3, the current is to be measured while the resistor is connected between ground and:

a) Each accessible part individually; and

b) All accessible parts collectively if the parts are simultaneously accessible.

The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, if the parts are simultaneously accessible.

48.6 With reference to the requirements in 48.5, parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is to be considered to be able to contact parts simultaneously if the parts are within a 4 by 8 inch (102 by 203 mm) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 6 feet (1.8 m) apart.

48.7 Electric shock current refers to all currents, including capacitively coupled currents.

48.8 If the product has a direct-current rating, measurements are to be made with the product connected in turn to each side of a 3-wire, direct-current supply circuit.

48.9 Current measurements are to be made:

a) With any operating control, or adjustable control that is subject to user operation, in all operating positions; and

b) Either with or without a vacuum tube, separable connector, or similar component in place.

These measurements are to be made with controls placed in the position that causes maximum current flow.

49 Overload Test

49.1 General

49.1.1 An access control product other than that operating from a primary battery shall operate as intended after 50 cycles of intended operation at a rate of not more than 15 cycles per minute while connected to a source of supply adjusted to 115 % of the rated test voltage. Each cycle shall begin with the product energized in the normal standby condition, followed by intended operation, and then restoration to normal standby.

49.1.2 Rated test loads are to be connected to the output circuits of the product. The test loads are to be remote indicators, relays, electric locking devices, or the equivalent, intended for connection to the product. If an equivalent load is employed for an intended inductive load, a power factor of 60 % is to be used. The rated loads are to be established with the product connected to a source of supply in accordance with 35.5.1. The voltage then is to be increased to 115 % of the initial value.

49.1.3 For DC circuits, an equivalent inductive test load is to have:

a) The required DC resistance for the test current; and

b) The inductance (calibrated) necessary to obtain a power factor of 60 % when the test load is connected to a 60-Hz AC voltage equal to the rated DC test voltage.

The resultant AC current shall be equal to 0.6 times the DC current when the load is connected first to an AC voltage and then to a voltage equal to the rms value of the AC source.

49.2 Separately energized circuits

49.2.1 A separately energized circuit, such as a dry contact, that does not receive energy from the product shall operate as intended after 50 cycles of signal operation at a rate of not more than 15 cycles per minute.

49.2.2 The circuit is to be connected to a voltage source in accordance with 35.5.1 and with 150 % rated current loads at 0.6 power factor applied to the output circuits.

49.3 Power supplies

49.3.1 An access control power supply shall operate as intended following 50 cycles of operation as described in 49.3.2.

49.3.2 With the input of the power supply connected to a voltage source of 115 % of the appropriate value specified in 35.5.1, a load(s) drawing 150 % of maximum rated output power is to be applied, then removed (or reduced to the manufacturer's specified minimum impedance value) at the rate of not more than 15 cycles per minute, where each cycle consists of the load(s) application followed by an equal time of the load(s) removal (or reduction).

49.3.3 A power supply for use with a grounded supply circuit is to be tested with the enclosure and all other normally grounded parts connected through a 15-ampere fuse to the grounded conductor of the supply circuit.

49.3.4 At the conclusion of this test, the power supply shall operate as intended and there shall be no electrical or mechanical malfunction of any components.

50 Endurance Test

50.1 General

50.1.1 An access control product shall operate as intended at rated voltage and current for its intended cycles of operation at a rate of not more than 15 cycles per minute or based on manufacturer's specifications. The intended cycles of operation will at a minimum meet the Endurance test level for the product.

50.1.2 Access Control Endurance Level I – An access control product shall operate as intended at rated voltage and current for 1,000 cycles of intended operation.

50.1.3 Access Control System Endurance Level II – An access control product shall operate as intended at rated voltage and current for 25,000 cycles of intended operation.

50.1.4 Access Control System Endurance Level III – An access control product shall operate as intended at rated voltage and current for 50,000 cycles of intended operation.

50.1.5 Access Control System Endurance Level IV – An access control product shall operate as intended at rated voltage and current for 100,000 cycles of intended operation.

50.1.6 A tamper switch or supplementary feature, such as an alarm for unauthorized operation, shall function as intended when subjected to a 6,000 cycle test.

Exception No. 1: For Access Control Endurance Level I products, the supplementary feature cycling should likewise follow the endurance cycling noted in 50.1.2 (1,000 cycles).

Exception No. 2: This requirement does not apply to components previously investigated for endurance cycling at full rated load during evaluation to the UL component standards noted in Annex A.

50.1.7 Key management system units shall function as intended when subjected to a 6,000 cycle test.

50.2 Separately energized circuits

50.2.1 Separately energized circuits that do not receive energy from the product (e.g. dry-contact relays) shall at a minimum meet the Endurance Test level for the product:

a) At a rate of not more than 15 cycles per minute while connected to a source of supply in accordance with 35.5.1; and

b) With rated load at 0.6 power factor applied to the output circuits.

50.2.2 For Access Control Endurance Level I products – Separately energized circuits shall operate as intended after 1,000 cycles of intended operation.

50.2.3 For Access Control Endurance Level II products – Separately energized circuits shall operate as intended after 25,000 cycles of intended operation.

50.2.4 For Access Control Endurance Level III products – Separately energized circuits shall operate as intended after 50,000 cycles of intended operation.

50.2.5 For Access Control Endurance Level IV products – Separately energized circuits shall operate as intended after 100,000 cycles of intended operation.

Exception: This requirement does not apply to components previously investigated for endurance cycling at full rated load during evaluation to the UL component standards noted in Annex A.

50.3 Power supplies

50.3.1 An access control power supply shall operate as intended following the minimum Endurance Test level as noted in 50.1.

50.3.2 With the input of the power supply connected to a voltage source in accordance with 35.5.1, a load(s) drawing maximum rated output power is to be alternately applied then removed (or reduced to the manufacturer's specified minimum impedance value) at the rate of not more than 15 cycles per minute, where each cycle consists of the load(s) application followed by an equal time of the load(s) removal (or reduction).

50.3.3 At the conclusion of this test, the power supply shall operate as intended and there shall be no electrical or mechanical malfunction of any components.

51 Jarring Test

51.1 An access control unit shall withstand jarring resulting from impact and vibration anticipated in the intended application without:

a) Resulting in a fire hazard or risk of electric shock;

b) Causing false operation of any part; and

c) Impairing its subsequent intended operation, as evidenced by compliance with the requirements in the Normal Operation Test, Section 36.

51.2 Product utilizing freestanding, or other non-wall- or ceiling-type mounting shall comply with the requirements in 51.1 when subjected to the jarring described in 51.4. Desktop products shall comply with the requirements in 51.1 when subjected to the conditions described in 51.6.

51.3 Products weighing less than 30 lbs (13.6 kg) and utilizing wall or ceiling mount configurations shall comply with the requirements in 51.1 when subjected to the jarring described in 51.5. Products weighing 30 lbs (13.6 kg) or more and utilizing wall or ceiling mount configurations shall comply with the requirements in 51.1 when subjected to the jarring described in either 51.4 or 51.5. The direct impact shall be applied to the center of the side of the product intended to be adjacent to the mounting surface during intended mounting.

51.4 An impact of 4.08 J (3 ft-lb) is to be applied directly to any non-display area of the product by means of a 1.18-lb (0.54 kg), 2-inch (51-mm) diameter steel sphere swung through a pendulum arc from a height (h) of 30.5 inches (775 mm). The at-rest suspension point of the steel sphere is to be 1-inch (25.4-mm) in front of the plane of the product to be impacted.

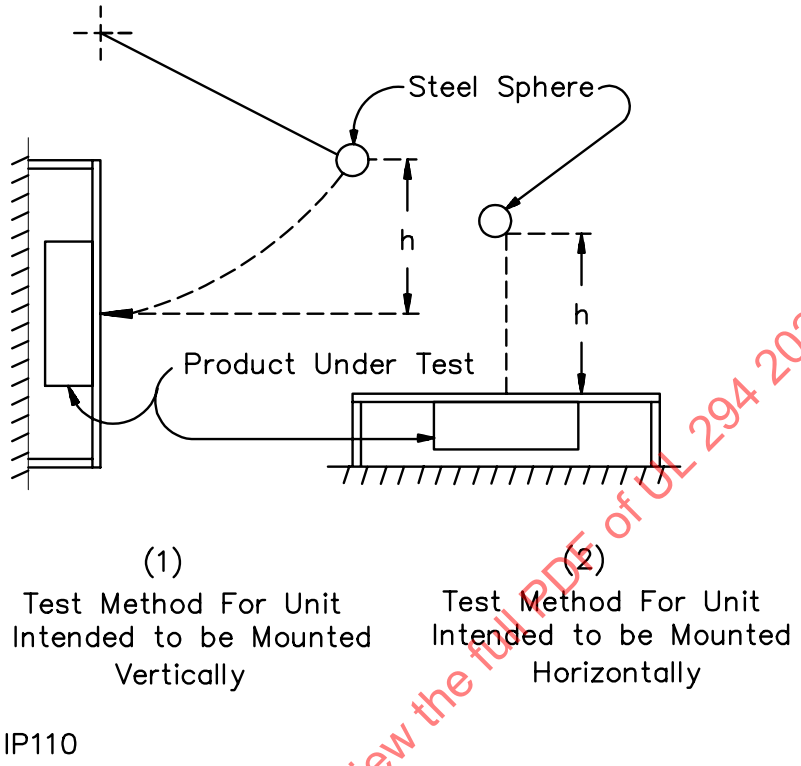
51.5 The product and associated equipment is to be mounted as intended to the center of a 6 by 4 foot (1.8 by 1.2 m), nominal 3/4 inch (19.1 mm) thick plywood board that is secured in place at four corners. A 4.08 J (3 ft-lb) impact is to be applied to the center of the reverse side of this board by means of a 1.18-lb (0.54 kg), 2 inch (50.8 mm) diameter steel sphere either:

a) Swung through a pendulum arc from a height (h) of 30.5 inches (775 mm), or

b) Dropped from the height (h) of 30.5 inches (775 mm), depending upon the mounting of the equipment. See Figure 51.1.

Figure 51.1

Jarring test



51.6 Products intended to be mounted on a desktop shall be permitted provided both of the following conditions are met:

a) The product is supervised such that a tamper event/signal is annunciated when it is displaced from the mounting position; and

b) The product operates as intended after being dropped four consecutive times onto a hardwood floor from a height of 775 mm. If the sample has corners, it is to be dropped on a different corner each time, selecting the four corners that appear to be most susceptible to damage. If the product has no corners, it is to be dropped on the four portions that appear to be most susceptible to damage. Reassembly without the use of tools is allowed provided no permanent damage has occurred.

51.7 During this test, the unit is to be operated in the normal standby condition and connected to a rated source of supply in accordance with the requirements in 35.5.1.

52 Dielectric Voltage-Withstand Test

52.1 An access control product shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential, between live parts and the enclosure, live parts and exposed dead-metal parts, and live parts of circuits operating at different potentials or frequencies. The test potential is to be (also, see 52.2):

a) For circuits rated 30 V AC rms (42.4 V DC or AC peak) or less – 500 V AC (707 V, when a DC potential is used);

Exception: This test can be waived for low-voltage, power-limited/Class 2 circuits.

b) For circuits rated greater than 30 and equal to or less than 150 V AC rms (42.4 and 212 V DC) – 1000 V AC (1414 V, when a DC potential is used);

c) For circuits rated more than 150 V AC rms (212 V DC) – 1000 V AC plus twice the rated voltage (1414 plus 2.828 times the rated AC rms voltage, when a DC potential is used).

52.2 For the application of a potential between live parts of circuits operating at different potentials or frequencies, the voltage is to be the applicable value specified in 52.1 (a), (b), or (c), based on the highest voltage of the circuits under test instead of the rated voltage of the access control product. Electrical connections between the circuits are to be disconnected before the test potential is applied.

52.3 Exposed dead-metal parts referred to in 52.1 are noncurrent-carrying metal parts that are likely to become energized and are accessible from outside of the enclosure of a unit during intended operation with the door of the enclosure closed.

52.4 If an autotransformer is in the circuit, the primary of the transformer is to be disconnected and an AC test potential in accordance with 52.1(c) is to be applied directly to all wiring involving more than 150 volts.

52.5 If the charging current through a capacitor or capacitor type filter connected across the line, or from line to earth ground, is sufficient to prevent maintenance of the specified AC test potential, the capacitor or filter is to be tested using a DC test potential in accordance with 52.1.

52.6 The test potential may be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. The method of applying the test voltage is to be such that there are no transient voltages that result in instantaneous voltage being applied to the circuit exceeding 105 % of the peak value of the specified test voltage. The applied potential is to be:

a) Increased from 0 at a uniform rate so as to arrive at the specified test potential in approximately 5 s; and then

b) Maintained at the test potential for 1 min without an indication of a breakdown.

Manual or automatic control of the rate of rise is not prohibited.

52.7 A printed wiring assembly or other electronic circuit component that would be damaged by the application of, or would short-circuit, the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly may be tested instead of an entire access control product. Rectifier diodes in the power supply may be individually shunted before the test to avoid destroying them in the case of a malfunction elsewhere in the secondary circuits.

52.8 A printed-wiring board, as specified in 34.2, shall withstand for 1 min without breakdown the application of a dielectric withstand potential between the traces having reduced spacings, in accordance with 52.1, as appropriate.

52.9 As specified in 52.8, power-dissipating component parts, electronic devices, and capacitors connected between traces having reduced spacings, are to be removed or disconnected so that the spacings and insulations, rather than these component parts, are subjected to the full dielectric voltage-withstand test potential.

53 Temperature Test

53.1 The materials used in the construction of an access control system unit shall not attain temperature rises greater than those indicated in Table 53.1 .

Table 53.1
Maximum Temperature Rises

Materials and components	Temperature rise limit	
	°C	(°F)
A. COMPONENTS		
1. Capacitors:[a,b]	–	–
a. Electrolytic types	40	(72)
b. Other types	65	(117)
2. Rectifiers – At any point		
a. Germanium	50	(90)
b. Selenium	50	(90)
c. Silicon	86	(135)
3. Relay, solenoid, transformer, and other coils with:		
a. Class 105 insulation system:		
Thermocouple method	65	(117)
Resistance method	85	(153)
b. Class 130 insulation system:		
Thermocouple method	85	(153)
Resistance method	105	(189)
c. Class 155 insulation system:		
(1) Class 2 transformers:		
Thermocouple method	95	(171)
Resistance method	115	(207)
(2) Power transformers:		
Thermocouple method	110	(198)
Resistance method	115	(207)
d. Class 180 insulation system:		
(1) Class 2 transformers:		
Thermocouple method	115	(207)
Resistance method	135	(243)
(2) Power transformers:		
Thermocouple method	125	(225)
Resistance method	135	(243)
4. Resistors:[c]		
a. Carbon	50	(90)
b. Wire wound	125	(225)
c. Other	50	(90)
5. Solid-state devices	See footnote d	

Table 53.1 Continued on Next Page

Table 53.1 Continued

Materials and components	Temperature rise limit °C	(°F)
6. Other components and materials:		
a. Fiber used as electrical insulation or cord bushings	65	(117)
b. Varnished cloth insulation	60	(108)
c. Thermoplastic materials	Rise based on temperature limits of the material	
d. Phenolic composition used as electrical insulation or as parts whose malfunction or deterioration will result in a risk of electric shock, explosion, fire, or injury to persons[e]	125	(225)
e. Wood or other combustibles	65	(117)
f. Sealing compound	15 °C (27 °F) less than the melting point of the material	
g. Fuses	65	(117)
B. CONDUCTORS		
1. Appliance wiring material[f]	25 °C (45 °F) less than the temperature limit of the wire	
2. Flexible cord (for example, SJO, SJT)	35	(63)
3. Conductors of field-wired circuits to be permanently connected to the product	35	(63)
C. GENERAL		
1. All surfaces of the product and surfaces adjacent to or upon which the product may be mounted	65	(117)
2. Surfaces normally contacted by the user in operating the unit (control knobs, push buttons, levers, and the like):		
a. Metal	35	(63)
b. Nonmetallic	60	(108)
3. Surfaces subjected to casual contact by the user (enclosure, grille, and the like):		
a. Metal	45	(81)
b. Nonmetallic	65	(117)
4. Printed-wiring board	See footnote g	

[a] For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure shall not be more than 65 °C (117 °F).

[b] A capacitor may be evaluated on the basis of its marked temperature rating, or with component reliability data based on actual performance in a similar application or the Military Handbook “Electronic Reliability Design Handbook, MIL-HDBK-338”, or equivalent (such as RIAC 217Plus) such that the failure rate is equal to or less than 0.5 failures per million hours of operation.

[c] The temperature rise of a resistor may exceed the values shown if the power dissipation is 50 % or less of the manufacturer's rating, or with component reliability data based on actual performance in a similar application or the Military Handbook “Electronic Reliability Design Handbook, MIL-HDBK-338”, or equivalent (such as RIAC 217Plus) such that the failure rate is equal to or less than 0.5 failures per million hours of operation.

[d] The temperature of a solid-state device (for example, transistor, SCR, integrated circuits) shall not exceed 75 % of its rated temperature under any condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0 °C (32 °F) is to be considered as 0 %. For integrated circuits the loading factor shall not exceed 75 % under any condition of operation.

In lieu of the above, both solid-state devices and integrated circuits may be operated up to 100 % of their rating under any condition of normal use if the components are subjected to one of the following:

1. For integrated circuits, the component complies with the requirements of MIL-STD 883H. For all other solid state devices (such as diodes, transistors, SCR's, LEDs) the component complies with the requirements of MIL-STD-750F.

Table 53.1 Continued on Next Page

Table 53.1 Continued

Materials and components	Temperature rise limit °C	Temperature rise limit (°F)
2. Component reliability data based on actual performance in a similar application, or the Military Handbook "Electronic Reliability Design Handbook, MIL-HDBK-338", or equivalent (such as RIAC 217Plus) such that the failure rate is equal to or less than 0.5 failures per million hours of operation.		
3. A quality-control program is established by the manufacturer consisting of an inspection stress test followed by operation of 100 % of all components, either on an individual basis, as part of a subassembly, or equivalent.		
4. Each assembled production unit is subjected to a burn-in test, under the condition which results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49 °C (120 °F).		
5. The component complies with the requirements for a benign environment in Table 3.14-3 of the Electronic Derating for Optimum Performance, RIAC (Reliability Information Analysis Center), dated November 15, 2006.		
[e] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds which have been investigated and determined to have special heat-resistant properties.		
[f] For standard insulated conductors other than those mentioned, reference should be made to NFPA 70; the maximum allowable temperature rise in any case is 25 °C (45 °F) less than the temperature limit of the wire in question.		
[g] Temperatures on the surface of any printed-wiring board shall not exceed the temperature limits of the printed-wiring board material.		

53.2 The values for temperature in Table 53.1 are based on an assumed ambient temperature of 25 ±15 °C (77 ±27 °F), and tests are to be conducted at an ambient temperature within that range. When equipment is intended specifically for use with a prevailing ambient temperature constantly more than 25 °C (77 °F), the test of the equipment is to be made with the higher ambient temperature, and the allowable temperature rises specified in Table 53.1 are to be reduced by the amount of the difference between that higher ambient temperature and 25 °C (77 °F).

53.3 For the purpose of pre-screening, thermocouples and an infrared temperature probe or the equivalent, are not prohibited from being employed to identify those components and/or materials in which compliance with 53.1 is questionable and, therefore, requiring the measurements indicated in 53.4.

53.4 Temperatures are to be measured by thermocouples except the change-of-resistance method shall be used for coil and winding temperatures where the coil is inaccessible for mounting of thermocouples (for example, a coil immersed in sealing compound) or where the coil wrap includes thermal insulation or more than two layers [1/32 inch (0.8 mm) maximum in total thickness] of cotton, paper, rayon, or the like.

53.5 Whenever temperature measurements by thermocouples are necessary, thermocouples consisting of not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2) iron and constantan wire and a potentiometer-type instrument are to be used. The thermocouple wire is to conform to the requirements in the Initial Calibration Tolerances for Thermocouples table in ASTM E230/E230M.

53.6 The temperature of a coil winding may be determined by the resistance method, wherein the resistance of the winding at the temperature to be determined is compared with the resistance at a known temperature by means of the formula:

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise, in °C;

R is the resistance in ohms at the end of the test;

r is the resistance in ohms at the start of the test;

k is 234.5 for copper or 225.0 for electrical conductor grade aluminum;

t_1 is the room temperature at the start of the test, in °C; and

t_2 is the room temperature at the end of the test, in °C.

53.7 To determine compliance with these requirements, the product is to be connected to a supply circuit of rated voltage and frequency in accordance with 35.5.1, connected to maximum rated load, and operated continuously under representative service conditions that are expected to produce the highest temperature.

53.8 If a current-regulating resistor or reactor is provided as a part of a unit, it is to be adjusted for the maximum resistance or reactance at normal current.

53.9 The test is to be continued until constant temperatures are attained during the condition that generates the highest component temperature rise under intended system operation (typically maximum loading conditions), as determined in conjunction with the manufacturer. A temperature is considered to be constant when there is no change between three successive measurements made at intervals of 10 % of the elapsed duration of the test but at not less than 5-minute intervals.

54 Abnormal Operation Test

54.1 The introduction of abnormal fault conditions shall not increase the risk of fire or electric shock while the access control product is operating.

54.2 To determine compliance with the requirement in 54.1, the product is to be connected to a source of supply in accordance with 35.5.1 and operated under the most severe anticipated circuit-fault conditions. There shall not be emission of flame or molten metal, or any other manifestation of a fire (see 54.4) or dielectric breakdown when the product is tested in accordance with the Dielectric Voltage-Withstand Test, Section 52.

54.3 The fault condition is to be maintained continuously until constant temperatures are attained or until burnout occurs, if the fault does not result in the operation of an overload protective device. Shorting of the secondary of the power supply transformer and shorting of an electrolytic capacitor represent typical fault conditions.

54.4 The product is to be wrapped in bleached cheesecloth running 14 – 15 square yards to the pound (26 – 26 m^2/kg) and having a thread count of 32 by 28. The product is then to be energized. There shall not be emission of molten metal or flame as a result of this test nor ignition or charring of the cheesecloth.

55 Electrical Transient Tests

55.1 General

55.1.1 While energized from a source of supply in accordance with 35.5.1 the product shall:

a) Not falsely actuate releasing device(s) or permit unauthorized access;

b) Experience no electrical or mechanical failure of any components of the product;

c) Operate as intended following the test; and

d) As appropriate, retain required stored memory (such as date, type, and location of a signal transmission) within the unit;

when subjected to the tests described in 55.2 – 55.4.

Exception No. 1: Annunciation of a trouble signal that, either automatically restores or is manually resettable through the operator interface, is acceptable during the internally induced and field-wiring transient tests.

Exception No. 2: Supplemental information stored within the product is not required to be retained during any of the transient tests.

55.2 Supply line (ring wave surge voltage) transients

55.2.1 A product intended to be powered from commercial AC power shall be subject to supply line transients induced directly between the power supply circuit conductors of the equipment under test.

55.2.2 For this test, the product is to be connected to a transient generator capable of producing the Location Category A3, 100 kHz Ring Wave transient as defined in IEEE C62.41 (6 kV at 200 A, 30 ohms impedance).

55.2.3 Each unit is to be subjected to 500 oscillatory transient pulses induced at an average rate of 3 pulses every minute. Each transient pulse is to be induced 90° into the positive half of the 60 hertz cycle. A total of 250 pulses are to be applied so that the polarity of the transients is positive with reference to earth ground, and the remaining 250 pulses are to be negative with respect to earth ground.

55.3 Internally induced transients

55.3.1 The product is to be energized in the intended standby condition while connected to a source of supply in accordance with 35.5.1. The supply source is to be alternately de-energized for approximately 1 second, then energized for approximately 9 seconds, for a total of 500 times. Each interruption is to be at a rate of not more than 6 interruptions per minute. Standby power is to be connected during this test if it is provided.

55.4 Input/output (low-voltage) field-wiring transients

55.4.1 The product is to be energized in the normal standby condition while connected to a source of supply in accordance with 35.5.1. All field-wiring circuits are to be tested as specified in 55.4.2 and 55.4.3.

Exception: This test is not required when manufacturer's installation instructions indicate that it is not permitted to connect cables greater than 98.5 ft (30 m) long to the product or to specific circuits of the product.

55.4.2 For this test, each input and output circuit is to be subjected to the transient waveforms specified in Table 55.1, as delivered into a 200-ohm load. The transient pulses are to be coupled directly onto the input/output circuit conductors of the equipment under test.

Table 55.1
Input/Output Circuit Transients

Peak voltage level, V	Minimum energy level, J	Minimum pulse duration, µs	Figure No.
2400	1.0	80	Figure 55.1
1000[a]	0.31	150	Figure 55.2
500[a]	0.10	250	Figure 55.3
100	0.011	1120	Figure 55.4

[a] Other applied transients having peak voltages representative of the entire range of 100 – 2400 volts shall be used in lieu of these values when the output circuit is only designed specifically to protect against these predetermined values. The transients shall meet or exceed the specified minimum pulse duration (Figure 55.5) and minimum energy level (Figure 55.6) parameters, and shall have an equal or faster minimum transient pulse rise time than that specified in Figure 55.7.

Figure 55.1
Input/output circuit transients – 2400V curve

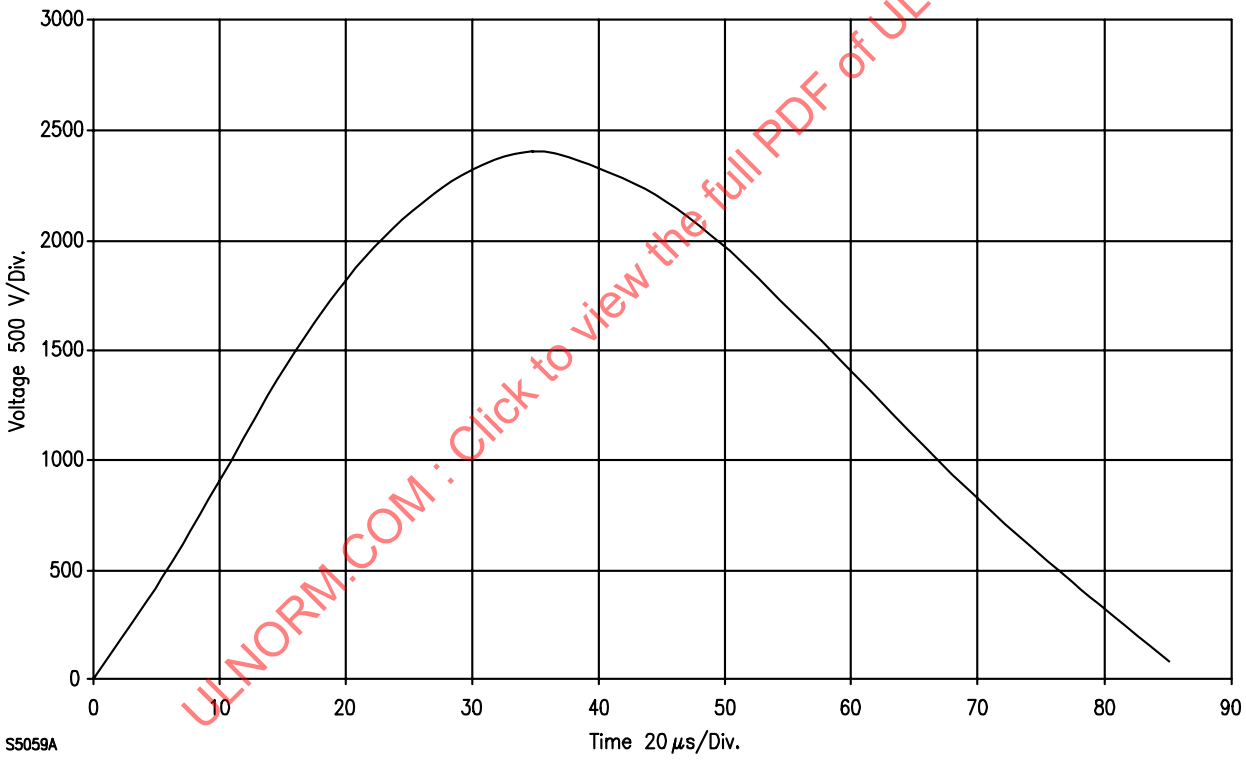


Figure 55.2

Input/output circuit transients – 1000V curve

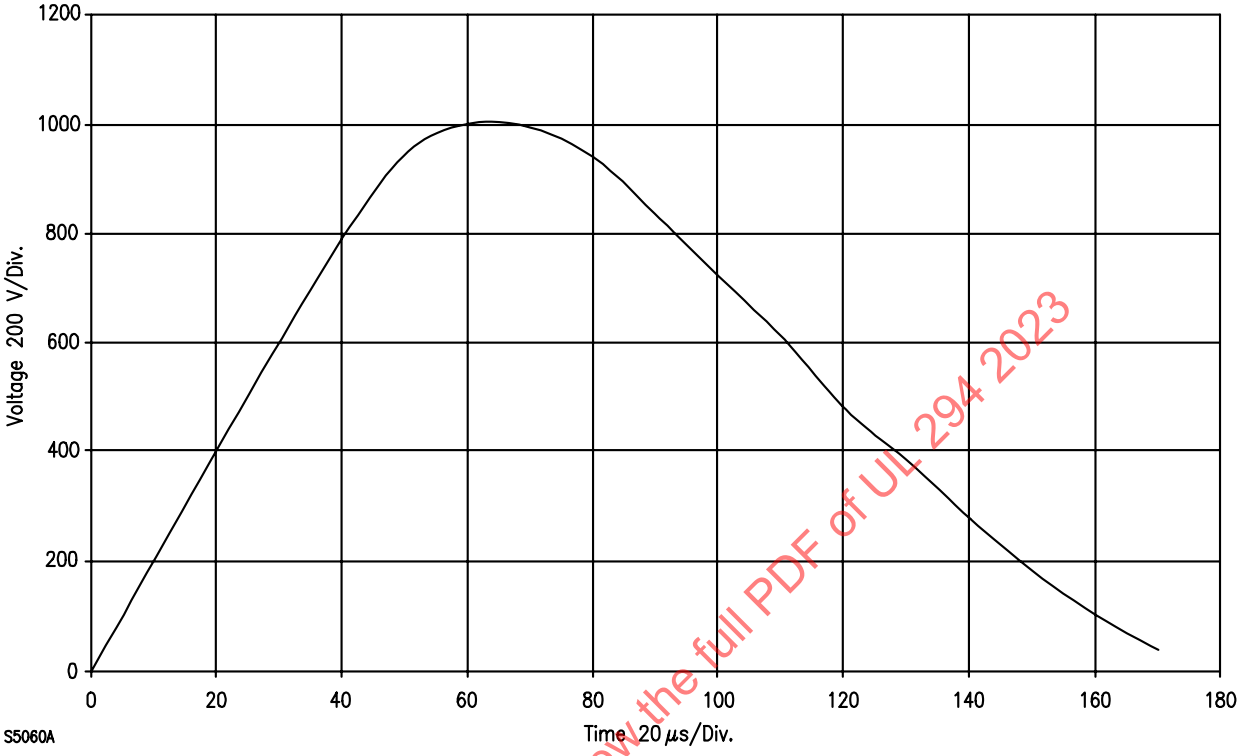


Figure 55.3

Input/output circuit transients – 500V curve

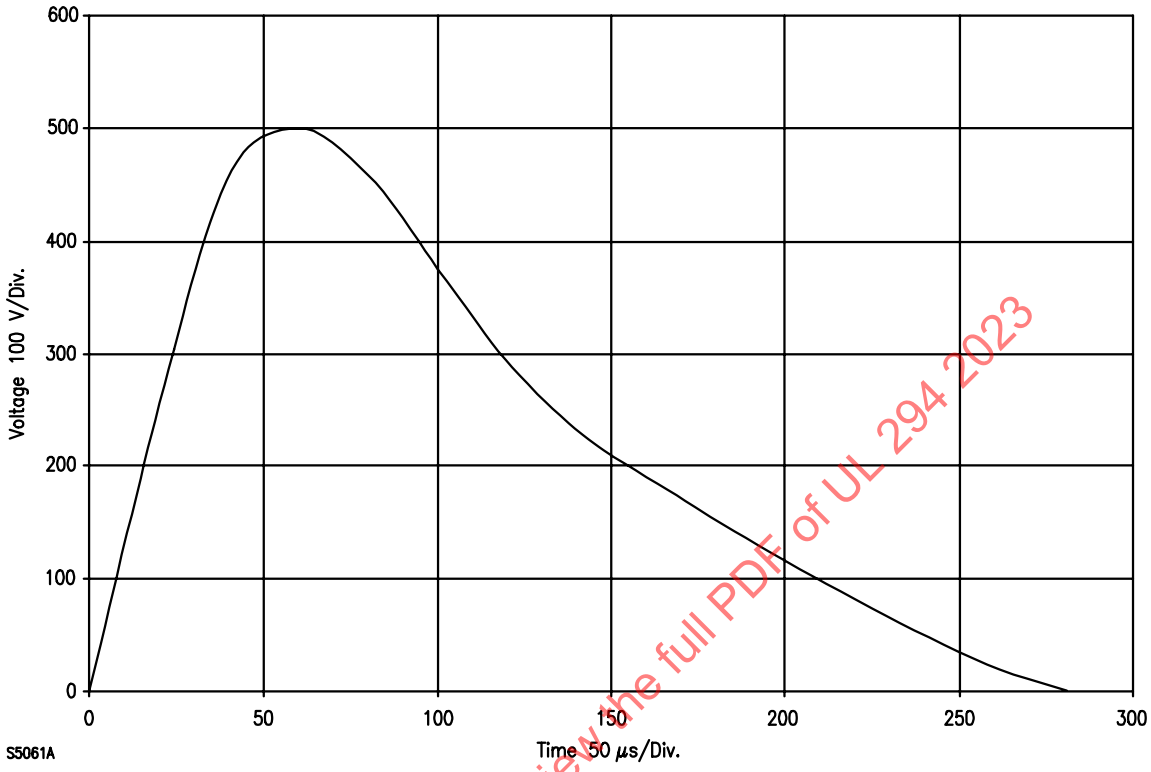


Figure 55.4

Input/output circuit transients – 100V curve

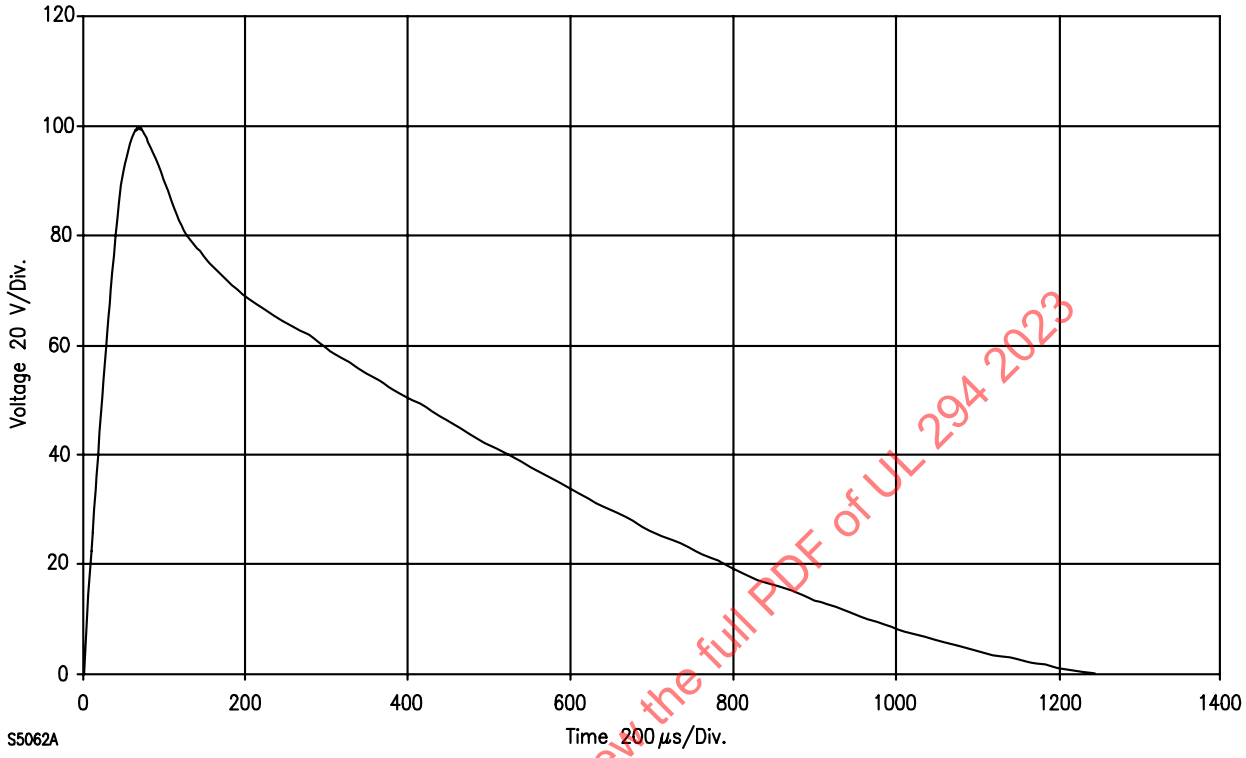


Figure 55.5

Minimum transient pulse duration vs. transient peak voltage

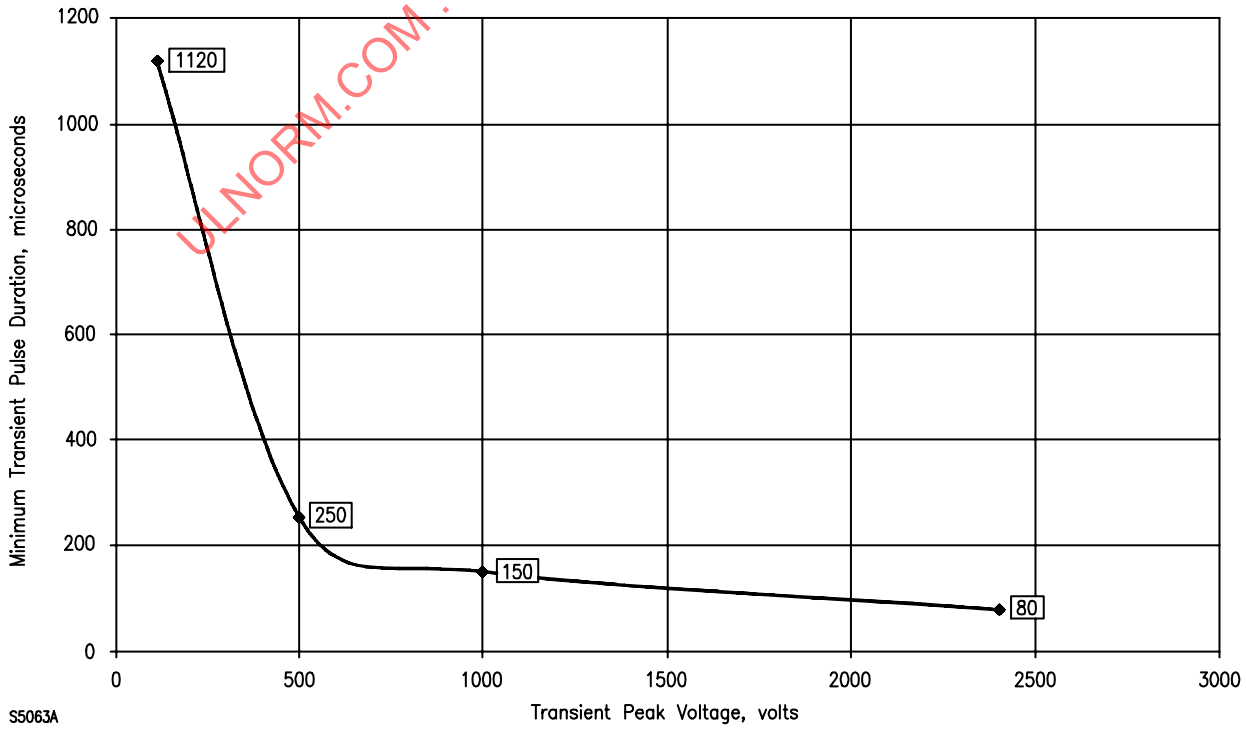


Figure 55.6

Minimum transient energy level vs. transient peak voltage

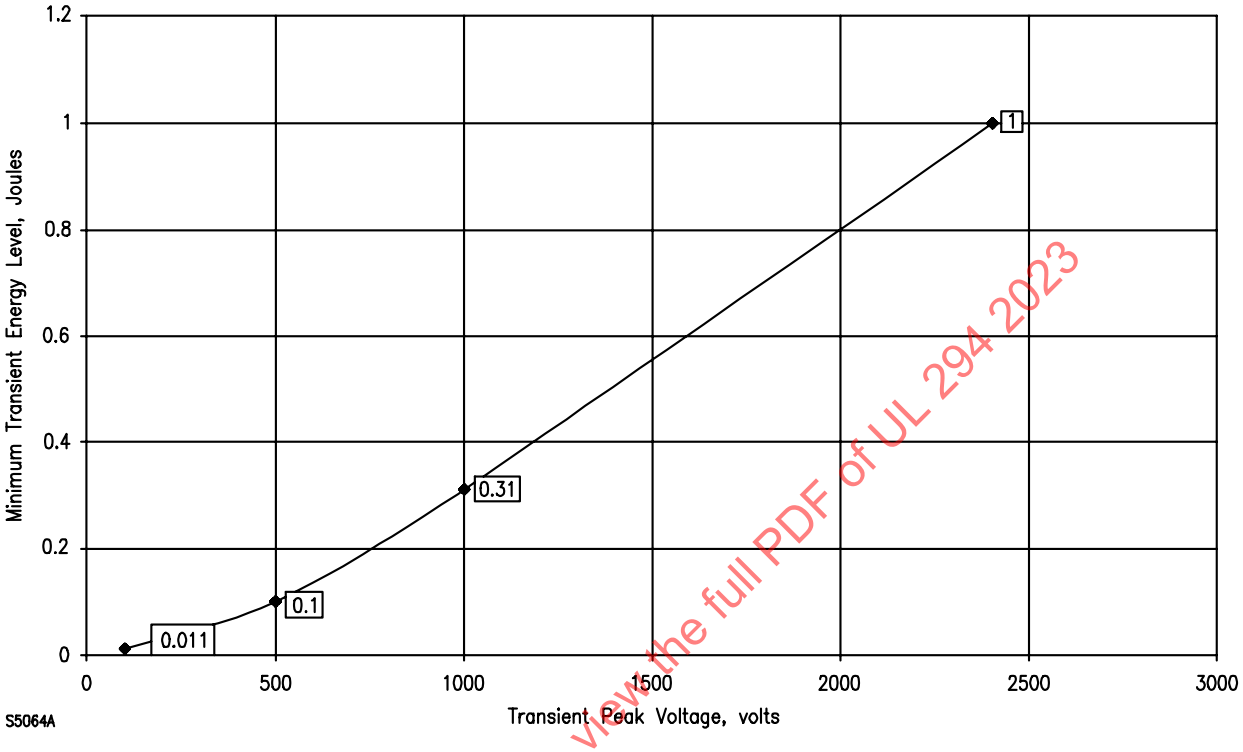
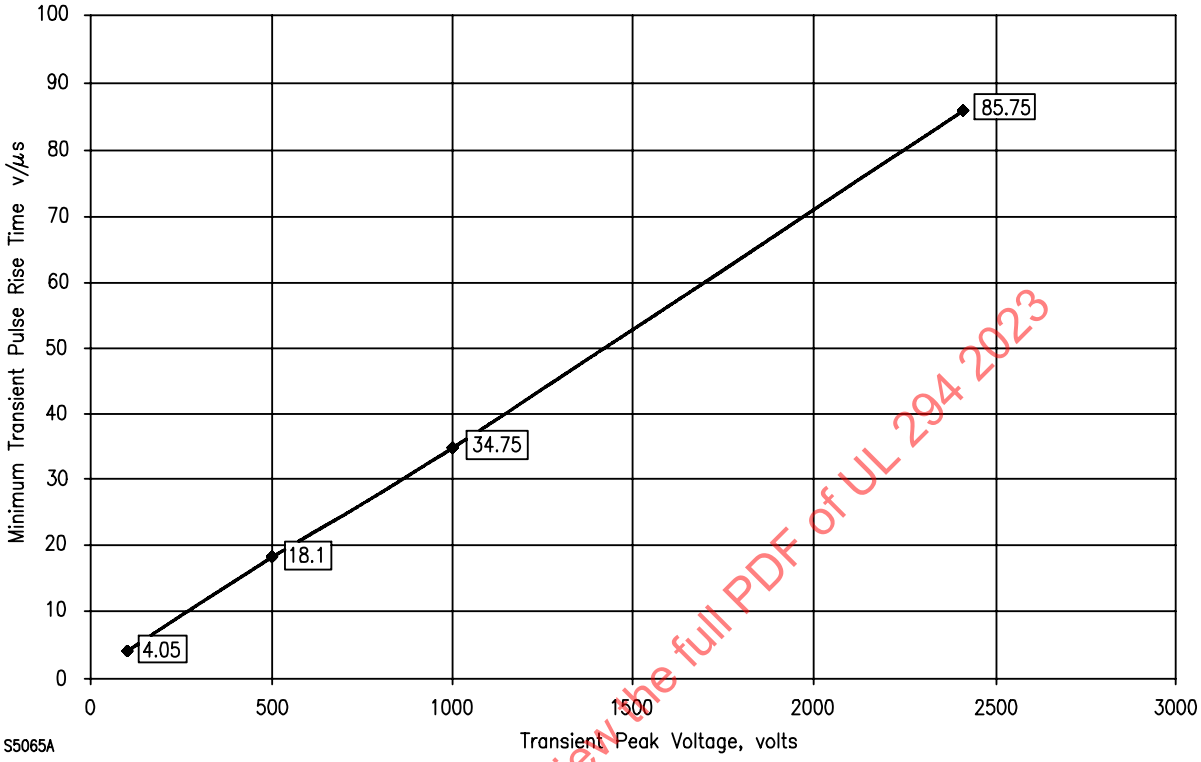


Figure 55.7

Minimum transient pulse rise time vs. transient peak voltage



55.4.3 Each conductor of a circuit is to be subjected to transient pulses induced at the rate of six pulses per minute as follows:

a) Twenty pulses (four at the 2400 peak voltage level and two at each of the other transient voltage levels specified in 55.4.2) between each lead or terminal and earth ground, consisting of ten pulses of one polarity, and ten of the opposite polarity (total of 40 pulses), and

b) Twenty pulses (four at the 2400 peak voltage level and two at each of the other transient voltage levels specified in 55.4.2) between each circuit pair consisting of ten pulses of one polarity and ten pulses of the opposite polarity (total of 20 pulses).

55.4.4 As an alternate to 55.4.1 – 55.4.3, the product shall be subjected to IEC 61000-4-5:2005, and in accordance with the following, and 55.4.5 – 55.4.9:

Open Circuit Test Voltage,[a, b] Line to Ground	0.5kV and 1kV
Polarity	+ and –
Minimum number of surges at each polarity, voltage, coupling mode and signal line at a maximum rate of 1 per 5 second	5
Impedance in series with the transient generator	40 Ohm
Combination Wave Generator	1.2/50 us

[a] This test is not required when manufacturer's installation instructions indicate that it is not permitted to connect cables greater than 98.5 ft (30 m) long.

[b] The test pulses are coupled into the leads to be tested by means of appropriate coupling networks that maintain the test pulses within IEC 61000-4-5 specification.

55.4.5 The product under test is to be connected in accordance with the manufacturer's installation instruction, with the intended ancillary equipment and interconnecting cables insulated from ground reference for this test. Normal operation of the product shall be confirmed prior to the test.

55.4.6 Input/output circuits shall be subjected to transients injected by line-to-ground coupling mode only, using a 40 ohm series resistor.

55.4.7 If the product has a large number of identical inputs/outputs circuits, then representative samples of each type of input/output circuit may be subjected to this test and considered representative of other identical circuits.

55.4.8 The length of the unshielded input/output circuit conductors between the product and the coupling/decoupling network(s) shall be less than or equal to 6.5 feet (2 m). If it is specified in the manufacturer's installation instructions that input/output circuits shall only be connected with shielded cables, then in these cases, the transients shall be applied directly (e.g. without the 40 ohm series resistor) to the shield of a 65.5 ft (20 m) length of shielded cable. Current compensated chokes may be used to decouple input/output circuits carrying high frequency signals, to reduce attenuation problems.

55.4.9 A minimum of 5 pulses of each polarity shall be applied at each of the 0.5 kV and 1 kV, voltage levels. The maximum pulse rate of 1 per 5 s is used. If it is necessary to ensure that any failures are not due to applying the pulses too frequently then the devices shall be replaced and the test repeated with pulses at a rate of less than 1/min.

55.4.10 As a result of this test the unit shall comply with the requirements of 55.1.1.

56 AC Induction Test

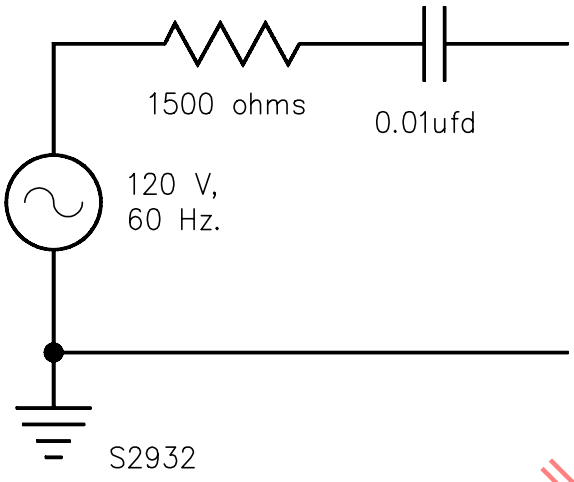
56.1 An access control product shall operate as intended when subjected to an alternating current (AC) induced on any signal leads, loops, DC power leads, or any other leads that extend from the unit.

Exception: AC power leads and any leads consisting of conductors insulated from and surrounded by a shielding conductive surface grounded at one or more ends are exempted from this requirement. This test is not required when the product installation instructions indicate that only shielded cables are to be used.

56.2 To determine compliance with the requirements in 56.1, the product is to be energized from a source of rated voltage and frequency in accordance with 35.5.1, and an AC (60-Hz) current is to be introduced into each circuit extending from the product. The AC signal current is to be induced as shown in Figure 56.1.

Figure 56.1

AC induction test circuit



57 Communication Circuits

57.1 Where a product has provisions for connection to communication circuits that use outside wiring as covered by Article 800 in NFPA 70, the product shall comply with the requirements for protection against overvoltage from power line crosses described in UL 60950-1 or UL 62368-1.

58 Polymeric Materials Test

58.1 Polymeric materials used as an enclosure or for the support of current-carrying parts shall comply with the applicable portion of UL 746C.

59 Battery Replacement Test

59.1 If provided, the battery connections of an access control product shall withstand 50 cycles of removal and replacement from the battery terminals without any reduction in contact integrity.

59.2 For this test, a product is to be installed as intended in service and the battery connections removed and replaced as recommended by the manufacturer. The product shall then comply with the requirements in the Normal Operation Test, Section 36.

60 Drop Test

60.1 When a sample is dropped on a floor as specified in 60.2, electrical spacings shall not be reduced below the limits specified in 33.2 – 33.5 and high-voltage live parts shall not be exposed. When the sample then is energized as specified in 60.3 there shall not be emission of molten metal or flame, nor shall there be any ignition or charring of the cheesecloth. The product shall then comply with the requirements in the Dielectric Voltage-Withstand Test, Section 52.

60.2 A sample of a cord-connected high-voltage product is to be dropped four times from a height of 3 feet (0.9 m) onto a hardwood floor. If it has corners, it is to be dropped on a different corner each time. The four corners that appear most susceptible to damage are to be selected. If the product has no corners, it is to be dropped on the different portions that appear most susceptible to damage. If the product is intended to use internally mounted batteries, the batteries are to be in place for this test.

60.3 The product is next to be wrapped in bleached cheesecloth running 14 – 15 square yards to the pound (25.75 – 27.59 m^2/kg) and having a thread count of 32 by 28. The product is then to be energized for 3 hours at rated voltage in accordance with 35.5.1.

61 Strain Relief Test

61.1 General

61.1.1 When tested in accordance with 61.1.2, the strain relief means provided on a flexible cord shall withstand for 1 minute without displacement a pull of 35 pounds-force (156 N) applied to the cord. The connections within the product are to be disconnected during the test.

61.1.2 To apply the force specified in 61.1.1, a 35-pound (15.88-kg) weight is to be secured to the cord and supported by the product so that the strain relief means will be stressed from any angle that the construction of the product permits. There shall not be movement of the cord sufficient to indicate that stress would have been transmitted to the internal connections.

61.2 Field-wiring leads

61.2.1 Each lead used for field connections shall withstand for 1 minute a pull of 10 pounds-force (44.5 N) without evidence of damage or of transmittal of stress to the internal connections.

62 Tests for Ignition Through Bottom-Panel Openings

62.1 General

62.1.1 Both of the bottom-panel constructions described in Figure 12.1 and Figure 12.5 may be used without test. Other constructions may be used if they comply with the requirements of either of the tests described in 62.1.2 – 62.3.3.

62.1.2 The tests do not apply to low-voltage power-limited products or to products in which an internal fault does not produce flame, molten metal, flaming or glowing particles, or flaming drops.

62.2 Hot, flaming oil

62.2.1 Openings in a bottom panel shall be sufficiently small in size, few in number, and arranged so that hot, flaming No. 2 furnace oil poured three times onto the openings from a position above the panel is extinguished as it passes through the openings.

62.2.2 A sample of the complete, finished bottom panel is to be securely supported in a horizontal position several inches above a horizontal surface under a hood or in another area that is well ventilated but free from drafts. Bleached cheesecloth having an area of 14 – 15 square yards to the pound (26 – 28 m^2/kg) and a thread count of 32 by 28 and that is of the size and shape to completely cover the pattern of openings in the panel is to be used for the test. However, the cheesecloth is not to be large enough to catch any of the oil that runs over the edge of the panel or otherwise fails to pass through the openings. A pan is to be centered under the pattern of openings in the panel. The center of the cheesecloth is to be 2 inches (50.8 mm) below the openings. Use of a metal screen or wired-glass enclosure surrounding the test area is recommended to reduce the risk of injury to persons and other damage due to splattering of the oil.

62.2.3 A small metal ladle, preferably not more than 2-1/2 inches (63.5 mm) in diameter, is to be partially filled with 10 milliliters of No. 2 furnace oil. No. 2 furnace oil is a medium-volatile distillate having:

a) An API gravity of 32 – 36 degrees,

b) A flash point of 110 – 190 °F (43 – 88 °C), and

c) An average calorific value of 136,900 Btu per gallon (39.7 MJ/L).

See ASTM D396. The ladle is to have a pouring lip and a long handle that must be tipped horizontally during pouring.

62.2.4 The ladle containing the oil is to be heated and the oil ignited and allowed to burn for 1 minute. At this time all of the hot, flaming oil is to be poured at the rate of approximately, but not less than, 1 milliliter per second in a steady stream onto the center of the pattern of openings from a position 4 inches (102 mm) above the openings.

62.2.5 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 10 milliliters of hot, flaming oil is to be poured from a ladle onto the openings. Five minutes later, the cheesecloth is to be replaced again and a third identical pouring is to be made. The openings are not acceptable if the cheesecloth is ignited in any of the three pourings.

62.3 Molten PVC and copper

62.3.1 Openings in a bottom panel shall be sufficiently small in size, few in number, and arranged so that molten polyvinyl chloride (PVC) or copper dripping onto the panel would not ignite cheesecloth below the panel if any molten material passes through the openings.

62.3.2 A sample of the complete, finished bottom panel is to be securely supported in a horizontal position 2-1/2 inches (63.5 mm) above a horizontal firebrick or other nonflammable surface located under a hood or in another area that is well ventilated. Two layers of bleached cheesecloth having an area of 14 – 15 square yards to the pound (26 – 28 m^2/kg) and having a thread count of 32 by 28 is to be placed on the nonflammable surface. The cheesecloth is to cover somewhat more area than that immediately under the pattern of openings in the panel. Use of a metal screen or wired-glass enclosure surrounding the test area is recommended to reduce the risk of injury and damage due to splattering of the molten materials.

62.3.3 A bare 12-inch (305-mm) length of 12 AWG (3.3 mm^2) solid copper wire and a 12-inch length of 12 AWG stranded copper wire insulated with 1/32 inch (0.8 mm) of PVC are to be melted simultaneously at an even rate by means of an oxy-acetylene torch and allowed to drip from a point 6 inches (152 mm) above the pattern of openings in the panel. The openings are not acceptable if the cheesecloth is ignited.

63 Mechanical Strength Tests for Enclosures

63.1 Constant-force test

63.1.1 The external enclosure of a product containing high-voltage circuits or circuits that are not power limited shall withstand a force of 25 pounds (111 N) for 1 minute without:

a) Permanent distortion to the extent that spacings are reduced below the values specified in 33.2 – 33.5,

b) Transient distortion resulting in contact with live parts, or

c) Creation of openings that expose uninsulated high- or low-voltage live parts.

63.1.2 The external enclosure of a product containing only non-power-limited low-voltage circuits is to be subjected to the test specified in 63.1.1, except that the applied force is to be 10 pounds (44 N). Products containing only power-limited, low-voltage circuits are exempt from this test.

63.1.3 The force specified in 63.1.1 is to be applied by means of a steel hemisphere 1/2 inch (12.7 mm) in diameter. Any openings that result from application of the force are to be judged under the requirements specified in 10.3.3 and 10.3.4.

Exception: The Mechanical Strength Test described in 63.1 is not required for metallic enclosures complying with the thickness requirements in 12.8, 12.9, and Table 12.2 – Table 12.4, however, areas of an enclosure containing perforated sheet steel or ventilation openings shall still be subjected to the tests noted above.

63.2 Impact test

63.2.1 The external enclosure of a product containing high-voltage circuits or circuits that are not power-limited shall withstand an impact of 5 foot-pounds (6.78 J) without:

a) Permanent distortion to the extent that spacings are reduced below the values specified in 33.2 – 33.5,

b) Transient distortion resulting in contact with live parts, or

c) Creation of openings that expose uninsulated high-voltage live parts or non-power-limited low-voltage live parts.

63.2.2 The impact is to be applied by means of a solid, smooth, steel sphere 2 inches (50.8 mm) in diameter and weighing approximately 1.18 pounds (0.54 kg). The sphere is to fall freely from rest through a vertical distance of 51 inches (1.31 m). Any openings resulting from the impact are to be evaluated under the requirements in 10.3.4 and 10.3.5.

63.2.3 The external enclosure of a product containing only non-power-limited low-voltage circuits is to be subjected to the test specified in 63.2.1 and 63.2.2, except that the impact is to be 2 foot-pounds (2.7 J), and the sphere is to fall freely from rest through a vertical distance of 20-13/32 inches (0.51 m). Products containing only power-limited, low-voltage circuits are exempt from this test.

Exception: The Mechanical Strength Test described in 63.2 is not required for metallic enclosures complying with the thickness requirements in 12.8, 12.9, and Table 12.2 – Table 12.4, however, areas of an enclosure containing perforated sheet steel or ventilation openings shall still be subjected to the tests noted above.

64 Special Terminal Assemblies Tests

64.1 General

64.1.1 To determine compliance with the requirements of 17.4.1 and 17.4.2, representative samples of the terminal assembly shall comply with the requirements specified in 64.3.1 – 64.6.2.

Exception: Terminals complying with the requirements in any of the standards specified in 17.3.2 (b) – (e) are not required to be subjected to these tests.

64.2 Disconnection and reconnection

64.2.1 If a wire is to be disconnected for testing or routine servicing and then reconnected, each terminal is to be subjected to 20 alternate disconnections and reconnections prior to execution of the tests described in 64.3.1 – 64.6.2.

64.3 Mechanical secureness

64.3.1 A terminal connection shall withstand, without separating from the wire, the application of a straight pull of 5 pounds-force (22.2 N) applied for 1 minute to the wire in the direction that would most likely result in pullout.

64.3.2 Six terminal assemblies using the maximum wire size and six using the minimum wire size are to be subjected to this test. If a special tool is required to assemble the connection it is to be used, in accordance with the manufacturer's instructions. Each sample is to be subjected to a gradually increasing pull on the wire until the test pull of 5 pounds-force (22.2 N) is attained.

64.4 Flexing test

64.4.1 The wire attached to a terminal shall withstand five right angle bends without breaking.

64.4.2 Six terminal assemblies using the maximum wire size and six using the minimum wire size are to be subjected to this test. The terminal is to be secured against movement. With the wire in 3 pounds-force (13.3 N) tension and held at a point 3 inches (76.2 mm) from the terminal-to-wire juncture, the wire is to be bent at a right angle from its nominal position. The wires are to be assembled to the terminals using any special tool required, according to the manufacturer's instructions.

64.5 Millivolt drop test

64.5.1 The millivolt drop across a terminal connection shall not be greater than 300 millivolts when the maximum current specified by the manufacturer is flowing through the terminal connections and the circuit is connected to rated voltage. The terminal assemblies are to be connected in series. In one trial, wiring is to be made with wire of the maximum size intended for use; in the other trial, wire is to be of minimum size intended.

64.5.2 Six terminal assemblies using the maximum wire size and six assemblies using the minimum size are to be subjected to this test. The wires are to be connected to the terminals, according to the manufacturer's instructions and using any special tools required. The millivolt drop then is to be measured using a high impedance millivoltmeter.

64.6 Temperature test

64.6.1 The maximum temperature rise on a terminal junction shall not be greater than 30 °C (54 °F) based on an ambient temperature of 25 °C (77 °F).

64.6.2 Six terminal assemblies using the maximum wire size and six using the minimum size are to be subjected to this test. The wire is to be assembled to the terminals using any special tools, if required, according to the manufacturer's instructions. The maximum current to which the wire will be subjected in service is next to be passed through the series connection of the terminals. The maximum temperature rise is then to be measured by the thermocouple method after temperatures have stabilized.

65 Destructive Attack Test

65.1 The provisions of this section shall apply to Level II and Level III and Level IV access control products. Level I access control products shall be exempt from the provisions of this section because either 65.2 is not applicable, or the products are only to be mounted/installed within the controlled / protected / restricted area, as indicated in the product installation instructions.

65.2 The enclosure protecting the internal parts of a product shall resist attempts to gain access to the parts if:

a) Manipulation of the parts can cause release of the remote locking mechanism and

b) The product is intended to be used outside of a controlled, protected or restricted area as defined in 6.29, 6.55 and 6.56 respectively.

65.3 The test sample shall be mounted in accordance with 65.6 and 65.7, and shall be mounted with the locking mechanism engaged during the testing.

65.4 The time that the enclosure shall resist attack shall be as follows:

a) Access Control Destructive Attack Test, Level II: 2 minutes,

b) Access Control Destructive Attack Test, Level III: 5 minutes, but shall be reduced to 2 minutes if an audible alarm is activated during the attack.

Exception: As applicable, key management system units shall undergo an attack of 5 minutes; no reduction in attack time allowance is considered for the activation of an audible alarm.

c) Access Control Destructive Attack Test, Level IV: 5 minutes, but shall generate an audible alarm in a maximum of 2 minutes of attack, and the alarm shall not be silenced for another 2 minutes.

The time limit, in continuous working minutes, shall include the time necessary to electrically manipulate components to cause the release of the remote locking mechanism in order to gain access into the protected or restricted area. The test time shall start at the moment the attack is initiated on the unit and shall not stop until the maximum time limit is met or if the remote locking mechanism is disengaged causing the door or gate to open.

65.5 The tools used in the attack test shall include hammers, chisels, adjustable wrenches, pry bars, punches, and screwdrivers. No hammer shall exceed 3 pounds (1.36 kg) in head weight, and no tool shall exceed 18 inches (457 mm) in length. During the test, a hammer shall only be used for a total time of 30 seconds.

65.6 The product under test shall be installed in accordance with the manufacturer's instructions, and the attack shall be carried out by one operator.

65.7 The building structure in which the product under attack may be mounted shall be represented by gypsum wallboard 5/8 inch (15.9 mm) thick.

65.8 To achieve Attack Test Level III or Level IV, the alarm sounding device shall additionally comply with the requirements in Section 66, Destructive Attack Alarm Test.

66 Destructive Attack Alarm Test

66.1 The requirements of Section 66 are to be applied to any sounding device deemed crtitical for proper system operation, as well as for those products achieving Destructive Attack Level III or Level IV, as applicable. Also see 65.8.

66.2 If the audible alarm occurs locally, the sounding device, mounted within its intended housing and in its intended mounting position, shall provide a sound output equivalent to that of an omni-directional source with an A-weighted sound pressure level of at least 85 decibels at 10 feet (3.05 m) while connected to a source of rated voltage. See 35.5.1.

66.3 The sound power output of the alarm sounding device is to be measured in a reverberant room qualified for pure tones under ANSI S12.31-1990, or ANSI S12.32-1990. The sound power in each 1/3 octave band shall be determined using the comparison method. The A-weighting factor shall be added to each 1/3 octave band. The total power shall then be determined on the basis of actual power. The total power shall then be converted to an equivalent sound pressure level for a radius of 10 feet (3.05 m) using the following formula:

$$L_p = L_w - 20Log_{10} R - 0.6$$

in which:

L_p is the converted sound pressure level,

L_w is the sound power level measured in the reverberation room, and

R is the radius for the converted sound pressure level (10 feet).

66.4 The output specified in 66.2 shall not be less than 82 decibels when the voltage is reduced to the minimum value specified in the Undervoltage Operation Test, Section 43.

66.5 When connected with its power supply, the alarm sounding device shall sound at the level specified in 66.2 for not less than 2 minutes.

67 Access Control Line Security

67.1 General

67.1.1 The provisions of this section shall apply to Line Security Level II, Level III and Level IV access control products. Line Security Level I access control products shall be exempt from the provisions of this section.

67.1.2 Line security equipment incorporates refinement in electric apparatus and circuit arrangement to guard against an attempt to compromise the connecting line or communication channel between two listed devices or components, thereby granting unauthorized access to the protected or restricted area.

67.1.3 Software/hardware, a firewall, and/or a network intrusion detection system (NIDS) shall be provided as applicable and maintained with the latest updates, as supplied by the manufacturer.

67.2 Access Control Line Security Level II – Standard line security

67.2.1 The connecting line between two listed devices or components shall be supervised so as to automatically detect a compromise attempt within 6 minutes by any of the methods described in 67.2.2.

67.2.2 Compromise attempt by any one of the following methods shall be detected:

a) Supervision – Opens, shorts, and ground faults on the communication channel between devices at the protected premises, or between the protected premises control unit and the monitoring station, either shall not adversely affect the intended operation of the end-to-end equipment, or shall be indicated by a trouble signal or an alarm signal at the protected premises (and the monitoring station if applicable).

b) Equipment Compromise – The connecting line between the monitoring station and the protected premises control unit, or between devices at the protected premises, shall be supervised to automatically detect a compromise attempt within 5 minutes by the direct substitution of randomly

selected equipment. Equipment used to make substitutions is to be identical in all aspects to the original equipment.

Exception: If a product has a unique digital signature, equipment compromise can be waived as applicable.

c) Compatibility – As evaluated, the access control devices and the monitoring station equipment determined to be compatible must be specifically described in the product installation instructions.

67.2.3 A compromise attempt by any one of the methods in 67.2.2 shall cause a visual and/or audible signal at both devices or components.

67.2.4 Where a number of products depend on one connecting line or communication channel, the product against which a compromise attempt is made in accordance with 67.2.2 shall be identified and the attempt shall not cause confusing signals from any of the other products on the line or channel.

67.3 Access Control Line Security Level III – Encrypted line security with 128 bit encryption

67.3.1 In addition to the requirements of Access Control Line Security Level II Equipment, Access Control Line Security Level III equipment shall use equipment encryption algorithms of a minimum of 128 bits to provide protection against a compromise attempt.

67.3.2 For products incorporating encrypted line security, evidence of a certificate of compliance for the validation of encryption algorithms [for example, FIPS 197 or FIPS 46-3] or validation of security requirements for cryptographic modules (for example, FIPS 140-2) with the National Institute of Standards and Technology (NIST) shall be provided.

67.3.3 A compromise attempt against a product provided with encrypted line security equipment shall cause an audible and visual signal within 6 minutes at both devices or components. Equipment complying with the requirements in this section shall be classified as Access Control Line Security Level III equipment.

67.4 Access Control Line Security Level IV – Encrypted line security with 256 bit encryption

67.4.1 In addition to the requirements of Access Control Line Security Level II Equipment, Access Control Line Security Level IV equipment shall use equipment encryption algorithms of a minimum of 256 bits to provide protection against a compromise attempt.

67.4.2 For products incorporating encrypted line security, evidence of compliance for the validation of encryption algorithms [for example, FIPS 197 or FIPS 46-3] or validation of security requirements for cryptographic modules (for example, FIPS 140-2) with the National Institute of Standards and Technology (NIST) shall be provided.

67.4.3 A compromise attempt against a product provided with encrypted line security equipment shall cause an audible and visual signal within 6 minutes at both devices or components. Equipment complying with the requirements in this section shall be classified as Access Control Line Security Level IV equipment.

68 Biometric Test

68.1 Biometric devices shall comply with the following:

a) When used indoor, shall be operational within 0 ° to 49 °C, and in a non-condensing, non-corrosive, non-flammable atmosphere, within the atmospheric pressure range of 86 kPa to 106 kPa.

b) When used outdoors, shall be operational within −40 °C to +66 °C and shall meet the requirements identified in Sections 74 – 86, Outdoor Use Equipment.

68.2 The product shall compare each biometric transaction with recorded credentials to accept or deny users identity claims and allow or deny access.

69 Controlled And Delayed Egress Equipment And Systems Operation

69.1 General Requirements

69.1.1 General

69.1.1.1 Equipment and systems intended to be used in controlled and delayed egress applications shall comply with this section.

69.1.2 Fire exit or panic hardware (if provided)

69.1.2.1 Equipment and systems designed as fire exit or panic hardware shall comply with UL 305 and this section.

69.1.3 Loss of power

69.1.3.1 Any interruption of power controlling the lock or locking mechanism, shall cause the unlock and release of the door latching mechanism without delay in a time frame not to exceed two seconds.

69.1.4 Fire alarm/sprinkler system connection

69.1.4.1 The egress release mechanism shall include provisions to connect to a fire alarm control unit. Activation of a fire alarm signal or fire sprinkler signal shall release the door latching mechanism to allow egress in a time frame not to exceed two seconds. The door shall remain unlocked until the fire alarm control unit has been reset.

69.1.5 Manual release switch interface

69.1.5.1 Equipment and systems shall be provided with a means to release door latches upon activation of a manual release switch within two seconds. Manual release switches are typically located at a fire command center, security command center, nursing station or other approved location.

69.1.6 Audible alarm (if provided)

69.1.6.1 Equipment and systems provided with an audible alarm shall operate as described in manufacturer's instructions. The audible alarm signals for the alarm shall be generated by devices such as bells, horns, sirens, or buzzers. The signal shall have a frequency in the range of 700 to 3400 Hz, either a cycle of the sound level pulsations of 4 to 5 per second or one continuous tone, and a sound level of at least 45 dB at 10 ft. (305 cm) in front of the device over the voltage range of operation.

69.2 Delayed egress requirements

69.2.1 General

69.2.1.1 Equipment and systems intended to be used in delayed egress applications shall comply with the requirements in 69.1.

69.2.2 Delay initiation

69.2.2.1 The equipment and systems shall be constructed so that when a horizontal force of 15 pounds (66 N) or less is applied to the release mechanism on the egress side of the door for not more than 3 seconds, the release mechanism will actuate and cause the time-delay feature to initiate an irreversible process for unlatching the door.

69.2.3 Time delay

69.2.3.1 Equipment and systems shall not be provided with a time-delay feature that allows more than a 30 second delay to unlatch the door after the release mechanism is actuated under any time adjustment or programming condition. Systems with a time-delay feature shall operate at a fifteen second delay, if provided, and at the maximum delay setting, shall unlatch the panic hardware within ±1 one second of the specified time delay setting. The equipment and release function shall operate as required for a minimum of 50 cycles without failure.

69.2.4 Audible alarm

69.2.4.1 Equipment and systems shall be provided with an audible alarm that shall activate upon initiation of the delayed timing process and continue signaling until the door lock is released.

69.3 Controlled egress requirements

69.3.1 General

69.3.1.1 Equipment and systems utilizing an electrically or electromagnetically locking mechanism intended to be used in controlled egress applications shall comply with the requirements in 69.1.

69.3.2 Sensor release

69.3.2.1 Equipment and systems intended to be operated with a sensor release feature shall be constructed to operate so that when the sensor detects an occupant within 5 feet of the egress side of the door, the door locking mechanism will unlock the door. The equipment and sensor shall operate as required for a minimum of 50 cycles without failure.

69.3.3 Manual release switch interface

69.3.3.1 Equipment and systems shall be provided with a means to release door latches upon activation of a manual release switch intended to be installed within 5 feet of the door. The activation of this manual release switch shall cause the door to remain unlocked for 30 seconds. The equipment and manual release switch shall operate as required for a minimum of 50 cycles without failure.

69.3.4 Electromagnetically locked egress doors

69.3.4.1 Equipment and systems utilizing an electromagnetic locking mechanism shall be capable of being operated with one hand. The releasing mechanism shall interrupt the power to the electromagnetic