



UL 294

STANDARD FOR SAFETY

Access Control System Units

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

Seventh Edition, Dated January 31, 2018

Summary of Topics

This revision of ANSI/UL 294 includes clarifications and corrections.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated August 3, 2018.

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Standard for Access Control System Units

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Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line 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, 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 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.

2 General information

2.1 For equipment utilizing power over communications cables, refer to 34.7, 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 Accept Rates, False Reject Rates, Failure to Enroll, Failure to Acquire, etc. are not specifically evaluated as part of this standard. See Section 67, Biometric Test.

2.3 Access control systems that include duress signaling features are additionally evaluated per the Standard for Hold Up Units and Alarm Systems, UL 636.

2.4 Products intended for use in air-handling spaces in Accordance with Section 300.22, (C) of the National Electrical Code, 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 initiating, annunciating, and remote 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 Sections 81 – 96 of the Standard for Central-Station Burglar-Alarm Units, UL 1610, as applicable.

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 Appendix 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.

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 Undated References

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.

6 Terminology

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

7 Glossary

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

7.2 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.

7.3 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.

7.4 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.

7.5 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.

7.6 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.

7.7 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.

7.8 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.

7.9 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.

7.10 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.

7.11 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.

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

7.13 ACCESS CONTROL LINE SECURITY LEVEL II – An access control product provided with standard communication line security. See 66.2.

7.14 ACCESS CONTROL LINE SECURITY LEVEL III – An access control product provided with 128 bit encryption. See 66.3.

7.15 ACCESS CONTROL LINE SECURITY LEVEL IV – An access control product provided with 256 bit encryption. See 66.4.

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

7.17 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.

7.18 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.

7.19 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.

7.20 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.

7.21 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.

7.22 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.

7.23 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.)

7.24 ALARM – A condition requiring human assessment or intervention.

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

7.26 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).

7.27 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 Tables 39.1 and 39.2.
- d) Power over Communications Cable – A limited energy circuit that meets the requirements of 34.7.
- 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 the 34.7, 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 34.7, Power over communications cable equipment, for equipment utilizing power over communications cables.

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

7.29 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.

7.30 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.

7.31 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.

7.32 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.

7.33 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.

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

7.35 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.

7.36 ESSENTIAL COMPUTER EQUIPMENT – Equipment connected to the access control system either on or off premises that is relied upon by the system for access control operations.

7.37 ETHERNET CABLING – A structured cabling system using 4 pair unshielded or shielded twisted pair cable, meeting Category 5e performance or higher and conforming to the Standard for Balanced Twisted-Pair Telecommunications Cabling and Components, ANSI/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.

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

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

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

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

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

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

7.44 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).

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

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

7.47 POWER INJECTOR (Alternative terms – Injector or Power Brick) – A powered device 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.

7.48 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 Appendix B) and USB.

7.49 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.

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

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

7.52 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.

7.53 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.

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

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

7.56 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.

7.57 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.

7.58 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.

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

7.60 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.

8 Performance Level Definitions for Access Control

8.1 The access control features identified in Table 8.1 shall be identified for the product or equipment by the Level specified by the manufacturer for that feature.

Table 8.1
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 alarm event in 2 minutes	Withstand attack test for 5 minutes, generate an 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
Standby power	No secondary power source	Can maintain normal operation for a minimum of 30 minutes (see 7.17)	Can maintain normal operation for a minimum of 2 hours (see 7.18)	Can maintain normal operation for a minimum of 4 hours (see 7.19)
Single Point Locking Device with Key Locks (see 34.2.2)	No attack test on key lock	Picking, Lock Bumping and Impression tests for key locks from Table 11.1 of the Standard for Key Locks, UL 437	All key lock attack resistance tests from Table 11.1 of the Standard for Key Locks, UL 437	

8.2 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 71.14.

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

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

8.5 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.

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9 Information Required for Assessment

9.1 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 90),
- 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,
- e) Mechanical drawings, and
- f) Markings to be applied to the product as required in MARKINGS, Details, Sections 71 and 89.

10 Version Number

10.1 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.

CONSTRUCTION

ASSEMBLY

11 General

11.1 Specific product requirements

11.1.1 Products that currently meet all the requirements of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, fulfill the requirements of 11.3 (Electrical Protection), 12 (Protection of Service Personnel), 13.1, 13.3 – 13.7 (Enclosure), 14 (Electric Shock), 15 (Corrosion Protection), 16 (Field Wiring Connection, General), 17 (Cord Connected Products), 18.6 (Polarity Identification), 19 (Grounding), 20 (Internal Wiring, General), 21 (Bonding for Grounding), 22 (Mounting of Components), 23 (Insulating Materials), 24 (Fuseholders and Current-Carrying Parts), 27 (Switches), 28 (Transformers and Coils), and 32 (Spacings).

11.2 Product assembly

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

11.2.2 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.

11.2.3 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.

11.3 Electrical protection

11.3.1 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.

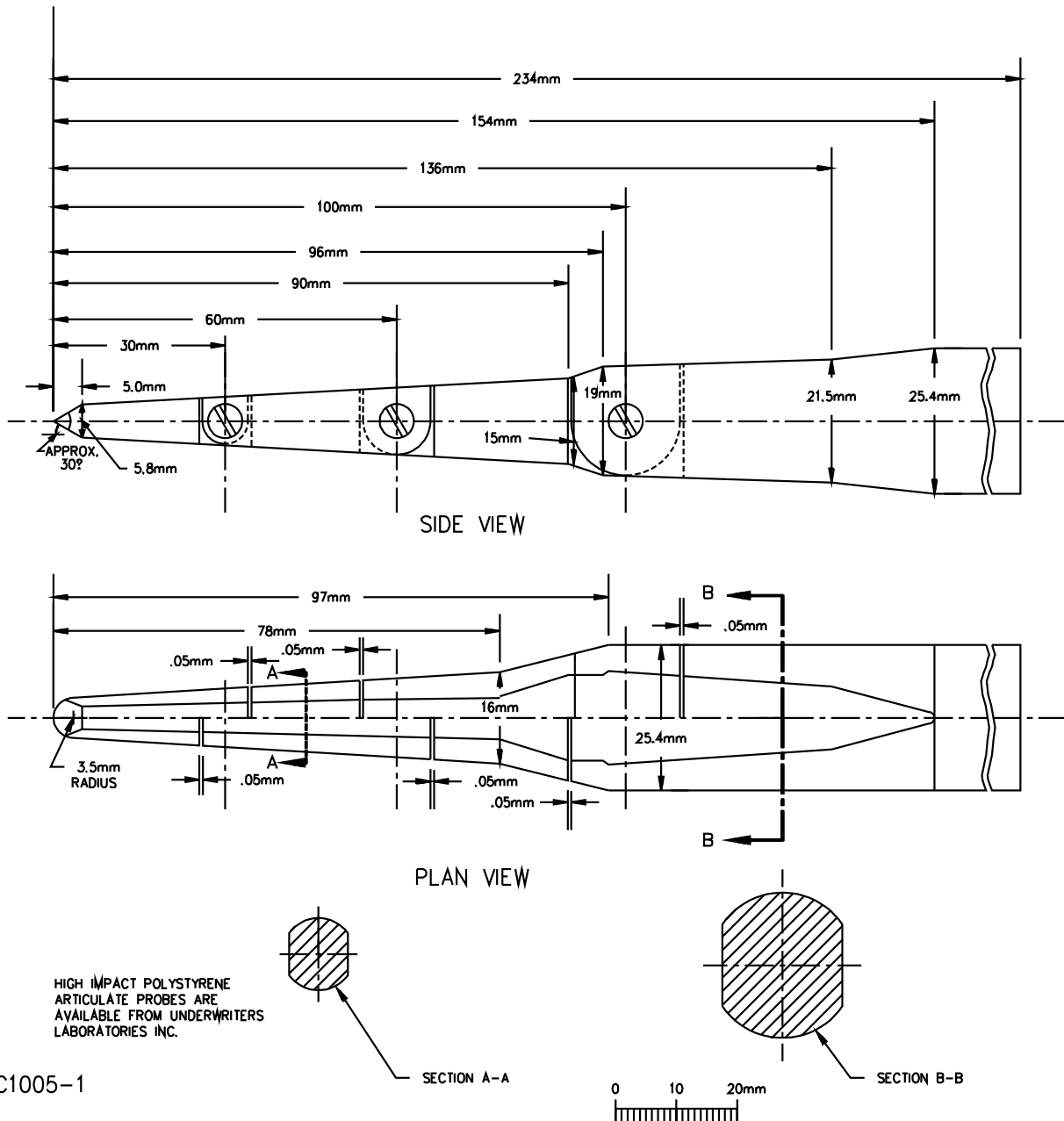
11.3.2 Uninsulated high-voltage live parts shall be located, guarded, or enclosed as indicated in 11.3.3 and 11.3.4.

11.3.3 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 13.2 for examples of top cover constructions which may be used.

11.3.4 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 11.1, cannot be made to contact any uninsulated live high-voltage electrical part when inserted through the opening in a straight or articulated position.

11.3.5 An opening that permits entrance of a 1-inch (25.4-mm) diameter rod may be used under the conditions described in Figure 11.2.

Figure 11.1
Articulate probe



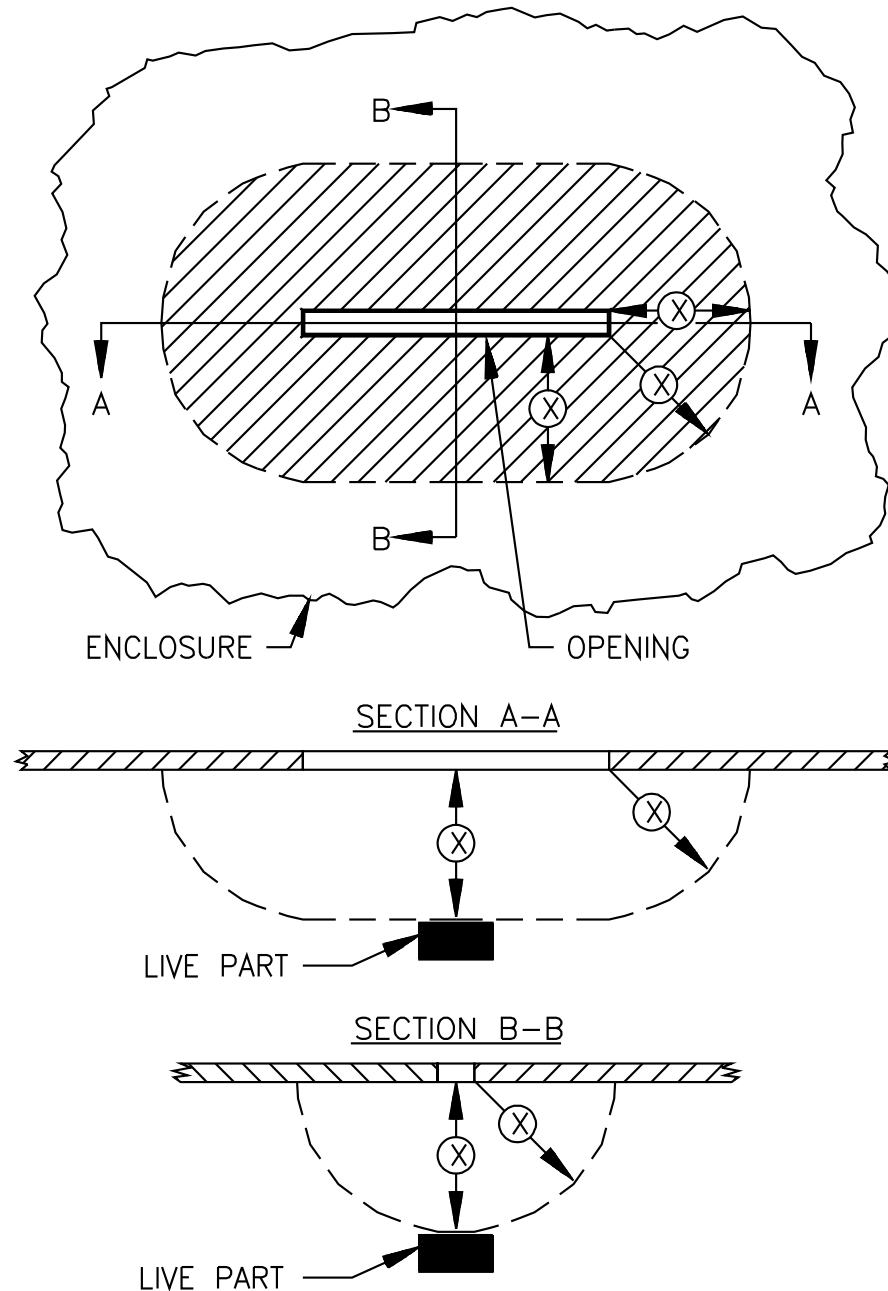
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Figure 11.2
Opening in enclosure



EC100A

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).

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12 Protection of Service Personnel

12.1 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.

12.2 The requirements specified in 12.1 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.

12.3 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.

12.4 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.

13 Enclosure

13.1 General

13.1.1 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 62.

13.1.2 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.

13.1.3 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 61.

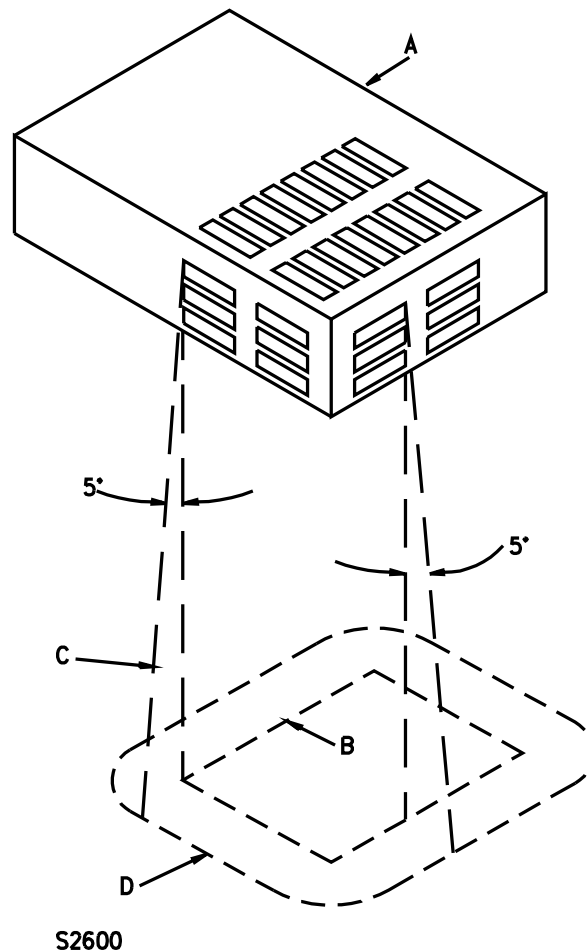
13.1.4 The requirement specified in 13.1.3 requires either a nonflammable bottom in accordance with 13.3.2, or a protective barrier as illustrated in Figure 13.1 under all areas containing combustible materials. However, openings in the bottom of an enclosure that comply with the requirements of 13.6 may be used.

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Figure 13.1
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 degree 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.

13.1.5 A construction using an individual barrier under a component, group of components, or an assembly, as specified in Figure 13.1, shall comply with the requirement specified in 13.1.3.

13.2 Doors and covers

13.2.1 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 40.1.2.

13.2.2 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.

13.3 Enclosure openings – general

13.3.1 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.

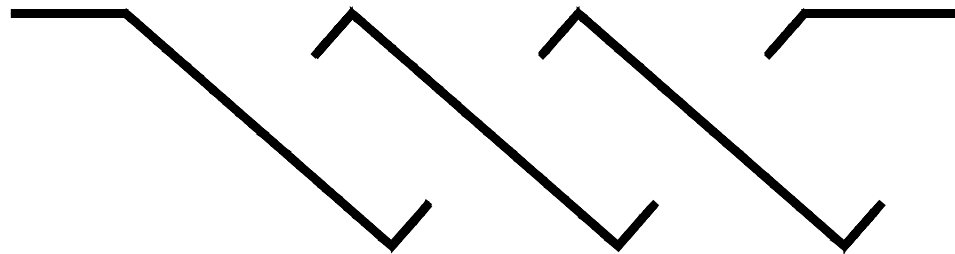
13.3.2 The requirement in 13.3.1 does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage) when:

- 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 mm²) 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 inches² (430 mm²) and there are no more holes than are needed to mount the product.

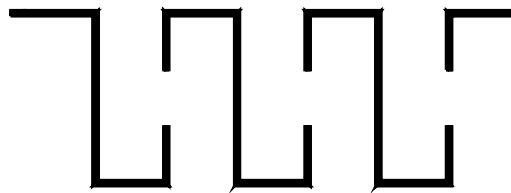
13.4 Enclosure top openings

13.4.1 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 13.2 for examples of top-cover designs complying with the intent of the requirement.

Figure 13.2
Top cover designs



SLANTED OPENINGS



EC500

VERTICAL OPENINGS

13.5 Enclosure side openings

13.5.1 An opening in the side of the enclosure shall:

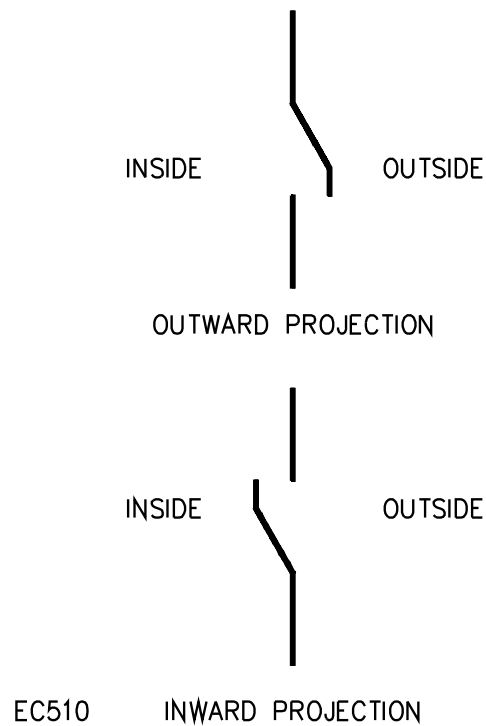
- Not exceed 0.19 inch (4.8 mm) in any dimension;
- Be provided with louvers shaped to deflect an external falling object outward (see Figure 13.3 for examples of louver designs complying with the requirement); or
- Be located and sized so that objects which are present cannot drop into the unit and 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 13.4).

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Figure 13.3
Louver designs



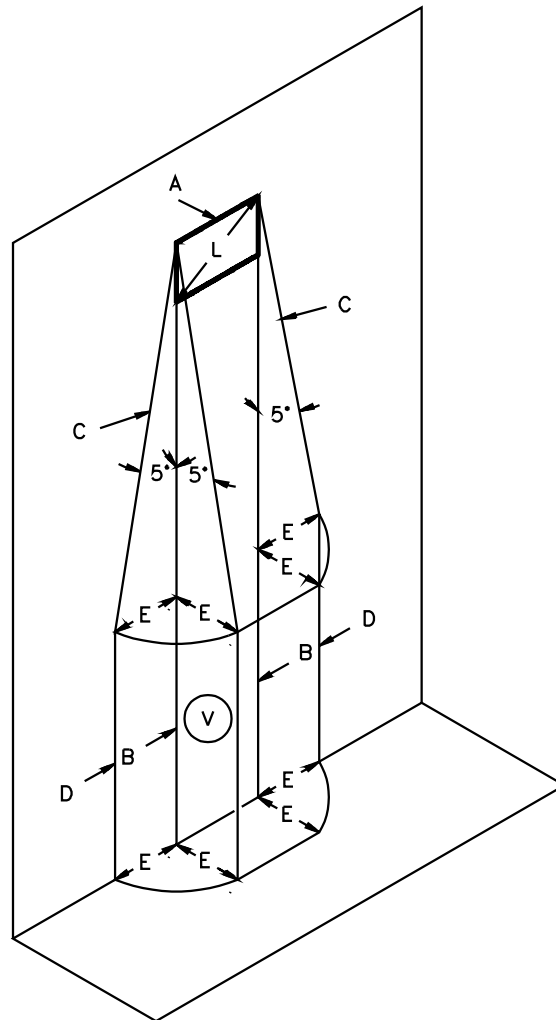
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Figure 13.4
Example of enclosure side opening



S3162A

A – Enclosure side opening.

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

C – Inclined lines that project at a 5-degree 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.

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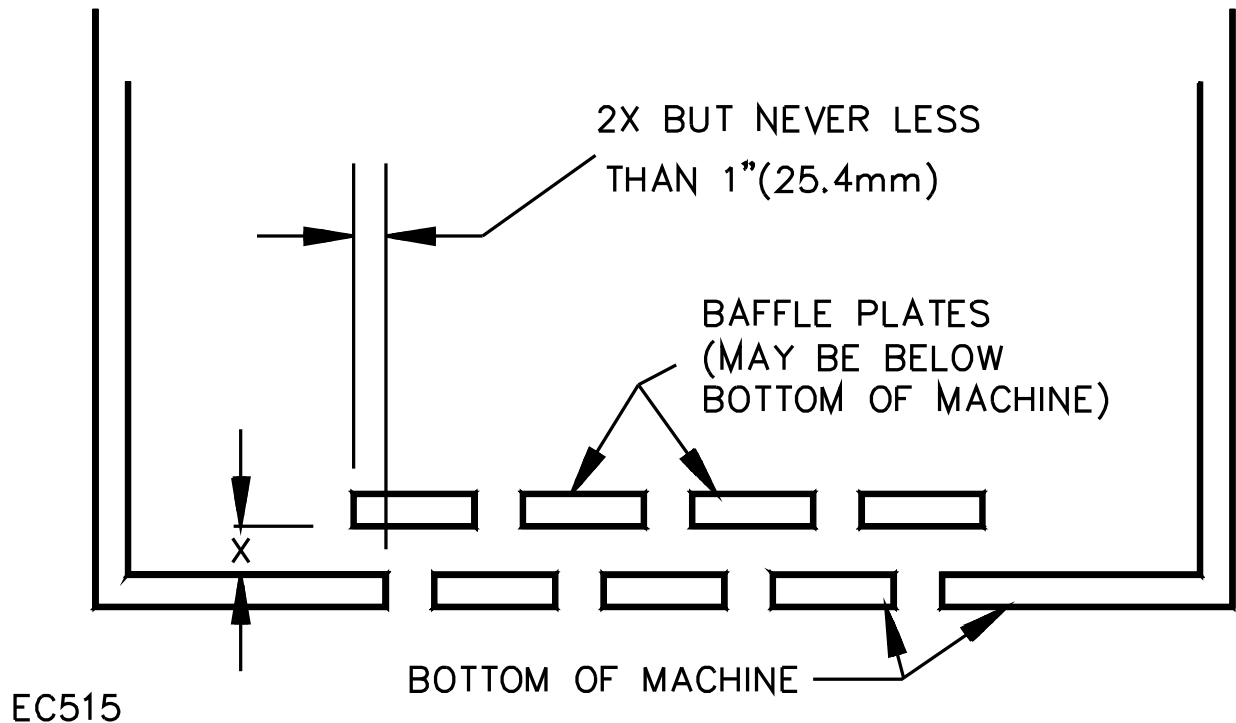
13.5.2 When a portion of a side panel falls within the area traced out by the 5-degree angle in Figure 13.1, that portion of the side panel shall be investigated as a bottom enclosure in accordance with 13.6.1 – 13.6.3.

13.6 Enclosure bottom openings

13.6.1 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 13.5, that complies with the ventilation opening requirements in 13.6.2 and 13.6.3 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 13.5
Baffle



13.6.2 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 13.1, 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 61.

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Table 13.1
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)

13.6.3 The bottom of the enclosure under areas containing only materials rated V-1 or less flammable shall have openings no larger than 1/16 inch² (40 mm²).

13.7 Screens and expanded metal

13.7.1 A screen or mesh of expanded metal used as a guard, enclosure or part of an enclosure shall comply with the requirements of 13.7.2 – 13.7.4 and with the Mechanical Strength Tests for Enclosures, Section 62.

13.7.2 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 mm²) 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).

13.7.3 With reference to the requirements in 13.7.2, 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 32). 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 cm²) 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).

13.7.4 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 mm²) or less in area and shall not be less than 12 AWG (2.05 mm diameter) steel for larger screen openings.

13.8 Cast metal

13.8.1 The thickness of cast metal for an enclosure shall be as specified in Table 13.2. 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 59, and the Mechanical Strength Tests for Enclosures, Section 62.

Table 13.2
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.				

13.8.2 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.

13.8.3 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.

13.9 Sheet metal

13.9.1 The thickness of sheet metal for an enclosure shall not be less than that specified in Table 13.3 or 13.4, 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 59, and the Mechanical Strength Tests for Enclosures, Section 62.

Table 13.3
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 inches (cm)	Maximum length, ^c inches (cm)	Maximum width, ^b inches (cm)	Maximum length, ^c inches (cm)	Uncoated [MSG]	Metal Coated [GSG]
4.0 (10.2)	Not limited	6.25 (15.9)	Not limited	0.020 (0.51)	0.023 (0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)	[24]	[24]
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026 (0.66)	0.029 (0.74)
7.0 (17.8)	11.5 (22.2)	10.0 (25.4)	12.5 (31.8)	[22]	[22]
8.0 (20.3)	Not limited	12.0 (30.5)	Not limited	0.032 (0.81)	0.034 (0.86)
9.0 (22.9)	18.0 (45.7)	13.0 (33.0)	16.0 (40.6)	[20]	[20]
12.5 (31.8)	Not limited	19.5 (49.5)	Not limited	0.042 (1.07)	0.045 (1.14)
14.0 (35.6)	18.0 (45.7)	21.0 (53.3)	25.0 (63.5)	[18]	[18]
18.0 (45.7)	Not limited	27.0 (68.6)	Not limited	0.053 (1.35)	0.056 (1.42)
20.0 (50.8)	25.0 (63.5)	29.0 (73.7)	36.0 (91.4)	[16]	[16]
22.0 (55.9)	Not limited	33.0 (83.8)	Not limited	0.060 (1.52)	0.063 (1.60)
25.0 (63.5)	31.0 (78.7)	35.0 (88.9)	43.0 (109.2)	[15]	[15]
25.0 (63.5)	Not limited	39.0 (99.1)	Not limited	0.067 (1.70)	0.070 (1.78)
29.0 (73.7)	36.0 (91.4)	41.0 (104.1)	51.0 (129.5)	[14]	[14]
33.0 (83.3)	Not limited	51.0 (129.5)	Not limited	0.080 (2.03)	0.084 (2.13)
38.0 (96.5)	47.0 (119.4)	54.0 (137.2)	66.0 (167.6)	[13]	[13]
42.0 (106.7)	Not limited	64.0 (162.6)	Not limited	0.093 (2.36)	0.097 (2.46)
47.0 (119.4)	59.0 (149.9)	68.0 (172.7)	84.0 (213.4)	[12]	[12]
52.0 (132.1)	Not limited	80.0 (203.2)	Not limited	0.108 (2.74)	0.111 (2.82)
60.0 (152.4)	74.0 (188.0)	84.0 (231.4)	103.0 (261.6)	[11]	[11]
63.0 (160.0)	Not limited	97.0 (246.4)	Not limited	0.123 (3.12)	0.126 (3.20)
73.0 (185.4)	90.0 (228.6)	103.0 (261.6)	127.0 (322.6)	[10]	[10]

^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.

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Table 13.4
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, inches (mm)
Maximum width, ^b inches (cm)	Maximum length, ^c inches (cm)	Maximum width, ^b inches (cm)	Maximum length, inches (cm)	
3.0 (7.6)	Not limited	7.0 (17.8)	Not limited	0.023 (0.58)
3.5 (8.9)	4.0 (10.2)	8.5 (21.6)	9.5 (24.1)	
4.0 (10.2)	Not limited	10.0 (25.4)	Not limited	0.029 (0.74)
5.0 (12.7)	6.0 (15.2)	10.5 (26.7)	12.5 (34.3)	
6.0 (15.2)	Not limited	14.0 (35.6)	Not limited	0.036 (0.91)
6.5 (16.5)	8.0 (20.3)	15.0 (38.1)	18.0 (45.7)	
8.0 (20.3)	Not limited	19.0 (48.3)	Not limited	0.045 (1.14)
9.5 (24.1)	11.5 (29.2)	21.0 (53.3)	25.0 (63.5)	
12.0 (30.5)	Not limited	28.0 (71.1)	Not limited	0.058 (1.47)
14.0 (35.6)	16.0 (40.6)	30.0 (76.2)	37.0 (94.0)	
18.0 (45.7)	Not limited	42.0 (106.7)	Not limited	0.075 (1.91)
20.0 (50.8)	25.0 (63.5)	45.0 (114.3)	55.0 (139.7)	
25.0 (63.5)	Not limited	60.0 (152.4)	Not limited	0.095 (2.41)
29.0 (73.7)	36.0 (91.4)	64.0 (162.6)	78.0 (198.1)	
37.0 (94.0)	Not limited	87.0 (221.0)	Not limited	0.122 (3.10)
42.0 (106.7)	53.0 (134.6)	93.0 (236.2)	114.0 (289.6)	
52.0 (132.1)	Not limited	123.0 (312.4)	Not limited	0.153 (3.89)
60.0 (152.4)	74.0 (188.0)	130.0 (330.2)	160.0 (406.4)	

^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.

13.9.2 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.

13.9.3 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,

for a hole having a maximum diameter of 1-3/8 inches (34.9 mm).

13.9.4 A closure for a hole larger than 1-3/8 inch (34.9 mm) diameter shall have a thickness equal to that required in 13.9.1 for the enclosure of the device. Otherwise, a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

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

13.9.6 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 32.

13.10 Product enclosure mounting

13.10.1 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.

13.11 Polymeric materials

13.11.1 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.

All these factors are considered with regard to aging in accordance with the Polymeric Materials Test, Section 57, and the Mechanical Strength Tests for Enclosures, Section 62.

14 Electric Shock

14.1 Any part that is exposed during operator servicing shall not present the risk of electric shock. See the Electric Shock Current Test, Section 47.

14.2 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.*

14.3 The maximum value of 5.2 megohms mentioned in 14.2 is to include the maximum tolerance of the resistor value used; that is, a resistor rated 4.2 megohms with 20 percent tolerance or a resistor rated 4.7 megohms with a 10 percent 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.

14.4 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.

15 Corrosion Protection

15.1 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.

15.2 The requirement specified in 15.1 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.

15.3 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.

15.4 Hinges and other attachments shall be resistant to corrosion.

FIELD WIRING CONNECTIONS

16 General

16.1 Wiring terminals or leads that are of at least the size required by the National Electrical Code, ANSI/NFPA 70, shall be provided for connection of conductors.

17 Cord Connected Products

17.1 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.*

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

17.3 The flexible cord shall be of Type SJ, SJT, or other types determined to be equivalent, minimum 18 AWG (0.82 mm²). It shall be rated for use at the voltage and current rating of the product.

17.4 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 60.

17.5 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.

17.6 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.

17.7 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.

18 Permanently Connected Products

18.1 General

18.1.1 A fixed product shall have provision for connection of one of the applicable wiring systems in accordance with the National Electrical Code, ANSI/NFPA 70.

18.1.2 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 18.1.

Table 18.1
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 Specifications for Zinc-Coated Rigid Steel Conduit, 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.

18.1.3 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.

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

18.1.5 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.

18.2 Power Limited/Class 2 or 3 circuits

18.2.1 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.

Compliance with this requirement 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.

18.3 Field-wiring terminals

18.3.1 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.

18.3.2 A field wiring terminal shall comply with:

a) 18.3.4 – 18.3.8; or

b) The field-wiring requirements in the Standard for Electrical Quick-Connect Terminals, UL 310; or

c) The Standard for Wire Connectors, UL 486A-486B; or

d) The Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E; or

- e) The field-wiring requirements (Code 2 application) in the Standard for Terminal Blocks, 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.

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 34.7, 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.

18.3.3 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.

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

18.3.4 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used with 8 AWG (8.4 mm²) 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.

18.3.5 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 mm²) 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 mm²) conductor.

18.3.6 For connection of other than power-supply (line-voltage) circuits using 10 AWG (5.3 mm²) 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 mm²) or smaller conductor. Also, a No. 4 (2.8 mm diameter) screw may be used as a 19 AWG (0.65 mm²) or smaller conductor.

18.3.7 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.

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18.3.8 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.

18.4 Qualified application

18.4.1 Any of the following terminal configurations may be used for connection of field wiring, if they also comply with the requirements in 18.4.2:

- 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 the Standard for Communications-Circuit Accessories, UL 1863, or the Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, 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 34.7, Power over communications cable equipment, then the field wiring terminal shall typically be an RJ-45 style jack that complies with the requirements of the Standard for Communications-Circuit Accessories, 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.

18.4.2 Any of the terminal configurations listed in 18.4.1 may be used for connection of field wiring if they comply with all of the following:

- 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.