

UL 1711

ISBN 1-55989-645-0

Amplifiers for Fire Protective Signaling Systems



Northbrook, Illinois • (708) 272-8800

Melville, New York • (516) 271-6200

Santa Clara, California • (408) 985-2400

Research Triangle Park,

North Carolina • (919) 549-1400

**Underwriters Laboratories Inc.®**

Underwriters Laboratories Inc., founded in 1894, is chartered as a not-for-profit organization without capital stock, under the laws of the State of Delaware, to establish, maintain, and operate laboratories for the examination and testing of devices, systems and materials to determine their relation to hazards to life and property, and to ascertain, define and publish standards, classifications and specifications for materials, devices, products, equipment, constructions, methods, and systems affecting such hazards.

UL Standards for Safety are developed under a procedure which provides for participation and comment from the affected public as well as industry. The procedure takes into consideration a survey of known existing standards and the needs and opinions of a wide variety of interests concerned with the subject matter of the standard. Thus manufacturers, consumers, individuals associated with consumer-oriented organizations, academicians, government officials, industrial and commercial users, inspection authorities, insurance interests and others provide input to UL in the formulating of UL Standards for Safety, to keep them consonant with social and technological advances.

A not-for-profit organization
dedicated to public safety and
committed to quality service



Underwriters Laboratories Inc.®

A not-for-profit organization dedicated to public safety
and committed to quality service

August 31, 1994

Standard for

Amplifiers for Fire Protective Signaling Systems

UL 1711, Second Edition

Accompanying this transmittal notice is a copy of the second edition of UL 1711.

THIS EDITION OF THE STANDARD IS NOW IN EFFECT.

As indicated on the title page, this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this standard outlining the procedures to be followed to retain the approved text of ANSI/UL 1711-1994.

Revised and/or additional pages may be issued from time to time.

AUGUST 31, 1994



1

UL 1711

Standard for

Amplifiers for Fire Protective Signaling Systems

First Edition – January, 1987

Second Edition**August 31, 1994**

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated August 31, 1994. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Approved as ANSI/UL 1711-1987, July 9, 1987
Approved as ANSI/UL 1711-1994, April 13, 1994

Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest published set of revision pages.

ISBN 1-55989-645-0

COPYRIGHT © 1987, 1994 UNDERWRITERS LABORATORIES INC.

CONTENTS**FOREWORD****INTRODUCTION**

1	Scope	6
2	General	6
3	Glossary	7

INSTRUCTIONS AND DRAWINGS

4	General	8
---	---------------	---

CONSTRUCTION**ASSEMBLY**

5	General	8
6	Protection of Service Personnel	8
7	Electrical Supervision	9
8	Enclosures	9
9	Electric Shock	18
10	Protection Against Corrosion	18

FIELD WIRING CONNECTIONS

11	General	19
12	Field-Wiring Compartment	19
13	Power-Limited Circuits	19
14	Field-Wiring Terminals	20
15	Leads	21
16	Cords and Plugs	21
17	Grounding	22

INTERNAL WIRING AND ASSEMBLY

18	General	23
19	Separation of Circuits	24
20	Bonding for Grounding	24

COMPONENTS — ELECTRICAL

21	General	25
22	Overcurrent Protection	27
23	Semiconductors	28
24	Switches	28
25	Transformers and Relays	28
26	Printed Wiring Boards	28
27	Spacings	28

OPERATING COMPONENTS

28	General	30
----	---------	----

PERFORMANCE

29	Test Samples	30
30	Test Voltages	31
31	Waveform Analysis Test	31
32	Power Input/Output Characteristics Tests	31
33	Variable Voltage Operation Test	32
34	Electrical Supervision Tests	32
35	Harmonic Distortion Test	32
36	Variable Ambient Temperature Test	33
37	Humidity Test	33
38	Electric Shock Current Test	33
39	Leakage Current Test	37
40	Temperature Test	40
41	Overload Test	43
42	Endurance Test	43
43	Burnout Test	43
44	Component Failure Test	43
45	Abnormal Operation Test	44
46	Transient Tests	44
47	Mechanical Strength Tests	46
48	Strain Relief Tests	47
49	Radio-Frequency Rejection Test	47
50	Power-Limited Circuits	48
51	Polymeric Materials Tests	51
52	Dielectric Voltage-Withstand Test	51

MANUFACTURING AND PRODUCTION TESTS

53	General	52
54	Production-Line Dielectric Voltage-Withstand Test	53
55	Production-Line Grounding Continuity Test	54

MARKING

56	General	54
57	Permanence of Marking	56

ACCESSORY EQUIPMENT

58	General	56
59	Construction	56
60	Performance (Installation) Test	57
61	Marking	57

APPENDIX A

Standards for Components	A1
--------------------------	----

FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover electrically- and electronically-operated amplifiers that provide speech communication and distinctive sounds in conjunction with fire protective signaling systems for indoor location in accordance with the following standards:

- a) National Electrical Code, NFPA 70.
- b) National Fire Alarm Code, NFPA 72.

1.2 These requirements do not cover amplifiers for use in hazardous locations, as defined in the National Electrical Code, NFPA 70.

1.3 These requirements do not cover commercial equipment for institutional and industrial use or theater equipment. Commercial sound equipment is covered by the Standard for Commercial Audio Equipment, UL 813.

1.4 These requirements do not cover signal generating or processing equipment, such as tone generators, tape decks, microphones, and the like.

1.5 These requirements do not include determination of compliance with regulations of the Federal Communications Commission (FCC). Should products covered by these requirements be required to comply with FCC regulations, a report of verification from the manufacturer is required as evidence of such compliance.

1.6 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involve a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, 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.

2.1.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

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

2.1.4 Specific components are recognized as being 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 for which they have been recognized.

2.2 Units of measurement

2.2.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

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

2.3 Undated references

2.3.1 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.

3 Glossary

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

3.2 CIRCUITS, ELECTRICAL:

a) High-Voltage — A circuit involving a potential of not more than 300 volts and having circuit characteristics in excess of those of a low-voltage circuit.

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

c) Power-Limited Circuit — A circuit wherein the power is limited in accordance with Power-Limited Circuits, Section 50.

3.3 FIELD-WIRING TERMINALS — Those terminals to which power supply (including equipment grounding) or control connections will be made in the field when the product is installed as intended.

3.4 OPERATOR — A person who may manipulate the control or amplification functions of a product but does not have access to portions of the product required for servicing and maintenance.

3.5 POWER, EVACUATE — Rated output power for a square wave signal used for evacuation purposes.

3.6 POWER, SPEECH — Rated output power while delivering audio frequency signals over the rated frequency band within the constraints of the distortion limits specified in this standard. Audio frequency signals are considered to be within the 15-hertz to 15-kilohertz frequency range.

3.7 PRODUCT — Any type of amplifier covered by these requirements.

3.8 RADIO FREQUENCY — All frequencies above 20 kilohertz.

INSTRUCTIONS AND DRAWINGS

4 General

4.1 Each product shall be provided with installation instructions and drawings that shall include the following information:

- a) Typical installation drawing layouts and complete representative installation wiring diagram for the product indicating recommended locations and wiring methods. The recommended locations and methods shall be in accordance with the National Electrical Code, ANSI/NFPA 70.
- b) A concise description of the operation, testing, and proper maintenance procedures for the product. The frequency of testing shall be in accordance with the requirements of the authorities having jurisdiction.
- c) Identification of replacement parts, such as lamps or batteries, by a part number, manufacturer's model number, or the equivalent.
- d) Typical installation wiring diagrams showing the interconnection of the product in a manner verifying electrical supervision in a complete system. See 4.3 for interconnection diagram specifications.

4.2 The instructions may be incorporated on the inside of the product, on a separate sheet, or as part of a manual. If not included directly on the product, the instructions or manual shall be referenced in the marking information on the product.

4.3 With reference to 7.1, the interconnection diagram that includes speakers and amplifiers interconnected as part of a fire protective signaling system is to be reviewed to verify that electrical supervision is provided for the amplifier and speaker circuits. The interconnection diagram shall be included with the installation wiring diagram or operating instructions, or both, furnished by the manufacturer, and shall indicate connections required for supervision.

CONSTRUCTION

ASSEMBLY

5 General

5.1 Unless specifically indicated otherwise, the construction requirements specified for a product also apply to any remote accessories with which it is to be used.

5.2 If provision is made for testing the operability of a product, the means provided shall not involve a risk of electric shock or injury to persons.

5.3 A test means shall be constructed and located so as to reduce the likelihood of tampering by unauthorized personnel.

6 Protection of Service Personnel

6.1 An uninsulated live part of a high-voltage circuit within the enclosure shall be located, guarded, or enclosed to reduce the likelihood of unintentional contact by persons performing service functions that may be performed while the equipment is energized.

6.2 During the examination of a product in connection with the requirements of 6.1, a part of the outer enclosure that may be removed without the use of tools, or part of the outer enclosure that may be removed by the user to allow access for making intended operating adjustments, is to be disregarded; it will not be assumed that the part in question affords protection against electric shock.

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

6.4 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 involved;
- b) Terminals and splices having insulation rated for the potential involved; and
- c) Insulated wire.

6.5 If the linear distance from a component requiring servicing to an uninsulated high-voltage live part is less than 6 inches (152 mm), the part shall be protected by insulating tape, barriers, or the equivalent.

Exception: A product need not comply with this requirement if either:

- a) An interlock is provided on the cover that de-energizes all live parts in the enclosure when the cover is removed, or*
- b) The cover is marked in accordance with 56.9.*

7 Electrical Supervision

7.1 An amplifier shall be provided with means for interconnection into a system of electrical supervision that will provide an audible trouble signal in the event of an open circuit in the input or output circuits of the amplifier or other malfunction (including internal malfunction of tone generators, preamplifiers, and amplifiers resulting in loss of their intended output or reduction of performance below the level required by this standard) that will impair intended signaling operation. See 4.3 for interconnection diagram specifications.

8 Enclosures

8.1 General

8.1.1 The frame and enclosure of a product shall have the strength and rigidity to resist total or partial collapse with attendant reduction of spacings, loosening or displacement of parts, and development of other conditions that could impair operation of the product and result in a risk of fire, electric shock, or injury to persons.

8.1.2 Uninsulated high-voltage live parts of a product shall be located or enclosed to provide protection from unintentional contact.

8.1.3 An operating part, such as a gear mechanism, a light-duty relay, or similar device, shall be enclosed to protect against malfunction from dust or other foreign material that may impair the intended operation.

8.1.4 The mounting means of an enclosure 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.

8.1.5 A material used within an enclosure shall be classified 94V-2 or 94HF-2, or less flammable, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: A motor, relay, capacitor, semiconductor, transformer, switch, insulating tubing or tape, or other electrical element need not comply with this requirement if it complies with the flame test applicable to the component.

Exception No. 2: A meter face and case (if intended for mounting live parts) and indicator lamp or jewel need not comply with this requirement.

Exception No. 3: The material used to form a gear, cam, belt, bearing, strain-relief bushing applied over a PVC-jacketed cord, or other small part that contributes negligible fuel to a fire need not be investigated, if the part is isolated from uninsulated electrical parts that are not power limited either by at least 0.5 inch (12.5 mm) of air, or a solid barrier of material classified 94V-2 or less flammable.

Exception No. 4: Tubing for air or fluid systems, and foamed plastic, need only be classified 94HB or 94HBF, if the tubing or foamed plastic is isolated from uninsulated electrical parts that are not power limited either by at least 0.5 inch (12.5 mm) of air, or a solid barrier of material classified 94V-2 or less flammable.

8.1.6 If an amplifier is not intended to be installed in a separate cabinet that has provision for connection to a Class I wiring system, as defined by the National Electrical Code, ANSI/NFPA 70, the enclosure of the amplifier shall have provision for connection to a Class I wiring system.

8.2 Openings

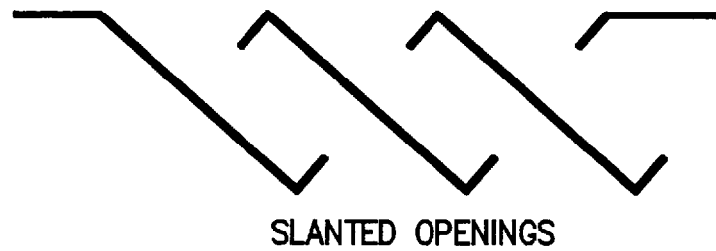
8.2.1 An opening in the top of the enclosure shall be sized and constructed so as to reduce the likelihood of entry of foreign objects.

8.2.2 To comply with the requirements in 8.2.1, an opening directly over an uninsulated live part shall not exceed 0.187 inch (4.75 mm) in any dimension unless the configuration of the opening prevents direct entry to uninsulated high-voltage live parts. See Figure 8.1 for examples of top cover constructions which may be used.

8.2.3 An opening in the side of the enclosure shall be sized and located so as to reduce the likelihood of entry of a foreign object, and contact by persons with internal parts. A louver may be used if shaped to deflect external falling objects outward. See Figure 8.2 for examples of louver constructions which may be used.

8.2.4 Openings shall not be provided in the bottom panels or protective pans under areas containing materials not classified 94V-1 or less flammable, in accordance with the Standard for Tests for Flammability of Plastic Material for Use in Devices and Appliances, UL 94, unless constructed in a manner that prevents materials from falling directly from the interior of the product onto the supporting surface or onto any other location under the product. Figure 8.3 illustrates a type of baffle that complies with this requirement. A second construction that complies with this requirement is a 0.040-inch (1.02-mm) thick sheet steel bottom panel in which round holes of 5/64 inch (2.0 mm) maximum diameter are spaced not closer together than 1/8 inch (3.2 mm) center-to-center. See Burnout Test, Section 43, and Abnormal Operation Test, Section 45.

Figure 8.1
Cross sections of top cover designs



EC500

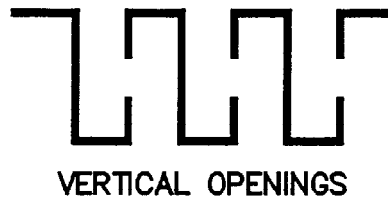
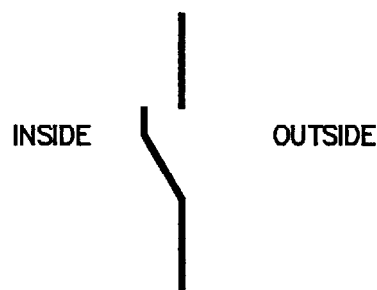
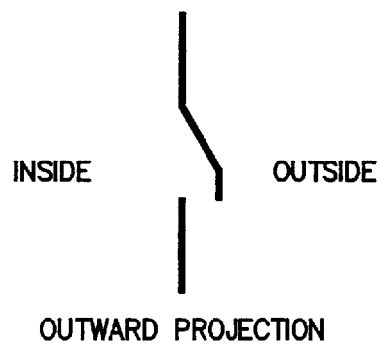


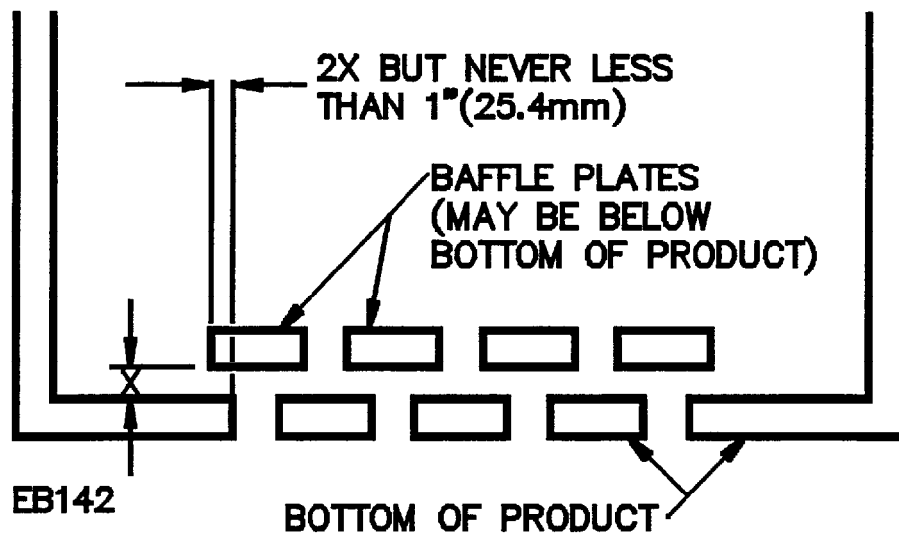
Figure 8.2
Louvers



EC510

INWARD PROJECTION

Figure 8.3
Bottom panel baffles



8.2.5 The bottom of the enclosure under areas containing only materials classified 94V-1 or less flammable, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, may have openings not larger than 1/16 square inch (40 mm²).

8.2.6 Openings may be used, without limitation on the size or number, in areas that contain only PVC, TFE, CTFE, FEP, and neoprene-insulated wire cable, and plugs and receptacles.

8.2.7 An opening in the enclosure shall not permit access to a relay, terminal, control, or related component that might be subject to tampering.

8.2.8 An enclosure intended for recessed mounting and having a front panel that is intended to be flush with the surface of the wall shall not have:

- a) Nonfunctional openings nor
- b) 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: The requirement in (b) does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage), if:

- a) *The opening has no dimension greater than 17/64 inch (6.75 mm) or an area greater than 0.055 square inch (35.5 mm²) and*
- b) *There is not more than one mounting screw hole for each 12 inches (305 mm) of length of mounting surface, or fraction thereof.*

8.3 Cast metal

8.3.1 The thickness of cast metal for an enclosure shall be at least the applicable value specified in Table 8.1.

Exception: Cast metal of lesser thickness may be used if, consideration being given to the shape, size, and function of the enclosure, it is determined to provide equivalent mechanical strength.

Table 8.1
Cast metal electrical enclosures

Use, or dimensions of area involved ^a	Minimum thickness, Inch (mm)	
	Die-cast metal	Cast metal of other than the die-cast type
Area of 24 square inches (155 cm 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.		

8.3.2 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 five threads in the metal, and the construction shall be such that a standard conduit bushing can be attached as intended.

8.3.3 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 full threads in the metal, and there shall be a smooth, rounded inlet hole that affords protection to the conductors that is determined to be equivalent to that provided by a standard conduit bushing.

8.3.4 A product intended to be supported by rigid conduit shall be provided with conduit hubs or the equivalent having not less than five full threads.

8.4 Sheet metal

8.4.1 The thickness of sheet metal employed for the enclosure of a product shall not be less than the applicable value specified in Table 8.2 or 8.3.

Exception: Sheet metal of lesser thickness may be used if, consideration being given to the shape, size, and function of the enclosure, it is determined to provide equivalent mechanical strength.

Table 8.2
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 uncoated, Inch (mm) [MSG]	Minimum thickness metal coated, Inch (mm) [GSG]
Maximum width, ^b Inches (cm)	Maximum length, ^c Inches (cm)	Maximum width, ^b Inches (cm)	Maximum length, ^c Inches (cm)		
4.0 (10.2) 4.75 (12.1)	Not limited 5.75 (14.6)	6.25 (15.9) 6.75 (17.1)	Not limited 8.25 (21.0)	0.020 (0.51) [24]	0.023 (0.58) [24]
6.0 (15.2) 7.0 (17.8)	Not limited 8.75 (22.2)	9.5 (24.1) 10.0 (25.4)	Not limited 12.5 (31.8)	0.026 (0.66) [22]	0.029 (0.74) [22]
8.0 (20.3) 9.0 (22.9)	Not limited 11.5 (29.2)	12.0 (30.5) 13.0 (33.0)	Not limited 16.0 (40.6)	0.032 (0.81) [20]	0.034 (0.86) [20]
12.5 (31.8) 14.0 (35.6)	Not limited 18.0 (45.7)	19.5 (49.5) 21.0 (53.3)	Not limited 25.0 (63.5)	0.042 (1.07) [18]	0.045 (1.14) [18]
18.0 (45.7) 20.0 (50.8)	Not limited 25.0 (63.5)	27.0 (68.6) 29.0 (73.7)	Not limited 36.0 (91.4)	0.053 (1.35) [16]	0.056 (1.42) [16]
22.0 (55.9) 25.0 (63.5)	Not limited 31.0 (78.7)	33.0 (83.8) 35.0 (88.9)	Not limited 43.0 (109.2)	0.060 (1.52) [15]	0.063 (1.60) [15]
25.0 (63.5) 29.0 (73.7)	Not limited 36.0 (91.4)	39.0 (99.1) 41.0 (104.1)	Not limited 51.0 (129.5)	0.067 (1.70) [14]	0.070 (1.78) [14]
33.0 (83.8) 38.0 (96.5)	Not limited 47.0 (119.4)	51.0 (129.5) 54.0 (137.2)	Not limited 66.0 (167.6)	0.080 (2.03) [13]	0.084 (2.13) [13]
42.0 (106.7) 47.0 (119.4)	Not limited 59.0 (149.9)	64.0 (162.6) 68.0 (172.7)	Not limited 84.0 (213.4)	0.093 (2.36) [12]	0.097 (2.46) [12]
52.0 (132.1) 60.0 (152.4)	Not limited 74.0 (188.0)	80.0 (203.2) 84.0 (213.4)	Not limited 103.0 (261.6)	0.108 (2.74) [11]	0.111 (2.82) [11]
63.0 (160.0) 73.0 (185.4)	Not limited 90.0 (228.6)	97.0 (246.4) 103.0 (261.6)	Not limited 127.0 (322.6)	0.123 (3.12) [10]	0.126 (3.20) [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 which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

- 1) 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 8.3
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, Inch (mm)
Maximum width, ^b Inches (cm)	Maximum length, ^c Inches (cm)	Maximum width, ^b Inches (cm)	Maximum length, Inches (cm)	
3.0 (7.6) 3.5 (8.9)	Not limited 4.0 (10.2)	7.0 (17.8) 8.5 (21.6)	Not limited 9.5 (24.1)	0.023 (0.58)
4.0 (10.2) 5.0 (12.7)	Not limited 6.0 (15.2)	10.0 (25.4) 10.5 (26.7)	Not limited 13.5 (34.3)	0.029 (0.74)
6.0 (15.2) 6.5 (16.5)	Not limited 8.0 (20.3)	14.0 (35.6) 15.0 (38.1)	Not limited 18.0 (45.7)	0.036 (0.91)
8.0 (20.3) 9.5 (24.1)	Not limited 11.5 (29.2)	19.0 (48.3) 21.0 (53.3)	Not limited 25.0 (63.5)	0.045 (1.14)
12.0 (30.5) 14.0 (35.6)	Not limited 16.0 (40.6)	28.0 (71.1) 30.0 (76.2)	Not limited 37.0 (94.0)	0.058 (1.47)
18.0 (45.7) 20.0 (50.8)	Not limited 25.0 (63.5)	42.0 (106.7) 45.0 (114.3)	Not limited 55.0 (139.7)	0.075 (1.91)
25.0 (63.5) 29.0 (73.7)	Not limited 36.0 (91.4)	60.0 (152.4) 64.0 (162.6)	Not limited 78.0 (198.1)	0.095 (2.41)
37.0 (94.0) 42.0 (106.7)	Not limited 53.0 (134.6)	87.0 (221.0) 93.0 (236.2)	Not limited 114.0 (289.6)	0.122 (3.10)
52.0 (132.1) 60.0 (152.4)	Not limited 74.0 (188.0)	123.0 (312.4) 130.0 (330.2)	Not limited 160.0 (406.4)	0.153 (3.89)

^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 which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

- 1) 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.

8.4.2 A hole larger than 1-3/8 inch (34.9 mm) diameter shall have a closure at least as thick as the enclosure of the product or shall have a standard knockout seal. Such plates or plugs shall be securely mounted.

8.4.3 A knockout in a sheet metal enclosure shall be reliably secured, but removal of the knockout shall not result in undue deformation of the enclosure.

8.4.4 A knockout shall be provided with a surrounding surface area of sufficient size to permit seating of a conduit bushing, and shall be located so that a bushing employed at any knockout likely to be used during installation will not reduce spacings between uninsulated live parts and the bushing to values less than those specified in Spacings, Section 27.

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

- a) 0.032 inch (0.81 mm) thick if uncoated steel,
- b) 0.034 inch (0.86 mm) thick if galvanized steel, and
- c) 0.045 inch (1.14 mm) thick if nonferrous metal.

8.5 Nonmetallic

8.5.1 An enclosure or part of an enclosure of nonmetallic material shall have sufficient mechanical strength and durability and shall be formed so that operating parts will be protected against damage. The mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 8.2.

8.5.2 Among the factors to be taken into consideration when determining the use of a nonmetallic enclosure or parts are:

- a) Flammability;
- b) Mechanical strength;
- c) Resistance to impact;
- d) Moisture absorptive properties;
- e) Dielectric strength, insulation resistance, resistance to arc tracking; and
- f) Resistance to distortion at temperatures to which the material may be subjected under conditions of anticipated use.

All these factors are to be considered with regard to aging. See Polymeric Materials Tests, Section 51.

8.5.3 A wooden enclosure shall:

- a) Be solid or laminated wood,
- b) Be at least 3/8 inch (9.5 mm) thick,

- c) Have no edge exposed to internal electrical parts, and
- d) Be spaced at least 1/2 inch (12.7 mm) from live or arcing parts and potential sources of ignition.

All electrical parts shall be mounted to a chassis having a metal liner at least 0.010 inch (0.25 mm) thick. The liner shall completely cover the bottom of the enclosure. All high-voltage circuits and nonpower-limited low-voltage circuits shall be completely enclosed by metal not less than 0.010 inch thick.

8.6 Doors and covers

8.6.1 An enclosure cover shall be hinged, sliding, or similarly attached to prevent its being removed if it:

- a) Gives access to a fuse or to any other overcurrent protective device, the intended functioning of which requires renewal, or
- b) Is necessary to open the cover in connection with the intended operation of the product.

Exception: A tamper switch may be used in lieu of a hinged cover, provided only an overcurrent protective device is enclosed.

8.6.2 Fasteners requiring the use of a tool or key shall be used for an enclosure if access is not required for intended operation of the product.

8.7 Screens and expanded metal

8.7.1 A screen and expanded metal used as a guard, enclosure, or part of an enclosure shall comply with the requirements in 8.7.2 and 8.7.3.

8.7.2 Perforated sheet steel and sheet steel used for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) thick [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, and shall not be less than 0.080 inch (2.03 mm) thick [0.084 inch (2.13 mm) if zinc coated] for larger openings. The largest dimension shall not exceed 4 inches (102 mm).

Exception: 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 intended operation of the product or reduce spacings below the minimum required values (see Spacings, Section 27), 0.020 inch (0.53 mm) expanded metal mesh or perforated sheet metal [0.023 inch (0.58 mm) if zinc coated] may be used, if:

- a) *The exposed mesh on any one side or surface of the product so protected has an area of not more than 72 square inches (464 cm²) and has no dimension greater than 12 inches (305 mm), or*
- b) *The width of a protected opening is not greater than 3-1/2 inches (89 mm).*

8.7.3 The wires of a screen shall not be smaller than No. 16 AWG (1.3 mm²) if the area of the screen openings is 1/2 square inch (323 mm²) or less, and shall not be smaller than No. 12 AWG (2.1 mm²) for larger screen openings.