UL 50

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Enclosures for Electrical Equipment

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Enclosures for Electrical Equipment, UL 50

Eleventh Edition, Dated October 19, 1995

Revisions: This Standard contains revisions through and including September 12, 2003.

Summary of Topics

This revision to ANSI/UL 50 is being issued to update the Title Page to indicate approval as an American National Standard.

UL Standards for Safety are developed and maintained in the Standard Generalized Markup Language (SGML). SGML -- an international standard (ISO 8879-1986) -- is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Due to formatting differences resulting from the use of UL's new electronic publishing system, please note that additional pages (on which no requirements have been changed) may be included in revision pages due to relocation of existing text and reformatting of the Standard.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated February 13, 2003 and July 8, 2003. The bulletin(s) is now obsolete and may be discarded.

The revisions dated September 12, 2003 include a reprinted title page (page1) for this Standard.

As indicated on the title page (page 1), 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 this ANSI/UL Standard.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if

the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, Classification, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

This Standard consists of pages dated as shown in the following checklist:

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OCTOBER 19, 1995
(Title Page Reprinted: September 12, 2003)

UL 50

Standard for Enclosures for Electrical Equipment

The First and Second editions were titled Standard for Cabinets and Cutout Boxes. The Third – Ninth editions were titled Standard for Cabinets and Boxes.

First Edition – March, 1916
Second Edition – March, 1929
Third Edition – February, 1941
Fourth Edition – May, 1956
Fifth Edition – November, 1962
Sixth Edition – October, 1970
Seventh Edition – June, 1975
Eighth Edition – April, 1980
Ninth Edition – September, 1988
Tenth Edition – July, 1992

Eleventh Edition

October 19, 1995

The most recent designation of ANSI/UL 50 as an American National Standard (ANSI) occurred on August 19, 2003.

This ANSI/UL Standard for Safety, which consists of the Eleventh edition with revisions through September 12, 2003, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to UL-RTP Standard Department, 12 Laboratory Dr., P.O. Box 13995, Research Triangle Park, NC, 27709-3995.

The Department of Defense (DoD) has adopted UL 50 on April 5, 1982 . The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

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 set of revised requirements.

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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 which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, 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 electrical equipment enclosures for use in accordance with the National Electrical Code, NFPA 70.

1.2 Specific applications covered by this standard include cabinets and cutout boxes and junction and pull boxes.

1.3 Specific applications not covered by this standard are junction boxes of the swimming pool type.

1.4 Each type of enclosure covered by this standard is described in general and functional terms where practicable, and omits reference to structural details and specific applications except where they are essential to the identification of the enclosure type. Such additional details and specifications are included in the applicable standards for the end-product involved.

1.5 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the 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 does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 Glossary

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

2.1.1 ACCESSORY – A part or combination of parts intended for installation in or connection to a product for the purpose of modifying or supplementing the functions of the product. It may be factory installed or intended for installation by the user or service personnel.

2.1.1 added October 1, 1996

2.2 CABINET – An enclosure intended either for flush or surface mounting, and provided with a frame, mat, or trim in which a door or doors may be hung.

2.3 CUTOUT BOX – An enclosure intended for surface mounting and having a swinging cover secured directly to the box proper.

2.4 COVER – An unhinged portion of an enclosure that covers an opening.

2.4 revised October 1, 1996

2.4.1 DEGREE OF PROTECTION – The extent of protection provided by an enclosure against access to parts which result in a risk of injury, ingress of foreign solid objects, and/or ingress of water as verified by standardized test methods.

2.4.1 added October 1, 1996

2.5 DOOR – A hinged portion of an enclosure that covers an opening.

2.5 revised October 1, 1996

2.6 ENCLOSURE – A surrounding case constructed to provide a degree of protection against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

*2.7 *Deleted October 1, 1996**

2.7.1 INDOOR LOCATIONS – Areas which are protected from exposure to the weather.

2.7.1 added October 1, 1996

2.8 JUNCTION OR PULL BOX – An enclosure intended either for flush or surface mounting, having a solid unhinged cover secured directly to the box proper.

2.8 revised October 1, 1996

2.9 KNOCKOUT – A portion of the wall of an enclosure so fashioned that it is capable of being readily removed by a hammer, screw driver, and pliers at the time of installation in order to provide an opening or hole for the attachment of an auxiliary device, raceway, cable, or fitting.

2.9 added October 1, 1996

2.10 NON-VENTILATED – Constructed to provide no intentional circulation of external air through the enclosure.

2.10 added October 1, 1996

2.11 OIL RESISTANT GASKETS – Gaskets made of material which is resistant to oil and oil fumes.

2.11 added October 1, 1996

2.12 OUTDOOR LOCATIONS – Areas which are exposed to the weather.

2.12 added October 1, 1996

2.13 VENTILATED – Constructed to provide for the circulation of external air through the enclosure for the purposes of removing excess heat, fumes, or vapors.

2.13 added October 1, 1996

Figure 2.1
Door and hinged cover constructions

Figure 2.1 deleted October 1, 1996

3 References

3.1 Deleted November 19, 1999

4 Units of Measurement

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

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CONSTRUCTION

GENERAL

5 General

5.1 An edge on an enclosure shall not be sufficiently sharp to constitute a risk of injury in normal maintenance or use.

5.2 An enclosure shall be made of iron, steel, brass, copper, or aluminum.

Exception: Other material may be used if the material is investigated and found to be acceptable and the enclosure has at least the equivalent strength and rigidity.

5.3 Both the inside and outside surfaces of an enclosure, including means for fastening, shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means.

Exception No. 1: An enclosure and means for fastening that are of metal that is inherently resistant to corrosion.

Exception No. 2: This requirement does not apply to:

a) Bearings, sliding surfaces of a hinge, or shaft and the like where such protection is impractical; and

b) Parts made of stainless steel.

5.4 The outside of a cast-aluminum enclosure marked in accordance with 50.4 shall be coated with asphalt paint, one coat of baked enamel, or other material that provides equivalent protection.

5.4 revised November 19, 1999

5.5 An enclosure shall have the necessary strength and rigidity to maintain its shape so that an enclosure door closes tightly.

5.5 revised October 1, 1996

5.6 Metal into which screws are threaded shall provide for the engagement of at least two full threads. Rivets, screws, bolts, and similar fastenings in a sheet-metal enclosure shall have a diameter at least 50 percent greater than the thickness of the finished sheet metal with which they are used.

5.7 A screw with 32 threads per inch (32 threads per 25.4 mm) installed in 0.053 inch (1.35 mm) thick minimum sheet metal shall be considered acceptable.

5.7 revised November 19, 1999

5.8 Sheet metal may be extruded at a tapped hole to give the thickness necessary for two full threads if the original thickness is not less than the pitch of the thread.

5.9 A fastener for use with a conventional screw, other than a tapped hole or nut, is acceptable if it has the necessary mechanical strength and is otherwise acceptable for the application.

5.10 Neutral terminals and equipment-grounding terminals provided as part of an enclosure are evaluated in accordance with the Standard for Panelboards, UL 67, and with regard to their intended use.

ENCLOSURES

6 General

6.1 A complete enclosure shall be provided for all live parts that may be housed in it.

6.1 revised October 1, 1996

6.2 An enclosure flange, or the side wall of an enclosure, may be punched to form an ear that may be bent out to facilitate the mounting of the enclosure or to form a bracket for securing a trim, provided that:

a) There is no direct opening into the enclosure when the ear is in any position; and

b) The overlap between the edges of the opening and the edge of the flange or other closing metal is not less than 1/8 inch (3.2 mm).

6.3 An enclosure shall be one or more of the types defined in Table 6.1 and described in Table 6.2.

Exception: An enclosure marked in accordance with 50.4.

6.3 revised November 19, 1999

Table 6.1
Enclosure types

Type	Intended use and description	Requirements or qualification tests, paragraph or section numbers
1	Indoor use primarily to provide a degree of protection against limited amounts of falling dirt.	Corrosion Protection – 5.3 or Rust Resistance – Section 38
2	Indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt.	Corrosion Protection – 5.3 or Rust Resistance– Section38, Drip – Section 31, Gaskets– Section 14, and Gasket Tests – Section 43
3	Outdoor use primarily to provide a degree of protection against rain, sleet, wind blown dust and damage from external ice formation.	Rain – Section 30, Outdoor Dust or Hose – Section 32 or 35, Icing – Section 34, Protective Coating – Section 15, Gaskets– Section 14, and Gasket Tests – Section 43
3R	Outdoor use primarily to provide a degree of protection against rain, sleet, and damage from external ice formation.	Rain – Section 30, Icing – Section 34, Protective Coating – Section 15, Gaskets – Section 14, and Gasket Tests – Section 43

Table 6.1 Continued on Next Page

Table 6.1 Continued

Type	Intended use and description	Requirements or qualification tests, paragraph or section numbers
3S	Outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust and to provide for operation of external mechanisms when ice laden.	Rain – Section 30, Outdoor Dust or Hose – Section 32 or 35, Icing – Section 34, Protective Coating – Section 15, Gaskets – Section 14, and Gasket Tests – Section 43

Table 6.1 Continued on Next Page

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Table 6.1 Continued

Type	Intended use and description	Requirements or qualification tests, paragraph or section numbers
4	Indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water and damage from external ice formation.	Hosedown – Section 35, Protective Coating – Section 15, Icing – Section 34, Gaskets – Section 14, and Gasket Tests – Section 43
4X	Indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.	Hosedown – Section 35, Protective Coating – Section 15, Corrosion Resistance – Section 39, Icing – Section 34, Gaskets – Section 14, and Gasket Tests – Section 43
5	Indoor use primarily to provide a degree of protection against settling airborne dust, falling dirt, and dripping noncorrosive liquids.	Corrosion Protection – 5.3 or Rust Resistance – Section 38, Drip – Section 31, Indoor Settling Airborne Dust or Atomized Water Method B – Section 32 or 33, Gaskets – Section 14, and Gasket Tests – Section 43
6	Indoor or outdoor use primarily to provide a degree of protection against hose-directed water, and the entry of water during occasional temporary submersion at a limited depth and damage from external ice formation.	Hosedown – Section 35, Icing – Section 34, Submersion – Section 36, Protective Coating – Section 15, Gaskets – Section 14, and Gasket Tests – Section 43
6P	Indoor or outdoor use primarily to provide a degree of protection against hose-directed water, the entry of water during prolonged submersion at a limited depth and damage from external ice formation.	Hosedown – Section 35, Icing – Section 34, Protective Coating – Section 15, Air Pressure – Section 40, Gaskets – Section 14, and Gasket Tests – Section 43
12, 12K	Indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids.	Corrosion Protection – 5.3 or Rust Resistance – Section 38, Drip – Section 31, Indoor Circulating Airborne Dust or Atomized Water Method A – Section 32 or 33, Gaskets – Section 14, and Gasket Tests – Section 43
13	Indoor use primarily to provide a degree of protection against dust, spraying of water, oil, and noncorrosive coolant.	Corrosion Protection – 5.3 or Rust Resistance – Section 38, Oil – Section 37, Gaskets – Section 14, and Gasket Tests – Section 43

Table 6.2
Environmental related constructional features for enclosure types

Table 6.2 revised November 19, 1999

Type	Requirements – Paragraph or section number
1	Equipment Openings – 8.2.1 Mounting Openings – 8.4.1 and 8.4.2 Conduit Knockouts and Conduit Openings – 8.5.1 Additional Openings – 8.6.1
2	Equipment Openings – 8.2.1 Drainage Openings – 8.3.1 Mounting Openings – 8.4.1 and 8.4.2 Conduit Knockouts and Conduit Openings – 8.5.1 Additional Openings – 8.6.2 Markings – 49.2, 49.3, 49.4, 49.5 and 49.7
3	Polymeric Enclosures/Parts – 7.1.2 Equipment Openings – 8.2.1 Mounting Openings – 8.4.1, Conduit Knockouts and Conduit Openings – 8.5.1 Covers and Doors – 16.4 Markings – 49.2, 49.6 and 49.7
3R	Polymeric Enclosures/Parts – 7.1.2 Equipment Openings – 8.2.1 Drainage Openings – 8.3.1 Mounting Openings – 8.4.1 and 8.4.2 Conduit Knockouts and Conduit Openings – 8.5.1 Additional Openings – 8.6.2 Covers and Doors – 16.4 Markings – 49.2, 49.3, 49.4, 49.5, 49.6 and 49.7
3S	Polymeric Enclosures/Parts – 7.1.2 Equipment Openings – 8.2.1 Mounting Openings – 8.4.1 and 8.4.3 Conduit Knockouts and Conduit Openings – 8.5.1 Covers and Doors – 16.4 Markings – 49.2, 49.6 and 49.7
4	Polymeric Enclosures/Parts – 7.1.2 Equipment Openings – 8.2.1 Mounting Openings – 8.4.1 and 8.4.3 Conduit Knockouts and Conduit Openings – 8.5.1 Markings – 49.2 and 49.7
4X	Polymeric Enclosures/Parts – 7.1.2 Equipment Openings – 8.2.1 Mounting Openings – 8.4.1 and 8.4.3 Conduit Knockouts and Conduit Openings – 8.5.1 Markings – 49.2 and 49.7
5	Equipment Openings– 8.2.1 Mounting Openings– 8.4.1 and 8.4.2 Conduit Knockouts and Conduit Openings – 8.5.1 Covers and Doors – 16.4 and 16.5 Markings – 49.2 and 49.7

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Table 6.2 Continued

Type	Requirements – Paragraph or section number
6	Polymeric Enclosures/Parts – 7.1.3 Equipment Openings – 8.2.1 Mounting Openings – 8.4.1 and 8.4.3 Conduit Knockouts and Conduit Openings – 8.5.1 Markings – 49.2 and 49.7
6P	Polymeric Enclosures/Parts – 7.1.3 Equipment Openings – 8.2.1 Mounting Openings – 8.4.1 and 8.4.3 Conduit Knockouts and Conduit Openings – 8.5.1 Markings – 49.2 and 49.7
12	Equipment Openings – 8.2.1 Mounting Openings – 8.4.1 and 8.4.4 Conduit Knockouts and Conduit Openings – 8.5.2 Markings – 49.2 and 49.7
12K	Equipment Openings – 8.2.1 Mounting Openings – 8.4.1 and 8.4.4 Conduit Knockouts and Conduit Openings – 8.5.1 Markings – 49.2 and 49.7
13	Equipment Openings – 8.2.1 Mounting Openings – 8.4.1 and 8.4.5 Conduit Knockouts and Conduit Openings – 8.5.4 Markings– 49.2 and 49.7

7 Polymeric Enclosures/Parts

7.1 General

7.1.1 A polymeric electrical enclosure or a polymeric part (such as a plug or other closure) that is relied upon to complete and maintain the integrity of an electrical enclosure shall comply with the Flammability – 5 Inch (127 mm) Flame, Crushing Resistance, Resistance to Impact (both normal and cold), and Mold Stress – Relief Distortion tests in the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C, and also with the additional requirements specified in this standard. Polymeric parts may be tested separately or may be tested as part of the overall electrical enclosure.

Exception No. 1: A polymeric plug or other closure made of a material classed in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and that serves to complete and maintain the integrity of an electrical enclosure is acceptable if the closure is:

a) Not more than 1 square inch (650 mm^2) in area and is:

1) Classed 5VA, 5VB, V-0, V-1, or V-2; or

2) Classed HB and complies with the Flammability – 5 Inch (127 mm) Flame test in the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C.

b) More than 1 square inch (650 mm^2) in area and is:

1) Classed 5VA and complies with the Resistance to Impact (both normal and cold) test in the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C; or

2) Classed 5VB, V-0, V-1, V-2 or HB and complies with the Flammability – 5 Inch (127 mm) Flame and the Resistance to Impact (both normal and cold) test in the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C.

Exception No. 2: Polymeric fastenings, hinges, or both that are relied upon to maintain the integrity of an electrical enclosure need not comply directly to the testing detailed in 7.1.1 because the strength and rigidity of these polymeric parts would be indirectly tested when the overall polymeric electrical enclosure complies with the Crushing Resistance, Resistance to Impact (both normal and cold), and Mold Stress – Relief Distortion tests detailed in 7.1.1.

7.1.1 revised November 19, 1999

7.1.2 In addition to the requirements in 7.1.1, polymeric materials used for Types 3, 3R, 3S, 4 and 4X enclosures or polymeric materials used for fastenings or hinges for these enclosure types shall comply with the Ultraviolet Light Exposure test in the Standard for Polymeric Materials– Use In Electrical Equipment Evaluations, UL 746C.

7.1.3 In addition to the requirements in 7.1.1, polymeric materials used for Types 6 and 6P enclosures or polymeric materials used for fastenings or hinges for these enclosure types shall comply with the Ultraviolet Light Exposure and the Water Exposure and Immersion tests in the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C.

7.2 Bonding

7.2.1 An enclosure made of insulating material, either wholly or in part, shall have an acceptable bonding means to provide continuity of grounding between all conduits entering the enclosure. The bonding means shall comply with the Polymeric Enclosure Bonding Test, Section 42. The bonding means shall be either completely assembled on the product or available as separate parts in the form of an accessory for field installation. When provided as an accessory, the enclosure and the bonding means shall comply with Section 50A, Markings and Instructions for Field Installed Accessories.

7.2.1 revised October 1, 1996

7.2.2 The continuity of a conduit system shall be provided by metal-to-metal contact not relying on a polymeric material.

7.2.3 A separate bonding conductor, whether in a plastic or metal enclosure shall be copper, a copper alloy, or other material acceptable for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means. Unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener, a separate bonding conductor shall:

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

b) Not be secured by a removable fastener used for any purpose other than bonding.

*7.2.4 *Deleted October 1, 1996**

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7.3 Nonmetallic-sheathed cable clamps

7.3.1 A clamp provided in an enclosure and intended for securement of nonmetallic-sheathed cable shall comply with the applicable requirements in the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

7.4 Rigid nonmetallic conduit

7.4.1 A polymeric enclosure intended for use with rigid nonmetallic conduit – glued, threaded, or the like – shall comply with the applicable requirements in the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

7.5 Rigid metallic conduit

7.5.1 A polymeric enclosure intended for connection to a rigid metallic conduit system shall comply with the requirements in Polymeric Enclosure Rigid Metallic Conduit Connection Tests, Section 41.

7.6 Provisions for support or mounting

7.6.1 Provisions for support or other mounting means shall be outside the polymeric enclosure, unless the enclosure is constructed so that the conductors within the enclosure cannot contact the supporting screws.

7.6.2 To comply with 7.6.1, a hole in an enclosure intended for an eyelet, a nail, a rivet, or a screw shall be located in a recess designed so that there will be a spacing of not less than 1/32 inch (0.8 mm) between the plane of the top of the recess and the head of the largest eyelet, nail, rivet, or screw that is provided with the enclosure. If a screw or a nail is not provided with an enclosure, this spacing shall be measured:

a) Using the largest round head screw that can be inserted in a hole that is not chamfered; or

b) Using the largest flathead screw that can be inserted in a hole that is chamfered.

8 Openings in Enclosures

8.1 General

8.1.1 Openings provided in any enclosure type shall be in accordance with this section and shall comply with the applicable tests in Table 6.1 with these openings unfilled.

Exception: Openings in accordance with 8.2.1 and 8.4.1 – 8.5.4, shall be appropriately filled to maintain the environmental integrity of the enclosure.

8.2 Equipment openings

8.2.1 All enclosure types may have openings that will be closed by field installed equipment (such as pushbutton switches, door latches, and the like) if these enclosures are marked in accordance with 49.7.

Exception: A Type 1 enclosure may have unmarked openings that will be closed by field installed equipment if these openings comply with Table 8.1.

Table 8.1
Equipment-mounting openings

Maximum linear dimension of enclosure,		Area of largest surface of enclosure,		Maximum total area of openings,		Maximum area of any one opening,	
inches	(cm)	square inches	(cm^2)	square inch	(cm^2)	square inch	(cm^2)
18	(45.7)	135	(870)	0.30	(1.93)	0.07	(0.452)
Over 18	(45.7)	Over 135	(870)	0.52	(3.36)	0.13	(0.839)

8.3 Drainage openings

8.3.1 Type 2 and 3R enclosures shall have provisions for drainage.

Exception No. 1: Provision for drainage is not required if the Type 2 or 3R enclosure is intended for mounting in concrete. Instructions shall be provided with the enclosure regarding its intended mounting in concrete.

Exception No. 2: A Type 2 or 3R enclosure that is also marked Type 12, 12K or 13 shall either be shipped without a drainhole or with the drain hole plugged. When shipped without a drainhole, instructions shall be provided with the enclosure indicating how to drill the drainhole, when in a Type 2 or 3R environment that a drainhole is to be provided. When shipped with the drainholes plugged, instructions shall be provided with the enclosure indicating that when installed in a Type 2 or 3R environment the drainhole plug is to be removed.

8.4 Mounting openings

8.4.1 All enclosure types shall be provided with mounting means.

Exception No. 1: Floor supported enclosures are not required to be provided with mounting means.

Exception No. 2: Enclosures designed for a specific installation, such as a cast-metal junction or pull box intended to be installed in poured concrete, are not required to be provided with mounting means.

8.4.1 revised October 1, 1996

8.4.2 For Type 1, 2, 3R or 5 enclosures, mounting means may be provided internal to the equipment cavity if the mounting openings comply with Table 8.2.

Exception: If mounting openings other than as noted in Table 8.2 are provided in Type 1, 2, 3R or 5 enclosures, instructions shall be included with the enclosure that indicate how to maintain the environmental integrity of the enclosure when mounted.

Table 8.2
Enclosure-mounting openings

Maximum linear dimension of enclosure,		Area of largest surface of enclosure,		Maximum number of openings	Maximum total area of openings,	
inches	(cm)	square inches	(cm^2)		square inches	(cm^2)
7	(17.8)	32	(206)	4	1.2	(7.7)
18	(45.7)	135	(870)	6	1.2	(7.7)
40	(102.0)	1000	(2540)	6	1.5	(9.7)
Over 40	(102.0)	Over 1000	(2540)	8	2.0	(12.9)

8.4.3 For Type 3, 3S, 4, 4X, 6 or 6P enclosures, mounting means shall be external to the equipment cavity.

Exception: The mounting means may pass through the enclosure wall into the equipment cavity if it attaches to an intermediate bracket or foot. The bracket or foot shall then rely on separate mounting hardware to attach it to the building wall. The mounting means shall not have the same mounting hardware both pass through the equipment cavity and attach directly to the building wall.

8.4.4 For Type 12 or 12K enclosures intended for wall mounting, the mounting means shall be external to the equipment cavity.

Exception: The mounting means may pass through the enclosure wall into the equipment cavity if it attaches to an intermediate bracket or foot. The bracket or foot shall then rely on separate mounting hardware to attach it to the building wall. The mounting means shall not have the same mounting hardware both pass through the equipment cavity and attach directly to the building wall.

8.4.5 For Type 13 enclosures intended for wall or machine mounting, the mounting means shall be external to the equipment cavity.

Exception: The mounting means may pass through the enclosure wall into the equipment cavity if it attaches to an intermediate bracket or foot. The bracket or foot shall then rely on separate mounting hardware to attach it to the building wall. The mounting means shall not have the same mounting hardware both pass through the equipment cavity and attach directly to the building wall.

8.4.6 The mounting means noted in 8.4.3, 8.4.4, and 8.4.5 may be provided as a kit if the kit, and the marking or instructions are included with the enclosure referencing this kit.

8.5 Conduit knockouts and conduit openings

8.5.1 All conduit knockouts and conduit openings for a Type 1, 2, 3, 3R, 3S, 4, 4X, 5, 6, 6P, or 12K enclosure shall comply with Details, Section 27.

8.5.1 revised November 19, 1999

8.5.2 A Type 12 enclosure shall have no conduit knockouts but may have conduit openings if these openings comply with Details, Section 27.

8.5.3 Deleted November 19, 1999

8.5.4 A Type 13 enclosure shall have no conduit knockouts but may have other conduit openings if these openings have provisions for oiltight connections and comply with Details, Section 27.

8.6 Additional openings

8.6.1 A Type 1 enclosure may be provided with no more than four additional openings (for the escape of air or for the drainage of paint during the painting process and the like). The size of these openings are to be no larger than two 1/8 by 1/8 inch (3.2 by 3.2 mm) openings and two 1/4 by 1/4 inch (6.4 by 6.4 mm) openings for enclosures not more than 18 inches (457 mm) long or wide in which the largest surface does not exceed 135 square inches (871 square cm). In a larger enclosure, an opening is not to be larger than 1/4 by 1/4 inch (6.4 by 6.4 mm).

8.6.2 A Type 2 or 3R enclosure may be provided with additional openings if these additional openings, in combination with any drainage openings, comply with 8.6.1.

9 Observation Windows

9.1 A material covering an observation opening and forming a part of the enclosure shall be reliably secured in such a manner that it cannot be readily displaced in service and shall provide mechanical protection of the enclosed parts.

9.2 Glass used for a window not more than 4 inches (102 mm) in any dimension and not less than 0.055 inch (1.40 mm) thick or used for a window having no dimension greater than 12 inches (305 mm) and not less than 0.115 inch (2.92 mm) thick need not be subjected to additional evaluation. Glass used to cover a larger opening shall comply with the Crushing Resistance and Resistance to Impact (normal only) tests in the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C.

9.3 A polymeric material used as an observation window as specified in 9.1 shall comply with Polymeric Enclosures/Parts, Section 7.

10 Thickness of Cast-Metal Enclosures

10.1 A cast-metal enclosure shall:

a) Be at least 1/8 inch (3.2 mm) thick at every point;

Exception: Malleable iron and a die-cast or permanent-mold cast aluminum, brass or bronze may be not less than 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (155 cm^2) or having any dimension greater than 6 inches (152 mm), and may be not less than 1/16 inch (1.6 mm) thick for an area of 24 square inches or less and having no dimension greater than 6 inches. The area limitation for metal 1/16 inch thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

b) Be more than 1/8 inch thick at reinforcing ribs and door edges; and

c) Comply with Table 10.1 in the area where tapped holes for the connection of conduit are provided or intended to be tapped in the field as noted in 50.7.

Exception No. 1: The maximum thickness specified in Table 10.1 may be exceeded if holes for smaller size conduit are counterbored and tapped if the tapped portion complies with the table for the conduit size involved.

Exception No. 2: The minimum thickness specified in Table 10.1 may be less if the cast-metal enclosure is subjected to the tests specified in Metallic Enclosures Threaded Opening Tests, Section 46, but not less than 1/8 inch (3.2 mm).

Table 10.1
Cast-metal enclosure thickness at tapped holes for conduit

Trade size of conduit, inches	Thickness of metal, inch (mm)			
	Minimum		Maximum	
1/2 – 3/4	7/32	(5.6)	1/2	(12.7)
1 – 2	17/64	(6.7)	45/64	(17.9)
2-1/2 – 6	3/8	(9.5)	1-1/8	(28.6)

No Text on This Page

10.2 Zinc-base die-cast metal shall not be used for an enclosure.

11 Thickness of Sheet-Metal Enclosures

11.1 An enclosure, other than for a cover or a door – see Thickness, Section 17 – shall not be thinner than specified in Table 11.1 or 11.2.

Exception: An enclosure without a supporting frame may be thinner than specified in Tables 11.1 and 11.2 if it complies with the Compression Test, Section 28, but shall not be less than 0.053 inch (1.35 mm), excluding any coating.

Table 11.1
Thickness of sheet metal for enclosures, carbon steel or stainless steel

Table 11.1 revised October 1, 1996

Without supporting frame				With supporting frame or equivalent reinforcing					
Maximum width[a]		Maximum length[b]		Maximum width[a]		Maximum length[b]		Minimum thickness[c],	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	inch	(mm)
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)		
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)		
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)		
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)		
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)		
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)		
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)		

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

[b] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

[c] The minimum thickness refers to the base material and does not include a coating thickness.

Table 11.2
Minimum thickness of sheet metal for enclosures aluminum, copper, or brass

Without supporting frame				With supporting frame or equivalent reinforcing				Minimum thickness	
Maximum width[a]		Maximum length[b]		Maximum width[a]		Maximum length[b]			
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(mm)
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] The smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[b] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

11.2 A supporting frame shall be formed of angles, channels, folded rigid sections of sheet metal, or the equivalent, rigidly fastened together and having essentially the same outside dimensions as the surfaces of the enclosure.

11.3 With reference to 11.2 and Tables 11.1 and 11.2, a construction is not considered to have a supporting frame if it is:

a) A single sheet with single formed flanges (formed edges);

b) A single sheet that is corrugated or ribbed; or

c) An enclosure formed or fabricated from sheet metal.

11.4 A separate flange shall not be thinner than the enclosure proper.

11.5 A reinforcing strip shall comply with the requirements for a separate flange used at the back edge of an enclosure.

Exception: The thickness of a reinforcing strip may be 25 percent less than that of the metal used in the enclosure proper.

12 Joints and Fastenings

12.1 All seams, joints, or splices at corners or back edges of an enclosure shall be closed by:

a) Overlapping flanges formed of sheet metal from which the enclosure is made;

b) Metal surfaces overlapping adjacent surfaces or supporting frame;

c) Separate overlapping flanges; or

d) Continuous welding that provide a construction equivalent to an integral-flanged construction.

12.2 With reference to the requirement in 12.1, the overlap shall be at least 1/2 inch (12.7 mm) and shall extend approximately the full length of the seam. See 21.3 for requirements pertaining to the joint between enclosure flanges and a flat cover.

12.2 revised November 19, 1999

12.3 A flange joining adjacent sides, including top and bottom, of an enclosure shall have at least one fastening for each 3 inches (76.2 mm), or fraction thereof, of enclosure depth. One such fastening shall be located not more than 1-1/2 inches (38.1 mm) from the front edge of the enclosure.

Exception: An enclosure having integral flanges and not over 4 inches (102 mm) deep may employ a single fastening at each front corner of the enclosure to secure adjacent sides, including top and bottom.

12.4 A flange at the back edge of an enclosure shall have fastenings located not more than 1-1/2 inches (38.1 mm) from each end and not more than 6 inches (152 mm) apart.

12.5 For an enclosure employing a metal supporting frame, the fastenings securing a metal surface to the frame shall comply with 18.1 – 18.4 and Figures 18.1 and 18.2.

12.6 A separate flange shall not have less than two fastenings on each side of a seam.

12.7 With reference to the requirements in 12.3 and 12.6, rivets, welds, bolts, and screws having machine-screw threads are acceptable forms of fastenings.

13 Notches

13.1 A flange in the enclosure proper may be notched to accommodate knockouts, as illustrated in Figure 13.1, under the following conditions:

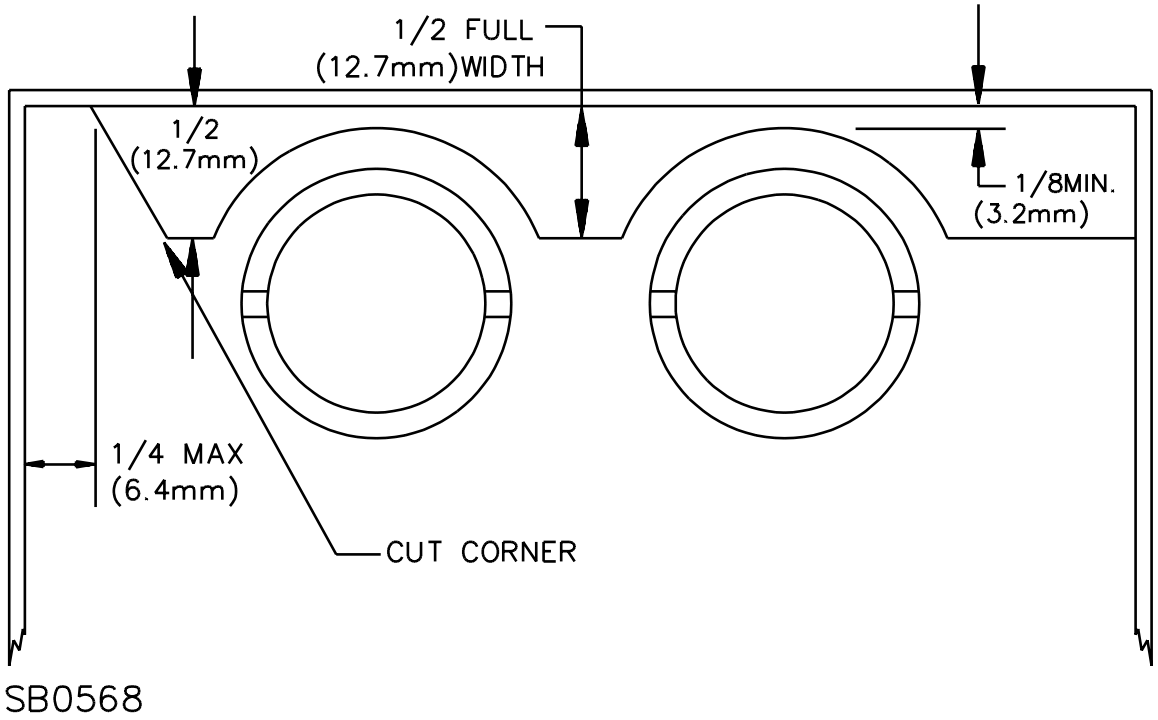
a) No individual notch is to be larger than is necessary to accommodate a conduit bushing corresponding in size to the adjacent knockout;

b) Each notch is to be circular rather than square and approximately concentric with the center of the knockout;

c) Notches may overlap each other only if the width of the flange between them is not reduced to less than 1/2 inch (12.7 mm); and

d) The flange width between any notch and the inside wall of the enclosure is to be not less than 1/8 inch (3.2 mm). The bottom end of a corner flange may be cut away at an angle to facilitate forming, as illustrated in Figure 13.1.

Figure 13.1
Notched flange construction



13.2 The front edge of each of the two side walls of an enclosure is not prohibited from being provided with not more than one notch for each enclosure door, for the purpose of holding the door in the open position, when:

a) The notch is not more than 11/16 inch (17.5 mm) wide; and

b) The flange of the closed door overlaps the deepest edge of the notch by at least 1/8 inch (3.2 mm).

See Figure 13.2.

Exception: The notch size limitation, the minimum cover flange overlap, or both do not apply to a notch located behind a fixed side flange, such as a hood, that overlaps the notch by at least 1/8 inch, and if the space between adjacent surfaces of the fixed side flange and the side of the enclosure is not more than 1/8 inch plus the thickness of the cover flange metal. See Figure 13.3.

13.2 revised October 1, 1996

Figure 13.2
Notch for holding cover open

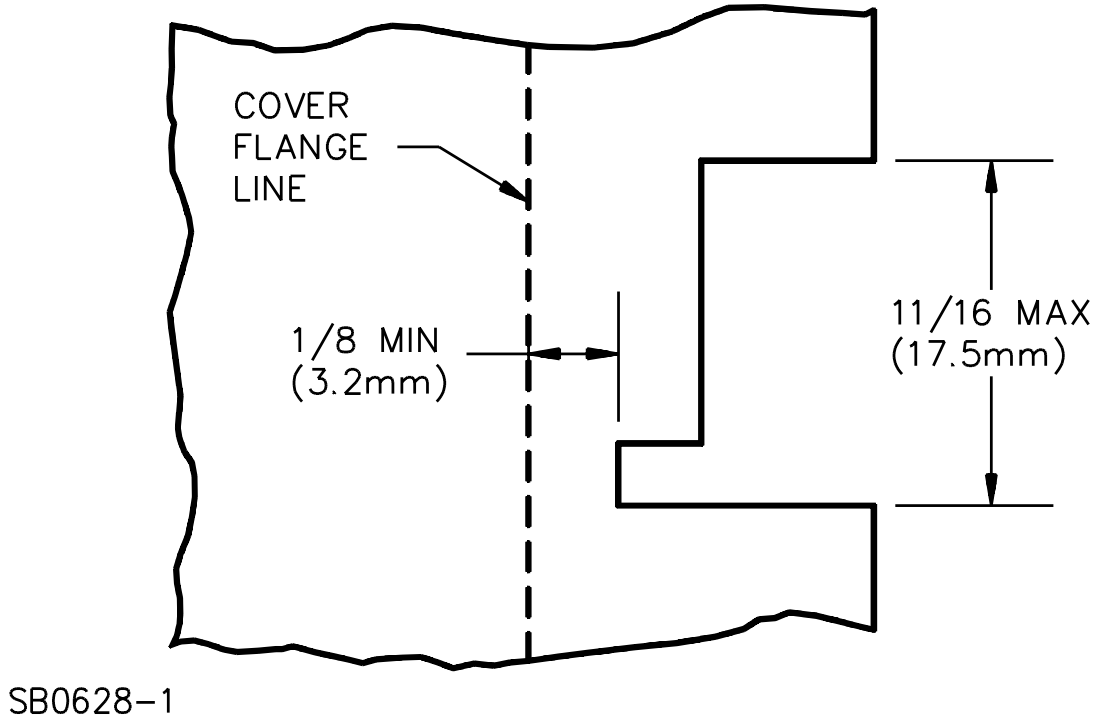
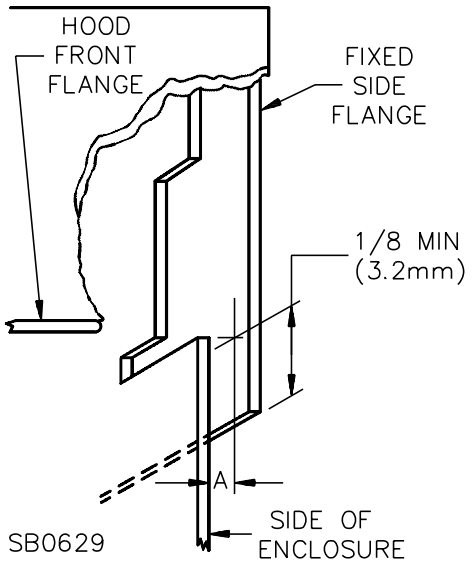


Figure 13.3
Notch behind fixed flange, front view



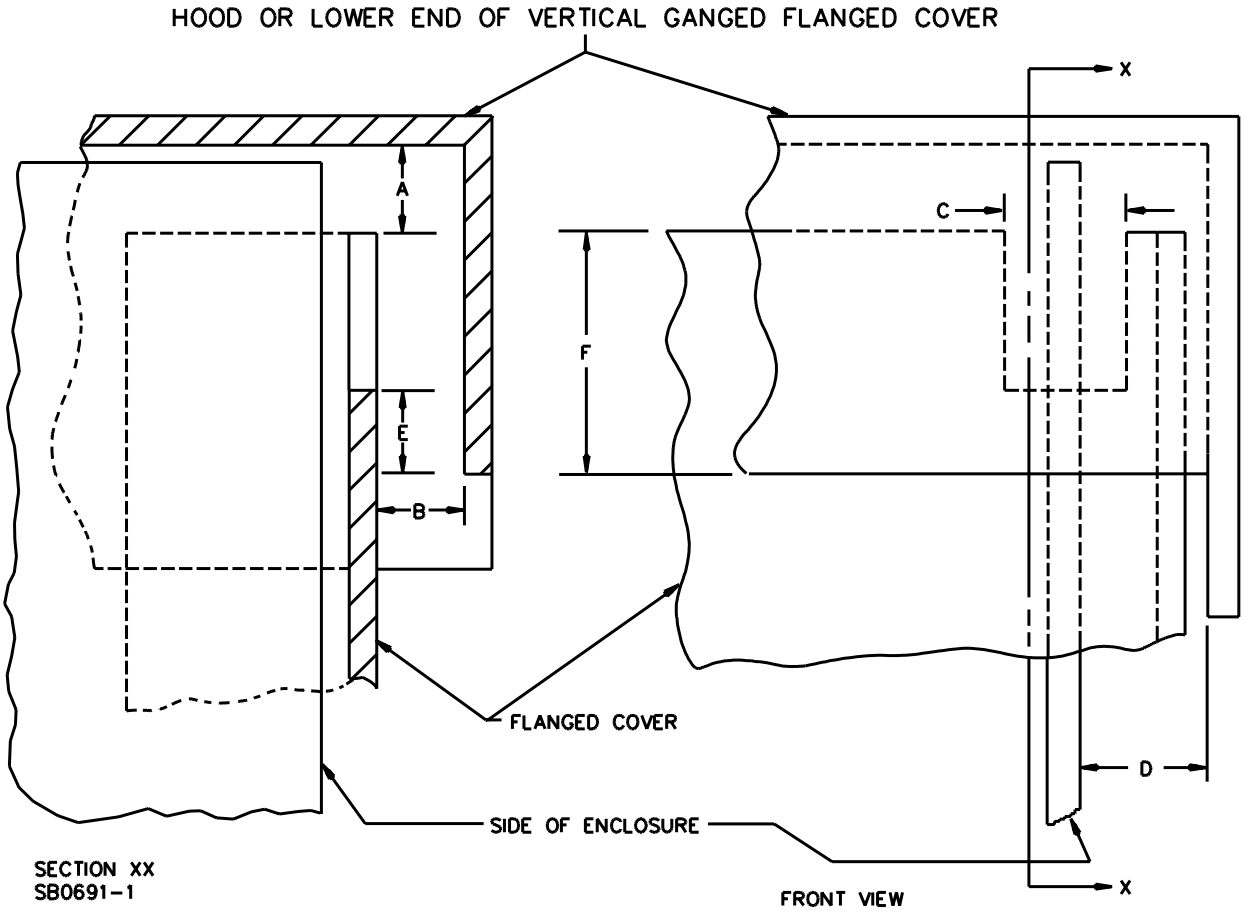
A – Space between adjacent surfaces of fixed side flange and side of enclosure to be not more than 1/8 inch (3.2 mm) plus thickness of cover flange metal.

13.3 The overlap and spacing at a flanged enclosure door and hood or vertically-ganged overlapping covers are to be within the limits shown in Figure 13.4. A hole in a cover is determined to be the same as a notch for purposes of the overlap and spacing requirements.

13.3 revised October 1, 1996

Figure 13.4
Overlap and spacing at hood and overlapping cover

Figure 13.4 revised November 6, 1997



A – Maximum 1/8 inch (3.2 mm) except no limit if B does not exceed 1/16 inch (1.6 mm).

B – Maximum 1/8 inch (3.2 mm).

C – Width of slot not to exceed three times the thickness of the metal of the side wall.

D – Space between adjacent surfaces of fixed side flange and side of enclosure to be not more than 1/8 inch (3.2 mm) plus thickness of cover flange metal.

E – 1/8 inch (3.2 mm) minimum.

F – 1/2 inch (12.7 mm) minimum.

14 Gaskets

14.1 Gasket material used to comply with the requirements for a Type 2, 3, 3R, 3S, 4, 4X, 5, 6 or 6P enclosure shall comply with the Aging tests, specified in 43.1.

14.1 revised October 1, 1996

14.2 Gasket material used to comply with the requirements for a 12, 12K or 13 enclosure shall comply with the Aging and Oil Immersion tests specified in 43.1 and 43.2.

14.2 revised October 1, 1996

14.3 The requirements in this section apply to a gasket that is required for an electrical enclosure to maintain a tight fit or to comply with the enclosure performance requirements.

14.4 A gasket shall be secured with adhesive or by mechanical means. The gasket and its securing means shall not be damaged when the joint is opened.

PROTECTION AGAINST CORROSION

15 Outdoor Enclosures

15.1 Hinges and other attachments used to maintain the integrity of an enclosure intended for outdoor use shall be resistant to corrosion.

15.2 Metals used in combinations shall be galvanically compatible.

15.3 A sheet-steel enclosure designated as Type 3, 3R, 3S, 4, 4X, 6, or 6P shall be protected against corrosion by one of the following coatings:

a) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G90 in Table I of ASTM Designation A525-87, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of the zinc coating may be determined by any acceptable method; however, in case of question the weight of coating shall be established in accordance with the test method of ASTM Designation A90-81. See 15.6 and 15.7;

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.015 mm) on each surface with a minimum thickness of 0.00054 inch (0.014 mm). The thickness of coating shall be established by the metallic- coating-thickness test described in ASTM Designation B555-91. An annealed coating shall comply with 15.4 and 15.5;

c) A zinc coating conforming with 15.3(c)(1) or 15.3(c)(2) with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint applied after forming on each surface. The acceptability of the paint may be determined by consideration of its composition or by corrosion tests if these are considered necessary:

1) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G60 or A60 in Table I of ASTM Designation A525-87, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any acceptable method; however, in case of question the weight of coating shall be established in accordance with the test method of ASTM Designation A90-81;

2) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.010 mm) on each surface with a minimum thickness of 0.00034 inch (0.009 mm). The thickness of the coating shall be established by the metallic-coating-thickness test described in Section 44;

d) A cadmium coating not less than 0.001 inch (0.025 mm) thick on both surfaces. The thickness of coating shall be established by the metallic-coating-thickness test described in Section 44;

e) A cadmium coating not less than 0.00075 inch (0.019 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.00051 inch (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established by the metallic-coating-thickness test described in Section 44 and the paint shall be as specified in 15.3 (c);

f) Other finishes, such as special metallic finishes, or metallic finish combined with paint may be accepted when comparative tests with galvanized sheet steel (without annealing, wiping, or other surface treatment) conform with 15.3 (a) or, when found to provide equivalent protection after exposure to both of the following:

1) A 600 hour salt spray test conducted in accordance with the Standard for Organic Coatings for Steel Enclosures for Outdoor-Use Electrical Equipment, UL 1332; and

2) A 1200 hour moist carbon-dioxide sulphur-dioxide air mixtures test conducted in accordance with UL 1332;

g) Paint may be accepted when the applicable requirements for Organic Coatings for Steel Enclosures for Outdoor Use Electrical Equipment, UL 1332, indicate that it provides equivalent protection.

15.3 revised November 19, 1999

15.4 An annealed coating on sheet steel that is bent or similarly formed or extruded or rolled at edge of holes after annealing shall be additionally painted in the affected area if the process damages the zinc coating. See 15.3 (b).

15.5 If flaking or cracking of the zinc coating, on sheet steel, at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered to be damaged. Simple sheared or cut edges and punched holes are not required to be additionally protected. See 15.3 (b).

15.6 A hot-dipped mill-galvanized G90 coating, on sheet steel, shall not be damaged during handling or fabrication to the extent that the base metal is exposed. See 15.3 (a).

Exception No. 1: Uncoated cross-sectional surfaces at cut edges and drilled or punched openings are acceptable.

Exception No. 2: The base metal may be exposed if:

a) The maximum width and length of the exposed metal does not exceed the thickness and length of any cut edge on the sheet; or

b) The surface has one coat of an organic finish of the epoxy or alkyd-resin type, or other outdoor paint applied after fabrication.

15.6 revised October 1, 1996

15.7 Sheet steel that employs a hot-dipped mill-galvanized G90 coating that is drawn, formed, extruded, or rolled shall be additionally painted with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint in the areas that are affected by a process that damages the coating as determined by the requirement in 15.5. See 15.3 (a).

15.8 Copper, bronze, brass containing at least 80 percent copper, or stainless steel may be used without additional protection against corrosion. Other metal shall be a grade or alloy known to be nonsusceptible to corrosion, or shall be subjected to appropriate tests, additionally protected against corrosion, or both.

15.9 All sheet, extruded, or cast aluminum alloys may be used without additional protection against corrosion.

15.10 An enclosure of cast iron or malleable iron at least 1/8 inch (3.2 mm) thick shall be protected against corrosion by:

a) A 0.00015 inch (0.0038 mm) thick coating of zinc, cadmium, or the equivalent, on the outside surface and a visible coating of such metal on the inside surface; or

b) One coat of an organic finish of the epoxy of alkyd-resin type or other outdoor paint on each surface. The acceptability of the paint may be determined by consideration of its composition or, if necessary, by corrosion tests.

15A Indoor Enclosures

15A.1 Types 1, 2, 5, 12, 12K, and 13 enclosures shall comply with 5.3 or with the Rust Resistance Test specified in Section 38.

15A.1 added October 1, 1996

15B Corrosion Resistant Enclosures

15B.1 In addition to complying with Section 15, Protection Against Corrosion, type 4X enclosures shall also comply with the Corrosion Resistance Test specified in Section 39.

15B.1 added October 1, 1996

COVERS AND DOORS

16 General

16.1 A door that does not provide a part of the required enclosure need not comply with the requirements in Sections 16 – 21.

16.2 A construction employing a gasketed joint may be used if it is investigated and found to be acceptable for the purpose. See Gasket Tests, Section 43.

16.3 A cover-mounting hole shall be either round or keyhole shaped and, with the cover installed, it shall not result in a direct opening into the enclosure.

16.4 A Type 3, 3R, 3S and 5 enclosure shall require the use of a tool to gain access to the equipment cavity or shall have provisions for locking. When the provision for locking is provided as an accessory:

a) The accessory shall be shipped with the enclosure of which it is intended to be installed; and

b) Both the accessory and the enclosure shall comply with Section 50A, Markings and Instructions for Field Installed Accessories.

16.4 revised November 19, 1999

16.5 The closing hardware referred to in 16.4 shall be captive for a Type 5 enclosure.

17 Thickness

17.1 A sheet-metal door, cover, or auxiliary door shall not be thinner than specified in Table 17.1 and shall comply with the requirements in 5.6 and 5.8.

Exception No. 1: A drawn, embossed, flanged, or similarly strengthened door or cover may employ metal having a thickness not less than 0.053 inch (1.35 mm) if steel, excluding any coatings, or 0.075 inch (1.91 mm) if aluminum, copper, or brass, provided the door or cover has the strength and rigidity to maintain its shape when open or unmounted and complies with the requirement in 29.1.

Exception No. 2: A door that covers small openings only, such as openings for latches and locks, shall not be less than 0.032 inch (0.81 mm) thick if steel, excluding any coatings, or 0.050 inch (1.27 mm) thick if aluminum, copper, or brass.

Exception No. 3: A cover for a flush-mounted enclosure having small openings for circuit-breaker handles, for which a door is not normally required, is not prohibited from employing sheet metal complying with the thickness requirements for surface-mounted enclosures, specified in column 5 of Table 17.1.

17.1 revised October 1, 1996

Table 17.1
Thickness of sheet metal for covers and doors

Table 17.1 revised October 1, 1996

Maximum dimensions				Minimum thickness based on maximum dimension, inch[a] (mm)							
				Flush-mounted enclosure[b]				Surface-mounted enclosure			
Linear		Area		Steel[d]		Aluminum, copper, or brass		Steel[d]		Aluminum, copper, or brass	
Inches	(cm)	Square inches	(cm^2)								
7	(17.8)	32	(206)	0.053	(1.35)	0.075	(1.91)	0.053	(1.35)	0.075	(1.91)
18	(45.7)	135	(870)	0.067	(1.70)	0.095	(2.41)	0.053	(1.35)	0.075	(1.91)
24	(61.0)	360	(2300)	0.067	(1.70)	0.095	(2.41)	0.053[c]	(1.35)	0.075[c]	(1.91)
40	(102.0)	1000	(2540)	0.093	(2.36)	0.122	(3.10)	0.067[c]	(1.70)	0.095[c]	(2.41)
60	(152.0)	1500	(9700)	0.093	(2.36)	0.122	(3.10)	0.093	(2.36)	0.122	(3.10)
Over 60	(152.0)	Over 1500	(9700)	0.123	(3.12)	0.153	(3.89)	0.123	(3.12)	0.153	(3.89)

[a] The thickness of a separate dome used in conjunction with a flat sheet is allowed to be based on the dimensions of the dome.

[b] The dimensions given are those of the opening in the enclosure. The extension required by 21.1 is not included in measuring the dimensions of a cover.

[c] If a surface-mounted enclosure has a frame or trim and in addition a door-in-door construction, the thickness of sheet metal used for the frame, trim, and doors shall be as specified for a flush-mounted enclosure.

[d] The minimum thickness refers to the base material and does not include a coating thickness.

17.2 The cover flange mentioned in 19.3(b) shall have a thickness not less than that of the enclosure wall.

17.3 A flat strip used to provide a rabbet, or an angle strip fastened to the edges of a door shall not be thinner than 60 percent of the thickness of the metal of the enclosure proper. It shall be secured at not less than two points, not more than 1-1/2 inches (38.1 mm) from each end of the strip, and at points between these end fastenings not more than 6 inches (152 mm) apart.

17.4 A formed strip may be made of metal thinner than that required for a flat strip if it is formed and attached so that it provides an equivalent rabbet.

18 Fastenings

18.1 Any door or cover provided as part of an enclosure shall be provided with means for holding it securely in place.

18.1 revised October 1, 1996

18.2 A flat cover shall be fastened to the enclosure with four or more fastenings.

Exception: Two screws, one at the center of each of two opposite sides, are capable of being used to fasten a flat cover having an area of not more than 51 square inches (329 cm^2), and having no dimension greater than 8-1/2 inches (216 mm), when the cover does not extend more than 3/4 inch (19.1 mm) beyond the edge of the enclosure in any direction.

18.2 revised October 1, 1996

18.3 A fastening screw or a screw of a clamp that secures a cover in position shall be 5/32 inch (4.0 mm) in diameter (No. 8) or larger for a cover 360 square inches (2300 cm^2) or less in area, and shall be 3/16 inch (4.8 mm) in diameter (No. 10) or larger for a cover more than 360 square inches in area.

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18.4 There shall be one or more fastenings located not more than 6 inches (152 mm) from each of the four corners of an enclosure. The spacing between adjacent fastenings shall not be more than 24 inches (610 mm). Acceptable locations of fastenings are shown in Figures 18.1 and 18.2.

Exception No. 1: Fastenings are not required along the vertical edge of a cover that is adjacent to an opening for installed equipment, when the vertical edge is flanged at least 1/2 inch (12.7 mm) for the full length of the opening and all other edges of the surface are secured by the required fastenings.

Exception No. 2: A flat (unflanged) cover that does not extend more than 3/4 inch (19.1 mm) beyond the edges of the enclosure for which it is intended may have fastenings located at not more than 6 inches from adjacent edges of the box – 8-1/2 inches (216 mm) from the corner – if:

a) The thickness of the cover of a surface-mounted enclosure is not less than that required for a flush-mounted cover for an enclosure of the same size; and

b) The enclosure is not more than 20 inches (508 mm) wide.

18.4 revised October 1, 1996

18.5 A flanged cover that is not hinged directly to the enclosure shall be securely fastened to the enclosure by screws or other means that have been found to be equivalent. The number and location of fastenings shall be as specified in 18.2 – 18.4 for the fastenings of a flat cover.

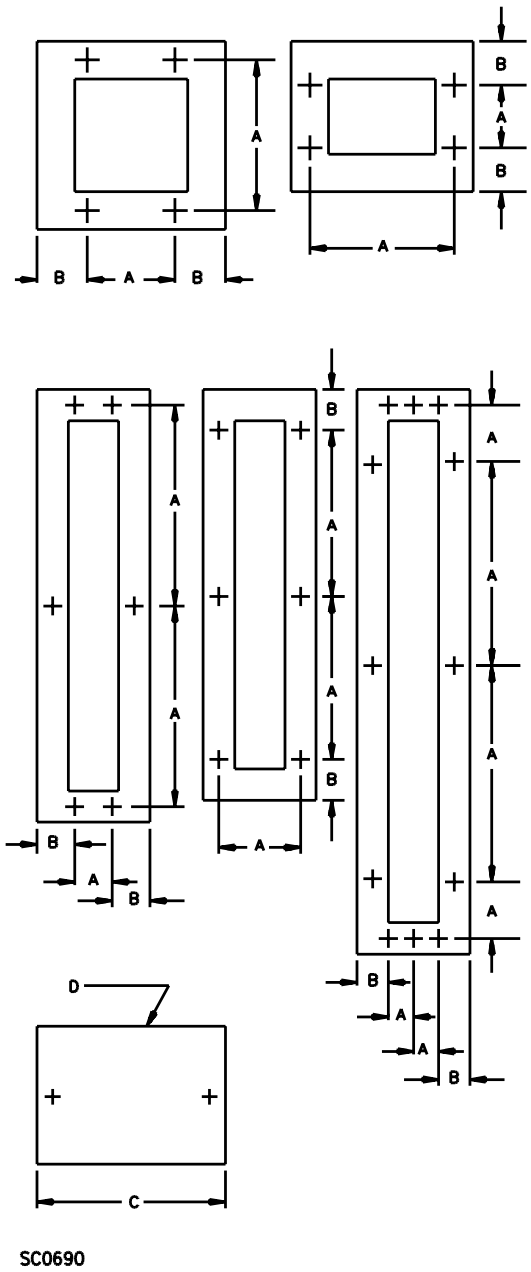
Exception: A flanged cover that is not hinged directly to the enclosure may be fastened to the enclosure by a combination of pins or similar projections, cooperating with holes or indentations and screws, or by screws alone, as described in 18.5 (a) and (b) below. If pins or similar projections are used, they are to be located at the top of the enclosure.

a) For a cover that is not more than 51 square inches (329 cm^2) in area and has no dimension larger than 8-1/2 inches (216 mm), one screw and one pin, or two screws may be used.

b) For a cover that is not more than 360 square inches (2300 cm^2) in area and has no dimension larger than 24 inches (610 mm), one screw and two pins, two screws and one pin, or three screws may be used.

18.6 The cover flange mentioned in 19.3(b) shall be permanently secured to the enclosure by two or more fastenings, such as spot welds or rivets. There shall be one or more of these fastenings for each 3 inches (76.2 mm) or fraction thereof along the length of the enclosure flange, and there shall be one or more of these fastenings within 1-1/2 inches (38.1 mm) of each end of the enclosure flange.

Figure 18.1
Permissible locations of fastenings



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A – 24 inches (610 mm) maximum

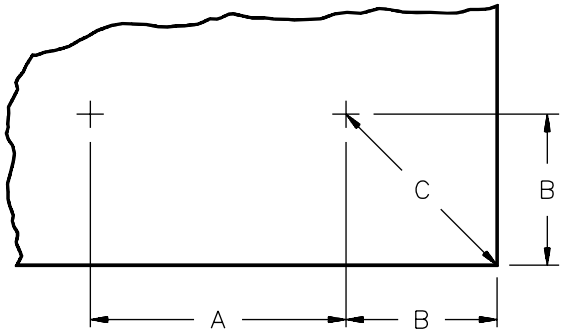
B – 6 inches (152 mm) maximum (from corner of box)

C – 8-1/2 inches (216 mm) maximum

D – 51 square inches (329 cm^2) maximum area (cover)

Figure 18.2
Permissible locations of fastenings

Figure 18.2 revised November 6, 1997



A – 24 inches (610 mm) maximum

B – 6 inches (152 mm) maximum (from edge of box)

C – 8-1/2 inches (216 mm) maximum

D – 51 square inches (329 cm^2) maximum area (cover)

19 Notched Flanges

19.1 The flange of a cover other than as noted in 19.2 – 19.4 shall not be notched.

19.2 The edge of a flanged cover that is intended to be fastened to the enclosure by four or more fastenings is not prohibited from being notched to provide space around a knockout in the enclosure when:

a) The notch is a circular segment, concentric with the knockout when the cover is in place;

b) The width of the cover flange is not less than 1/8 inch (3.2 mm) at any point; and

c) A flange as described in 19.3 and 19.4 is provided on the enclosure.

19.2 revised October 1, 1996

19.3 The flange mentioned in 19.2(b) may be either:

a) Integral with the enclosure wall – that is, formed from the same sheet as, and comprising an extension of the enclosure wall; or

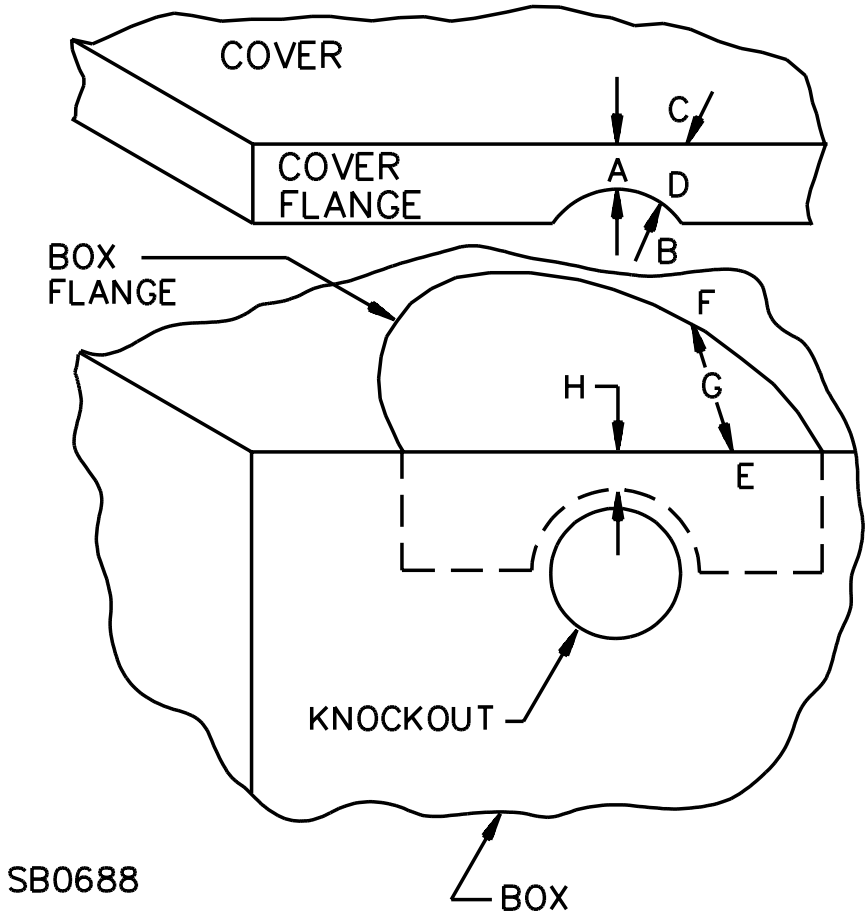
b) A separate flange that complies with the requirement in 18.6 and is attached to the side of the enclosure.

The flange shall have a width and length in accordance with Figure 19.1.

19.4 A notch in an attached flange shall be a circular segment, concentric with the knockout and, on the face of the flange attached to the enclosure, shall have a width of not less than 1/8 inch (3.2 mm).

Figure 19.1
Notched-cover-flange construction

Figure 19.1 revised November 6, 1997



A – Depth of cover flange at notch – minimum 1/8 inch (3.2 mm), measured inside cover.

B – Any point on edge of notch in cover flange.

C – Any point on edge of cover.

D – Distance from B to C.

E – Point on edge of enclosure coincident with C.

F – Any point on edge of enclosure flange.

G – Distance from E to F. The shape and dimensions of the notch and enclosure flange are to be such that D plus G is not less than 1/2 inch (12.7 mm) for all points B, C, E, and F.

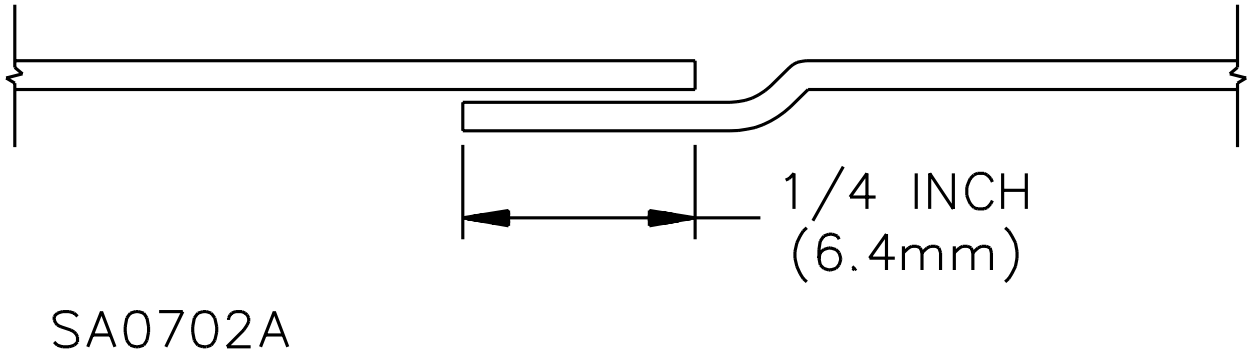
H – Depth of enclosure flange at notch – minimum 1/8 inch (3.2 mm), measured inside flange. Dimension H and the dotted line are applicable only to the attached enclosure flange.

20 Depth of Flange

20.1 A door shall shut closely against a 1/4 inch (6.4 mm) rabbet as illustrated in Figure 20.1 or the equivalent.

Figure 20.1
Rabbet

Figure 20.1 revised November 6, 1997



20.2 An enclosure door shall have flanges for the full length of all edges. The flange on a cover shall:

a) Fit closely with the outside wall of the enclosure proper in accordance with Table 20.1;

b) Have a width in accordance with Table 20.1;

c) Be one of the constructions illustrated in Figure 20.2. Other constructions may be evaluated; and

d) Where a telescoping cover meets the body of a surface-mounted enclosure, overlap all edges in accordance with Table 20.1.

Exception No. 1: A construction is not prohibited from employing notches, holes and indentations as specified in 13.2, and 13.3.

Exception No. 2: A construction employing an enclosure and a cover, both of which are flanged, as specified in 20.4 and 21.5 is capable of being used.

20.2 revised October 1, 1996

Table 20.1
Dimensions for flanged cover constructions

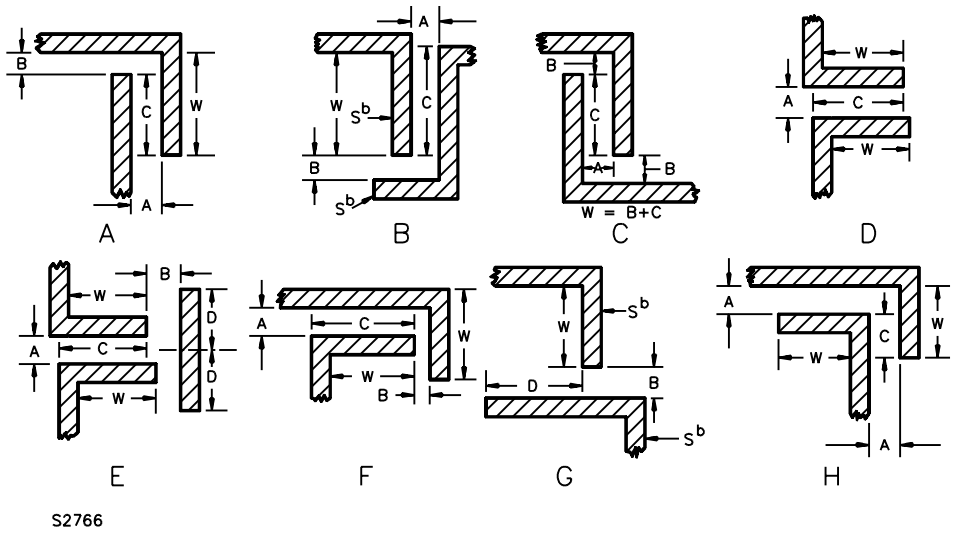
Sketch – see Figure 20.2	Dimensions									
	W Minimum flange width[a]		A Maximum space between parts		B Maximum gap		C Minimum overlap		D Minimum barrier extension	
	Inch	(mm)	Inch	(mm)	Inch	(mm)	Inch	(mm)	Inch	(mm)
A	1/2	12.7	1/8	3.2	1/8	3.2	7/16	11.1	–	–
A	3/4	19.1	3/16	4.8	3/16	4.8	5/8	15.9	–	–
A	1	25.4	1/4	6.4	1/4	6.4	7/8	22.2	–	–
B	1/2	12.7	1/8	3.2	1/8	3.2	7/16	11.1	–	–
B	3/4	19.1	3/16	4.8	3/16	4.8	5/8	15.9	–	–
B	1	25.4	1/4	6.4	1/4	6.4	7/8	22.2	–	–
C	1/2	12.7	3/16	4.8	3/16	4.8	1/4	6.4	–	–
C	3/4	19.1	1/4	6.4	1/4	6.4	7/16	11.1	–	–
D	1/2	12.7	3/32	2.4	–	–	7/16	11.1	–	–
E	1/2	12.7	1/8	3.2	1/8	3.2	7/16	11.1	1/4	6.4
F	1/2	12.7	1/8	3.2	1/4	6.4	7/16	11.1	–	–
G[b]	1/2	12.7	–	–	1/32	0.8	–	–	1/2	12.7
H	1/4	6.4	1/8	3.2	–	–	3/16	4.8	–	–

[a] Tolerance: Minus 1/16 inch (1.6 mm).

[b] Equipment within the enclosure must be located on the side of the barrier extension D that is opposite the gap B.

20.3 To determine whether a flanged cover complies with the requirement in 20.2(b), the distance between the flat portion of the cover – clear of forming radii, beads, draws, or the like – and a straightedge placed across any two flanges at any point is to be measured.

Figure 20.2
Flanged cover constructions[a]



[a] See Table 20.1 for dimensions for Sketches A – H.

[b] The surfaces ″S″ may be in line with one another – not as shown.

20.4 For the construction described in 20.2(d), the flange on the upper edge of a cover may be reduced in depth or may be omitted if the cover cooperates with the top wall of the enclosure and a flange formed from the top wall overlaps the cover at least 1/2 inch (12.7 mm) and either:

a) The cover is not more than 10 inches (254 mm) wide; or

b) A cover more than 10 inches wide complies with the requirement in 29.2.

21 Overlap

21.1 A flat – unflanged – cover attached to an enclosure for flush mounting shall extend at least 1/2 inch (12.7 mm) beyond each of the outer walls of the enclosure proper. The extension may be bent inward for reinforcement not more than 1/16 inch (1.6 mm) from the plane of the face of the cover.

Exception: The extension is not prohibited from being bent more than 1/16 inch (1.6 mm), and not more than 3/16 inch (4.8 mm) from the plane of the face of the cover, when the enclosure is marked in accordance with 50.5.

21.1 revised October 1, 1996

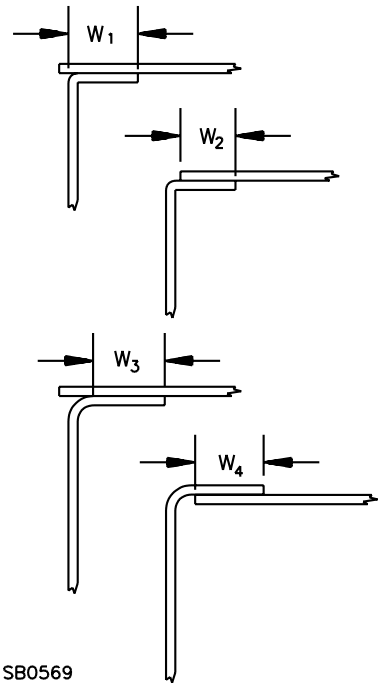
21.2 When a flat – unflanged – cover is attached to an enclosure intended for surface mounting, each wall of the enclosure shall have a flange, at right angles to the wall. The minimum metal-to-metal contact between the cover and the flange on the enclosure shall not be less than 7/16 inch (11.1 mm).

21.2 revised October 1, 1996

21.3 Figure 21.1 illustrates the method of determining the amount of contact between a flat cover and a flanged enclosure wall – 21.2 – and the amount of overlap at a corner or enclosure seam – 12.2. If the radius of the flange bend is small, the flange width and overlap is considered to be W_1 or W_2, depending upon the actual construction, and may be not less than 7/16 inch (11.1 mm). If the radius of the flange bend is excessive or if the flat sheet is on the inside of the flange, the overlap, W_3 or W_4, is to be measured over only that portion where the two pieces of metal are actually in contact with each other, and may be not less than 7/16 inch.

Figure 21.1
Overlap between flat cover and enclosure flange and at corner or enclosure seam

Figure 21.1 revised November 6, 1997



21.4 To determine whether a telescoping cover complies with the requirement in 20.2(c), the cover is to be in its normally closed position, and a mark is to be scribed on all walls of the enclosure along the edge of the flange. The overlap is the measured distance, W, between the scribed marks and the edges of the enclosure walls, as illustrated in Figure 21.2. In scribing the marks, the cover is to be held in a fixed position so as to prevent displacement of the cover by the scribing tool, but without bending or distorting any portion of the enclosure, the cover, or other part of the enclosure.

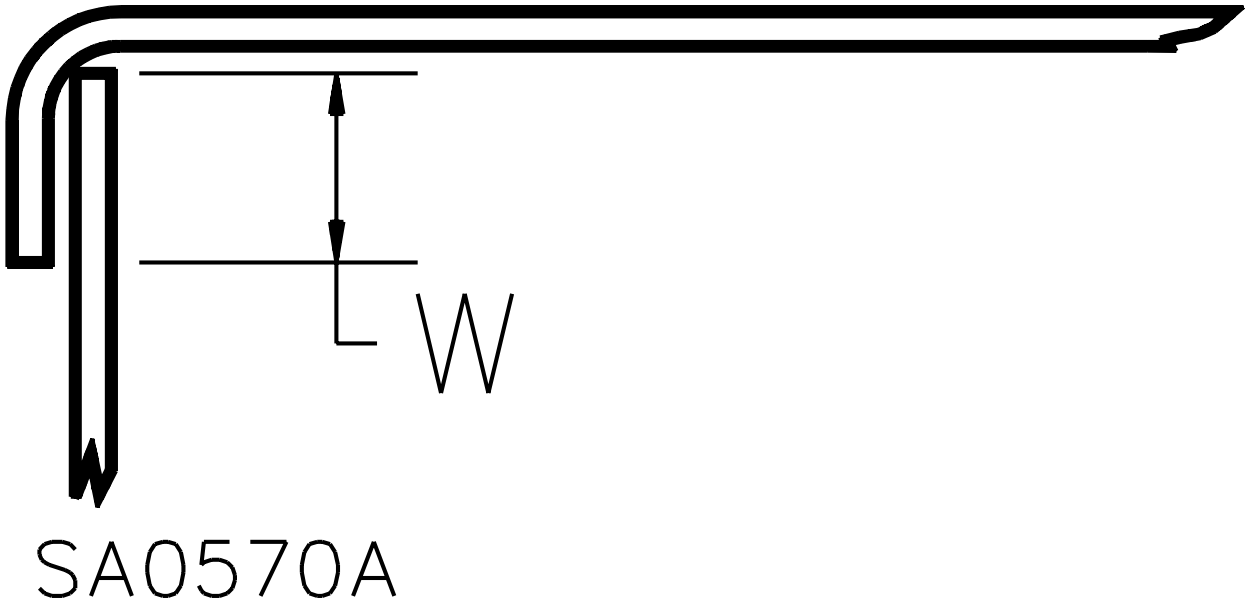
21.5 The overlap of a telescoping cover may be not less than 1/4 inch (6.4 mm) if:

a) The cover is secured in place by screws or by a combination of hinges and screws, and

b) The cover and the box wall are flanged in accordance with Sketch H of Figure 20.2.

Figure 21.2
Measurement of overlap

Figure 21.2 revised November 6, 1997



HINGES

22 Butt Hinges

22.1 A hinge for a door or a cover shall be of metal and sufficiently strong to perform its intended function without distortion. A leaf of a hinge shall be securely fastened, at two or more points, to the enclosure or trim and to the door or the cover.

Exception: This requirement does not apply to a hinge as described in 22.6 – 22.8.

22.2 A metal hinge pin shall not be less than 5/32 inch (4.0 mm) in diameter if made of brass or aluminum and 1/8 inch (3.2 mm) in diameter if made of steel for a door or a cover 360 square inches (2300 cm^2) or less in area, and not less than 3/16 inch (4.8 mm) in diameter for a larger door or cover.

Exception: This requirement does not apply to a hinge complying with 22.5.

22.3 At least two hinges shall be provided for each door or cover.

Exception No. 1: A single hinge may be used on either side of a door or cover not exceeding 5 by 9 inches (127 by 229 mm) provided the length of the hinge is not less than one-third the length of the longer side and is centered on the door or the cover.

Exception No. 2: A single hinge may be used on a door or cover having dimensions greater than 5 by 9 inches (127 by 229 mm) provided the length of the hinge is not less than 80 percent the full length of the door or cover and is centered on the door or the cover.

22.4 Hinges shall be spaced as specified in Table 22.1. The spacing between hinges is to be measured between centers of the hinges; the spacing between a hinge and the end of a door or cover is to be measured from the edge of the hinge.

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Table 22.1
Hinge spacing for metallic enclosures

Maximum spacing				Construction of door or cover			
From each end of door or cover		Between hinge centers		Flange width		Metal and minimum thickness[c]	
Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)
4	(102)	24	(610)	None	None	–	–
4	(102)	32	(813)	None	None	Uncoated steel, 0.093 (2.36); zinc coated steel, 0.097 (2.46); or Al, Cu, or brass, 0.122 (3.09)	
4	(102)	36	(914)	1/2	(12.7)	–	–
6[a]	(152)	36	(914)	1/2	(12.7)	–	–
10[b]	(254)	36	(914)	1/2	(12.7)	–	–
9	(229)	36	(914)	1	(25.4)	–	–
12	(305)	40	(1016)	1	(25.4)	Uncoated steel, 0.093 (2.36); zinc coated steel, 0.097 (2.46); or Al, Cu, or brass, 0.122 (3.09)	

[a] Hinges may be spaced 6 inches (152 mm) from the end of a door or a cover not more than 45 inches (1.14 m) long on the hinged side.

[b] Hinges may be spaced 10 inches (254 mm) from the end of a door or a cover having three hinges.

[c] See Tables 11.1 and 11.2.

22.5 For constructions other than as described in 22.2, a hinged door or cover shall withstand a load of four times its weight, but not less than 20 pounds (9.1 kg) without causing permanent deformation of the hinge. The load is to be applied vertically downward through the center of gravity of the door or cover.

22.6 If two or more hinges are provided with each door or cover, each leaf may be secured to the door or cover and to the enclosure by a single fastener if additional means, such as a boss or flange, is provided to maintain hinge alignment.

22.7 A single weld is acceptable for securing a hinge not larger than 1 inch (25.4 mm) square provided the hinge remains in place after the door or cover has been subjected to abuse such as might be expected in service.

22.8 Hinge securing constructions other than those described in 22.6 and 22.7 may be accepted if found to be equivalent in performance to the construction required by 22.1.

23 Piano Hinges

23.1 A continuous piano hinge shall be sufficiently strong to perform its intended function without distortion.

24 Ear-Type Hinges

24.1 A hinge of the ear type consists of projections on a pair of opposite side or end walls, and corresponding projections on flanges on the cover cooperating with them by means of rivets or bolts that serve as hinge pins.

24.2 Hinges of the ear type shall not be spaced more than 24 inches (610 mm) apart, regardless of the thickness of the metal used.

25 Formed Hinges

25.1 A formed hinge consists of a strip of sheet metal secured to or integral with the enclosure or trim. The strip is formed so that it will cooperate with a slot in the cover or door to form a hinge.

25.2 Formed hinges shall not be used for a door or cover having any edge longer than 24 inches (610 mm) and having an area of more than 360 square inches (2300 cm^2).

25.3 Formed hinges shall be located not more than 4 inches (102 mm) from the ends of the door or cover and not more than 10 inches (254 mm) apart. Hinge spacings are to be measured from the centers of hinges. At least two hinges shall be provided for each door or cover.

Exception: A single hinge may be used on the shorter side of a door or cover if the length of the hinge is not less than one-third that of the longer side of the door or cover.

25.4 For formed hinges used with a cover having turned flanges or on a door in a trim, the width of a hinge that is a part of the enclosure or trim, or that is a separate strip secured at only one end, shall not be less than 1 inch (25.4 mm). The width of a hinge formed from a separate strip secured at both ends shall not be less than 1/2 inch (12.7 mm).

25.5 The thickness of a separate strip shall not be less than 0.053 inch (1.35 mm) thick.

Exception: Metal not less than 0.050 inch (1.27 mm) thick may be used if the smaller dimension of the door or cover is not more than 4-1/2 inches (114 mm) and the length of the hinged side is not more than 7 inches (178 mm).

25.6 The slot in a door or cover shall not be less than 1/8 inch (3.2 mm) from the edge of the metal and only slightly longer than the width of the hinge.

LATCHES AND HANDLES

26 Details

26.1 Each enclosure door shall be provided with a means – such as latches, locks, or screws – for firmly securing it in place. The means shall be positive in action and of substantial design and construction.

Exception: Screw fastenings may be used in lieu of a latch for an enclosure that has an enclosure door provided the contemplated use of the device is such that hinges are not needed on the door.

26.1 revised November 19, 1999

26.2 Double doors that overlap shall have a minimum two-point latch that will hold the doors closed at points near the top and bottom. Double doors that do not overlap shall have a minimum two-point latch on each door.

26.3 A single door more than 48 inches (1219 mm) long on the hinged side shall have a two-point or three-point latch operated by a single knob or handle, two or more spring latches, or one knob-operated latch and one spring latch.

26.4 For an enclosure door that has flanged edges and that does not exceed 18 inches (457.2 mm) in width or length, a latch shall consist of:

a) A button stamped in the side wall of the enclosure engaging an indentation or close-fitting hole in the door flange; or

b) A button stamped on the door flange engaging an indentation or close-fitting hole in the side wall of the enclosure.

An enclosure having a door 18 inches or less in both dimensions is not prohibited from employing a snap catch that provides a fastening equivalent to the button catch on a flanged cover.

26.4 revised November 19, 1999

26.5 A spring latch consisting of a steel strip spot-welded or riveted to the wall of an enclosure and cooperating with a slot in the cover shall engage the edge of the cover slot away from the wall, or shall be adjustable so as to maintain the effectiveness of the latch in holding the cover closed.

26.6 A substantial knob, a door handle, or an equivalent means shall be provided for opening a rabbeted door, unless a pin-tumbler, self-locking latch is used.

CONNECTIONS FOR WIRING SYSTEMS

27 Details

27.1 In a general use enclosure, an opening for connection of a wiring system that may not be used shall be closed by a knockout, cover, or plug. The closure shall be formed of metal not less than 0.053 inch (1.35 mm) thick or of a nonmetallic material acceptable for the purpose. The closure shall be such that it may be readily removed, but will not drop out in ordinary handling.

27.2 Holes for knockouts shall be located so as to provide space for the turning of locknuts or bushings that may be used for securing conduit or armored-cable connectors.

27.3 Concentric and eccentric knockouts shall be constructed so that any size knockout may be removed without disturbing the next larger size provided.

27.4 A threaded hole for the connection of conduit that is tapped all the way through an enclosure shall be provided with not less than two full threads and shall comply with the Metallic Enclosure Threaded Opening Tests, Section 46. The construction shall be such that a conduit bushing can be properly attached as intended. The threads shall be tapered in an enclosure marked Type 2, 3, 3R, or 3S. The Metallic Enclosure Threaded Opening Tests, Section 46, need not be conducted on a threaded hole having at least three threads.

27.5 If the threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than five full threads in the metal and the edges of the inlet hole shall be smooth and round.

27.6 The inlet hole shall:

a) Afford protection to the conductors equivalent to that provided by a standard conduit bushing; and

b) Have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

27.7 With reference to the requirements in 27.5 and 27.6, a threaded hole in an enclosure marked Type 2, 3, 3R, or 3S shall be provided with a conduit end stop.

Exception: The end stop may be omitted if:

a) The enclosure is marked or provided with instructions in accordance with 49.7; or

b) The threads are tapered.

27.8 A conduit hub in an enclosure shall be threaded and shall have a wall thickness before threading not less than that of the corresponding trade size of conduit.

27.9 A conduit hub shall not depend upon friction alone to prevent its turning.

27.10 A conduit hub intended to be secured to a metallic enclosure shall be subjected to the Metallic Enclosure Conduit Hub Test, Section 45.

Exception: A conduit hub evaluated in accordance with the Standard for Fittings for Conduit and Outlet Boxes, UL 514B, need not be subjected to this test.

27.11 A separable conduit hub shall comply with the requirements in 27.4 – 27.9.

27.12 An environmental type connection, such as provided for conduit entrance on a Type 2, 3, 3R, 3S, 4, 4X, 5, 6, or 6P enclosure, shall be a conduit hub, a knockout, a fitting, a threaded hole, or the equivalent in accordance with 8.5.1 and on a Type 12, 12K or 13 enclosure, shall be a conduit hub, a fitting, a threaded hole or the equivalent in accordance with 8.5.2 – 8.5.4. This connection shall be located so that when conduit is connected and the enclosure is mounted in the intended manner, the enclosure is found to be acceptable when subjected to the tests specified in Table 6.1. See 27.13.

Exception No. 1: For Type 2 and 3R enclosures, a hole for conduit need not be threaded if it is wholly below the lowest terminal lug or other live part intended for use within the enclosure. See 49.4 also.

Exception No. 2: Enclosures intended for use with conduit hubs or closure plates, but shipped from the factory without them, shall be marked or provided with instructions in accordance with 49.7.

27.13 The conduit mentioned in 27.12 is to be tightened to the applicable torque value specified in Table 45.1. No sealing compound other than that normally provided by the manufacturer is to be used.

Exception: When conducting the Air Pressure Test, Section 40, and the Submersion Test, Section 36, a pipe thread sealing compound may be used when connecting conduit.

27.14 A hole for open wiring in an enclosure marked Type 2, 3, 3R, or 3S shall be provided with a bushing and shall not be located either in the top or back of the enclosure unless a hood fitting is provided. If located in the side, the hole and hood shall be formed to provide a downward direction for wires leaving the enclosure.

27A Accessories

27A.1 Accessories shall be capable of being used as intended, and when installed in the intended manner, shall comply with the requirements of this Standard.

27A.1 added October 1, 1996

27A.2 Field installed accessories shall be constructed such that the use of a special tool is not required for installation.

Exception: The use of a special tool is not prohibited from being used during installation only when the tool and instructions for its use are provided with each accessory.

27A.2 added October 1, 1996

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PERFORMANCE

28 Compression Test

28.1 When subjected to the Compression Test described in 28.2, an enclosure that is thinner than that specified in Tables 11.1 and 11.2 – see the Exception to 11.1 – shall be constructed so that its deflection is shown to be not more than that of a sheet-metal enclosure of the maximum length and width and having the required thickness.

28.2 The force is to be applied to the end, side, and rear walls of each enclosure. The value of force and limit of deflection are not specified, but the force on each wall of both the test and reference enclosures is to be sufficient to result in a measurable deflection of the test enclosure. For the test, the enclosure is to rest on a smooth, solid, horizontal surface. A vertical force is to be applied, at any point, through a rod having a 1/2-inch (12.7 mm) square, flat steel face.

29 Deflection Test

29.1 A drawn, embossed, flanged, or similarly strengthened door or cover made of metal having the thicknesses specified in Exception No. 1 to 17.1 shall not deflect inward more than 1/4 inch (6.4 mm) when a vertical force of 100 pounds (445 N) is applied at any point on the door or cover. The force is to be applied through a rod having a 1/2-inch (12.7 mm) square, flat steel face. For the test, the enclosure is to rest on its back on a smooth, solid, horizontal surface with the door closed and the cover secured as intended. If more than one test is necessary, separate samples are to be used for additional tests.

29.1 revised October 1, 1996

29.2 If a flange on the upper edge of a telescoping door or cover is reduced in depth or is omitted as indicated in 20.4(b), the door or cover shall not deflect more than 3/8 inch (9.5 mm) when subjected to a force of 100 pounds (445 N) applied at any point 1 inch (25.4 mm) from the edges. The test is to be conducted with the door or cover mounted on the enclosure in the intended manner, and the enclosure placed with its back on a smooth, solid, horizontal surface. The force is to be applied through the end of a rod having a 1/2-inch (12.7 mm) square, flat steel face.

30 Rain Test

30.1 To determine whether an enclosure complies with the requirement for rain as specified in Table 6.1, the enclosure is to be tested as described in 30.3. At the conclusion of the test:

a) A Type 3R enclosure shall have no significant accumulation of water within the enclosure and shall have no water within the enclosure at a level higher than any area intended for live parts; and

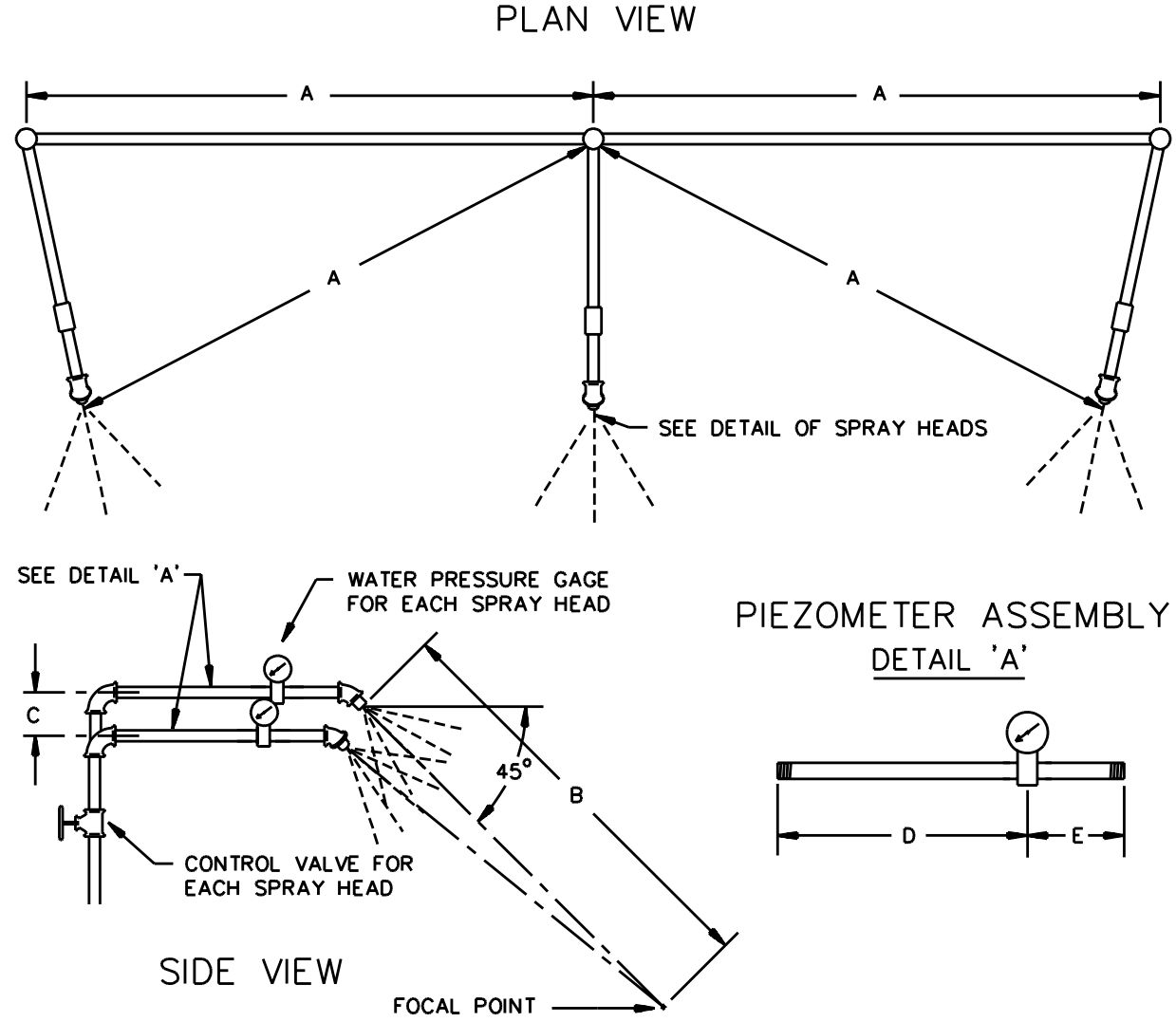
Exception: For enclosures containing live parts, the water may enter the enclosure above these live parts if the construction is such that the water is not visible on live parts, insulating material or mechanism parts. However, no water shall enter any space that is above live parts and in which wiring may be present under any proper installation conditions.

b) A Type 3 or 3S enclosure shall have no water inside the enclosure.

30.2 A Type 3R enclosure that allows water to enter shall comply with 49.5.

30.3 The water-spray-test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 30.1. Spray heads are to be constructed in accordance with the details shown in Figure 30.2. The enclosure is to be set up as in a normal installation with conduit connections – without pipe compound – if so intended. The conduit is to be tightened using the torque values specified in Table 45.1. The enclosure is to be positioned in the focal area of the spray heads so that the greatest quantity of water is likely to enter the enclosure. The water pressure is to be maintained at 5 pounds per square inch (34.5 kPa) at each spray head. The enclosure is to be exposed to the water spray for 1 hour.

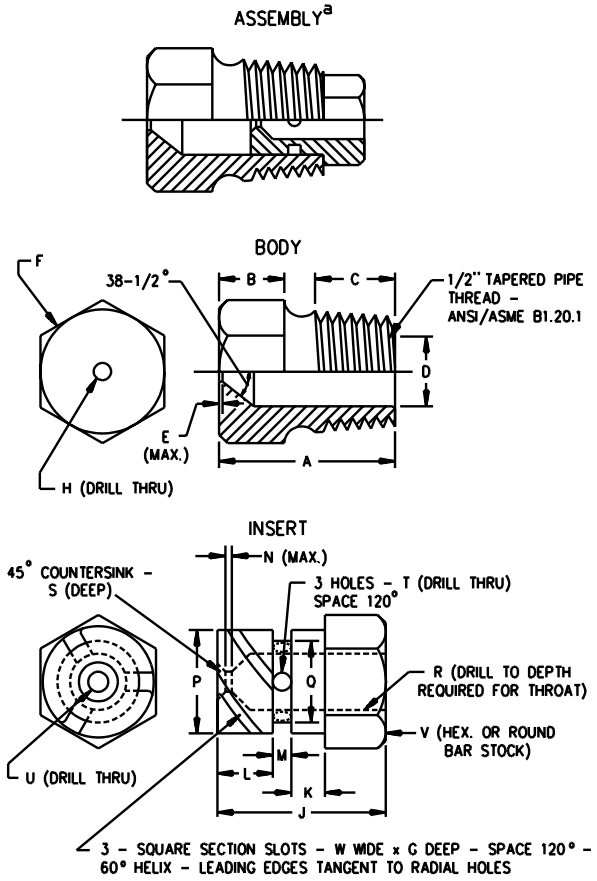
Figure 30.1
Rain-test spray-head piping



Item	mm	inch
A	710	28
B	1400	55
C	55	2–1/4
D	230	9
E	75	3

RT101F

Figure 30.2
Rain-test spray head



Item	mm	inch	Item	mm	inch
A	31.0	1-7/32	N	0.80	1/32
B	11.0	7/16	P	14.61	.575
C	14.0	9/16		14.63	.576
D	14.68	.578	Q	11.51	.453
	14.73	.580		11.53	.454
E	0.40	1/64	R	6.35	1/4
F	c	c	S	0.80	1/32
G	1.52	.06	T	2.80	(No. 35)[b]
H	5.0	(No.9)[b]	U	2.50	(No. 40)[b]
J	18.3	23/32	V	16.0	5/8
K	3.97	5/32	W	1.52	0.06
L	6.35	1/4			
M	2.38	3/32			

[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional - To serve as a wrench grip.

RT100F

30.4 Unless the construction is such that a test on one side is representative of a test on another side, the test in 30.1 and 30.3 is to be repeated on other sides of the enclosure as necessary.

30.5 The water spray is to produce a uniform spray over the entire surface or surfaces under test. The various vertical surfaces of an enclosure may be tested separately or collectively, provided that a uniform spray is simultaneously applied to both of the following:

a) The roof surfaces, from nozzles located at a proper height; and

b) The floor outside the enclosure for a distance of approximately 3 feet in front of the surface under that with the enclosure located at its normal height above the floor level.

31 Drip Test

31.1 At the conclusion of the test specified in 31.3:

a) A Type 2 enclosure shall have no significant accumulation of water within the enclosure, and shall have no water within the enclosure at a level higher than any area intended for live parts; and

Exception: For enclosures containing live parts, the water may enter the enclosure above these live parts if the construction is such that the water is not visible on live parts, insulating materials or mechanism parts. However, no water shall enter any space that is above live parts and in which wiring may be present under any proper installation conditions.

b) A Type 5, 12, or 12K enclosure shall have no water inside the enclosure.

31.2 A Type 2 enclosure that allows water to enter shall comply with 49.5.

31.3 The enclosure is to extends beyond all exposed sides of the enclosure. The bottom of the drip pan is to be equipped with uniformly distributed spouts; one spout for each 20 square inches (129 cm^2) of pan area. Each spout is to drip water at a rate of at least 20 drops per minute. The enclosure is to be subjected to continuously dripping water for 30 minutes.

32 Dust Test

32.1 General

32.1.1 At the conclusion of the test specified in 32.2.1, a Type 3 or 3S enclosure shall have no dust inside.

Exception: An enclosure is considered to comply with this requirement if it complies with the requirements for the hose or hosedown tests, Section 35.

32.1.2 At the conclusion of the test specified in 32.3.1 and 32.3.2, a Type 12 or 12K enclosure shall have no dust inside.

Exception: An enclosure is considered to comply with this requirement if it complies with the requirements for the Atomized Water Test specified in 33.1, 33.2, and 33.3 or the hose or hosedown tests, Section 35.

32.1.3 At the conclusion of the test specified in 32.3.1 and 32.4.1, a Type 5 enclosure shall have no dust inside.

Exception: An enclosure is considered to comply with this requirement if it complies with the requirements for the Atomized Water Test specified in 33.1.1, 33.1.3, and 33.3.1 or the hose or hosedown tests specified in Section 35.

32.2 Outdoor method

32.2.1 The enclosure is to be subjected to a blast of compressed air mixed with dry cement as specified in 32.2.2 by means of a suction-type sandblast gun equipped with a 3/16-inch (4.7-mm) diameter air jet and a 3/8-inch (9.5-mm) diameter nozzle. The air is to be at a pressure of 90 – 100 psig (621 – 689 kPa). The cement is to be supplied by a suction feed. No less than 4 pounds of cement per linear foot (5.95 kilograms of cement per linear meter) of test length – the sum of the height plus the width plus the depth of the test specimen – is to be applied at a rate of 5 pounds (2.27 kg) per minute. The nozzle is to be held 12 – 15 inches (305 – 381 mm) away from the enclosure, and the blast of air and cement is to be directed at all areas of potential dust entry such as seams, joints, and external operating mechanisms. A conduit may be installed to equalize the internal and external pressure.

32.2.2 Type 1 general-purpose portland cement is to be used as it has a controlled maximum particle size. The analysis of a typical sample is as indicated in Table 32.1.

Table 32.1
Particle size of cement

Mesh	Particle size		Percent content
	Inch	mm	
Coarser than 200	Larger than 0.0029	0.0737	3
200	0.0029	0.0737	8
325	0.0017	0.0432	7
400	0.0015 or smaller	0.0381	82

32.3 Indoor circulating airborne method

32.3.1 The sample is to be mounted in its intended position in an airtight chamber, having an internal volume of at least 6 cubic feet (0.169 m^3). The volume of the chamber is to be not less than 150 percent of the volume of the sample – the height times the width times the depth of the product. The chamber is to be maintained at the test room ambient temperature with a relative humidity of 20 to 50 percent.

32.3.2 At least 1.5 ounces of the cement specified in 30.3 per cubic foot of test chamber (1.5 kilograms per cubic meter) is to be circulated for 5 minutes by means of a blower suction unit so as to completely envelop the sample in the chamber. The air velocity at the outlet of the blower is to be at least 1000 feet (305 m) per minute.

32.4 Indoor settling airborne method

32.4.1 At least 0.85 ounces of cement as specified in 32.2.2 per cubic foot of test chamber (0.85 g/l) is to be circulated by means of a blower suction unit so as to completely envelop the enclosure in the chamber. The air velocity at the outlet of the blower is to be at least 1000 feet (305 m) per minute, with the blower cycled for 15 seconds on and 30 seconds off, for seven complete cycles. If the test is conducted with more than 0.85 ounce of cement and the results are not acceptable, the test is to be repeated with 0.85 ounce of cement.

33 Atomized Water Test

33.1 General

33.1.1 The Atomized Water Test methods are alternates to the Indoor Dust Test Methods described in Section 32.

33.1.2 At the conclusion of the test specified in 33.2.1, a Type 12 or 12K enclosure shall have no water inside.

33.1.3 At the conclusion of the test specified in 33.3.1, a Type 5 enclosure shall have no water inside.

33.2 Atomized water test–method A (Type 12 or 12K)

33.2.1 The enclosure is to be subjected to a spray of atomized water by using a nozzle that produces a round pattern 3 – 4 inches (76 – 102 mm) in diameter measured 12 inches (305 mm) from the nozzle. The air pressure is to be 30 psi (207 kPa). The water is to be supplied by a suction feed with a siphon height of 4 – 8 inches (102 – 204 mm). No less than 5 fluid ounces (148 cc) per linear foot (305 mm) of test length – the sum of all areas of potential dust entry – are to be applied at a rate of 3 gallons (11.4 L) per hour. The nozzle is to be held 12 – 15 inches (305 – 381 mm) from the enclosure, and the spray of water is to be directed at all areas of potential dust entry, such as seams, joints, and external operating mechanisms. Conduit shall be permitted to be installed to equalize the internal and external pressure, but shall not serve as a drain. No sealing compound other than that normally provided by the manufacturer is to be used.

33.3 Atomized water test–method B (Type 5)

33.3.1 The enclosure is to be subjected to a spray of atomized water by using a nozzle that produces a round pattern 3 – 4 inches (76 – 102 mm) in diameter when measured 12 inches (305 mm) from the nozzle. The air pressure is to be 25 psi (172 kPa). A quantity of 3 fluid ounces (89 milliliters) of water per linear foot (305 mm) of test length is to be applied in 28 seconds. The nozzle is to be held from 18 – 21 inches (457 – 533 mm) away from the enclosure, and the spray of water is to be directed at all areas of potential settling airborne dust entry, such as seams, joints, external operating mechanisms, and such. Conduit shall be permitted to be installed to equalize the internal and external pressure, but shall not serve as a drain. No sealing compound other than that normally provided by the manufacturer is to be used.

34 Icing Test

34.1 An enclosure marked Type 3S and its external mechanisms are acceptable if at the conclusion of the test specified in 34.3, while ice laden, the mechanisms can be operated manually or as intended by one person without damage to the enclosure, the enclosed equipment, or the mechanisms. If an auxiliary mechanism is provided to break the ice, it shall be used in the test. A separate test is required for each maintained position of each external operator. If necessary, a hand tool may be used to remove ice to gain access to the interior of the enclosure. The use of the hand tool shall not result in functional damage to the enclosure or the mechanisms.

34.2 An enclosure marked Type 3, 3R, 4, 4X, 6, or 6P and its external mechanisms are acceptable if at the conclusion of the test specified in 34.3 it is undamaged after the ice has melted. An enclosure that has no external cavities that trap water is acceptable for a Type 3, 3R, 4, 4X, 6, or 6P designation without being tested.

34.3 The enclosure is to be mounted in a room that can be cooled to 20°F (minus 6.7°C). A metal test bar, 1 inch (25.4 mm) in diameter and 2 feet (610 mm) long, is to be mounted in a horizontal position in a location where it will receive the same water spray as the enclosure being tested. Provision are to be made for spraying the entire enclosure from above with water at an angle of approximately 45 degrees from the vertical. The water is to be 32 – 37°F (0 – 2.8°C). Spraying facilities that provide 1 – 2 gallons (3.8 – 7.6 L) per hour per square foot (928 cm^2) of area to be sprayed are acceptable. The room temperature is to be lowered to 35°F (1.7°C). The spray of water is to be started and continued for at least 1 hour, maintaining the room temperature at 33 – 37°F (0.56 – 2.8°C). The room temperature is then to be lowered to 20 – 27°F (minus 6.7 – minus 2.8°C) while continuing the water spray. The rate of change in the room temperature is not critical and is to be whatever is obtainable with the cooling method employed. The water spray is to be controlled to cause ice to build up on the bar at a rate of approximately 1/4 inch (6.4 mm) per hour and is to be continued until 3/4 inch (19 mm) of ice has formed on the top surface of the bar. The spray is then to be discontinued, but the room temperature is to be maintained at 20 – 27°F (minus 6.7 – minus 2.8°C) for 3 hours so that all parts of the enclosure and the ice coating have reached the same temperature.

35 Hose and Hosedown Tests

35.1 General

35.1.1 At the conclusion of the test described in 35.1.2 – 35.3.1, a Type 3, 3S, 4, 4X, 6, or 6P enclosure shall have no water inside.

35.1.2 A conduit may be installed on the enclosure to equalize internal and external pressures, but it is not to serve as a drain. No sealing compound other than that normally provided by the manufacturer is to be used. The enclosure interior is to be dry.

35.2 Hosedown test (Type 4, 4X, 6 or 6P)

35.2.1 The enclosure and its external mechanisms are then to be sprayed by water from a hose having a 1-inch (25.4-mm) inside diameter nozzle that delivers at least 65 gallons (246 L) of water per minute. The water stream is to be directed at the joints of the enclosure from a distance of 10 – 12 feet (3.0 – 3.7 m) and is to be moved along the joints or surface at a minimum rate of 4 seconds per linear inch (1.6 s/cm). See also 35.2.2.

35.2.2 For an enclosure having a test length - height plus width plus depth dimension - of 75 inches (1.91 m) or less, the duration of the water stream contact with the enclosure is to be 5 minutes. For an enclosure having a test length exceeding 75 inches (1.91 m), the duration of water stream contact in minutes is to be the test length measured in inches divided by 15 (2.62 times the test length measured in meters).

35.3 Hose test (Type 3 or 3S)

35.3.1 The same procedure as specified in the hosedown test specified in 35.2.1 and 35.2.2 is to be used for the hose test, except the rate of the water delivery is to be 45 gallons (170 L) per minute.

36 Submersion Test

36.1 An enclosure marked Type 6 is acceptable if no water has entered the enclosure at the conclusion of the test specified in 36.2.

36.2 The complete enclosure is to be mounted in a tank with conduit connected, using a pipe thread sealing compound. The conduit is to be tightened with the torque specified in Table 45.1. The tank is to be filled with water so that the highest point on the enclosure is 6 feet (1.8 m) below the surface of the water. The enclosure need not be submersed to a depth of 6 feet if an equivalent pressure differential between the interior and the exterior of the enclosure is maintained for the required period of time. This differential may be achieved either by reducing the air pressure inside the enclosure or by pressurizing the water surrounding the enclosure. After 30 minutes, the enclosure is to be removed from the tank, the excess water is to be removed from the exterior surface of the enclosure, and the enclosure is to be opened.

36.3 An enclosure complying with the requirements in 36.1 and 36.2, providing it is tested without pipe thread sealing compound, also complies with the Dust Test, Section 32, and the Hose and Hosedown Tests, Section 35.

37 Oil Test

37.1 An enclosure marked Type 13 is acceptable if no water has entered the enclosure at the completion of the test specified in 37.2.

37.2 The enclosure is to be subjected to a stream of water, with a wetting agent added, through a nozzle having a 3/8-inch (9.5-mm) inside diameter opening that delivers at least 2 gallons (7.6 L) of the mixture per minute. The wetting agent shall be at a concentration of approximately 0.1 percent by weight (or by volume if the wetting agent is liquid). The stream is to be directed at the enclosure from all angles from a distance of 12 – 18 inches (305 – 457 mm) for 30 minutes. If the enclosure houses an externally operated device, the device is to be operated at a rate of approximately 30 operations per minute for the duration of the test. A conduit may be installed to equalize internal and external pressures, but is not to serve as a drain.

37.3 An enclosure complying with the requirements in 37.1 and 37.2 also complies with the Dust Test, Section 32, and the Drip Test, Section 31.

38 Rust Resistance Test

38.1 An enclosure marked Type 1, 2, 5, 12, 12K, or 13 is acceptable if there is no visible rust at the conclusion of the test specified in 38.2.

Exception: Rust is acceptable in locations where protection is impractical, such as a sliding surface of a hinge, a shaft, or the like.

38.2 The enclosure or representative parts of the enclosure are to be subjected to a salt spray (fog) using the test method in Salt Spray (Fog) Testing, ASTM B117-1985, and employing a 5 percent, by weight salt solution for 24 hours. At the end of the test, the specimens are to be removed from the chamber, are to be washed in clean running water not warmer than 100°F (37.8°C) to remove salt deposits from the surface, and are to be dried immediately. Corrosion products may be removed by light brushing if required to observe corrosion of the underlying surface.

39 Corrosion Resistance Test

39.1 An enclosure marked Type 4X is acceptable if, upon completion of the test specified in 39.2, it does not show pitting, cracking, or other deterioration more severe than that resulting from a similar test on passivated American Iron and Steel Institute Type 304 stainless steel.

Exception: An enclosure constructed of American Iron and Steel Institute Type 304 or Type 316 stainless steel is not required to be subjected to the test specified in 39.2.

39.1 revised October 1, 1996

39.2 The enclosure is to be subjected to the test described in 38.2, except that the exposure time is to be 200 hours.

40 Air Pressure Test

40.1 An enclosure marked Type 6P is acceptable if the pressure drop does not exceed 2 psig (13.8 kPa) at the conclusion of the test specified in 40.2.

40.2 The enclosure is to be fitted with piping, pressure gauge and check valve. The conduit is to be connected with pipe thread sealing compound and is to be tightened to the torque values specified in Table 45.1. The internal pressure of the enclosure is then to be raised to 6 psig (41.3 kPa) and the check valve is to be closed. The pressure is to be read 24 hours later.

40.3 If the enclosure does not have connections for pressurizing the interior, an enclosure marked Type 6P is acceptable if it complies with the Submersion Test described in Section 36, except that the duration of the submersion is to be increased from 30 minutes to 24 hours.

41 Polymeric Enclosure Rigid Metallic Conduit Connection Tests

41.1 General

41.1.1 A polymeric enclosure intended for connection to a rigid metallic conduit system shall not pull apart or sustain damage such as cracking and breaking as a result of the pull-out, torque, and bending procedures described in 41.2.1 – 41.4.1. If knockouts are incorporated in the enclosure, they shall remain in place as a result of the procedure described in 41.5.1.

Exception: The Torque Test need not be conducted on an enclosure that is not provided with a preassembled hub and that complies with 50.6.

41.1.1 revised November 19, 1999

41.2 Pullout test

41.2.1 The enclosure is to be suspended by a length of rigid conduit installed in one wall of the enclosure or mounted as intended in service and a pulling force of 200 pounds (890 N) is to be applied for 5 minutes to a length of conduit in the opposite wall.

41.3 Torque test

41.3.1 The enclosure is to be securely mounted as intended in service. A torque in accordance with Table 45.1 is to be applied to a length of installed conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit.

Exception: An end-of-line enclosure – an enclosure that is intended to be connected at the end of a run of conduit and has only one 3/4-inch maximum trade size opening for the connection of conduit – need only be subjected to a tightening torque of 200 pound-inches (22.6 N·m).

41.4 Bending test

41.4.1 A 10 foot (3.05 m) length of conduit of the intended size is to be installed;

a) In a hub or an opening if provided as part of the enclosure; or

b) If a hub or opening is not provided in the center of the largest unreinforced surface intended for the connection of conduit.

The enclosure is to be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. The test is to be terminated once the deflection of the conduit end exceeds 10 ainches (255 mm). If a weight is necessary to cause the conduit end to deflect, the test is to be terminated once the deflection of the conduit end exceeds 10 inches or once a bending moment as specified in Table 41.1 is achieved. The magnitude of the weight is to be determined from the equation:

$$W = \frac{M - 0.5CL}{L}$$

in which:

W is the weight, in pounds, to be hung at the end of the conduit;

L is the length of the conduit, in inches, from the wall of the enclosure to the point at which the weight is suspended;

C is the weight of the conduit, in pounds; and

M is the bending moment required, in pound-inches.

For the SI system of units, the equation is:

$$W = \frac{0.1M - 0.5CL}{L}$$

in which:

W and C are measured in kilograms,

M is in newton-meters, and

L is in meters.

Table 41.1
Bending moment

Normal mounting plane of enclosure surface[a]	Conduit size, inches	Bending moment for metallic conduit pound-inches[b] (N·m)	
Horizontal	All	300	(33.9)
Vertical	1/2 – 3/4	300	(33.9)
	1 – up	600	(67.8)

[a] If the enclosure surface may be installed in either a horizontal or a vertical plane, the vertical bending moment value is to be used.
[b] For an end-of-line enclosure as defined in the exception to 41.3.1, the bending moment is to be 150 pound-inches (17.0 N·m).

41.5 Knockouts test

41.5.1 A knockout is to be subjected to a force of 20 pounds (89 N) applied at right angles by means of a mandrel with a 1/4-inch (6.4 mm) diameter flat end. The mandrel is to be applied at the point most likely to cause movement of the knockout.

42 Polymeric Enclosure Bonding Test

42.1 The resistance between two parts connected by a bonding conductor shall not be more than 0.005 ohm. The resistance is to be determined by a resistance measuring instrument, except that if unacceptable results are recorded, an alternating or direct current of at least 20 amperes from a power supply of not more than 12 volts is to be passed from the point of connection of the equipment grounding means to the metal part in the grounding circuit. The resulting drop in potential and the test current are to be measured between the two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes.

43 Gasket Tests

43.1 Gasket material, used in a Type 2, 3, 3R, 3S, 4, 4X, 5, 6, 6P, 12, 12K, or 13 enclosure, shall be of such quality that samples subjected to a temperature of 69 – 70°C (156 – 158°F) in circulating air for 168 hours have a tensile strength of not less than 75 percent and an elongation of not less than 60 percent of values determined for unaged samples. At the conclusion of the tests, there shall be no visible deterioration, deformation, melting, or cracking of the material and the material shall not harden as determined by normal hand flexing.

43.2 Gasket material used in a Type 12, 12K, or 13 enclosure shall not swell more than 25 percent or shrink more than 1 percent as a result of immersion in IRM immersion oil, No. 903 for 70 hours at room temperature.

43.2 revised August 19, 1997

44 Metallic Coating Thickness Test

44.1 The method of determining the thickness of the zinc or cadmium coating mentioned in 15.3 is described in 44.2 – 44.9. This applies only if the required thickness is specified.

44.2 The solution to be used for the test is to be made from distilled water and is to contain 200 grams per liter of reagent grade chromic acid ($HCrO_3$) and 50 grams per liter of reagent grade concentrated sulfuric acid (H_2SO_4). The latter is equivalent to 27 milliliters per liter of reagent grade concentrated sulfuric acid, specific gravity 1.84, containing 96 percent of H_2SO_4.

44.3 The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube having an inside bore of 0.025 inch (0.64 mm) and a length of 5.5 inches (139.7 mm). The lower end of the capillary tube is to be tapered to form a tip, the drops from which are about 0.025 milliliters each. To preserve an effectively constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100 ±5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

44.4 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room, which is to be noted and recorded. The test is to be conducted at a room temperature of 70 – 90°F (21 – 32°C).

44.5 Each sample is to be cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed using solvents. Samples are then to be thoroughly rinsed in water and dried with clean cheesecloth. Care is to be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

44.6 The sample to be tested is to be supported 0.7 – 1 inch (17.8 – 25.4 mm) below the orifice, so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested is to be inclined about 45 degrees from horizontal.

44.7 The stopcock is to be opened and the time in seconds until the dropping solution dissolves the protective metal coating, exposing the base metal is to be measured. The end point is the first appearance of the base metal recognizable by a change in color at that point.

44.8 Each sample of a test lot is to be subjected to the test at three or more points, excluding cut, stenciled, and threaded surfaces, on the inside surface and at an equal number of points on the outside surface, at places where the metal coating may be expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation are likely to have thin coatings.

44.9 To calculate the thickness of the coating being tested, select from Table 44.1 the thickness factor appropriate for the temperature at which the test was conducted and multiply by the time in seconds required to expose base metal as described in 44.7.

Table 44.1
Coating thickness factors

Temperature, degrees F (C)	Thickness factors, 0.00001 inches (0.0003 mm) per second	
	Cadmium platings	Zinc platings
70 (21.1)	1.331	0.980
71 (21.7)	1.340	0.990
72 (22.2)	1.352	1.000
73 (22.8)	1.362	1.010
74 (23.3)	1.372	1.015
75 (23.9)	1.383	1.025
76 (24.4)	1.395	1.033
77 (25.0)	1.405	1.042
78 (25.6)	1.416	1.050
79 (26.1)	1.427	1.060
80 (26.7)	1.438	1.070
81 (27.2)	1.450	1.080
82 (27.8)	1.460	1.085
83 (28.3)	1.470	1.095
84 (28.9)	1.480	1.100
85 (29.4)	1.490	1.110
86 (30.0)	1.501	1.120
87 (30.6)	1.513	1.130
88 (31.1)	1.524	1.141
89 (31.7)	1.534	1.150
90 (32.2)	1.546	1.160

45 Metallic Enclosure Conduit Hub Test

45.1 A conduit hub intended to be secured to a metallic enclosure – see 27.10 – shall withstand the tightening torque specified in Table 45.1 applied to a short length of rigid conduit threaded into the hub in the intended manner. There shall be no turning of the hub in the enclosure and no stripping of any threads. The enclosure shall be securely (rigidly) mounted or supported during the test.

45.1 revised November 19, 1999

Table 45.1
Tightening torque

Trade size of conduit hub, inches	Tightening torque, pound-inches	(N·m)
3/4 and smaller	800	(90.4)
1, 1-1/4, and 1-1/2	1000	(113)
2 and larger	1600	(181)

46 Metallic Enclosure Threaded Opening Tests

46.1 General

46.1.1 A threaded hole as noted in 27.4, with less than three threads for the connection of conduit, shall be subjected to the Torque Test described in 46.2 and the Bending Moment Test described in 46.3. Threads shall not strip and the walls of the enclosure shall not fracture.

46.2 Torque test

46.2.1 With conduit installed and the enclosure rigidly mounted, the tightening torque is to be applied for 5 minutes as specified in Table 46.1.

Table 46.1
Tightening torque

Trade size of conduit, inches	Tightening torque, pound-inches	(N·m)
3/4 and smaller	1000	(113)
1, 1-1/4, and 1-1/2	1250	(141)
2 and larger	2000	(226)

46.3 Bending test

46.3.1 With conduit installed and the enclosure rigidly mounted, a bending moment of 600 pound-inches (68 N·m) is to be applied for 5 minutes to the conduit at a right angle to its axis. The lever arm is to be measured from the wall of the enclosure to the point of application of the force.

47 Permanence of Marking

47.1 A required marking shall be molded, die-stamped, ink-stamped, paint-stenciled; stamped or etched metal that is permanently secured; or indelibly applied lettering on a label secured by adhesive that, upon investigation, is found to be acceptable for the application. Ordinary usage, including likely exposure to weather and other ambient conditions, handling, storage, and the like, of the equipment shall be considered in the determination of the acceptability of the application. The need for exposure tests on forms of marking other than labels shall be individually evaluated.

47.2 After being subjected to the tests specified in Table 47.1, the sample is to rest, dry or cool as applicable, for the period of time specified for the test involved. Subsequently, the labels shall show no separation from the test surface other than at the corners or edges. The total area of separation at the corners or edges shall not exceed 10 percent of the label area. The marking shall be legible.

Table 47.1
Label performance criteria

Table 47.1 revised November 19, 1999

Enclosure type number	Inside the enclosure	Outside the enclosure
1	B	B
2, 5	B	A
3, 3R, 3S, 4	A	C
4X, 6, 6P	A	A, D
12, 12K, 13	B	A

The requirement and qualification tests from the Standard for Marking and Labeling Systems, UL 969, are as follows:[a]

A Exposure conditions for labels for use indoors where exposed to high humidity or occasional exposure to water.

B Exposure conditions for labels intended only for indoor dry locations.

C Exposure conditions for labels intended for both indoor or outdoor use where exposed to high humidity or occasional exposure to water.

D Additional exposure conditions for labels depending on application.

[a] Applies to nonmetallic labels and labels secured by adhesive.

47.3 For the purpose of the aging test conducted as part of the exposure conditions required in the Standard for Marking and Labeling Systems, UL 969, rated surface temperatures are considered to be those specified in Table 47.2.

Exception: A rated surface temperature other than those specified in Table 47.2 may be used for the purposes of the aging test if it can be demonstrated that the temperature will not be exceeded in service.

Table 47.2
Rated surface temperatures

	Indoor use	Outdoor use
High Temperature	60°C (140°F)	80°C (176°F)
Low Temperature	0°C (32°F)	minus 35°C (minus 31°F)

MARKING

48 General

48.1 Each enclosure shall be marked with the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified. If the front is shipped separately from the body of the enclosure, then both the front and the body shall bear this marking.

48.2 Marking and instructions on the exterior of an enclosure shall have a degree of permanence and legibility acceptable for the environment and application for which the enclosure is intended.

48.3 If an enclosure that employs a notched flanged cover is not shipped complete – that is, with the cover not included with the body of the enclosure – the cover and the body of the enclosure shall be marked so that it can be readily determined which cover is specifically intended for use with the overall enclosure.

48.4 If a manufacturer produces or assembles enclosures at more than one factory, each enclosure shall have a distinctive marking by which it may be identified as the product of a particular factory. If the front is shipped separately from the body of the enclosure, then both the front and the body shall bear this marking.

48.5 The marking may consist of a stamping in the metal, stenciling with paint, a decalcomania transfer, or a metal plate securely fastened in place. It may be placed at any point on the enclosure or door where it can be readily seen after installation.

49 Environmental Related Markings

49.1 An enclosure shall be marked with a type number, for example, ″Type _____ Enclosure,″ indicating the external conditions for which it is acceptable. See Table 6.1. An enclosure that complies with the requirements for more than one type of enclosure may have multiple designations. The marking may be on the inside or outside surface but shall be visible after installation.

49.2 Enclosures marked with a type may also be marked as follows:

a) A Type 3, 3S, 4, 4X, 6, or 6P enclosure may be marked ″raintight.″

b) A Type 3R enclosure may be marked ″rainproof.″

c) A Type 4, 4X, 6, or 6P enclosure may be marked ″watertight.″

d) A Type 4X or 6P enclosure may be marked ″corrosion resistant.″

e) A Type 2, 5, 12, 12K, or 13 enclosure may be marked ″driptight.″

f) A Type 3, 3S, 5, 12, 12K, or 13 enclosure may be marked ″dust-tight.″

49.3 If the acceptability of a Type 2 or 3R enclosure is dependent upon a particular mounting orientation, the enclosure shall be marked to indicate the required orientation.

49.4 A Type 2 or 3R enclosure that has knockouts for conduit in the sides or back of the enclosure and in which the equipment to be installed is not known shall be marked to indicate the area in which live parts are to be installed. See Exception No. 1 to 27.11.

49.5 A Type 2 or 3R enclosure that allows water to enter shall be marked or provided with instructions indicating the areas in which live parts shall or shall not be located.

Exception: For enclosures containing live parts or intended to enclose specific parts or equipment, markings or instructions do not have to be provided if it can be determined that the water does not enter the enclosure above an area intended for live parts.

49.6 A cast-metal enclosure marked Type 3, 3R, or 3S shall be marked to indicate that, after determining the mounting position of the enclosure, any holes drilled in the field shall be located in the lowest part of the bottom wall. See 27.12.

Exception No. 1: The marking may be omitted if the enclosure is marked in accordance with 50.7.

Exception No. 2: The location of a hole in a cast-metal enclosure designated Type 3R may comply with 49.4 and Exception No. 1 to 27.12.

49.7 Any environmental type enclosure intended for use with conduit hubs, closure plates and/or other field installed equipment (such as push-button switches, door latches, and the like), but shipped from the factory without them (as noted in 8.2.1 and Exception No. 2 to 27.12), shall be marked or provided with instructions that identifies the type of equipment that shall be used to maintain the environmental integrity of the enclosure. This may be accomplished by identifying the necessary environmental type designation or by identifying the specific manufacturer and model number of the field installed equipment.

50 Non-environmental Enclosure Ratings

50.1 The marking on an enclosure shipped with any factory-installed parts such as neutral terminals, equipment-grounding terminals – see 5.10 – partitions, barriers, or similar parts shall identify such parts if the manufacturer intends that they be judged under these requirements.

Exception: An enclosure need not be marked to identify such factory-installed parts as neutral terminals or equipment-grounding terminals if the enclosure is marked for use with other equipment.

50.1 revised November 19, 1999

50.2 Unless an enclosure containing items other than metal mounting brackets or studs is marked in accordance with 50.1 and 50.2, it shall be marked:

a) ″Investigation of the Enclosure (or Cabinet Box, Cutout, Junction or Pull Box) Does Not Include Investigation of Any Equipment or Material Contained Therein ″; or

b) ″Investigation of the Enclosure (or Cabinet Box, Cutout Box, Junction or Pull Box) Covers The Enclosure Only.″

50.3 An enclosure not containing any of the items mentioned in 50.1 and 50.2 need not be marked with any supplementary information.

50.4 If a manufacturer intends that a cast-aluminum enclosure be acceptable for use in concrete or cinder fill and the enclosure has been investigated and found to be acceptable for such use, the enclosure or the packaging carton shall be marked ″Suitable For Use In Concrete Or Cinder Fill ″ or the equivalent.

50.5 An enclosure employing a construction as specified in the exception to 21.1 shall be marked to indicate that if intended to be flush mounted in a wall of combustible material, the enclosure shall protrude 1/8 inch (3.2 mm) from the finished surface of the wall.

50.6 A polymeric enclosure that is intended for connection to a rigid metallic conduit system, has not been subjected to the torque test described in 41.1.1, and is not provided with a preassembled hub shall have instructions stating that the hub is to be connected to the conduit before the hub is connected to the enclosure.

50.7 If a manufacturer intends that a cast-metal enclosure be acceptable for field drilling and tapping of holes for conduit connections, the enclosure shall be marked to indicate the location and trade sizes of conduit for which the enclosure has been found to be acceptable. If counter-boring is necessary to accommodate certain sizes of conduit, such information shall also be given.

Exception: The instructions for drilling and tapping may be provided on an instruction sheet provided with the enclosure or marked on the packaging carton.

50A Markings and Instructions for Field Installed Accessories

50A.1 An enclosure marking shall include the following:

a) Identification of each field installed accessory, or reference to a separate publication that identifies each accessory; and

b) The type designation of the enclosure.

Exception: When a new accessory has been designed for an existing enclosure, the accessory shall be marked with the enclosure type with which it is intended to be used.

50A.1 added October 1, 1996

50A.2 An accessory which is not shipped in the same carton as the equipment with which it is intended to be used shall be plainly marked with the following:

a) The manufacturer’s name, trademark, or other descriptive marking by which the organization responsible for the product may be identified; and

b) The catalog number or other specific identifying number for the product.

50A.2 added October 1, 1996

50A.3 An accessory shall be provided with instructions that contain the following information:

a) Identification of all parts to be used during installation; and

b) Description of the method of installation.

50A.3 added October 1, 1996

51 Cautionary Markings

51.1 Cautionary markings shall be located on a part that cannot be removed without impairing the operation or appearance of the equipment.

51.2 A cautionary marking shall be prefixed with the word ″CAUTION″ or ″WARNING,″ as applicable, in letters not less than 1/8 inch (3.2 mm) high. The remaining letters of such marking, unless specified otherwise in individual marking requirements, shall not be less than 1/16 inch (1.6 mm) high.

51.3 A cautionary marking intended to instruct the operator shall be legible and visible to the operator during the normal operation of the equipment. A marking that provides servicing instructions shall be legible and visible when such servicing is being performed.

51.4 The cautionary marking required for enclosures that are intended for field assembly of the bonding means in accordance with 7.2.1 shall:

a) Alert the installer that bonding between metallic conduit connections is not automatic, and therefore bonding must be provided as part of the installation; and

b) Be located where visible during installation, such as inside the cover.

51.4 revised October 1, 1996

SPECIFIC ENCLOSURES

52 Cabinets and Cutout Boxes

52.1 A cabinet or cutout box shall comply with the requirements for enclosures.

53 Junction and Pull Boxes

53.1 General

53.1.1 In addition to the requirements in this section, a junction or pull box shall comply with the requirements for enclosures. However, the requirements in this section shall supersede equivalent requirements for enclosures.

53.2 Covers and doors

53.2.1 A junction or pull box cover shall have no door and shall be secured to the box by screws, bolts, or the equivalent in lieu of hinges.

53.3 Raceway openings

53.3.1 A junction or pull box provided with one or more integral conduit hubs for raceways 3/4-inch trade size or larger – if permanent barriers are installed in a box, each section shall be considered as a separate box – shall comply with the following:

a) The inside dimensions of the box between opposite walls shall not be less than eight times the trade diameter of any size raceway opening in such walls; and

b) The inside dimension of the box between each raceway opening and the opposite wall of the box shall not be less than six times the trade diameter of the largest raceway plus the sum of the trade diameters of all other raceway openings in the same wall of the box.

Exception No. 1: A box may be smaller if marked in accordance with 53.8.1.

Exception No. 2: If the raceway opening is in the wall of the box opposite a removable cover, the distance from the wall to the cover may be as specified in Table 53.1.

Table 53.1
Distance from removable cover to opposite wall with raceway opening

Trade diameter of raceway opening, inches	Minimum distance – wall to cover, inches	(mm)
1	2-1/2	63.5
1-1/4	3-1/2	88.9
1-1/2	4	102.0
2	5	127.0
2-1/2	6	152.0
3	8	203.0
3-1/2	10	254.0
4	10	254.0
4-1/2	12	305.0
5	12	305.0
6	12	305.0

53.4 Equipment-grounding

53.4.1 A junction or pull box shall be provided with means for connection of an equipment-grounding conductor.

Exception No. 1: A junction or pull box that is marked in accordance with 53.7.1 or 53.7.2 need not be provided with means for connection of an equipment-grounding conductor.

Exception No. 2: A cast metal junction or pull box need not be provided with means for connection of an equipment-grounding conductor.

53.4.1 revised November 19, 1999

53.4.2 An equipment-grounding terminal or terminal assembly and associated parts shall be of a metal or metals that are not likely to be adversely affected by electrolysis in service.

53.4.3 Metal employed for an equipment-grounding terminal shall be nonferrous, stainless steel, or other metal that is inherently resistant to corrosion, or it shall be protected by a coating of zinc or cadmium that complies with Section 44, Metallic Coating Thickness Test, or by an equivalent metallic plated coating.

53.4.4 A protective coating of zinc or cadmium on other than a mounting screw or wire-binding screw shall be such that it will withstand the metallic-coating-thickness test for the interval specified in Table 53.2.

Table 53.2
Metallic coating thickness test

Temperature		Time, seconds	
°F	°C	Zinc	Cadmium
65	18.3	106	78
70	21.1	102	76
75	23.9	98	72
80	26.7	94	70
85	29.4	90	68
90	32.2	86	64
95	35.0	84	62

53.4.5 A pressure wire connector employed at an equipment-grounding terminal shall comply with the requirements for such devices except that:

a) It may be of iron or steel;

b) It need not comply with the requirements for the temperature test; and

c) A single opening of the connector is considered to be acceptable for only one No. 8 AWG (8.4 mm^2) or larger conductor and for not more than three No. 10 AWG (5.3 mm^2) or smaller conductors.

53.4.6 When installed as intended, an equipment-grounding terminal shall:

a) Provide a reliable bond to the enclosure; and

b) Be such that the resistance of the connection between an installed equipment-grounding conductor and the enclosure is not more than 0.005 ohm.

53.4.7 To determine if a connection complies with the requirements in 53.4.6(b), a current of 30 amperes is to be passed through the bonding connection. The resulting voltage drop is to be measured between a point – file mark – on the conductor 1/16 inch (1.6 mm) from the connection and a similar point on the enclosure not less than 1/16 inch from the bonding connection.

53.4.8 An equipment-grounding terminal or assembly shall be green or the heads of the terminal screws thereon shall be green.

Exception: The color identification is not required to be provided when the equipment-grounding terminal or assembly is identified by the marking "Equipment-Grounding Terminal" or an equivalent abbreviation, or the symbol ⏚ (IEC Publication 417, Symbol 5019), adjacent to the terminal or on a wiring diagram.

53.4.8 revised October 1, 1996

53.5 Covers and doors

53.5.1 A junction or pull box may have, in addition to the cover, one or more removable sides. The fastenings for these sides shall comply with the requirements in Section 18.

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53.6 Fastenings

53.6.1 A junction or pull box cover shall be secured to the box by screws, bolts, or the equivalent.

53.7 Marking details

53.7.1 A junction or pull box, that is not provided with a means of terminating equipment-grounding conductors and does not have a means for the field installation of an equipment-grounding assembly – see 53.7.2 – shall be marked to indicate that the junction or pull box is to be used in an installation in which equipment is grounded by connection to metal raceway or metallic cable sheaths.

53.7.2 If an equipment grounding terminal or terminal assembly is intended for field installation: the junction or pull box in which the terminal or assembly is intended to be used shall be marked to indicate:

a) The catalog or type number of the terminal or assembly intended to be used therein; and

b) Proper installation instruction and information stating the wire size of terminals available.

Exception: The marking required by 53.7.2 may be provided on or in the individual shipping package or carton of the terminal or terminal assembly instead of on the box

53.7.3 A junction or pull box that is smaller than required by 53.3.1 – see Exception No. 1 to 53.3.1 – shall be marked with the following: ″

When used as a pull box, installation shall be in accordance with Section 370-28 of the National Electrical Code, ANSI/NFPA 70-1996.

″

53.8.1 revised and relocated as 53.7.3 October 1, 1996

53.8 Cautionary markings

*53.8.1 *Revised and relocated as 53.7.3 October 1, 1996**

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SUPPLEMENT SA - ENCLOSURES FOR ELECTRICAL EQUIPMENT FOR MARINE USE

GENERAL

SA1 Scope

SA1.1 The requirements in this supplement cover sheet-metal, cast-metal, and nonmetallic enclosures having a volume of more than 100 cubic inches (1638 cm^3) intended for use with lighting fixtures, electrical equipment, and the like in marine applications.

SA1.2 The products covered by the requirements in this supplement are intended for installation in accordance with the manufacturer's instructions and the applicable requirements of the United States Coast Guard (USCG); IEEE Recommended Practice for Electric Installation on Shipboard, IEEE Standard 45; the American Boat and Yacht Council (ABYC); and the National Fire Protection Association Standard for Pleasure and Commercial Motor Craft, NFPA 302.

SA1.3 A product intended for marine use shall comply with the requirements in Sections 5 – 53 inclusive, as applicable; except as modified or superseded by the requirements in this supplement.

SA1.4 The requirements in this supplement do not cover enclosures for use in hazardous locations.

CONSTRUCTION

SA2 General

SA2.1 Junction and pull boxes not designated as Type 4 or 4X are to be tested as Type 2, 3R, or 12 enclosures.

SA3 Mounting

SA3.1 An enclosure designated as Type 4 or 4X shall be provided with external mounting means. There shall be no holes through the total thickness of the enclosure walls, except those for supply connections.

SA4 Supply Connections

SA4.1 An enclosure designated as Type 4 or 4X may have stuffing tubes or other cable entry fittings acceptable for the application. For example, nonmetallic junction and pull boxes are acceptable for use with rigid nonmetallic conduit. See SA8.4.

PERFORMANCE

SA5 Salt Spray Test

SA5.1 A metallic enclosure shall comply with the Salt-Spray (Fog) Test – Pigmented and Clear Coatings in the Standard for Organic Coatings for Steel Enclosures for Outdoor-Use Electrical Equipment, UL 1332.

SA6 Watertightness Test

SA6.1 There shall be no evidence of water leakage so as to reach live parts when a enclosure is tested as specified in SA6.2 and SA6.3.

Exception: An enclosure designated as Type 4, 4X, 6, or 6P complies with this requirement and need not be tested.

SA6.2 The assembly is to be mounted as intended in service. A solid stream of water from a nozzle not less than 1 inch (25.4 mm) in diameter and a flow rate of 65 gallons (256 L) per minute, measured at the nozzle, is to be directed at the enclosure in all directions from a distance of 10 feet (3.1 m) for 5 minutes.

SA6.3 Any water on the exterior of the enclosure is to be removed with a cloth and the enclosure then opened and examined for any evidence of leakage.

SA7 Drip Test

SA7.1 An enclosure is acceptable if at the conclusion of the test specified in SA7.2, no accumulation of water is retained.

Exception: An enclosure designated as Type 1 with a dripshield, Type 2, Type 3R or a Type 12 complies with this requirement and need not be tested.

SA7.2 The enclosure is to be mounted beneath a drip pan as specified in Section 31; except the enclosure is to be oriented from 0 – 15 degrees from the vertical.

MARKING

SA8 General

SA8.1 The shipping labels or the cartons used to ship these products shall be marked ″For Marine Use,″ or the equivalent.

SA8.2 An enclosure designated as a Type 4, 4X, 6, or 6P may additionally be marked ″Watertight″ either on the enclosure or on the carton in which the enclosure is shipped.

SA8.3 An enclosure designated as a Type 1 with a dripshield, Type 2, 3R, or 12 may additionally be marked ″Dripproof″ either on the enclosure or on the carton in which the enclosure is shipped.

SA8.4 Cast-metal enclosures intended for field drilling and tapping of holes for conduit connection are to be marked to indicate the proper location and trade sizes for the openings.