UL 50

STANDARD FOR SAFETY

Enclosures for Electrical Equipment, Non-Environmental Considerations

UL Standard for Safety for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50

Fourteenth Edition, Dated February 29, 2024

Summary of Topics

This new Fourteenth Edition of ANSI/UL 50 dated February 29, 2024 includes (a) Optional Performance Tests for Certain Construction Requirements; (b) Revisions to Table 6.6; (c) Corrections to Annex B and Annex F; (d) Revision of Sketch F of Figure 6.10; (e) Addition of Annex G

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated December 16, 2022 and June 23, 2023.

No Text on This Page

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UL 50
Fourteenth Edition

Enclosures for Electrical Equipment, Non-Environmental Considerations

February 29, 2024

ANSI/UL 50-2024

Commitment for Amendments

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This ANSI/UL Standard for Safety consists of the Fourteenth Edition. The most recent designation of ANSI/UL 50 as an American National Standard (ANSI) occurred on February 29, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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Preface

This is the harmonized ANCE, CSA Group, and ULSE standard for Enclosures for Electrical Equipment, Non-Environmental Considerations. It is the fourth edition of NMX-J-235/1-ANCE, the third edition of CAN/CSA C22.2 No. 94.1, and the fourteenth edition of UL 50. This edition of NMX-J-235/1-ANCE supersedes the previous edition published on October 16, 2015. This edition of CSA C22.2 No. 94.1 supersedes the previous edition published in 2015. This edition of UL 50 supersedes the previous edition published on October 16, 2015.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), CSA Group, and ULSE. The efforts and support of the CANENA Technical Harmonization Committee 70/31 Enclosures Working Group are gratefully acknowledged.

This Standard is considered suitable for use for conformity assessment within the stated scope of the standard.

The present Mexican standard was developed by the CT CDI Control y Distribución Industrial from the Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of the enclosures manufacturers and users.

This Standard was reviewed by the CSA Integrated Committee on Enclosures, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee. This Standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard.

This standard is published as an equivalent standard for ANCE, CSA Group, and ULSE.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Reasons for differences from IEC

The THSC investigated and found no existing IEC standards or work programs covering the scope of the products in this Standard.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

ENCLOSURES FOR ELECTRICAL EQUIPMENT, NON-ENVIRONMENTAL CONSIDERATIONS

1 Scope

1.1 This standard applies to enclosures for electrical equipment intended to be installed and used in non-hazardous locations in accordance with the Canadian Electrical Code, Part I, CSA C22.1, the provisions of the National Electrical Code, NFPA 70, and the provisions of Mexico's Electrical Installations, NOM-001-SEDE, as follows:

a) Enclosures for indoor locations, Types 1, 2, 5, 12, 12K, and 13; and

b) Enclosures for indoor or outdoor locations, Types 3, 3X, 3R, 3RX, 3S, 3SX, 4, 4X, 6, and 6P.

1.2 This standard covers the non-environmental construction and performance requirements for enclosures to provide a degree of protection to personnel against incidental contact with the enclosed equipment. The additional environmental construction and performance requirements for enclosures are located in CSA C22.2 No. 94.2, UL 50E, and NMX-J-235/2-ANCE (See Annex B, Ref. No. 15), which are intended to be used in conjunction with this standard.

1.3 Where an individual product standard contains requirements that are at variance with those of this standard, the requirements of the individual product standard take precedence.

1.4 In the United States and Mexico, cabinets and cutout boxes and junction and pull boxes are covered by Clauses 9 and 10 of this Standard. In Canada, junction boxes, cutout boxes, and pull boxes are covered by CSA C22.2 No. 40 and are not covered by this standard. See Annex B, Ref. No. 12.

1.5 Outlet boxes having a volume of not more than 1640 cm^3 (100 in^3) are covered by CSA C22.2 No. 18.1, NMX-J-023/1-ANCE, and the UL 514 series (see Annex B, Ref. No. 6 and 13) and are not covered by this standard.

1.6 In Canada and the United States, swimming pool type junction boxes are covered by CSA C22.2 No. 89 and UL 1241 (see Annex B, Ref. No. 11) and are not covered by this standard.

2 Units of Measurement

2.1 The values given in SI (metric) units shall be normative. Any other values given shall be for informational purposes only.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Annex A for a list of standards covering components generally used in the products covered by this standard. A component shall comply with the ANCE, CSA Group, or UL standards as appropriate for the country where the product is to be used.

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

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

b) Is superseded by a requirement in this standard.

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

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

4 References

4.1 For undated references to standards, such reference shall be considered to refer to the latest edition and all revisions to that edition up to the time when this standard was approved. For dated references to standards, such reference shall be considered to refer to the dated edition and all revisions published up to the time the standard was approved.

4.2 In Canada, general requirements are as indicated in Annex B, Ref. No. 10.

5 Definitions

5.1 The following definitions apply in this standard:

5.2 ACCESSIBLE EDGES – Edges that are subject to contact by persons installing, using, or maintaining the product.

5.3 BOX – That portion of an enclosure not including the cover or door.

5.4 BREAKOUT – A portion of a wall of a cast or molded enclosure so fashioned, usually by the use of one or more rings of reduced thickness of the wall material, that the material within the outer perimeter of the ring to be removed may be readily broken away at the time of installation in order to provide an opening similar to that provided by a knockout.

5.5 CABINET – See Annex B, Ref. No. 17.

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

5.7 CUTOUT BOX – See Annex B, Ref. No. 17.

5.8 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.

5.9 DESIGN TESTS – Tests to demonstrate performance of a product designed to applicable standards; they are not intended to be production tests.

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

5.11 ENCLOSURE – A surrounding case constructed to provide a degree of protection to personnel against access to hazardous parts and to provide a degree of protection to the enclosed equipment against specified environmental conditions. The specific enclosure types, their applications, and the environmental conditions for which they are designed to protect against are as follows:

TYPE 1 – Enclosures constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts and to provide a degree of protection against ingress of solid foreign objects (falling dirt).

TYPE 2 – Enclosures constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt); and to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing).

TYPE 3 – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, and snow); and that will be undamaged by the external formation of ice on the enclosure.

TYPE 3R – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, and snow); and that will be undamaged by the external formation of ice on the enclosure.

TYPE 3S – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, and snow); and for which the external mechanism(s) remain operable when ice laden.

TYPE 3X – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, and snow); that provide an increased level of protection against corrosion; and that will be undamaged by the external formation of ice on the enclosure.

TYPE 3RX – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, and snow); that provide an increased level of protection against corrosion; and that will be undamaged by the external formation of ice on the enclosure.

TYPE 3SX – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, and snow); that provide an increased level of protection against corrosion; and for which the external mechanism(s) remain operable when ice laden.

TYPE 4 – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose-directed water) and that will be undamaged by the external formation of ice on the enclosure.

TYPE 4X – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts ; to provide a degree of protection against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose-directed water); that provides an increased level of protection against corrosion; and that will be undamaged by the external formation of ice on the enclosure.

TYPE 5 – Enclosures constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt and settling airborne dust, lint, fibers, and flyings); and to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing).

TYPE 6 – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, hose-directed water and the entry of water during occasional temporary submersion at a limited depth); and that will be undamaged by the external formation of ice on the enclosure.

TYPE 6P – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, hose-directed water, and the entry of water during prolonged submersion at a limited depth); and that will be undamaged by the external formation of ice on the enclosure.

TYPE 12 – Enclosures constructed (without knockouts) for indoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt and circulating dust, lint, fibers, and flyings); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing); and to provide a degree of protection against light splashing and consequent seepage of oil and non-corrosive coolants.

TYPE 12K – Enclosures constructed (with knockouts) for indoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection against ingress of solid foreign objects (falling dirt and circulating dust, lint, fibers, and flyings); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing); and to provide a degree of protection against light splashing and consequent seepage of oil and non-corrosive coolants.

TYPE 13 – Enclosures constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts ; to provide a degree of protection against ingress of solid foreign objects (falling dirt and circulating dust, lint, fibers, and flyings); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing); and to provide a degree of protection against the spraying, splashing, and seepage of oil and non-corrosive coolants.

5.12 INDOOR LOCATIONS – Areas that are protected from exposure to the weather.

5.13 JUNCTION OR PULL BOX – An enclosure which is provided with a cover secured by fasteners other than hinges.

5.14 KNOCKOUT – A portion of a wall of a sheet metal enclosure so fashioned that it may be removed readily by a hammer, screwdriver, and pliers at the time of installation in order to provide a hole for the attachment of an auxiliary device or raceway, cable, or fitting.

5.15 NONVENTILATED– Constructed so as to provide no intentional circulation of external air through the enclosure.

5.16 OIL-RESISTANT GASKETS – Gaskets made of material that is resistant to oil and oil fumes.

5.17 OUTDOOR LOCATIONS – Areas that are exposed to the weather.

5.18 THREADED CONDUIT ENTRY – A conduit entry that is threaded so as to secure a rigid conduit without the use of a bushing or locknut.

5.19 VENTILATED – Constructed so as to provide for the circulation of external air through the enclosure to remove excess heat, fumes, or vapors.

6 Construction

6.1 General

6.1.1 An enclosure shall completely enclose all live parts that may be housed in it.

6.1.2 All enclosures, other than those designed to be free standing or those designed for a specific installation, such as a cast-metal box intended to be installed in poured concrete, shall be provided with means for mounting.

6.1.3 Any part that is not required in order to comply with the requirements in this standard and does not serve to maintain the mechanical, electrical, or environmental integrity of the enclosure need not comply with the requirements of this standard.

6.1.4 An enclosure, frame, or similar device shall not have accessible edges that are sharp or pointed such that they constitute a risk of injury to persons during normal installation, maintenance, and use, unless:

a) Accessible edges are protected by guards or the use of handles to minimize access to sharp edges or points, or

b) An accessible edge or portion of an accessible edge is required to be sharp in order to perform a working function, or

c) If it is possible to avoid the hazard through proper procedures, then signs, labels or the manufacturer's instructions shall describe the procedure to avoid the hazard during installation, maintenance, and use.

When considering sharp edges and points, all stages of the installation process shall be considered.

6.1.5 Whenever reference measurements are necessary to determine that a part as mentioned in 6.1.4 is not sufficiently sharp to constitute a risk of injury to persons, the method described in Annex B, Ref. No. 9, shall apply. In Canada, 6.1.5 shall not apply.

6.1.6 An enclosure shall have the necessary strength and rigidity to maintain its shape so that doors will close tightly .

6.1.7 Metal into which screws are threaded shall provide for the engagement of at least two full threads, other than as permitted by 6.1.8. Sheet metal shall be permitted to 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. 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.

6.1.8 The following combinations of minimum number of threads and minimum thickness steel shall be considered acceptable:

a) 32 threads per 25.4 mm (32 threads per inch) installed in 1.35 mm (0.053 in);

b) 28 threads per 25.4 mm (28 threads per inch) installed in 1.70 mm (0.067 in);

c) 24 threads per 25.4 mm (24 threads per inch) installed in 2.03 mm (0.080 in);

d) 20 threads per 25.4 mm (20 threads per inch) installed in 2.36 mm (0.093 in);

e) 18 threads per 25.4 mm (18 threads per inch) installed in 2.74 mm (0.108 in); and

f) 16 threads per 25.4 mm (16 threads per inch) installed in 3.12 mm (0.123 in).

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

6.1.10 Other than the following items, both the inside and outside surfaces of an enclosure made of ferrous material shall be protected against corrosion as specified in 7.2 of Annex B, Ref. No. 15:

a) Bearings, sliding surfaces of a hinge or shaft, and the like, located on the exterior of enclosures;

b) Sheared or cut edges and punched holes of galvanized sheet steel; and

c) Parts such as a decorative grille, and the like, that are not required to form part of the enclosure.

6.2 Observation windows

6.2.1 A material used for an observation window and forming a part of the enclosure shall be reliably secured in such a manner that it cannot be readily displaced in service in accordance with 6.2.5 or 6.2.6 and shall provide mechanical protection of the enclosed parts, in accordance with 6.2.2 or 6.2.4.

6.2.2 Except as permitted by 6.2.3, glass used for an observation window not more than 102 mm (4 inches) in any dimension and not less than 1.40 mm (0.055 inch) thick or glass used for an observation window having no dimension greater than 305 mm (12 inches) and not less than 2.92 mm (0.115 inch) thick need not be subject to additional evaluation. Glass used to cover a larger opening shall comply with the Crushing resistance test (see 8.10) and Resistance to impact (normal only) test specified in Annex B, Ref. No. 1.

6.2.3 For glass made of clear safety type or wire-reinforced type designated AS2 to ANSI Z26.1, 6.2.2 does not apply.

6.2.4 A polymeric material used as an observation window shall comply with the requirements of 6.6.

6.2.5 In the United States, a material used for an observation window shall be mechanically secured or shall be secured using an adhesive complying with the adhesive requirements specified in Annex B, Ref. No. 16, or Annex E.

6.2.6 In Canada, a material used for an observation window shall be mechanically secured or shall be secured using an adhesive complying with Annex E.

6.3 Openings

6.3.1 General

6.3.1.1 Other than as covered in 6.3.1.2, openings provided in any enclosure type shall comply with the applicable tests in Annex B, Ref. No. 15, with these openings unfilled.

6.3.1.2 Openings in accordance with 6.3.2, 6.3.4, and 6.3.5 shall be appropriately filled to maintain the environmental integrity of the enclosure.

6.3.2 Equipment openings

6.3.2.1 Enclosures may be provided with openings that are intended to be closed by field installed equipment (such as pushbutton switches, door latches, etc.) if these enclosures are marked in accordance with 7.7.

6.3.2.2 Openings that comply with Table 6.1 do not require the enclosures to be marked in accordance with 7.7.

Table 6.1
Equipment-Mounting Holes

Maximum linear dimension of enclosure mm (inch)	Area of largest surface of enclosure mm² (square inch)	Maximum total area of holes mm² (square inch)	Maximum area of any one hole mm² (square inch)
457 (18)	87 000 (135)	193 (0.30)	45.2 (0.07)
Over 457 (18)	Over 87 000 (135)	335 (0.52)	83.9 (0.13)

6.3.3 Ventilation

6.3.3.1 Ventilated enclosures shall comply with NMX-J-235/2-ANCE/CSA C22.2 No. 94.2/UL 50E, 7.3.5.1.

6.3.4 Mounting openings

6.3.4.1 For Type 1, 2, 3R, 3RX, or 5 enclosures, mounting means may be provided internal to the equipment cavity if the mounting openings comply with Table 6.2.

6.3.4.2 If mounting openings other than as noted in Table 6.2 are provided in Type 1, 2, 3R, 3RX, or 5 enclosures, instructions shall be included with the enclosure that indicate how to maintain the environmental integrity of the enclosure when mounted.

Table 6.2
Enclosure-Mounting Holes

Maximum linear dimension of enclosure mm (inches)	Area of largest surface of enclosure mm² (square inch)	Maximum number of holes	Maximum total area of holes mm² (square inches)
178 (7)	20 600 (32)	4	774 (1.2)
457 (18)	87 000 (135)	6	774 (1.2)
1020 (40)	254 000 (1 000)	6	970 (1.5)
Over 1020 (40)	Over 254 000 (1 000)	8	1 290 (2.0)

6.3.4.3 Mounting openings for enclosures constructed from a polymeric material shall additionally comply with 6.6.5. Mounting openings requirements for enclosure Types 3, 3X, 3S, 3SX, 4, 4X, 6, 6P,12, 12K, and 13 are in 7.3.4 of Annex B, Ref. No. 15.

6.3.5 Breakouts, knockouts and conduit openings

6.3.5.1 All breakouts, knockouts, and conduit openings shall comply with 6.10.

6.3.5.2 A Type 12 enclosure shall not contain breakouts or knockouts but may have conduit openings if these openings comply with 6.10.

6.3.6 Additional openings

6.3.6.1 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 shall be no larger than two 3.2 by 3.2 mm (1/8 by 1/8 inch) openings and two 6.4 by 6.4 mm (1/4 by 1/4 inch) openings for enclosures not more than 457 mm (18 inches) long or wide in which the largest surface does not exceed 87,100 mm^2 (135 in^2). In a larger enclosure, an opening shall not be larger than 6.4 by 6.4 mm (1/4 by 1/4 inch).

6.4 Sheet metal enclosures

6.4.1 Thickness

6.4.1.1 Other than as permitted by 6.4.1.2, a box shall not be thinner than specified in Table 6.3 or Table 6.4.

Table 6.3
Thickness of Sheet Metal for Boxes, Steel

Without supporting frame				With supporting frame or equivalent reinforcing				Minimum thickness[c]	
Maximum width[a]		Maximum length[b]		Maximum width[a]		Maximum length[b]			
mm	(inches)	mm	(inches)	mm	(inches)	mm	(inches)	mm	(inch)
457	(18.0)	Not limited		686	(27.0)	Not limited		1.35	(0.053)
508	(20.0)	635	(25.0)	737	(29.0)	914	(36.0)		
559	(22.0)	Not limited		838	(33.0)	Not limited		1.52	(0.060)
635	(25.0)	787	(31.0)	889	(35.0)	1092	(43.0)		
635	(25.0)	Not limited		991	(39.0)	Not limited		1.70	(0.067)
737	(29.0)	914	(36.0)	1041	(41.0)	1295	(51.0)		
838	(33.0)	Not limited		1295	(51.0)	Not limited		2.03	(0.080)
965	(38.0)	1194	(47.0)	1372	(54.0)	1676	(66.0)		
1067	(42.0)	Not limited		1626	(64.0)	Not limited		2.36	(0.093)
1194	(47.0)	1499	(59.0)	1727	(68.0)	2134	(84.0)		
1321	(52.0)	Not limited		2032	(80.0)	Not limited		2.74	(0.108)
1524	(60.0)	1880	(74.0)	2134	(84.0)	2616	(103.0)		
1600	(63.0)	Not limited		2464	(97.0)	Not limited		3.12	(0.123)
1844	(73.0)	2286	(90.0)	2616	(103.0)	3226	(127.0)		

[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 12.7 mm (1/2 inch) 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 6.4
Minimum Thickness of Sheet Metal for Boxes – Aluminum, Copper, or Brass

Without supporting frame				With supporting frame or equivalent				Minimum thickness	
Maximum width[a]		Maximum length[b]		Maximum width[a]		Maximum length[b]			
mm	(inches)	mm	(inches)	mm	(inches)	mm	(inches)	mm	(inch)
457	(18.0)	Not limited		1067	(42.0)	Not limited		1.91	(0.075)
508	(20.0)	635	(25.0)	1143	(45.0)	1397	(55.0)		
635	(25.0)	Not limited		1524	(60.0)	Not limited		2.41	(0.095)
737	(29.0)	914	(36.0)	1626	(64.0)	1981	(78.0)		
940	(37.0)	Not limited		2210	(87.0)	Not limited		3.10	(0.122)
1067	(42.0)	1346	(53.0)	2362	(93.0)	2896	(114.0)		
1321	(52.0)	Not limited		3124	(123.0)	Not limited		3.89	(0.153)
1524	(60.0)	1880	(74.0)	3302	(130.0)	4064	(160.0)		

[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 12.7 mm (1/2 inch) or fastened to adjacent surfaces not normally removed in use.

6.4.1.2 A box without a supporting frame may be thinner than required by 6.4.1.1 if it complies with the Deflection test described in 8.1, but it shall not be less than 1.35 mm (0.053 inch) excluding any coating.

6.4.1.3 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. A construction shall not be 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.

6.4.2 Joints and fastenings

6.4.2.1 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;

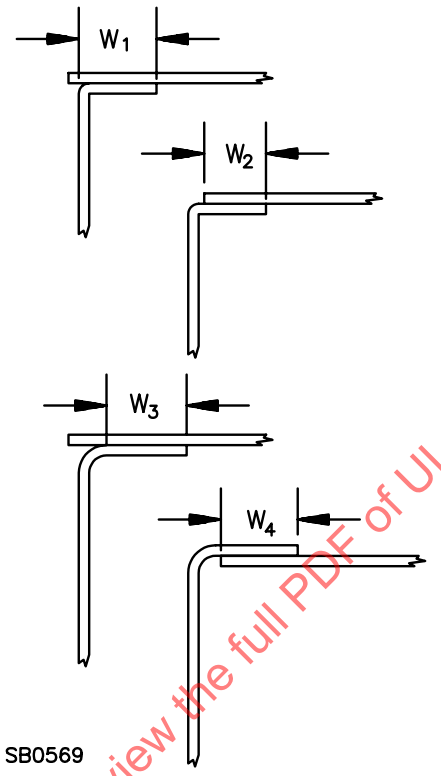
c) Separate overlapping flanges; or

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

6.4.2.2 The overlap required by 6.4.2.1 shall be at least 11.1 mm (7/16 inch) and shall extend approximately the full length of the seam. See Figure 6.1.

Figure 6.1

Overlap Between Flat Cover and Enclosure Flange and at Corner or Enclosure Seam



The figure illustrates the method of determining the amount of contact between a flat cover and a flanged enclosure wall and the amount of overlap at a corner or enclosure seam. 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 shall not be less than 11.1 mm (7/16 inch). 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, shall be measured over only that portion where the two pieces of metal are actually in contact with each other, and shall not be less than 11.1 mm (7/16 inch).

NOTE: To determine whether a telescoping cover complies with the requirement in 6.7.6.3, the cover shall be in its normally closed position, and a mark shall 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 scribing the marks, the cover shall 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.

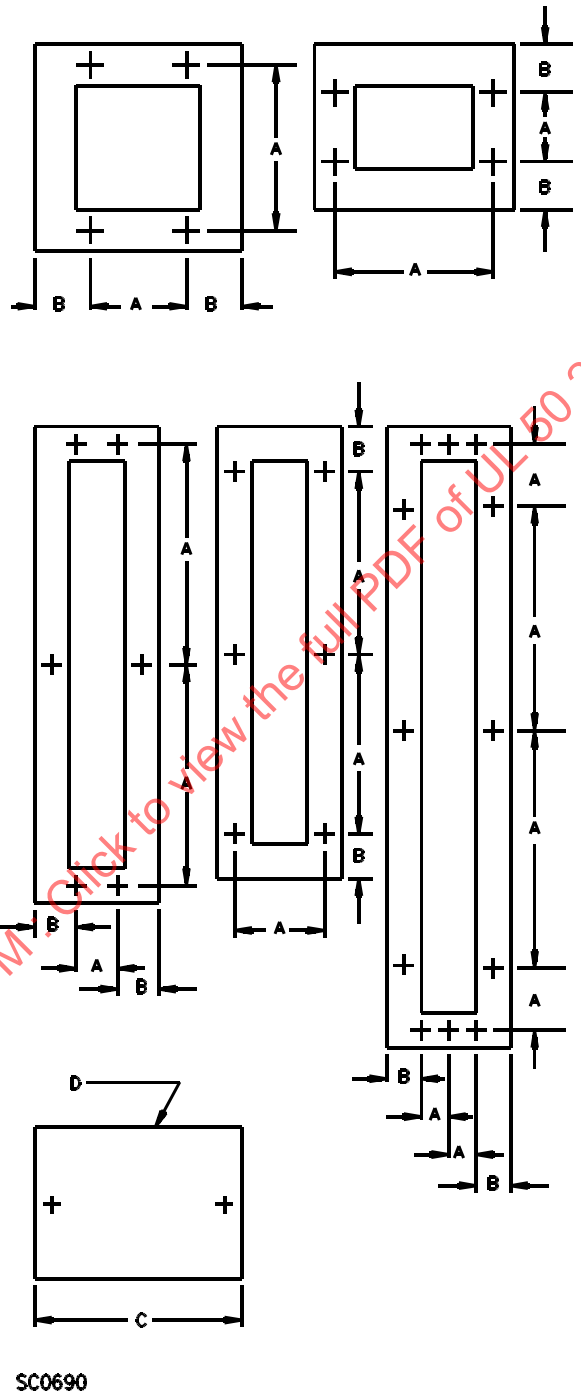
6.4.2.3 A flange joining adjacent sides, including top and bottom, of an enclosure shall have at least one fastening for each 76.2 mm (3 inches), or fraction thereof, of enclosure depth. One such fastening shall be located not more than 38.1 mm (1-1/2 inches) from the front edge of the enclosure.

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

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

6.4.2.6 For an enclosure employing a metal supporting frame, the fastenings securing a metal surface to the frame shall comply with 6.7.3 and Figure 6.2 and Figure 6.3.

Figure 6.2
Permissible Locations of Fastenings



A – 610 mm (24 inches)

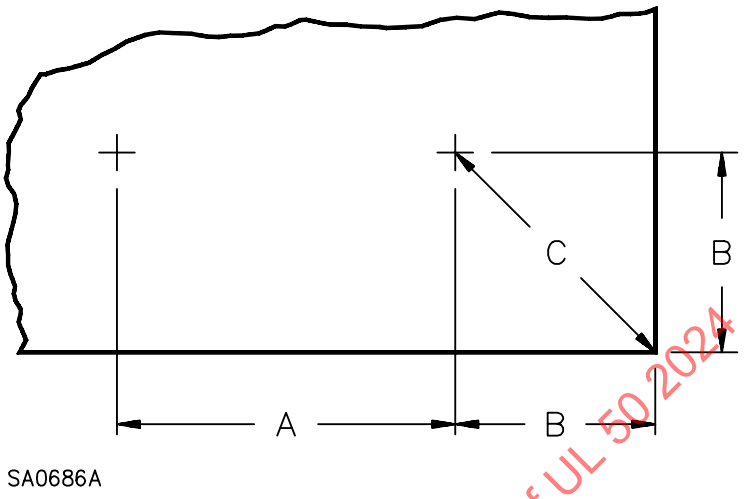
B – 152 mm (6 inches) maximum (from corner of box)

C – 216 mm (8-1/2 inches) maximum

D – 32 900 mm^2 (51 square inches) maximum area (cover)

Figure 6.3

Permissible Locations of Fastenings



A – 610 mm (24 inches) maximum

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

C – 216 mm (8-1/2 inches) maximum

Note: 32 900 mm^2 (51 square inches) maximum area (cover)

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

6.4.2.8 With reference to the requirements in 6.4.2.3 to 6.4.2.6, rivets, welds, bolts and screws having machine-screw threads shall be acceptable forms of fastenings.

6.4.3 Notches

6.4.3.1 A flange shall be permitted to be notched to accommodate knockouts and breakouts, as illustrated in Figure 6.4 under the following conditions:

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

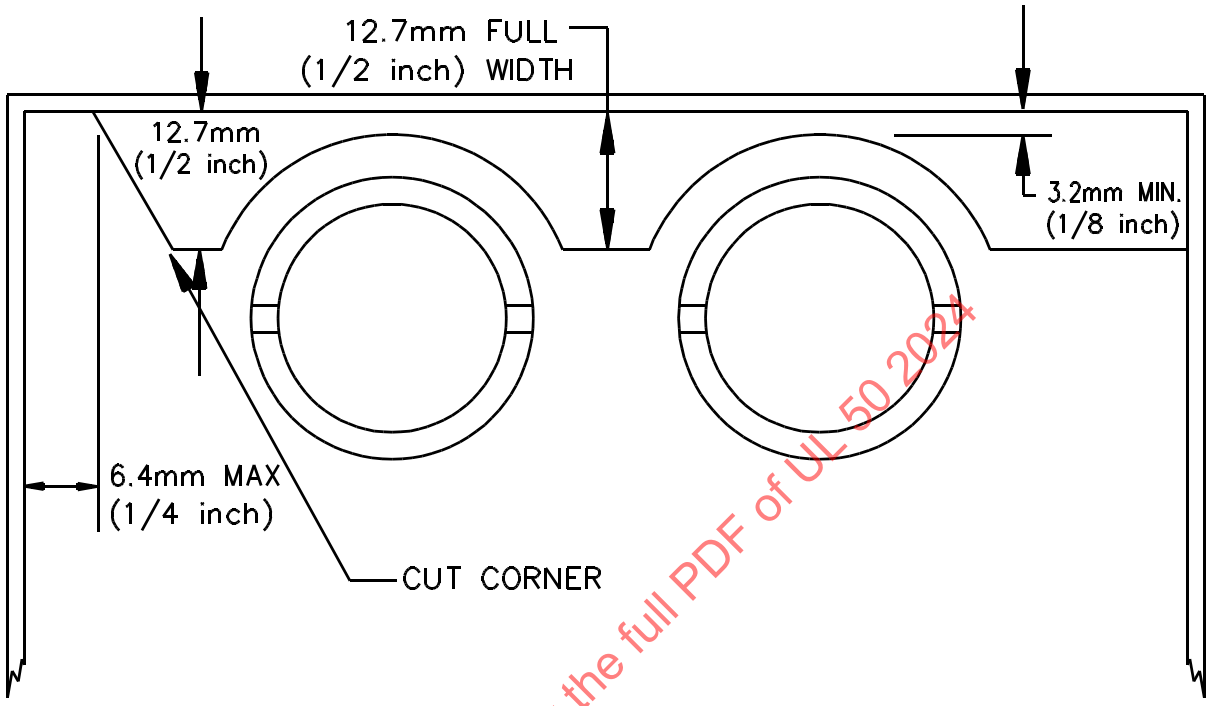
b) Each notch shall be circular and approximately concentric with the center of the knockout or breakout;

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

d) The flange width between any notch and the inside wall of the enclosure shall not be less than 3.2 mm (1/8 inch).

Figure 6.4

Notched Flange Construction



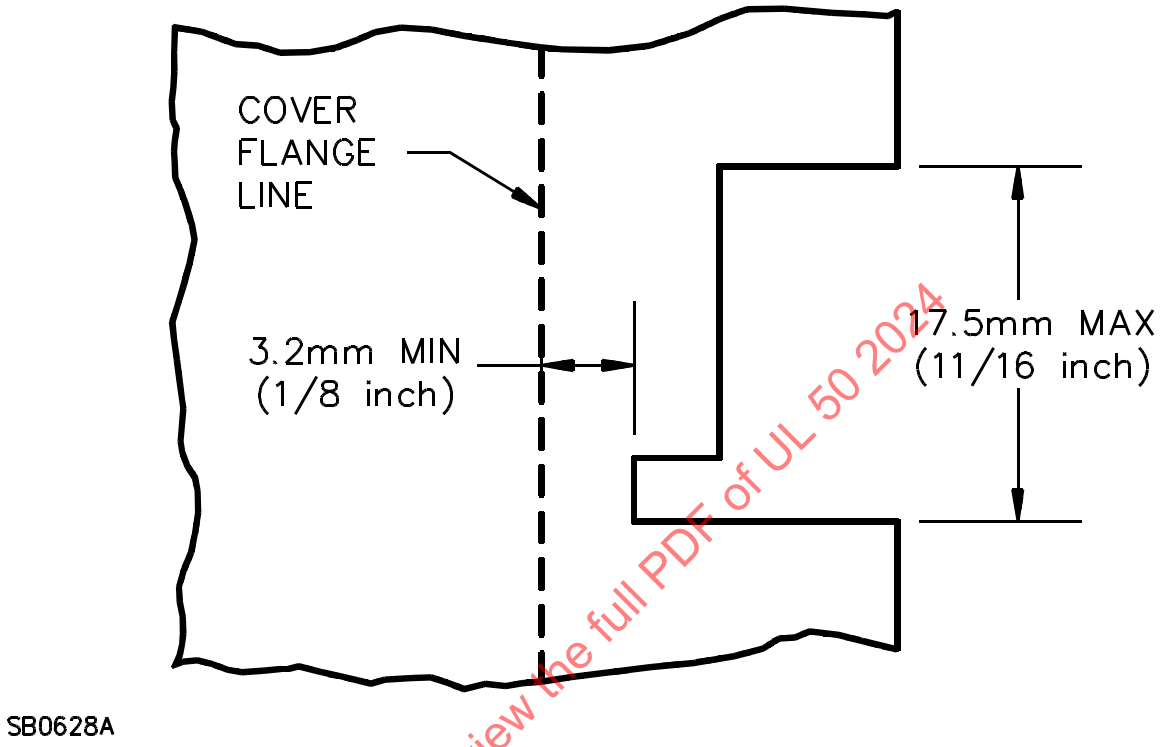
6.4.3.2 The bottom end of a corner flange shall be permitted to be cut away at an angle to facilitate forming.

6.4.3.3 The front edge of each of the two side walls of an enclosure may have one notch for each enclosure door, for the purpose of holding the door in the open position, when the construction complies with 6.4.3.4 or 6.4.3.5.

6.4.3.4 The notch shall not be more than 17.5 mm (11/16 inch) wide, and the flange of the closed door shall overlap the deepest edge of the notch by at least 3.2 mm (1/8 inch). See Figure 6.5.

Figure 6.5

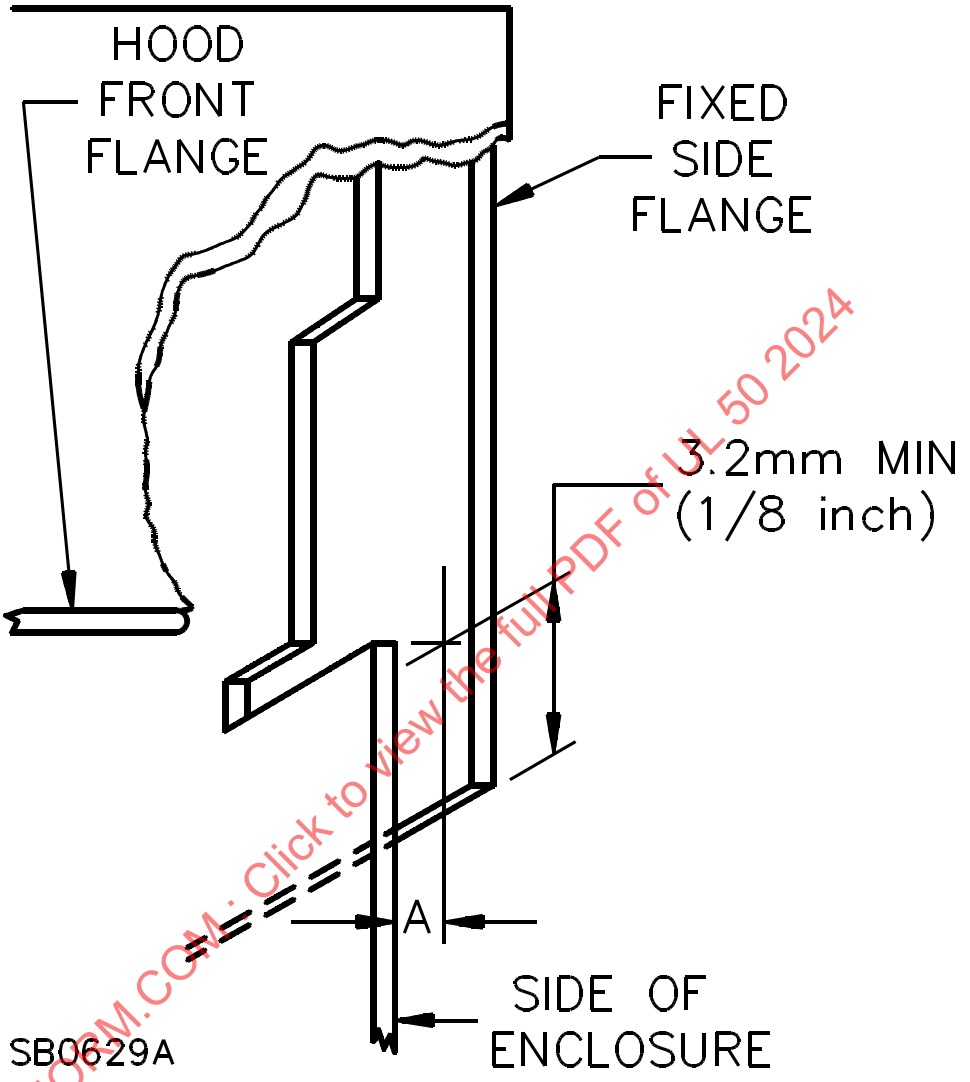
Notch for Holding Cover Open



6.4.3.5 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 3.2 mm (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 3.2 mm (1/8 inch) plus the thickness of the cover flange metal. See Figure 6.6.

Figure 6.6

Notch Behind Fixed Flange, Front View

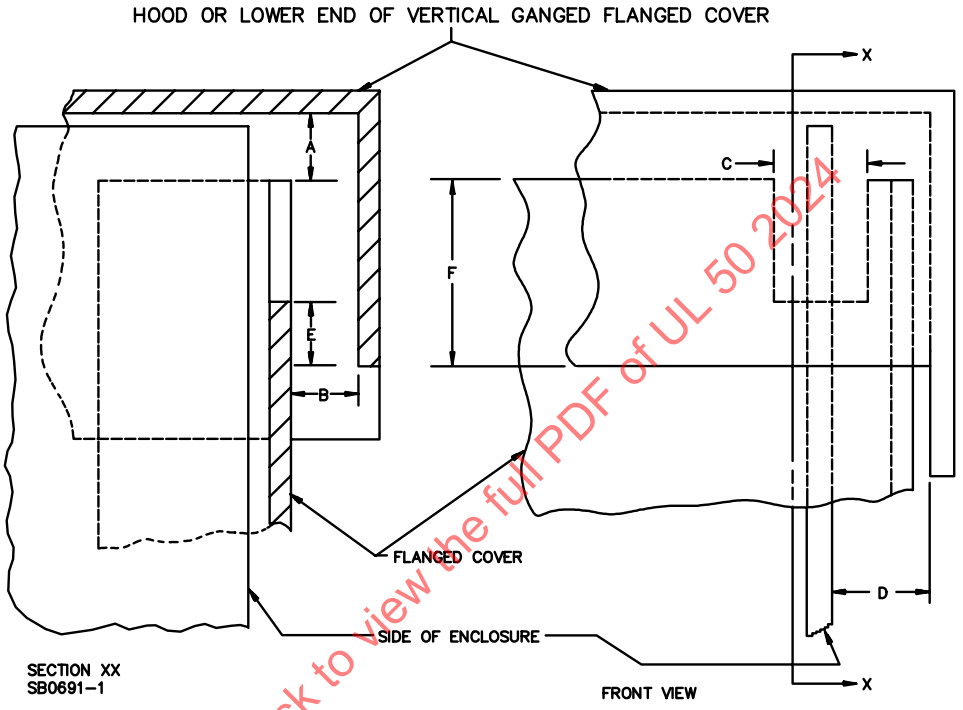


A – Space between adjacent surfaces of the fixed side flange and the side of the enclosure shall not be more than 3.2 mm (1/8 inch) plus the thickness of cover flange metal.

6.4.3.6 The overlap and spacing at a flanged enclosure door and hood or vertically-ganged overlapping covers shall be within the limits shown in Figure 6.7. A hole in a cover is determined to be the same as a notch for purposes of the overlap and spacing requirements.

Figure 6.7

Overlap and Spacing at Hood and Overlapping Cover



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

B – Maximum 3.2 mm (1/8 inch).

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 shall not be more than 3.2 mm (1/8 inch) plus thickness of cover flange metal.

E – 3.2 mm (1/8 inch) minimum.

F – 12.7 mm (1/2 inch) minimum.

6.5 Cast metal enclosures

6.5.1 A cast metal enclosure shall be not less than 2.4 mm (3/32 inch) thick for an area greater than 15 500 mm^2 (24 $inch^2$) or having any dimension greater than 152 mm (6 inches) and shall not be less than 1.6 mm (1/16 inch) thick for an area of 15,500 mm^2 (24 $inch^2$) or less and having no dimension greater than 152 mm (6 inches). The area limitation for metal 1.6 mm (1/16 inch) thick may be obtained by providing reinforcing ribs subdividing a larger area.

6.5.2 Except as permitted in 6.5.3 and 6.5.4, the thickness of a cast metal enclosure shall be as specified in Table 6.5 in any area where tapped holes for the connection of conduit are provided or intended to be tapped in the field. (See 7.2 and 7.3.)

6.5.3 The maximum thickness specified in Table 6.5 may be exceeded if holes for smaller size conduit are counter-bored and tapped if the tapped portion complies with the table for the conduit size involved.

6.5.4 In Mexico and the United States the following applies: The minimum thickness specified in Table 6.5 may be less if the cast metal box is subjected to the test specified in 8.8, but not less than 3.2 mm (1/8 inch).

6.5.5 An enclosure may be constructed of iron, steel, copper, brass, or aluminum cast metal. Aluminum-base cast metal containing less than 80 % aluminum shall not be used. Magnesium-base cast metal shall not be used. Zinc-base cast metal shall not be used for an enclosure.

Table 6.5
Cast Metal Enclosure Thickness at Tapped Holes for Conduit

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

6.6 Polymeric materials

6.6.1 General

6.6.1.1 Other than as detailed in 6.6.1.3 and 6.6.1.4, a polymeric electrical enclosure or 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:

a) Flammability – 5 inch (127 mm) flame test specified in Annex B, Ref. No. 2;

b) Resistance to impact (both normal and cold) tests specified in Annex B, Ref. No. 3;

c) Crushing resistance test (see 8.10);

d) Mold stress relief distortion test (see 8.11); and

e) Additional requirements specified in 8.6.

6.6.1.2 Polymeric parts may be tested on their own or may be tested as part of the overall electrical enclosure.

6.6.1.3 A polymeric plug or other closure made of a material classed in accordance with Annex B, Ref. No. 4, and that serves to complete and maintain the integrity of an electrical enclosure shall be acceptable if the opening the plug fills or the opening the closure covers is:

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

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

2) Class HB and acceptable in accordance with the Flammability – 5 inch (127 mm) flame test specified in Annex B, Ref. No. 2; or

b) More than 650 mm^2 (1 in^2) in area and the material is:

1) Class 5VA or 5VB and is subjected to the Resistance to impact (both normal and cold) test specified in Annex B, Ref. No. 3; or

2) Class V-0, V-1, V-2 or HB and is subjected to the Flammability – 127 mm (5 inch) flame and the resistance to impact (both normal and cold) test specified in Annex B, Ref. No. 2 and No. 3.

6.6.1.4 Polymeric fastenings and/or hinges that are relied upon to maintain the integrity of an electrical enclosure need not be subjected directly to the testing detailed in 6.6.1.1. However, the strength and rigidity of these polymeric parts would be indirectly tested when the overall polymeric electrical enclosure is subjected to the Crushing resistance, Resistance to impact (both normal and cold) and Mold stress relief distortion tests detailed in 6.6.1.1.

6.6.1.5 In the United States, an adhesive that is used as the sole means of securement of a polymeric plug or other closure shall comply with the adhesive requirements specified in Annex B, Ref. No. 16, or Annex E.

6.6.1.6 In Canada, an adhesive that is used as the sole means of securement of a polymeric plug or other closure shall comply with the adhesive requirements specified in Annex E.

6.6.2 Electrical continuity

6.6.2.1 An enclosure made of insulating material, either wholly or in part, shall have an acceptable bonding means to provide continuity of grounding between multiple conduit openings in the enclosure. The bonding means shall comply with the electrical continuity test in 8.5. Except as permitted in 6.6.2.2, the bonding means shall be completely assembled on the enclosure.

6.6.2.2 The bonding means may be provided as a separate accessory/kit for field installation if:

a) The bonding means accessory/kit complies with 6.12; and

b) The enclosure is marked in accordance with 7.5.

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

6.6.2.4 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 enamelling, plating, or other equivalent means. 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, unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

6.6.2.5 Other than exposed metal parts such as hinge pins, metal latches, screws, rivets, and metal inserts in polymeric enclosures, an enclosure shall be so constructed that all exposed conductive non-current carrying parts that could become energized are electrically interconnected with the equipment grounding conductor.

6.6.3 Rigid nonmetallic conduit

6.6.3.1 A polymeric enclosure intended for use with rigid nonmetallic conduit – glued, threaded, or the like – shall comply with the applicable requirements of Annex B, Ref. No. 6.

6.6.4 Rigid metallic conduit

6.6.4.1 A polymeric enclosure intended for connection to a rigid metallic conduit system shall comply with the requirements in 8.6.

6.6.5 Provisions for support or mounting

6.6.5.1 If constructed of conductive materials, 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 conductive materials.

6.6.5.2 To comply with 6.6.5.1, 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 0.8 mm (1/32 inch) 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 roundhead 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.

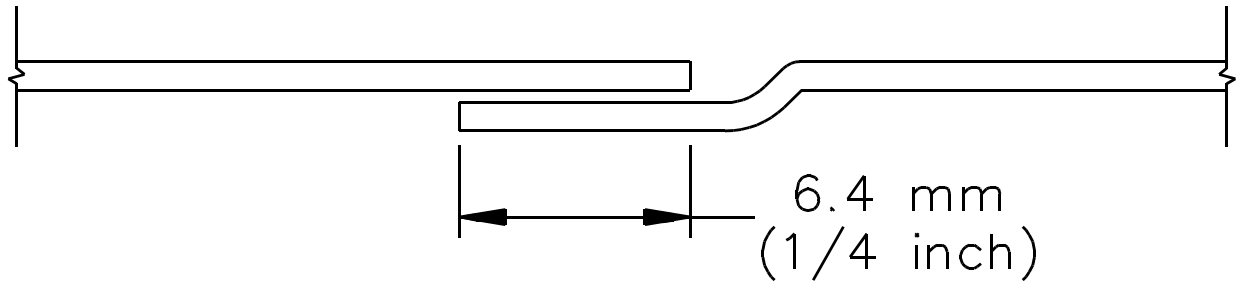
6.7 Covers and doors

6.7.1 General

6.7.1.1 A door shall shut closely against a 6.4 mm (1/4 inch) rabbet as illustrated in Figure 6.8, or the equivalent.

Figure 6.8

Rabbet



6.7.1.2 The enclosure shall be constructed so that all doors are able to be opened to a minimum of 90° from the closed position.

6.7.2 Thickness

6.7.2.1 Other than as permitted by 6.7.2.2 and 6.7.2.3, a sheet-metal door, front, cover, or auxiliary door shall not be thinner than as specified in Table 6.6 and shall comply with the requirements in 6.1.7.

Table 6.6
Minimum Thickness of Sheet Metal for Covers and Doors

Maximum dimensions[b]				Minimum thickness based on maximum dimension, mm[a] (inch)							
				Flush-mounted enclosure				Surface-mounted enclosure			
Linear		Area									
mm	(inches)	mm^2	square inches	Steel[d]		Aluminum, copper, or brass		Steel[d]		Aluminum, copper, or brass	
178	(7)	20 650	(32)	1.35	(0.053)	1.91	(0.075)	1.35	(0.053)	1.91	(0.075)
457	(18)	87 100	(135)	1.70	(0.067)	2.41	(0.095)	1.35	(0.053)	1.91	(0.075)
610	(24)	232 250	(360)	1.70	(0.067)	2.41	(0.095)	1.35[c]	(0.053[c])	1.91[c]	(0.075[c])
1 020	(40)	645 200	(1 000)	2.36	(0.093)	3.10	(0.122)	1.70[c]	(0.067[c])	2.41[c]	(0.095[c])
1 520	(60)	967 750	(1 500)	2.36	(0.093)	3.10	(0.122)	2.36	(0.093)	3.10	(0.122)
Over 1 520	(Over 60)	Over 967 750	(Over 1 500)	3.12	(0.123)	3.89	(0.153)	3.12	(0.123)	3.89	(0.153)

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

[b] The dimensions given are those of the opening in the enclosure. Neither the linear dimension nor the area of the opening shall exceed the indicated value in order to use the minimum thickness specified in that line. The extension required by 6.7.6.1 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.

6.7.2.2 A drawn, embossed, flanged, or similarly strengthened door, front, or cover shall be permitted to employ metal having a thickness not less than 1.35 mm (0.053 inch) if steel or 1.91 mm (0.075 inch) if aluminum, copper, or brass, provided that the door, front, or cover has the strength and rigidity to maintain its shape when open or unmounted and complies with the requirement in 8.2.1.

6.7.2.3 A door that covers an opening not greater than 50 mm (2 inches) in any dimension, such as an opening intended for latches and locks, shall not be less than 0.81 mm (0.032 inch) thick if steel or 1.27 mm (0.050 inch) if aluminum, copper or brass.

6.7.2.4 The cover flange mentioned in 6.7.4.3(b) shall have a thickness not less than that of the enclosure wall.

6.7.2.5 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 box proper. It shall be secured at two or more points not more than 38.1 mm (1-1/2 inches) from each end of the strip, and at points between these end fastenings not more than 152 mm (6 inches) apart.

6.7.2.6 A formed strip shall be permitted to 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.

6.7.3 Fastenings

6.7.3.1 Any door or cover shall be provided with means for holding it securely in place.

6.7.3.2 Other than as permitted by 6.7.3.3, a cover shall be fastened to the box with four or more fastenings.

6.7.3.3 Two fastenings, one at the center of each short side of two opposite sides shall be permitted to be used to fasten a cover having an area of not more than 32,900 mm^2 (51 in^2) and having no dimension greater than 216 mm (8-1/2 inches), provided that the cover does not extend more than 19.1 mm (3/4 inch) beyond the edge of the box in any direction.

6.7.3.4 A fastening screw or a screw of a clamp that secures a cover in position shall be M4, No. 8, or larger for a cover 232,300 mm^2 (360 in^2) or less in area, and shall be M4.5, No. 10, or larger for a cover more than 232,300 mm^2 (360 in^2) in area.

6.7.3.5 Other than as detailed in 6.7.3.6 and 6.7.3.7, there shall be one or more fastenings located not more than 152 mm (6 inches) from each of the four corners of an enclosure. The spacing between adjacent fastenings shall not be more than 610 mm (24 inches). See Figure 6.2 and Figure 6.3.

6.7.3.6 Fastenings may be omitted along the vertical edge of a cover that is adjacent to an opening for installed equipment, if the vertical edge is flanged at least 12.7 mm (1/2 inch) for the full length of the opening and all other edges of the surface are secured by the required fastenings.

6.7.3.7 An unflanged cover that does not extend more than 19.1 mm (3/4 inch) beyond the edges of the box for which it is intended may have fastenings located at not more than 152 mm (6 inches) from adjacent edges of the box, 216 mm (8-1/2 inches) 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 a box of the same size; and

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

6.7.3.8 Other than as permitted by 6.7.3.9, a flanged cover shall be securely fastened to the box by screws or other means that have been found to be equivalent. The number and location of fastenings shall be as specified in 6.7.3.2 to 6.7.3.5 for the fastenings of a flat cover.

6.7.3.9 A flanged cover may be fastened to the box by a combination of pins or similar projections, cooperating with holes or indentations and screws, or by screws alone, provided that:

a) If the cover area is not more than 32,900 mm^2 (51 in^2) in area and has no dimension greater than 216 mm (8-1/2 inches), not less than either 1 screw and 1 pin or 2 screws are used; or

b) If the cover area is not more than 232,300 mm^2 (360 in^2) in area and has no dimension greater than 610 mm (24 inches), not less than 2 screws and 1 pin, 1 screw and 2 pins, or 3 screws are used.

6.7.3.10 The cover flange mentioned in 6.7.4.3(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 76.2 mm (3 inches) or fraction thereof along the length of the enclosure flange, and there shall be one or more of these fastenings within 38.1 mm (1-1/2 inches) of each of the enclosure flange.

6.7.4 Notched flanges

6.7.4.1 The flange of a cover other than as noted in 6.7.4.2 to 6.7.4.4 shall not be notched.

6.7.4.2 The edge of a flanged cover that is intended to be fastened to the box by four or more fastenings may be notched to provide space around a knockout in the box if:

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 3.2 mm (1/8 inch) at any point; and

c) The front edges of the box are flanged in accordance with 6.7.4.3.

6.7.4.3 The flange mentioned in 6.7.4.2(c) may be either:

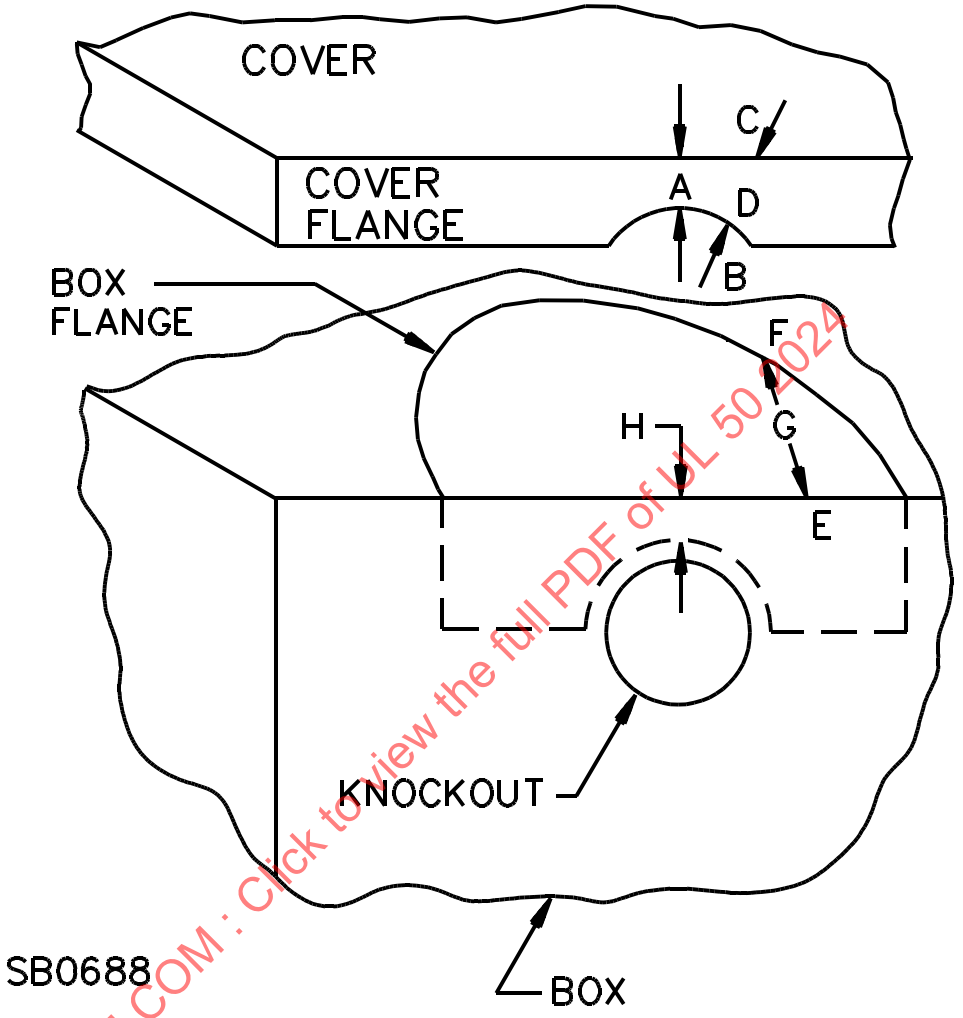
a) Integral with the enclosure wall, that is, formed from the same sheet as and comprising an extension of the enclosure wall; or

b) A separate flange that complies with the requirement in 6.7.3.10 and is attached to the side of the enclosure.

The flange shall have a width and length in accordance with Figure 6.9.

Figure 6.9

Notched-Cover-Flange Construction



A – Depth of cover flange at notch – minimum 3.2 mm (1/8 inch), measure 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 12.7 mm (1/2 inch) for all points B, C, E, and F.

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

6.7.4.4 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 3.2 mm (1/8 inch).

6.7.5 Depth of flange

6.7.5.1 Other than as permitted by 6.7.5.2 and 6.7.5.3, the flange on a cover or door shall:

a) Comply with Figure 6.10 or be evaluated in accordance with Figure 6.11;

b) Fit closely with the outside wall of the enclosure proper in accordance with Figure 6.10;

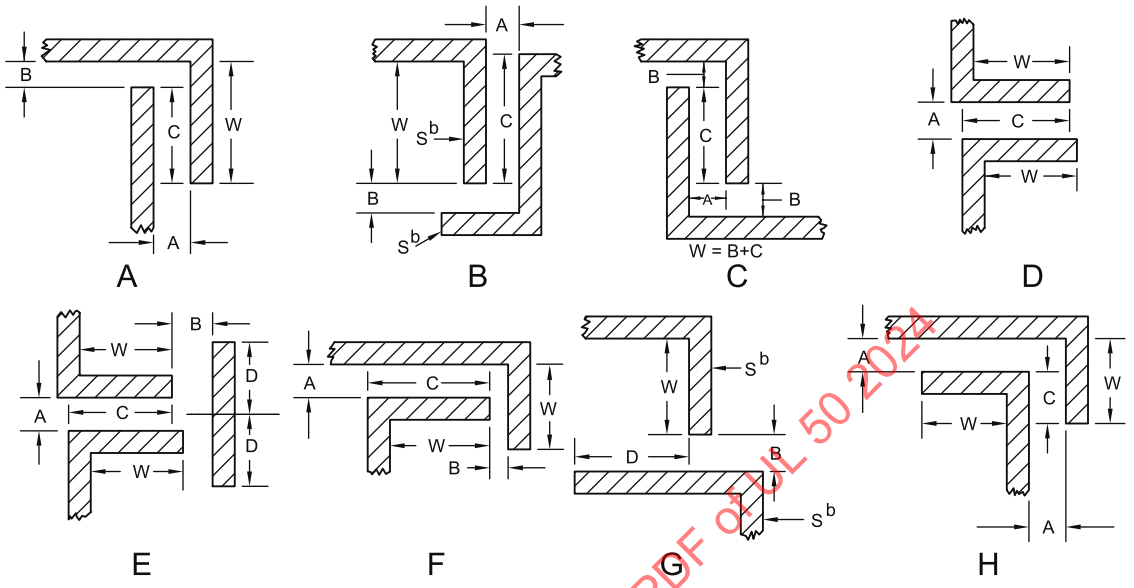
c) Have a width in accordance with Figure 6.10;

d) Except as permitted by 6.7.4.2, have flanges for the full length; and

e) Where a telescoping cover meets the box of a surface mounted enclosure (see Drawing H of Figure 6.10), overlap all edges in accordance with Figure 6.10.

Figure 6.10

Flanged Cover and Door Constructions[a]



[a] See the following Table for the dimensions of sketches A – H.

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

Dimensions for Figure 6.10

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

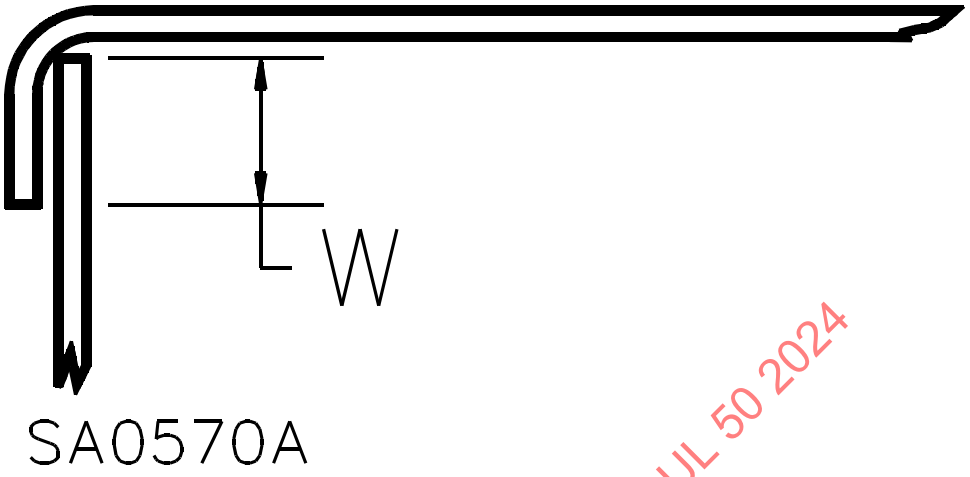
[a] To determine whether a flanged cover complies with this requirement, the distance between the flat portion of the cover - clear of forming radii, beads, draws, or the like – and a straightedge placed across any two flanges at any point shall be measured.

[b] Tolerances – minus 1.6 mm (1/16 inch).

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

Figure 6.11

Measurement of Overlap



6.7.5.2 A construction may employ notches, holes, and indentations as specified in 6.4.3.3 and 6.4.3.6.

6.7.5.3 A construction employing an enclosure and a cover, both of which are flanged, as specified in 6.7.5.5 and 6.7.6.4 may be used.

6.7.5.4 To determine whether a flanged cover complies with the requirement in 6.7.5.1, 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 shall be measured.

6.7.5.5 For the construction described in 6.7.5.1, 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 12.7 mm (1/2 inch) and either:

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

b) A cover more than 254 mm (10 inches) wide complies with the requirement in 8.2.2.

6.7.6 Overlap

6.7.6.1 An unflanged cover attached to a box for flush mounting shall extend at least 12.7 mm (1/2 inch) beyond each of the outer walls of the box. The extension may be bent inward for reinforcement not more than 1.6 mm (1/16 inch) from the plane of the face of the cover, other than as modified by 6.7.6.2.

6.7.6.2 The extension allowed by 6.7.6.1 may be bent more than 1.6 mm (1/16 inch) but not more than 4.8 mm (3/16 inch) from the plane of the face of the cover if the box is marked in accordance with 7.4.

6.7.6.3 If an unflanged cover is attached to a box intended for surface mounting, each wall of the box shall have a flange, at right angles to the wall. The minimum metal-to-metal contact between the cover and the flange on the box shall not be less than 11.1 mm (7/16 inch). See Figure 6.1.

6.7.6.4 The overlap of a telescoping cover may be not less than 6.4 mm (1/4 inch) 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 6.10.

6.8 Hinges

6.8.1 Butt hinges

6.8.1.1 A hinge for a door shall be sufficiently strong to perform its intended function without distortion and shall be securely fastened:

a) At two or more points to the box or trim and to the door;

b) By a single fastener if additional means, such as a boss or flange, is provided to maintain hinge alignment and there are two or more hinges;

c) By a single weld for a hinge not larger than 25.4 mm^2 (1 in^2) provided the hinge remains in place after the door has been subjected to abuse such as might be expected in service; or

d) By other hinge securing constructions if found to be equivalent in performance.

6.8.1.2 Unless the door is tested in accordance with 8.3, hinge pins shall:

a) For a door 232,300 mm^2 (360 in^2) or less in area, be not less than 4.0 mm (5/32 inch) in diameter if made of brass or aluminum and not less than 3.2 mm (1/8 inch) in diameter if made of steel; or

b) For a larger door, be not less than 4.8 mm (3/16 inch) in diameter.

6.8.1.3 Two or more hinges shall be provided for each door, except that:

a) A single hinge shall be permitted on either side of a door not exceeding 127 by 229 mm (5 by 9 inches) provided the length of the hinge is not less than one-third the length of the longer side and is centered on the door;

b) A single hinge shall be permitted on a door having dimensions greater than 127 by 229 mm (5 by 9 inches) provided the length of the hinge is not less than 80 percent the full length of the door and is centered on the door; or

c) A single hinge that extends approximately the full length of the door shall be permitted.

6.8.1.4 Hinges shall be spaced as specified in Table 6.7. The spacing between hinges shall be measured between centers of the hinges; the spacing between a hinge and the end of a door shall be measured from the edge of the hinge.

Table 6.7
Hinge Spacings 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]		
mm	(inch)	mm	(inch)	mm	(inch)		mm	(inches)
102	(4)	610	(24)	None	None		–	–
102	(4)	813	(32)	None	None	steel	2.36	(0.093)
						or Al, Cu, or brass	3.09	(0.122)
102	(4)	914	(36)	12.7	(1/2)		–	–

Table 6.7 Continued on Next Page

Table 6.7 Continued

Maximum spacing				Construction of door or cover				
From each end of door or cover		Between hinge centers		Flange width		Metal and minimum thickness[c]		
mm	(inch)	mm	(inch)	mm	(inch)		mm	(inches)
152	(6)[a]	914	(36)	12.7	(1/2)		–	–
254	(10)[b]	914	(36)	12.7	(1/2)		–	–
229	(9)	914	(36)	25.4	(1/2)		–	–
305	(12)	1016	(40)	25.4	(1/2)	steel	2.36	(0.093)
						or Al, Cu, or brass	3.09	(0.122)

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

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

[c] See Table 6.3 and Table 6.4.

6.8.2 Ear-type hinges

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

6.8.2.2 Hinges of the ear type shall not be spaced more than 610 mm (24 inches) apart.

6.8.3 Formed hinges

6.8.3.1 A formed hinge consists of a strip of sheet metal secured to or integral with the box or trim formed so that it will cooperate with a slot in the door to form a hinge.

6.8.3.2 Formed hinges shall not be used for a door having any edge longer than 610 mm (24 inches) and having an area of more than 232,300 mm^2 (360 in^2).

6.8.3.3 Formed hinges shall be located not more than 102 mm (4 inches) from the ends of the door and not more than 254 mm (10 inches) apart. Hinge spacings shall be measured from the centers of the hinges. Except as permitted by 6.8.3.4, at least two hinges shall be provided for each door.

6.8.3.4 A single hinge shall be permitted on the shorter side of a door if the length of the hinge is not less than one-third that of the longer side of the door.

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

6.8.3.6 The thickness of a separate strip shall not be less than 1.35 mm (0.053 inch), other than as follows. Metal not less than 1.27 mm (0.050 inch) thick may be used if the smaller dimension of the door is not more than 114 mm (4-1/2 inches) and the length of the hinged side is not more than 178 mm (7 inches).

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

6.9 Latches and handles

6.9.1 Each door shall be provided with a latch that is positive in action and of substantial design and construction, except that screw fastenings or locks shall be permitted in place of a latch for an enclosure that has a door.

6.9.2 Double doors that overlap shall be secured at a minimum of two latched points, one located at each end. Latches are only required on the door that closes last. Double-doors that do not overlap shall have two latched points per door, one located at each end of each door.

6.9.3 A door more than 1.22 m (48 inches) long on the hinged side shall be fastened at two or more latched points.

6.9.4 For a door that has flanged edges and that does not exceed 457 mm (18 inches) in width or length, a latch may 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.

6.9.5 An enclosure having a door 457 mm (18 inches) or less in both dimensions may employ a snap catch providing a fastening equivalent to the button catch.

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

6.9.7 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.

6.10 Connections for wiring systems

6.10.1 General

6.10.1.1 Openings in enclosures for conduit or threaded connectors shall be of such sizes and so located that the conduit can be readily inserted and shall permit the proper seating of a conduit bushing or locknut (see Annex D for knockout dimension information).

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

6.10.2 Knockouts

6.10.2.1 Knockouts shall be so formed that they are capable of being readily removed but will not drop out during ordinary handling. Multiple ring knockouts shall have sufficient strength to meet the test requirements of 8.4.

6.10.3 Breakouts

6.10.3.1 Breakouts shall be so formed that:

a) The material can be readily removed, using ordinary care, to provide an opening of the required size without damaging the remainder of the enclosure or any outer rings; and

b) The strength of any remaining rings will withstand the loading test specified in 8.4.3(b).

6.10.4 Threaded openings

6.10.4.1 Notwithstanding 6.10.4.2 to 6.10.4.5, in Canada, threaded conduit entries for the connection of conduit shall comply with the requirements of Annex B, Ref. No. 7, except two full threads shall be acceptable if the threaded opening complies with the Metallic enclosure threaded opening test in 8.7.

6.10.4.2 A threaded hole for the connection of conduit that is tapped all the way through an enclosure shall be provided with not less than three full threads, except as permitted by 6.10.4.3. The construction shall be such that a conduit bushing can be properly attached as intended.

6.10.4.3 Two full threads shall be acceptable if the threaded opening complies with the Metallic enclosure threaded opening test in 8.7.

6.10.4.4 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.

6.10.4.5 The inlet hole shall:

a) Be smooth and rounded to 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.

6.10.5 Nonmetallic-sheathed cable clamps

6.10.5.1 A separable or integral clamp provided as part of a factory assembled enclosure and intended for securement of nonmetallic-sheathed cable shall comply with the applicable requirements of Annex B, Ref. No. 5 and No. 6. Size of openings shall comply with 6.10.5.2.

6.10.5.2 A separable or integral clamp provided as part of a factory assembled enclosure and intended for securement of nonmetallic-sheathed cable shall substantially close the opening in the enclosure as determined by the following:

a) the clamp, constructed or mounted as part of the factory assembled enclosure with no cable installed, shall inhibit the passage of a 2.5 mm (3/32 inch) diameter probe, no force being applied to the probe that would result in repositioning of the clamp; or

b) the clamp shall be provided, at the factory, with a means to individually close each opening.

6.11 Conduit hubs

6.11.1 A conduit hub shall be threaded and shall have a wall thickness before threading not less than that for the corresponding trade size of conduit.

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

6.11.3 A conduit hub intended to be secured to a metallic enclosure shall either have been evaluated in accordance with Annex B, Ref. No. 5, or shall be subjected to the Metallic enclosure conduit hub test described in 8.8.

6.12 Field-installed accessories/kits

6.12.1 These requirements apply to enclosure accessories/kits intended to be installed on an enclosure in the field.

6.12.2 These accessory/kits shall comply with the following:

a) Each accessory/kit shall be acceptable for the intended use and when installed in the intended manner shall comply with all applicable requirements of this standard.

b) Each accessory/kit shall be capable of being installed without the use of a special tool unless such a tool, and instructions for its use, are furnished with each accessory/kit.

c) Each accessory/kit shall be provided with installation instructions that identify all parts involved and that specify the method of installation.

d) Each accessory/kit shall be marked in accordance with 7.1.

7 Marking

Advisory Note: In Canada, there are two official languages, English and French. Markings required by this standard will in some cases have to be provided in other languages to conform with the language requirements of the country where the product is to be used.

7.1 Enclosures and accessories/kits

7.1.1 Enclosures and accessories/kits for use with enclosures shall be marked with the manufacturer's name or trademark and the catalog number or equivalent.

7.1.2 If the cover or door is shipped separately from the box, then both the cover or door and the box shall bear this marking.

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

7.2 Cast metal enclosure

7.2.1 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 is acceptable. If counter-boring is necessary to accommodate certain sizes of conduit, such information shall be given. The instructions may be provided on an instruction sheet provided with the enclosure or marked on the packaging carton.

7.3 Cast-aluminum enclosure

7.3.1 If it is intended that a cast-aluminum enclosure be acceptable for use in concrete or cinder fill and the enclosure has been found to be acceptable for such use, the enclosure or packaging carton shall be marked, "Suitable for use in concrete or cinder fill", or the equivalent.

7.4 Extension

7.4.1 An enclosure constructed as permitted by 6.7.6.2 shall be marked to indicate that if flush mounted in a wall of combustible material the enclosure shall protrude 3.2 mm (1/8 inch) from the finished surface of the wall.

7.5 Insulating material

7.5.1 The marking required for enclosures that are made of insulating material in accordance with 6.6.2.1 shall:

a) Be located where visible during installation, such as inside the cover; and

b) Consist of the following or the equivalent, "Bonding between conduit connections is not automatic and shall be provided as a part of the installation."

7.6 Polymeric enclosure

7.6.1 A polymeric enclosure that is intended for connection to a rigid metallic conduit system that has not been subjected to the Torque test described in 8.6.3, and that is not provided with a pre-assembled hub, shall have instructions stating that the hub shall be connected to the conduit before the hub is connected to the enclosure.

7.7 Conduit hubs, closure plates, and other equipment

7.7.1 Enclosures intended for use with conduit hubs, closure plates, and other equipment (such as push-button switches) intended to be field installed shall be marked or provided with instructions that identify the equipment necessary 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.

7.8 Ventilated enclosures

7.8.1 Ventilated enclosures in which the equipment to be installed is not known, and in which compliance with 8.9 depends upon the location of such equipment, shall be marked to indicate the area in which live parts are to be installed.

8 Tests

8.1 Comparative deflection test (enclosure)

8.1.1 When subjected to the deflection test in 8.1.2, an enclosure that is thinner than that specified in Table 6.3 and Table 6.4 (see 6.4.1.2) 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.

8.1.2 Force shall 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 shall be sufficient to result in a measurable deflection of the test enclosure. For the test, the enclosure shall rest on a smooth, solid, horizontal surface. A vertical force shall be applied, at any point, through a rod having a 12.7 mm (1/2 inch) square flat steel face.

8.2 Deflection test (doors and covers)

8.2.1 A door or cover constructed as permitted by 6.7.2.1 shall not deflect inward more than 6.4 mm (1/4 inch) when a vertical force of 445 N (100 pounds) is applied at any point on the door, or cover. The force shall be applied through a rod having a 12.7 mm (1/2 inch) square flat steel face. For the test, the enclosure shall 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 may be used for additional tests.

8.2.2 If a flange on the upper edge of a telescoping door or cover is reduced in depth or is omitted as indicated in 6.7.5.5(b), the door or cover shall not deflect more than 9.5 mm (3/8 inch) when subjected to a force of 445 N (100 pounds) applied at any point 25.4 mm (1 inch) from the edges. The test shall 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 shall be applied through the end of a rod having a 12.7 mm (1/2 inch) square flat steel face.

8.3 Hinge strength test

8.3.1 For constructions requiring tests as permitted by 6.8.1.2, a door shall withstand a load of 4 times its weight but not less than 9.1 kg (20 pounds) without causing permanent deformation of the hinge. The load shall be applied vertically downward through the center of gravity of the door.

8.4 Multiple knockouts test

8.4.1 This clause provides test requirements to determine that a combination consisting of an inner knockout surrounded by additional rings has been manufactured such that when one or more of its elements are removed there will be no change to the remaining rings, if any, or to the enclosure in which the combination is located, either during the removal or when conduit has been properly secured in place.

8.4.2 Samples for testing shall be in the form of either complete enclosures or sample plates that fulfill the requirements of Figure 8.1.

8.4.3 With a sample enclosure securely held or a test plate supported as in Figure 8.1, the following tests shall be applied:

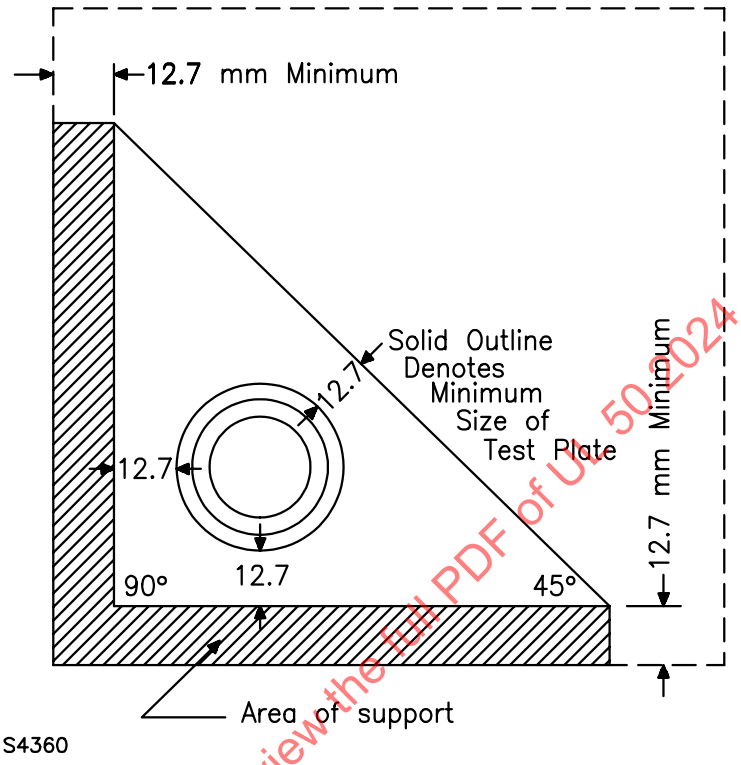
a) The knockout shall remain in place when subjected to a load of 44 N (9.9 pounds) steadily applied for not less than 1 minute normal to the face of the plate by means of a mandrel with a 6.35 mm (1/4 inch) diameter flat end. The mandrel shall be applied at the point most liable to cause movement of the knockout in the direction in which it was originally punched; and

b) A load of 220 N (49.4 pounds) shall be steadily applied for not less than 1 minute, first in compression and second in tension, through a conduit properly installed in the knockout opening. When this test is being conducted, the conduit shall not be more than 5° from the normal to the surface. There shall be no appreciable distortion of the rings or fracture of the ties.

8.4.4 The knockout and each additional ring, starting at the smallest, shall be capable of being easily and cleanly removed without disturbing the other rings or distorting the enclosure. The sample, if a test plate, shall be supported as shown in Figure 8.1.

Figure 8.1

Diagram of Test Plate



8.5 Polymeric enclosures – bonding test

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

8.6 Polymeric enclosures – rigid metallic conduit connection test

8.6.1 Criteria

8.6.1.1 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 pullout, torque, and bending procedures described in 8.6.2 to 8.6.4. If breakouts are incorporated in the enclosure, they shall remain in place following the procedure described in 8.6.5.

8.6.1.2 The torque test need not be conducted on an enclosure that is not provided with a preassembled hub and that complies with 7.6.

8.6.2 Pullout

8.6.2.1 The enclosure shall 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 890 N (200 pounds) shall be applied for 5 minutes to a length of conduit in the opposite wall.

8.6.3 Torque

8.6.3.1 The enclosure shall be securely mounted as intended in service. A torque in accordance with Table 8.1 shall be applied to a length of installed conduit in a direction tending to tighten the connection. The lever arm shall be measured from the center of the conduit.

Table 8.1
Tightening Torque

Trade size of conduit	Tightening torque[a]	
	N·m	(pound-inches)
3/4 and smaller	90.4	(800)
1, 1-1/4, and 1-1/2	113.0	(1000)
2 and larger	181.0	(1600)

[a] In accordance with 1.3, other values may be specified by end-use product standards.

8.6.3.2 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 maximum trade size opening for the connection of conduit, need only be subjected to a tightening torque of 22 N·m (200 pound-inches).

8.6.4 Bending

8.6.4.1 A 3.0 m minimum (9 feet – 10-7/64 inch) length of conduit of the intended size shall 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.

8.6.4.2 The enclosure shall be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. The test shall be terminated once the deflection of the conduit end exceeds 255 mm (10 inches). If a weight is necessary to cause the conduit end to deflect, the test shall be terminated once the deflection of the conduit end exceeds 255 mm (10 inches) or once a bending moment as specified in Table 8.2 is achieved.

For the SI system of units, the magnitude of the weight shall be determined from the equation:

$$W = (0.1M - 0.5CL) / L$$

in which,

W and *C* are measured in kilograms;

M is in Newton-meters; and

L is in meters.

For inch-pound units, the magnitude of the weight shall be determined from the equation:

$$W = (M - 0.5\,CL) / L$$

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.

Table 8.2
Bending Moment

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

[a] If the enclosure surface may be installed in either a horizontal or a vertical plane, the vertical bending moment value shall be used.

[b] For an end-of-line enclosure as defined in 8.6.3.2, the bending moment shall be 17.0 N·m (150 pound-inches).

8.6.5 Breakouts

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

8.7 Metallic enclosure threaded opening test

8.7.1 General

8.7.1.1 A threaded hole for the connection of conduit (see 6.10.4.1) shall be subjected to the Torque test in 8.7.2 and the Bending moment test in 8.7.3. Threads shall not strip and the walls of the enclosure shall not fracture.

8.7.2 Torque

8.7.2.1 With conduit installed and the enclosure rigidly mounted, the tightening torque shall be applied for 5 minutes as specified in Table 8.1.

8.7.3 Bending moment

8.7.3.1 With conduit installed and the enclosure rigidly mounted, a bending moment of 68 N·m (600 pound-inches) shall be applied to its axis. The lever arm shall be measured from the wall of the enclosure to the point of application of the force.

8.8 Metallic enclosure conduit hub test

8.8.1 A conduit hub (see 6.11.3) shall withstand the tightening torque specified in Table 8.1 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.

8.9 Rod entry test

Note: This test is intended to simulate incidental contact with enclosed equipment.

8.9.1 Ventilated enclosures test method

8.9.1.1 For ventilated enclosures with live parts located less than 102 mm (less than 4 inches) from the openings, this test shall be made by attempting to insert a rod having a diameter of 12.7 mm (1/2 inch).

8.9.1.2 For ventilated enclosures with live parts located 102 mm or more (4 inches or more) from the openings, this test shall be made by attempting to insert a rod having a diameter of 19 mm (3/4 inch).

8.9.2 Evaluation

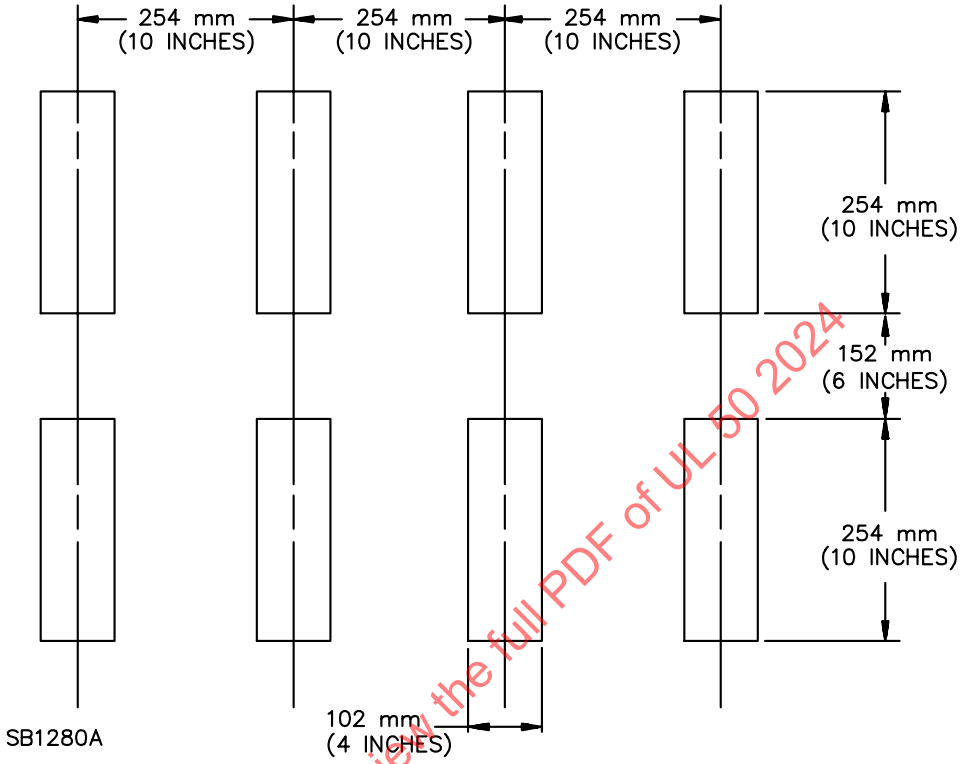
8.9.2.1 The enclosure shall be considered to have met the requirement if the rod cannot enter the enclosure.

8.10 Crushing resistance test

8.10.1 Three samples of equipment shall be supported on the mounting side by a fixed rigid supporting surface, in the position that is recommended by the manufacturer. Crushing force shall be applied to the exposed surfaces of the enclosure. The compression force shall be applied by flat surfaces each 102 by 254 mm (4 by 10 inches). Each force applicator shall exert 445 N (100 pounds) on the sample for 1 minute. As many applicators shall be applied as the sample can accommodate, up to a maximum of 8, based upon an arrangement of applicators as indicated in Figure 8.2.

Figure 8.2

Location of Applicators for Crush-Resistance Test



8.10.2 The test shall be considered successful if at the conclusion none of the following occur:

a) Spacings are reduced below the minimum acceptable values;

b) Bare live parts or internal wiring are made accessible to contact;

c) Breakage, cracking, rupture, and the like produce an adverse effect on the insulation; and

d) Any other condition that would increase the likelihood of electric shock or fire, or both, during use of the equipment.

8.11 Mold stress relief test

8.11.1 One representative sample of the insulating material (except for rigid thermosetting materials) assembled as intended shall be placed in a full draft circulating air oven maintained at a uniform temperature at least 10 °C (50 °F) higher than the maximum temperature of the material measured during the temperature test, but not less than 70 °C (178 °F) in any case. The sample shall remain in the oven for 7 hours. After its removal from the oven and return to room temperature, the sample shall be investigated for compliance with 8.11.2.

8.11.2 Conditioning of the equipment as described in 8.11.1 shall not cause softening of the material as determined by handling immediately after the conditioning, nor shall there be any shrinkage, warpage, or other distortion, as judged after cooling to room temperature, that results in any of the following:

a) Reduction of spacings between uninsulated live parts of opposite polarity, uninsulated live parts and accessible grounded metal, uninsulated live parts and the enclosure below the minimum acceptable values;

b) Making uninsulated live parts or internal wiring accessible to contact, or defeating the integrity of the enclosure so that acceptable mechanical protection is not afforded to internal parts of the equipment; or

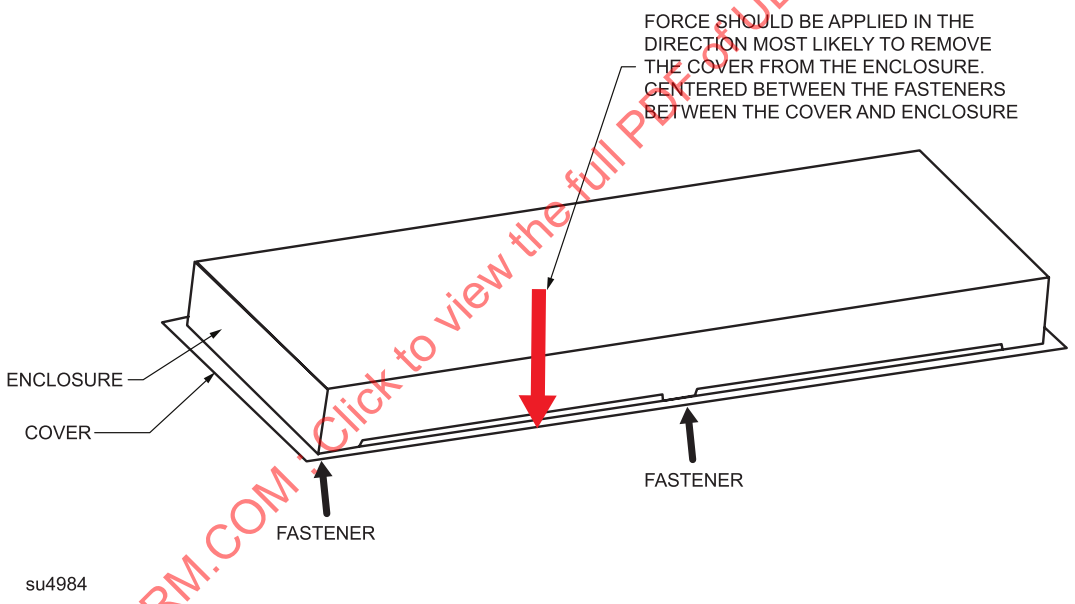
c) Causing interference with the intended operation or servicing of the equipment.

8.12 Cover pull test

8.12.1 For tests permitted by 9.2.3, a cover that is fastened as intended to a fully assembled box shall not permit an opening of 12.7 mm (1/2 inch) or greater to be created between the cover and the box, when subjected to a 156 N (35 lb) pull force (see Figure 8.3).

Figure 8.3

Cover Pull Test



NOTE: Force is centered between the two furthest fasteners and may be the worst case representative in a product line.

8.12.2 To determine compliance with 8.12.1, the force shall be gradually applied (creating no impulse force) through a 12.7 mm (1/2 inch) square flat surface, at the point on the cover edge that is centered between adjacent fasteners, and in the direction perpendicular to the plane of the cover and away from the box in order to create separation between the cover and the box.

8.12.3 The cover shall be considered to have met the requirement if no opening of 12.7 mm (1/2 inch) or greater is created, when measured by acceptable means. If a gage is used, it shall be in the shape of a rod with a diameter of 12.7 mm (1/2 inch). No additional force shall be exerted by or through the gage that results in greater than 156 N (35 lb) of total force being applied to the test location, similarly, no additional force shall be applied to the gage that tends to increase the size of the opening being measured.

8.13 Side wall deflection test

8.13.1 For tests permitted by 9.2.3, the side walls of a box, when fully assembled and fastened to a cover, shall not permit an opening of 12.7 mm (1/2 inch) or greater to be created between the cover and the box, when subjected to a 220 N (49.5 lb) pull force.

8.13.2 To determine compliance with 8.13.1, the force shall be gradually applied (creating no impulse force), at a point on the side wall that is centered between adjacent fasteners, and in the direction perpendicular to the plane of the side wall in order to create separation between the edge of the cover and the box side wall, as follows (see Figure 8.4):

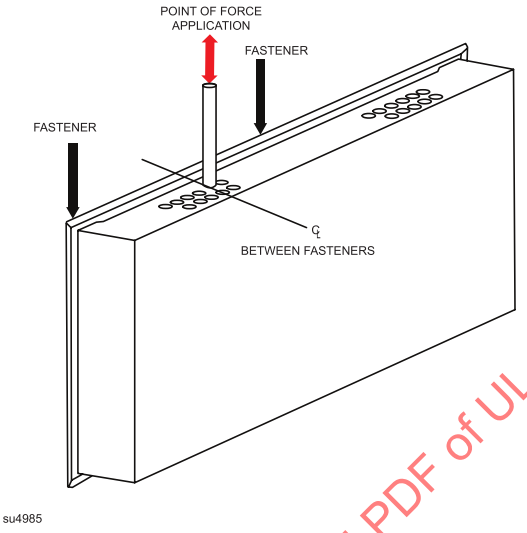
a) Using any convenient means, the force shall be applied to the end of an attached conduit (or similar means if there is no knockout at the location) resulting in a compressive load tending to deflect the side wall into the enclosure;

b) Using any convenient means, the force shall be applied to the end of an attached conduit (or similar means if there is no knockout at the location) resulting in a tensile load tending to deflect the side wall outward.

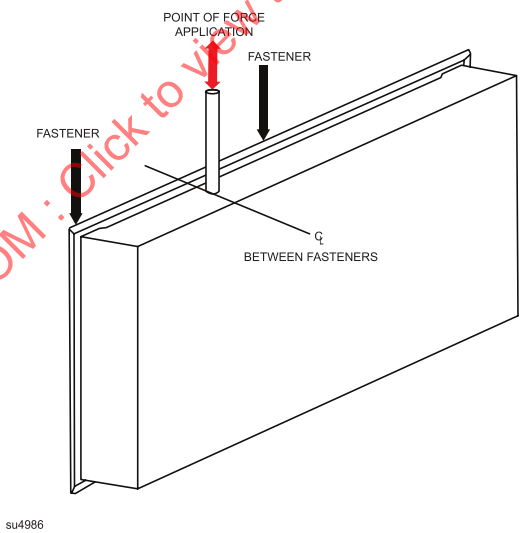
Figure 8.4

Side Wall Deflection Test

a) Conduit installed in a knockout or an opening, provided as a part of the enclosure.



b) Created hole at the center of the largest distance between adjacent fastenings



8.13.3 The box side walls shall be considered to have met the requirement if no opening of 12.7 mm (1/2 inch) or greater is created, when measured by acceptable means. If a gage is used, it shall be in the shape of a rod with a diameter of 12.7 mm (1/2 inch). No additional force shall be exerted by or through the gage that results in greater than 220 N (49.5 lb) of total force being applied to the test location, similarly, no additional force shall be applied to the gage that tends to increase the size of the opening being measured.

9 Cabinets and Cutout Boxes

9.1 General

9.1.1 In Mexico and the United States, a cabinet or cutout box shall comply with the requirements for enclosures. However, the requirements in 9.2 shall supersede equivalent requirements for enclosures. In Canada, this requirement does not apply.

9.2 Sheet metal cabinets

9.2.1 Notches

9.2.1.1 The front flange of each of the two side walls of a Type 1 enclosure intended for use with a panelboard may have one notch to accommodate means for installing the cover. Each notch shall not be more than 17.5 mm (11/16 inch) wide.

9.2.2 Slot and tab fastenings

9.2.2.1 Slot and tab fastenings, consisting of a small cutout on the inner flange surface and a tab created by pushing in a small segment of metal from the overlapping flange, are considered as an acceptable fastening only when used in Type 1 enclosures and are used in combination with a rivet, weld, bolt, or screw having machine screw threads in at least one of the following locations on each length of a flange:

a) At the back edge of the enclosure, provided that the distance between the fastenings (including the slot and tab fastenings) comply with 6.4.2.5; or

b) Joining adjacent sides, including a top or bottom side, to comply with 6.4.2.3, except that a rivet, weld, bolt or screw having machine screw threads shall be used to secure the front edge of the enclosure in accordance with 6.4.2.3 and 6.4.2.4.

9.2.3 Box and cover (Alternative to construction requirement)

9.2.3.1 Alternative to the construction requirements of 6.7.6.3, a box and cover shall be permitted to be unflanged if the combination complies with the Cover Pull Test described in 8.12 and the Side Wall Deflection Test described in 8.13.

9.2.3.2 When these cabinets and cutout boxes are rated other than Type 1, the applicable environmental tests shall be conducted with the same sample after it has completed tests in 8.12 and 8.13.

10 Junction and Pull Boxes

10.1 General

10.1.1 In Mexico and the United States, the requirements in 10.1 to 10.9 apply. In Canada, these requirements do not apply.

10.1.2 In addition to the requirements in 10.2 to 10.9, a junction or pull box shall comply with the requirements for enclosures. However, the requirements in 10.2 to 10.9 shall supersede equivalent requirements for enclosures.

10.1.3 A junction or pull box shall not include ventilation openings.

10.2 Covers and doors

10.2.1 A junction or pull box cover shall have no door and shall be secured to the box by screws, bolts, or the equivalent.

10.3 Conduit openings

10.3.1 Other than as permitted by 10.3.2 and 10.3.3, a junction or pull box provided with one or more integral conduit hubs, for 3/4 trade size or larger, shall comply with the following:

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

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

10.3.2 If permanent barriers are installed in a box, each section shall be considered as a separate box.

10.3.3 A box may be smaller if marked in accordance with 10.6.4.

10.3.4 If the conduit 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 10.1.

Table 10.1
Distance from Removable Cover to Opposite Wall with Raceway Opening

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

10.4 Equipment grounding

10.4.1 Other than as permitted in 10.4.2 and 10.4.3, a junction or pull box shall be provided with means for connection of an equipment-grounding conductor.

10.4.2 A junction or pull box that is marked in accordance with 10.6.1 or 10.6.2 need not be provided with means for connection of an equipment grounding conductor.

10.4.3 A cast metal junction or pull box need not be provided with means for connection of an equipment grounding conductor.

10.4.4 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 in service by electrolysis.

10.4.5 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 the metallic coating thickness test described in Annex B, Ref. No. 8.

10.4.6 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 10.2.

Table 10.2
Metallic Coating Thickness Test

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

10.4.7 A pressure wire connector employed at an equipment grounding terminal shall comply with the requirements of Annex B, Ref. No. 14 , 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 8 AWG (8.4 mm^2) or larger conductor and for not more than three 10 AWG (5.3 mm^2) or smaller conductors.

10.4.8 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 Ω .

10.4.9 To determine if a connection complies with the requirements in 10.4.8(b), a current of 30 A shall be passed through the bonding connection. The resulting voltage drop shall be measured between a point (file mark) on the conductor 1.6 mm (1/16 inch) from the connection and a similar point on the enclosure not less than 1.6 mm (1/16 inch) from the bonding connection.

10.4.10 Other than as permitted by 10.4.11, an equipment grounding terminal or assembly shall be green or the heads of the terminal screws thereon shall be green.

10.4.11 The color identification specified in 10.4.10 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 ⏚ (from IEC Publication 60417, Symbol 5019), adjacent to the terminal or on a wiring diagram.

10.4.12 A tapped hole provided for a grounding screw shall have a minimum of two full threads or shall comply with 10.4.13.

10.4.13 The threads of holes provided in a box for attachment of a ground screw having fewer than 2 full threads shall not strip when a No. 8 screw is tightened to a torque of 2.26 N·m (20 lbf-in), or a No. 10 screw is tightened to a torque of 3.96 N·m (35 lbf-in). During the test, a plated flat steel washer of a size appropriate for the screw shall be centered under the head of the screw. Holes having at least two full threads are not required to be tested.

10.4.14 Wire binding screws of equipment grounding terminals shall comply with Annex B, Ref. No.18.

10.5 Removable sides

10.5.1 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 6.4.2.

10.6 Marking details

10.6.1 A junction or pull box that is not provided with a means of terminating equipment grounding conductors and that does not have a means for the field installation of an equipment grounding assembly, see 10.6.2, shall be marked to indicate that the junction or pull box shall be used in an installation in which equipment is grounded by connection to metal raceway or metallic cable sheaths.

10.6.2 Other than as permitted by 10.6.3, 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 instructions and information stating the wire size of terminals available.

10.6.3 The information required by 10.6.2 may be provided on or in the individual shipping package or carton of the terminal or terminal assembly instead of on the box.

10.6.4 A junction or pull box that is smaller than required by 10.3.1 (see 10.3.2) shall be marked with the following:

“When used as a pull box, installation shall be in accordance with Section 370-28 of Mexico’s Electrical Installations, NOM-001-SEDE, and Section 314.28 of the National Electrical Code, NFPA 70.”

10.6.5 Junction and pull boxes with a volume of less than 1640 cm^3 (100 in^3) shall be marked with the enclosure volume in accordance with 10.8.1.

10.7 Air handling spaces

10.7.1 General

10.7.1.1 Nonmetallic junction and pull boxes intended to enclose only wires, barriers, or terminals as allowed by Section 300.22(C) of the National Electrical Code, intended to be installed in air-handling spaces shall additionally comply with the requirements in the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043.

Note: Products evaluated in accordance with these requirements are considered to comply with the fire retardant and low smoke producing requirements of Section 300.22(C)(3) of NFPA 70, Chapter 4 of NFPA 90A, Section 602 of the International Mechanical Code, and Section 602 of the Uniform Mechanical Code.

10.7.2 Markings

10.7.2.1 A junction or pull box intended for installation in air handling spaces and complying with 10.7.1 shall be marked as appropriate, "Suitable for Use In Air Handling Spaces Only When Containing Wiring Methods and Accessories as Allowed in Section 300.22(C) of the National Electrical Code", or equivalent wording.

10.8 Volume

10.8.1 A junction or pull box with an internal volume of less than 1640 cm^3 (100 in^3) shall be marked in accordance with 10.6.5 and the internal volume measured by test in accordance with 10.9 or by another equivalent means.

10.9 Performance

10.9.1 Volume measurement of boxes

10.9.1.1 Each box with an internal volume of less than 1640 cm^3 (100 in^3) shall hold a volume of water equal to or greater than the marked volume when three samples are tested in accordance with this Clause.

10.9.1.2 All separable cable clamps, fixture/luminaire studs, grounding conductors, internal screws, and other internal accessories shall be removed. Any projections that extend outside the plane of the open face of a box, such as ears for mounting a cover or a flush device, shall be ground flush with the face of the box.

10.9.1.3 All large openings shall be closed by flat, rigid plates clamped in place across the openings. One of the plates shall contain two small holes, one for the entrance of water and the other for venting air. See Figure 10.1 and Figure 10.2.

Figure 10.1

Volume Measurement

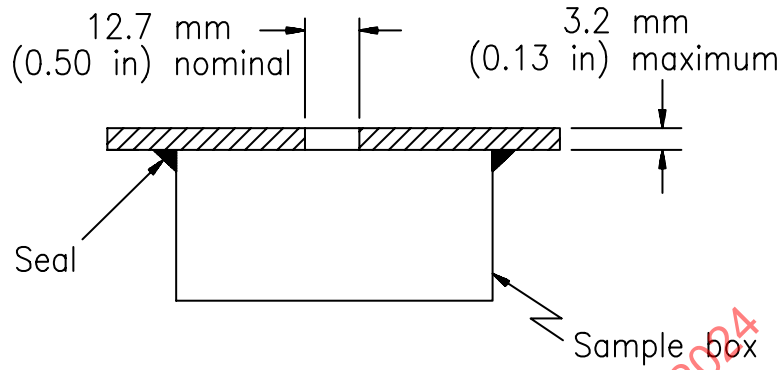


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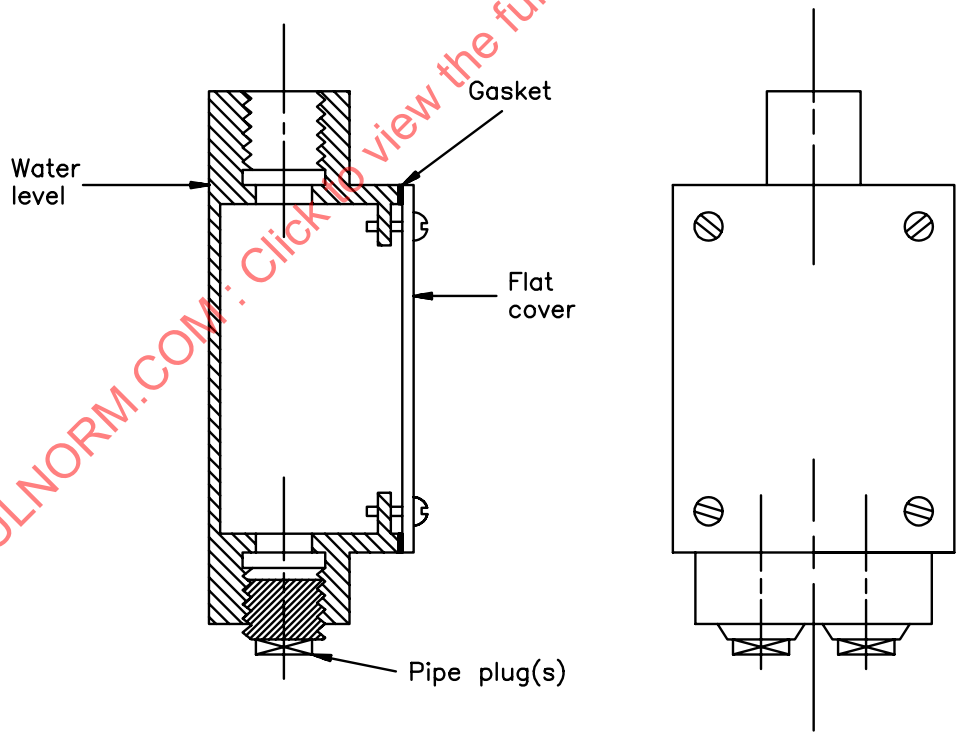
Figure 10.2

Volume Measurement, Cast-Metal Boxes



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10.9.1.4 Using modeling clay, putty, glazing compound, or similar material:

a) Holes through the side or bottom of the sample and a hole between the sample and the plate specified in 10.9.1.3 shall be filled flush with the inside surface.

b) Internal hubs, when tapped through, shall be filled flush with the end of the hub.

c) Openings that are bushed shall be filled flush with the conduit stop.

10.9.1.5 A clean, graduated vessel, pipette, or the equivalent, having a volume equal to or greater than the marked volume of the test sample, shall be filled with water at room temperature, and the volume of the water shall be measured. The water shall then be transferred from the vessel to the test sample through the hole in the plate as specified in 10.9.1.3 until the test sample is filled. The difference in the volume of water in the supply vessel, as measured before and after the filling of the test sample, indicates the volume of the test sample.

ANNEX A (Normative) – STANDARDS FOR COMPONENTS

A1.1 The ANCE, CSA Group, and UL Standards listed below are used for evaluation of components and features of products covered by this standard. Components need only comply with the applicable component standard acceptable in the country where the product is to be used. These standards shall be considered to refer to the latest edition and all revisions published to that edition.

A1.2 Standards under which components of the products covered by this standard are evaluated include the following:

ANCE Standards

NMX-J-017-ANCE, *Conduit, Tubing and Cable Fittings*

NMX-J-023/1-ANCE, *Metallic Outlet Boxes*

NMX-J-515-ANCE, *Industrial Distribution and Control Equipment*

CSA Group Standards

C22.1, *Canadian Electrical Code, Part I*

C22.2 No. 0.15, *Adhesive Labels*

CSA C22.2 No. 0.17, *Evaluation of Properties of Polymeric Materials*

C22.2 No. 18.3, *Conduit, Tubing, and Cable Fittings*

C22.2 No. 41, *Grounding and Bonding Equipment*

UL Standards

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 467, *Grounding and Bonding Equipment*

UL 514B, *Conduit, Tubing and Cable Fittings*

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

UL 969, *Marking and Labeling Systems*