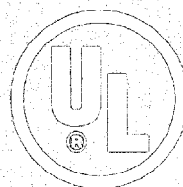


Standard for Safety

UL 1062

● Unit Substations

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April 30, 1993

Standard for

Unit Substations

UL 1062, Second Edition

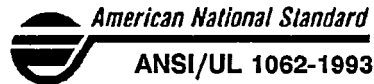
Accompanying this transmittal notice is a copy of the second edition of UL 1062.

THIS EDITION OF THE STANDARD IS NOW IN EFFECT.

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

Subscribers to UL's services in the area covered by this standard will receive these revised and/or additional pages automatically. Others may receive such pages by subscribing to UL's subscription service for revisions. See UL's CATALOG OF STANDARDS FOR SAFETY for a description of the revision subscription service, the cost of the service for this standard, and ordering information.

APRIL 30, 1993



1

UL 1062**Standard for****Unit Substations**

Prior to the first edition, the requirements for products covered by this standard were derived from the Standard for Enclosures for Electrical Equipment, UL 50 (when the title for UL 50 was Cabinets and Boxes); the Standard for Specialty Transformers, UL 506; the Standard for Service Equipment, UL 869; and the Standard for Dead-Front Switchboards, UL 891.

First Edition — March, 1983

Second Edition**April 30, 1993**

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated April 30, 1993. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

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

Approved as ANSI/UL 1062-1985, June 18, 1985
Approved as ANSI/UL 1062-1993, January 20, 1993

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

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(1 — 04/30/93 — 04/30/93)

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FOREWORD

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

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

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

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

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

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

INTRODUCTION

1 Scope

1.1 These requirements cover unit substations of 1000 kVA single phase and 3000 kVA 3-phase maximum having a maximum nominal primary or secondary rating of 600 volts. Their construction, installation, and use are intended to be in accordance with the National Electrical Code, ANSI/NFPA 70.

1.2 A product that contains features, characteristics, components, materials, or systems new or different from those in use when the standard was developed, and that involves a risk of fire, electric shock, or injury to persons, shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the level of safety for the user of the product as originally anticipated by the intent of this standard.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

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

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

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

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

2.2 Units of measurement

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

2.2.2 All applicable alternating-current electrical measurements are in root-mean-square (rms) units unless otherwise stated.

2.3 Undated references

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

3 Glossary

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

3.2 DUMMY FUSE — A current-carrying part made of copper having such dimensions that it will fit its fuse mounting means with the same conditions of pressure, contact, and cross-sectional areas as are obtained on terminals of the fuse that it is intended to replace.

3.3 FILLER PLATE — A plate intended to close an opening that would otherwise be closed by the subsequent installation of a circuit breaker or other device.

3.4 NEUTRAL — Neutral refers to the grounded circuit conductor, such as:

- a) The center point of a wye-connected system; or
- b) The corner of a delta-connected system; or
- c) The midpoint of a 3-wire, single phase or the midpoint of one side of a delta-connected system; or
- d) The grounded side of a 2-wire circuit.

3.5 UNIT SUBSTATION — A transformer in combination with primary or secondary overcurrent protective devices or switching devices housed in a single enclosure.

CONSTRUCTION

4 General

4.1 A unit substation shall be complete when it is shipped from the factory. If a switch, circuit breaker, or the like, mounted in a unit substation must be interconnected in order for it to perform its intended function, such interconnecting busing or wiring shall be complete before it is shipped from the factory.

Exception No. 1: A unit substation may have provision for the installation of a switch or circuit breaker in the secondary. If appropriate, markings as covered in 40.4.5 and 40.11.1 — 40.11.5 shall be provided.

Exception No. 2: A unit substation:

- a) *Employing circuit breakers or switches of different physical size that require branch bus bars of different physical size or shape, or*
- b) *In which circuit breakers or switches rated at more than 200 amperes may be added by bolted connections,*

is acceptable without the branch bus bars necessary for such additions being mounted in place when the unit substation is shipped from the factory provided branch bus bars complying with 15.3.19 are available, and markings as covered in 40.11.1 and 40.11.2 are provided.

4.2 A unit substation shall be designed so that any component intended to be field installed can be installed by the use of ordinary tools such as pliers, a screwdriver, or a wrench.

4.3 If a branch bus bar as covered in Exception No. 2 to 4.1 needs a barrier to comply with the spacing requirements in Spacings, Section 21, the barrier shall be attached to the unit substation or to the field-installed branch bus bar.

4.4 In a space that can physically accommodate a branch circuit switch or circuit breaker, but is not intended for this, any hole for securing a branch bus bar to the secondary bus bar shall be plugged with a solid metal rivet or one way screw. A dead-front shield over the portion of bus with holes is not acceptable in lieu of plugging or omitting the holes in the bus bars.

5 Materials

5.1 Materials used shall be combustion and moisture resistant.

Exception: The requirement does not apply to a minor part such as a handle, rubber-insulated wire, magnet insulation, and the like, or as otherwise permitted in these requirements.

6 Rust and Corrosion Resistance

6.1 Iron and steel parts of enclosing cases, walls, and barriers, all springs and other parts upon which mechanical operation may depend, and sheet steel parts of fastening devices, shall be protected against rust by enameling, galvanizing, sherardizing, plating, or equivalent means. Corrosion resistance requirements for an enclosure designated as Type 3R are covered in 8.5.8 — 8.5.12.

7 Mechanical Assembly

7.1 A unit substation shall be constructed to provide strength and rigidity in order that it will keep its shape and that doors will close tightly.

7.2 Metal into which a screw is threaded shall provide for the engagement of at least two full threads. A rivet, screw, bolt, or similar fastener in a sheet metal enclosure shall have a diameter at least 50 percent greater than the thickness of the finished sheet metal with which it is used.

Exception: A fastening device as described in 7.3 is acceptable.

7.3 With respect to 7.2, a different type of fastening device may be used if employed with a conventional screw. Other types of fastening devices may be used if investigated for the particular application. A single-threaded sheet metal nut designed to slip over the edge of sheet metal to receive a retaining screw may be used to secure a dead front to supports, a unit such as a switch or circuit breaker to a mounting panel, or a mounting pan to an enclosure if:

- a) The nut is protected against corrosion by enameling, galvanizing, sherardizing, plating, or other equivalent means.
- b) The threads do not strip when a torque of 30 pound-inches (3.4 N • m) is applied.

7.4 Sheet metal may be extruded at a tapped hole to provide the thickness necessary for two full threads, provided the original metal is not less in thickness than the pitch of the thread.

7.5 Unless otherwise noted, an electrical component shall be securely mounted and prevented from turning.

7.6 A unit substation shall be provided with a means for lifting by forklift or cable and shall be marked in accordance with 40.18.1. A lifting means, if provided for lifting by cable, shall be provided with a minimum 5/8 inch (15.9 mm) diameter hole. The lifting means shall be subjected to the test specified in the Lifting Hook or Bracket Test, Section 34.

Exception: The test specified in the Lifting Hook or Bracket Test, Section 34, need not be conducted on a unit substation intended only for lifting from underneath by a forklift or other means.

8 Framework and Enclosure

8.1 Frame

8.1.1 The framework of a unit substation shall provide strength for the support of all the component parts of the device and the operation of all switching mechanisms in the intended manner.

8.2 Enclosure

8.2.1 A unit substation shall have an enclosure of moisture resistant material. The enclosure shall house all uninsulated live parts.

Exception: A bottom for the enclosure need not be provided for a unit substation intended to be pad mounted if the walls will be flush or within 3/8 inch (9.6 mm) of the pad and if the unit substation is marked in accordance with 40.14.3.

8.2.2 If a unit substation is intended to be mounted on a concrete pad, aluminum parts of an enclosure shall be located at least 1/4 inch (6.4 mm) above the mounting pad.

Exception: Aluminum parts of an enclosure coated with a metallic or nonmetallic coating may be in contact with a concrete pad if the coating is tested to demonstrate resistance to corrosion equivalent to that of galvanized (G90) steel 0.061 inch (1.55 mm) thick.

8.2.3 The enclosure shall be provided with mounting or securing means.

8.2.4 With respect to 8.2.3, for a wall mounted unit substation, the construction shall be such that, if the enclosure is mounted on a plane surface, it will make contact at points of support only, and shall maintain a clearance of not less than 1/4 inch (6.4 mm) at other points. The means for mounting shall be subjected to the test specified in the Wall-Mounting Means Test, Section 35.

8.2.5 An enclosure of polymeric material shall be made the subject of an investigation in accordance with the Standard for Polymeric Materials — Use in Electrical Equipment Evaluations, UL 746C. Among the factors to be taken into consideration are:

- a) Mechanical strength,
- b) Resistance to impact at low temperature,
- c) Moisture absorptive properties,
- d) Resistance to distortion at temperatures to which the material will be subjected under conditions of normal or abnormal use,
- e) Resistance to arcing,
- f) Aging characteristics, and
- g) Combustibility.

8.3 Sheet metal

8.3.1 A sheet metal enclosure shall be made of iron, steel, brass, copper, or aluminum.

Exception: Other materials may be employed if, upon investigation, the material is found to be acceptable for the purpose and the enclosure is found to be equivalent to the sheet metals specified.

8.3.2 A sheet metal enclosure shall have a minimum thickness as specified in Table 8.1 or 8.2.

Exception No. 1: An enclosure without supporting frame may be thinner than specified in Tables 8.1 and 8.2 if it complies with the requirements in the Compression Test, Section 31, and the Deflection Test, Section 32, but not less than 0.053 inch (1.35 mm) for uncoated steel, 0.056 inch (1.42 mm) for coated steel, and 0.075 inch (1.91 mm) for aluminum, copper, or brass.

Exception No. 2: The thickness of a cover, door, front, or panel may be as specified in 8.3.5 and 8.3.6.

Table 8.1
Minimum thickness of sheet metal for enclosures – carbon steel or stainless steel

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^b		Minimum thickness			
Maximum width ^a Inches (cm)	Maximum length Inches (cm)	Maximum width ^{a,c} Inches (cm)	Maximum length ^c Inches (cm)	Uncoated Inch (mm)		Metal coated Inch (mm)	
18.0	45.7	Not Limited ^d	27.0	0.053	1.35	0.056	1.42
20.0	50.8		29.0				
22.0	55.9	Not Limited ^d	33.0	0.060	1.52	0.063	1.60
25.0	63.5		35.0				
25.0	63.5	Not Limited ^d	39.0	0.067	1.70	0.070	1.78
29.0	73.7		41.0				
33.0	83.8	Not Limited ^d	51.0	0.080	2.03	0.084	2.13
38.0	96.5		54.0				
42.0	106.7	Not Limited ^d	64.0	0.093	2.36	0.097	2.46
47.0	119.4		68.0				
52.0	132.1	Not Limited ^d	80.0	0.108	2.74	0.111	2.82
60.0	152.4		84.0				
63.0	160.0	Not Limited ^d	97.0	0.123	3.12	0.126	3.20
73.0	185.4		103.0				

^a The smaller dimension of a rectangular sheet metal piece that is part of an enclosure other than as covered in 8.3.7. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

^b Refer to 8.3.3 and 8.3.4.

^c Length of sides to be measured between supporting frames as shown in Figure 8.1.

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

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

Table 8.2
Minimum thickness of sheet metal for enclosures — aluminum, copper, or brass

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^b		Minimum thickness Inches (mm)
Maximum width ^a Inches (cm)	Maximum length Inches (cm)	Maximum width ^{a,c} Inches (cm)	Maximum length ^c Inches (cm)	
18.0 45.7	Not Limited ^d	42.0 106.7	Not Limited ^d	0.075 1.91
20.0 50.8	25.0 63.4	45.0 114.3	55.0 139.7	
25.0 63.5	Not Limited ^d	60.0 152.4	Not Limited ^d	0.095 2.41
29.0 73.7	36.0 91.4	64.0 162.6	78.0 198.1	
37.0 94.0	Not Limited ^d	87.0 221.0	Not Limited ^d	0.122 3.10
42.0 106.7	53.0 134.6	93.0 236.2	114.0 289.6	
52.0 132.1	Not Limited ^d	123.0 312.4	Not Limited ^d	0.153 3.89
60.0 152.4	74.0 188.0	130.0 330.2	160.0 406.4	

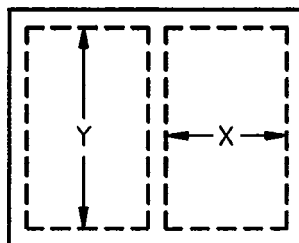
^a The smaller dimension of a rectangular sheet metal piece that is part of an enclosure other than as covered in 8.3.7. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

^b Refer to 8.3.3 and 8.3.4.

^c Length of sides to be measured between supporting frames as shown in Figure 8.1.

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

Figure 8.1
Length or width between support frames



SA1142

X, Y — Length or width between supporting frames, see note c, Tables 8.1 and 8.2.

8.3.4 With reference to 8.3.3 and Tables 8.1 and 8.2, a construction is not considered to have a supporting frame if it is:

- a) A single sheet with single formed flanges (formed edges);
- b) A single sheet that is corrugated or ribbed; or
- c) An enclosure formed or fabricated from sheet metal.

8.3.5 With respect to Tables 8.1 and 8.2, part of a door, front, panel, or cover that has a supporting frame may employ metal having a thickness not less than 0.056 inch (1.42 mm) if zinc-coated steel, 0.053 inch (1.35 mm) if uncoated steel, or 0.075 inch (1.91 mm) if aluminum, copper, or brass provided that:

- a) The door, front, panel, or cover has the strength and rigidity to maintain its shape when open or unmounted; and
- b) The construction complies with the test specified in 32.2

Exception: A door that is not part of the required enclosure need not comply with this requirement.

8.3.6 If a door covers a small opening only, such as an opening for a latch and lock, it shall have a thickness not less than 0.035 inch (0.89 mm) if zinc-coated steel, 0.032 inch (0.81 mm) if uncoated steel, or 0.050 inch (1.27 mm) if aluminum, copper, or brass.

8.3.7 If two or more covers or panels are provided to close a single opening, the thickness of each cover or panel shall be no less than a single sheet, that would cover the complete opening, as specified in the "without supporting frame" columns of Table 8.1 or 8.2. The adjacent edges of such multiple panels or covers shall comply with one of the following conditions:

- a) Be flanged at least 1/2 inch (12.7 mm).
- b) Be supported against an inward force at 10 inch (254 mm) maximum intervals.
- c) Overlap each other at least 1/2 inch and be secured together at 10 inch maximum intervals.
- d) Comply with the deflection test specified in 32.2.

Exception: The cover thickness may comply with Exception No. 1 to 8.3.2 or with 8.3.5(b).

8.3.8 Sheet metal, where formed into angles or corners, shall show no evidence of fracture.

8.3.9 Slight surface crazing is not considered to be evidence of fracture.

8.4 Specific environmental conditions

8.4.1 An enclosure shall be marked as specified in 40.15.1 for a specific environmental condition as specified in Table 8.3. An enclosure that complies with the requirements for more than one type of enclosure may be marked accordingly with multiple type designations. Such enclosures shall be subjected to the applicable tests specified in the Standard for Enclosures for Electrical Equipment, UL 50.

8.5 Type 3R enclosures

8.5.1 A unit substation marked as Type 3R (rainproof) as specified in 40.16.1 shall comply with 8.5.2 — 8.5.14 and be subjected to the Rain Test, Section 26. A switch, circuit breaker, receptacle (complete with its associated attachment-plug), fuseholder, or similar device, as well as any opening associated with an operating handle, shall be shielded from rain.

8.5.2 In an enclosure intended for horizontal pad mounting, any live part shall be located at least 4 inches (102 mm) above the enclosure mounting surface.

Table 8.3
Enclosure types

Type number	Intended use and description	Qualification tests ^a
1	Indoor use primarily to provide a degree of protection against contact with the enclosed equipment and against a limited amount of falling dirt.	Corrosion Protection — 4.3 or Rust Resistance — Section 36
2	Indoor use to provide a degree of protection against limited amounts of falling water and dirt.	Corrosion Protection — 4.3 or Rust Resistance — Section 36, and Drip — Section 29
3R	Outdoor use to provide a degree of protection against falling rain undamaged by the formation of ice on the enclosure.	Rain — Section 28, Icing — Section 32, and Protective Coating — Section 13

^a Qualification tests shall be conducted in accordance with the applicable requirements specified in the Standard for Enclosures for Electrical Equipment, UL 50.

8.5.3 A hole for conduit in an enclosure shall be threaded unless it is entirely located below the lowest live part within the enclosure, or unless it accommodates a specific hub or closure fitting. The area surrounding a threaded conduit hole shall be reinforced to provide metal at least 1/4 inch (6.4 mm) thick. A threaded hole for conduit shall be provided with a conduit end stop unless the thread is tapered.

8.5.4 A gasket of thermoplastic material or composition may be accepted after consideration of the effects of heat aging, distortion under conditions of use, and the means of securing the gasket to the cover or enclosure.

8.5.5 If an enclosure is provided with a rubber or rubber-like gasket, the quality of the gasket shall be such that samples subjected to a temperature of $70 \pm 1^\circ\text{C}$ ($158 \pm 1.8^\circ\text{F}$) in circulating air for 168 hours will have a tensile strength of not less than 60 percent and an elongation of not less than 75 percent of the values determined with unaged samples.

8.5.6 In an enclosure, a hinge or other attachment shall be resistant to corrosion.

8.5.7 Metals shall not be used in combinations such that galvanic action may cause an adverse effect on any part of the product.

8.5.8 A sheet steel enclosure marked Type 3R (rainproof) shall be made corrosion resistant by one of the following coatings:

- a) Hot-dipped mill galvanized sheet steel conforming with the coating designation G90 in Table I of ASTM A525-1986, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM Standard. The weight of the zinc coating may be determined by any method; however, in case of question the weight of coating shall be established in accordance with the test method of ASTM A90-1981.
- b) A zinc coating, other than that provided on hot-dipped mill galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.0155 mm) on each surface with a minimum thickness of 0.00054 inch (0.0137 mm). The thickness of coating shall be established by the coating thickness test specified in 30.1.
- c) A zinc coating conforming with (1) or (2) and with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint applied after forming on each surface. The acceptability of the paint may be determined by consideration of its composition or by corrosion tests if these are considered necessary.
 - 1) Hot-dipped mill galvanized sheet steel conforming with the coating designation G60 or A60 in Table I of ASTM A525-1986, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM Standard. The weight of zinc coating may be determined by any method; however, in case of question the weight of coating shall be established in accordance with the test method of ASTM A90-1981.
 - 2) A zinc coating, other than that provided on hot-dipped mill galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.0104 mm) on each surface with a minimum thickness of 0.00034 inch (0.0086 mm). The thickness of the coating shall be established by the coating thickness test specified in 30.1.
- d) A cadmium coating not less than 0.0010 inch (0.025 mm) thick on both surfaces. The thickness of coating shall be established by the coating thickness test specified in 30.1.
- e) A cadmium coating not less than 0.00075 inch (0.0190 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.00051 inch (0.0130 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established by the coating thickness test specified in 30.1 and the paint shall be as described in (c).
- f) Other finishes, including paints, metal finishes, or combinations of the two may be accepted when comparative tests with galvanized sheet steel (without annealing, wiping, or other surface treatment) conforming with (a), indicate they provide equivalent protection. Such comparative tests are specified in the Standard for Organic Coatings for Steel Enclosures for Outdoor-Use Electrical Equipment, UL 1332.

8.5.9 An annealed coating on sheet steel that is bent or similarly formed or extruded, or rolled at edges of holes after annealing shall be additionally painted in the affected area if the process damages the zinc coating.

8.5.10 If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered to be damaged. Sheared or cut edges and punched holes are not required to be additionally protected.

8.5.11 If the hot-dipped mill galvanized G90 coating on drawn, formed, extruded, or rolled sheet steel becomes damaged during handling or fabrication to the extent that the base metal is exposed, at least one coat of an organic finish of the epoxy or alkyd-resin type, or other outdoor paint, shall be applied after fabrication to the entire area where the damage to the coating occurred.

Exception: Exposed base metal of an uncoated cross-section surface at a cut edge or at a drilled opening is acceptable.

8.5.12 Sheet steel that employs a hot-dipped mill galvanized G90 coating that is drawn, formed, extruded, or rolled shall be additionally painted with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint in the areas that are affected by a process that damages the coating as determined by the requirement in 8.5.10.

8.5.13 Aluminum in an enclosure shall not be in contact with concrete. A metallic or nonmetallic coating used to separate aluminum from a concrete pad shall be tested to demonstrate resistance to corrosion equivalent to that of galvanized (G90 zinc coating) steel 0.061 inch (1.55 mm) thick.

8.5.14 In an enclosure marked Type 3R (rainproof), guides for latch rods shall be located so that the latch rods will not be deformed by a direct pull of 200 pounds (890 N) applied to the door handle for 1 minute in the direction that the door will open.

8.6 Components mounted on doors and covers

8.6.1 An electrical component shall be mounted independent of a door or removable cover.

Exception No. 1: A meter base may be mounted on a door as covered in 8.6.5.

Exception No. 2: Metering and monitoring equipment provided by the serving agency (electric utility or power company) may be mounted on a door or cover.

Exception No. 3: A component may be mounted on a hinged door if it complies with 8.6.2 — 8.6.4, and 8.6.6.

Exception No. 4: A meter, selector switch, pilot light, or push button station may be mounted on an unhinged cover not exceeding 12 inches (305 mm) high nor 24 inches (610 mm) wide provided a fuse is not located behind the cover.

8.6.2 With respect to Exception No. 3 to 8.6.1, a wire subject to flexing when the cover is opened shall:

- a) Be stranded and if larger than No. 6 AWG (13.3 mm²) shall have copper conductors of the extra flexible type;
- b) Have insulation at least 1/32 inch (0.8 mm) thick; and
- c) Be cabled, routed, secured, and protected so that the wire will not be damaged during opening and closing of the door or cover.

8.6.3 With respect to Exception No. 3 to 8.6.1, if a wire larger than No. 12 AWG (3.3 mm²) is used for connecting components mounted on a door, the door shall:

- a) Be hinged on one side and secured on the opposite side with screws or means for locking;
- b) Serve as access only to a bus bar, a wiring space, a terminal block, or similar component not requiring replacement, adjustment, resetting, or removal; and
- c) Be provided with means for keeping it open while installing field wiring.

8.6.4 With respect to Exception No. 3 to 8.6.1, a door having wire not larger than No. 12 AWG (3.3 mm²) shall comply with:

- a) 19.11 if the door provides access to a fuse; and
- b) 10.4 if the door provides access to any part requiring adjustment, or the like, after the original installation of the unit substation.

8.6.5 A meter socket base shall be mounted independently of the cover unless it is intended to be used with current transformers.

8.6.6 Any uninsulated live part involving a potential of more than 42.4 volts peak mounted on the inside of a door shall be guarded, recessed, or enclosed to reduce the risk of unintentional contact. One method of accomplishing this would be to provide a fiber barrier at least 0.028 inch (0.71 mm) thick that is secured in place.

8.7 Ventilation - general

8.7.1 A louver shall be 12 inches (305 mm) or less in length.

8.7.2 The total area of enclosure material removed from a wall for ventilation (together with the total area of ventilation openings as a result of forming the enclosure material) shall not exceed 25 percent of the area of the entire surface of any wall in which such ventilation openings are located.

Exception: The 25 percent area limitation may be exceeded provided that reinforcing means, such as stiffeners, are employed.

8.7.3 The area of any ventilation opening, as defined by the opening in the enclosure metal, shall not exceed 200 square inches (1290 cm²) if the ventilation closing panel is formed from material having a thickness less than that of the enclosure metal. A ventilation closing panel lighter than 0.060 inch (1.52 mm) thick uncoated steel, 0.063 inch (1.60 mm) zinc-coated steel or 0.075 inch (1.91 mm) aluminum, copper, or brass, or No. 14 AWG (2.1 mm²) or lighter wire mesh shall not be used to close an opening of more than 80 square inches (516 cm²).

8.7.4 The wires of a screen of a ventilating opening shall have a minimum diameter of:

- a) 0.054 inch (1.37 mm) for screen openings 1/2 square inch (3.2 cm²) or less in area, or
- b) 0.080 inch (2.03 mm) for openings larger than 1/2 square inch in area.

8.7.5 Perforated sheet steel and sheet steel employed for expanded metal mesh shall be in accordance with Table 8.4.

Exception: If the indentation of a guard or enclosure will not alter the clearance between the uninsulated live parts and grounded metal so as to affect performance adversely or reduce spacings below the minimum values given in Table 21.1, 0.020 inch (0.51 mm) minimum expanded metal mesh [0.023 inch (0.58 mm) if zinc coated] may be employed.

Table 8.4
Minimum thickness of perforated sheet steel
or sheet steel used for expanded metal mesh

Area of perforation or mesh openings		Minimum thickness of metal			
		Uncoated		Zinc coated	
Inches ²	(cm ²)	Inches	(mm)	Inches	(mm)
1/2 or less	3.2 or less	0.042	1.07	0.045	1.14
More than 1/2	More than 3.2	0.080	2.03	0.084	2.13

8.7.6 A grille construction complying with the intent of the requirements in 8.7.5 may be used if it has been found to be acceptable for the particular application.

8.7.7 A ventilation opening in the top of the enclosure shall be covered by a hood or provided with a shield so spaced with respect to the opening to reduce the risk of the entry of foreign material.

8.8 Ventilation - panelboard section

8.8.1 A ventilation opening shall be constructed, located, or provided with a barrier, in compliance with 12.4.1 and 12.4.2, so that:

- a) No flame or molten metal will be emitted during arcing encountered during the operation of a fuse, switch, or circuit breaker; and
- b) No access to an uninsulated live part is provided.

Exception No. 1: With regard to an arcing part, the ventilation opening need not be provided with a barrier if:

- a) *During a switch overload test, based on the requirements of the switch involved, there is no emission of flame or molten material from the opening; or*
- b) *The opening is located at least 12 inches (305 mm) from the arcing part.*

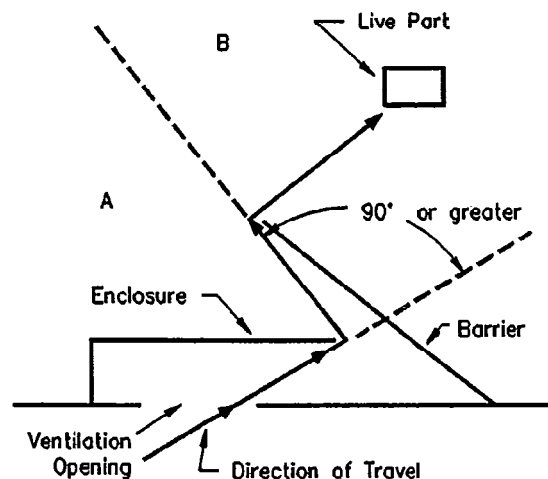
Exception No. 2: With regard to a nonarcing uninsulated live part, the ventilation opening need not be provided with a barrier if:

- a) *The opening is located at least 4 inches (102 mm) from the live part; or*
- b) *The live part is part of the neutral circuit.*

8.8.2 A ventilation opening (slot, louver, or the like) shall be protected by one or more baffles, barriers, or other obstructions of such dimension and location that any access path to a live part requires at least two changes of direction, one of which involves an angle of 90 degrees or more from a straight line as shown in Figure 8.2. In addition, if the minor dimension of a ventilation opening is larger than 1/4 inch (6.4 mm), it shall be protected by a screen having a minor dimension no larger than 1/4 inch.

Exception: A screen is not required if live parts cannot be contacted by the articulate probe illustrated in Figure 8.3.

Figure 8.2
Angle of change of direction



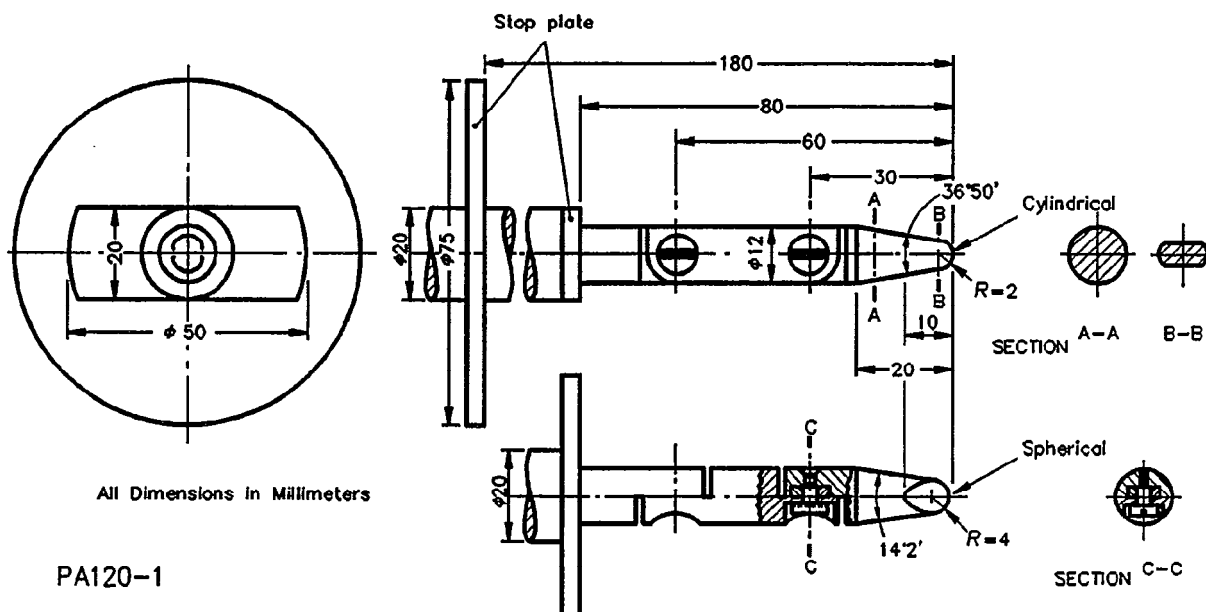
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- a) No live parts permitted in this area.
- b) Live parts acceptable this side of barrier.

8.8.3 The probe specified in the Exception to 8.8.2 and illustrated in Figure 8.3 shall be applied to any depth that the opening will permit and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probe shall be applied in any possible configuration and, if necessary, the configuration shall be changed after insertion through the opening.

8.8.4 The probe specified in the Exception to 8.8.2 shall be used as a measuring instrument to judge the accessibility provided by an opening and not as an instrument to judge the strength of a material. It shall be applied with the minimum force necessary to determine accessibility.

Figure 8.3
Articulate probe



8.9 Ventilation - transformer section

8.9.1 Any opening in an enclosure shall have such size or shape that a test rod having the diameter specified in 8.9.2 will be prevented from entering.

Exception: An opening is acceptable if, by means of its size, location, baffling, or the like, it will prevent a straight rod that is 33/64 inch (13.1 mm) in diameter from passing within 4 inches (102 mm) of any uninsulated live part inside the enclosure.

8.9.2 The test rod specified in 8.9.1 shall be 33/64 inch (13.1 mm) in diameter if the plane of the opening is less than 4 inches (102 mm) from an uninsulated live part or 49/64 inch (19.4 mm) in diameter if the plane of the opening is 4 inches or more from such a part.

9 Doors and Covers

9.1 General

9.1.1 A door, front, panel, or cover shall be provided with means for holding it in place.

9.1.2 A dead front shield or a removable cover shall be constructed so that it can be installed and removed without contacting a bare live part or causing damage to the insulation of any insulated live part inside the enclosure.

9.1.3 With respect to the requirement in 9.1.2, a dead front shield or cover is considered likely to fall backward into the interior unless it is supported during removal until it can be extracted directly from the enclosure without a sliding or twisting motion.

9.1.4 A door that is not part of the required enclosure need not comply with the requirements of 8.3.1 — 8.3.9 and 9.2.1 — 9.4.2.

9.1.5 A hinged cover or door over a live part shall be provided with a stop to reduce the risk of the cover or door from contacting the live part. The stop shall be independent of any other door or removable cover.

9.1.6 A metal cover plate intended to be opened for inspection purposes shall not exceed 12 square feet (1.12 m²) in area or 60 pounds (27 kg) in weight unless it is equipped with lifting means or hinges.

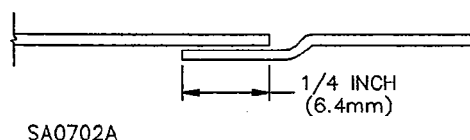
9.1.7 A cover that is likely to be removed to permit the connection of circuit or ground conductors or to make tap changes shall not be provided with means for the connection of any wiring method.

9.2 Flanges for metallic enclosures

9.2.1 A door or a cover shall shut closely against a 1/4 inch (6.4 mm) rabbet as illustrated in Figure 9.1 or have flanges for the full length of all edges.

Exception: A gasketed joint may be used in place of a 1/4 inch rabbet if the gasket is investigated for the particular application. Among the factors considered are resistance to aging, heat, cold, distortion under the conditions of use, and the means of securing the gasket in place.

Figure 9.1
Rabbet



9.2.2 A flat strip used to provide a rabbet shall not be less in thickness than 60 percent of the required thickness of the metal to which it is secured. It shall be secured at not less than two points, not more than 1-1/2 inches (38.1 mm) from each end of the strip, and at points between these end fastenings not more than 6 inches (152 mm) apart. A formed strip may be made of metal thinner than that required for a flat strip if it is so formed and attached that it provides an equivalent rabbet. A rabbet is not required behind a piano type hinge.

9.2.3 A flange on a cover shall:

- a) Fit closely with the outside wall of the box proper in accordance with Table 9.1;
- b) Have a width in accordance with Table 9.1;
- c) Be one of the constructions illustrated in Figures 9.2 and 9.3.

Exception No. 1: A hinged cover that is flanged on all four edges to a depth of not less than 1/2 inch (12.7 mm) may be constructed as shown in Figure 9.4 on the hinge side only if the following conditions are met:

- 1) There are no arcing parts located behind the cover, or

2) It has been demonstrated by test that no flame or molten metal will be emitted during the arcing normally encountered during the operation of a fuse, switch, or circuit breaker.

Exception No. 2: Other constructions may be evaluated.

d) Where a telescoping cover meets the cabinet or box of a surface-mounted enclosure, overlap all edges in accordance with Table 9.1.

Exception: The overlap may be as provided in 9.2.7.

Table 9.1
Dimensions for flanged cover constructions

Figure 9.2 constructions	Dimensions									
	W Minimum flange width ^a		A Minimum space between parts		B Maximum gap		C Minimum overlap		D Minimum barrier extension	
	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
A	1/2	12.7	1/8	3.2	1/8	3.2	7/16	11.1	—	—
A	3/4	19.1	3/16	4.8	3/16	4.8	5/8	15.9	—	—
A	1	25.4	1/4	6.4	1/4	6.4	7/8	22.2	—	—
B	1/2	12.7	1/8	3.3	1/8	3.2	7/16	11.1	—	—
B	3/4	19.1	3/16	4.8	3/16	4.8	5/8	15.9	—	—
B	1	25.4	1/4	6.4	1/4	6.4	7/8	22.2	—	—
C	1/2	12.7	3/16	4.8	3/16	4.8	1/4	6.4	—	—
C	3/4	19.1	1/4	6.4	1/4	6.4	7/16	11.1	—	—
D	1/2	12.7	3/32	2.4	—	—	7/16	11.1	—	—
E	1/2	12.7	1/8	3.2	1/8	3.2	7/16	11.1	1/4	6.4
F	1/2	12.7	1/8	3.2	1/4	6.4	7/16	11.1	—	—
G ^b	1/2	12.7	—	—	1/8	3.2	—	—	1/2	12.7
H	1/4	6.4	1/8	3.2	—	—	3/16	4.8	—	—

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

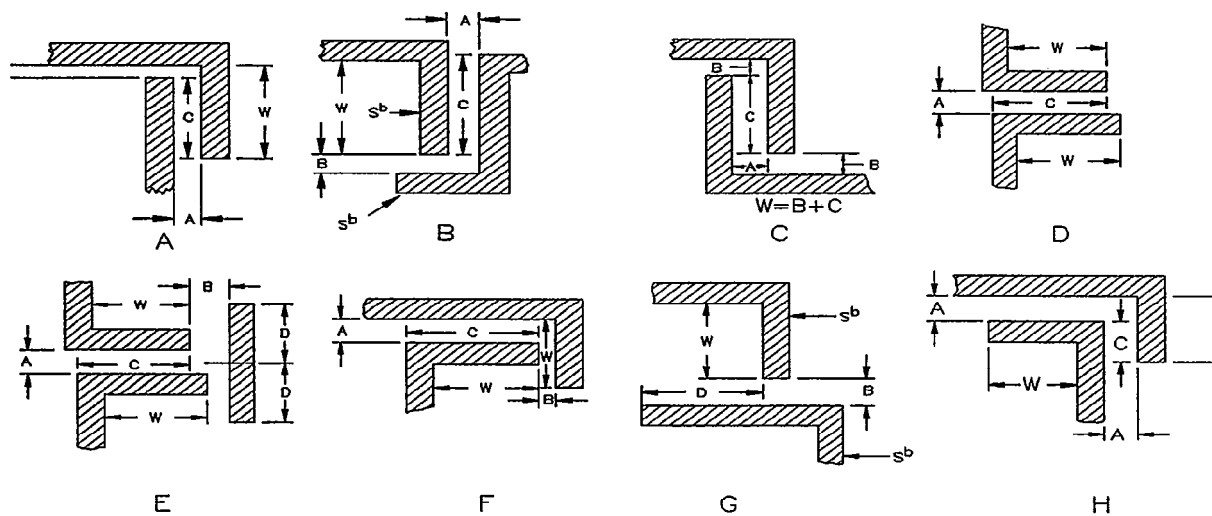
^b Equipment within the enclosure must be located on the side of the barrier extension D that is opposite the gap B.

9.2.4 The constructions illustrated in Figures 9.2 and 9.3 are also acceptable on dead front covers that are held in place by screws. For such covers, the clearances between adjacent flanges may be as described in 9.2.6 and Figure 9.5.

9.2.5 To determine if a flanged cover complies with the requirement in 9.2.3(b), the distance between the flat portion of the cover — clear of forming radii, beads, draws, or the like — and the edge of the flanged portion of the cover is to be measured.

9.2.6 With respect to the Exception to 9.2.1, the clearance between flanges of covers that are held in place by screws may be 1/8 inch (3.2 mm) maximum. If a barrier is located behind the flanged opening as shown in Figure 9.3, if there are no live parts in the open area, and if the construction complies with 8.8.1, clearances may be 1/4 inch (6.4 mm) maximum.

Figure 9.2
Flanged cover constructions^a



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a Dimensions for construction A — H are given in Table 9.1.

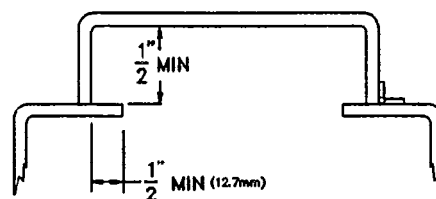
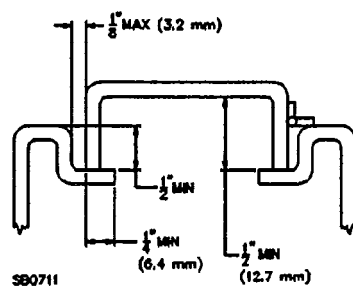
b The surfaces "S" may be in line with one another — not as shown.

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

- a) The cover is secured in place by screws or by a combination of hinges and screws, and
- b) The cover and the box wall are flanged in accordance with Sketch H of Figure 9.2.

9.2.8 To determine if a telescoping cover complies with the requirement in 9.2.3(c), the cover is to be in its closed position, and a mark is to be scribed on all walls of the box along the edge of the flange. The overlap is the measured distance W between the scribed marks and the edges of the box walls, as illustrated in Figure 9.6. In scribing the marks, the cover is to be restrained in position so that there is no displacement of the cover by the scribing tool, but without bending or distorting any portion of the box, or cover, or other part of the enclosure.

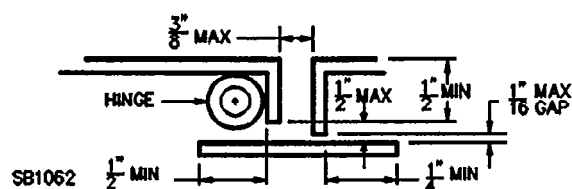
Figure 9.3
Flanged cover constructions



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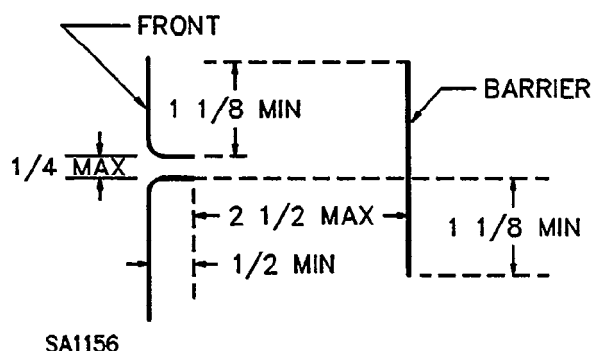
inch	(mm)
1/8	3.2
1/4	6.4
1/2	12.7

Figure 9.4
Flanges on hinge side



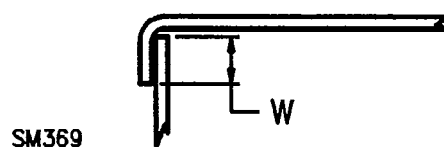
inch	(mm)
1/16	1.6
1/4	6.4
3/8	9.5
1/2	12.7

Figure 9.5
Barrier behind flanged opening



inch	(mm)
1/4	6.4
1/2	12.7
1-1/8	28.6
2-1/2	63.5

Figure 9.6
Measurement of overlap



9.3 Fastenings

9.3.1 A removable front panel or trim shall be secured by at least four fastenings. There shall be at least one fastening located not more than 6 inches (152 mm) from each of the four corners, and fastenings shall not be spaced more than 24 inches (610 mm) apart along any vertical side.

Exception No. 1: Any panel or cover having dimensions not exceeding 6 inches high by 20 inches (508 mm) wide or having flanges on all four sides and having dimensions not exceeding 9 inches (229 mm) high by 20 inches wide, or 6 inches wide by 36 inches (914 mm) high, may be fastened by one screw in each of the two opposite sides. The screws need not be at the center of the sides provided the construction is such as to hold the front panel or cover against the adjacent flange of the section.

Exception No. 2: A removable panel more than 24 inches long on any side that is flanged 1/2 inch (12.7 mm) minimum may have fastenings spaced not more than 36 inches apart and not more than 10 inches (254 mm) from each of the four corners providing the fastenings are not less than 1/4 inch (6.4 mm) in diameter.

9.3.2 Fastening screws or the screws of clamps or hinges shall not be less than 5/32 inch (4.0 mm) in diameter (No. 8 screw size) for a panel 360 square inches (2323 cm²) or less in area, and not less than 3/16 inch (4.8 mm) in diameter (No. 10 screw size) for a larger panel or cover.

9.3.3 Fastenings may be omitted along that vertical side of a panel that is adjacent to a panelboard, or the like, if the panel is supported at all four corners, and if the panel is either:

- a) Flanged the full length of both the longer sides; or
- b) Flanged the full length of one of the longer sides, with the unflanged side secured to a rigid member.

9.4 Butt hinges

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

Exception: Means of fastening may be as provided in 9.4.4 — 9.4.7.

9.4.2 A metal hinge pin shall not be less than 5/32 inch (4 mm) in diameter if made of brass or aluminum and 1/8 inch (3.2 mm) if made of steel for a door or a cover 360 square inches (2322 mm²) or less in area, and not less than 3/16 inch (4.8 mm) in diameter for a larger door or cover.

Exception: Other hinge constructions may be acceptable as provided in 9.4.3.

9.4.3 For constructions other than as described in 9.4.2, a hinged door or cover shall withstand a load of four times its weight, but not less than 20 pounds (9 kg), without causing permanent deformation of the hinge. The load is to be applied vertically downward through the center of gravity of the door or cover.

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

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

9.4.6 Hinge securing constructions other than those described in 9.4.4 and 9.4.5 may be accepted if found to be equivalent in performance to the construction required in 9.4.1.

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

Exception: A single hinge may be acceptable as provided in 9.4.8.

9.4.8 The length of a single hinge used on either side of a door or cover not exceeding 5 by 9 inches (127 by 229 mm) shall be not less than 1/3 the length of the longer side. The length of a single hinge used on a door or cover having dimensions exceeding 5 by 9 inches shall be not less than 80 percent of the length of the longer side of the door or cover. A single hinge is to be centered on the door or the cover.

9.4.9 Hinges shall be spaced as specified in Table 9.2. The spacing between hinges is to be measured between centers of the hinges; the spacing between a hinge and the end of a door or cover is to be measured from the edge of the hinge.

Table 9.2
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	
Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)
4	(102)	24	(610)	None	None	—	—
4	(102)	32	(712)	None	None	Uncoated steel	
						0.093	(2.4);
						Zinc coated steel	
						0.097	(2.5); or
						Al, Cu, or brass	
						0.122	(3.1)
4	(102)	36	(914)	1/2	(12.7)	—	—
6 ^a	(152)	36	(914)	1/2	(12.7)	—	—
10 ^b	(254)	36	(914)	1/2	(12.7)	—	—
9	(229)	36	(914)	1	(25.4)	—	—
12	(305)	40	(1016)	1	(25.4)	Uncoated steel	
						0.093	(2.4);
						Zinc coated steel	
						0.097	(2.5); or
						Al, Cu, or brass	
						0.122	(3.1)

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

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

9.5 Piano hinges

9.5.1 A continuous piano hinge shall be able to perform its intended function without distortion.

9.6 Latches

9.6.1 Each door shall be provided with a positive latch or a captive screw. A captive screw shall be operable by hand or by a conventional tool. A captive screw may be the simple 1/4 or 1/2 turn or multiturn type.

Exception: A noncaptive screw fastening may be used in the case of an enclosure that has a hinged cover but where the hinge construction is not strictly necessary under these requirements.

9.6.2 A spring latch consisting of a strip of steel spot welded or riveted to the wall of an enclosure and cooperating with a slot in the cover shall be so formed and attached that it will engage the edge of the cover slot away from the wall or shall otherwise be acceptable for the particular application.

9.6.3 A door more than 48 inches (1.22 m) long on the hinged side shall have a two point or a three point latch operated by a single knob or handle; two or more spring latches; one knob-operated latch and one spring latch; or two or more captive screws as a fastening means.

Exception: If applicable, the fastening means may be as noted in the Exception to 9.6.1.

9.6.4 A knob, door handle, or equivalent means shall be provided for opening a door.

9.6.5 With respect to 9.6.4, a captive screw or other fastening that is readily grasped is considered an "equivalent means."

10 Dead Front Construction

10.1 The enclosure of a unit substation shall be such that no uninsulated live part will be exposed from the front to contact by the operator during intended operation. There shall be no unnecessary opening in the enclosure. Openings around a circuit breaker and for a switch unit shall not be larger than necessary to allow practical fabrication and assembly.

Exception: The requirement does not apply to the renewal of fuses.

10.2 An opening may be provided for a close-fitting operating handle if the opening, with the handle in any operating position, is such that the clearance between the edge of the opening and the handle does not exceed 3/32 inch (2.4 mm) on either side (one side only) and 1/8 inch (3.2 mm) total (both sides). The clearance is to be measured with the handle in the intended on and off positions and with the handle and its supporting member assembled in any position that will result from ordinary factory assembly.

10.3 A dead front shield of sheet steel shall have a thickness not less than 0.032 inch (0.81 mm) if uncoated and not less than 0.034 inch (0.86 mm) if galvanized, and shall be supported independent of support provided by units that will be installed in the field.

10.4 A component that requires renewal, replacement, adjustment, or the like under the intended conditions of use shall be accessible without the exposure of any live part or wiring.

10.5 A fuse and fuseholder, including a pull out switch, shall be located behind a hinged, sliding, or similarly attached door having the fastening required in 9.6.1.

Exception: Removal of a cover or a dead front to replace a fuse in a fused circuit breaker is acceptable and the integral cover in a circuit breaker over the fuse may be exposed through an opening in the unit substation cover.

11 Filler Plates

11.1 Filler plates shall be factory installed in positions in a unit substation where circuit breakers, fuseholders, or the like may be installed in the field.

11.2 Filler plates intended to be installed in a unit substation shall comply with the applicable requirements for filler plates in the Standard for Panelboards, UL 67.