UL 1558

STANDARD FOR SAFETY

Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

UL Standard for Safety for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear, UL 1558

Fifth Edition, Dated February 18, 2016

SUMMARY OF TOPICS

This revision of ANSI/UL 1558 dated November 6, 2019 is issued to add was issued to incorporate the following changes to the standard:

Addition of Requirements to Section 19.6 for the Allowance for Emergency Use Switchgear

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated October 19, 2018, February 22, 2019 and March 6, 2019.

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UL 1558

Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

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This ANSI/UL Standard for Safety consists of the Fifth Edition including revisions through November 6, 2019.

The most recent designation of ANSI/UL 1558 as an American National Standard (ANSI) occurred on November 6, 2019. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover metal-enclosed low-voltage power circuit breaker switchgear assemblies containing but not limited to such devices as low-voltage power circuit breakers, other interrupting devices, switches, control, instrumentation and metering, protective and regulating equipment.

1.2 These requirements cover equipment intended for use in ordinary locations in accordance with the National Electrical Code.

1.3 These requirements are intended to supplement and be used in conjunction with the Standard for Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear, ANSI C37.20.1, and the Standard for Conformance Testing of Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies, ANSI C37.51.

1.4 These requirements cover equipment rated 1000 V ac or less nominal, 1058 V ac maximum.

2 Glossary

2.1 TAP – A terminal or provision for a terminal intended for field wiring that is located on the supply side of the service disconnecting means. The tap is intended to be used in accordance with the National Electrical Code, ANSI/NFPA 70.

3 References

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.

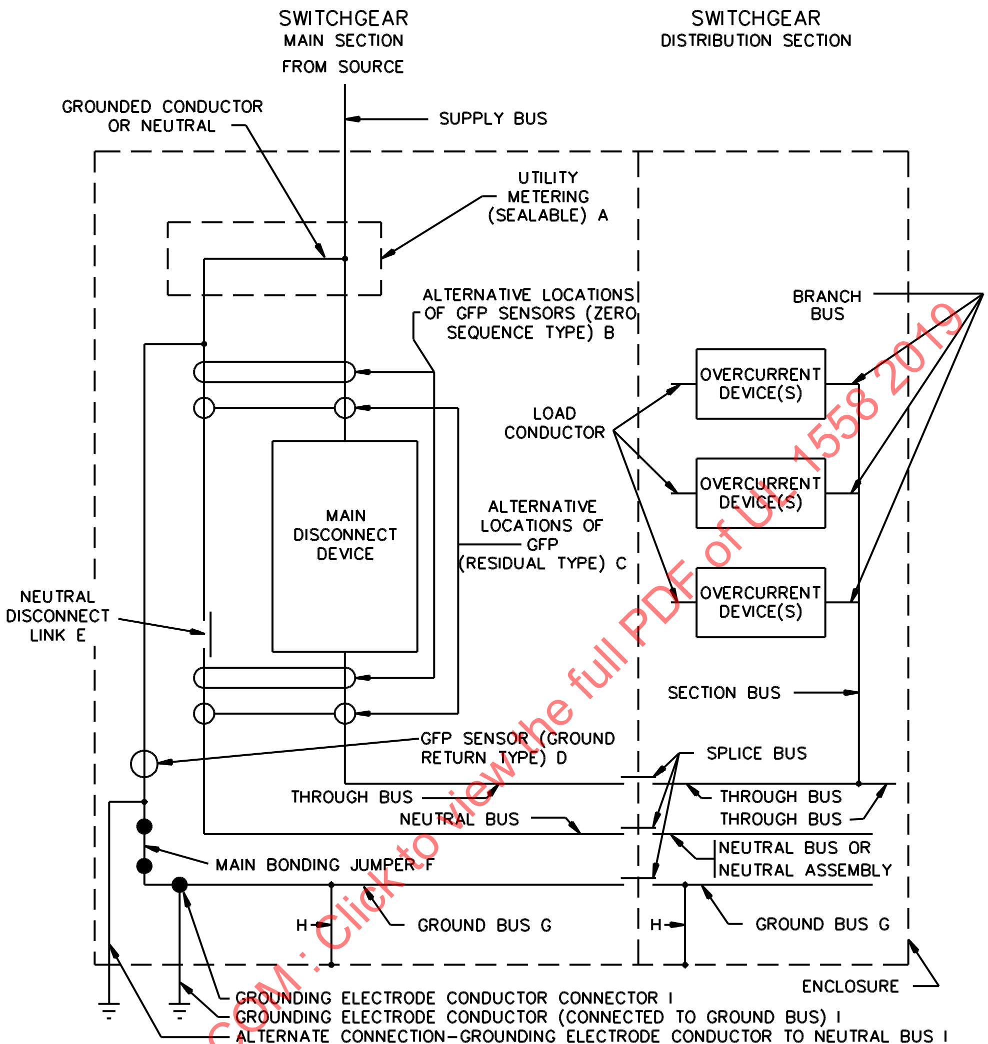
4 General

4.1 Requirements for the equipment covered by this Standard are contained in the Standard for Metal-Enclosed Low-Voltage Circuit Breaker Switchgear, ANSI C37.20.1 and the Standard for Conformance Testing of Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies, ANSI C37.51. The requirements in this Standard shall be applied in addition to those contained in the above documents, or as alternatives where so specified.

4.2 It is specifically not intended that these requirements be used alone to evaluate these devices.

4.3 Figure 4.1 – Figure 4.3 show typical switchgear layouts. It is recognized that other arrangements are possible.

Figure 4.1
Typical switchgear layout



A. Utility Metering, see 13.2.5.

B. GFP Sensor (Zero Sequence Type), see 13.1.5 – 13.1.13.

C. GFP Sensor (Residual Type), see 13.1.5 – 13.1.13.

D. GFP Sensor (Ground Return Type), see 13.1.5 – 13.1.13.

E. Neutral Disconnect Link, see 7.11, 13.1.5 – 13.1.13, and 13.2.1 – 13.2.5. (For other than ground return type GFP, the neutral disconnect link may be located on the line or load side of the GFP sensor.)

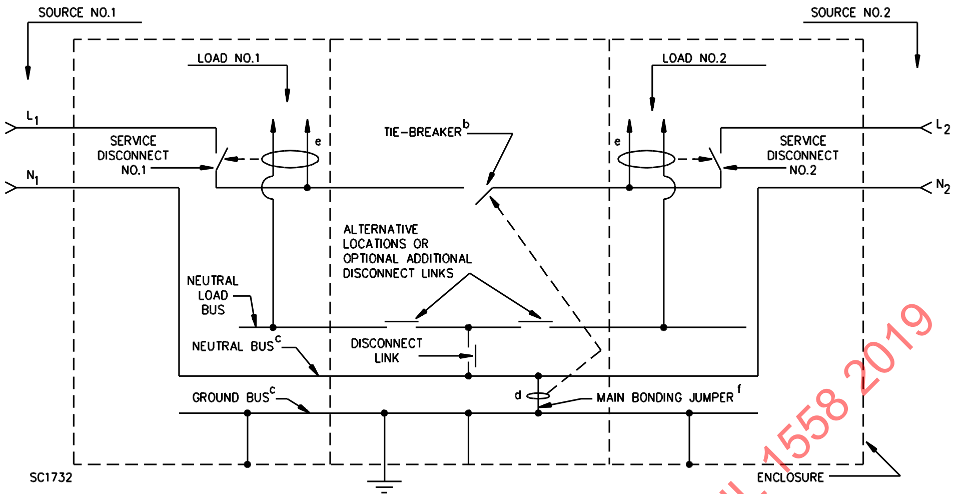
F. Main Bonding Jumper, see 7.6.

G. Ground Bus, see 7.1 – 7.8.

H. Frame and Structure Grounding, see 7.2.

I. Grounding Electrode Conductor, see 7.4 and 13.1.5 – 13.1.13.

Figure 4.2
Typical double-ended switchgear



[a] Other variations are possible.

[b] Tie breaker disconnect. See 14.1 and 14.2.

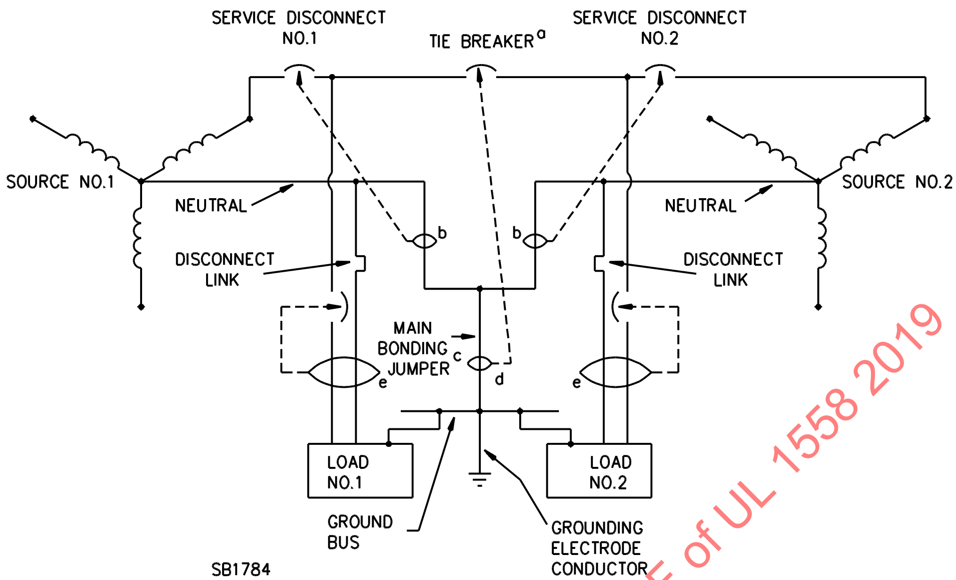
[c] The neutral bus and ground bus may be combined if ground return type ground fault protection is not used and the sections are marked "Suitable only for use as service equipment".

[d] Ground return type ground fault protection sensor in accordance with 13.1.9.

[e] Zero sequence or residual type ground fault protection sensor in accordance with 13.1.7 and 13.1.8.

[f] Size of main bonding jumper based on largest service disconnect.

Figure 4.3
Typical double-ended switchgear



[a] Tie breaker disconnect. See 14.1 and 14.2.

[b] Additional ground return type ground fault protection sensors utility interlocked with (d) so as to function only when fault current is also sensed by (d).

[c] Size of main bonding jumper based on largest service disconnect.

[d] Ground return type ground fault protection sensor in accordance with 13.1.9.

[e] Zero sequence or residual type ground fault protection sensor in accordance with 13.1.7 and 13.1.8.

CONSTRUCTION

5 Accelerated Aging of Gaskets

5.1 The requirements of this section are applicable to gaskets relied upon to enable an enclosure to meet the rain test specified in 6.2.10 of ANSI C37.20.1-2002.

5.2 A gasket of an elastomeric or thermoplastic material or a composition gasket utilizing an elastomeric material employed to make an enclosure rainproof shall comply with 5.3 and 5.4.

5.3 If an enclosure is provided with a rubber or rubber-like gasket, samples of the gasket shall be subjected to a temperature of 70 ±1°C (158 ±1.8°F) in circulating air for 168 hours. The tensile strength after the exposure shall not be less than 60 percent and the elongation shall not be less than 75 percent of the values determined with unaged samples.

5.4 A gasket of thermoplastic material, or a composition thereof, 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.

6 Primary or Power Carrying Circuits

6.1 General

6.1.1 The requirements of this section shall be applied in addition to those specified in 7.1.1 of ANSI C37.20.1-2002.

6.2 Bus bars

6.2.1 The bending of a bus bar shall not result in visible cracks, but roughening or slight surface crazing is acceptable.

6.2.2 A bolted joint involving aluminum bus bars shall comply with the requirements of 6.2.3 and 6.2.4, unless:

a) A spring washer as described in 6.2.6 is used at one end of each bolt securing current-carrying parts together is used, or

b) A locknut or a split-ring lock washer and a flat washer as described in 6.2.5 is used and each aluminum bus in the joint has a tensile yield strength of at least 20,000 psi (138 MPa).

c) A flat washer, as described in 6.2.5, and aluminum bolts are used with aluminum bus bars.

6.2.3 A switchgear bus, as mentioned in 6.2.2, that employs a bolted joint construction with aluminum bus bars shall be subjected to the test described in 6.2.4. The temperature rise at the joint during the 500th cycle shall not be more than 15°C (27°F) higher than the temperature rise at the 25th cycle.

Exception: Constructions described in 6.2.2 (a), (b), or (c), need not comply with this requirement.

6.2.4 The test sample is to consist of an assembly of bus bars connected together to form a series circuit. The bus bars are to be clamped together with the joint construction used in actual production. The number and size of the bus bars are to represent the maximum ampere rating and the maximum current density in which the joint construction is to be employed. This may necessitate more than one test. The length of each bus bar is to be not less than 2 ft (610 mm). The bus bar is to be connected to a power supply by any convenient means that will not affect the joint temperature. The power supply is to be adjusted to deliver a value of current that will result in a temperature of 75° C (135° F) above room temperature at the joint. The assembly is then to be subjected to a 500 cycle test. At the end of the 24th cycle, the current is to be readjusted to bring the temperature of the joint to 75° C (135° F) above room temperature. At the end of the 25th and 500th cycles, the temperatures are to be recorded. The temperatures are to be measured on both sides of the joint as close as possible to the bolt. The cycling rate is to be 3 hours on and 1 hour off. The on period during which temperatures are recorded may be extended to more than 3 hours if necessary for the joint to attain thermal equilibrium.

6.2.5 The flat washer mentioned in 6.2.2 (b) and (c) shall have a nominal thickness of at least 1/6 that of the diameter of the bolt and shall have an outer diameter at least 150 percent of bolt and not less than the outer diameter of any spring washer employed.

6.2.6 A typical spring washer as mentioned in 6.2.2 is a dished washer of stainless, or hardened and tempered steel, having an outer diameter not less than 150 percent of the bolt diameter, a thickness not less than 1/8 of the bolt diameter, and nominally dished not less than 3-1/2 percent of the bolt diameter. Other configurations are acceptable if they provide equivalent spring action.

6.2.7 A construction other than described in 6.2.2 may be accepted if it is investigated and found acceptable for the particular application.

6.2.8 Unless investigated for such use, a bolted connection between two bus bars or between a bus bar and another current carrying part shall not depend on any polymeric insulation to maintain the clamping force and shall not depend on thermoplastic material in any case.

6.2.9 When bolts, nuts, and washers are provided for connecting through bus to other sections, the length of the bolts shall be such that spacings in accordance with Table 12.1 are maintained.

6.2.10 A bus bar or uninsulated live part, other than a pressure wire connector as mentioned in the Exception of 12.2.7, shall be secured so that ordinary vibration will not loosen the securing means, and shall be prevented from turning or shifting in position if any spacings less than half those indicated in Table 12.1 would result from such turning or shifting. A bus bar provided with one or more insulators that must be removed when a unit is installed shall be prevented from any turning that would result in spacings less than half those specified in Table 12.1 with all insulators in place, or that would result in spacings less than 1/8 inch (3.2 mm) for any voltage up to 250 V, or 1/4 inch (6.4 mm) for any voltage of 251 to 1000 V, with any insulators omitted.

6.2.11 Friction between surfaces is not acceptable as a means to prevent turning or shifting of an uninsulated live part. Turning or shifting may be prevented by the use of two screws or rivets, by noncircular shoulders or mortises, by a dowel pin, lug, or offset, by a connecting strap or clip fitted into an adjacent part, or by an equivalent method. No reliance is to be placed on a single branch circuit fuseholder, circuit breaker, or switch unit for preventing turning of the branch bus feeding such unit, if such turning would reduce spacings to less than those specified in Table 12.1 or 6.2.10.

6.2.12 In determining the acceptability of means to prevent turning or shifting in regard to 6.2.11, any screw or nut is to be loosened and retightened fingertight without a tool. The bus is then to be pushed to the extent limited by the screws or other means and the resulting spacings determined.

7 Grounding

7.1 The requirements of this section shall be applied in addition to those specified in 7.1.2 of ANSI C37.20.1-2002.

7.2 There shall be provision for grounding a switchgear section frame or structure, and, in addition, where accessible to other than qualified persons:

a) The metal case of a frame or instrument transformer,

b) The metal case of an instrument, meter or relay, or

c) The secondary circuit of a current or potential transformer. All exposed dead metal parts and the grounding contact of a grounding type receptacle shall be in reliable contact with the means for grounding. The resistance

1) shall not exceed 0.1 ohm between the ground bus and either an exposed dead metal part or the grounding contact of a grounding type receptacle rated 30 A or less, and

2) shall not exceed 0.005 ohm between the ground bus and the grounding contact of a grounding type receptacle rated more than 30 A.

Exception: The case of an instrument, relay, meter, or similar device, if mounted on a grounded metal surface and secured thereto by means of metal screws, is considered to be grounded.

7.3 A pressure wire connector when provided as the grounding means shall be capable of receiving and holding a conductor of the size indicated in Table 7.1.

Table 7.1
Minimum size of bonding, equipment grounding, grounding electrode conductors and ground bus

Maximum ampere rating[a]	Size of equipment grounding or bonding conductor minimum (AWG or MCM)		Size of grounding electrode conductor minimum (AWG or MCM)		Size of main bonding jumper minimum (AWG or MCM)	
	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum
20	12	10	–	–	–	–
60	10	8	–	–	–	–
90	8	6	8	6	8	6
100	8	6	6	4	6	4
150	6	4	6	4	6	4
200	6	4	4	2	4	2
300	4	2	2	1/0	2	1/0
400	2	1/0	1/0[b]	3/0[b]	1/0[b]	3/0[b]
500	1	2/0	1/0	3/0	1/0	3/0
600	1	2/0	2/0	4/0	2/0	4/0
800	1/0	3/0	2/0	4/0	2/0	4/0
1000	2/0	4/0	3/0	250	3/0	250
1200	3/0	250	3/0	250	250[c]	250
1600	4/0	350	3/0	250	300[c]	400[c]
2000	250	400	3/0	250	400[c]	500[c]
2500	350	600	3/0	250	500[c]	700[c]
3000	400	600	3/0	250	600[c]	750[c]
4000	500	800	3/0	250	750[c]	1000[c]
5000	700	1200	3/0	250	900[c]	1250[c]
6000	800	1200	3/0	250	1250[c]	1500[c]

NOTE – See Table 7.2 for equivalent area of bus. Size of ground bus to be per Table 7.2 based on columns 1 – 3 of Table 7.1.

[a] Maximum ampere rating of switchgear or circuit overcurrent device ahead of equipment grounding means.

Table 7.1 Continued on Next Page

Table 7.1 Continued

Maximum ampere rating[a]	Size of equipment grounding or bonding conductor minimum (AWG or MCM)		Size of grounding electrode conductor minimum (AWG or MCM)		Size of main bonding jumper minimum (AWG or MCM)	
	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum

[b] If the ampere rating is 400 and the wire terminal connectors for the main service conductors are rated for two 3/0 AWG (85.0 mm^2) copper or two No. 250 MCM (127 mm^2) aluminum conductors but will not accept a No. 600 MCM (304 mm^2) conductor, these values may be reduced to 2 AWG (33.6 mm^2) copper or 1/0 AWG (53.5 mm^2) aluminum.

[c] The cross section may be reduced to 12.5 percent of the total cross section of the largest main service conductor of the same material (copper or aluminum) for any phase on switchgear rated 1200 A and above. This applies when the cross section of the service is limited by the wire terminal connectors specified.

7.4 A switchgear section marked for service equipment use and provided with a neutral shall have a terminal for the connection of the grounding electrode conductor to the neutral bus or to the ground bus in accordance with Table 7.1 or Table 7.2. The connections shall not depend on solder for securing the grounding electrode conductor. If located on the neutral bus, the terminal shall be on the supply side of a switching type disconnect means as specified in 13.2.1 or a disconnect link as specified in 13.2.3. The terminal may be located in another section as covered by the Exception for 13.1.2.

Table 7.2
Equivalent cross sectional areas

Wire size (AWG or MCM)	Minimum cross section inch²	(mm²)
8	0.013	(8.4)
6	0.021	(13.3)
4	0.033	(21.1)
3	0.041	(26.7)
2	0.052	(33.6)
1	0.066	(42.4)
1/0	0.083	(53.5)
2/0	0.105	(67.4)
3/0	0.132	(85.0)
4/0	0.166	(107)
250	0.196	(127)
300	0.236	(152)
350	0.275	(177)
400	0.314	(203)
500	0.393	(253)
600	0.471	(304)
700	0.550	(355)
750	0.589	(380)
800	0.628	(405)
1000	0.785	(507)
1200	0.942	(608)
1250	0.981	(633)
1500	1.18	(760)

7.5 The terminal for the grounding electrode conductor shall be accessible without opening a compartment intended to be sealed or otherwise rendered inaccessible by the serving agency (electric utility or power company).

7.6 In a switchgear section marked for service equipment use, a main bonding jumper shall be provided to bond the enclosure and the ground bus to the grounded conductor of an alternating current circuit. The construction shall be such that when the bonding means is not used, the spacings given in Table 12.1 will exist. Unless the intended use and method of installation of the bonding means are obvious, instructions for its installation shall be provided.

Exception: If several sections, each containing overcurrent protective and disconnection facilities, are intended to be used in a group, only one section need contain a main bonding jumper.

7.7 A secondary circuit of a power or control power transformer shall be grounded under any of the following conditions if the circuit extends or may extend beyond the section in which the transformer is mounted:

a) If the secondary is less than 50 V and the transformer supply is over 150 V to ground or the transformer supply at any voltage is ungrounded, or

b) If the secondary is 50 V or greater and the secondary circuit can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 V.

7.8 If a transformer secondary is required to be grounded in accordance with 7.7, a main bonding jumper shall be factory connected to the transformer secondary and to the ground bus or to the enclosure if a ground bus is not provided. The size of the main bonding jumper shall be as specified in Table 7.1 and Table 7.2 based on the transformer secondary current rating. A grounding electrode conductor connector sized in accordance with Table 7.1 (columns 4 and 5) and Table 7.2 shall be provided:

a) On the ground bus (if any) in the section containing the transformer; or

b) In an adjoining section and a marking as covered in 19.7.1 shall be provided.

7.9 The enclosure shall not be bonded to the neutral when the unit is shipped.

Exception: The enclosure may be bonded to the neutral if the switchgear is intended for a particular installation in which it is known that it will be used as service equipment as indicated on the manufacturer's shop drawing or equivalent.

7.10 With respect to 7.6 and 7.7, a switchgear section may have the main bonding jumper factory connected to the neutral bus and to the ground bus, or to the switchgear frame if a ground bus is not provided, if the switchgear is intended for a particular installation in which it is known that it will be used as service equipment as indicated on the manufacturer's shop drawing or equivalent.

7.11 In a switchgear section incorporating ground-fault protection of the ground-return type as described in 13.1.9, the main bonding jumper as covered in 7.6 shall be factory connected to the neutral bus and to the ground bus, or the switchgear frame if a ground bus is not provided, if the switchgear is intended for a particular installation in which it is known that it will be used as service equipment as indicated on the manufacturer's shop drawing or equivalent.

7.12 A main bonding jumper shall be as specified in Table 7.1 and Table 7.2. The connection of the main bonding jumper to the neutral shall be on the supply side of a switching type disconnect means as specified in 13.2.1 or a disconnect link as specified in 13.2.3.

7.13 The main bonding jumper shall be accessible without opening a compartment intended to be sealed or otherwise rendered inaccessible by a utility.

7.14 Ground bus – Multisection switchgear shall include a ground bus complying with 7.2. A section having through bus bars extending beyond the section bus bars with provision for another section to be added at a later time is considered a part of multisection switchgear.

8 Control and Secondary Wiring

8.1 General

8.1.1 The requirements of this section shall be applied in addition to those specified in 7.1.3.1 of ANSI C37.20.1-2002.

8.1.2 Means shall be provided to space field or factory installed wiring at least 3 inches (76.2 mm) away from a control power transformer, or heating element.

Exception No. 1: Wiring going directly to the terminals of the control power transformer, or heating element may be within 3 inches (76.2 mm) of such unit.

Exception No. 2: The spacing to a control transformer need not be provided, if the operating surface temperatures of the transformer do not exceed:

a) 60°C (140°F) for field installed wiring; and

b) The temperature rating of any factory installed wiring.

8.1.3 An insulated conductor provided as part of (a control circuit or secondary wiring) a switchgear assembly shall be rated for the particular application and shall have an ampacity not less than the continuous current rating of the circuit in which it is connected. See Table 16.3. Where loads are of an intermittent nature, such as in trip circuits, conductors shall be sized to provide their intended function with respect to voltage drop and mechanical strength.

8.2 Wiring terminals – control circuits

8.2.1 A terminal, pressure wire connector or wire binding screw, shall be provided for connection of each control circuit conductor intended to be installed in the switchgear in the field.

8.2.2 Wire binding screws are acceptable for securing a 10 AWG (5.3 mm^2) or smaller conductor only.

8.2.3 Load terminals, including neutral load terminals and connections to the ground bus for load equipment grounding conductors, shall be so located that when the load terminals are deenergized:

a) There will be no need to reach across or beyond an uninsulated ungrounded bus in order to make a load connection; and

b) A tool 10 inches (254 mm) long or shorter, used to tighten a load connection, will not contact a live part that is not obvious to the person making the connection. This shall be determined with branch units connected.

8.2.4 Copper and brass are not acceptable plating for corrosion protection of steel wire binding screws, nuts, and stud terminals, but a plating of cadmium, zinc, tin, silver, and the like, is acceptable.

9 Location of Operating Means

9.1 Circuit breakers and switches shall be located in accordance with 9.2 – 9.4.

9.2 Other than as noted in 9.3 and 9.4, switches and circuit breakers with manual operating means shall be so installed that the center of the grip of the operating handle of the device, when in its highest position, will not be more than 6 ft 7 in (2 m) above the bottom of the switchgear. If the handle grip is not clearly defined, the center of the handle grip shall be considered to be a point 3 inches (76.2 mm) in from the end of the handle.

9.3 If the switchgear is intended for a particular installation where it is known that a raised working platform will be provided, the handle may be more than 6 ft 7 in (2 m) above the bottom of a switchgear but not more than 6 ft 7 in (2 m) above the platform. Drawings or installation instructions provided with the switchgear shall clearly indicate the required location of such a platform.

9.4 For an electrically operated switch or circuit breaker, the controls for opening and closing the device shall be located no higher than 6 ft 7 in (2 m) above the bottom of the switchgear and the manual operating handle for the device, if any, may be above the 6 ft 7 in (2 m) level. The electrical operation controls shall be located in the same vertical section as the switch or circuit breaker they control.

10 Receptacles

10.1 The requirements of this section shall be applied in addition to those specified in 7.1.4.2 of ANSI C37.20.1-2002.

10.2 A receptacle shall be rated for the voltage involved. A single receptacle installed on an individual branch circuit shall have an ampere rating of not less than that of the branch circuit.

10.3 Overcurrent protection for a receptacle branch circuit shall be provided within the section.

Exception: The overcurrent protection may be located in another section of a group of sections intended to be used together.

10.4 A duplex receptacle or two or more receptacles on the same branch circuit shall have overcurrent protection equal to the individual receptacle rating.

Exception No. 1: Receptacles rated 15 A may be used on a 20 A circuit.

Exception No. 2: A 50 A receptacle may be used on a 40 A circuit.

11 Impact and Pressure – Viewing Panes

11.1 The requirements of this section shall be applied in addition to those specified in 7.1.4.3 of ANSI C37.20.1-2002.

11.2 Glass covering an observation opening and forming a part of the enclosure shall be reliably secured in such a manner that it cannot be readily displaced in service, and shall provide mechanical protection for the enclosed parts. Glass for an opening not more than 4 inches (102 mm) in any dimension shall not be less than 0.055 inch (1.40 mm) thick. Glass for an opening having no dimension greater than 12 inches (305 mm) shall not be less than 0.115 inch (2.92 mm) thick. Transparent materials other than glass shall provide resistance to impact and pressure equivalent to the glass specified above.

11.3 Viewing panes having a dimension of more than 12 inches (305 mm) shall comply with the requirements of 11.4 – 11.7.

11.4 Viewing panes as indicated in 11.3 shall not shatter, crack or become dislodged when both sides of the viewing pane, in turn, are subjected to the tests described in 11.5 and 11.6.

11.5 A force of 200 lbf (890 N) shall be exerted perpendicular to the surface in which the viewing pane is mounted. This force shall be evenly distributed over an area of 16 square inches (0.010 m^2), as nearly square as possible and as near the geometric center of the viewing pane as possible. If the viewing pane has an area less than 16 square inches, the force shall be evenly distributed over the entire viewing area. The 200 lbf force shall be sustained for a period of 1 minute. The instrument used to apply the force shall have rounded edges where the glass is contacted.

11.6 The viewing pane shall be subjected to an impact of 5 ft-lbf (6.8 N·m) using a steel ball weighing approximately 1.18 lb (0.535 kg) and approximately 2 inches (50 mm) in diameter.

11.7 Separate samples may be used for each of the tests described in 11.5 and 11.6.

12 Spacings

12.1 General

12.1.1 The requirements of this section shall be applied in addition to those specified in Section 7.1 of ANSI C37.20.1-2002.

12.2 Details

12.2.1 The spacings in a switchgear section shall be as indicated in Table 12.1.

Exception No. 1: Spacings within a component, such as within low-voltage power circuit breakers, industrial control equipment, a meter socket, a heating element, a clock operated switch, and the like, within switchgear sections, and located on the load side of the service disconnect and overcurrent protection, shall comply with the requirements applicable to that component. Spacings between exposed live parts of the component and the overall enclosure, other than inherent spacings, and spacings between exposed live parts of adjacent components, and any adjacent exposed live part, shall comply with Table 12.1 or Table 12.2 as applicable.

Exception No. 2: Spacings in the control circuit may be as indicated in Table 12.3.

Table 12.1
Minimum acceptable spacings – power circuits

Voltage involved		Minimum spacing between live parts opposite polarity				Minimum spacing through air and over surface and grounded metal parts	
		Through air		Over surface			
Greater than	Maximum	inch	(mm)	inch	(mm)	inch	(mm)
0	125	1/2	(12.7)	3/4	(19.1)	1/2	(12.7)
125	250	3/4	(19.1)	1-1/4	(31.8)	1/2	(12.7)
250	600	1	(25.4)	2	(50.8)	1[a]	(25.4)

Table 12.1 Continued on Next Page

Table 12.1 Continued

Voltage involved		Minimum spacing between live parts opposite polarity				Minimum spacing through air and over surface and grounded metal parts	
		Through air		Over surface			
Greater than	Maximum	inch	(mm)	inch	(mm)	inch	(mm)
600	1000	1	(25.4)	2	(50.8)	1[a]	(25.4)

[a] A through air spacing of not less than 1/2 inch (12.7 mm) is acceptable:

1) At a molded-case circuit breaker or a switch, other than a snap switch,

2) Between uninsulated live parts of a meter mounting base and grounded dead metal, and

3) Between grounded dead metal and the neutral of a 480Y/277-V, 3-phase, 4-wire switchgear section.

Table 12.2
Conduit bushing dimensions

Trade size of conduit,	Overall diameter		Height	
inches	inches	(mm)	inches	(mm)
1/2	1	(25.4)	3/8	(9.5)
3/4	1-15/64	(31.4)	27/64	(10.7)
1	1-19/32	(40.5)	33/64	(13.1)
1-1/4	1-15/16	(49.2)	9/16	(14.3)
1-1/2	2-13/64	(56.0)	19/32	(15.1)
2	2-45/64	(68.5)	5/8	(15.9)
2-1/2	3-7/32	(81.8)	3/4	(19.1)
3	3-7/8	(98.4)	13/16	(20.6)
3-1/2	4-7/16	(113.1)	15/16	(23.8)
4	4-31/32	(126.6)	1	(25.4)
4-1/2	5-35/64	(141.0)	1-1/16	(27.0)
5	6-7/32	(158.0)	1-3/16	(30.2)
6	7-7/32	(183.4)	1-1/4	(31.8)

Table 12.3
Control circuit spacings

Voltage involved		Minimum acceptable spacings					
		Between uninsulated live parts of opposite polarity and between an uninsulated live part and an exposed or uninsulated dead metal part other than the enclosure				Between uninsulated live parts and the walls of a metal enclosure, including fittings for conduit or armored cable[b]	
		Over surface		Through air		Shortest distance	
Greater than	Maximum	inch	(mm)	inch	(mm)	inch	(mm)
0	125	1/4	(6.4)	1/8[a]	(3.2)	1/2	(12.7)
125	250	3/8	(9.5)	1/4	(6.4)	1/2	(12.7)
250	600	1/2	(12.7)	3/8	(9.5)	1/2	(12.7)

Table 12.3 Continued on Next Page

Table 12.3 Continued

Voltage involved		Minimum acceptable spacings					
		Between uninsulated live parts of opposite polarity and between an uninsulated live part and an exposed or uninsulated dead metal part other than the enclosure				Between uninsulated live parts and the walls of a metal enclosure, including fittings for conduit or armored cable[b]	
Greater than	Maximum	Over surface		Through air		Shortest distance	
		inch	(mm)	inch	(mm)	inch	(mm)
600	1000	1/2	(12.7)	3/8	(9.5)	1/2	(12.7)

[a] The spacing between wiring terminals of opposite polarity shall not be less than 1/4 inch (6.4 mm) in any case if the terminals are in the same plane.

[b] A metal piece attached to the enclosure shall be considered to be a part of the enclosure for the purpose of this note if deformation of the enclosure is likely to reduce the spacing between the metal piece and a live part.

12.2.2 In applying Table 12.1 and Table 12.3 it is to be assumed that:

a) The voltage from a live part, other than the neutral, to grounded dead metal equals the line-to-line voltage of the system.

b) The voltage from a neutral live part to grounded dead metal equals the line-to-neutral voltage of the system.

Exception: Terminals and other parts intended to be connected to the grounded conductor of a circuit are considered to be uninsulated live parts unless such parts are mounted directly on or in permanent electrical connection with grounded dead metal.

c) Spacings at a fuseholder are to be measured with a fuse of the maximum standard dimensions (including the maximum projections for assembly screws and rivets) in place. Dimensions of fuses and fuseholders will be found in the following:

1) The Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1,

2) The Standard for Low-Voltage Fuses – Part 4: Class CC Fuses, UL 248-4,

3) The Standard for Low-Voltage Fuses – Part 5: Class G Fuses, UL 248-5,

4) The Standard for Low-Voltage Fuses – Part 6: Class H Non-Renewable Fuses, UL 248-6,

5) The Standard for Low-Voltage Fuses – Part 8: Class J Fuses, UL 248-8,

6) The Standard for Low-Voltage Fuses – Part 10: Class L Fuses, UL 248-10,

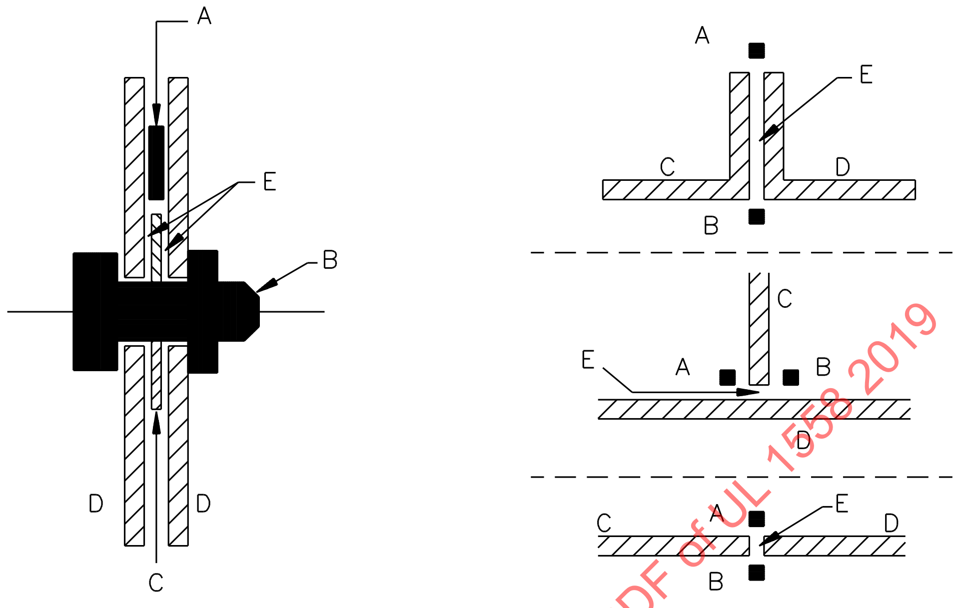
7) The Standard for Low-Voltage Fuses – Part 11: Plug Fuses, UL 248-11, and

8) The Standard for Low-Voltage Fuses – Part 12: Class R Fuses, UL 248-12,

9) The Standard for Low-Voltage Fuses – Part 15: Class T Fuses, UL 248-15

d) Spacings are to be measured through cracks unless a clamped joint complies with the test requirements in 12.4.1. A clamped joint is a joint between two pieces of insulation that are under pressure as shown in Figure 12.1. Adhesives, cements, and the like, if used to effect a seal in place of a tightly mated joint, shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Figure 12.1
Clamped joint



Parts A, B – Live parts of opposite polarity, or a live part and grounded metal part, with spacing through the crack between C and D less than required in Table 12.1 or Table 12.3.

Parts C, D – Insulating barriers clamped tightly together so that the dielectric strength between A and B is greater than the equivalent air spacing.

Part E – The clamped joint.

12.2.3 With respect to Table 12.1 and Table 12.3:

a) An isolated dead metal part, such as a screwhead or a washer, interposed between uninsulated live parts of opposite polarity or between an uninsulated live part and grounded dead metal is to be considered to reduce the spacing by an amount equal to the dimension of the interposed part along the path of measurement.

b) In measuring an over-surface spacing, any slot, groove, and the like, 0.013 inch (0.33 mm) wide or less, in the contour of insulating material is to be disregarded.

c) In measuring spacings, an air space of 0.013 inch or less between a live part and an insulating surface is to be disregarded, and the live part is to be considered in contact with the insulating material.

12.2.4 Terminals and other parts intended to be connected to the grounded conductor of a circuit are considered to be uninsulated live parts unless such parts are mounted directly on or in permanent electrical connection with grounded dead metal.

12.2.5 Spacings are to be measured with all terminals:

a) Unwired; and

b) Wired with the intended conductors determined in accordance with manufacturers instructions, but no conductor smaller than 12 AWG (3.3 mm^2) is to be employed.

12.2.6 In measuring between an uninsulated live part and a bushing installed at a knockout, it is to be assumed that a bushing having the dimensions indicated in Table 12.2 – but without a locknut inside the enclosure – is in place.

12.2.7 A pressure wire connector shall be prevented from turning that would result in less than the minimum acceptable spacings. The means for turn prevention shall be reliable, such as a shoulder or boss. A lockwasher alone is not acceptable.

Exception: Means to prevent turning need not be provided if spacings are not less than the minimum acceptable values:

a) When the connector, and any connector of opposite polarity, have each been turned 30 degrees toward the other, and

b) When the connector has been turned 30 degrees toward other opposite polarity live parts and toward grounded dead metal parts.

12.3 Insulating barriers

12.3.1 In 12.3.2 – 12.3.8 the liner or barrier referred to is insulating material that separates uninsulated live parts of opposite polarity or separates an uninsulated live part from a grounded dead metal part, including the enclosure, if the through air spacing between the parts would otherwise be less than the minimum acceptable value.

12.3.2 A barrier or liner used in conjunction with an air space shall have a thickness of 0.028 inch (0.71 mm) or more.

Exception No. 1: A barrier or liner used in conjunction with an air space of 1/2 or more of the required through air spacing may have a thickness of not less than 0.013 inch (0.33 mm) if it is:

a) Of material acceptable for supporting uninsulated live parts, *b) Of such strength to withstand exposure to mechanical damage,*

c) Secured in place, and

d) So located that it will not be adversely affected by operation of the equipment in service.

Exception No. 2: Insulating material having a thickness less than that indicated may be accepted if it has been found to be acceptable for the particular application.

12.3.3 If the barrier mentioned in 12.3.2 is of fiber, the air space shall not be less than 1/32 inch (0.8 mm).

12.3.4 If the barrier mentioned in 12.3.2 is of material – other than fiber – that is not rated for the support of uninsulated live parts, the air space shall be adequate for the particular application.

12.3.5 A barrier less than 0.028 inch (0.71 mm) thick that is used in accordance with 12.3.2 shall be subjected to the application of a 5000 V, 60 Hz potential. A barrier less than 0.013 inch (0.33 mm) thick that is used in accordance with Exception No. 1 of 12.3.2 shall be subjected to the application of a 2500 V, 60 Hz potential. The mechanical strength and flammability shall be acceptable for the particular application.

12.3.6 With respect to 12.3.5, the barrier material is to be placed between two flat metal electrodes and the test potential increased to the test value. The maximum test potential is to be maintained for 1 second. The result is acceptable if there is no electrical breakdown.

12.3.7 A wrap of thermoplastic tape, rated for use as sole insulation, may be employed if the tape is not subject to compression, is not wrapped over a sharp edge, and if:

a) At a point where the spacing prior to the application of the tape is not less than half the required through air spacing, the wrap is not less than 0.013 inch (0.33 mm) thick and is applied in two or more layers.

b) At a point where the spacing prior to the application of the tape is less than half the required through air spacing, the wrap is not less than 0.028 inch (0.71 mm) thick.

c) The tape has a temperature rating of 105°C (221°F) or higher.

12.3.8 If spacings would otherwise be less than the minimum acceptable values, thermoplastic tubing may be employed if:

a) It is not subjected to compression, repeated flexure, or sharp bends,

b) All edges of the conductor covered with the tubing are rounded and free from sharp edges,

c) For chemically dilated tubing, a solvent recommended by the tubing manufacturer is used,

d) Its wall thickness (after assembly) is not less than 0.022 inch (0.56 mm) for tubing 1/2 inch (12.7 mm) or less in diameter, not less than 0.027 inch (0.69 mm) for tubing 9/16 or 5/8 inch (14.3 or 15.9 mm) in diameter, and not less than 0.028 inch (0.71 mm) for larger tubing, and

e) Its temperature marking is not less than 105°C (221°F).

12.4 Clamped joint

12.4.1 With respect to 12.2.2 (d), a clamped joint between two insulators is to be tested using two samples.

a) The first sample is to have the clamped joint opened up to produce a space 1/8 inch (3.2 mm) wide. This is to be accomplished by loosening the clamping means or by drilling a 1/8 inch diameter hole at the joint between the insulators at a point of minimum spacing between the metal parts on the opposite sides of the joint. The drilled hole shall not decrease spacings between the opposite polarity parts as measured through the crack between the insulators. The 60 Hz dielectric breakdown voltage through this hole is then determined by applying a gradually increasing voltage, 500 volts per second, until breakdown occurs.

b) The second sample with the clamped joint intact is to be subjected to a gradually increasing 60 Hz voltage until 110 percent of the breakdown voltage of (a) has been reached. If the breakdown voltage of (a) is less than 4600 V rms, the voltage applied to the second sample is to be further increased to 5000 V rms and held for 1 second. The clamped joint is acceptable if there is no electrical breakdown of the second sample.

13 Service Equipment Use

13.1 General

13.1.1 The requirements of this section shall be applied in addition to those specified in 7.1.4.4 of ANSI C37.20.1-2002.

13.1.2 A switchgear section marked for service equipment use shall be provided with both overcurrent protective and disconnection facilities for the service conductors as well as the means for grounding the neutral service conductor if one is provided.

Exception: If several sections, each of which:

a) Contains overcurrent protection and service disconnects, and

b) Is marked as covered in 19.2.1, are intended to be used in a group, only one section need contain means for grounding the neutral service conductor. Means for disconnecting the neutral from the service conductors may be in only one section of such a group if it disconnects the neutrals in all the sections from the service conductors.

13.1.3 A switchgear section, or several sections intended to be used in a group, marked for service equipment use shall be so constructed that all ungrounded load conductors – other than through bus – can be disconnected from the source of supply by the operation of not more than six operating handles when all of the disconnecting means for which space is provided are installed at the factory or in the field. The operation of each handle shall simultaneously disconnect all ungrounded conductors of each circuit controlled by that handle. Markings in accordance with 19.3.1 – 19.5.3 shall be provided.

Exception No. 1: Additional disconnecting means for the control circuits of power operable service disconnects may be connected to the source on the line side of the service disconnects.

Exception No. 2: A disconnecting means used solely for the control circuit of the ground-fault protection system shall not be counted as one of the six disconnecting means.

13.1.4 In a switchgear section marked for use as service equipment, any uninsulated bus bar or terminal on the line side of a service disconnect shall be isolated by a barrier so that with every service disconnect in the off position no uninsulated live part is exposed to contact while servicing any load terminal, including a neutral load terminal, a branch circuit equipment grounding terminal, or the neutral disconnect link.

13.1.5 A switchgear section marked for service equipment use for 3-phase, 4-wire, wye connected services rated in excess of 150 V to ground, but not exceeding 1000 V phase-to-phase, shall be provided with ground-fault protection for each service disconnecting means rated 1000 A or more. The ground-fault sensing and relaying equipment provided shall operate to cause the service disconnecting means to open all ungrounded conductors of the faulted circuit. The maximum setting of the ground fault protection shall be 1200 A. It is assumed that a 3-phase, 3-wire switchgear assembly may be connected to a solidly grounded 3-phase, 4-wire, wye-connected service.

Exception No. 1: If each service disconnecting means rated 1000 A or more, is provided with a shunt trip that is intended for use with ground-fault protection, the ground-fault sensors or relaying equipment or both may be in a separate section of the switchgear if several sections are intended for use in a group.

Exception No. 2: Ground-fault protection need not be provided for a switchgear section marked in accordance with 19.4.5.

Exception No. 3: If marked in accordance with 19.4.6, ground-fault protection need not be provided for a source intended to supply power to a fire pump or a legally required standby system.

13.1.6 If ground-fault protection is provided, though not required by 13.1.5, it shall comply with the requirements for the installation of ground fault protection equipment in this Standard.

Exception No. 1: Testing of the ground-fault protection system in accordance with Field Testing of Ground-Fault Protection of Equipment, Section 20, is not required.

Exception No. 2: If marked in accordance with 19.4.7, the ground-fault protection may initiate an audible or visual signal rather than open a source intended for legally required standby systems.

13.1.7 A ground-fault protection system that employs a sensing element that encircles the neutral conductor, if any, and all ungrounded conductors of the protected circuit – zero sequence type – shall be installed in such a manner that the sensing element is located on the load side of any grounding or bonding connections to the neutral. The sensing element may be on the line or load side of the disconnecting device for the protected circuit.

Exception: Differential types of sensors used on double-ended assemblies need not comply with this requirement.

13.1.8 A ground-fault protection system that combines the outputs of separate sensing elements for the neutral, if any, and each ungrounded conductor – residual type – shall be installed in such a manner that the neutral sensing element is located on the load side of any grounding or bonding connection to the neutral. The ungrounded conductor sensors may be on the line or load side of the disconnecting device for the protected circuit.

Exception: Differential types of sensors used on double ended assemblies need not comply with this requirement.

13.1.9 A ground-fault protection system that employs a single sensing element to detect the actual fault current – ground return type – shall be installed in such a manner that the sensing element detects any current that flows in the grounding electrode conductor, the main bonding jumper, and any other grounding connections within the switchgear section that may be made to the neutral. The neutral is to be insulated from noncurrent carrying metal. See 7.11.

13.1.10 If switchgear incorporates ground-fault protection, the load termination part of the neutral bus marked in accordance with 19.4.2 shall be insulated from the enclosure and shall have no terminal or other provision for grounding or bonding. If the ground-fault protection is of the zero sequence or residual type, all neutral load terminations on the neutral bus shall be on the load side of the sensing elements but provision for grounding and bonding shall be on the line side of the sensing element. For ground-fault protection of the ground return type, grounding and bonding of the neutral shall be effected only by means of a conductor (or conductors), the current through which is detected by the sensing element.

13.1.11 If the enclosure or ground bus is factory bonded to the neutral because of known use, as covered in 7.10 and 7.11, any conductive part connected to the neutral that would interfere with the operation of a ground-fault protection system, if in contact with the enclosure, shall be insulated and provided with at least 1/8 inch (3.2 mm) spacing through air or over surface to the enclosure. For zero-sequence and residual types ground-fault protection, parts that would interfere with its operation, if grounded, include all neutral parts on the load side of the neutral-current-sensing means. For the ground-return type, parts that would interfere with its operation, if grounded, include all conductive parts connected to the neutral except those on the ground side of the sensing means.

13.1.12 A ground-fault protection sensor shall be securely mounted to minimize the possibility of damage to it or its leads during shipment.

13.1.13 If the construction of ground-fault sensing and relaying equipment is such that a reset operation is required to restore the equipment to functional status following operation due to a ground fault or test:

a) The construction shall be such as to prevent closing and maintaining contact of the disconnecting device to be controlled by the ground-fault sensing and relaying equipment until the reset operation is performed, or

b) Such means shall be incorporated in the disconnect device.

Exception: The requirement does not apply to flag and annunciator indicators requiring separate reset operation not affecting the ability of the unit to respond to a ground fault.

13.1.14 The service disconnecting means shall be capable of external manual operation to disconnect all ungrounded conductors under rated load conditions.

13.1.15 The disconnecting means referred to in 13.1.3 and 13.1.14 may be either manually operable circuit breakers equipped with a handle or other operating means or power-operated circuit breakers that can be manually opened (tripped) in the event of a power supply failure.

13.2 Neutral disconnecting means

13.2.1 In a switchgear section having a neutral and intended for service equipment use, means shall be provided for disconnecting the neutral-service conductor from the interior wiring. This may be incorporated in the disconnecting means referred to in 13.1.3 or may be in the form of one or more removable links. The disconnecting means shall be on the load side of the grounding-electrode terminal and of the main-bonding jumper. The disconnecting means may be located in another section of a group as covered by the Exception in 13.1.2.

13.2.2 In a group of switchgear sections having a neutral and not intended for service equipment use, means shall be provided for disconnecting the neutral supply conductor from the switchgear neutral. The disconnecting means may be:

a) A disconnect link,

b) A similar conducting piece,

c) By the removal of the conductor from its terminal, or

d) By removal of the terminal.

13.2.3 The disconnect link mentioned in 13.2.1 shall take the form of a link, or similar conducting piece, constructed to make connection between two terminals. Simple removal of bolts from a single bus-bar joint is not acceptable.

13.2.4 A disconnect link shall be located, guarded, recessed, or enclosed so that unintentional contact with any uninsulated, ungrounded part on the line side of the main switch or circuit breaker will not occur while the link is being removed or replaced.

13.2.5 The disconnect link shall be accessible without opening a compartment intended to be sealed or otherwise rendered inaccessible by the serving agency (electric utility or power company).

13.2.6 A switchgear section may have provision for the connection of a meter and any associated current transformers on the supply side of the disconnecting means or service overcurrent protective devices or both.

13.3 Equipment on supply side of disconnect

13.3.1 Equipment shall not be connected to the supply side of the service disconnecting means.

Exception No. 1: Meters nominally rated not in excess of 1000 V located in the switchgear may be connected to the supply side of the service disconnecting means.

Exception No. 2: Instrument transformers (current and potential), high-impedance shunts, surge-protective devices identified for use on the supply side of the service disconnect, load management devices, and surge arresters located in the switchgear may be connected to the supply side of the service disconnecting means.

Exception No. 3: Taps as described in 4.1 may be located on the supply side of the service disconnecting means.

Exception No. 4: Control circuits of power operable service disconnecting means, including a ground-fault protection system, as covered in Exception No. 2 of 13.1.3, may be connected to the supply side of the service disconnecting means.

14 Multiple Source Switchgear

14.1 Unless intended for parallel operation, the disconnect identified in Figure 4.2 and Figure 4.3 as the tie-breaker shall be provided with mechanical, key, or electrical interlocking with the service disconnects shown in the figures so that sources can not be paralleled.

14.2 If a switchgear assembly is intended to parallel different sources, synchronizing equipment shall be provided. Other equipment that may be provided include over and under voltage relays, reverse power relays, and under and over frequency relays.

Exception: Synchronizing equipment is not required for induction generators.

15 Corrosion Protection

15.1 The corrosion protection for switchgear shall comply with 7.2.2 of ANSI C37.20.1-2002.

16 Wiring Space

16.1 General

16.1.1 The requirements of this section shall be applied in addition to those specified in 7.12 of ANSI C37.20.1-2002.

16.1.2 There shall be space within the enclosure of a switchgear section for the installation of those wires and cables likely to be employed in connecting the mains and branch circuits, including feed through conductors that may continue to another section.

16.1.3 In determining the adequacy of wiring space, it is to be assumed that:

a) The size, type, and conductor material of a wire is to be used at a terminal in accordance with Table 16.3, and

b) The full complement of branch circuit devices necessitating the largest wiring space will be installed as indicated on the manufacturer's drawings.

If a terminal is to be for use with two or more combinations of conductors in multiple, each of which would be appropriate for that terminal, it is to be assumed that the combination necessitating the largest wiring space will be used, unless there is an appropriate marking. It is to be assumed that if provision is made for conductors in multiple, each set of conductors will be run in a separate conduit.

16.2 Wire bending space and gutter width

16.2.1 Wire bending space for field installed wires shall be provided opposite any wire connector and also opposite any opening or knockout for a conduit or wireway as specified in 16.2.2 or 16.2.3.

Exception No. 1: The wire bending space for a connector for a grounding conductor may be less than specified.

Exception No. 2: For a connector located on a separate neutral block in a wiring gutter, the spacing may be less than that indicated in Table 16.1, depending upon the amount less than a right angle that the connected conductor will have to be bent in order that it may be installed in a normal manner without damaging its insulation.

Table 16.1
Minimum width of gutter and wire-bending space in inches (mm)

Size of wire		Wires per terminal (pole)					
AWG or MCM	(mm^2)	1		2	3	4	5
14 – 10	(2.1 – 5.3)	Not Specified		–	–	–	–
8 – 6	(8.4 – 13.3)	1-1/2	(38.1)	–	–	–	–
4 – 3	(21.1 – 26.7)	2	(50.8)	–	–	–	–
2	(33.6)	2-1/2	(63.5)	–	–	–	–
1	(42.4)	3	(76.2)	–	–	–	–
1/0 – 2/0	(53.5 – 67.4)	3-1/2	(88.9)	5 (127)	7 (178)	–	–
3/0 – 4/0	(85.0 – 107)	4	(102)	6 (152)	8 (203)	–	–

Table 16.1 Continued on Next Page

Table 16.1 Continued

Size of wire		Wires per terminal (pole)					
AWG or MCM	(mm^2)	1		2	3	4	5
250	(127)	4-1/2	(114)	6 (152)	8 (203)	10 (254)	–
300 – 350	(157 – 177)	5	(127)	8 (203)	10 (254)	12 (305)	
400 – 500	(203 – 253)	6	(152)	8 (203)	10 (254)	12 (305)	14 (356)
600 – 700	(304 – 355)	8	(203	10 (254)	12 (305)	14 (356)	16 (406)
750 – 900	(380 – 456)	8	(203)	12 (305)	14 (356)	16 (406)	18 (457)
1000 – 1250	(507 – 633)	10	(254)	–	–	–	–
1500 – 2000	(760 – 1010)	12	(305)	–	–	–	–
NOTE – The table includes only those multiple-conductor combinations that are likely to be used. Combinations not mentioned may be given further consideration.							

16.2.2 If a conductor is likely to enter or leave the enclosure surface or open bottom opposite its wire connector, the wire bending space shall be as specified in Table 16.2. A wire is considered likely to enter or leave a top, back or side surface if there is an opening or knockout for a wireway or conduit.

Exception: The wire bending space may be in accordance with Table 16.1 if:

a) A barrier is provided between the connector and the opening, or

b) Drawings are provided specifying that the conductors are not to enter or leave the enclosure surface that is opposite the wire connector.

Table 16.2
Minimum wire-bending space at terminals in inches (mm)

Wire size AWG or MCM (mm^2)		Wires per terminal (pole)[a]						
		1		2		3		4 or more
14 – 10	(2.1 – 5.3)	Not Specified		–	–	–	–	–
8	(8.4)	1-1/2		–	–	–	–	–
6	(13.3)	2		–	–	–	–	–
4	(21.2)	3		–	–	–	–	–
3	(26.7)	3		–	–	–	–	–
2	(33.6)	3-1/2		–	–	–	–	–
1	(42.4)	4-1/2		–	–	–	–	–
1/0	(53.5)	5-1/2		5-1/2		7		–
2/0	(67.4)	6		6		7-1/2		–
3/0	(85.0)	6-1/2	(1/2)	6-1/2	(1/2)	8		–
4/0	(107)	7	(1)	7-1/2	(1-1/2)	8-1/2	(1/2)	–
250	(127)	8-1/2	(2)	8-1/2	(2)	9	(1)	10
300	(152)	10	(3)	10	(2)	11	(1)	12
350	(177)	12	(3)	12	(3)	13	(3)	14 (2)

Table 16.2 Continued on Next Page

Table 16.2 Continued

Wire size AWG or MCM (mm[2])		Wires per terminal (pole)[a]						
		1		2		3		4 or more
400	(203)	13	(3)	13	(3)	14	(3)	15 (3)
500	(253)	14	(3)	14	(3)	15	(3)	16 (3)
600	(304)	15	(3)	16	(3)	18	(3)	19 (3)
700	(355)	16	(3)	18	(3)	20	(3)	22 (3)
750	(380)	17	(3)	19	(3)	22	(3)	24 (3)
800	(405)	18		20	–	22		24
900	(456)	19		22	–	24		24
1000	(507)	20			–		–	–
1250	(633)	22			–		–	–
1500	(760)	24			–		–	–
1750	(887)	24			–		–	–
2000	(1010)	24			–		–	–

[a] Wire bending space shall be permitted to be reduced by the number of inches shown in parentheses under the following conditions:

1. Only removable or lay-in wire connectors receiving one wire each are used, (there may be more than one removable wire connector per terminal).

2. The removable wire connectors can be removed from their intended location without disturbing structural or electrical parts other than a cover, and can be reinstalled with the conductor in place.

For SI units one inch = 25.4 mm

16.2.3 If a conductor is not likely to enter or leave the enclosure surface opposite its wire connector, the wire bending space shall be as specified in Table 16.1.

16.2.4 If there is no barrier between two sections of a group, up to one-third of the required wire bending space may be in the adjacent section.

16.2.5 If a conductor is restricted by a barrier or other means from being bent where it leaves the connector, the distance is to be measured from the end of the barrier.

16.2.6 Where conductors are installed in parallel, the width of the gutter shall be judged on the basis of the number of conductors in parallel.

16.2.7 The distance mentioned in 16.2.1 – 16.2.4 and specified in Table 16.1 and Table 16.2 is to be measured in a straight line from the edge of the wire terminal closest to the wall in a direction perpendicular to the enclosure wall or barrier. The wire terminal shall be turned so that the axis of the wire opening in the connector is as close to perpendicular to the wall of the enclosure as it can assume without defeating any reliable means provided to prevent its turning, such as a boss, shoulder, walls of a recess, multiple bolts securing the connector, or the like. That is, no credit is to be given for angling of terminals as illustrated by distance D1 in Figure 16.1; the correct method is to measure perpendicular to the enclosure wall from the edge of the terminal, as illustrated by distance D2 in Figure 16.1. A barrier, shoulder, or the like is to be disregarded when the measurement is being made if it does not reduce the radius to which the wire must be bent. If a terminal is provided with one or more connectors for the connection of conductors in multiple, the distance is to be measured from the wire opening closest to the wall of the enclosure. If the connectors for a circuit are fixed in position – for example, by the walls of a recess – so that they are turned toward each other, the distance is to be measured at the wire opening nearest to the wall in a direction perpendicular to the wall.

Exception No. 1: When measuring bending space for compliance with Table 16.1, the distance (distance D3 in Figure 16.2) may be measured in a straight line from the center of the wire opening in the direction the wire leaves the terminal.

Exception No. 2: If the intended method of wiring is clearly indicated on the manufacturer's drawings and if the equivalent wiring space is provided.

Figure 16.1
Measurement of wire bending space distances