

DOCUMENT NUMBER: UL 347

### ORDER OF DATA

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**Underwriters Laboratories Inc.®**

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

**April 16, 1996**

**Revision pages for**

**Standard for**

**High Voltage Industrial Control Equipment**

**UL 347, Fourth Edition**

Attached to this transmittal notice is a revision of the Fourth edition of UL 347.

A CHANGE ON A PAGE DATED APRIL 16, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THESE NEW AND REVISED REQUIREMENTS IN THIS STANDARD ARE NOW IN EFFECT EXCEPT FOR THOSE PARAGRAPHS, SECTIONS, TABLES, FIGURES, AND OTHER ELEMENTS OF THE STANDARD HAVING FUTURE EFFECTIVE DATES AS INDICATED IN THE NOTE FOLLOWING THE AFFECTED ITEM. TO RETAIN THE REQUIREMENTS IN EFFECT UNTIL THESE FUTURE EFFECTIVE DATES, DO NOT DISCARD THE PAGES REPLACED BY THOSE HAVING FUTURE EFFECTIVE DATES UNTIL THOSE DATES.

THE FOLLOWING REVISIONS ARE CONSIDERED NON-SUBSTANTIVE AND WERE ISSUED TO:

ELIMINATE THE OXYGEN BOMB TEST. THE OXYGEN BOMB TEST IS NO LONGER APPROPRIATE IN MOST CASES DUE TO THE ADDITION OF ANTIOXIDANTS TO RUBBER AND POLYMERIC COMPOUNDS. THEREFORE, UL IS ELIMINATING THE OXYGEN BOMB TEST AND REPLACING IT WITH AN AIR OVEN AGING TEST WHICH IS USED FOR THERMOPLASTIC COMPOUNDS.

Attention is directed to the note on the title page of this standard outlining the procedure to be followed to retain the approved text of ANSI/UL 347-1995.

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

With the inclusion of the accompanying material, the standard consists of pages dated as shown in the following checklist:

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**AUGUST 31, 1993**  
(Title Page Reprinted: April 16, 1996)



**ANSI/UL 347-1995**

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**UL 347**

**Standard for**

**High Voltage Industrial Control Equipment**

First Edition – July, 1976  
Second Edition – January, 1979  
Third Edition – September, 1985

**Fourth Edition**

**August 31, 1993**

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated August 31, 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 347-1978, October 16, 1978  
Approved as ANSI/UL 347-1985, March 29, 1985  
Approved as ANSI/UL 347-1995, February 13, 1995

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

**ISBN 1-55989-468-7**

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34.2 The enclosure to be tested shall be fully equipped and complete with all appurtenances, such as roof bushings, conduits, and the like, and mounted in the intended manner in the area to be supplied with artificial precipitation. For multiple unit construction a minimum of two units shall be used to test the joints between units, including a roof joint.

34.3 The tightening torque for rigid conduit threaded into the opening in the enclosure is to be 800 pound-inches (90 N·m) for 3/4-inch and smaller trade sizes, 1000 pound-inches (113 N·m) for 1-, 1-1/4-, and 1-1/2-inch trade sizes, and 1600 pound-inches (181 N·m) for 2-inch and larger trade sizes.

34.4 The artificial precipitation shall be supplied by a sufficient number of nozzles to produce a uniform spray over the entire surface or surfaces under test. The various vertical surfaces of an enclosure may be tested separately or collectively, provided that a uniform spray is simultaneously applied to both of the following:

- a) The roof surfaces, from nozzles located at an appropriate height.
- b) The floor outside the enclosure for a distance of approximately 1 m (3 ft) in front of the surface under test with the enclosure located at its normal height above the floor level.

34.5 The nozzles used for this test shall deliver a square shaped spray pattern with uniform spray distribution and shall have a capacity of at least 450 cm<sup>3</sup>/s (7.1 gallons per minute) at 41.4 N/cm<sup>2</sup> (60 psig) pressure, and a spray angle of approximately 75 degrees. The center line of the nozzles shall be inclined downward so that the top of the spray is horizontal as it is directed towards the vertical and roof surfaces being tested.

\*34.5 revised August 11, 1995\*

34.6 The pressure at the nozzles shall be a minimum of 41.4 N/cm<sup>2</sup> (60 psig) under flow conditions. This is approximately equivalent to rain driven by a 29 m/s (65 miles per hour) wind. The quantity of water applied to each surface under test shall be at least 0.5 cm (0.2 inch) per unit surface per minute, and each surface so tested shall receive this rate of artificial precipitation for a duration of 5 minutes. The spray nozzle shall not be more than 3 m (10 ft) from the nearest vertical surface under test.

34.7 At the conclusion of the test, an enclosure marked rainproof shall be considered to have met the requirements of this test if:

- a) No water visibly observable on primary or secondary insulation.
- b) No water visibly observable on any electrical components or mechanisms of the assembly.
- c) No significant accumulation of water retained by the structure or other noninsulating parts (to minimize corrosion).

34.8 At the conclusion of the test, an enclosure marked raintight shall be considered to have met the requirements of this test if there is no entrance of water.

### 35 Accelerated Aging of Gaskets Tests

35.1 A gasket of an elastomeric or thermoplastic material or a composition gasket utilizing an elastomeric material employed to make an enclosure rainproof or raintight shall be resistant to aging as determined by the accelerated-aging tests described either in 35.2 or 35.3.

35.2 A gasket of rubber or neoprene, or a composition thereof, is to be exposed for 70 hours to a temperature of 100°C (212°F) in an air oven. The gasket is considered acceptably resistant to aging if there is no visible evidence of deterioration, such as softening, hardening, or cracking after flexing.

\*35.2 revised April 16, 1996\*

35.3 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.

### 36 Impact and Pressure Tests – Viewing Panes

36.1 Viewing panes as indicated in 7.1.33 shall not shatter, crack or become dislodged when both sides of the viewing pane in turn are subjected to the tests described in 36.2 and 36.3.

36.1 revised August 11, 1995

36.2 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<sup>2</sup>), 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 (890-N) force shall be sustained for a period of 1 minute.

36.3 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.

36.4 Separate samples may be used for each of the tests described in 35.2 and 35.3.

### 37 Metallic Coating Thickness Tests

37.1 The method of determining the thickness of a zinc or cadmium coating is described in 37.2 – 37.9.

37.2 The solution used for the test is to be made from distilled water and is to contain 200 g/L of American Chemical Society (ACS) reagent grade chromic acid (CrO<sub>3</sub>) and 50 g/L of ACS reagent grade concentrated sulfuric acid (H<sub>2</sub>SO<sub>4</sub>). The latter is equivalent to 27 mL/L of ACS reagent grade concentrated sulfuric acid, specific gravity 1.84, containing 96 percent of H<sub>2</sub>SO<sub>4</sub>.

37.3 The test solution is to be contained in a glass vessel, such as a separately funnel, with the outlet equipped with a stopcock and a capillary tube having an inside bore of 0.025 inch (0.64 mm) and a length of 5.5 inches (140 mm). The lower end of the capillary tube is to be tapered to form a tip, the drops from which are about 0.05 mL each. To preserve an effectively constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100±5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

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

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



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**August 11, 1995**

**Revision pages for**

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A CHANGE ON A PAGE DATED AUGUST 11, 1995 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THIS REVISION IS BEING ISSUED TO CORRECT INACCURATE REFERENCES. THE REQUIREMENTS ARE NOW IN EFFECT.

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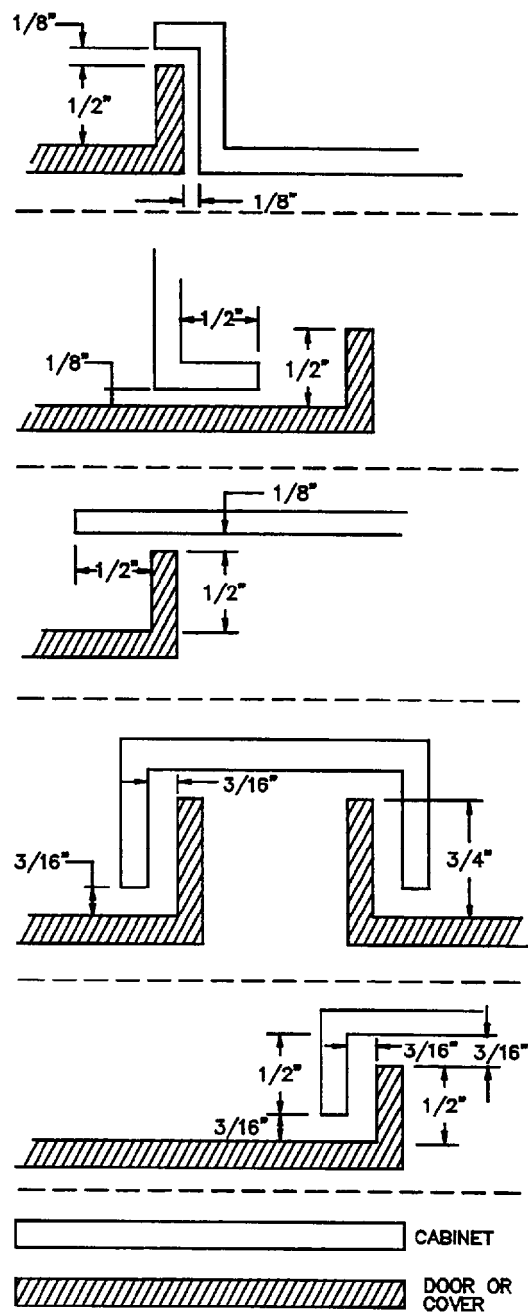
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**Figure 7.2**  
**Typical constructions**



SC1187

| Inch | 1/8 | 3/16 | 1/2  | 3/4  |
|------|-----|------|------|------|
| mm   | 3/2 | 4.8  | 12/7 | 19.1 |

7.1.8 To determine whether a flanged door or cover complies with the requirement in 7.1.7 regarding depth of flange, the distance between the flat portion of the door or cover – clear of forming radii, beads, draws, and the like – and a straight edge placed across any two flanges at any points is to be measured.

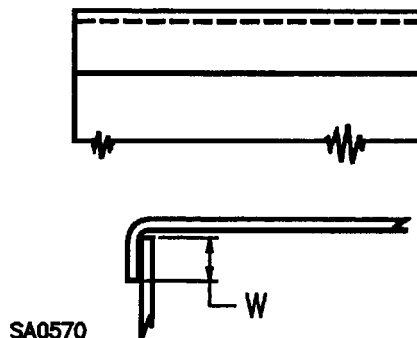
\*7.1.8 revised August 11, 1995\*

7.1.9 If the rabbet construction mentioned in 7.1.7 is not employed, there shall be an overlap of not less than 7/16 inch (11.1 mm) at each edge at which a telescoping door or cover meets the cabinet or box of a surface-mounted enclosure.

\*7.1.9 revised August 11, 1995\*

7.1.10 To determine whether a telescoping door or cover complies with the requirement in 7.1.9, the door or cover is to be in its normally closed position, and a mark 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 shown in Figure 7.3. In scribing the marks, the door or cover is to be held in a fixed position with sufficient firmness to prevent displacement of the cover by the scribing tool, but without bending or distorting any portion of the box, door, or cover, or other part of the enclosure.

**Figure 7.3**  
**Measurement of overlap**



7.1.11 A flat strip used to provide a rabbet, or an angle strip fastened to the edges of a door or cover giving access to a fuse or any portion of a circuit breaker other than the operating handle shall not be less in thickness than 60 percent of the required thickness of the metal of the box proper, but not less than 0.042 inch (1.07 mm) if of uncoated steel, not less than 0.045 inch (1.14 mm) if of zinc-coated steel, and not less than 0.058 inch (1.47 mm) thick if of nonferrous metal. It shall be secured at no fewer than two points. There shall not be more than 1-1/2 inches (38 mm) between an end of the strip and a point at which it is secured, and the distance between adjacent points at which the strip is secured shall not be more than 6 inches (152 mm).

7.1.12 An enclosure of cast metal shall be at least 1/8 inch (3.2 mm) thick at every point, greater than 1/8 inch thick at reinforcing ribs and door edges, and not less than 1/4 inch (6.4 mm) thick at tapped holes for conduit.

**Exception:** At other than at plain or threaded conduit holes, die-cast metal shall be:

- a) Not less than 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (0.015 m<sup>2</sup>) or having any dimensions greater than 6 inches (152 mm) and
- b) Not less than 1/16 inch (1.6 mm) thick for an area of 24 square inches or less and having no dimensions greater than 6 inches. The area limitation may be obtained by the provision of reinforcing ribs subdividing a larger area.

**Table 7.2**  
**Minimum thickness of sheet metal for enclosures**  
**carbon steel or stainless steel**

| Without supporting frame <sup>a</sup>              |                                                       | With supporting frame or equivalent reinforcing <sup>a</sup> |                                                     | Minimum thickness, inches (millimeters) |                                        |
|----------------------------------------------------|-------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------|----------------------------------------|
| Maximum width <sup>b</sup> in inches (millimeters) | Maximum length <sup>c,d</sup> in inches (millimeters) | Maximum width <sup>b</sup> in inches (millimeters)           | Maximum length <sup>d</sup> in inches (millimeters) |                                         |                                        |
| 4.0 (101)                                          | Not limited                                           | 6.25 (159)                                                   | Not limited                                         | 0.020 <sup>e</sup> (0.51) <sup>e</sup>  | 0.023 <sup>e</sup> (0.58) <sup>e</sup> |
| 4.75 (121)                                         | 5.75 (146)                                            | 6.75 (171)                                                   | 8.25 (210)                                          |                                         |                                        |
| 6.0 (152)                                          | Not limited                                           | 9.5 (241)                                                    | Not limited                                         | 0.026 <sup>e</sup> (0.66) <sup>e</sup>  | 0.029 <sup>e</sup> (0.74) <sup>e</sup> |
| 7.0 (178)                                          | 8.75 (222)                                            | 10.0 (254)                                                   | 12.5 (318)                                          |                                         |                                        |
| 8.0 (203)                                          | Not limited                                           | 12.0 (305)                                                   | Not limited                                         | 0.032 (0.81)                            | 0.034 (0.86)                           |
| 9.0 (229)                                          | 11.5 (292)                                            | 13.0 (330)                                                   | 16.0 (406)                                          |                                         |                                        |
| 12.5 (318)                                         | Not limited                                           | 19.5 (495)                                                   | Not limited                                         | 0.042 (1.07)                            | 0.045 (1.14)                           |
| 14.0 (356)                                         | 18.0 (457)                                            | 21.0 (533)                                                   | 25.0 (635)                                          |                                         |                                        |
| 18.0 (457)                                         | Not limited                                           | 27.0 (686)                                                   | Not limited                                         | 0.053 (1.35)                            | 0.056 (1.42)                           |
| 20.0 (508)                                         | 25.0 (635)                                            | 29.0 (737)                                                   | 36.0 (914)                                          |                                         |                                        |
| 22.0 (559)                                         | Not limited                                           | 33.0 (838)                                                   | Not limited                                         | 0.060 (1.52)                            | 0.063 (1.60)                           |
| 25.0 (635)                                         | 31.0 (787)                                            | 35.0 (889)                                                   | 43.0 (1092)                                         |                                         |                                        |
| 25.0 (635)                                         | Not limited                                           | 39.0 (991)                                                   | Not limited                                         | 0.067 (1.70)                            | 0.070 (1.78)                           |
| 29.0 (737)                                         | 36.0 (914)                                            | 41.0 (1041)                                                  | 51.0 (1295)                                         |                                         |                                        |
| 33.0 (838)                                         | Not limited                                           | 51.0 (1295)                                                  | Not limited                                         | 0.080 (2.03)                            | 0.084 (2.13)                           |
| 38.0 (965)                                         | 47.0 (1194)                                           | 54.0 (1372)                                                  | 66.0 (1676)                                         |                                         |                                        |
| 42.0 (1067)                                        | Not limited                                           | 64.0 (1626)                                                  | Not limited                                         | 0.093 (2.36)                            | 0.097 (2.46)                           |
| 47.0 (1194)                                        | 59.0 (1499)                                           | 68.0 (1727)                                                  | 84.0 (2134)                                         |                                         |                                        |
| 52.0 (1321)                                        | Not limited                                           | 80.0 (2032)                                                  | Not limited                                         | 0.108 (2.74)                            | 0.111 (2.82)                           |
| 60.0 (1524)                                        | 74.0 (1880)                                           | 84.0 (2134)                                                  | 103.0 (2616)                                        |                                         |                                        |
| 63.0 (1600)                                        | Not limited                                           | 97.0 (2464)                                                  | Not limited                                         | 0.123 (3.12)                            | 0.126 (3.20)                           |
| 73.0 (1854)                                        | 90.0 (2286)                                           | 103.0 (2616)                                                 | 127.0 (3226)                                        |                                         |                                        |

<sup>a</sup> See 7.1.20.

<sup>b</sup> The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made from a single sheet.

<sup>c</sup> For Panels which are not supported along one side (for example, side panels of boxes) the length of the unsupported side shall be limited to dimensions specified.

<sup>d</sup> "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.

<sup>e</sup> Sheet steel for an enclosure intended for outdoor use (rainproof or raintight) is required to be not less than 0.034 inch (0.86 mm) in thickness if zinc coated and not less 0.032 inch (0.81 mm) in thickness if uncoated.

\*Table 7.2 revised August 11, 1995\*

**Table 7.3**  
**Minimum thickness of sheet metal for enclosures**  
**aluminum, copper, or brass**

| Without supporting frame <sup>a</sup>        |                                                 | With supporting frame or equivalent reinforcing <sup>a</sup> |                                               | Minimum thickness<br>in inches (mm) |                     |
|----------------------------------------------|-------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------|-------------------------------------|---------------------|
| Maximum width <sup>b</sup> in<br>inches (mm) | Maximum length <sup>c,d</sup> in<br>inches (mm) | Maximum width <sup>b</sup> in<br>inches (mm)                 | Maximum length <sup>d</sup> in<br>inches (mm) |                                     |                     |
| 3.0 ( 76)                                    | Not limited                                     | 7.0 ( 178)                                                   | Not limited                                   | 0.023 <sup>e</sup>                  | (0.58) <sup>e</sup> |
| 3.5 ( 89)                                    | 4.0 ( 101)                                      | 8.5 ( 216)                                                   | 9.5 ( 241)                                    |                                     |                     |
| 4.0 ( 101)                                   | Not limited                                     | 10.0 ( 254)                                                  | Not limited                                   | 0.029                               | (0.74)              |
| 5.0 ( 127)                                   | 6.0 ( 152)                                      | 10.5 ( 267)                                                  | 13.5 ( 343)                                   |                                     |                     |
| 6.0 ( 152)                                   | Not limited                                     | 14.0 ( 356)                                                  | Not limited                                   | 0.036                               | (0.91)              |
| 6.5 ( 165)                                   | 8.0 ( 203)                                      | 15.0 ( 381)                                                  | 18.0 ( 457)                                   |                                     |                     |
| 8.0 ( 203)                                   | Not limited                                     | 19.0 ( 483)                                                  | Not limited                                   | 0.045                               | (1.14)              |
| 9.5 ( 241)                                   | 11.5 ( 292)                                     | 21.0 ( 533)                                                  | 25.0 ( 635)                                   |                                     |                     |
| 12.0 ( 305)                                  | Not limited                                     | 28.0 ( 711)                                                  | Not limited                                   | 0.058                               | (1.47)              |
| 14.0 ( 356)                                  | 16.0 ( 406)                                     | 30.0 ( 762)                                                  | 37.0 ( 940)                                   |                                     |                     |
| 18.0 ( 457)                                  | Not limited                                     | 42.0 (1067)                                                  | Not limited                                   | 0.075                               | (1.90)              |
| 20.0 ( 508)                                  | 25.0 ( 635)                                     | 45.0 (1143)                                                  | 55.0 (1397)                                   |                                     |                     |
| 25.0 ( 635)                                  | Not limited                                     | 60.0 (1524)                                                  | Not limited                                   | 0.095                               | (2.41)              |
| 29.0 ( 737)                                  | 36.0 ( 914)                                     | 64.0 (1626)                                                  | 78.0 (1981)                                   |                                     |                     |
| 37.0 ( 940)                                  | Not limited                                     | 87.0 (2210)                                                  | Not limited                                   | 0.122                               | (3.10)              |
| 42.0 (1067)                                  | 53.0 (1346)                                     | 93.0 (2362)                                                  | 114.0 (2896)                                  |                                     |                     |
| 52.0 (1321)                                  | Not limited                                     | 123.0 (3124)                                                 | Not limited                                   | 0.153                               | (3.89)              |
| 60.0 (1524)                                  | 74.0 (1880)                                     | 130.0 (3302)                                                 | 160.0 (4064)                                  |                                     |                     |

<sup>a</sup> See 7.1.20.

<sup>b</sup> The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made from a single sheet.

<sup>c</sup> For panels which are not supported along one side (for example, side panels of boxes) the length of the unsupported side shall be limited to dimensions specified.

<sup>d</sup> "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.

<sup>e</sup> Sheet copper, brass, or aluminum for an enclosure intended for outdoor use (rainproof or raintight) is required to be not less than 0.029 inch (0.74 mm) in thickness.

\*Table 7.3 revised August 11, 1995\*

7.1.25 A door, 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 (1.90 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 inward deflection is not more than 1/4 inch (6.4 mm) when a force of 100 lbf (445 N) is applied perpendicular to the surface at any point on the door, front, panel or cover through a rod having a 1/2 by 1/2 inch (12.7 by 12.7 mm) square steel face. For the test, the enclosure may be laid on its back on a smooth, solid, horizontal surface with the door closed and the front, panel or cover secured as intended. The test force shall be applied at various points on the door likely to cause deflection. The same sample may be used for more than one test provided there is no permanent deflection due to a previous test.

7.1.26 If ventilating openings are provided, the construction shall comply with 7.1.27, 7.1.30, and 30.19.

7.1.27 A ventilating opening in an enclosure, including a louver, or an opening protected by means of wire screening, expanded metal, or a perforated cover, shall be of such size or shape that a rod having a diameter of 33/64 inch (13.1 mm) will not enter any opening. Barriers shall be provided behind all ventilating openings that are acceptable for the particular application.

7.1.28 In determining the acceptability of a barrier as mentioned in 7.1.27 consideration shall be given to the following

- a) the barrier shall be effectively secured in place,
- b) the barrier shall be capable of withstanding the forces to which it may be subjected to in service,
- c) the barrier shall be so located that it will intercept all live parts from line of sight with the opening protected, and
- d) a component, so located or an enclosure so formed as to meet the above intent, is considered acceptable.

7.1.29 An enclosure may be provided without a bottom, provided it is marked in accordance with 40.25.

7.1.30 The diameter of the wires of a screen shall not be less than 0.051 inch (1.30 mm) if the screen openings are 1/2 square inch (322 mm<sup>2</sup>) or less in area, and shall not be less than 0.081 inch (2.06 mm) for larger screen openings.

7.1.31 Perforated sheet steel and sheet steel employed for expanded-metal mesh shall not be less than 0.042 inch (1.07 mm) thick if uncoated and not less than 0.046 inch (1.17 mm) if zinc-coated for mesh openings or perforations 1/2 square inch (322 mm<sup>2</sup>) or less in area, and shall not be less than 0.080 inch (2.03 mm) thick if uncoated and not less than 0.084 inch (2.13 mm) if zinc-coated for larger openings.

*Exception: In a small device where the indentation of a guard or enclosure does not (1) alter the clearance between uninsulated movable live parts and grounded metal so as to affect performance adversely nor (2) reduce spacings below the minimum values given in Table 19.1, expanded-metal mesh of uncoated steel not less than 0.020 inch (0.51 mm) thick and of zinc-coated steel not less than 0.023 inch (0.58 mm) thick may be employed, provided that:*

a) *The exposed mesh on any one side or surface of the device so protected has an area of not more than 72 square inches (0.046 m<sup>2</sup>) and has no dimensions greater than 12 inches (305 mm), or*

b) *The width of an opening so protected is not greater than 3 – 1/2 inches (88.9 mm).*

7.1.32 TRANSFORMER OR AUTOTRANSFORMER ENCLOSURES – A case for a transformer coil or the switch of an autotransformer starter shall provide access to the interior for inspection. Means shall be provided for renewal of any oil used.

7.1.33 VIEWING PANES – A transparent material covering an observation opening and forming a part of the enclosure shall be secured in such a manner that it cannot be readily displaced in service, and shall meet the requirements of Impact and Pressure Tests – Viewing Panes, Section 36.

7.1.34 If a viewing pane is intended to be exposed to insulating oil in a tank or compartment, it shall be of a material that is resistant to the corrosive effects of the insulating oil.

7.1.35 Provision shall be made for securely mounting industrial control equipment to a supporting surface. A bolt, screw, or other part used to mount a component within the equipment shall not be used for securing the complete device to the supporting surface.

7.1.36 An autotransformer starter or resistance device shall be constructed so there will be an air clearance (for cooling purposes) of not less than 1/4 inch (6.4 mm) between the device and a plane mounting surface, except at the points of support.

7.1.37 If a controller is mounted in a cabinet separable from and completely surrounding the control device as a whole, the requirement in 7.1.36 will be considered to be met if the interior base, frame, or panel is mounted in and separated from the cabinet as indicated.

7.1.38 Low-voltage control equipment, relays, motors, and the like – except instrument or control transformers that are connected to the high-voltage – shall not be located in compartments with exposed high-voltage parts or high-voltage wiring unless the access door or cover is interlocked with the high-voltage switch or disconnecting means to prevent the door or cover from being opened or removed unless the switch or disconnecting means is in its isolating position.

7.1.39 Cover plates intended to be removed for inspection purposes shall not exceed 12 ft<sup>2</sup> (1.11 m<sup>2</sup>) in area or 60 lb (27.2 kg) in weight unless they are equipped with lifting means or hinges.

\*7.1.39 revised August 11, 1995\*

## 7.2 Outdoor Enclosures

7.2.1 An enclosure designated rainproof or raintight shall comply with the Water Spray Test, Section 34.

7.2.2 Hinges and other attachments shall be resistant to corrosion. Metals shall not be used in combinations that result in galvanic action that adversely affects any part of the device.

7.2.3 The acceptability of a nonmetallic enclosure is to be determined on the basis of the effect of exposure to ultraviolet light and water.

7.2.4 A rainproof or raintight construction requiring a gasketed joint shall be investigated to determine whether or not it is acceptable for the particular application. See the Accelerated Aging of Gaskets Tests, Section 35.

7.2.5 External hinged doors or covers for rainproof or raintight equipment shall be provided with stops to hold them in the open position.

7.2.6 A rainproof enclosure shall have provision for drainage. A raintight enclosure may have provision for drainage.

7.2.7 An outdoor enclosure, either rainproof or raintight shall be marked in accordance with 40.7 or 40.8, respectively.

7.2.8 Copper, bronze, brass containing not less than 80 percent copper or stainless steel may be used without additional protection against corrosion. Aluminum (sheet, extrusion, or casting), die cast zinc, or another metal shall be of a grade or alloy known to be corrosion resistant, or shall be subjected to appropriate tests or shall be additionally protected from corrosion.

7.2.9 An outdoor sheet steel enclosure shall be protected against corrosion by one of the following coatings:

- a) Hot-dipped mill galvanized sheet steel conforming with the coating Designation G90 in Table I of Specification for Steel Sheet Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-94 with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM designation. The weight of the zinc coating may be determined by any accepted method; however, in case of question the weight of coating shall be established in accordance with the test method of ASTM Designation A90-81.
- b) A zinc coating, other than that provided on hot-dipped mill galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.015 mm) on each surface with a minimum thickness of 0.00054 inch (0.014 mm). The thickness of the coating shall be established by the metallic coating thickness test as indicated in Impact and Pressure Tests – Viewing Panes, Section 36. An annealed coating shall comply with 7.2.10.
- c) A zinc coating conforming with item 1 or 2 below 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 A653/A653M-94, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any accepted method; however, in case of question the weight of coating shall be established in accordance with the test method of ASTM Designation A90-81.
  - 2) A zinc coating, other than that provided on hot-dipped mill galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.010 mm) on each surface with a minimum thickness of 0.00034 inch (0.009 mm). The thickness of the coating shall be established by the metallic coating thickness test as indicated in the Impact and Pressure Tests – Viewing Panes, Section 36.
- 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 metallic coating thickness test as indicated in the Impact and Pressure Tests – Viewing Panes, Section 36.

e) A cadmium coating not less than 0.00075 inch (0.019 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.00051 inch (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established by the metallic coating thickness tests as indicated in Metallic Coating Thickness Tests, Section 37, and the paint shall be as described in item c.

f) Other finishes, including paints, special 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 item A, indicate they provide equivalent protection. Among the factors which are taken into consideration when determining the acceptability of such coating systems are exposure to salt spray, moist carbon dioxide-sulphur dioxide-air mixtures, moist hydrogen sulphide-air mixtures, ultraviolet light, and water.

\*7.2.9 revised August 11, 1995\*

7.2.10 An annealed coating on sheet steel that is bent or similarly formed or extruded or rolled at edge of holes after annealing shall be additionally painted in the affected area if the process damages the zinc coating. If flaking or cracking of the zinc coating at the outside radius of the bent formed section is visible at 25 power magnification, the zinc coating is considered to be damaged. Simple sheared or cut edges and punched holes are not required to be additionally protected.

7.2.11 Aluminum in an outdoor enclosure shall be so located that it will not be in contact with the mounting pad.

7.2.12 If a rainproof enclosure has any opening for passage of a wire or bus bar to a switchboard section or to a wireway, auxiliary gutter or busway, gasket or other means shall be provided that will keep water from entering at such opening. If the opening is for attachment of a busway, the outdoor enclosure and the busway are to be investigated together to determine that water does not enter along the bus bars.

## 8 Arrangement of Components

8.1 Arrangement of devices in assemblies shall be such that individual components can perform their intended function without adversely affecting the operation of other components in the assembly.

8.2 Gas discharged during operation of interrupting devices shall be so directed as not to endanger personnel or impinge on other components of a controller.

8.3 External handles and pushbuttons shall be located in accordance with the following:

a) Control and transfer switch handles or pushbuttons shall be located in a readily accessible location at an elevation above the mounting surface not in excess of 78 inches (1.98 m).

b) Operating handles requiring more than 50 lbf (222 N) to operate, shall not be higher than 66 inches (1.67 m) in either the open or closed position.

c) Operating handles for infrequently operated devices, such as, isolating means reset devices, draw out fuses, fused potential or control transformer primary disconnects, and bus transfer switches, need not comply with items a and b above.

8.4 In determining compliance with 8.3, measurements are to be made from the mounting surface to the center of the handle grip with the handle in its highest possible position. If the handle grip is not clearly defined, the center of the handle grip shall be considered to be at a point 3 inches (76 mm) in from the end of the handle.

- b) The control-circuit transformer shall be provided with primary and secondary fuses. Instrument potential transformers shall be provided with primary fuses.
- c) Class E1 controllers shall be provided with instantaneous fault overcurrent protection in each ungrounded conductor of the power supply in addition to the foregoing motor-running overload protection.
- d) Class E2 controllers shall be provided with high voltage motor circuit fuses for interrupting faults exceeding operating overloads.

11.2 A combination of three overload relays and two current transformers, arranged to sense the current in all three phases, is considered to comply with item a of 11.1.

11.3 Overload devices shall operate to de-energize any connected magnetically operated devices.

11.4 Controllers shall be arranged such that when the high-voltage isolating means is open all high-voltage fuses will be readily accessible, so that they may be replaced without a person touching any live part. The electrical arrangement of a single-throw switch shall be such that, when properly connected, fuse terminals will be dead when the switch contacts are open. See 13.7 and 40.9.

11.5 If the design of a controller is such that a low-voltage control circuit fuse is accessible with the control transformer energized, a warning marking shall be provided in the vicinity of the fuseholder. See 40.23.

11.6 An open-phase protective device when provided shall operate upon the loss of power in one conductor of a polyphase circuit, to cause and maintain the interruption of power in all of the circuit, except that an open-phase protective device for such intermittently operated machines as cranes and elevators, which have a definitely limited travel and a limited time for continuous running, may function only to keep the motor from restarting upon the loss of power in one conductor to the motor.

11.7 A phase-reversal protective device when provided shall operate on the reversal of the phase rotation in a polyphase circuit to cause and maintain the interruption of power in all of the circuit.

## 12 Overload Relays

12.1 Industrial control equipment employing overload relays shall be subjected to the calibration tests indicated in Calibration Tests – Overload Relays, Section 38.

12.2 An overload relay used with a current transformer shall be marked in accordance with 40.11, unless it is so interlocked that the motor cannot be energized with the overload relay current element either removed or open.

12.3 An overload relay shall provide positive electrical and mechanical performance under all conditions of operation for which it is intended.

12.4 An adjustable overload relay shall be provided with instructions for such adjustment.

### 13 Isolating Means

13.1 A controller shall be provided with an externally-operable, gang-operated, high-voltage, power circuit isolating means with position indication. The isolating means shall be capable of interrupting the no-load current of the control-circuit transformer in accordance with Mechanical Operation and Interlock Integrity Test, Section 27. The isolating means can be any one of the following:

- a) Three-pole isolating switch.
- b) Three-pole isolating switch in mechanical combination with high-voltage motor circuit fuses.
- c) Draw out contactor that may or may not include fuse assembly.

13.2 The isolating mechanism, indicated in 13.1, shall be arranged to be operated from a location where the operator is not exposed to energized parts and shall be arranged to open all ungrounded conductors of the circuit simultaneously with one operation. One pole of the disconnecting means may disconnect a permanently grounded conductor, provided that the disconnecting means is so constructed that the pole in the grounded conductor cannot be opened without disconnecting all conductors of the circuit in the same operation.

13.3 The isolating means shall provide visible evidence of an isolating gap in the circuit adequate for the operating voltage.

13.4 To comply with 13.3, the isolation gap or a mechanically operated indicator shall be visible through a viewing pane or by opening a door when the isolating gap is open. The mechanical operator shall be actuated by the movement of the actual isolating switch assembly, the shutter of a draw-out assembly, or the like. The action of the mechanical indicator shall not be dependent on the movement of the operating handle or mechanism alone.

13.5 The power-circuit isolating means shall be interlocked as indicated in Interlocking, Section 14.

13.6 The power-circuit isolating means shall have provision for being padlocked in the open position.

13.7 All switch blades shall be de-energized when the switch is in the open position.

*Exception: Switches that must necessarily be energized from both sides (bus tie, loop sectionalizing, and the like) may have energized blades in the open position if,*

- a) *Barriers or enclosures are installed over the switches for protection against contact with the energized switch blades, and*
- b) *The switch is marked in accordance with 40.9.*

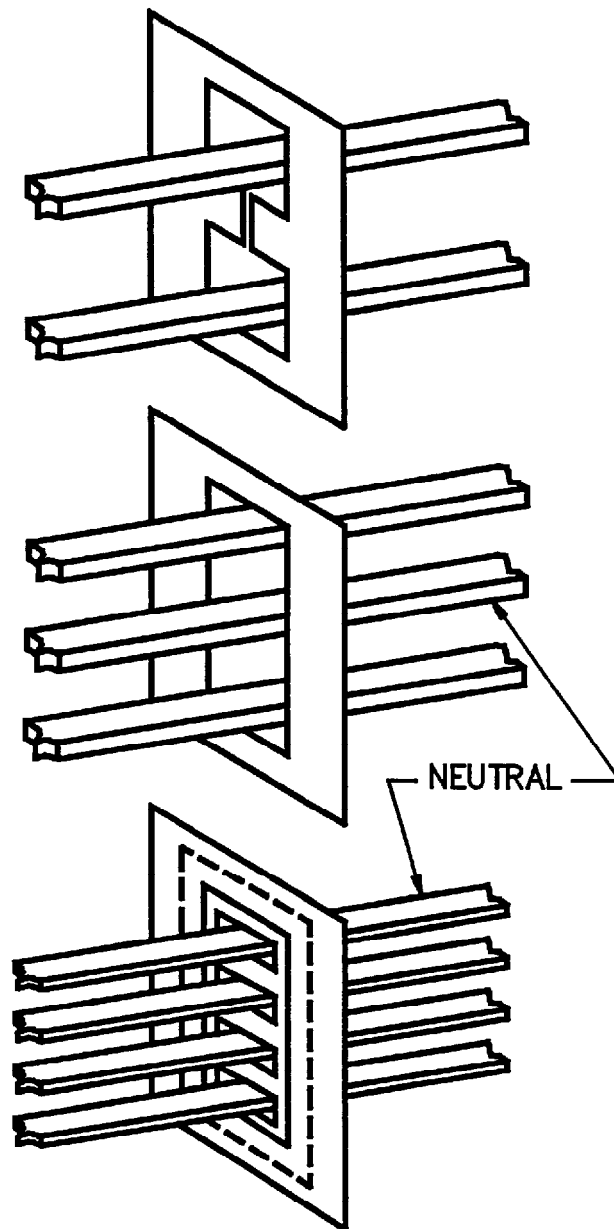
\*13.7 revised August 11, 1995\*

### 14 Interlocking

14.1 Interlocking shall be provided by mechanical means or by a combination of mechanical and electrical means and shall provide the following features:

- a) Keep the isolating means from being opened or closed unless all line contactors are open.
- b) Keep a high-voltage-compartment door from opening unless the isolating means is open by a distance necessary to comply with the withstand requirements of the Dielectric Voltage – Withstand Test, Section 29 and Impulse Withstand, Section 33.

Figure 16.1  
Conductors through openings



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### 16.3 Restricting barriers

16.3.1 Where barriers are employed to define wireways, the requirements of 16.3.2 – 16.3.7 shall apply.

16.3.2 A sheet-steel barrier shall not be less than 0.053 inch (1.35 mm) thick if uncoated and not less than 0.056 inch (1.42 mm) thick if galvanized.

*Exception: A metal barrier may be steel of a lesser thickness than that indicated provided that its strength and rigidity is not less than that of a flat sheet of steel having the same dimensions as the barrier and of the specified thickness.*

16.3.3 A nonmetallic barrier shall not be less than 1/4 inch (6.4 mm) thick and shall be supported to provide the required strength and rigidity, except that if the barrier is so located that it will not be subject to mechanical abuse during installation and is so supported that it will have physical strength and rigidity, the thickness may be less than 1/4 inch.

16.3.4 An air space shall be provided between live parts and a nonmetallic barrier unless the barrier is of a material that has been investigated and found to have acceptable track resistant properties.

16.3.5 An opening in a metal barrier through which a factory-installed wire or cable passes, or through which a field-installed wire can pass, shall be provided with a bushing or shall be so formed that there will not be any sharp edges with which insulated conductors may come in contact. See 16.1.5.

\*16.3.5 revised August 11, 1995\*

16.3.6 A bushing employed at the opening mentioned in 16.3.5 may be of glass, ceramic, hard fiber, phenolic composition, cold-molded composition or other polymeric materials that are of the thermoset type. A metal eyelet or grommet having a smooth well-rounded surface on which the wire or cable can bear is acceptable in place of a bushing. A bushing of rubber, neoprene, or hot-molded shellac-and-tar composition is not acceptable.

16.3.7 The bushing may be of material other than those enumerated in 16.3.6 if it has been investigated and found to be acceptable for the particular application.

### 17 Control Circuit Wiring

#### 17.1 Internal wiring

17.1.1 The internal wiring of the control circuit of industrial control equipment shall consist of general use wire or appliance wiring material (AWM) acceptable for the particular application, when considered with respect to the temperature and voltage and conditions of service to which the wiring is likely to be subjected.

17.1.2 Appliance wiring material of one or more of the types indicated in Table 17.1 may be used for internal wiring when considered with respect to the requirements in 17.1.1.

\*17.1.2 revised August 11, 1995\*

**Table 17.1**  
**Appliance wiring material**

| Type of Insulation                                                                                                                                                                                                                                                                                                                                           | Nominal thickness of Insulation <sup>a</sup>          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                              | 600-V Applications                                    |
| Thermoplastic                                                                                                                                                                                                                                                                                                                                                | 1/32 inch (0.8 mm)                                    |
| Silicone                                                                                                                                                                                                                                                                                                                                                     | 1/32 inch (0.8 mm) plus an impregnated - braid cover  |
|                                                                                                                                                                                                                                                                                                                                                              | 1/32 inch (0.8 mm) without a braid cover <sup>b</sup> |
| <sup>a</sup> The minimum thickness of 0.028 inch (0.71 mm) for 1/32 inch (0.8 mm) nominal thick insulation.<br><sup>b</sup> Only if routed away from live parts of opposite polarity and protected from mechanical damage both during installation of field wiring and while in operation, unless the material has adequate resistance to mechanical damage. |                                                       |

17.1.3 Appliance wiring material having lesser thicknesses of insulation than those indicated in Table 17.1 may be used for a particular application provided the insulation, when considered with respect to temperature and voltage and condition of service is equivalent to one of those given in that table.

17.1.4 The internal wiring and connections between parts of industrial control equipment shall be protected or enclosed.

17.1.5 Wireways shall be smooth and entirely free from sharp edges, burrs, fins, moving parts, and the like, that may cause abrasion of the insulation on conductors.

17.1.6 A hole in a sheet-metal wall through which insulated wires pass and on the edges of which they may bear shall be provided with a smoothly rounded bushing or shall have a smooth, well-rounded surface upon which the wires may bear, to prevent abrasion of the insulation.

17.1.7 A bare conductor, including pigtailed and coil leads, shall be so supported that the spacings required elsewhere in this standard will be maintained unless the conductor is covered by insulating sleeving or tubing.

17.1.8 All joints and connections shall be mechanically secure and shall provide reliable electrical contact without strain on connections and terminals.

17.1.9 A splice where used shall be provided with insulation equivalent to that of the wires involved.

17.1.10 Electrical components may be mounted on hinged covers, drawout equipment, or doors provided conductors subject to flexing are not larger than No. 12 AWG ( $3.3 \text{ mm}^2$ ), are stranded, and have at least 1/32 inch (0.8 mm) thick insulation or are part of a flexible cord assembly, see 17.2. These conductors shall be cabled, routed, secured and protected so that they will not be damaged during the opening and closing of the door or cover or during the movement of a drawout unit.

*Exception: Conductors larger than No. 12 AWG may be used to connect door, drawout or cover mounted components provided that:*

- a) *The component requires the use of the larger conductor (such as a d-c ammeter used without an external shunt) and*
- b) *Consideration is given to the ability of the conductor to withstand repeated flexing.*

\*17.1.10 revised August 11, 1995\*

## 17.2 Cord-connected circuits – internal control

17.2.1 Cord-connected circuits in industrial control equipment shall be provided with the correct length, size, and type of hard-service or junior hard-service flexible cord (Type S, SJ, and the like), or the equivalent, that is acceptable for use at the temperature and voltage involved, terminating with an attachment plug.

17.2.2 All splices and connections shall be mechanically secure and shall be arranged so that strain will not be transmitted to the connection and terminals.

## 18 Field Connect Control Circuit Terminals

18.1 Terminal parts by which field-wiring connections are made shall provide serviceable connections even under hard usage. Solderless (pressure) terminal connectors shall be used, except that for a No. 10 AWG ( $5.3 \text{ mm}^2$ ) or smaller wire, the parts to which wiring connections are made may consist of clamps or binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position.

18.2 A wire-binding screw to which field-wiring connections are made shall not be smaller than No. 8 (8.4 mm diameter), except that a No. 6 (3.5 mm diameter) screw may be used for a terminal to which No. 14 AWG ( $2.1 \text{ mm}^2$ ) or smaller wire would usually be connected.

18.3 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick for a No. 14 AWG ( $2.1 \text{ mm}^2$ ) or smaller wire, and not less than 0.050 inch (1.27 mm) thick for a wire larger than No. 14 AWG. In either case there shall not be fewer than two full threads in the metal.

*Exception: A terminal plate formed from stock having the minimum required thickness, may have the metal extruded at the tapped hole for the binding screw to provide two full threads. Two full threads are not required if fewer threads result in a sufficiently secure connection in which the threads will not strip upon application of a 20 pound-inch (2.3 N-m) tightening torque.*

18.4 A wire-binding screw shall thread into metal.

## 19 Spacings

### 19.1 General

19.1.1 The electrical through-air and over surface spacings shall be not less than those indicated in Table 19.1.

19.1.2 The spacings indicated for control circuits in Table 19.1 are applicable between live parts of control circuit components and grounded metal and to live parts of other control circuit components.

19.1.3 The spacings in a component device — such as a snapswitch, lampholder, and the like — supplied as part of industrial control equipment, other than in motor circuits, shall not be less than the minimum spacings required for the component device or the spacings indicated in Table 19.1, whichever are smaller.

**Table 19.1**  
**Spacings**

| Group                                    | Voltage rating, volts (rms or direct-current) <sup>a,b</sup> | Minimum clearance and creepage distance    |       |        |       |                |       |        |       |                                            |       |                          |        |
|------------------------------------------|--------------------------------------------------------------|--------------------------------------------|-------|--------|-------|----------------|-------|--------|-------|--------------------------------------------|-------|--------------------------|--------|
|                                          |                                                              | To other than enclosure walls <sup>c</sup> |       |        |       |                |       |        |       | To walls of metal enclosure <sup>d,e</sup> |       |                          |        |
|                                          |                                                              | Clearance through                          |       |        |       | Creepage along |       |        |       | Clearance                                  |       | Creepage                 |        |
|                                          |                                                              | Air                                        |       | Oil    |       | Air            |       | Oil    |       | through air or oil                         |       | along surface air or oil |        |
|                                          |                                                              | Inches                                     | mm    | Inches | mm    | Inches         | mm    | Inches | mm    | Inches                                     | mm    | Inches                   | mm     |
| Line Voltage Circuits                    | 2500 max <sup>f</sup>                                        | 1.000                                      | 25.40 | 0.750  | 19.05 | 2.000          | 50.80 | 1.000  | 25.40 | 2.000                                      | 50.80 | 3.000                    | 76.20  |
|                                          | 7200 max <sup>f</sup>                                        | 2.000                                      | 50.80 | 1.500  | 38.10 | 3.500          | 88.90 | 2.000  | 50.80 | 3.000                                      | 76.20 | 4.000                    | 101.60 |
| Series Connected Components <sup>g</sup> | 601 – 1000                                                   | 0.550                                      | 13.95 | 0.450  | 11.43 | 0.850          | 21.59 | 0.625  | 15.87 | 0.800                                      | 20.32 | 1.000                    | 25.40  |
|                                          | 1001 – 1500                                                  | 0.700                                      | 17.78 | 0.600  | 15.24 | 1.200          | 30.48 | 0.700  | 17.78 | 1.200                                      | 30.48 | 1.650                    | 41.90  |
| Control Circuits <sup>h</sup>            | 0 – 50                                                       | 0.125                                      | 3.17  | 0.125  | 3.17  | 0.125          | 3.17  | 0.125  | 3.17  | 0.500                                      | 12.70 | 0.500                    | 12.70  |
|                                          | 51 – 150                                                     | 0.125                                      | 3.17  | 0.125  | 3.17  | 0.250          | 6.35  | 0.250  | 6.35  | 0.500                                      | 12.70 | 0.500                    | 12.70  |
|                                          | 151 – 300                                                    | 0.250                                      | 6.35  | 0.250  | 6.35  | 0.375          | 9.52  | 0.375  | 9.52  | 0.500                                      | 12.70 | 0.500                    | 12.70  |
|                                          | 301 – 600                                                    | 0.375                                      | 9.52  | 0.375  | 9.52  | 0.500          | 12.70 | 0.500  | 12.70 | 0.500                                      | 12.70 | 0.500                    | 12.70  |

<sup>a</sup> Where the repetitive peak voltage on which the device used is more than 1.5 times the rms volts, the peak voltage shall be divided by 2 to obtain an equivalent rms rating in volts.

<sup>b</sup> For grounded power systems, such as 3-phase, 4-wire systems, the clearance and creepage distances to ground shall be governed by the voltage to ground.

<sup>c</sup> The spacing between screw type wiring terminals of opposite polarity shall be not less than 0.250 inch (6.35 mm) if the terminals are in the same plane.

<sup>d</sup> For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce clearance and creepage distances between the metal piece and uninsulated live parts.

<sup>e</sup> For subassembly enclosures where clearance and creepage distances are rigidly maintained, and when mounted inside another enclosure, the distances for "to other than enclosure walls" may be used instead of "to walls of metal enclosure."

<sup>f</sup> Because of the effect of configuration, spacings in excess of those indicated may be required to meet the performance requirements of this standard.

<sup>g</sup> In a series circuit, the spacings between resistor terminals, transformer taps, and the like are to be based on the normal operating voltage existing between such parts.

<sup>h</sup> Where line voltage is connected to control circuits, the line voltage spacings shall apply.

\*Table 19.1 revised August 11, 1995\*

19.1.4 The spacings at a field-wiring terminal are to be measured with wire of the appropriate size connected to the terminal as in actual service. The connected wire shall be the next larger size than would be required for the rating except that the required wire size shall be used if:

- a) the terminal will not accept the larger size or
- b) the device is marked to restrict the use of oversized conductors.

19.1.5 The spacings at fuses and fuseholders, measured with the fuses in place, are to be based on the use of fuses having maximum standard dimensions and are not to be less than the spacings indicated in Table 19.1. Where the fuseholder construction permits a fuse to be partially inserted and remain in that position, spacings shall be measured with the fuse in the partially inserted position as well as in the fully inserted position.

19.1.6 The type and thickness of crossover-lead insulation and insulation under coil terminals secured to the coil winding may be less than that specified in 19.2.1 – 19.2.4 provided that for thicknesses less than 0.013 inch (0.33 mm) the coil is capable of withstanding a dielectric voltage-withstand test between coil end leads after breaking the inner coil lead where it enters the layer, or an equivalent-opposite polarity test. The application of the test potential is to be in accordance with Dielectric Voltage – Withstand Test, Section 29.

19.1.7 A ceramic, vitreous-enamel, or similar coating is not acceptable as insulation in place of spacings unless, upon investigation, the coating is found to be uniform, reliable, and otherwise acceptable for the purpose.

19.1.8 Enamel-insulated and similar film-insulated wire is considered to be the same as an uninsulated live part in determining compliance of a device with the spacing requirements in this standard.

19.1.9 An insulated low-voltage – 600 V or less to ground – conductor shall be considered uninsulated, for the purpose of measuring spacings to uninsulated high-voltage parts, unless the insulation is acceptable for the high-voltage involved.

## 19.2 Circuits of 600 V or less to ground

19.2.1 19.2.2 – 19.2.4 refer only to circuits where the voltage to ground is 600 V or less.

19.2.2 An insulating barrier or liner used as the sole separation between uninsulated live parts and grounded dead metal parts – including the enclosure – or between uninsulated live parts of opposite polarity shall be of material of a type that is acceptable for the mounting of uninsulated live parts and shall not be less than 0.028 inch (0.71 mm) thick.

*Exception: Fiber not less than 0.028 inch thick may be used as the sole separation between the enclosure and an uninsulated metal part electrically connected to a grounded circuit conductor.*

19.2.3 An insulating barrier or liner used in addition to an air space in place of the required spacing through air shall not be less than 0.028 inch (0.71 mm) thick. If the barrier or liner is a fiber, the air space shall not be less than 1/32 inch (0.8 mm), and if the barrier or liner is of other material of a type that is not acceptable for the support of uninsulated live parts, the air space provided shall be such that upon investigation it is found to be adequate for the particular application.

*Exception: A barrier or liner used in addition to not less than one half the required spacing through air may be less than 0.028 inch but shall not be less than 0.013 inch (0.33 mm) thick provided that the barrier or liner is of material of a type that is acceptable for the mounting of uninsulated live parts, of necessary mechanical strength if exposed or otherwise likely to be subjected to mechanical damage, effectively held in place, and so located that it will not be affected adversely by operation of the equipment in service.*

19.2.4 Insulating material having a thickness less than that indicated in 19.2.2 and 19.2.3 may be used if, upon investigation, it is found to be acceptable for the particular application.

## 20 Current Carrying Parts

20 A current-carrying part shall have the required mechanical strength and ampacity for the service, and shall be of metal or other material that is acceptable for the particular application.

20.2 An uninsulated live part, including a terminal, shall be so secured to its supporting surface by a method other than friction between surfaces that it will be kept from turning or shifting in position if such motion may result in reduction of spacings to less than those required elsewhere in this standard. The security of a contact assembly shall provide for the continued alignment of contacts.

*Exception: A pressure terminal connector that is intended for field connection and that is not capable of receiving a conductor larger than No. 3/0 AWG (85.0 mm<sup>2</sup>), need not be prevented from turning provided no spacings less than those required result when the connectors are turned 30 degrees toward each other, or toward other uninsulated parts of opposite polarity, or toward grounded metal parts.*

## PERFORMANCE

### 21 General

21.1 The performance of high-voltage industrial control equipment shall be investigated by subjecting a representative sample or samples in commercial form to the tests described in Sections 22 – 38. Except as indicated in Table 21.1, the sequence in which these tests are conducted is not specified. Unless otherwise indicated, these tests shall be conducted at rated frequency. When selecting representative samples consideration shall be given to optional features, such as bus structures in multiunit assemblies, and the like, and the effects of such features on the performance during specific tests.

21.2 A motor controller intended for use with non-motor loads, such as capacitors or transformers, may need to be given special consideration.

**Table 21.1**  
**Sequence of tests**

| Section | Test                                            | Sequence a,b,c,d |   |   |   |
|---------|-------------------------------------------------|------------------|---|---|---|
|         |                                                 | 1                | 2 | 3 | 4 |
| 22      | Operating Voltage                               |                  |   |   |   |
| 23      | Short Time Capability                           | X                |   |   |   |
| 24      | Temperature                                     | X                |   |   |   |
| 25      | Make and Break Capability                       |                  |   |   | X |
| 26      | Overload                                        |                  | X |   |   |
| 27      | Mechanical Operation and<br>interlock Integrity |                  |   |   |   |
| 28      | Switching Capability –<br>Isolating Means       |                  |   |   |   |
| 29      | Dielectric Voltage – Withstand                  | X                |   |   |   |
| 30      | Short Circuit Interruption                      |                  |   | X |   |
| 31      | Dielectric Voltage – Withstand<br>(Repeated)    |                  | X | X | X |
| 32      | Short Circuit Withstand                         |                  |   |   |   |
| 33      | Impulse Withstand                               |                  |   |   |   |
| 34      | Water Spray                                     |                  |   |   |   |
| 35      | Accelerated Aging of Gaskets                    |                  |   |   |   |
| 36      | Impact and Pressure –<br>Viewing Panes          |                  |   |   |   |
| 37      | Metallic Coating Thickness                      |                  |   |   |   |
| 38      | Calibration – Overload<br>Relays                |                  |   |   |   |

<sup>a</sup> All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. In the event that a single sample is used for more than one sequence, the sample may be repaired and parts replaced upon the completion of a specific sequence.

<sup>b</sup> For any sequence the tests shall be conducted in the order indicated except that if sequences 2 and 4 are combined as permitted in 25.4 and 25.6, the dielectric voltage-withstand test (repeated) specified in sequence 4 need not be conducted.

<sup>c</sup> One sequence need not be started as a prerequisite to the starting of another.

<sup>d</sup> A dielectric voltage-withstand test may be conducted prior to the start of any sequence.

\*Table 21.1 revised August 11, 1995\*

## 22 Operating Voltage Test

22.1 The operating coil of a contactor shall be capable of withstanding without injury 110 percent of its rated voltage continuously, and shall operate successfully at 85 percent of its rated voltage.

22.2 For the operation at minimum voltage, the electromagnet is to be energized at rated voltage until constant temperature is reached, and then tested immediately to determine that full closure of the armature results when the minimum test potential is applied.

## 25 Make and Break Capability Test

25.1 A contactor that is part of a Class E2 controller, and that has not been tested for the interrupting capabilities of a Class E1 controller, shall be capable of making and breaking the maximum current at which the overload relays alone cause interruption (crossover point). The crossover point shall be determined from the characteristic curves of the overload relays and the high-voltage motor circuit fuse total clearing time-current curves as provided by the respective manufacturers.

25.2 To determine compliance with 25.1, a contactor shall be subjected to 10 make and break operations at the current indicated in 25.1 but not less than 10 times the continuous current rating of the contactor. These operations shall be conducted in a single continuous test without intervening maintenance or service.

\*25.2 revised August 11, 1995\*

25.3 The contactor shall be operated at the rate of operation specified in Table 25.1 with an on time of not less than 0.1 second.

**Table 25.1**  
**Rate of operation for**  
**make and break capability test**

| Contactor rating, amperes                                                       | Rate of operation <sup>a</sup> |
|---------------------------------------------------------------------------------|--------------------------------|
| 0 – 400                                                                         | 1 per minute                   |
| 401 – 800                                                                       | 1 per 5 minutes                |
| <sup>a</sup> May be conducted at a faster rate if agreeable to those concerned. |                                |

25.4 Except as indicated in 25.1 – 25.3, the conditions for this test shall be the same as for the overload test described in the Make and Break Capability Test, Section 25.

25.5 This test may be performed on a separate sample, or if agreeable to those concerned may be combined with the overload test.

25.6 If the make and break test is performed on a separate sample, the contactor shall be in substantially the same mechanical condition at the conclusion of the test as at the beginning and shall be capable of withstanding applied potentials in accordance with the Short Circuit Interruption Test, Section 31. The fuse specified in 25.7 shall not have opened.

\*25.6 revised August 11, 1995\*

25.7 If the make and break test is combined with the overload test, the first 10 operations shall be performed in accordance with 25.1 and 25.2 and the remaining 40 operations, without the contactor being serviced, shall be performed in accordance with the Overload Test, Section 26.

## 26 Overload Test

26.1 A controller shall perform acceptably when subjected to an overload test consisting of 50 operations making and breaking 6 times its rated continuous current in a continuous test, without intervening maintenance or servicing. See 25.7 if combined with make and break capacity test.

\*26.1 revised August 11, 1995\*

26.2 The test shall be performed at rated maximum voltage and a lagging power factor not greater than 0.35.

26.3 The controller shall be mounted as in actual service with the door or cover closed. Any other openings, except intentional ventilation openings shall be closed.

26.4 The controller shall be connected as shown in Figure 26.1 or 26.2. All or part of the limiting impedance may be connected on the load side. The test circuit may include current-limiting reactors, resistors and transformers in addition to the generating system. In setting up the test circuit, the leads between the reactors and the controllers shall be made as short as practicable so as to keep the capacitance to ground at the controller terminals small. No capacitance shall be added in the circuit.

26.5 Reactive components of the impedance in the line may be paralleled if of the air core type but no reactance shall be connected in parallel with resistances except that an air core reactor(s) in any phase may be shunted by resistance, the volt-ampere loss which is approximately 0.6 percent of the reactive volt-amperes in the air core reactor(s) in that phase.

26.6 With reference to 26.5, the shunting resistance used with an air-core reactor having negligible resistance may be calculated from the formula:

$$R = 167 \frac{E}{I}$$

where E is the voltage across the air-core reactor with current I flowing as determined by oscillographic measurement during the short-circuit calibration or, by proportion, from meter measurements at some lower current.

26.7 The controller structure and enclosure shall be grounded through a 3-A, 5000-V fuse, or the equivalent, connected as shown in Figure 26.1 or 26.2.

26.8 The high-voltage motor circuit fuses may be shunted or replaced with dummy fuses.

26.9 The open-circuit voltage of the supply circuit shall be not less than 100 percent nor more than 110 percent of the rated maximum voltage of the controller. An open circuit voltage in excess of 110 percent may be used if acceptable to those concerned.

26.10 The closed-circuit voltage is not specified, but the normal-frequency recovery voltage shall be not less than the rated voltage of the controller when measured in accordance with Test Procedure for AC High-Voltage Circuit Breakers Rated on A Symmetrical Current Basis, ANSI/IEEE C37.09-1979.

26.11 Circuit characteristics are to be determined using either laboratory type meters or oscillographic means. When oscillographic means are employed, the method indicated in the Guide for Methods of Power Factor Measurement for Low-Voltage Inductive Test Circuits, ANSI/IEEE C37.26-1972(R1990) shall be used for determining power factor.

26.12 The controller shall be operated at the rate of one operation per minute. These operations may be conducted in groups of 5 with 15 minutes maximum between groups.

26.13 During each operation, the on time shall be at least 4 electrical cycles before contact parting commences, as determined by oscillographic or equivalent measurements.

26.14 For a reversing controller, the on period shall consist of a forward operation immediately followed by a reverse operation. The on time for each operation (forward and reverse) shall comply with 26.13.

26.15 If the reversing circuit arrangement is such that both operating coils can be energized simultaneously, 10 additional cycles of operation are to be conducted with both coils energized simultaneously.

27.2 At the end of this test the sample shall:

- a) Be in substantially the same mechanical condition as at the beginning of the test, and
- b) Shall comply with the dielectric voltage withstand requirements of Section 31. The ability of any interlock to function in the intended manner shall not have been impaired.

\*27.2 revised August 11, 1995\*

27.3 All drawout components and isolating means shall be subjected to 50 mechanical opening and closing operations. During each operation it shall be determined that all interlock functions are operative by attempting to open any doors, operate electrical circuits, or any other operation intended to be prevented by the interlocking arrangement. In the case of a drawout component, one operation shall consist of the complete withdrawal and insertion of the draw out component. See Isolating Means, Section 13.

27.4 Where drawout components are used it shall be determined that

- a) the device cannot be inserted in any condition of misalignment that will permit the operation of the device while impairing the effectiveness of the interlocking arrangement, and
- b) the device cannot be withdrawn in the closed position.

27.5 The effort required to perform the 50th operation shall be essentially the same as that required to perform the first operation. Upon the completion of the 50 operations, the sample shall be in substantially the same mechanical condition as at the beginning of the test.

## 28 Switching Capability Test – Isolating Means

28.1 A controller employing a disconnect switch or mechanism, used to interrupt the magnetizing current of the control transformer, shall be subjected to 25 close–open operations of the disconnect device with the transformer connected in the intended manner. The voltage for this test shall be 110 percent of the maximum rated voltage of the controller. The control transformer mentioned above shall be the transformer having the largest magnetizing current intended to be used in the motor controller.

28.2 The controller structure and enclosure shall be connected to ground through a 3–A, 5000–V fuse.

28.3 The fuse described in 28.2 shall not open and the device shall be capable of continuing the test program without servicing or replacement of parts.

28.4 If a disconnect switch is not interlocked to prevent opening when the control transformer is providing secondary current, such a switch shall be the subject of an appropriate investigation. The investigation shall include consideration of the ability of the disconnect switch to make and break the transformer primary current under the most adverse conditions.

## 29 Dielectric Voltage-Withstand Test

### 29.1 General

29.1.1 A controller shall be capable of withstanding for 1 minute without breakdown the application of a  $60 \pm 2$  Hz essentially sinusoidal potential as indicated in Table 29.1:

- a) Between uninsulated live parts of each electric circuit and the grounded metal parts with the contacts opened and closed.
- b) Between uninsulated live parts of each principle electric circuit and all other principal circuits.
- c) Between terminals of opposite polarity with the contacts closed.
- d) Between the contacts of the isolating means with the contactor in the test position. If the test position is obtained by means of a removable element, the test shall be conducted between the line terminals of the isolating means and the grounded parts of the removable element both with the contactor contacts open and closed.

**Table 29.1**  
**Test voltages for dielectric**  
**voltage-withstand test**

| Voltage rating<br>volts | Test voltage                                     |
|-------------------------|--------------------------------------------------|
| 0 – 600                 | 1000 V plus (2 times nominal voltage rating)     |
| 601 – 7200              | 2000 V plus (2-1/4 times nominal voltage rating) |

29.1.2 For definition of the applied wave shape, see Standard Techniques for High-Voltage Testing, ANSI/IEEE Std 4-1978.

29.1.3 With reference to 29.1.1, a transformer, a coil, or a similar device connected between lines of opposite polarity is to be disconnected from one side of the line during test between terminals of opposite polarity, item c.

\*29.1.3 revised August 11, 1995\*

### 29.2 Meters

29.2.1 If controller includes a meter or meters, such instruments shall be disconnected from the circuit and the complete device subjected to a dielectric voltage-withstand test as indicated in 29.1.1. The meter or meters shall be tested separately for dielectric voltage-withstand, with an applied potential of 1000 V in the case of an ammeter, and 1000 V plus twice rated voltage in the case of any other instrument having a potential circuit. The test potential shall be applied between live parts and the mounting panel, including the meter face, zero adjuster, and so forth.