**Chapter 4 Equipment for General Use**

Article 400 Flexible Cords and Flexible Cables

Part I General

400.1 Scope

This article covers general requirements, applications, and construction specifications for flexible cords and flexible cables.

400.2 Other Articles

Flexible cords and flexible cables shall comply with this article and with the applicable provisions of other articles of this Code.

400.3 Suitability

Flexible cords and flexible cables and their associated fittings shall be suitable for the conditions of use and location.

400.4 Types

Flexible cords and flexible cables shall conform to the description in Table 400.4. The use of flexible cords and flexible cables other than those in Table 400.4 shall require permission by the authority having jurisdiction.

Table 400.4 Flexible Cords and Flexible Cables

Trade Name Type Letter Voltage AWG or

kcmil Number of Conductors Insulation AWG or kcmil Nominal Insulation Thickness Braid on Each Conductor Outer Covering Use

mm mils

Lamp cord C 300 18—16 2 or more Thermoset or thermoplastic 18—16 0.76 30 Cotton None Pendant or

portable Dry locations Not hard

usage

600 15—10 15—10 1.14 45

Elevator cable E1,2,3,4 300 or 600 20—2 2 or more Thermoset 20—16 0.51 20 Cotton Three cotton; outer

one flame-retardant and

moisture-resistant Elevator lighting

and control Unclassified locations

15—12 0.76 30

12—10 1.14 45

8—2 1.52 60

20—16 0.51 20 Flexible nylon jacket

15—12 0.76 30

12—10 1.14 45

8—2 1.52 60

Elevator cable EO1,2,4 300 or 600 20—2 2 or more Thermoset 20—16 0.51 20 Cotton Three cotton; outer

one flame-retardant and

moisture-resistant Elevator lighting

and control Unclassified locations

15—12 0.76 30

12—10 1.14 45

8—2 1.52 60

One cotton and a

neoprene jacket Hazardous (classified)

locations

Elevator cable ETP2,4 300 or 600 Rayon Thermoplastic Hazardous

(classified) locations

ETT2,4 300 or 600 None One cotton or equivalent

and a thermoplastic jacket

Electric vehicle cable EV5,6 1000 18—500 2 or more plus equipment

grounding conductor(s),

plus optional hybrid data,

signal communications,

and optical fiber cables Thermoset with optional nylon 18—15 0.76

(0.51) 30

(20) Optional Oil-resistant thermoset Electric vehicle

charging Wet locations Extra-hard usage

14—10 1.14

(0.76) 45

(30)

8—2 1.52

(1.14) 60

(45)

1—4/0 2.03

(1.52) 80

(60)

250—500 2.41

(1.90) 95

(75)

EVJ5,6 300 18—12 18—12 0.76

(0.51) 30

(20) Hard usage

EVE5,6 1000 18—500 2 or more plus equipment

grounding conductor(s),

plus optional hybrid data,

signal communications,

and optical fiber cables Thermoplastic elastomer

with optional nylon 18—15 0.76

(0.51) 30

(20) Oil-resistant

thermoplastic elastomer Extra-hard usage

14—10 1.14

(0.76) 45

(30)

8—2 1.52

(1.14) 60

(45)

1—4/0 2.03

(1.52) 80

(60)

250—500 2.41

(1.90) 95

(75)

EVJE5,6 300 18—12 18—12 0.76

(0.51) 30

(20) Hard usage

EVT5,6 1000 18—500 2 or more plus equipment

grounding conductor(s),

plus optional hybrid data,

signal communications,

and optical fiber cables Thermoplastic with optional nylon 18—15 0.76

(0.51) 30

(20) Oil-resistant thermoplastic Extra-hard usage

14—10 1.14

(0.76) 45

(30)

8—2 1.52

(1.14) 60

(45)

1—4/0 2.03

(1.52) 80

(60)

250—500 2.41

(1.90) 95

(75)

EVJT5,6 300 18—12 18—12 0.76

(0.51) 30

(20) Hard usage

Portable power cable G 2000 12—500 2—6 plus equipment

grounding conductor(s) Thermoset 12—2 1.52 60 Oil-resistant thermoset Portable and

extra-hard usage

1—4/0 2.03 80

250—500 2.41 95

G-GC7 2000 12—500 3—6 plus equipment

grounding conductors

and 1 ground check conductor Thermoset 12—2 1.52 60 Oil-resistant thermoset

1—4/0 2.03 80

250—500 2.41 95

Heater cord HPD 300 18—12 2, 3, or 4 Thermoset 18—16 0.38 15 None Cotton or rayon Portable heaters Dry locations Not hard

usage

15—12 0.76 30

Parallel heater cord HPN8 300 18—12 2 or 3 Oil-resistant thermoset 18—16 1.14 45

None Oil-resistant thermoset Portable Damp locations Not hard

usage

15 1.52 60

14 2.41 95

12

Thermoset jacketed

heater cords HSJ 300 18—12 2, 3, or 4 Thermoset 18—16

0.76

30

None Cotton and thermoset Portable or

portable heater Damp locations Hard usage

15—12 0.14 45

HSJW 300 18—12 Thermoset Cotton and thermoset Damp locations

HSJO 300 18—12 Cotton and

oil-resistant thermoset Damp and wet Locations

HSJOW9 300 18—12 Damp locations

HSJOO 300 18—12 Oil-resistant thermoset

HSJOOW9 300 18—12 Damp and wet Locations

Non-integral parallel cords NISP-1 300 20—18 2 or 3 Thermoset 20—18 0.38 15 None Thermoset Pendant or portable Damp locations Not hard

usage

NISP-2 300 18—16 18—16 0.76 30

NISPE-18 300 20—18 Thermoplastic elastomer 20—18 0.38 15 Thermoplastic elastomer

NISPE-28 300 18—16 18—16 0.76 30

NISPT-18 300 20—18 Thermoplastic 20—18 0.38 15 Thermoplastic

NISPT-28 300 18—16 18—16 0.76 30

Twisted portable cord PD 300 18—16 2 or more Thermoset or thermoplastic 18—16 0.76 30 Cotton Cotton or rayon Pendant or portable Dry locations Not hard

usage

600 14—10 15—10 1.14 45

Portable power cable PPE7 2000 12—500 1-6 plus optional

equipment grounding

conductor(s) Thermoplastic elastomer 12—2 1.52 60 Oil-resistant

thermoplastic elastomer Portable,

extra-hard usage

1—4/0 2.03 80

250—500 2.41 95

Hard service cord S7 600 18—2 2 or more Thermoset 18—15 0.76 30 None Thermoset Pendant or portable Damp locations Extra-hard usage

14—10 1.14 45

8—2 1.52 60

Flexible stage and

lighting power cable SC7,10 600 8—250 1 or more Thermoset 8—2 1.52 60 Thermoset Portable,

extra-hard usage

SCE7,10 600 Thermoplastic elastomer 1—4/0 2.03 80 Thermoplastic elastomer

SCT7,10 600 Thermoplastic 250 2.41 95 Thermoplastic

Hard service cord SE7 600 18—2 2 or more Thermoplastic elastomer 18—15

14—9

8—2 0.76

1.14

1.52 30

45

60 None Thermoplastic elastomer Pendant or portable Damp locations Extra-hard usage

SEW7,9 600 Damp and wet Locations

SEO7 600 Oil-resistant

thermoplastic elastomer Damp locations

SEOW7,9 600 Damp and wet Locations

SEOO7 600 Oil-resistant

thermoplastic elastomer Damp locations

SEOOW7,9 600 Damp and wet Locations

Junior hard service cord SJ 300 18—10 2-6 Thermoset 18—11

10 0.76

1.14 30

45 None Thermoset Pendant or portable Damp locations Hard usage

SJE 300 Thermoplastic elastomer Thermoplastic elastomer

SJEW9 300 Damp and wet Locations

SJEO 300 Oil-resistant

thermoplastic elastomer Damp locations

SJEOW9 300 Damp and wet Locations

SJEOO 300 Oil-resistant

thermoplastic elastomer Damp locations

SJEOOW9 300 Damp and wet Locations

SJO 300 Thermoset Oil-resistant thermoset Damp locations

SJOW9 300 Damp and wet Locations

SJOO 300 Oil-resistant thermoset Damp locations

SJOOW9 300 Damp and wet Locations

SJT 300 Thermoplastic Thermoplastic Damp locations

SJTW9 300 Damp and wet locations

SJTO 300 18—12

10 0.76

1.14 30

45 Oil-resistant thermoplastic Damp locations

SJTOW9 300 Damp and wet locations

SJTOO 300 Oil-resistant thermoplastic Damp locations

SJTOOW9 300 Damp and wet locations

Hard service cord SO7 600 18—2 2 or more Thermoset 18—15 0.76 30 None Oil-resistant thermoset Pendant or portable Damp locations Extra-hard usage

SOW7,9 600 Damp and wet locations

SOO7 600 Oil-resistant thermoset 14—9

8—2 1.14

1.52 45

60 Damp locations

SOOW7,9 600 Damp and wet locations

All thermoset parallel cord SP-1 300 20—18 2 or 3 Thermoset 20—18 0.76 30 None None Pendant or portable Damp locations Not hard

usage

SP-2 300 18—16 18—16 1.14 45

SP-3 300 18—10 18—16

15—14

12

10 1.52

2.03

2.41

2.80 60

80

95

110 Refrigerators,

room air conditioners,

and as permitted

in 422.16(B)

All elastomer

(thermoplastic)

parallel cord SPE-18 300 20—18 2 or 3 Thermoplastic elastomer 20—18 0.76 30 None None Pendant or portable Damp locations Not hard

usage

SPE-28 300 18—16 18—16 1.14 45

SPE-38 300 18—10 18—16

15

14

12

10 1.52

2.03

2.41

2.80 60

80

95

110 Refrigerators, room

air conditioners,

and as permitted

in 422.16(B)

All thermoplastic

parallel cord SPT-1 300 20—18 2 or 3 Thermoplastic 20—18 0.76 30 None None Pendant or portable Damp locations Not hard

usage

SPT-1W9 300 2 Damp and wet locations

SPT-2 300 18—16 2 or 3 18—16 1.14 45 Damp locations

SPT-2W9 300 2 Damp and wet locations

SPT-3 300 18—10 2 or 3 18—16

15—14

12

10 1.52

2.03

2.41

2.80 60

80

95

110 Refrigerators, room

air conditioners,

and as permitted

in 422.16(B) Damp locations Not hard

usage

Range, dryer cable SRD 300 10—4 3 or 4 Thermoset 10—4 1.14 45 None Thermoset Portable Damp locations Ranges,

dryers

SRDE 300 10—4 3 or 4 Thermoplastic elastomer None Thermoplastic elastomer

SRDT 300 10—4 3 or 4 Thermoplastic None Thermoplastic

Hard service cord ST7 600 18—2 2 or more Thermoplastic 18—15

14—9

8—2 0.76

1.14

1.52 30

45

60 None Thermoplastic Pendant or portable Damp locations Extra-hard usage

STW7,9 600 Damp and wet locations

STO7 600 Oil-resistant thermoplastic Damp locations

STOW7, 9 600 Damp and wet locations

STOO7 600 Oil-resistant thermoplastic Damp locations

STOOW7 600 Damp and wet locations

Vacuum cleaner cord SV 300 18—16 2 or 3 Thermoset 18—16 0.38 15 None Thermoset Pendant or portable Damp locations Not hard

usage

SVE 300 Thermoplastic elastomer Thermoplastic elastomer

SVEO 300 Oil-resistant

Thermoplastic elastomer

SVEOO 300 Oil-resistant

thermoplastic elastomer

SVO 300 Thermoset Oil-resistant thermoset

SVOO 300 Oil-resistant thermoset Oil-resistant thermoset

SVT 300 Thermoplastic Thermoplastic

SVTO 300 Thermoplastic Oil-resistant Thermoplastic

SVTOO 300 Oil-resistant thermoplastic

Parallel tinsel cord TPT11 300 27 2 Thermoplastic 27 0.76 30 None Thermoplastic Attached to an appliance Damp locations Not hard

usage

Jacketed tinsel cord TST11 300 27 2 Thermoplastic 27 0.38 15 None Thermoplastic Attached to an appliance Damp locations Not hard

usage

Portable power cable W7 2000 12—500 1—6 Thermoset 12—2 1.52 60 Oil-resistant thermoset Portable, extra-hard usage

501—1000 1 1—4/0 2.03 80

250—500 2.41 95

501—1000

2.80

110

Notes:

All types listed in Table 400.4 shall have individual conductors twisted together, except for Types HPN, SP-1, SP-2, SP-3, SPE-1, SPE-2,

SPE-3, SPT-1, SPT-2, SPT-3, SPT-1W, SPT-2W, TPT, NISP-1, NISP-2, NISPT-1, NISPT-2, NISPE-1, NISPE-2, and three-conductor parallel versions of SRD, SRDE, and SRDT.

The individual conductors of all cords, except those of heat-resistant cords, shall have a thermoset or thermoplastic insulation, except

that the equipment grounding conductor, where used, shall be in accordance with 400.23(B).

1Rubber-filled or varnished cambric tapes shall be permitted as a substitute for the inner braids.

2Elevator traveling cables for operating control and signal circuits shall contain nonmetallic fillers as necessary to maintain concentricity.

Cables shall have steel supporting members as required for suspension by 620.41. In locations subject to excessive moisture or corrosive

vapors or gases, supporting members of other materials shall be permitted. Where steel supporting members are used, they shall run

straight through the center of the cable assembly and shall not be cabled with the copper strands of any conductor.

In addition to conductors used for control and signaling circuits, Types E, EO, ETP, and ETT elevator cables shall be permitted to

incorporate in the construction one or more 20 AWG telephone conductor pairs, one or more coaxial cables, or one or more optical fibers.

The 20 AWG conductor pairs shall be permitted to be covered with suitable shielding for telephone, audio, or higher frequency

communications circuits; the coaxial cables shall consist of a center conductor, insulation, and a shield for use in video or

other radio frequency communications circuits. The optical fiber shall be suitably covered with flame-retardant thermoplastic.

The insulation of the conductors shall be rubber or thermoplastic of a thickness not less than specified for the other conductors

of the particular type of cable. Metallic shields shall have their own protective covering. Where used, these components shall be

permitted to be incorporated in any layer of the cable assembly but shall not run straight through the center.

3Insulations and outer coverings that meet the requirements as flame retardant, limited smoke, and are so listed, shall be

permitted to be marked for limited smoke after the Code type designation.

4Elevator cables in sizes 20 AWG through 14 AWG are rated 300 volts, and sizes 10 AWG through 2 AWG are rated 600 volts.

12 AWG is rated 300 volts with a 0.76 mm (30 mil) insulation thickness and 600 volts with a 1.14 mm (45 mil) insulation thickness.

5Conductor size for Types EV, EVJ, EVE, EVJE, EVT, and EVJT cables apply to nonpower-limited circuits only.

Conductors of power-limited (data, signal, or communications) circuits may extend beyond the stated AWG size range.

All conductors shall be insulated for the same cable voltage rating.

6InsuIation thickness for Types EV, EVJ, EVEJE, EVT, and EVJT cables of nylon construction is indicated in parentheses.

7Types G, G-GC, S, SC, SCE, SCT, SE, SEO, SEOO, SEW, SEOW, SEOOW, SO, SOO, SOW, SOOW, ST, STO, STOO, STW, STOW,

STOOW, PPE, and W shall be permitted for use on theater stages, in garages, and elsewhere where flexible cords are permitted by this Code.

8The third conductor in Type HPN shall be used as an equipment grounding conductor only. The insulation of the

equipment grounding conductor for Types SPE-1, SPE-2, SPE-3, SPT-1, SPT-2, SPT-3, NISPT-1, NISPT-2, NISPE-1, and

NISPE-2 shall be permitted to be thermoset polymer.

9Cords that comply with the requirements for outdoor cords and are so listed shall be permitted to be designated as

weather and water resistant with the suffix "W" after the Code type designation. Cords with the "W" suffix are suitable for use in wet locations and are sunlight resistant.

10The required outer covering on some single-conductor cables may be integral with the insulation.

11Types TPT and TST shall be permitted in lengths not exceeding 2.5 m (8 ft) where attached directly, or by means of

a special type of plug, to a portable appliance rated at 50 watts or less and of such nature that extreme flexibility of the cord is essential.

400.5 Ampacities for Flexible Cords and Flexible Cables

(A) Ampacity Tables

Table 400.5(A)(1) provides the ampacities, and Table 400.5(A)(2) provides the ampacities for flexible cords and flexible cables with not more than three current-carrying conductors. These tables shall be used in conjunction with applicable end-use product standards to ensure selection of the proper size and type. Where cords and cables are used in ambient temperatures other than 30°C (86°F), the temperature correction factors from Table 310.15(B)(1) that correspond to the temperature rating of the cord or cable shall be applied to the ampacity in Table 400.5(A)(1) and Table 400.5(A)(2). Cords and cables rated 105°C shall use correction factors in the 90°C column of Table 310.15(B)(1) for temperature correction. Where the number of current-carrying conductors exceeds three, the ampacity of each conductor shall be reduced from the three-conductor rating as shown in Table 400.5(A)(3).

Informational Note: See Informative Annex B, Table B.2(11), for adjustment factors for more than three current-carrying conductors in a raceway or cable with load diversity.

A neutral conductor that carries only the unbalanced current from other conductors of the same circuit shall not be required to meet the requirements of a current-carrying conductor.

In a 3-wire circuit consisting of two phase conductors and the neutral conductor of a 4-wire, 3-phase, wye-connected system, a common conductor carries approximately the same current as the line-to-neutral currents of the other conductors and shall be considered to be a current-carrying conductor.

On a 4-wire, 3-phase, wye circuit where more than 50 percent of the load consists of nonlinear loads, there are harmonic currents present in the neutral conductor and the neutral conductor shall be considered to be a current-carrying conductor.

An equipment grounding conductor shall not be considered a current-carrying conductor.

Where a single conductor is used for both equipment grounding and to carry unbalanced current from other conductors, as provided for in 250.140 for electric ranges and electric clothes dryers, it shall not be considered as a current-carrying conductor.

Table 400.5(A)(1) Ampacity for Flexible Cords and Flexible Cables

[Based on Ambient Temperature of 30°C (86°F). See 400.13 and Table 400.4.]

Copper Conductor Size (AWG) Thermoplastic Types TPT, TST Thermoset Types C, E, EO, PD, S, SJ, SJO, SJOW, SJOO, SJOOW, SO, SOW, SOO, SOOW, SP-1, SP-2, SP-3, SRD, SV, SVO, SVOO, NISP-1, NISP-2 Types HPD, HPN, HSJ, HSJO, HSJOW, HSJOO, HSJOOW

Thermoplastic Types ETP, ETT, NISPE-1, NISPE-2, NISPT-1, NISPT-2, SE, SEW, SEO, SEOO, SEOW, SEOOW, SJE, SJEW, SJEO, SJEOO, SJEOW, SJEOOW, SJT, SJTW, SJTO, SJTOW, SJTOO, SJTOOW, SPE-1, SPE-2, SPE-3, SPT-1, SPT-1W, SPT-2, SPT-2W, SPT-3, ST, STW, SRDE, SRDT, STO, STOW, STOO, STOOW, SVE, SVEO, SVEOO, SVT, SVTO, SVTOO

Column A1 Column B2

273 0.5 — — —

20 — 54 5 —

18 — 7 10 10

17 — 9 12 13

16 — 10 13 15

15 — 12 16 17

14 — 15 18 20

13 — 17 21 —

12 — 20 25 30

11 — 23 27 —

10 — 25 30 35

9 — 29 34 —

8 — 35 40 —

7 — 40 47 —

6 — 45 55 —

5 — 52 62 —

4 — 60 70 —

3 — 70 82 —

2 — 80 95 —

1The currents under Column A apply to three-conductor cords and other multiconductor cords connected to utilization equipment so that only three-conductors are current-carrying.

2The currents under Column B apply to two-conductor cords and other multiconductor cords connected to utilization equipment so that only two conductors are current-carrying.

3Tinsel cord.

4Elevator cables only.

57 amperes for elevator cables only; 2 amperes for other types.

Table 400.5(A)(2) Ampacity of Cable Types SC, SCE, SCT, PPE, G, G-GC, and W

[Based on Ambient Temperature of 30°C (86°F). See Table 400.4.]

Copper Conductor Size (AWG or kcmil) Temperature Rating of Cable

60°C (140°F) 75°C (167°F) 90°C (194°F)

D1 E2 F3 D1 E2 F3 D1 E2 F3

12 — 31 26 — 37 31 — 42 35

10 — 44 37 — 52 43 — 59 49

8 60 55 48 70 65 57 80 74 65

6 80 72 63 95 88 77 105 99 87

4 105 96 84 125 115 101 140 130 114

3 120 113 99 145 135 118 165 152 133

2 140 128 112 170 152 133 190 174 152

1 165 150 131 195 178 156 220 202 177

1/0 195 173 151 230 207 181 260 234 205

2/0 225 199 174 265 238 208 300 271 237

3/0 260 230 201 310 275 241 350 313 274

4/0 300 265 232 360 317 277 405 361 316

250 340 296 259 405 354 310 455 402 352

300 375 330 289 445 395 346 505 449 393

350 420 363 318 505 435 381 570 495 433

400 455 392 343 545 469 410 615 535 468

500 515 448 392 620 537 470 700 613 536

600 575 — — 690 — — 780 — —

700 630 — — 755 — — 855 — —

750 655 — — 785 — — 885 — —

800 680 — — 815 — — 920 — —

900 730 — — 870 — — 985 — —

1000 780 — — 935 — — 1055 — —

1The ampacities under subheading D shall be permitted for single-conductor Types SC, SCE, SCT, PPE, and W cable only where the individual conductors are not installed in raceways and are not in physical contact with each other except in lengths not to exceed 600 mm (24 in.) where passing through the wall of an enclosure.

2The ampacities under subheading E apply to two-conductor cables and other multiconductor cables connected to utilization equipment so that only two conductors are current-carrying.

3The ampacities under subheading F apply to three-conductor cables and other multiconductor cables connected to utilization equipment so that only three conductors are current-carrying.

Table 400.5(A)(3) Adjustment Factors for More Than Three Current-Carrying Conductors in a Flexible Cord or Flexible Cable

Number of Conductors Percent of Value in Table 400.5(A)(1) and Table 400.5(A)(2)

4—6 80

7—9 70

10—20 50

21—30 45

31—40 40

41 and above 35

(B) Ultimate Insulation Temperature

In no case shall conductors be associated together in such a way with respect to the kind of circuit, the wiring method used, or the number of conductors such that the limiting temperature of the conductors is exceeded.

(C) Engineering Supervision

Under engineering supervision, conductor ampacities shall be permitted to be calculated in accordance with 310.14(B).

400.6 Markings

(A) Standard Markings

Flexible cords and flexible cables shall be marked by means of a printed tag attached to the coil reel or carton. The tag shall contain the information required in 310.8(A). Types S, SC, SCE, SCT, SE, SEO, SEOO, SJ, SJE, SJEO, SJEOO, SJO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, STOO, SEW, SEOW, SEOOW, SJEW, SJEOW, SJEOOW, SJOW, SJTW, SJTOW, SJTOOW, SOW, SOOW, STW, STOW, and STOOW flexible cords and G, G-GC, PPE, and W flexible cables shall be durably marked on the surface at intervals not exceeding 610 mm (24 in.) with the type designation, size, and number of conductors. Required markings on tags, cords, and cables shall also include the maximum operating temperature of the flexible cord or flexible cable.

(B) Optional Markings

Flexible cords and cable types listed in Table 400.4 shall be permitted to be surface marked to indicate special characteristics of the cable materials. These markings include, but are not limited to, markings for limited smoke, sunlight resistance, and so forth.

400.10 Uses Permitted

(A) Uses

Flexible cords and flexible cables shall be used only for the following:

Pendants.

Wiring of luminaires.

Connection of portable luminaires, portable and mobile signs, or appliances.

Elevator cables.

Wiring of cranes and hoists.

Connection of utilization equipment to facilitate frequent interchange.

Prevention of the transmission of noise or vibration.

Appliances where the fastening means and mechanical connections are specifically designed to permit ready removal for maintenance and repair, and the appliance is intended or identified for flexible cord connection.

Connection of moving parts.

Where specifically permitted elsewhere in this Code.

Between an existing receptacle outlet and an inlet, where the inlet provides power to an additional single receptacle outlet. The wiring interconnecting the inlet to the single receptacle outlet shall be a Chapter 3 wiring method. The inlet, receptacle outlet, and Chapter 3 wiring method, including the flexible cord and fittings, shall be a listed assembly specific for this application.

(B) Attachment Plugs

Where used as permitted in 400.10(A)(3), (A)(6), and (A)(8), each flexible cord shall be equipped with an attachment plug and shall be energized from a receptacle outlet or cord connector body.

Exception: As permitted in 368.56.

400.12 Uses Not Permitted

Unless specifically permitted in 400.10, flexible cords, flexible cables, cord sets, and power supply cords shall not be used for the following:

As a substitute for the fixed wiring of a structure

Where run through holes in walls, structural ceilings, suspended ceilings, dropped ceilings, or floors

Where run through doorways, windows, or similar openings

Where attached to building surfaces

Exception to (4): Flexible cord and flexible cable shall be, permitted to be attached to building surfaces in accordance with 368.56(B) and 590.4.

Where concealed by walls, floors, or ceilings or located above suspended or dropped ceilings

Exception to (5): Flexible cords, flexible cables, and power supply cords shall be permitted if contained within an enclosure for use in other spaces used for environmental air as permitted by 300.22(C)(3).

Where installed in raceways, except as otherwise permitted in this Code

Where subject to physical damage

Informational Note: For proper application see UL 817, Cord Sets and Power-Supply Cords, and UL 62, Flexible Cords and Cables.

400.13 Splices

Flexible cord shall be used only in continuous lengths without splice or tap where initially installed in applications permitted by 400.10(A). The repair of hard-service cord and junior hard-service cord (see Trade Name column in Table 400.4) 14 AWG and larger shall be permitted if conductors are spliced in accordance with 110.14(B) and the completed splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

400.14 Pull at Joints and Terminals

Flexible cords and flexible cables shall be connected to devices and to fittings so that tension is not transmitted to joints or terminals.

Exception: Listed portable single-pole devices that are intended to accommodate such tension at their terminals shall be permitted to be used with single-conductor flexible cable.

Informational Note: Some methods of preventing pull on a cord from being transmitted to joints or terminals include knotting the cord, winding with tape, and using support or strain-relief fittings.

400.15 In Show Windows and Showcases

Flexible cords used in show windows and showcases shall be Types S, SE, SEO, SEOO, SJ, SJE, SJEO, SJEOO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, STOO, SEW, SEOW, SEOOW, SJEW, SJEOW, SJEOOW, SJOW, SJOOW, SJTW, SJTOW, SJTOOW, SOW, SOOW, STW, STOW, or STOOW.

Exception No. 1: For the wiring of chain-supported luminaires.

Exception No. 2: As supply cords for portable luminaires and other merchandise being displayed or exhibited.

400.16 Overcurrent Protection

Flexible cords not smaller than 18 AWG, and tinsel cords or cords having equivalent characteristics of smaller size approved for use with specific appliances, shall be considered as protected against overcurrent in accordance with 240.5.

400.17 Protection From Damage

Flexible cords and flexible cables shall be protected by bushings or fittings where passing through holes in covers, outlet boxes, or similar enclosures.

In industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation, flexible cords and flexible cables shall be permitted to be installed in aboveground raceways that are no longer than 15 m (50 ft) to protect the flexible cord or flexible cable from physical damage. Where more than three current-carrying conductors are installed within the raceway, the ampacity shall be adjusted in accordance with Table 400.5(A)(3).

Part II Construction Specifications

400.20 Labels

Flexible cords shall be examined and tested at the factory and labeled before shipment.

400.21 Construction

(A) Conductors

The individual conductors of a flexible cord or flexible cable shall have copper flexible stranding and shall not be smaller than the sizes specified in Table 400.4.

(B) Nominal Insulation Thickness

The nominal thickness of insulation for conductors of flexible cords and flexible cables shall not be less than specified in Table 400.4.

400.22 Grounded-Conductor Identification

One conductor of flexible cords that is intended to be used as a grounded circuit conductor shall have a continuous marker that readily distinguishes it from the other conductor or conductors. The identification shall consist of one of the methods indicated in 400.22(A) through (F).

(A) Colored Braid

A braid finished to show a white or gray color and the braid on the other conductor or conductors finished to show a readily distinguishable solid color or colors.

(B) Tracer in Braid

A tracer in a braid of any color contrasting with that of the braid and no tracer in the braid of the other conductor or conductors. No tracer shall be used in the braid of any conductor of a flexible cord that contains a conductor having a braid finished to show white or gray.

Exception: In the case of Types C and PD and cords having the braids on the individual conductors finished to show white or gray. In such cords, the identifying marker shall be permitted to consist of the solid white or gray finish on one conductor, provided there is a colored tracer in the braid of each other conductor.

(C) Colored Insulation

A white or gray insulation on one conductor and insulation of a readily distinguishable color or colors on the other conductor or conductors for cords having no braids on the individual conductors.

For jacketed cords furnished with appliances, one conductor having its insulation colored light blue, with the other conductors having their insulation of a readily distinguishable color other than white or gray.

Exception: Cords that have insulation on the individual conductors integral with the jacket.

The insulation shall be permitted to be covered with an outer finish to provide the desired color.

(D) Colored Separator

A white or gray separator on one conductor and a separator of a readily distinguishable solid color on the other conductor or conductors of cords having insulation on the individual conductors integral with the jacket.

(E) Tinned Conductors

One conductor having the individual strands tinned and the other conductor or conductors having the individual strands untinned for cords having insulation on the individual conductors integral with the jacket.

(F) Surface Marking

One or more ridges, grooves, or white stripes located on the exterior of the cord so as to identify one conductor for cords having insulation on the individual conductors integral with the jacket.

400.23 Equipment Grounding Conductor Identification

A conductor intended to be used as an equipment grounding conductor shall have a continuous identifying marker readily distinguishing it from the other conductor or conductors. Conductors having a continuous green color or a continuous green color with one or more yellow stripes shall not be used for other than equipment grounding conductors. Cords or cables consisting of integral insulation and a jacket without a nonintegral equipment grounding conductor shall be permitted to be green. The identifying marker shall consist of one of the methods in 400.23(A) or (B).

(A) Colored Braid

A braid finished to show a continuous green color or a continuous green color with one or more yellow stripes.

(B) Colored Insulation or Covering

For cords having no braids on the individual conductors, an insulation of a continuous green color or a continuous green color with one or more yellow stripes.

400.24 Attachment Plugs

Where a flexible cord is provided with an equipment grounding conductor and equipped with an attachment plug, the attachment plug shall comply with 250.138(A) and (B).

Part III Portable Cables Over 600 Volts, Nominal

400.30 Scope

Part III applies to single and multiconductor portable cables used to connect mobile equipment and machinery.

400.31 Construction

(A) Conductors

The conductors shall be 12 AWG copper or larger and shall employ flexible stranding.

(B) Equipment Grounding Conductor(s)

An equipment grounding conductor(s) shall be provided in cables with three or more conductors. The total area shall not be less than that of the size of the equipment grounding conductor required in 250.122.

400.32 Shielding

All shields shall be connected to an equipment grounding conductor.

400.33 Equipment Grounding Conductors

Equipment grounding conductors shall be connected in accordance with Parts VI and VII of Article 250.

400.34 Minimum Bending Radii

The minimum bending radii for portable cables during installation and handling in service shall be adequate to prevent damage to the cable.

400.35 Fittings

Connectors used to connect lengths of cable in a run shall be of a type that locks firmly together. Provisions shall be made to prevent opening or closing these connectors while energized. Suitable means shall be used to eliminate tension at connectors and terminations.

400.36 Splices and Terminations

Portable cables shall not contain splices unless the splices are of the permanent molded, vulcanized types in accordance with 110.14(B). Terminations on portable cables rated over 600 volts, nominal, shall be accessible only to authorized and qualified personnel.

Article 402 Fixture Wires

402.1 Scope

This article covers general requirements and construction specifications for fixture wires.

402.2 Other Articles

Fixture wires shall comply with this article and also with the applicable provisions of other articles of this Code.

Informational Note: For application in luminaires, see Article 410.

402.3 Types

Fixture wires shall be of a type listed in Table 402.3, and they shall comply with all requirements of that table. The fixture wires listed in Table 402.3 are all suitable for service at 600 volts, nominal, unless otherwise specified.

Informational Note: Thermoplastic insulation may stiffen at temperatures lower than —10°C (+14°F). Thermoplastic insulation may also be deformed at normal temperatures where subjected to pressure, such as at points of support.

Table 402.3 Fixture Wires

Name Type Letter Insulation AWG Thickness of Insulation Outer Covering Maximum Operating Temperature Application Provisions

mm mils

Heat-resistant rubber-covered fixture wire — flexible stranding FFH-2 Heat-resistant

rubber or cross-linked synthetic polymer 18—16 0.76 30 Nonmetallic covering 75°C

(167°F) Fixture wiring

FFHH-2 90°C

(194°F)

ECTFE — solid or 7-strand HF Ethylene

chlorotrifluoroethylene 18—14 0.38 15 None 150°C

(302°F) Fixture wiring

ECTFE — flexible stranding HFF Ethylene

chlorotrifluoroethylene 18—14 0.38 15 None 150°C

(302°F) Fixture wiring

Tape insulated fixture wire — solid or 7-strand KF-1 Aromatic

polyimide tape 18—10 0.14 5.5 None 200°C

(392°F) Fixture wiring — limited to 300 volts

KF-2 Aromatic

polyimide tape 18—10 0.21 8.4 None 200°C

(392°F) Fixture wiring

Tape insulated fixture wire — flexible stranding KFF-1 Aromatic

polyimide tape 18—10 0.14 5.5 None 200°C

(392°F) Fixture wiring — limited to 300 volts

KFF-2 Aromatic

polyimide tape 18—10 0.21 8.4 None 200°C

(392°F) Fixture wiring

Perfluoro-alkoxy — solid or 7-strand (nickel or nickel-coated copper) PAF Perfluoroalkoxy 18—14 0.51 20 None 250°C

(482°F) Fixture wiring (nickel or nickel-coated copper)

Perfluoro-alkoxy — flexible stranding PAFF Perfluoroalkoxy 18—14 0.51 20 None 150°C

(302°F) Fixture wiring

Fluorinated ethylene propylene fixture wire — solid or 7-strand PF Fluorinated

ethylene propylene 18—14 0.51 20 None 200°C

(392°F) Fixture wiring

Fluorinated ethylene propylene fixture wire — flexible stranding PFF Fluorinated

ethylene propylene 18—14 0.51 20 None 150°C

(302°F) Fixture wiring

Fluorinated ethylene propylene fixture wire — solid or 7-strand PGF Fluorinated

ethylene propylene 18—14 0.36 14 Glass braid 200°C

(392°F) Fixture wiring

Fluorinated ethylene propylene fixture wire — flexible stranding PGFF Fluorinated

ethylene propylene 18—14 0.36 14 Glass braid 150°C

(302°F) Fixture wiring

Extruded polytetrafluoroethylene — solid or 7-strand (nickel or nickel-coated copper) PTF Extruded

polytetrafluoroethylene 18—14 0.51 20 None 250°C

(482°F) Fixture wiring (nickel or nickel-coated copper)

Extruded polytetrafluoroethylene — flexible stranding 26-36 (AWG silver or nickel-coated copper) PTFF Extruded

polytetrafluoroethylene 18—14 0.51 20 None 150°C

(302°F) Fixture wiring (silver or nickel-coated copper)

Heat-resistant rubber-covered fixture wire — solid or 7-strand RFH-1 Heat-resistant

rubber 18 0.38 15 Nonmetallic covering 75°C

(167°F) Fixture wiring — limited to 300 volts

RFH-2 Heat-resistant

rubber Cross-linked synthetic polymer 18—16 0.76 30 None or nonmetallic covering 75°C

(167°F) Fixture wiring

Heat-resistant cross-linked synthetic polymer-insulated fixture wire — solid or 7-strand RFHH-2\* Cross-linked

synthetic polymer 18—16 0.76 30 None or nonmetallic covering 90°C

(194°F) Fixture wiring

RFHH-3\* 18—16 1.14 45

Silicone insulated fixture wire — solid or 7-strand SF-1 Silicone rubber 18 0.38 15 Nonmetallic covering 200°C

(392°F) Fixture wiring — limited to 300 volts

SF-2 Silicone rubber 18—12 0.76 30 Nonmetallic covering 200°C Fixture wiring

10 1.14 45 (392°F)

Silicone insulated fixture wire — flexible stranding SFF-1 Silicone rubber 18 0.38 15 Nonmetallic covering 150°C

(302°F) Fixture wiring — limited to 300 volts

SFF-2 Silicone rubber 18—12 0.76 30 Nonmetallic covering 150°C Fixture wiring

10 1.14 45 (302°F)

Thermoplastic covered fixture wire — solid or 7-strand TF\* Thermoplastic 18—16 0.76 30 None 60°C

(140°F) Fixture wiring

Thermoplastic covered fixture wire — flexible stranding TFF\* Thermoplastic 18—16 0.76 30 None 60°C

(140°F) Fixture wiring

Heat-resistant thermoplastic covered fixture wire — solid or 7-strand TFN\* Thermoplastic 18—16 0.38 15 Nylon-jacketed or equivalent 90°C

(194°F) Fixture wiring

Heat-resistant thermoplastic covered fixture wire — flexible stranded TFFN\* Thermoplastic 18—16 0.38 15 Nylon-jacketed or equivalent 90°C

(194°F) Fixture wiring

Cross-linked polyolefin insulated fixture wire — solid or 7-strand XF\* Cross-linked

polyolefin 18—14 0.76 30 None 150°C

(302°F) Fixture wiring — limited to 300 volts

12—10 1.14 45

Cross-linked polyolefin insulated fixture wire — flexible stranded XFF\* Cross-linked

polyolefin 18—14 0.76 30 None 150°C

(302°F) Fixture wiring — limited to 300 volts

12—10 1.14 45

Modified ETFE — solid or 7-strand ZF Modified ethylene

tetrafluoroethylene 18—14 0.38 15 None 150°C

(302°F) Fixture wiring

Modified ETFE — flexible stranding ZFF Modified ethylene

tetrafluoroethylene 18—14 0.38 15 None 150°C

(302°F) Fixture wiring

High temp. modified ETFE — solid or 7-strand ZHF Modified ethylene

tetrafluoroethylene 18—14 0.38 15 None 200°C

(392°F) Fixture wiring

\*Insulations and outer coverings that meet the requirements of flame retardant, limited smoke, and are so listed, shall be permitted to be marked for limited smoke after the Code type designation.

402.5 Ampacities for Fixture Wires

The ampacity of fixture wire shall be as specified in Table 402.5.

No conductor shall be used under such conditions that its operating temperature exceeds the temperature specified in Table 402.3 for the type of insulation involved.

Informational Note: See 310.14(A)(3) for temperature limitation of conductors.

Table 402.5 Ampacity for Fixture Wires

Size (AWG) Ampacity

18 6

16 8

14 17

12 23

10 28

402.6 Minimum Size

Fixture wires shall not be smaller than 18 AWG.

402.7 Number of Conductors in Conduit or Tubing

The number of fixture wires permitted in a single conduit or tubing shall not exceed the percentage fill specified in Table 1, Chapter 9.

402.8 Grounded Conductor Identification

Fixture wires that are intended to be used as grounded conductors shall be identified by one or more continuous white stripes on other than green insulation or by the means described in 400.22(A) through (E).

402.9 Marking

(A) Method of Marking

Thermoplastic insulated fixture wire shall be durably marked on the surface at intervals not exceeding 610 mm (24 in.). All other fixture wire shall be marked by means of a printed tag attached to the coil, reel, or carton.

(B) Optional Marking

Fixture wire types listed in Table 402.3 shall be permitted to be surface marked to indicate special characteristics of the cable materials. These markings include, but are not limited to, markings for limited smoke, sunlight resistance, and so forth.

402.10 Uses Permitted

Fixture wires shall be permitted (1) for installation in luminaires and in similar equipment where enclosed or protected and not subject to bending or twisting in use, or (2) for connecting luminaires to the branch-circuit conductors supplying the luminaires.

402.12 Uses Not Permitted

Fixture wires shall not be used as branch-circuit conductors except as permitted elsewhere in this Code.

402.14 Overcurrent Protection

Overcurrent protection for fixture wires shall be as specified in 240.5.

Article 404 Switches

Part I Installation

404.1 Scope

This article covers all switches, switching devices, and circuit breakers used as switches operating at 1000 volts and below, unless specifically referenced elsewhere in this Code for higher voltages.

404.2 Switch Connections

(A) Three-Way and Four-Way Switches

Three-way and four-way switches shall be wired so that all switching is done only in the ungrounded circuit conductor. Where in metal raceways or metal-armored cables, wiring between switches and outlets shall be in accordance with 300.20(A).

Exception: Switch loops shall not require a grounded conductor.

(B) Grounded Conductors

Switches or circuit breakers shall not disconnect the grounded conductor of a circuit.

Exception: A switch or circuit breaker shall be permitted to disconnect a grounded circuit conductor where all circuit conductors are disconnected simultaneously, or where the device is arranged so that the grounded conductor cannot be disconnected until all the ungrounded conductors of the circuit have been disconnected.

(C) Switches Controlling Lighting Loads

The grounded circuit conductor for the controlled lighting circuit shall be installed at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit serving bathrooms, hallways, stairways, and habitable rooms or occupiable spaces as defined in the applicable building code. Where multiple switch locations control the same lighting load such that the entire floor area of the room or space is visible from the single or combined switch locations, the grounded circuit conductor shall only be required at one location. A grounded conductor shall not be required to be installed at lighting switch locations under any of the following conditions:

Where conductors enter the box enclosing the switch through a raceway, provided that the raceway is large enough for all contained conductors, including a grounded conductor

Where the box enclosing the switch is accessible for the installation of an additional or replacement cable without removing finish materials

Where snap switches with integral enclosures comply with 300.15(E)

Where lighting in the area is controlled by automatic means

Where a switch controls a receptacle load

The grounded conductor shall be extended to any switch location as necessary and shall be connected to switching devices that require line-to-neutral voltage to operate the electronics of the switch in the standby mode and shall meet the requirements of 404.22.

Exception: The connection requirement shall become effective on January 1, 2020. It shall not apply to replacement or retrofit switches installed in locations prior to local adoption of 404.2(C) and where the grounded conductor cannot be extended without removing finish materials. The number of electronic control switches on a branch circuit shall not exceed five, and the number connected to any feeder on the load side of a system or main bonding jumper shall not exceed 25. For the purpose of this exception, a neutral busbar, in compliance with 200.2(B) and to which a main or system bonding jumper is connected shall not be limited as to the number of electronic lighting control switches connected.

Informational Note: The provision for a (future) grounded conductor is to complete a circuit path for electronic lighting control devices.

404.3 Enclosure

(A) General

Switches and circuit breakers shall be of the externally operable type mounted in an enclosure listed for the intended use. The minimum wire-bending space at terminals and minimum gutter space provided in switch enclosures shall be as required in 312.6.

Exception No. 1: Pendant- and surface-type snap switches and knife-switches mounted on an open-face switchboard or panelboard shall be permitted without enclosures.

Exception No. 2: Switches and circuit breakers installed in accordance with 110.27(A)(1), (A)(2), (A)(3), or (A)(4) shall be permitted without enclosures.

(B) Used as a Raceway

Enclosures shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices, unless the enclosure complies with 312.8.

404.4 Damp or Wet Locations

(A) Surface-Mounted Switch or Circuit Breaker

A surface-mounted switch or circuit breaker shall be enclosed in a weatherproof enclosure or cabinet that complies with 312.2.

(B) Flush-Mounted Switch or Circuit Breaker

A flush-mounted switch or circuit breaker shall be equipped with a weatherproof cover.

(C) Switches in Tub or Shower Spaces

Switches shall not be installed within tub or shower spaces unless installed as part of a listed tub or shower assembly.

404.5 Time Switches, Flashers, and Similar Devices

Time switches, flashers, and similar devices shall be of the enclosed type or shall be mounted in cabinets or boxes or equipment enclosures. Energized parts shall be barriered to prevent operator exposure when making manual adjustments or switching.

Exception: Devices mounted so they are accessible only to qualified persons shall be permitted without barriers, provided they are located within an enclosure such that any energized parts within 152 mm (6.0 in.) of the manual adjustment or switch are covered by suitable barriers.

404.6 Position and Connection of Switches

(A) Single-Throw Knife Switches

Single-throw knife switches shall be placed so that gravity will not tend to close them. Single-throw knife switches, approved for use in the inverted position, shall be provided with an integral mechanical means that ensures that the blades remain in the open position when so set.

(B) Double-Throw Knife Switches

Double-throw knife switches shall be permitted to be mounted so that the throw is either vertical or horizontal. Where the throw is vertical, integral mechanical means shall be provided to hold the blades in the open position when so set.

(C) Connection of Switches

Single-throw knife switches and switches with butt contacts shall be connected such that their blades are de-energized when the switch is in the open position. Bolted pressure contact switches shall have barriers that prevent inadvertent contact with energized blades. Single-throw knife switches, bolted pressure contact switches, molded case switches, switches with butt contacts, and circuit breakers used as switches shall be connected so that the terminals supplying the load are de-energized when the switch is in the open position.

Exception: The blades and terminals supplying the load of a switch shall be permitted to be energized when the switch is in the open position where the switch is connected to circuits or equipment inherently capable of providing a backfeed source of power. For such installations, a permanent sign shall be installed on the switch enclosure or immediately adjacent to open switches with the following words or equivalent: WARNING — LOAD SIDE TERMINALS MAY BE ENERGIZED BY BACKFEED. The warning sign or label shall comply with 110.21(B).

404.7 Indicating

General-use and motor-circuit switches, circuit breakers, and molded case switches, where mounted in an enclosure as described in 404.3, shall indicate, in a location that is visible when accessing the external operating means, whether they are in the open (off) or closed (on) position.

Where these switch or circuit breaker handles are operated vertically rather than rotationally or horizontally, the up position of the handle shall be the closed (on) position.

Exception No. 1: Vertically operated double-throw switches shall be permitted to be in the closed (on) position with the handle in either the up or down position.

Exception No. 2: On busway installations, tap switches employing a center-pivoting handle shall be permitted to be open or closed with either end of the handle in the up or down position. The switch position shall be clearly indicating and shall be visible from the floor or from the usual point of operation.

404.8 Accessibility and Grouping

(A) Location

All switches and circuit breakers used as switches shall be located so that they may be operated from a readily accessible place. They shall be installed such that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, is not more than 2.0 m (6 ft 7 in.) above the floor or working platform.

Exception No. 1: On busway installations, fused switches and circuit breakers shall be permitted to be located at the same level as the busway. Suitable means shall be provided to operate the handle of the device from the floor.

Exception No. 2: Switches and circuit breakers installed adjacent to motors, appliances, or other equipment that they supply shall be permitted to be located higher than 2.0 m (6 ft 7 in.) and to be accessible by portable means.

Exception No. 3: Hookstick operable isolating switches shall be permitted at greater heights.

(B) Voltage Between Adjacent Devices

A snap switch shall not be grouped or ganged in enclosures with other snap switches, receptacles, or similar devices, unless they are arranged so that the voltage between adjacent devices does not exceed 300 volts, or unless they are installed in enclosures equipped with identified, securely installed barriers between adjacent devices.

(C) Multipole Snap Switches

A multipole, general-use snap switch shall not be permitted to be fed from more than a single circuit unless it is listed and marked as a two-circuit or three-circuit switch.

Informational Note: See 210.7 for disconnect requirements where more than one circuit supplies a switch.

404.9 General-Use Snap Switches, Dimmers, and Control Switches

(A) Faceplates

Faceplates provided for snap switches, dimmers, and control switches mounted in boxes and other enclosures shall be installed so as to completely cover the opening and, where the switch is flush mounted, seat against the finished surface.

(B) Grounding

Snap switches, dimmers, and control switches shall be connected to an equipment grounding conductor and shall provide a means to connect metal faceplates to the equipment grounding conductor, whether or not a metal faceplate is installed. Metal faceplates shall be bonded to the equipment grounding conductor. Snap switches, dimmers, control switches, and metal faceplates shall be connected to an equipment grounding conductor using either of the following methods:

The switch is mounted with metal screws to a metal box or metal cover that is connected to an equipment grounding conductor or to a nonmetallic box with integral means for connecting to an equipment grounding conductor.

An equipment grounding conductor or equipment bonding jumper is connected to an equipment grounding termination of the snap switch.

Exception No. 1 to (B): Where no means exists within the enclosure for bonding to the equipment grounding conductor, or where the wiring method does not include or provide an equipment grounding conductor, a snap switch without a connection to an equipment grounding conductor shall be permitted for replacement purposes only. A snap switch wired under the provisions of this exception and located within 2.5 m (8 ft) vertically, or 1.5 m (5 ft) horizontally, of ground or exposed grounded metal objects shall be provided with a faceplate of nonconducting noncombustible material with nonmetallic attachment screws, unless the switch mounting strap or yoke is nonmetallic or the circuit is protected by a ground-fault circuit interrupter.

Exception No. 2 to (B): Listed kits or listed assemblies shall not be required to be bonded to an equipment grounding conductor if all of the following conditions are met:

The device is provided with a nonmetallic faceplate, and the device is designed such that no metallic faceplate replaces the one provided.

The device does not have mounting means to accept other configurations of faceplates.

The device is equipped with a nonmetallic yoke.

All parts of the device that are accessible after installation of the faceplate are manufactured of nonmetallic materials.

Exception No. 3 to (B): A snap switch with integral nonmetallic enclosure complying with 300.15(E) shall be permitted without a bonding connection to an equipment grounding conductor.

(C) Construction

Metal faceplates shall be of ferrous metal not less than 0.76 mm (0.030 in.) in thickness or of nonferrous metal not less than 1.02 mm (0.040 in.) in thickness. Faceplates of insulating material shall be noncombustible and not less than 2.54 mm (0.100 in.) in thickness, but they shall be permitted to be less than 2.54 mm (0.100 in.) in thickness if formed or reinforced to provide adequate mechanical strength.

404.10 Mounting of General-Use Snap Switches, Dimmers, and Control Switches

(A) Surface Type

General-use snap switches, dimmers, and control switches used with open wiring on insulators shall be mounted on insulating material that separates the conductors at least 13 mm (1/2 in.) from the surface wired over.

(B) Box Mounted

Flush-type general-use snap switches, dimmers, and control switches mounted in boxes that are set back of the finished surface as permitted in 314.20 shall be installed so that the extension plaster ears are seated against the surface. Flush-type devices mounted in boxes that are flush with the finished surface or project from it shall be installed so that the mounting yoke or strap of the device is seated against the box. Screws used for the purpose of attaching a device to a box shall be of the type provided with a listed device, or shall be machine screws having 32 threads per inch or part of listed assemblies or systems, in accordance with the manufacturer's instructions.

404.11 Circuit Breakers as Switches

A hand-operable circuit breaker equipped with a lever or handle, or a power-operated circuit breaker capable of being opened by hand in the event of a power failure, shall be permitted to serve as a switch if it has the required number of poles.

Informational Note: See the provisions contained in 240.81 and 240.83.

404.12 Grounding of Enclosures

Metal enclosures for switches or circuit breakers shall be connected to an equipment grounding conductor as specified in Part IV of Article 250. Metal enclosures for switches or circuit breakers used as service equipment shall comply with the provisions of Part V of Article 250. Where nonmetallic enclosures are used with metal raceways or metal-armored cables, they shall comply with 314.3, Exception No. 1 or No. 2.

Except as covered in 404.9(B), Exception No. 1, nonmetallic boxes for switches shall be installed with a wiring method that provides or includes an equipment grounding conductor.

404.13 Knife Switches

(A) Isolating Switches

Knife switches rated at over 1200 amperes at 250 volts or less, and at over 1000 amperes at 251 to 1000 volts, shall be used only as isolating switches and shall not be opened under load.

(B) To Interrupt Currents

To interrupt currents over 1200 amperes at 250 volts, nominal, or less, or over 600 amperes at 251 to 1000 volts, nominal, a circuit breaker or a switch listed for such purpose shall be used.

(C) General-Use Switches

Knife switches of ratings less than specified in 404.13(A) and (B) shall be considered general-use switches.

Informational Note: See the definition of General-Use Switch in Article 100.

(D) Motor-Circuit Switches

Motor-circuit switches shall be permitted to be of the knife-switch type.

Informational Note: See the definition of a Motor-Circuit Switch in Article 100.

404.14 Rating and Use of Switches

Switches shall be listed and used within their ratings. Switches of the types covered in 404.14(A) through (E) shall be limited to the control of loads as specified accordingly. Switches used to control cord-and-plug-connected loads shall be limited as covered in 404.14(F).

Informational Note No. 1: For switches for signs and outline lighting, see 600.6.

Informational Note No. 2: For switches controlling motors, see 430.83, 430.109, and 430.110.

(A) Alternating-Current General-Use Snap Switch

This form of switch shall only be used on ac circuits and used for controlling the following:

Resistive and inductive loads not exceeding the ampere rating of the switch at the voltage applied

Tungsten-filament lamp loads not exceeding the ampere rating of the switch at 120 volts

Electric discharge lamp loads not exceeding the marked ampere and voltage rating of the switch

Motor loads not exceeding 80 percent of the ampere rating of the switch at its rated voltage

Electronic ballasts, self-ballasted lamps, compact fluorescent lamps, and LED lamp loads with their associated drivers, not exceeding 20 amperes and not exceeding the ampere rating of the switch at the voltage applied

(B) Alternating-Current or Direct-Current General-Use Snap Switch

This form of switch shall be permitted on either ac or dc circuits and used only for controlling the following:

Resistive loads not exceeding the ampere rating of the switch at the voltage applied.

Inductive loads not exceeding 50 percent of the ampere rating of the switch at the applied voltage. Switches rated in horsepower are suitable for controlling motor loads within their rating at the voltage applied.

Tungsten-filament lamp loads not exceeding the ampere rating of the switch at the applied voltage if T-rated.

Electronic ballasts, self-ballasted lamps, compact fluorescent lamps, and LED lamp loads with their associated drivers, not exceeding the ampere rating of the switch at the voltage applied.

(C) CO/ALR Snap Switches

Snap switches directly connected to aluminum conductors and rated 20 amperes or less shall be marked CO/ALR.

(D) Alternating-Current General-Use Snap Switches Rated for 347 Volts

This form of switch shall not be rated less than 15 amperes at a voltage of 347 volts ac, and they shall not be readily interchangeable in box mounting with switches covered in 404.14(A) and (B). These switches shall be used only for controlling any of the following:

Noninductive loads other than tungsten-filament lamps not exceeding the ampere and voltage ratings of the switch.

Inductive loads not exceeding the ampere and voltage ratings of the switch. Where particular load characteristics or limitations are specified as a condition of the listing, those restrictions shall be observed regardless of the ampere rating of the load.

Electronic ballasts, self-ballasted lamps, compact fluorescent lamps, and LED lamp loads with their associated drivers, not exceeding 20 amperes and not exceeding the ampere rating of the switch at the voltage applied.

(E) Dimmer and Electronic Control Switches

General-use dimmer switches shall be used only to control permanently installed incandescent luminaires unless listed for the control of other loads and installed accordingly. Other electronic control switches, such as timing switches and occupancy sensors, shall be used to control permanently connected loads. They shall be marked by their manufacturer with their current and voltage ratings and used for loads that do not exceed their ampere rating at the voltage applied.

(F) Cord- And Plug-Connected Loads

Where a snap switch or control device is used to control cord-and-plug-connected equipment on a general-purpose branch circuit, each snap switch or control device controlling receptacle outlets or cord connectors that are supplied by permanently connected cord pendants shall be rated at not less than the rating of the maximum permitted ampere rating or setting of the overcurrent device protecting the receptacles or cord connectors, as provided in 210.21(B).

Informational Note: See 210.50(A) and 400.10(A)(1) for equivalency to a receptacle outlet of a cord connector that is supplied by a permanently connected cord pendant.

Exception: Where a snap switch or control device is used to control not more than one receptacle on a branch circuit, the switch or control device shall be permitted to be rated at not less than the rating of the receptacle.

Part II Construction Specifications

404.20 Marking

(A) Ratings

Switches shall be marked with the current, voltage, and, if horsepower rated, the maximum rating for which they are designed.

(B) Off Indication

Where in the off position, a switching device with a marked OFF position shall completely disconnect all ungrounded conductors to the load it controls.

404.22 Electronic Control Switches

Electronic control switches shall be listed. Electronic control switches shall not introduce current on the equipment grounding conductor during normal operation. The requirement to not introduce current on the equipment grounding conductor shall take effect on January 1, 2020.

Exception: Electronic control switches that introduce current on the equipment grounding conductor shall be permitted for applications covered by 404.2(C), Exception. Electronic control switches that introduce current on the equipment grounding conductor shall be listed and marked for use in replacement or retrofit applications only.

404.26 Knife Switches Rated 600 to 1000 Volts

Auxiliary contacts of a renewable or quick-break type or the equivalent shall be provided on all knife switches rated 600 to 1000 volts and designed for use in breaking current over 200 amperes.

404.27 Fused Switches

A fused switch shall not have fuses in parallel except as permitted in 240.8.

404.28 Wire-Bending Space

The wire-bending space required by 404.3 shall meet Table 312.6(B) spacings to the enclosure wall opposite the line and load terminals.

Article 406 Receptacles, Cord Connectors, and Attachment Plugs (Caps)

406.1 Scope

This article covers the rating, type, and installation of receptacles, cord connectors, and attachment plugs (cord caps).

406.2 Definitions

The definitions in this section shall apply only within this article.

Child Care Facility. A building or structure, or portion thereof, for educational, supervisory, or personal care services for more than four children 7 years old or less.

Outlet Box Hood. A housing shield intended to fit over a faceplate for flush-mounted wiring devices, or an integral component of an outlet box or of a faceplate for flush-mounted wiring devices. The hood does not serve to complete the electrical enclosure; it reduces the risk of water coming in contact with electrical components within the hood, such as attachment plugs, current taps, surge protective devices, direct plug-in transformer units, or wiring devices.

406.3 Receptacle Rating and Type

(A) Receptacles

Receptacles shall be listed and marked with the manufacturer's name or identification and voltage and ampere ratings. Receptacles shall not be permitted to be reconditioned.

(B) Rating

Receptacles and cord connectors shall be rated not less than 15 amperes, 125 volts, or 15 amperes, 250 volts, and shall be of a type not suitable for use as lampholders.

Informational Note: See 210.21(B) for receptacle ratings where installed on branch circuits.

(C) Receptacles for Aluminum Conductors

Receptacles rated 20 amperes or less and designed for the direct connection of aluminum conductors shall be marked CO/ALR.

(D) Isolated Ground Receptacles

Receptacles incorporating an isolated equipment grounding conductor connection intended for the reduction of electromagnetic interference as permitted in 250.146(D) shall be identified by an orange triangle located on the face of the receptacle.

(1) Isolated Equipment Grounding Conductor Required

Receptacles so identified shall be used only with equipment grounding conductors that are isolated in accordance with 250.146(D).

(2) Installation in Nonmetallic Boxes

Isolated ground receptacles installed in nonmetallic boxes shall be covered with a nonmetallic faceplate.

Exception: Where an isolated ground receptacle is installed in a nonmetallic box, a metal faceplate shall be permitted if the box contains a feature or accessory that permits the connection of the faceplate to the equipment grounding conductor.

(E) Controlled Receptacle Marking

All nonlocking-type, 125-volt, 15- and 20-ampere receptacles that are controlled by an automatic control device, or that incorporate control features that remove power from the receptacle for the purpose of energy management or building automation, shall be permanently marked with the symbol shown in Figure 406.3(E) and the word "controlled."

For receptacles controlled by an automatic control device, the marking shall be located on the receptacle face and visible after installation.

In both cases where a multiple receptacle device is used, the required marking of the word "controlled" and symbol shall denote which contact device(s) are controlled.

Exception: The marking shall not be required for receptacles controlled by a wall switch that provide the required room lighting outlets as permitted by 210.70.

FIGURE 406.3(E) Controlled Receptacle Marking Symbol.

(F) Receptacle With USB Charger

A 125-volt 15- or 20-ampere receptacle that additionally provides Class 2 power shall be listed and constructed such that the Class 2 circuitry is integral with the receptacle.

406.4 General Installation Requirements

Receptacle outlets shall be located in branch circuits in accordance with Part III of Article 210. General installation requirements shall be in accordance with 406.4(A) through (F).

(A) Grounding Type

Except as provided in 406.4(D), receptacles installed on 15- and 20-ampere branch circuits shall be of the grounding type. Grounding-type receptacles shall be installed only on circuits of the voltage class and current for which they are rated, except as provided in 210.21(B)(1) for single receptacles or Table 210.21(B)(2) and Table 210.21(B)(3) for two or more receptacles.

(B) To Be Grounded

Receptacles and cord connectors that have equipment grounding conductor contacts shall have those contacts connected to an equipment grounding conductor.

Exception No. 1: Receptacles mounted on portable and vehicle-mounted generator sets and generators in accordance with 250.34.

Exception No. 2: Replacement receptacles as permitted by 406.4(D).

(C) Methods of Grounding

The equipment grounding conductor contacts of receptacles and cord connectors shall be connected to the equipment grounding conductor of the circuit supplying the receptacle or cord connector.

Informational Note: For installation requirements for the reduction of electromagnetic interference, see 250.146(D).

The branch-circuit wiring method shall include or provide an equipment grounding conductor to which the equipment grounding conductor contacts of the receptacle or cord connector are connected.

Informational Note No. 1: See 250.118 for acceptable grounding means.

Informational Note No. 2: For extensions of existing branch circuits, see 250.130.

(D) Replacements

Replacement of receptacles shall comply with 406.4(D)(1) through (D)(7), as applicable. Arc-fault circuit-interrupter type and ground-fault circuit-interrupter type receptacles shall be installed in a readily accessible location.

(1) Grounding-Type Receptacles

Where a grounding means exists in the receptacle enclosure or an equipment grounding conductor is installed in accordance with 250.130(C), grounding-type receptacles shall be used and shall be connected to the equipment grounding conductor in accordance with 406.4(C) or 250.130(C).

(2) Non—Grounding-Type Receptacles

Where attachment to an equipment grounding conductor does not exist in the receptacle enclosure, the installation shall comply with 406.4(D)(2)(a), (D)(2)(b), or (D)(2)(c).

(a) A non—grounding-type receptacle(s) shall be permitted to be replaced with another non—grounding-type receptacle(s).

(b) A non—grounding-type receptacle(s) shall be permitted to be replaced with a ground-fault circuit interrupter-type of receptacle(s). These receptacles or their cover plates shall be marked "No Equipment Ground." An equipment grounding conductor shall not be connected from the ground-fault circuit-interrupter-type receptacle to any outlet supplied from the ground-fault circuit-interrupter receptacle.

(c) A non-grounding-type receptacle(s) shall be permitted to be replaced with a grounding-type receptacle(s) where supplied through a ground-fault circuit interrupter. Where grounding-type receptacles are supplied through the ground-fault circuit interrupter, grounding-type receptacles or their cover plates shall be marked "GFCI Protected" and "No Equipment Ground," visible after installation. An equipment grounding conductor shall not be connected between the grounding-type receptacles.

Informational Note No. 1: Some equipment or appliance manufacturers require that the branch circuit to the equipment or appliance includes an equipment grounding conductor.

Informational Note No. 2: See 250.114 for a list of a cord-and-plug-connected equipment or appliances that require an equipment grounding conductor.

(3) Ground-Fault Circuit-Interrupter Protection

Ground-fault circuit-interrupter protected receptacles shall be provided where replacements are made at receptacle outlets that are required to be so protected elsewhere in this Code.

Exception: Where the outlet box size will not permit the installation of the GFCI receptacle, the receptacle shall be permitted to be replaced with a new receptacle of the existing type, where GFCI protection is provided and the receptacle is marked "GFCI Protected" and "No Equipment Ground," in accordance with 406.4(D)(2)(a), (D)(2)(b), or (D)(2)(c), as applicable.

(4) Arc-Fault Circuit-Interrupter Protection

If a receptacle outlet located in any areas specified in 210.12(A), (B), or (C) is replaced, a replacement receptacle at this outlet shall be one of the following:

A listed outlet branch-circuit type arc-fault circuit-interrupter receptacle

A receptacle protected by a listed outlet branch-circuit type arc-fault circuit-interrupter type receptacle

A receptacle protected by a listed combination type arc-fault circuit-interrupter type circuit breaker

Exception: Section 210.12(D), Exception, shall not apply to replacement of receptacles.

(5) Tamper-Resistant Receptacles

Listed tamper-resistant receptacles shall be provided where replacements are made at receptacle outlets that are required to be tamper-resistant elsewhere in this Code, except where a non-grounding receptacle is replaced with another non-grounding receptacle.

(6) Weather-Resistant Receptacles

Weather-resistant receptacles shall be provided where replacements are made at receptacle outlets that are required to be so protected elsewhere in this Code.

(7) Controlled Receptacles

Automatically controlled receptacles shall be replaced with equivalently controlled receptacles. If automatic control is no longer required, the receptacle and any associated receptacles marked in accordance with 406.3(E) shall be replaced with a receptacle and faceplate not marked in accordance with 406.3(E).

(E) Cord- And Plug-Connected Equipment

The installation of grounding-type receptacles shall not be used as a requirement that all cord-and plug-connected equipment be of the grounded type.

Informational Note: See 250.114 for types of cord-and plug-connected equipment to be grounded.

(F) Noninterchangeable Types

Receptacles connected to circuits that have different voltages, frequencies, or types of current (ac or dc) on the same premises shall be of such design that the attachment plugs used on these circuits are not interchangeable.

406.5 Receptacle Mounting

Receptacles shall be mounted in identified boxes or assemblies. The boxes or assemblies shall be securely fastened in place unless otherwise permitted elsewhere in this Code. Screws used for the purpose of attaching receptacles to a box shall be of the type provided with a listed receptacle, or shall be machine screws having 32 threads per inch or part of listed assemblies or systems, in accordance with the manufacturer's instructions.

(A) Boxes That Are Set Back

Receptacles mounted in boxes that are set back from the finished surface as permitted in 314.20 shall be installed such that the mounting yoke or strap of the receptacle is held rigidly at the finished surface.

(B) Boxes That Are Flush

Receptacles mounted in boxes that are flush with the finished surface or project therefrom shall be installed such that the mounting yoke or strap of the receptacle is held rigidly against the box or box cover.

(C) Receptacles Mounted on Covers

Receptacles mounted to and supported by a cover shall be held rigidly against the cover by more than one screw or shall be a device assembly or box cover listed and identified for securing by a single screw.

(D) Position of Receptacle Faces

After installation, receptacle faces shall be flush with or project from faceplates of insulating material and shall project a minimum of 0.4 mm (0.015 in.) from metal faceplates.

Exception: Listed kits or assemblies encompassing receptacles and nonmetallic faceplates that cover the receptacle face, where the plate cannot be installed on any other receptacle, shall be permitted.

(E) Receptacles in Countertops

Receptacle assemblies for installation in countertop surfaces shall be listed for countertop applications. Where receptacle assemblies for countertop applications are required to provide ground-fault circuit-interrupter protection for personnel in accordance with 210.8, such assemblies shall be permitted to be listed as GFCI receptacle assemblies for countertop applications.

(F) Receptacles in Work Surfaces

Receptacle assemblies and GFCI receptacle assemblies listed for work surface or counter-top applications shall be permitted to be installed in work surfaces.

(G) Receptacle Orientation

(1) Countertop and Work Surfaces

Receptacles shall not be installed in a face-up position in or on countertop surfaces or work surfaces unless listed for countertop or work surface applications.

(2) Under Sinks

Receptacles shall not be installed in a face-up position in the area below a sink.

(H) Receptacles in Seating Areas and Other Similar Surfaces

In seating areas or similar surfaces, receptacles shall not be installed in a face-up position unless the receptacle is any of the following:

Part of an assembly listed as a furniture power distribution unit

Part of an assembly listed either as household furnishings or as commercial furnishings

Listed either as a receptacle assembly for countertop applications or as a GFCI receptacle assembly for counter-top applications

Installed in a listed floor box

(I) Exposed Terminals

Receptacles shall be enclosed so that live wiring terminals are not exposed to contact.

(J) Voltage Between Adjacent Devices

A receptacle shall not be grouped or ganged in enclosures with other receptacles, snap switches, or similar devices, unless they are arranged so that the voltage between adjacent devices does not exceed 300 volts, or unless they are installed in enclosures equipped with identified, securely installed barriers between adjacent devices.

406.6 Receptacle Faceplates (Cover Plates)

Receptacle faceplates shall be installed so as to completely cover the opening and seat against the mounting surface.

Receptacle faceplates mounted inside a box having a recess-mounted receptacle shall effectively close the opening and seat against the mounting surface.

(A) Thickness of Metal Faceplates

Metal faceplates shall be of ferrous metal not less than 0.76 mm (0.030 in.) in thickness or of nonferrous metal not less than 1.02 mm (0.040 in.) in thickness.

(B) Grounding

Metal faceplates shall be grounded.

(C) Faceplates of Insulating Material

Faceplates of insulating material shall be noncombustible and not less than 2.54 mm (0.10 in.) in thickness but shall be permitted to be less than 2.54 mm (0.10 in.) in thickness if formed or reinforced to provide adequate mechanical strength.

(D) Receptacle Faceplate (Cover Plates) With Integral Night Light and/or USB Charger

A flush device cover plate that additionally provides a night light and/or Class 2 output connector(s) shall be listed and constructed such that the night light and/or Class 2 circuitry is integral with the flush device cover plate.

406.7 Attachment Plugs, Cord Connectors, and Flanged Surface Devices

All attachment plugs, cord connectors, and flanged surface devices (inlets and outlets) shall be listed and marked with the manufacturer's name or identification and voltage and ampere ratings. Attachment plugs, cord connectors, and flanged surface devices shall not be permitted to be reconditioned.

(A) Construction of Attachment Plugs and Cord Connectors

Attachment plugs and cord connectors shall be constructed so that there are no exposed current-carrying parts except the prongs, blades, or pins. The cover for wire terminations shall be a part that is essential for the operation of an attachment plug or connector (dead-front construction).

(B) Connection of Attachment Plugs

Attachment plugs shall be installed so that their prongs, blades, or pins are not energized unless inserted into an energized receptacle or cord connectors. No receptacle shall be installed so as to require the insertion of an energized attachment plug as its source of supply.

(C) Attachment Plug Ejector Mechanisms

Attachment plug ejector mechanisms shall not adversely affect engagement of the blades of the attachment plug with the contacts of the receptacle.

(D) Flanged Surface Inlet

A flanged surface inlet shall be installed such that the prongs, blades, or pins are not energized unless an energized cord connector is inserted into it.

406.8 Noninterchangeability

Receptacles, cord connectors, and attachment plugs shall be constructed such that receptacle or cord connectors do not accept an attachment plug with a different voltage or current rating from that for which the device is intended. However, a 20-ampere T-slot receptacle or cord connector shall be permitted to accept a 15-ampere attachment plug of the same voltage rating. Non—grounding-type receptacles and connectors shall not accept grounding-type attachment plugs.

406.9 Receptacles in Damp or Wet Locations

(A) Damp Locations

A receptacle installed outdoors in a location protected from the weather or in other damp locations shall have an enclosure for the receptacle that is weatherproof when the receptacle is covered (attachment plug cap not inserted and receptacle covers closed).

An installation suitable for wet locations shall also be considered suitable for damp locations.

A receptacle shall be considered to be in a location protected from the weather where located under roofed open porches, canopies, marquees, and the like, and will not be subjected to a beating rain or water runoff. All 15- and 20-ampere, 125-and 250-volt nonlocking receptacles shall be a listed weather-resistant type.

Informational Note: The types of receptacles covered by this requirement are identified as 5-15, 5-20, 6-15, and 6-20 in ANSI/NEMA WD 6-2016, Wiring Devices — Dimensional Specifications.

(B) Wet Locations

(1) Receptacles of 15 and 20 Amperes in a Wet Location

Receptacles of 15 and 20 amperes, 125 and 250 volts installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed and shall be identified as "extra-duty." Other listed products, enclosures, or assemblies providing weatherproof protection that do not utilize an outlet box hood need not be marked "extra duty."

Informational Note No. 1: Requirements for extra-duty outlet box hoods are found in ANSI/UL 514D-2016, Cover Plates for Flush-Mounted Wiring Devices. "Extra duty" identification and requirements are not applicable to listed receptacles, faceplates, outlet boxes, enclosures, or assemblies that are identified as either being suitable for wet locations or rated as one of the outdoor enclosure-type numbers of Table 110.28 that does not utilize an outlet box hood.

Exception: 15- and 20-ampere, 125-through 250-volt receptacles installed in a wet location and subject to routine high-pressure spray washing shall be permitted to have an enclosure that is weatherproof when the attachment plug is removed.

All 15- and 20-ampere, 125-and 250-volt nonlocking-type receptacles shall be listed and so identified as the weather-resistant type.

Informational Note No. 2: The configuration of weather-resistant receptacles covered by this requirement are identified as 5-15, 5-20, 6-15, and 6-20 in ANSI/NEMA WD 6-2016, Wiring Devices — Dimensional Specifications.

(2) Other Receptacles

All other receptacles installed in a wet location shall comply with 406.9(B)(2)(a) or (B)(2)(b).

(a) A receptacle installed in a wet location, where the product intended to be plugged into it is not attended while in use, shall have an enclosure that is weatherproof with the attachment plug cap inserted or removed.

(b) A receptacle installed in a wet location where the product intended to be plugged into it will be attended while in use (e.g., portable tools) shall have an enclosure that is weatherproof when the attachment plug is removed.

(C) Bathtub and Shower Space

Receptacles shall not be installed within a zone measured 900 mm (3 ft) horizontally and 2.5 m (8 ft) vertically from the top of the bathtub rim or shower stall threshold. The identified zone is all-encompassing and shall include the space directly over the tub or shower stall.

Exception: In bathrooms with less than the required zone the receptacle(s) shall be permitted to be installed opposite the bathtub rim or shower stall threshold on the farthest wall within the room.

(D) Protection for Floor Receptacles

Standpipes of floor receptacles shall allow floor-cleaning equipment to be operated without damage to receptacles.

(E) Flush Mounting With Faceplate

The enclosure for a receptacle installed in an outlet box flush-mounted in a finished surface shall be made weatherproof by means of a weatherproof faceplate assembly that provides a watertight connection between the plate and the finished surface.

406.10 Grounding-Type Receptacles, Adapters, Cord Connectors, and Attachment Plugs

(A) Grounding Poles (Connections)

Grounding-type receptacles, cord connectors, and attachment plugs shall be provided with one fixed grounding pole in addition to the circuit poles. The grounding contacting pole of grounding-type plug-in ground-fault circuit interrupters shall be permitted to be of the movable, self-restoring type on circuits operating at not over 150 volts between any two conductors or any conductor and ground.

(B) Grounding-Pole (Connection) Identification

Grounding-type receptacles, adapters, cord connections, and attachment plugs shall have a means for connection of an equipment grounding conductor to the grounding pole.

A terminal for connection to the grounding pole shall be designated by one of the following:

A green-colored hexagonal-headed or -shaped terminal screw or nut, not readily removable.

A green-colored pressure wire connector body (a wire barrel).

A similar green-colored connection device, in the case of adapters. The grounding terminal of a grounding adapter shall be a green-colored rigid ear, lug, or similar device. The equipment grounding connection shall be so designed that it cannot make contact with current-carrying parts of the receptacle, adapter, or attachment plug. The adapter shall be polarized.

If the terminal for the equipment grounding conductor is not visible, the conductor entrance hole shall be marked with the word green or ground, the letters G or GR, a grounding symbol, or otherwise identified by a distinctive green color. If the terminal for the equipment grounding conductor is readily removable, the area adjacent to the terminal shall be similarly marked.

Informational Note: See Informational Note Figure 406.10(B)(4).

Informational Note Figure 406.10(B)(4) One Example of a Symbol Used to Identify the Termination Point for an Equipment Grounding Conductor.

(C) Grounding Terminal Use

A grounding terminal shall not be used for purposes other than connection to the equipment grounding conductor.

(D) Grounding-Pole (Connection) Requirements

Grounding-type attachment plugs and mating cord connectors and receptacles shall be designed such that the equipment grounding connection is made before the current-carrying connections. Grounding-type devices shall be so designed that grounding poles of attachment plugs cannot be brought into contact with current-carrying parts of receptacles or cord connectors.

(E) Use

Grounding-type attachment plugs shall be used only with a cord having an equipment grounding conductor.

Informational Note: See 250.126 for identification of equipment grounding conductor terminals.

406.11 Connecting Receptacle Grounding Terminal to Box

The connection of the receptacle grounding terminal shall comply with 250.146.

406.12 Tamper-Resistant Receptacles

All 15- and 20-ampere, 125-and 250-volt nonlocking-type receptacles in the areas specified in 406.12(1) through (8) shall be listed tamper-resistant receptacles.

Dwelling units, including attached and detached garages and accessory buildings to dwelling units, and common areas of multifamily dwellings specified in 210.52 and 550.13

Guest rooms and guest suites of hotels, motels, and their common areas

Child care facilities

Preschools and education facilities

Business offices, corridors, waiting rooms and the like in clinics, medical and dental offices, and outpatient facilities

Subset of assembly occupancies described in 518.2 to include places of awaiting transportation, gymnasiums, skating rinks, and auditoriums

Dormitory units

Assisted living facilities

Informational Note No. 1: This requirement would include receptacles identified as 5-15, 5-20, 6-15, and 6-20 in ANSI/NEMA WD 6-2016, Wiring Devices — Dimensional Specifications.

Informational Note No. 2: Assisted living facilities are Institutional Use Group I-1 per IBC 2015.

Exception to (1), (2), (3), (4), (5), (6), (7) and (8): Receptacles in the following locations shall not be required to be tamper resistant:

Receptacles located more than 1.7 m (5 1/2 ft) above the floor

Receptacles that are part of a luminaire or appliance

A single receptacle, or a duplex receptacle for two appliances, located within the dedicated space for each appliance that, in normal use, is not easily moved from one place to another and that is cord-and-plug-connected in accordance with 400.10(A)(6), (A)(7), or (A)(8)

Nongrounding receptacles used for replacements as permitted in 406.4(D)(2)(a)

406.13 Single-Pole Separable-Connector Type

Single-pole separable connectors shall be listed and labeled and shall comply with 406.13(A) through (D).

(A) Locking or Latching Type

Single-pole separable connectors shall be of either the locking or latching type and marked with the manufacturer's name or identification and voltage and ampere ratings.

(B) Identification

Connectors designated for connection to the grounded circuit conductor shall be identified by a white-colored housing; connectors designated for connection to the grounding circuit conductor shall be identified by a green-colored housing.

(C) Interchangeability

Single-pole separable connectors shall be permitted to be interchangeable for ac or dc use or for different current ratings or voltages on the same premises, provided they are listed for ac/dc use and marked in a suitable manner to identify the system to which they are intended to be connected.

(D) Connecting and Disconnecting

The use of single-pole separable connectors shall be performed by a qualified person and shall comply with at least one of the following conditions:

Connection and disconnection of connectors are only possible where the supply connectors are interlocked to the source, and it is not possible to connect or disconnect connectors when the supply is energized.

Line connectors are of the listed sequential-interlocking type so that load connectors are connected in the following sequence and that disconnection is in the reverse sequence:

Equipment grounding conductor connection

Grounded circuit conductor connection, if provided

Ungrounded conductor connection

A caution notice that complies with 110.21(B) is provided on the equipment employing single-pole separable connectors, adjacent to the line connectors, indicating that connections are to be performed in the following sequence and that disconnection is in the reverse sequence:

Equipment grounding conductor connectors

Grounded circuit-conductor connectors, if provided

Ungrounded conductor connectors

Informational Note: A single-pole locking-type separable connector is investigated in accordance with ANSI/UL 1691—2014, Single Pole Locking-Type Separable Connectors.

Article 408 Switchboards, Switchgear, and Panelboards

Part I General

408.1 Scope

This article covers switchboards, switchgear, and panelboards. It does not apply to equipment operating at over 1000 volts, except as specifically referenced elsewhere in the Code.

408.2 Other Articles

Switches, circuit breakers, and overcurrent devices used on switchboards, switchgear, and panelboards and their enclosures shall comply with this article and also with the requirements of Articles 240, 250, 312, 404, and other articles that apply. Switchboards, switchgear, and panelboards in hazardous (classified) locations shall comply with the applicable provisions of Articles 500 through 517.

408.3 Support and Arrangement of Busbars and Conductors

(A) Conductors and Busbars on a Switchboard, Switchgear, or Panelboard

Conductors and busbars on a switchboard, switchgear, or panelboard shall comply with 408.3(A)(1) and (A)(2) as applicable.

(1) Location

Conductors and busbars shall be located so as to be free from physical damage and shall be held firmly in place.

(2) Same Vertical Section

Other than the required interconnections and control wiring, only those conductors that are intended for termination in a vertical section of a switchboard or switchgear shall be located in that section.

Exception: Conductors shall be permitted to travel horizontally through vertical sections of switchboards and switchgear where such conductors are isolated from busbars by a barrier.

(B) Overheating and Inductive Effects

The arrangement of busbars and conductors shall be such as to avoid overheating due to inductive effects.

(C) Used as Service Equipment

Each switchboard, switchgear, or panelboard, if used as service equipment, shall be provided with a main bonding jumper sized in accordance with 250.28(D) or the equivalent placed within the panelboard or one of the sections of the switchboard or switchgear for connecting the grounded service conductor on its supply side to the switchboard, switchgear, or panelboard frame. All sections of a switchboard or switchgear shall be bonded together using an equipment-bonding jumper or a supply-side bonding jumper sized in accordance with 250.122 or 250.102(C)(1) as applicable.

Exception: Switchboards, switchgear, and panelboards used as service equipment on high-impedance grounded neutral systems in accordance with 250.36 shall not be required to be provided with a main bonding jumper.

(D) Terminals

In switchboards and switchgear, load terminals for field wiring shall comply with 408.18(C).

(E) Bus Arrangement

(1) AC Phase Arrangement

Alternating-current phase arrangement on 3-phase buses shall be A, B, C from front to back, top to bottom, or left to right, as viewed from the front of the switchboard, switchgear, or panelboard. The B phase shall be that phase having the higher voltage to ground on 3-phase, 4-wire, delta-connected systems. Other busbar arrangements shall be permitted for additions to existing installations and shall be marked.

Exception: Equipment within the same single section or multisection switchboard, switchgear, or panelboard as the meter on 3-phase, 4-wire, delta-connected systems shall be permitted to have the same phase configuration as the metering equipment.

Informational Note: See 110.15 for requirements on marking the busbar or phase conductor having the higher voltage to ground where supplied from a 4-wire, delta-connected system.

(2) DC Bus Arrangement

Direct-current ungrounded buses shall be permitted to be in any order. Arrangement of dc buses shall be field marked as to polarity, grounding system, and nominal voltage.

(F) Switchboard, Switchgear, or Panelboard Identification

A caution sign(s) or a label(s) provided in accordance with 408.3(F)(1) through (F)(5) shall comply with 110.21(B).

(1) High-Leg Identification

A switchboard, switchgear, or panelboard containing a 4-wire, delta-connected system where the midpoint of one phase winding is grounded shall be legibly and permanently field marked as follows:

"Caution \_\_\_\_\_ Phase Has \_\_\_\_\_ Volts to Ground"

(2) Ungrounded AC Systems

A switchboard, switchgear, or panelboard containing an ungrounded ac electrical system as permitted in 250.21 shall be legibly and permanently field marked as follows:

"Caution Ungrounded System Operating — \_\_\_\_\_ Volts Between Conductors"

(3) High-Impedance Grounded Neutral AC System

A switchboard, switchgear, or panelboard containing a high-impedance grounded neutral ac system in accordance with 250.36 shall be legibly and permanently field marked as follows:

CAUTION: HIGH-IMPEDANCE GROUNDED NEUTRAL AC SYSTEM OPERATING — \_\_\_\_\_ VOLTS BETWEEN CONDUCTORS AND MAY OPERATE — \_\_\_\_\_ VOLTS TO GROUND FOR INDEFINITE PERIODS UNDER FAULT CONDITIONS

(4) Ungrounded DC Systems

A switchboard, switchgear, or panelboard containing an ungrounded dc electrical system in accordance with 250.169 shall be legibly and permanently field marked as follows:

CAUTION: UNGROUNDED DC SYSTEM OPERATING — \_\_\_\_\_ VOLTS BETWEEN CONDUCTORS

(5) Resistively Grounded DC Systems

A switchboard, switch-gear, or panelboard containing a resistive connection between current-carrying conductors and the grounding system to stabilize voltage to ground shall be legibly and permanently field marked as follows:

CAUTION: DC SYSTEM OPERATING — \_\_\_\_\_ VOLTS BETWEEN CONDUCTORS AND MAY OPERATE — \_\_\_\_\_ VOLTS TO GROUND FOR INDEFINITE PERIODS UNDER FAULT CONDITIONS

(G) Minimum Wire-Bending Space

The minimum wirebending space at terminals and minimum gutter space provided in switchboards, switchgear, and panelboards shall be as required in 312.6.

408.4 Field Identification Required

(A) Circuit Directory or Circuit Identification

Every circuit and circuit modification shall be legibly identified as to its clear, evident, and specific purpose or use. The identification shall include an approved degree of detail that allows each circuit to be distinguished from all others. Spare positions that contain unused overcurrent devices or switches shall be described accordingly. The identification shall be included in a circuit directory that is located on the face, inside of, or in an approved location adjacent to the panel door in the case of a panelboard and at each switch or circuit breaker in a switchboard or switchgear. No circuit shall be described in a manner that depends on transient conditions of occupancy.

(B) Source of Supply

All switchboards, switchgear, and panelboards supplied by a feeder(s) in other than one-or two-family dwellings shall be permanently marked to indicate each device or equipment where the power originates. The label shall be permanently affixed, of sufficient durability to withstand the environment involved, and not handwritten.

408.5 Clearance for Conductor Entering Bus Enclosures

Where conduits or other raceways enter a switchboard, switchgear, floor-standing panelboard, or similar enclosure at the bottom, approved space shall be provided to permit installation of conductors in the enclosure. The wiring space shall not be less than shown in Table 408.5 where the conduit or raceways enter or leave the enclosure below the busbars, their supports, or other obstructions. The conduit or raceways, including their end fittings, shall not rise more than 75 mm (3 in.) above the bottom of the enclosure.

Table 408.5 Clearance for Conductors Entering Bus Enclosures

Conductor Minimum Spacing Between Bottom of Enclosure and Busbars, Their Supports, or Other Obstructions

mm in.

Insulated busbars, their supports, or other obstructions 200 8

Noninsulated busbars 250 10

408.6 Short-Circuit Current Rating

Switchboards, switchgear, and panelboards shall have a short-circuit current rating not less than the available fault current. In other than one-and two-family dwelling units, the available fault current and the date the calculation was performed shall be field marked on the enclosure at the point of supply. The marking shall comply with 110.21(B)(3).

408.7 Unused Openings

Unused openings for circuit breakers and switches shall be closed using identified closures, or other approved means that provide protection substantially equivalent to the wall of the enclosure.

408.8 Reconditioning of Equipment

Reconditioning of equipment within the scope of this article shall be limited as described in 408.8(A) and (B). The reconditioning process shall use design qualified parts verified under applicable standards and be performed in accordance with any instructions provided by the manufacturer. If equipment has been damaged by fire, products of combustion, or water, it shall be specifically evaluated by its manufacturer or a qualified testing laboratory prior to being returned to service.

(A) Panelboards

Panelboards shall not be permitted to be reconditioned. This shall not prevent the replacement of a panelboard within an enclosure. In the event the replacement has not been listed for the specific enclosure and the available fault current is greater than 10,000 amperes, the completed work shall be field labeled, and any previously applied listing marks on the cabinet that pertain to the panelboard shall be removed.

(B) Switchboards and Switchgear

Switchboards and switchgear, or sections of switchboards or switchgear, shall be permitted to be reconditioned. Reconditioned switchgear shall be listed or field labeled as reconditioned, and previously applied listing marks, if any, within the portions reconditioned shall be removed.

Part II Switchboards and Switchgear

408.16 Switchboards and Switchgear in Damp or Wet Locations

Switchboards and switchgear in damp or wet locations shall be installed in accordance with 312.2.

408.17 Location Relative to Easily Ignitible Material

Switchboards and switchgear shall be placed so as to reduce to a minimum the probability of communicating fire to adjacent combustible materials. Where installed over a combustible floor, suitable protection thereto shall be provided.

408.18 Clearances

(A) From Ceiling

For other than a totally enclosed switchboard or switchgear, a space not less than 900 mm (3 ft) shall be provided between the top of the switchboard or switchgear and any combustible ceiling, unless a noncombustible shield is provided between the switchboard or switchgear and the ceiling.

(B) Around Switchboards and Switchgear

Clearances around switchboards and switchgear shall comply with the provisions of 110.26.

(C) Connections

Each section of equipment that requires rear or side access to make field connections shall be so marked by the manufacturer on the front. Section openings requiring rear or side access shall comply with 110.26. Load terminals for field wiring shall comply with 408.18(C)(1), (C)(2), or (C)(3) as applicable.

(1) Equipment Grounding Conductors

Load terminals for field wiring shall be so located that it is not necessary to reach across uninsulated ungrounded bus in order to make connections.

(2) Grounded Circuit Conductors

Where multiple branch or feeder grounded circuit conductor load terminals for field wiring are grouped together in one location, they shall be so located that it is not necessary to reach across uninsulated ungrounded bus, whether or not energized, in order to make connections.

Where only one branch or feeder set of load terminals for field wiring are grouped with its associated ungrounded load terminals, they shall be so located that it is not necessary to reach across energized uninsulated bus including other branch or feeder bus in order to make connections. Bus on the line side of service, branch, or feeder disconnects is considered energized with respect to its associated load side circuits.

(3) Ungrounded Conductors

Load terminals for ungrounded conductors shall be so located that it is not necessary to reach across energized uninsulated bus in order to make connections. Bus on the line side of service, branch, or feeder disconnects is considered energized with respect to its associated load side circuits.

408.19 Conductor Insulation

An insulated conductor used within a switchboard or switchgear shall be listed, shall be flame retardant, and shall be rated not less than the voltage applied to it and not less than the voltage applied to other conductors or busbars with which it may come into contact.

408.20 Location of Switchboards and Switchgear

Switchboards and switchgear that have any exposed live parts shall be located in permanently dry locations and then only where under competent supervision and accessible only to qualified persons. Switchboards and switchgear shall be located such that the probability of damage from equipment or processes is reduced to a minimum.

408.22 Grounding of Instruments, Relays, Meters, and Instrument Transformers on Switchboards and Switchgear

Instruments, relays, meters, and instrument transformers located on switchboards and switchgear shall be grounded as specified in 250.170 through 250.178.

408.23 Power Monitoring and Energy Management Equipment

The requirements of 312.8(B) shall apply.

Part III Panelboards

408.30 General

All panelboards shall have a rating not less than the minimum feeder capacity required for the load calculated in accordance with Part III, IV, or V of Article 220, as applicable.

408.36 Overcurrent Protection

In addition to the requirement of 408.30, a panelboard shall be protected by an overcurrent protective device having a rating not greater than that of the panelboard. This overcurrent protective device shall be located within or at any point on the supply side of the panelboard.

Exception No. 1: Individual protection shall not be required for a panelboard protected by two main circuit breakers or two sets of fuses in other than service equipment, having a combined rating not greater than that of the panelboard. A panelboard constructed or wired under this exception shall not contain more than 42 overcurrent devices. For the purposes of determining the maximum of 42 overcurrent devices, a 2-pole or a 3-pole circuit breaker shall be considered as two or three overcurrent devices, respectively.

Exception No. 2: For existing panelboards, individual protection shall not be required for a panelboard used as service equipment for an individual residential occupancy.

(A) Snap Switches Rated at 30 Amperes or Less

Panelboards equipped with snap switches rated at 30 amperes or less shall have overcurrent protection of 200 amperes or less.

(B) Supplied Through a Transformer

Where a panelboard is supplied through a transformer, the overcurrent protection required by 408.36 shall be located on the secondary side of the transformer.

Exception: A panelboard supplied by the secondary side of a transformer shall be considered as protected by the overcurrent protection provided on the primary side of the transformer where that protection is in accordance with 240.21(C)(1).

(C) Delta Breakers

A 3-phase disconnect or overcurrent device shall not be connected to the bus of any panelboard that has less than 3-phase buses. Delta breakers shall not be installed in panelboards.

(D) Back-Fed Devices

Plug-in-type overcurrent protection devices or plug-in type main lug assemblies that are backfed and used to terminate field-installed ungrounded supply conductors shall be secured in place by an additional fastener that requires other than a pull to release the device from the mounting means on the panel.

408.37 Panelboards in Damp or Wet Locations

Panelboards in damp or wet locations shall be installed to comply with 312.2.

408.38 Enclosure

Panelboards shall be mounted in cabinets, cutout boxes, or identified enclosures and shall be dead-front.

Exception: Panelboards other than of the dead-front, externally operable-type shall be permitted where accessible only to qualified persons.

408.39 Relative Arrangement of Switches and Fuses

In panelboards, fuses of any type shall be installed on the load side of any switches.

Exception: Fuses installed as part of service equipment in accordance with the provisions of 230.94 shall be permitted on the line side of the service switch.

408.40 Grounding of Panelboards

Panelboard cabinets and panelboard frames, if of metal, shall be in physical contact with each other and shall be connected to an equipment grounding conductor. Where the panelboard is used with nonmetallic raceway or cable or where separate equipment grounding conductors are provided, a terminal bar for the equipment grounding conductors shall be secured inside the cabinet. The terminal bar shall be bonded to the cabinet and panelboard frame, if of metal; otherwise it shall be connected to the equipment grounding conductor that is run with the conductors feeding the panelboard.

Exception: Where an isolated equipment grounding conductor for a branch circuit or a feeder is provided as permitted by 250.146(D), the insulated equipment grounding conductor that is run with the circuit conductors shall be permitted to pass through the panelboard without being connected to the panelboard's equipment grounding terminal bar.

Equipment grounding conductors shall not be connected to a terminal bar provided for grounded conductors or neutral conductors unless the bar is identified for the purpose and is located where interconnection between equipment grounding conductors and grounded circuit conductors is permitted or required by Article 250.

408.41 Grounded Conductor Terminations

Each grounded conductor shall terminate within the panelboard in an individual terminal that is not also used for another conductor.

Exception: Grounded conductors of circuits with parallel conductors shall be permitted to terminate in a single terminal if the terminal is identified for connection of more than one conductor.

408.43 Panelboard Orientation

Panelboards shall not be installed in the face-up position.

Part IV Construction Specifications

408.50 Panels

The panels of switchboards and switchgear shall be made of moisture-resistant, noncombustible material.

408.51 Busbars

Insulated or bare busbars shall be rigidly mounted.

408.52 Protection of Instrument Circuits

Instruments, pilot lights, voltage (potential) transformers, and other switchboard or switchgear devices with potential coils shall be supplied by a circuit that is protected by standard overcurrent devices rated 15 amperes or less.

Exception No. 1: Overcurrent devices rated more than 15 amperes shall be permitted where the interruption of the circuit could create a hazard. Short-circuit protection shall be provided.

Exception No. 2: For ratings of 2 amperes or less, special types of enclosed fuses shall be permitted.

408.53 Component Parts

Switches, fuses, and fuseholders used on panelboards shall comply with the applicable requirements of Articles 240 and 404.

408.54 Maximum Number of Overcurrent Devices

A panelboard shall be provided with physical means to prevent the installation of more overcurrent devices than that number for which the panelboard was designed, rated, and listed.

For the purposes of this section, a 2-pole circuit breaker or fusible switch shall be considered two overcurrent devices; a 3-pole circuit breaker or fusible switch shall be considered three overcurrent devices.

408.55 Wire-Bending Space Within an Enclosure Containing a Panelboard

(A) Top and Bottom Wire-Bending Space

The enclosure for a panelboard shall have the top and bottom wire-bending space sized in accordance with Table 312.6(B) for the largest conductor entering or leaving the enclosure.

Exception No. 1: Either the top or bottom wire-bending space shall be permitted to be sized in accordance with Table 312.6(A) for a panelboard rated 225 amperes or less and designed to contain not over 42 overcurrent devices. For the purposes of this exception, a 2-pole or a 3-pole circuit breaker shall be considered as two or three overcurrent devices, respectively.

Exception No. 2: Either the top or bottom wire-bending space for any panelboard shall be permitted to be sized in accordance with Table 312.6(A) where at least one side wire-bending space is sized in accordance with Table. 312.6(B) for the largest conductor to be terminated in any side wire-bending space.

Exception No. 3: The top and bottom wire-bending space shall be permitted to be sized in accordance with Table 312.6(A) spacings if the panelboard is designed and constructed for wiring using only a single 90-degree bend for each conductor, including the grounded circuit conductor, and the wiring diagram shows and specifies the method of wiring that shall be used.

Exception No. 4: Either the top or the bottom wire-bending space, but not both, shall be permitted to be sized in accordance with Table 312.6(A) where there are no conductors terminated in that space.

(B) Side Wire-Bending Space

Side wire-bending space shall be in accordance with Table 312.6(A) for the largest conductor to be terminated in that space.

(C) Back Wire-Bending Space

Where a raceway or cable entry is in the wall of the enclosure opposite a removable cover, the distance from that wall to the cover shall be permitted to comply with the distance required for one wire per terminal in Table 312.6(A). The distance between the center of the rear entry and the nearest termination for the entering conductors shall not be less than the distance given in Table 312.6(B).

408.56 Minimum Spacings

The distance between uninsulated metal parts, busbars, and other uninsulated live parts shall not be less than specified in Table 408.56.

Where close proximity does not cause excessive heating, parts of the same polarity at switches, enclosed fuses, and so forth shall be permitted to be placed as close together as convenience in handling will allow.

Exception: The distance shall be permitted to be less than that specified in Table 408.56 at circuit breakers and switches and in listed components installed in switchboards, switchgear, and panelboards.

Table 408.56 Minimum Spacings Between Bare Metal Parts

AC or DC Voltage Opposite Polarity Where Mounted on the Same Surface Opposite Polarity Where Held Free in Air Live Parts to Ground\*

mm in. mm in. mm in.

Not over 125 volts, nominal 19.1 3/4 12.7 1/2 12.7 1/2

Not over 250 volts, nominal 31.8 11/4 19.1 3/4 12.7 1/2

Not over 1000 volts, nominal 50.8 2 25.4 1 25.4 1

\*For spacing between live parts and doors of cabinets, the dimensions in 312.11(A) shall apply.

408.58 Panelboard Marking

Panelboards shall be durably marked by the manufacturer with the voltage and the current rating and the number of ac phases or dc buses for which they are designed and with the manufacturer's name or trademark in such a manner so as to be visible after installation, without disturbing the interior parts or wiring.

Article 409 Industrial Control Panels

Part I General

409.1 Scope

This article covers industrial control panels intended for general use and operating at 1000 volts or less.

Informational Note: ANSI/UL 508A, Standard for Industrial Control Panels, is a safety standard for industrial control panels.

409.3 Other Articles

In addition to the requirements of Article 409, industrial control panels that contain branch circuits for specific loads or components, or are for control of specific types of equipment addressed in other articles of this Code, shall be constructed and installed in accordance with the applicable requirements from the specific articles in Table 409.3.

Table 409.3 Other Articles

Equipment/Occupancy Article Section

Branch circuits 210

Luminaires 410

Motors, motor circuits, and controllers 430

Air-conditioning and refrigerating equipment 440

Capacitors 460.8, 460.9

Hazardous (classified) locations 500, 501, 502, 503, 504, 505

Commercial garages; aircraft hangars; motor fuel dispensing facilities; bulk storage plants; spray application, dipping, and coating processes; and inhalation anesthetizing locations 511, 513, 514, 515, 516, and 517 Part IV

Cranes and hoists 610

Electrically driven or controlled irrigation machines 675

Elevators, dumbwaiters, escalators, moving walks, wheelchair lifts, and stairway chair lifts 620

Industrial machinery 670

Resistors and reactors 470

Transformers 450

Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits 725

Part II Installation

409.20 Conductor — Minimum Size and Ampacity

The size of the industrial control panel supply conductor shall have an ampacity not less than 125 percent of the full-load current rating of all heating loads plus 125 percent of the full-load current rating of the highest rated motor plus the sum of the full-load current ratings of all other connected motors and apparatus based on their duty cycle that may be in operation at the same time.

409.21 Overcurrent Protection

(A) General

Industrial control panels shall be provided with overcurrent protection in accordance with Parts I, II, and IX of Article 240.

(B) Location

This protection shall be provided for each incoming supply circuit by either of the following:

An overcurrent protective device located ahead of the industrial control panel.

A single main overcurrent protective device located within the industrial control panel. Where overcurrent protection is provided as part of the industrial control panel, the supply conductors shall be considered as either feeders or taps as covered by 240.21.

(C) Rating

The rating or setting of the overcurrent protective device for the circuit supplying the industrial control panel shall not be greater than the sum of the largest rating or setting of the branch-circuit short-circuit and ground-fault protective device provided with the industrial control panel, plus 125 percent of the full-load current rating of all resistance heating loads, plus the sum of the full-load currents of all other motors and apparatus that could be in operation at the same time.

Exception: Where one or more instantaneous trip circuit breakers or motor short-circuit protectors are used for motor branch-circuit short-circuit and ground-fault protection as permitted by 430.52(C), the procedure specified above for determining the maximum rating of the protective device for the circuit supplying the industrial control panel shall apply with the following provision: For the purpose of the calculation, each instantaneous trip circuit breaker or motor short-circuit protector shall be assumed to have a rating not exceeding the maximum percentage of motor-full-load current permitted by Table 430.52 for the type of control panel supply circuit protective device employed.

Where no branch-circuit short-circuit and ground-fault protective device is provided with the industrial control panel for motor or combination of motor and non-motor loads, the rating or setting of the overcurrent protective device shall be based on 430.52 and 430.53, as applicable.

409.22 Short-Circuit Current Rating

(A) Installation

An industrial control panel shall not be installed where the available fault current exceeds its short-circuit current rating as marked in accordance with 409.110(4).

(B) Documentation

If an industrial control panel is required to be marked with a short-circuit current rating in accordance with 409.110(4), the available fault current at the industrial control panel and the date the available fault current calculation was performed shall be documented and made available to those authorized to inspect, install, or maintain the installation.

409.30 Disconnecting Means

Disconnecting means that supply motor loads shall comply with Part IX of Article 430.

409.60 Grounding

Multisection industrial control panels shall be bonded together with an equipment grounding conductor or an equivalent equipment grounding bus sized in accordance with Table 250.122. Equipment grounding conductors shall be connected to this equipment grounding bus or to an equipment grounding termination point provided in a single-section industrial control panel.

Part III Construction Specifications

409.100 Enclosures

Table 110.28 shall be used as the basis for selecting industrial control panel enclosures for use in specific locations other than hazardous (classified) locations. The enclosures are not intended to protect against conditions such as condensation, icing, corrosion, or contamination that may occur within the enclosure or enter via the conduit or unsealed openings.

409.102 Busbars and Conductors

Industrial control panels utilizing busbars shall comply with 409.102(A) and (B).

(A) Support and Arrangement

Busbars shall be protected from physical damage and be held firmly in place.

(B) Phase Arrangement

The phase arrangement on 3-phase horizontal common power and vertical buses shall be A, B, C from front to back, top to bottom, or left to right, as viewed from the front of the industrial control panel. The B phase shall be that phase having the higher voltage to ground on 3-phase, 4-wire, delta-connected systems. Other busbar arrangements shall be permitted for additions to existing installations, and the phases shall be permanently marked.

409.104 Wiring Space

(A) General

Industrial control panel enclosures shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices or other equipment, unless the conductors fill less than 40 percent of the cross-sectional area of the wiring space. In addition, the conductors, splices, and taps shall not fill the wiring space at any cross section to more than 75 percent of the cross-sectional area of that space.

(B) Wire Bending Space

Wire bending space within industrial control panels for field wiring terminals shall be in accordance with the requirements in 430.10(B).

409.106 Spacings

Spacings in feeder circuits between uninsulated live parts of adjacent components, between uninsulated live parts of components and grounded or accessible non—current-carrying metal parts, between uninsulated live parts of components and the enclosure, and at field wiring terminals shall be as shown in Table 430.97(D).

Exception: Spacings shall be permitted to be less than those specified in Table 430.97(D) at circuit breakers and switches and in listed components installed in industrial control panels.

409.108 Service Equipment

Where used as service equipment, each industrial control panel shall be of the type that is suitable for use as service equipment.

Where a grounded conductor is provided, the industrial control panel shall be provided with a main bonding jumper, sized in accordance with 250.28(D), for connecting the grounded conductor, on its supply side, to the industrial control panel equipment ground bus or equipment ground terminal.

409.110 Marking

An industrial control panel shall be marked with the following information that is plainly visible after installation:

Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified.

Supply voltage, number of phases, frequency, and full-load current for each incoming supply circuit.

Industrial control panels supplied by more than one electrical source where more than one disconnecting means is required to disconnect all circuits 50-volts or more within the control panel shall be marked to indicate that more than one disconnecting means is required to de-energize the equipment. The location of the means necessary to disconnect all circuits 50-volts or more shall be documented and available.

Short-circuit current rating of the industrial control panel based on one of the following:

Short-circuit current rating of a listed and labeled assembly

Short-circuit current rating established utilizing an approved method

Informational Note: ANSI/UL 508A, Standard for Industrial Control Panels, Supplement SB, is an example of an approved method.

Exception to (4): Short-circuit current rating markings are not required for industrial control panels containing only control circuit components.

If the industrial control panel is intended as service equipment, it shall be marked to identify it as being suitable for use as service equipment.

Electrical wiring diagram or the identification number of a separate electrical wiring diagram or a designation referenced in a separate wiring diagram.

An enclosure type number shall be marked on the industrial control panel enclosure.

Article 410 Luminaires, Lampholders, and Lamps

Part I General

410.1 Scope

This article covers luminaires, portable luminaires, lampholders, pendants, incandescent filament lamps, arc lamps, electric-discharge lamps, decorative lighting products, lighting accessories for temporary seasonal and holiday use, portable flexible lighting products, and the wiring and equipment forming part of such products and lighting installations.

410.2 Definition

The definition in this section shall apply only within this article.

Clothes Closet Storage Space. The volume bounded by the sides and back closet walls and planes extending from the closet floor vertically to a height of 1.8 m (6 ft) or to the highest clothes-hanging rod and parallel to the walls at a horizontal distance of 600 mm (24 in.) from the sides and back of the closet walls, respectively, and continuing vertically to the closet ceiling parallel to the walls at a horizontal distance of 300 mm (12 in.) or the width of the shelf, whichever is greater; for a closet that permits access to both sides of a hanging rod, this space includes the volume below the highest rod extending 300 mm (12 in.) on either side of the rod on a plane horizontal to the floor extending the entire length of the rod. See Figure 410.2.

FIGURE 410.2 Clothes Closet Storage Space.

410.5 Live Parts

Luminaires, portable luminaires, lampholders, and lamps shall have no live parts normally exposed to contact. Exposed accessible terminals in lampholders and switches shall not be installed in metal luminaire canopies or in open bases of portable table or floor luminaires.

Exception: Cleat-type lampholders located at least 2.5 m (8 ft) above the floor shall be permitted to have exposed terminals.

410.6 Listing Required

All luminaires, lampholders, and retrofit kits shall be listed.

410.7 Reconditioned Equipment

Luminaires, lampholders, and retrofit kits shall not be permitted to be reconditioned. If a retrofit kit is installed in a luminaire in accordance with the installation instructions, the retrofitted luminaire shall not be considered reconditioned.

410.8 Inspection

Luminaires shall be installed such that the connections between the luminaire conductors and the circuit conductors can be inspected without requiring the disconnection of any part of the wiring unless the luminaires are connected by attachment plugs and receptacles.

Part II Luminaire Locations

410.10 Luminaires in Specific Locations

(A) Wet and Damp Locations

Luminaires installed in wet or damp locations shall be installed such that water cannot enter or accumulate in wiring compartments, lampholders, or other electrical parts. All luminaires installed in wet locations shall be marked, "Suitable for Wet Locations." All luminaires installed in damp locations shall be marked "Suitable for Wet Locations" or "Suitable for Damp Locations."

(B) Corrosive Locations

Luminaires installed in corrosive locations shall be of a type suitable for such locations.

(C) In Ducts or Hoods

Luminaires shall be permitted to be installed in commercial cooking hoods where all of the following conditions are met:

The luminaire shall be identified for use within commercial cooking hoods and installed such that the temperature limits of the materials used are not exceeded.

The luminaire shall be constructed so that all exhaust vapors, grease, oil, or cooking vapors are excluded from the lamp and wiring compartment. Diffusers shall be resistant to thermal shock.

Parts of the luminaire exposed within the hood shall be corrosion resistant or protected against corrosion, and the surface shall be smooth so as not to collect deposits and to facilitate cleaning.

Wiring methods and materials supplying the luminaire(s) shall not be exposed within the cooking hood.

Informational Note: See 110.11 for conductors and equipment exposed to deteriorating agents.

(D) Bathtub and Shower Areas

A luminaire installed in a bathtub or shower area shall meet all of the following requirements:

No parts of cord-connected luminaires, chain-, cable-, or cord-suspended luminaires, lighting track, pendants, or ceiling-suspended (paddle) fans shall be located within a zone measured 900 mm (3 ft) horizontally and 2.5 m (8 ft) vertically from the top of the bathtub rim or shower stall threshold. This zone is all-encompassing and includes the space directly over the tub or shower stall.

Luminaires located within the actual outside dimension of the bathtub or shower to a height of 2.5 m (8 ft) vertically from the top of the bathtub rim or shower threshold shall be marked suitable for damp locations or marked suitable for wet locations. Luminaires located where subject to shower spray shall be marked suitable for wet locations.

(E) Luminaires in Indoor Sports, Mixed-Use, and All-Purpose Facilities

Luminaires subject to physical damage, using a mercury vapor or metal halide lamp, installed in playing and spectator seating areas of indoor sports, mixed-use, or all-purpose facilities shall be of the type that protects the lamp with a glass or plastic lens. Such luminaires shall be permitted to have an additional guard.

(F) Luminaires Installed in or Under Roof Decking

Luminaires installed in exposed or concealed locations under metal-corrugated sheet roof decking shall be installed and supported so there is not less than 38 mm (11/2 in.) measured from the lowest surface of the roof decking to the top of the luminaire.

410.11 Luminaires Near Combustible Material

Luminaires shall be constructed, installed, or equipped with shades or guards so that combustible material is not subjected to temperatures in excess of 90°C (194°F).

410.12 Luminaires Over Combustible Material

Lampholders installed over highly combustible material shall be of the unswitched type. Unless an individual switch is provided for each luminaire, lampholders shall be located at least 2.5 m (8 ft) above the floor or shall be located or guarded so that the lamps cannot be readily removed or damaged.

410.14 Luminaires in Show Windows

Chain-supported luminaires used in a show window shall be permitted to be externally wired. No other externally wired luminaires shall be used.

410.16 Luminaires in Clothes Closets

(A) Luminaire Types Permitted

Only luminaires of the following types shall be permitted in a clothes closet:

Surface-mounted or recessed incandescent or LED luminaires with completely enclosed light sources

Surface-mounted or recessed fluorescent luminaires

Surface-mounted fluorescent or LED luminaires identified as suitable for installation within the clothes closet storage space

(B) Luminaire Types Not Permitted

Incandescent luminaires with open or partially enclosed lamps and pendant luminaires or lampholders shall not be permitted.

(C) Location

The minimum clearance between luminaires installed in clothes closets and the nearest point of a clothes closet storage space shall be as follows:

300 mm (12 in.) for surface-mounted incandescent or LED luminaires with a completely enclosed light source installed on the wall above the door or on the ceiling.

150 mm (6 in.) for surface-mounted fluorescent luminaires installed on the wall above the door or on the ceiling.

150 mm (6 in.) for recessed incandescent or LED luminaires with a completely enclosed light source installed in the wall or the ceiling.

150 mm (6 in.) for recessed fluorescent luminaires installed in the wall or the ceiling.

Surface-mounted fluorescent or LED luminaires shall be permitted to be installed within the clothes closet storage space where identified for this use.

410.18 Space for Cove Lighting

Coves shall have adequate space and shall be located so that lamps and equipment can be properly installed and maintained.

Part III Provisions at Luminaire Outlet Boxes, Canopies, and Pans

410.20 Space for Conductors

Canopies and outlet boxes taken together shall provide sufficient space so that luminaire conductors and their connecting devices are capable of being installed in accordance with 314.16.

410.21 Temperature Limit of Conductors in Outlet Boxes

Luminaires shall be of such construction or installed so that the conductors in outlet boxes shall not be subjected to temperatures greater than that for which the conductors are rated.

Branch-circuit wiring, other than 2-wire or multiwire branch circuits supplying power to luminaires connected together, shall not be passed through an outlet box that is an integral part of a luminaire unless the luminaire is identified for through-wiring.

Informational Note: See 410.64(C) for wiring supplying power to luminaires connected together.

410.22 Outlet Boxes to Be Covered

In a completed installation, each outlet box shall be provided with a cover unless covered by means of a luminaire canopy, lampholder, receptacle that covers the box or is provided with a faceplate, or similar device.

410.23 Covering of Combustible Material at Outlet Boxes

Any combustible wall or ceiling finish exposed between the edge of a luminaire canopy or pan and an outlet box having a surface area of 1160 mm2 (180 in.2) or more shall be covered with noncombustible material.

410.24 Connection of Electric-Discharge and LED Luminaires

(A) Independent of the Outlet Box

Electric-discharge and LED luminaires supported independently of the outlet box shall be connected to the branch circuit through metal raceway, nonmetallic raceway, Type MC cable, Type AC cable, Type MI cable, nonmetallic sheathed cable, or by flexible cord as permitted in 410.62(B) or 410.62(C).

(B) Access to Boxes

Electric-discharge and LED luminaires surface mounted over concealed outlet, pull, or junction boxes and designed not to be supported solely by the outlet box shall be provided with suitable openings in the back of the luminaire to provide access to the wiring in the box.

Part IV Luminaire Supports

410.30 Supports

(A) General

Luminaires and lampholders shall be securely supported. A luminaire that weighs more than 3 kg (6 lb) or exceeds 400 mm (16 in.) in any dimension shall not be supported by the screw shell of a lampholder.

(B) Metal or Nonmetallic Poles Supporting Luminaires

Metal or nonmetallic poles shall be permitted to be used to support luminaires and as a raceway to enclose supply conductors, provided the following conditions are met:

A pole shall have a handhole not less than 50 mm × 100 mm (2 in. × 4 in.) with a cover suitable for use in wet locations to provide access to the supply terminations within the pole or pole base.

Exception No. 1: No handhole shall be required in a pole 2.5 m (8 ft) or less in height abovegrade where the supply wiring method continues without splice or pull point, and where the interior of the pole and any splices are accessible by removing the luminaire.

Exception No. 2: No handhole shall be required in a pole 6.0 m (20 ft) or less in height abovegrade that is provided with a hinged base.

Where raceway risers or cable is not installed within the pole, a threaded fitting or nipple shall be brazed, welded, or attached to the pole opposite the handhole for the supply connection.

A metal pole shall be provided with an equipment grounding terminal as follows:

A pole with a handhole shall have the equipment grounding terminal accessible from the handhole.

A pole with a hinged base shall have the equipment grounding terminal accessible within the base.

Exception to (3): No grounding terminal shall be required in a pole 2.5 m (8 ft) or less in height abovegrade where the supply wiring method continues without splice or pull, and where the interior of the pole and any splices are accessible by removing the luminaire.

A metal pole with a hinged base shall have the hinged base and pole bonded together.

Metal raceways or other equipment grounding conductors shall be bonded to the metal pole with an equipment grounding conductor recognized by 250.118 and sized in accordance with 250.122.

Conductors in vertical poles used as raceway shall be supported as provided in 300.19.

410.36 Means of Support

(A) Luminaires Supported by Outlet Boxes

Luminaires shall be permitted to be supported by outlet boxes or fittings installed as required by 314.23. The installation shall comply with the following requirements:

The outlet boxes or fittings shall comply with 314.27(A)(1) and 314.27(A)(2).

Luminaires shall be permitted to be supported in accordance with 314.27(E).

Outlet boxes complying with 314.27(E) shall be considered lighting outlets as required by 210.70(A), (B), and (C).

(B) Suspended Ceilings

Framing members of suspended ceiling systems used to support luminaires shall be securely fastened to each other and shall be securely attached to the building structure at appropriate intervals. Luminaires shall be securely fastened to the ceiling framing member by mechanical means such as bolts, screws, or rivets. Listed clips identified for use with the type of ceiling framing member(s) and luminaire(s) shall also be permitted.

(C) Luminaire Studs

Luminaire studs that are not a part of outlet boxes, hickeys, tripods, and crowfeet shall be made of steel, malleable iron, or other material suitable for the application.

(D) Insulating Joints

Insulating joints that are not designed to be mounted with screws or bolts shall have an exterior metal casing, insulated from both screw connections.

(E) Raceway Fittings

Raceway fittings used to support a luminaire(s) shall be capable of supporting the weight of the complete fixture assembly and lamp(s).

(F) Busways

Luminaires shall be permitted to be connected to busways in accordance with 368.17(C).

(G) Trees

Outdoor luminaires and associated equipment shall be permitted to be supported by trees.

Informational Note No. 1: See 225.26 for restrictions for support of overhead conductors.

Informational Note No. 2: See 300.5(D) for protection of conductors.

Part V Grounding

410.40 General

Luminaires and lighting equipment shall be connected to an equipment grounding conductor as required in Article 250 and Part V of this article.

410.42 Luminaire(s) With Exposed Conductive Parts

Exposed conductive parts that are accessible to unqualified persons shall be connected to an equipment grounding conductor or be separated from all live parts and other conducting surfaces by a listed system of double insulation.

Small isolated parts, such as mounting screws, clips, and decorative bands on glass spaced at least 38 mm (11/2 in.) from lamp terminals, shall not require connection to an equipment grounding conductor.

Portable luminaires with a polarized attachment plug shall not require connection to an equipment grounding conductor.

410.44 Methods of Grounding

Luminaires and equipment shall be mechanically connected to an equipment grounding conductor as specified in 250.118 and sized in accordance with 250.122.

Exception No. 1: Replacement luminaires shall be permitted to connect an equipment grounding conductor in the same manner as replacement receptacles in compliance with 250.130(C). The luminaire shall then comply with 410.42.

Exception No. 2: Where no equipment grounding conductor exists at the outlet, replacement luminaires that are GFCI protected or do not have exposed conductive parts shall not be required to be connected to an equipment grounding conductor.

410.46 Equipment Grounding Conductor Attachment

Luminaires with exposed metal parts shall be provided with a means for connecting an equipment grounding conductor.

Part VI Wiring of Luminaires

410.48 Luminaire Wiring — General

Wiring on or within luminaires shall be neatly arranged and shall not be exposed to physical damage. Excess wiring shall be avoided. Conductors shall be arranged so that they are not subjected to temperatures above those for which they are rated.

410.50 Polarization of Luminaires

Luminaires shall be wired so that the screw shells of lampholders are connected to the same luminaire or circuit conductor or terminal. The grounded conductor, where connected to a screw shell lampholder, shall be connected to the screw shell.

410.52 Conductor Insulation

Luminaires shall be wired with conductors having insulation suitable for the environmental conditions, current, voltage, and temperature to which the conductors will be subjected.

Informational Note: For ampacity of fixture wire, maximum operating temperature, voltage limitations, minimum wire size, and other information, see Article 402.

410.54 Pendant Conductors for Incandescent Filament Lamps

(A) Support

Pendant lampholders with permanently attached leads, where used for other than festoon wiring, shall be hung from separate stranded rubber-covered conductors that are soldered directly to the circuit conductors but supported independently thereof.

(B) Size

Unless part of listed decorative lighting assemblies, pendant conductors shall not be smaller than 14 AWG for mogul-base or medium-base screw shell lampholders or smaller than 18 AWG for intermediate or candelabra-base lampholders.

(C) Twisted or Cabled

Pendant conductors longer than 900 mm (3 ft) shall be twisted together where not cabled in a listed assembly.

410.56 Protection of Conductors and Insulation

(A) Properly Secured

Conductors shall be secured in a manner that does not tend to cut or abrade the insulation.

(B) Protection Through Metal

Conductor insulation shall be protected from abrasion where it passes through metal.

(C) Luminaire Stems

Splices and taps shall not be located within luminaire arms or stems.

(D) Splices and Taps

No unnecessary splices or taps shall be made within or on a luminaire.

Informational Note: For approved means of making connections, see 110.14.

(E) Stranding

Stranded conductors shall be used for wiring on luminaire chains and on other movable or flexible parts.

(F) Tension

Conductors shall be arranged so that the weight of the luminaire or movable parts does not put tension on the conductors.

410.59 Cord-Connected Showcases

Individual showcases, other than fixed, shall be permitted to be connected by flexible cord to permanently installed receptacles, and groups of not more than six such showcases shall be permitted to be coupled together by flexible cord and separable locking-type connectors with one of the group connected by flexible cord to a permanently installed receptacle.

The installation shall comply with 410.59(A) through (E).

(A) Cord Requirements

Flexible cord shall be of the hard-service type, having conductors not smaller than the branch-circuit conductors, having ampacity at least equal to the branch-circuit overcurrent device, and having an equipment grounding conductor.

Informational Note: See Table 250.122 for size of equipment grounding conductor.

(B) Receptacles, Connectors, and Attachment Plugs

Receptacles, connectors, and attachment plugs shall be of a listed grounding type rated 15 or 20 amperes.

(C) Support

Flexible cords shall be secured to the undersides of showcases such that all of the following conditions are ensured:

The wiring is not exposed to physical damage.

The separation between cases is not in excess of 50 mm (2 in.), or more than 300 mm (12 in.) between the first case and the supply receptacle.

The free lead at the end of a group of showcases has a female fitting not extending beyond the case.

(D) No Other Equipment

Equipment other than showcases shall not be electrically connected to showcases.

(E) Secondary Circuit(s)

Where showcases are cord-connected, the secondary circuit(s) of each electric-discharge lighting ballast shall be limited to one showcase.

410.62 Cord-Connected Lampholders and Luminaires

(A) Lampholders

Where a metal lampholder is attached to a flexible cord, the inlet shall be equipped with an insulating bushing that, if threaded, is not smaller than metric designator 12 (trade size 3/8) pipe size. The cord hole shall be of a size appropriate for the cord, and all burrs and fins shall be removed in order to provide a smooth bearing surface for the cord.

Bushing having holes 7 mm (9/32 in.) in diameter shall be permitted for use with plain pendant cord and holes 11 mm (13/32 in.) in diameter with reinforced cord.

(B) Adjustable Luminaires

Luminaires that require adjusting or aiming after installation shall not be required to be equipped with an attachment plug or cord connector, provided the exposed cord is suitable for hard-usage or extra-hard-usage and is not longer than that required for maximum adjustment. The cord shall not be subject to strain or physical damage.

Informational Note: For application provisions, see Table 400.4, "Use" column.

(C) Electric-Discharge and LED Luminaires

Electric-discharge and LED luminaires shall comply with 410.62(C)(1), (C)(2), and (C)(3), as applicable.

(1) Cord-Connected Installation

A luminaire or a listed assembly in compliance with any of the conditions in 410.62(C)(1)(a) through (C)(1)(c) shall be permitted to be cord connected provided the luminaire is located directly below the outlet or busway, the cord is not subject to strain or physical damage, and the cord is visible over its entire length except at terminations.

(a) A luminaire shall be permitted to be connected with a cord terminating in a grounding-type attachment plug or busway plug. If grounding is not required in accordance with 410.42, a polarized-type plug shall be permitted.

(b) A luminaire assembly equipped with a strain relief and canopy shall be permitted to use a cord connection between the luminaire assembly and the canopy. The canopy shall be permitted to include a section of raceway not over 150 mm (6 in.) in length and intended to facilitate the connection to an outlet box mounted above a suspended ceiling.

(c) Listed luminaires connected using listed assemblies that incorporate manufactured wiring system connectors in accordance with 604.100(C) shall be permitted to be cord connected.

(2) Provided With Mogul-Base, Screw Shell Lampholders

Electric-discharge luminaires provided with mogul-base, screw shell lampholders shall be permitted to be connected to branch circuits of 50 amperes or less by cords complying with 240.5. Receptacles and attachment plugs shall be permitted to be of a lower ampere rating than the branch circuit but not less than 125 percent of the luminaire full-load current.

(3) Equipped With Flanged Surface Inlet

Electric-discharge luminaires equipped with a flanged surface inlet shall be permitted to be supplied by cord pendants equipped with cord connectors. Inlets and connectors shall be permitted to be of a lower ampere rating than the branch circuit but not less than 125 percent of the luminaire load current.

410.64 Luminaires as Raceways

Luminaires shall not be used as a raceway for circuit conductors unless they comply with 410.64(A), (B), or (C).

(A) Listed

Luminaires listed and marked for use as a raceway shall be permitted to be used as a raceway.

(B) Through-Wiring

Luminaires identified for through-wiring, as permitted by 410.21, shall be permitted to be used as a raceway.

(C) Luminaires Connected Together

Luminaires designed for end-to-end connection to form a continuous assembly, or luminaires connected together by recognized wiring methods, shall be permitted to contain the conductors of a 2-wire branch circuit, or one multiwire branch circuit, supplying the connected luminaires and shall not be required to be listed as a raceway. One additional 2-wire branch circuit separately supplying one or more of the connected luminaires shall also be permitted.

Informational Note: See Article 100 for the definition of Multiwire Branch Circuit.

410.68 Feeder and Branch-Circuit Conductors and Ballasts

Feeder and branch-circuit conductors within 75 mm (3 in.) of a ballast, LED driver, power supply, or transformer shall have an insulation temperature rating not lower than 90°C (194°F), unless supplying a luminaire marked as suitable for a different insulation temperature.

410.69 Identification of Control Conductor Insulation

Where control conductors are spliced, terminated, or connected in the same luminaire or enclosure as the branch-circuit conductors, the field-connected control conductor shall not be of a color reserved for the grounded branch-circuit conductor or the equipment grounding conductor. This requirement shall become effective January 1, 2022.

Informational Note: See 200.6 for identification of grounded conductor and 250.119 for identification of equipment grounding conductor.

Exception: A field-connected gray-colored control conductor shall be permitted if the insulation is permanently re-identified by marking tape, painting, or other effective means at its termination and at each location where the conductor is visible and accessible. Identification shall encircle the insulation and shall be a color other than white, gray, or green.

410.70 Combustible Shades and Enclosures

Air space shall be provided between lamps and shades or other enclosures of combustible material.

Part VII Construction of Luminaires

410.74 Luminaire Rating

(A) Marking

All luminaires shall be marked with the maximum lamp wattage or electrical rating, manufacturer's name, trademark, or other suitable means of identification. A luminaire requiring supply wire rated higher than 60°C (140°F) shall be marked with the minimum supply wire temperature rating on the luminaire and shipping carton or equivalent.

(B) Electrical Rating

The electrical rating shall include the voltage and frequency and shall indicate the current rating of the unit, including the ballast, transformer, LED driver, power supply, or autotransformer.

410.82 Portable Luminaires

Portable luminaires shall be wired with flexible cord recognized by 400.4 and an attachment plug of the polarized or grounding type. If used with Edison-base lampholders, the grounded conductor shall be identified and attached to the screw shell and the identified blade of the attachment plug.

410.84 Cord Bushings

A bushing or the equivalent shall be provided where flexible cord enters the base or stem of a portable luminaire. The bushing shall be of insulating material unless a jacketed type of cord is used.

Part VIII Installation of Lampholders

410.90 Screw Shell Type

Lampholders of the screw shell type shall be installed for use as lampholders only. Where supplied by a circuit having a grounded conductor, the grounded conductor shall be connected to the screw shell.

410.93 Double-Pole Switched Lampholders

Where supplied by the ungrounded conductors of a circuit, the switching device of lampholders of the switched type shall simultaneously disconnect both conductors of the circuit.

410.96 Lampholders in Wet or Damp Locations

Lampholders installed in wet locations shall be listed for use in wet locations. Lampholders installed in damp locations shall be listed for damp locations or shall be listed for wet locations.

410.97 Lampholders Near Combustible Material

Lampholders shall be constructed, installed, or equipped with shades or guards so that combustible material is not subjected to temperatures in excess of 90°C (194°F).

Part IX Lamps and Auxiliary Equipment

410.103 Bases, Incandescent Lamps

An incandescent lamp for general use on lighting branch circuits shall not be equipped with a medium base if rated over 300 watts, or with a mogul base if rated over 1500 watts. Special bases or other devices shall be used for over 1500 watts.

410.104 Electric-Discharge Lamp Auxiliary Equipment

(A) Enclosures

Auxiliary equipment for electric-discharge lamps shall be enclosed in noncombustible cases and treated as sources of heat.

(B) Switching

Where supplied by the ungrounded conductors of a circuit, the switching device of auxiliary equipment shall simultaneously disconnect all conductors.

Part X Special Provisions for Flush and Recessed Luminaires

410.110 General

Diagram

Luminaires installed in recessed cavities in walls or ceilings, including suspended ceilings, shall comply with 410.115 through 410.122.

UpCodes Diagrams

P

Air Barriers: Commercial

410.115 Temperature

(A) Combustible Material

Luminaires shall be installed so that adjacent combustible material will not be subjected to temperatures in excess of 90°C (194°F).

(B) Recessed Incandescent Luminaires

Incandescent luminaires shall have thermal protection and shall be identified as thermally protected.

Exception No. 1: Thermal protection shall not be required in a recessed luminaire identified for use and installed in poured concrete.

Exception No. 2: Thermal protection shall not be required in a recessed luminaire whose design, construction, and thermal performance characteristics are equivalent to a thermally protected luminaire and are identified as inherently protected.

410.116 Clearance and Installation

(A) Clearance

(1) Non-Type IC

A recessed luminaire that is not identified for contact with insulation shall have all recessed parts spaced not less than 13 mm (1/2 in.) from combustible materials. The points of support and the trim finishing off the openings in the ceiling, wall, or other finished surface shall be permitted to be in contact with combustible materials.

(2) Type IC

A recessed luminaire that is identified for contact with insulation, Type IC, shall be permitted to be in contact with combustible materials at recessed parts, points of support, and portions passing through or finishing off the opening in the building structure.

(B) Installation

Thermal insulation shall not be installed above a recessed luminaire or within 75 mm (3 in.) of the recessed luminaire's enclosure, wiring compartment, ballast, transformer, LED driver, or power supply unless the luminaire is identified as Type IC for insulation contact.

(C) Installation in Fire-Resistant Construction

Luminaires marked "FOR USE IN NON-FIRE-RATED INSTALLATIONS" shall not be used in fire-rated installations. Where a luminaire is recessed in fire-resistant material in a building of fire-resistant construction, the recessed luminaire shall satisfy one of the following:

The recessed luminaire shall be listed for use in a fire resistance-rated construction.

The recessed luminaire shall be installed in or used with a luminaire enclosure that is listed for use in a fire resistance-rated construction.

The recessed luminaire shall be listed and shall be installed in accordance with a tested fire resistance-rated assembly. When a tested fire resistance-rated assembly allows the installation of a recessed fluorescent luminaire, a recessed LED luminaire of comparable construction shall be permitted.

410.117 Wiring

(A) General

Conductors that have insulation suitable for the temperature encountered shall be used.

(B) Circuit Conductors

Branch-circuit conductors that have an insulation suitable for the temperature encountered shall be permitted to terminate in the luminaire.

(C) Tap Conductors

Tap conductors of a type suitable for the temperature encountered shall be permitted to run from the luminaire terminal connection to an outlet box placed at least 300 mm (1 ft) from the luminaire. Such tap conductors shall be in suitable raceway or Type AC or MC cable of at least 450 mm (18 in.) but not more than 1.8 m (6 ft) in length.

410.118 Access to Other Boxes

Luminaires recessed in ceilings, floors, or walls shall not be used to access outlet, pull, or junction boxes or conduit bodies, unless the box or conduit body is an integral part of the listed luminaire.

Part XI Construction of Flush and Recessed Luminaires

410.119 Temperature

Luminaires shall be constructed such that adjacent combustible material is not subject to temperatures in excess of 90°C (194°F).

410.120 Lamp Wattage Marking

Incandescent lamp luminaires shall be marked to indicate the maximum allowable wattage of lamps. The markings shall be permanently installed, in letters at least 6 mm (1/4 in.) high, and shall be located where visible during relamping.

410.121 Solder Prohibited

No solder shall be used in the construction of a luminaire recessed housing.

410.122 Lampholders

Lampholders of the screw shell type shall be of porcelain or other suitable insulating materials.

Part XII Special Provisions for Electric-Discharge Lighting Systems of 1000 Volts or Less

410.130 General

(A) Open-Circuit Voltage of 1000 Volts or Less

Equipment for use with electric-discharge lighting systems and designed for an open-circuit voltage of 1000 volts or less shall be of a type identified for such service.

(B) Considered as Energized

The terminals of an electric-discharge lamp shall be considered as energized where any lamp terminal is connected to a circuit of over 300 volts.

(C) Transformers of the Oil-Filled Type

Transformers of the oil-filled type shall not be used.

(D) Additional Requirements

In addition to complying with the general requirements for luminaires, such equipment shall comply with Part XII of this article.

(E) Thermal Protection — Fluorescent Luminaires

(1) Integral Thermal Protection

The ballast of a fluorescent luminaire installed indoors shall have integral thermal protection. Replacement ballasts shall also have thermal protection integral with the ballast.

(2) Simple Reactance Ballasts

A simple reactance ballast in a fluorescent luminaire with straight tubular lamps shall not be required to be thermally protected.

(3) Exit Luminaires

A ballast in a fluorescent exit luminaire shall not have thermal protection.

(4) Egress Luminaires

A ballast in a fluorescent luminaire that is used for egress lighting and energized only during a failure of the normal supply shall not have thermal protection.

(F) High-Intensity Discharge Luminaires

(1) Recessed

Recessed high-intensity luminaires designed to be installed in wall or ceiling cavities shall have thermal protection and be identified as thermally protected.

(2) Inherently Protected

Thermal protection shall not be required in a recessed high-intensity luminaire whose design, construction, and thermal performance characteristics are equivalent to a thermally protected luminaire and are identified as inherently protected.

(3) Installed in Poured Concrete

Thermal protection shall not be required in a recessed high-intensity discharge luminaire identified for use and installed in poured concrete.

(4) Recessed Remote Ballasts

A recessed remote ballast for a high-intensity discharge luminaire shall have thermal protection that is integral with the ballast and shall be identified as thermally protected.

(5) Metal Halide Lamp Containment

Luminaires that use a metal halide lamp other than a thick-glass parabolic reflector lamp (PAR) shall be provided with a containment barrier that encloses the lamp, or shall be provided with a physical means that only allows the use of a lamp that is Type O.

Informational Note: See ANSI Standard C78.389, American National Standard for Electric Lamps — High Intensity Discharge, Methods of Measuring Characteristics.

(G) Disconnecting Means

(1) General

In indoor locations other than dwellings and associated accessory structures, fluorescent luminaires that utilize double-ended lamps and contain ballast(s) that can be serviced in place shall have a disconnecting means either internal or external to each luminaire. For existing installed luminaires without disconnecting means, at the time a ballast is replaced, a disconnecting means shall be installed. The line side terminals of the disconnecting means shall be guarded.

Exception No. 1: A disconnecting means shall not be required for luminaires installed in hazardous (classified) location(s).

Exception No. 2: A disconnecting means shall not be required for luminaires that provide emergency illumination required in 700.16.

Exception No. 3: For cord-and-plug-connected luminaires, an accessible separable connector or an accessible plug and receptacle shall be permitted to serve as the disconnecting means.

Exception No. 4: Where more than one luminaire is installed and supplied by other than a multiwire branch circuit, a disconnecting means shall not be required for every luminaire when the design of the installation includes disconnecting means, such that the illuminated space cannot be left in total darkness.

(2) Multiwire Branch Circuits

When connected to multiwire branch circuits, the disconnecting means shall simultaneously break all the supply conductors to the ballast, including the grounded conductor.

(3) Location

The disconnecting means shall be located so as to be accessible to qualified persons before servicing or maintaining the ballast. Where the disconnecting means is external to the luminaire, it shall be a single device, and shall be attached to the luminaire or the luminaire shall be located within sight of the disconnecting means.

410.134 Direct-Current Equipment

Luminaires installed on dc circuits shall be equipped with auxiliary equipment and resistors designed for dc operation. The luminaires shall be marked for dc operation.

410.135 Open-Circuit Voltage Exceeding 300 Volts

Equipment having an open-circuit voltage exceeding 300 volts shall not be installed in dwelling occupancies unless such equipment is designed so that there will be no exposed live parts when lamps are being inserted, are in place, or are being removed.

410.136 Luminaire Mounting

(A) Exposed Components

Luminaires that have exposed ballasts, transformers, LED drivers, or power supplies shall be installed such that ballasts, transformers, LED drivers, or power supplies shall not be in contact with combustible material unless listed for such condition.

(B) Combustible Low-Density Cellulose Fiberboard

Where a surface-mounted luminaire containing a ballast, transformer, LED driver, or power supply is to be installed on combustible low-density cellulose fiberboard, it shall be marked for this condition or shall be spaced not less than 38 mm (11/2 in.) from the surface of the fiberboard. Where such luminaires are partially or wholly recessed, the provisions of 410.110 through 410.122 shall apply.

Informational Note: Combustible low-density cellulose fiberboard includes sheets, panels, and tiles that have a density of 320 kg/m3 (20 lb/ft3) or less and that are formed of bonded plant fiber material but does not include solid or laminated wood or fiberboard that has a density in excess of 320 kg/m3 (20 lb/ft3) or is a material that has been integrally treated with fire-retarding chemicals to the degree that the flame spread index in any plane of the material will not exceed 25, determined in accordance with tests for surface burning characteristics of building materials. See ASTM E84-18a, Standard Test Method for Surface Burning Characteristics of Building Materials, or ANSI/UL 723-2018, Standard for Test for Surface Burning Characteristics of Building Materials.

410.137 Equipment Not Integral With Luminaire

(A) Metal Cabinets

Auxiliary equipment, including reactors, capacitors, resistors, and similar equipment, where not installed as part of a luminaire assembly, shall be enclosed in accessible, permanently installed metal cabinets.

(B) Separate Mounting

Separately mounted ballasts, transformers, LED drivers, or power supplies that are listed for direct connection to a wiring system shall not be required to be additionally enclosed.

(C) Wired Luminaire Sections

Wired luminaire sections are paired, with a ballast(s) or LED driver(s) supplying a light source or light sources in both. For interconnection between paired units, it shall be permissible to use metric designator 12 (trade size 3/8) flexible metal conduit in lengths not exceeding 7.5 m (25 ft), in conformance with Article 348. Luminaire wire operating at line voltage, supplying only the ballast(s) or LED driver(s) of one of the paired luminaires, shall be permitted in the same raceway as the light source supply wires of the paired luminaires where the voltage rating of the light source supply wires is greater than the line voltage.

410.138 Autotransformers

An autotransformer that is used to raise the voltage to more than 300 volts, as part of a ballast for supplying lighting units, shall be supplied only by a grounded system.

410.139 Switches

Snap switches shall comply with 404.14.

Part XIII Special Provisions for Electric-Discharge Lighting Systems of More Than 1000 Volts

410.140 General

(A) Listing

Electric-discharge lighting systems with an open-circuit voltage exceeding 1000 volts shall be listed and installed in conformance with that listing.

(B) Dwelling Occupancies

Equipment that has an open-circuit voltage exceeding 1000 volts shall not be installed in or on dwelling occupancies.

(C) Live Parts

The terminal of an electric-discharge lamp shall be considered as a live part.

(D) Additional Requirements

In addition to complying with the general requirements for luminaires, such equipment shall comply with Part XIII of this article.

Informational Note: For signs and outline lighting, see Article 600.

410.141 Control

(A) Disconnection

Luminaires or lamp installation shall be controlled either singly or in groups by an externally operable switch or circuit breaker that opens all ungrounded primary conductors.

(B) Within Sight or Locked Type

The switch or circuit breaker shall be located within sight from the luminaires or lamps, or it shall be permitted to be located elsewhere if it is lockable open in accordance with 110.25.

410.142 Lamp Terminals and Lampholders

Parts that must be removed for lamp replacement shall be hinged or held captive. Lamps or lampholders shall be designed so that there are no exposed live parts when lamps are being inserted or removed.

410.143 Transformers

(A) Type

Transformers shall be enclosed, identified for the use, and listed.

(B) Voltage

The secondary circuit voltage shall not exceed 15,000 volts, nominal, under any load condition. The voltage to ground of any output terminals of the secondary circuit shall not exceed 7500 volts under any load conditions.

(C) Rating

Transformers shall have a secondary short-circuit current rating of not more than 150 mA if the open-circuit voltage is over 7500 volts, and not more than 300 mA if the open-circuit voltage rating is 7500 volts or less.

(D) Secondary Connections

Secondary circuit outputs shall not be connected in parallel or in series.

410.144 Transformer Locations

(A) Accessible

Transformers shall be accessible after installation.

(B) Secondary Conductors

Transformers shall be installed as near to the lamps as practicable to keep the secondary conductors as short as possible.

(C) Adjacent to Combustible Materials

Transformers shall be located so that adjacent combustible materials are not subjected to temperatures in excess of 90°C (194°F).

410.145 Exposure to Damage

Lamps shall not be located where normally exposed to physical damage.

410.146 Marking

Each luminaire or each secondary circuit of tubing having an open-circuit voltage of over 1000 volts shall have a clearly legible marking in letters not less than 6 mm (1/4 in.) high reading "Caution \_\_\_\_ volts." The voltage indicated shall be the rated open-circuit voltage. The caution sign(s) or label(s) shall comply with 110.21(B).

Part XIV Lighting Track

410.151 Installation

(A) Lighting Track

Lighting track shall be permanently installed and permanently connected to a branch circuit. Only lighting track fittings shall be installed on lighting track. Lighting track fittings shall not be equipped with general-purpose receptacles.

(B) Connected Load

The connected load on lighting track shall not exceed the rating of the track. Lighting track shall be supplied by a branch circuit having a rating not more than that of the track. The load calculation in 220.43(B) shall not be required to limit the length of track on a single branch circuit, and it shall not be required to limit the number of luminaires on a single track.

(C) Locations Not Permitted

Lighting track shall not be installed in the following locations:

Where likely to be subjected to physical damage

In wet or damp locations

Where subject to corrosive vapors

In storage battery rooms

In hazardous (classified) locations

Where concealed

Where extended through walls or partitions

Less than 1.5 m (5 ft) above the finished floor except where protected from physical damage or track operating at less than 30 volts rms open-circuit voltage

Where prohibited by 410.10(D)

(D) Support

Fittings identified for use on lighting track shall be designed specifically for the track on which they are to be installed. They shall be securely fastened to the track, shall maintain polarization and connections to the equipment grounding conductor, and shall be designed to be suspended directly from the track.

410.153 Heavy-Duty Lighting Track

Heavy-duty lighting track is lighting track identified for use exceeding 20 amperes. Each fitting attached to a heavy-duty lighting track shall have individual overcurrent protection.

410.154 Fastening

Lighting track shall be securely mounted so that each fastening is suitable for supporting the maximum weight of luminaires that can be installed. Unless identified for supports at greater intervals, a single section 1.2 m (4 ft) or shorter in length shall have two supports, and, where installed in a continuous row, each individual section of not more than 1.2 m (4 ft) in length shall have one additional support.

410.155 Construction Requirements

(A) Construction

The housing for the lighting track system shall be of substantial construction to maintain rigidity. The conductors shall be installed within the track housing, permitting insertion of a luminaire, and designed to prevent tampering and accidental contact with live parts. Components of lighting track systems of different voltages shall not be interchangeable. The track conductors shall be a minimum 12 AWG or equal and shall be copper. The track system ends shall be insulated and capped.

(B) Grounding

Lighting track shall be grounded in accordance with Article 250, and the track sections shall be securely coupled to maintain continuity of the circuitry, polarization, and grounding throughout.

Part XV Decorative Lighting and Similar Accessories

410.160 Listing of Decorative Lighting

Decorative lighting and similar accessories used for holiday lighting and similar purposes, in accordance with 590.3(B), shall be listed.

Part XVI Special Provisions for Horticultural Lighting Equipment

410.170 General

Luminaires complying with Parts, I, II, III, IV, V, VI, VII, IX, X, XI, and XII of this article shall be permitted to be used for horticultural lighting. Part XVI shall additionally apply to lighting equipment specifically identified for horticultural use.

Informational Note: Lighting equipment identified for horticultural use is designed to provide a spectral characteristic needed for the growth of plants and can also provide supplemental general illumination within the growing environment.

410.172 Listing

Lighting equipment identified for horticultural use shall be listed.

410.174 Installation and Use

Lighting equipment identified for horticultural use shall be installed and used in accordance with the manufacturer's installation instructions and installation markings on the equipment as required by that listing.

410.176 Locations Not Permitted

(A) General Lighting

Lighting equipment identified for horticultural use shall not be installed as lighting for general illumination unless such use is indicated in the manufacturer's instructions.

(B) Installed Location

Lighting equipment identified for horticultural use shall not be installed where it is likely to be subject to physical damage or where concealed.

410.178 Flexible Cord

Flexible cord shall only be permitted when provided as part of listed lighting equipment identified for horticultural use for any of the following uses:

Connecting a horticultural lighting luminaire directly to a branch circuit outlet

Interconnecting horticultural lighting luminaires

Connecting a horticultural lighting luminaire to a remote power source

Informational Note: Remote power sources include LED drivers, fluorescent ballasts, or HID ballasts.

410.180 Fittings and Connectors

Fittings and connectors attached to flexible cords shall be provided as part of a listed horticultural lighting equipment device or system and installed in accordance with the instructions provided as part of that listing.

410.182 Grounding

Lighting equipment identified for horticultural use shall be grounded as required in Article 250 and Part V of this article.

410.184 Ground-Fault Circuit-Interrupter Protection

Lighting equipment identified for horticultural use employing flexible cord(s) with one or more conductors shall be supplied by lighting outlets protected by a listed ground-fault circuit interrupter.

410.186 Support

Special fittings identified for support of horticultural lighting equipment shall be designed specifically for the horticultural lighting equipment on which they are installed and shall be used in accordance with the installation instructions provided and shall be securely fastened.

410.188 Hazardous (Classified) Locations

Where installed in hazardous (classified) locations, horticultural lighting equipment shall conform to Articles 500 through 517 in addition to this article.

Article 411 Low-Voltage Lighting

411.1 Scope

This article covers lighting systems and their associated components operating at no more than 30 volts ac or 60 volts dc. Where wet contact is likely to occur, the limits are 15 volts ac or 30 volts dc.

Informational Note: Refer to Article 680 for applications involving immersion.

411.3 Low-Voltage Lighting Systems

Low voltage lighting systems shall consist of an isolating power supply, low-voltage luminaires, and associated equipment that are all identified for the use. The output circuits of the power supply shall be rated for 25 amperes maximum under all load conditions.

411.4 Listing Required

Low-voltage lighting systems shall comply with 411.4(A) or (B). Listed low-voltage lighting systems or a lighting system assembled from listed parts shall not be permitted to be reconditioned.

(A) Listed System

The luminaires, power supply, and luminaire fittings (including the exposed bare conductors) of an exposed bare conductor lighting system shall be listed for the use as part of the same identified lighting system.

(B) Assembly of Listed Parts

A lighting system assembled from the following listed parts shall be permitted:

Low-voltage luminaires identified for the use

Power supply identified for the use

Low-voltage luminaire fittings identified for the use

Suitably rated cord, cable, conductors in conduit, or other fixed Chapter 3 wiring method for the secondary circuit

411.5 Specific Location Requirements

(A) Walls, Floors, and Ceilings

Conductors concealed or extended through a wall, floor, or ceiling shall be in accordance with (1) or (2):

Installed using any of the wiring methods specified in Chapter 3

Installed using wiring supplied by a listed Class 2 power source and installed in accordance with 725.130

(B) Pools, Spas, Fountains, and Similar Locations

Lighting systems shall be installed not less than 3 m (10 ft) horizontally from the nearest edge of the water, unless permitted by Article 680.

411.6 Secondary Circuits

(A) Grounding

Secondary circuits shall not be grounded.

(B) Isolation

The secondary circuit shall be insulated from the branch circuit by an isolating transformer.

(C) Bare Conductors

Exposed bare conductors and current-carrying parts shall be permitted for indoor installations only. Bare conductors shall not be installed less than 2.1 m (7 ft) above the finished floor, unless specifically listed for a lower installation height.

411.7 Branch Circuit

Lighting systems covered by this article shall be supplied from a maximum 20-ampere branch circuit.

411.8 Hazardous (Classified) Locations

Where installed in hazardous (classified) locations, these systems shall conform with Articles 500 through 517 in addition to this article.

Article 422 Appliances

Part I General

422.1 Scope

This article covers electrical appliances used in any occupancy.

422.3 Other Articles

The requirements of Article 430 shall apply to the installation of motor-operated appliances, and the requirements of Article 440 shall apply to the installation of appliances containing a hermetic refrigerant motor-compressor(s), except as specifically amended in this article.

422.4 Live Parts

Appliances shall have no live parts normally exposed to contact other than those parts functioning as open-resistance heating elements, such as the heating element of a toaster, which are necessarily exposed.

422.5 Ground-Fault Circuit-Interrupter (GFCI) Protection for Personnel

(A) General

Appliances identified in 422.5(A)(1) through (A)(7) rated 150 volts or less to ground and 60 amperes or less, single-or 3-phase, shall be provided with Class A GFCI protection for personnel. Multiple Class A GFCI protective devices shall be permitted but shall not be required.

Automotive vacuum machines

Drinking water coolers and bottle fill stations

Cord-and-plug-connected high-pressure spray washing machines

Tire inflation machines

Vending machines

Sump pumps

Dishwashers

Informational Note: Section 210.8 specifies requirements for GFCI protection for the branch-circuit outlet where the covered location warrants such protection.

(B) Type and Location

The GFCI shall be readily accessible, listed, and located in one or more of the following locations:

Within the branch-circuit overcurrent device

A device or outlet within the supply circuit

An integral part of the attachment plug

Within the supply cord not more than 300 mm (12 in.) from the attachment plug

Factory installed within the appliance

422.6 Listing Required

All appliances supplied by 50 volts or higher shall be listed.

Part II Installation

422.10 Branch Circuits

This section specifies the requirements for branch circuits capable of carrying appliance current without overheating under the conditions specified.

(A) Individual Branch Circuits

The ampacities of branch-circuit conductors shall not be less than the marked rating of the appliance or the marked rating of an appliance having combined loads.

The ampacities of branch-circuit conductors for motor-operated appliances not having a marked rating shall be in accordance with Part II of Article 430.

The branch-circuit rating for an appliance that is a continuous load, other than a motor-operated appliance, shall not be less than 125 percent of the marked rating, or not less than 100 percent of the marked rating if the branch-circuit device and its assembly are listed for continuous loading at 100 percent of its rating.

Branch circuits and branch-circuit conductors for household ranges and cooking appliances shall be permitted to be in accordance with Table 220.55 and shall be sized in accordance with 210.19(A)(3).

(B) Branch Circuits Supplying Two or More Loads

For branch circuits supplying appliance and other loads, the rating shall be determined in accordance with 210.23.

422.11 Overcurrent Protection

Appliances shall be protected against overcurrent in accordance with 422.11(A) through (G) and 422.10.

(A) Branch-Circuit Overcurrent Protection

Branch circuits shall be protected in accordance with 240.4.

If a protective device rating is marked on an appliance, the branch-circuit overcurrent device rating shall not exceed the protective device rating marked on the appliance.

(B) Household-Type Appliances With Surface Heating Elements

Household-type appliances with surface heating elements having a maximum demand of more than 60 amperes calculated in accordance with Table 220.55 shall have their power supply subdivided into two or more circuits, each of which shall be provided with overcurrent protection rated at not over 50 amperes.

(C) Infrared Lamp Commercial and Industrial Heating Appliances

Infrared lamp commercial and industrial heating appliances shall have overcurrent protection not exceeding 50 amperes.

(D) Open-Coil or Exposed Sheathed-Coil Types of Surface Heating Elements in Commercial-Type Heating Appliances

Open-coil or exposed sheathed-coil types of surface heating elements in commercial-type heating appliances shall be protected by overcurrent protective devices rated at not over 50 amperes.

(E) Single Non—Motor-Operated Appliance

If the branch circuit supplies a single non—motor-operated appliance, the rating of overcurrent protection shall comply with the following:

Not exceed that marked on the appliance.

Not exceed 20 amperes if the overcurrent protection rating is not marked and the appliance is rated 13.3 amperes or less; or

Not exceed 150 percent of the appliance rated current if the overcurrent protection rating is not marked and the appliance is rated over 13.3 amperes. Where 150 percent of the appliance rating does not correspond to a standard overcurrent device ampere rating, the next higher standard rating shall be permitted.

(F) Electric Heating Appliances Employing Resistance-Type Heating Elements Rated More Than 48 Amperes

(1) Electric Heating Appliances

Electric heating appliances employing resistance-type heating elements rated more than 48 amperes, other than household appliances with surface heating elements covered by 422.11(B), and commercial-type heating appliances covered by 422.11(D), shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes, and each subdivided load shall be protected at not more than 60 amperes.

These supplementary overcurrent protective devices shall be (1) factory-installed within or on the heater enclosure or provided as a separate assembly by the heater manufacturer; (2) accessible; and (3) suitable for branch-circuit protection.

The main conductors supplying these overcurrent protective devices shall be considered branch-circuit conductors.

(2) Commercial Kitchen and Cooking Appliances

Commercial kitchen and cooking appliances using sheathed-type heating elements not covered in 422.11(D) shall be permitted to be subdivided into circuits not exceeding 120 amperes and protected at not more than 150 amperes where one of the following is met:

Elements are integral with and enclosed within a cooking surface.

Elements are completely contained within an enclosure identified as suitable for this use.

Elements are contained within an ASME-rated and stamped vessel.

(3) Water Heaters and Steam Boilers

Resistance-type immersion electric heating elements shall be permitted to be subdivided into circuits not exceeding 120 amperes and protected at not more than 150 amperes as follows:

Where contained in ASME-rated and stamped vessels

Where included in listed instantaneous water heaters

Where installed in low-pressure water heater tanks or open-outlet water heater vessels

Informational Note: Low-pressure and open-outlet heaters are atmospheric pressure water heaters as defined in IEC 60335-2-21, Household and similar electrical appliances — Safety — Particular requirements for storage water heaters.

(G) Motor-Operated Appliances

Motors of motor-operated appliances shall be provided with overload protection in accordance with Part III of Article 430. Hermetic refrigerant motor-compressors in air-conditioning or refrigerating equipment shall be provided with overload protection in accordance with Part VI of Article 440. Where appliance overcurrent protective devices that are separate from the appliance are required, data for selection of these devices shall be marked on the appliance. The minimum marking shall be that specified in 430.7 and 440.4.

422.12 Central Heating Equipment

Central heating equipment other than fixed electric space-heating equipment shall be supplied by an individual branch circuit.

Exception No. 1: Auxiliary equipment, such as a pump, valve, humidifier, or electrostatic air cleaner directly associated with the heating equipment, shall be permitted to be connected to the same branch circuit.

Exception No. 2: Permanently connected air-conditioning equipment shall be permitted to be connected to the same branch circuit.

422.13 Storage-Type Water Heaters

The branch-circuit overcurrent device and conductors for fixed storage-type water heaters that have a capacity of 450 L (120 gal) or less shall be sized not smaller than 125 percent of the rating of the water heater.

Informational Note: For branch-circuit rating, see 422.10.

422.15 Central Vacuum Outlet Assemblies

(A)

Listed central vacuum outlet assemblies shall be permitted to be connected to a branch circuit in accordance with 210.23(A).

(B)

The ampacity of the connecting conductors shall not be less than the ampacity of the branch circuit conductors to which they are connected.

(C)

Accessible non—current-carrying metal parts of the central vacuum outlet assembly likely to become energized shall be connected to an equipment grounding conductor in accordance with 250.110. Incidental metal parts such as screws or rivets installed into or on insulating material shall not be considered likely to become energized.

422.16 Flexible Cords

(A) General

Flexible cord shall be permitted as follows:

To connect appliances to facilitate their frequent interchange or to prevent the transmission of noise or vibration or

To facilitate the removal or disconnection of appliances that are fastened in place, where the fastening means and mechanical connections are specifically designed to permit ready removal for maintenance or repair and the appliance is intended or identified for flexible cord connection.

(B) Specific Appliances

(1) Electrically Operated In-Sink Waste Disposers

Electrically operated in-sink waste disposers shall be permitted to be cord-and-plug-connected with a flexible cord identified as suitable in the installation instructions of the appliance manufacturer where all of the following conditions are met:

The length of the cord shall not be less than 450 mm (18 in.) and not over 900 mm (36 in.).

Receptacles shall be located to protect against physical damage to the flexible cord.

The receptacle shall be accessible.

The flexible cord shall have an equipment grounding conductor and be terminated with a grounding-type attachment plug.

Exception: A listed appliance distinctly marked to identify it as protected by a system of double insulation shall not be required to be terminated with a grounding-type attachment plug.

(2) Built-in Dishwashers and Trash Compactors

Built-in dishwashers and trash compactors shall be permitted to be cord-and-plug-connected with a flexible cord identified as suitable for the purpose in the installation instructions of the appliance manufacturer where all of the following conditions are met:

For a trash compactor, the length of the cord shall be 0.9 m to 1.2 m (3 ft to 4 ft) measured from the face of the attachment plug to the plane of the rear of the appliance.

For a built-in dishwasher, the length of the cord shall be 0.9 m to 2.0 m (3 ft to 6.5 ft) measured from the face of the attachment plug to the plane of the rear of the appliance.

Receptacles shall be located to protect against physical damage to the flexible cord.

The receptacle for a trash compactor shall be located in the space occupied by the appliance or adjacent thereto.

The receptacle for a built-in dishwasher shall be located in the space adjacent to the space occupied by the dishwasher. Where the flexible cord passes through an opening, it shall be protected against damage by a bushing, grommet, or other approved means.

The receptacle shall be accessible.

The flexible cord shall have an equipment grounding conductor and be terminated with a grounding-type attachment plug.

Exception: A listed appliance distinctly marked to identify it as protected by a system of double insulation shall not be required to be terminated with a grounding-type attachment plug.

(3) Wall-Mounted Ovens and Counter-Mounted Cooking Units

Wall-mounted ovens and counter-mounted cooking units complete with provisions for mounting and for making electrical connections shall be permitted to be permanently connected or cord-and-plug-connected with a flexible cord identified as suitable for the purpose in the installation instructions of the appliance manufacturer.

A separable connector or a plug and receptacle combination in the supply line to an oven or cooking unit shall be identified for the temperature of the space in which it is located.

(4) Range Hoods and Microwave Oven/Range Hood Combinations

Range hoods and over-the-range microwave ovens with integral range hoods shall be permitted to be cord-and-plug-connected with a flexible cord identified as suitable for use on range hoods in the installation instructions of the appliance manufacturer, where all of the following conditions are met:

The length of the cord is not less than 450 mm (18 in.) and not over 1.2 m (4 ft).

Receptacles are located to protect against physical damage to the flexible cord.

The receptacle is supplied by an individual branch circuit.

The receptacle shall be accessible.

The flexible cord shall have an equipment grounding conductor and be terminated with a grounding-type attachment plug.

Exception: A listed appliance distinctly marked to identify it as protected by a system of double insulation shall not be required to be terminated with a grounding-type attachment plug.

422.17 Protection of Combustible Material

Each electrically heated appliance that is intended by size, weight, and service to be located in a fixed position shall be placed so as to provide protection between the appliance and adjacent combustible material.

422.18 Support of Ceiling-Suspended (Paddle) Fans

Ceiling-suspended (paddle) fans shall be supported independently of an outlet box or by one of the following:

A listed outlet box or listed outlet box system identified for the use and installed in accordance with 314.27(C)

A listed outlet box system, a listed locking support and mounting receptacle, and a compatible factory installed attachment fitting designed for support, identified for the use and installed in accordance with 314.27(E)

422.19 Space for Conductors

The combined volume of the canopy of ceiling-suspended (paddle) fans and outlet box shall provide sufficient space so that conductors and their connecting devices are capable of being installed in accordance with 314.16.

422.20 Outlet Boxes to Be Covered

In a completed installation, each outlet box shall be provided with a cover unless covered by means of a ceiling-suspended (paddle) fan canopy.

422.21 Covering of Combustible Material at Outlet Boxes

Any combustible ceiling finish that is exposed between the edge of a ceiling-suspended (paddle) fan canopy or pan and an outlet box and that has a surface area of 1160 mm2 (180 in.2) or more shall be covered with noncombustible material.

422.22 Utilizing Separable Attachment Fittings

Appliances shall be permitted to utilize listed locking support and mounting receptacles in combination with compatible attachment fittings utilized within their ratings and used in accordance with 314.27(E).

422.23 Other Installation Methods

Appliances employing methods of installation other than covered by this article shall be permitted to be used only by special permission.

Part III Disconnecting Means

422.30 General

A means shall be provided to simultaneously disconnect each appliance from all ungrounded conductors in accordance with the following sections of Part III. If an appliance is supplied by more than one branch circuit or feeder, these disconnecting means shall be grouped and identified as being the multiple disconnecting means for the appliance. Each disconnecting means shall simultaneously disconnect all ungrounded conductors that it controls.

422.31 Disconnection of Permanently Connected Appliances

(A) Rated at Not over 300 Volt-Amperes or 1/8 Horsepower

For permanently connected appliances rated at not over 300 volt-amperes or 1/8 hp, the branch-circuit overcurrent device shall be permitted to serve as the disconnecting means where the switch or circuit breaker is within sight from the appliance or be capable of being locked in the open position in compliance with 110.25.

(B) Appliances Rated Over 300 Volt-Amperes

For permanently connected appliances rated over 300 volt-amperes, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means where the switch or circuit breaker is within sight from the appliance or be capable of being locked in the open position in compliance with 110.25.

Informational Note: For appliances employing unit switches, see 422.34.

(C) Motor-Operated Appliances Rated over 1/8 Horsepower

The disconnecting means shall comply with 430.109 and 430.110. For permanently connected motor-operated appliances with motors rated over 1/8 hp, the disconnecting means shall be within sight from the appliance or be capable of being locked in the open position in compliance with 110.25.

Exception: If an appliance of more than 1/8 hp is provided with a unit switch that complies with 422.34(A), (B), (C), or (D), the switch or circuit breaker serving as the other disconnecting means shall be permitted to be out of sight from the appliance.

422.33 Disconnection of Cord-and-Plug-Connected or Attachment Fitting—Connected Appliances

(A) Separable Connector or an Attachment Plug (or Attachment Fitting) and Receptacle

For cord-and-plug-(or attachment fitting—) connected appliances, an accessible separable connector or an accessible plug (or attachment fitting) and receptacle combination shall be permitted to serve as the disconnecting means. The attachment fitting shall be a factory installed part of the appliance and suitable for disconnection of the appliance. Where the separable connector or plug (or attachment fitting) and receptacle combination are not accessible, cord-and-plug-connected or attachment fitting-and-plug-connected appliances shall be provided with disconnecting means in accordance with 422.31.

(B) Connection at the Rear Base of a Range

For cord-and-plug-connected household electric ranges, an attachment plug and receptacle connection at the rear base of a range, accessible from the front by removal of a drawer, shall meet the intent of 422.33(A).

(C) Rating

The rating of a receptacle or of a separable connector shall not be less than the rating of any appliance connected thereto.

Exception: Demand factors authorized elsewhere in this Code shall be permitted to be applied to the rating of a receptacle or of a separable connector.

422.34 Unit Switch(es) as Disconnecting Means

A unit switch(es) with a marked-off position that is a part of an appliance and disconnects all ungrounded conductors shall be permitted as the disconnecting means required by this article where other means for disconnection are provided in occupancies specified in 422.34(A) through (D).

(A) Multifamily Dwellings

In multifamily dwellings, the other disconnecting means shall be within the dwelling unit, or on the same floor as the dwelling unit in which the appliance is installed, and shall be permitted to control lamps and other appliances.

(B) Two-Family Dwellings

In two-family dwellings, the other disconnecting means shall be permitted either inside or outside of the dwelling unit in which the appliance is installed. In this case, an individual switch or circuit breaker for the dwelling unit shall be permitted and shall also be permitted to control lamps and other appliances.

(C) One-Family Dwellings

In one-family dwellings, the service disconnecting means shall be permitted to be the other disconnecting means.

(D) Other Occupancies

In other occupancies, the branch-circuit switch or circuit breaker, where readily accessible for servicing of the appliance, shall be permitted as the other disconnecting means.

422.35 Switch and Circuit Breaker to Be Indicating

Switches and circuit breakers used as disconnecting means shall be of the indicating type.

Part IV Construction

422.40 Polarity in Cord-and-Plug-Connected Appliances

If the appliance is provided with a manually operated, line-connected, single-pole switch for appliance on-off operation, an Edison-base lampholder, or a 15- or 20-ampere receptacle, the attachment plug shall be of the polarized or grounding type.

A 2-wire, nonpolarized attachment plug shall be permitted to be used on a listed double-insulated shaver.

Informational Note: For polarity of Edison-base lampholders, see 410.82.

422.41 Cord-and-Plug-Connected Appliances Subject to Immersion

Cord-and-plug-connected portable, freestanding hydromassage units and hand-held hair dryers shall be constructed to provide protection for personnel against electrocution when immersed while in the "on" or "off" position.

422.42 Signals for Heated Appliances

In other than dwelling-type occupancies, each electrically heated appliance or group of appliances intended to be applied to combustible material shall be provided with a signal or an integral temperature-limiting device.

422.43 Flexible Cords

(A) Heater Cords

All cord-and-plug-connected smoothing irons and electrically heated appliances that are rated at more than 50 watts and produce temperatures in excess of 121°C (250°F) on surfaces with which the cord is likely to be in contact shall be provided with one of the types of approved heater cords listed in Table 400.4.

(B) Other Heating Appliances

All other cord-and-plug-connected electrically heated appliances shall be connected with one of the approved types of cord listed in Table 400.4, selected in accordance with the usage specified in that table.

422.44 Cord-and-Plug-Connected Immersion Heaters

Electric heaters of the cord-and-plug-connected immersion type shall be constructed and installed so that current-carrying parts are effectively insulated from electrical contact with the substance in which they are immersed.

422.45 Stands for Cord-and-Plug-Connected Appliances

Each smoothing iron and other cord-and-plug-connected electrically heated appliance intended to be applied to combustible material shall be equipped with an approved stand, which shall be permitted to be a separate piece of equipment or a part of the appliance.

422.46 Flatirons

Electrically heated smoothing irons shall be equipped with an identified temperature-limiting means.

422.47 Water Heater Controls

All storage or instantaneous-type water heaters shall be equipped with a temperature-limiting means in addition to its control thermostat to disconnect all ungrounded conductors. Such means shall comply with both of the following:

Installed to sense maximum water temperature.

Be either a trip-free, manually reset type or a type having a replacement element. Such water heaters shall be marked to require the installation of a temperature and pressure relief valve.

Exception No. 1: Storage water heaters that are identified as being suitable for use with a supply water temperature of 82°C (180°F) or above and a capacity of 60 kW or above.

Exception No. 2: Instantaneous-type water heaters that are identified as being suitable for such use, with a capacity of 4 L (1 gal) or less.

Informational Note: See ANSI Z21.22-1999/CSA 4.4-M99, Relief Valves for Hot Water Supply Systems.

422.48 Infrared Lamp Industrial Heating Appliances

(A) 300 Watts or Less

Infrared heating lamps rated at 300 watts or less shall be permitted with lampholders of the medium-base, unswitched porcelain type or other types identified as suitable for use with infrared heating lamps rated 300 watts or less.

(B) Over 300 Watts

Screw shell lampholders shall not be used with infrared lamps rated over 300 watts, unless the lampholders are identified as being suitable for use with infrared heating lamps rated over 300 watts.

422.50 Cord-and-Plug-Connected Pipe Heating Assemblies

Cord-and-plug-connected pipe heating assemblies intended to prevent freezing of piping shall be listed.

Part V Marking

422.60 Nameplate

(A) Nameplate Marking

Each electrical appliance shall be provided with a nameplate giving the identifying name and the rating in volts and amperes, or in volts and watts. If the appliance is to be used on a specific frequency or frequencies, it shall be so marked.

Where motor overload protection external to the appliance is required, the appliance shall be so marked.

Informational Note: See 422.11 for overcurrent protection requirements.

(B) To Be Visible

Marking shall be located so as to be visible or easily accessible after installation.

422.61 Marking of Heating Elements

All heating elements that are rated over one ampere, replaceable in the field, and a part of an appliance shall be legibly marked with the ratings in volts and amperes, or in volts and watts, or with the manufacturer's part number.

422.62 Appliances Consisting of Motors and Other Loads

(A) Nameplate Horsepower Markings

Where a motor-operated appliance nameplate includes a horsepower rating, that rating shall not be less than the horsepower rating on the motor nameplate. Where an appliance consists of multiple motors, or one or more motors and other loads, the nameplate value shall not be less than the equivalent horsepower of the combined loads, calculated in accordance with 430.110(C)(1).

(B) Additional Nameplate Markings

Appliances, other than those factory-equipped with cords and attachment plugs and with nameplates in compliance with 422.60, shall be marked in accordance with 422.62(B)(1) or (B)(2).

(1) Marking

In addition to the marking required in 422.60, the marking on an appliance consisting of a motor with other load(s) or motors with or without other load(s) shall specify the minimum supply circuit conductor ampacity and the maximum rating of the circuit overcurrent protective device. This requirement shall not apply to an appliance with a nameplate in compliance with 422.60 where both the minimum supply circuit conductor ampacity and maximum rating of the circuit overcurrent protective device are not more than 15 amperes.

(2) Alternate Marking Method

An alternate marking method shall be permitted to specify the rating of the largest motor in volts and amperes, and the additional load(s) in volts and amperes, or volts and watts in addition to the marking required in 422.60. The ampere rating of a motor 1/8 horsepower or less or a nonmotor load 1 ampere or less shall be permitted to be omitted unless such loads constitute the principal load.

Article 424 Fixed Electric Space-Heating Equipment

Part I General

424.1 Scope

This article covers fixed electric equipment used for space heating. For the purpose of this article, heating equipment includes heating cables, unit heaters, boilers, central heating systems, or other fixed electric space-heating equipment. This article does not apply to process heating and room air conditioning.

424.2 Definitions

The definitions in this section shall apply only within this article.

Heating Panel. A complete assembly provided with a junction box or a length of flexible conduit for connection to a branch circuit.

Heating Panel Set. A rigid or nonrigid assembly provided with nonheating leads or a terminal junction assembly identified as being suitable for connection to a wiring system.

424.3 Other Articles

Fixed electric space-heating equipment incorporating a hermetic refrigerant motor-compressor shall also comply with Article 440.

424.4 Branch Circuits

(A) Branch-Circuit Requirements

An individual branch circuit shall be permitted to supply any volt-ampere or wattage rating of fixed electric space-heating equipment for which the branch circuit is rated.

Branch circuits supplying two or more outlets for fixed electric space-heating equipment shall be rated not over 30 amperes. In other than a dwelling unit, fixed infrared heating equipment shall be permitted to be supplied from branch circuits rated not over 50 amperes.

(B) Branch-Circuit Sizing

The branch-circuit conductors for fixed electric space-heating equipment and any associated motors shall be sized not smaller than 125 percent of the load.

424.6 Listed Equipment

Electric baseboard heaters, heating cables, duct heaters, and radiant heating systems shall be listed and labeled.

Part II Installation

424.9 General

Factory-installed receptacle outlets that are part of a permanently installed electric baseboard heater, or outlets provided as a separate listed assembly of an electric baseboard heater, shall be permitted in lieu of a receptacle outlet(s) that is required by 210.52. Such receptacle outlets shall not be connected to the baseboard heater circuits.

Informational Note: Listed baseboard heaters include instructions that may not permit their installation below receptacle outlets.

424.10 Special Permission

Fixed electric space-heating equipment and systems installed by methods other than those covered by this article shall be permitted only by special permission.

424.11 Supply Conductors

Fixed electric space-heating equipment requiring supply conductors with an insulation rating greater than 60°C shall be clearly and permanently marked. This marking shall be plainly visible after installation and shall be permitted to be adjacent to the field connection box.

424.12 Locations

(A) Exposed to Physical Damage

Where subject to physical damage, fixed electric space-heating equipment shall be protected in an approved manner.

(B) Damp or Wet Locations

Heaters and related equipment installed in damp or wet locations shall be listed for such locations and shall be constructed and installed so that water or other liquids cannot enter or accumulate in or on wired sections, electrical components, or ductwork.

Informational Note No. 1: See 110.11 for equipment exposed to deteriorating agents.

Informational Note No. 2: See 680.27(C) for pool deck areas.

424.13 Spacing From Combustible Materials

Fixed electric space-heating equipment shall be installed to provide the required spacing between the equipment and adjacent combustible material, unless it is listed to be installed in direct contact with combustible material.

Part III Control and Protection of Fixed Electric Space-Heating Equipment

424.19 Disconnecting Means

Means shall be provided to simultaneously disconnect the heater, motor controller(s), and supplementary overcurrent protective device(s) of all fixed electric space-heating equipment from all ungrounded conductors. Where heating equipment is supplied by more than one source, feeder, or branch circuit, the disconnecting means shall be grouped and identified as having multiple disconnecting means. Each disconnecting means shall simultaneously disconnect all ungrounded conductors that it controls. The disconnecting means specified in 424.19(A) and (B) shall have an ampere rating not less than 125 percent of the total load of the motors and the heaters and shall be capable of being locked in the open position in compliance with 110.25.

(A) Heating Equipment With Supplementary Overcurrent Protection

The disconnecting means for fixed electric space-heating equipment with supplementary overcurrent protection shall be within sight from the supplementary overcurrent protective device(s), on the supply side of these devices, if fuses, and, in addition, shall comply with either 424.19(A)(1) or (A)(2).

(1) Heater Containing No Motor Rated over 1/8 Horsepower

The disconnecting means provided shall be within sight from the motor controller(s) and the heater, or shall be lockable as specified in 424.19, or shall be a unit switch complying with 424.19(C).

(2) Heater Containing a Motor(s) Rated over 1/8 Horsepower

The disconnecting means required by 424.19 shall be permitted to serve as the required disconnecting means for both the motor controller(s) and heater under either of the following conditions:

Where the disconnecting means is in sight from the motor controller(s) and the heater and complies with Part IX of Article 430.

Where a motor(s) of more than 1/8 hp and the heater are provided with a single unit switch that complies with 422.34(A), (B), (C), or (D), the disconnecting means shall be permitted to be out of sight from the motor controller.

(B) Heating Equipment Without Supplementary Overcurrent Protection

(1) Without Motor or with Motor Not over 1/8 Horsepower

For fixed electric space-heating equipment without a motor rated over 1/8 hp, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means where the switch or circuit breaker is within sight from the heater or is capable of being locked in the open position in compliance with 110.25.

(2) Over 1/8 Horsepower

For motor-driven electric space-heating equipment with a motor rated over 1/8 hp, a disconnecting means shall be located within sight from the motor controller or shall be permitted to comply with the requirements in 424.19(A)(2).

(C) Unit Switch(es) as Disconnecting Means

A unit switch(es) with a marked "off' position that is part of a fixed heater and disconnects all ungrounded conductors shall be permitted as the disconnecting means required by this article where other means for disconnection are provided in the types of occupancies in 424.19(C)(1) through (C)(4).

(1) Multifamily Dwellings

In multifamily dwellings, the other disconnecting means shall be within the dwelling unit, or on the same floor as the dwelling unit in which the fixed heater is installed, and shall also be permitted to control generalpurpose circuits and appliance circuits.

(2) Two-Family Dwellings

In two-family dwellings, the other disconnecting means shall be permitted either inside or outside of the dwelling unit in which the fixed heater is installed. In this case, an individual switch or circuit breaker for the dwelling unit shall be permitted and shall also be permitted to control general-purpose circuits and appliance circuits.

(3) One-Family Dwellings

In one-family dwellings, the service disconnecting means shall be permitted to be the other disconnecting means.

(4) Other Occupancies

In other occupancies, the branch-circuit switch or circuit breaker, where readily accessible for servicing of the fixed heater, shall be permitted as the other disconnecting means.

424.20 Thermostatically Controlled Switching Devices

(A) Serving as Both Controllers and Disconnecting Means

Thermostatically controlled switching devices and combination thermostats and manually controlled switches shall be permitted to serve as both controllers and disconnecting means, provided they meet all of the following conditions:

Provided with a marked "off" position

Directly open all ungrounded conductors when manually placed in the "off" position

Designed so that the circuit cannot be energized automatically after the device has been manually placed in the "off" position

Located as specified in 424.19

Located in an accessible location

(B) Thermostats That Do Not Directly Interrupt All Ungrounded Conductors

Thermostats that do not directly interrupt all ungrounded conductors and thermostats that operate remote-control circuits shall not be required to meet the requirements of 424.20(A). These devices shall not be permitted as the disconnecting means.

424.21 Switch and Circuit Breaker to Be Indicating

Switches and circuit breakers used as disconnecting means shall be of the indicating type.

424.22 Overcurrent Protection

(A) Branch-Circuit Devices

Electric space-heating equipment, other than motor-operated equipment required to have additional overcurrent protection by Parts III and IV of Article 430 or Parts III and VI of Article 440, shall be permitted to be protected against overcurrent where supplied by one of the branch circuits in Part II of Article 210.

(B) Resistance Elements

Resistance-type heating elements in electric space-heating equipment shall be protected at not more than 60 amperes. Equipment rated more than 48 amperes and employing such elements shall have the heating elements subdivided, and each subdivided load shall not exceed 48 amperes. Where a subdivided load is less than 48 amperes, the rating of the supplementary overcurrent protective device shall comply with 424.4(B). A boiler employing resistance-type immersion heating elements contained in an ASME-rated and stamped vessel shall be permitted to comply with 424.72(A).

(C) Overcurrent Protective Devices

The supplementary overcurrent protective devices for the subdivided loads specified in 424.22(B) shall meet all of the following conditions:

Be factory-installed within or on the heater enclosure or supplied for use with the heater as a separate assembly by the heater manufacturer

Be accessible

Be suitable for branch-circuit protection

Informational Note: See 240.10.

Where cartridge fuses are used to provide overcurrent protection for the subdivided loads, a single disconnecting means shall be permitted to be used as the disconnecting means for all of the subdivided loads.

Informational Note No. 1: For supplementary overcurrent protection, see 240.10.

Informational Note No. 2: For disconnecting means for cartridge fuses in circuits of any voltage, see 240.40.

(D) Branch-Circuit Conductors

The conductors supplying the supplementary overcurrent protective devices shall be considered branch-circuit conductors.

Where the heaters are rated 50 kW or more, the conductors supplying the supplementary overcurrent protective devices specified in 424.22(C) shall be permitted to be sized at not less than 100 percent of the nameplate rating of the heater, provided all of the following conditions are met:

The heater is marked with a minimum conductor size.

The conductors are not smaller than the marked minimum size.

A temperature-actuated device controls the cyclic operation of the equipment.

(E) Conductors for Subdivided Loads

Field-wired conductors between the heater and the supplementary overcurrent protective devices shall be sized at not less than 125 percent of the load served. The supplementary overcurrent protective devices specified in 424.22(C) shall protect these conductors in accordance with 240.4.

Where the heaters are rated 50 kW or more, the ampacity of field-wired conductors between the heater and the supplementary overcurrent protective devices shall be permitted to be not less than 100 percent of the load of their respective subdivided circuits, provided all of the following conditions are met:

The heater is marked with a minimum conductor size.

The conductors are not smaller than the marked minimum size.

A temperature-activated device controls the cyclic operation of the equipment.

Part IV Marking of Heating Equipment

424.28 Nameplate

(A) Marking Required

Each unit of fixed electric space-heating equipment shall be provided with a nameplate giving the identifying name and the normal rating in volts and watts or in volts and amperes.

Electric space-heating equipment intended for use on alternating current only, direct current only, or both shall be marked to so indicate. The marking of equipment consisting of motors over 1/8 hp and other loads shall specify the rating of the motor in volts, amperes, and frequency, and the heating load in volts and watts or in volts and amperes.

(B) Location

This nameplate shall be located so as to be visible or accessible after installation.

424.29 Marking of Heating Elements

All heating elements that are replaceable in the field and are part of an electric heater shall be legibly marked with the ratings in volts and watts or in volts and amperes.

Part V Electric Space-Heating Cables

424.34 Heating Cable Construction

Factory-assembled nonheating leads of heating cables, if any, shall be at least 2.1 m (7 ft) in length.

424.35 Marking of Heating Cables

Each unit shall be marked with the identifying name or identification symbol, catalog number, and ratings in volts and watts or in volts and amperes.

424.36 Clearances of Wiring in Ceilings

Wiring located above heated ceilings shall be spaced not less than 50 mm (2 in.) above the heated ceiling. The ampacity of conductors shall be calculated on the basis of an assumed ambient temperature of not less than 50°C (122°F), applying the correction factors in accordance with 310.15(B)(1). If this wiring is located above thermal insulation having a minimum thickness of 50 mm (2 in.), it shall be subject to the ambient correction in accordance with 310.15(B)(1).

424.38 Area Restrictions

(A) Extending Beyond the Room or Area

Heating cables shall be permitted to extend beyond the room or area in which they originate unless prohibited by 424.38(B).

(B) Uses Not Permitted

Heating cables shall not be installed as follows:

In closets, other than as noted in 424.38(C)

Over the top of walls where the wall intersects the ceiling

Over partitions that extend to the ceiling, unless they are isolated single runs of embedded cable

Under or through walls

Over cabinets whose clearance from the ceiling is less than the minimum horizontal dimension of the cabinet to the nearest cabinet edge that is open to the room or area

In tub and shower walls

Under cabinets or similar built-ins having no clearance to the floor

(C) In Closet Ceilings as Low-Temperature Heat Sources to Control Relative Humidity

The provisions of 424.38(B) shall not prevent the use of cable in closet ceilings as low-temperature heat sources to control relative humidity, provided they are used only in those portions of the ceiling that are unobstructed to the floor.

424.39 Clearance From Other Objects and Openings

Heating elements of cables installed in ceilings shall be separated at least 200 mm (8 in.) from the edge of outlet boxes and junction boxes that are to be used for mounting surface luminaires. A clearance of not less than 50 mm (2 in.) shall be provided from recessed luminaires and their trims, ventilating openings, and other such openings in room surfaces. No heating cable shall be covered by any ceiling surface-mounted equipment.

424.40 Splices

The length of heating cable shall only be altered using splices identified in the manufacturer's instructions.

424.41 Ceiling Installation of Heating Cables on Dry Board, in Plaster, and on Concrete

(A) In Walls

Cables shall not be installed in walls unless it is necessary for an isolated single run of cable to be installed down a vertical surface to reach a dropped ceiling.

(B) Adjacent Runs

Adjacent runs of heating cable shall be installed in accordance with the manufacturer's instructions.

(C) Surfaces to Be Applied

Heating cables shall be applied only to gypsum board, plaster lath, or other fire-resistant material. With metal lath or other electrically conductive surfaces, a coat of plaster or other means employed in accordance with the heating cable manufacturer's instructions shall be applied to completely separate the metal lath or conductive surface from the cable.

Informational Note: See also 424.41(F).

(D) Splices

All heating cables, the splice between the heating cable and nonheating leads, and 75-mm (3-in.) minimum of the nonheating lead at the splice shall be embedded in plaster or dry board in the same manner as the heating cable.

(E) Ceiling Surface

The entire ceiling surface shall have a finish of thermally noninsulating sand plaster that has a nominal thickness of 13 mm (1/2 in.), or other noninsulating material identified as suitable for this use and applied according to specified thickness and directions.

(F) Secured

Cables shall be secured by means of approved stapling, tape, plaster, nonmetallic spreaders, or other approved means either at intervals not exceeding 400 mm (16 in.) or at intervals not exceeding 1.8 m (6 ft) for cables identified for such use. Staples or metal fasteners that straddle the cable shall not be used with metal lath or other electrically conductive surfaces.

(G) Dry Board Installations

In dry board installations, the entire ceiling below the heating cable shall be covered with gypsum board not exceeding 13 mm (1/2 in.) thickness. The void between the upper layer of gypsum board, plaster lath, or other fire-resistant material and the surface layer of gypsum board shall be completely filled with thermally conductive, nonshrinking plaster or other approved material or equivalent thermal conductivity.

(H) Free From Contact With Conductive Surfaces

Cables shall be kept free from contact with metal or other electrically conductive surfaces.

(I) Joists

In dry board applications, cable shall be installed parallel to the joist, leaving a clear space centered under the joist of 65 mm (21/2 in.) (width) between centers of adjacent runs of cable. A surface layer of gypsum board shall be mounted so that the nails or other fasteners do not pierce the heating cable.

(J) Crossing Joists

Cables shall cross joists only at the ends of the room unless the cable is required to cross joists elsewhere in order to satisfy the manufacturer's instructions regarding clearance from ceiling penetrations and luminaires.

424.42 Finished Ceilings

Finished ceilings shall not be covered with decorative panels or beams constructed of materials that have thermal insulating properties, such as wood, fiber, or plastic. Finished ceilings shall be permitted to be covered with paint, wallpaper, or other approved surface finishes.

424.43 Installation of Nonheating Leads of Cables

(A) Free Nonheating Leads

Free nonheating leads of cables shall be installed in accordance with Chapter 3 wiring methods, or other listed means, from the junction box to a location within the ceiling.

(B) Leads in Junction Box

Not less than 150 mm (6 in.) of free nonheating lead shall be within the junction box. The marking of the leads shall be visible in the junction box.

(C) Excess Leads

Excess leads of heating cables shall not be cut but shall be secured to the underside of the ceiling and embedded in plaster or other approved material, leaving only a length sufficient to reach the junction box with not less than 150 mm (6 in.) of free lead within the box.

424.44 Installation of Cables in Concrete or Poured Masonry Floors

(A) Adjacent Runs

Adjacent runs of heating cable shall be installed in accordance with the manufacturer's instructions.

(B) Secured in Place

Cables shall be secured in place by nonmetallic frames or spreaders or other approved means while the concrete or other finish is applied.

(C) Leads Protected

Leads shall be protected where they leave the floor by rigid metal conduit, intermediate metal conduit, rigid nonmetallic conduit, electrical metallic tubing, or by other approved means.

(D) Bushings or Approved Fittings

Bushings or approved fittings shall be used where the leads emerge within the floor slab.

(E) Ground-Fault Circuit-Interrupter Protection

In addition to the requirements in 210.8, ground-fault circuit-interrupter protection for personnel shall be provided for cables installed in electrically heated floors of bathrooms, kitchens, and in hydromassage bathtub locations.

424.45 Installation of Cables Under Floor Coverings

(A) Identification

Heating cables for installation under floor covering shall be identified as suitable for installation under floor covering.

(B) Expansion Joints

Heating cables shall not be installed where they bridge expansion joints unless provided with expansion and contraction fittings applicable to the manufacture of the cable.

(C) Connection to Conductors

Heating cables shall be connected to branch-circuit and supply wiring by wiring methods described in the installation instructions.

(D) Anchoring

Heating cables shall be positioned and secured in place under the floor covering, in accordance with the manufacturer's instructions.

(E) Ground-Fault Circuit-Interrupter Protection

In addition to the requirements in 210.8, ground-fault circuit-interrupter protection for personnel shall be provided.

(F) Grounding Braid or Sheath

Grounding means, such as copper braid, metal sheath, or other approved means, shall be provided as part of the heated length.

424.46 Inspection

Cable installations shall be made with due care to prevent damage to the cable assembly and shall be inspected and approved before cables are covered or concealed.

424.47 Label Provided by Manufacturer

The manufacturers of electric space-heating cables shall provide marking labels that indicate that the space-heating installation incorporates electric space-heating cables and instructions that the labels shall be affixed to the panelboards to identify which branch circuits supply the circuits to those space-heating installations. If the electric space-heating cable installations are visible and distinguishable after installation, the labels shall not be required to be provided and affixed to the panelboards.

Part VI Duct Heaters

424.57 General

Part VI shall apply to any heater mounted in the airstream of a forced-air system where the air-moving unit is not provided as an integral part of the equipment.

424.58 Identification

Heaters installed in an air duct shall be identified as suitable for the installation.

424.59 Airflow

Means shall be provided to ensure uniform airflow over the face of the heater in accordance with the manufacturer's instructions.

Informational Note: Heaters installed within 1.2 m (4 ft) of the outlet of an air-moving device, heat pump, air conditioner, elbows, baffle plates, or other obstructions in ductwork may require turning vanes, pressure plates, or other devices on the inlet side of the duct heater to ensure an even distribution of air over the face of the heater.

424.60 Elevated Inlet Temperature

Duct heaters intended for use with elevated inlet air temperature shall be identified as suitable for use at the elevated temperatures.

424.61 Installation of Duct Heaters With Heat Pumps and Air Conditioners

Heat pumps and air conditioners having duct heaters closer than 1.2 m (4 ft) to the heat pump or air conditioner shall have both the duct heater and heat pump or air conditioner identified as suitable for such installation and so marked.

424.62 Condensation

Duct heaters used with air conditioners or other air-cooling equipment that could result in condensation of moisture shall be identified as suitable for use with air conditioners.

424.63 Fan Circuit Interlock

Means shall be provided to ensure that the fan circuit is energized when any heater circuit is energized. However, time-or temperature-controlled delay in energizing the fan motor shall be permitted.

424.64 Limit Controls

Each duct heater shall be provided with an approved, integral, automatic-reset temperature-limiting control or controllers to de-energize the circuit or circuits.

In addition, an integral independent supplementary control or controllers shall be provided in each duct heater that disconnects a sufficient number of conductors to interrupt current flow. This device shall be manually resettable or replaceable.

424.65 Location of Disconnecting Means

Duct heater controller equipment shall be accessible with the disconnecting means installed within sight from the controller or as permitted by 424.19(A).

424.66 Installation

Duct heaters shall be installed in accordance with the manufacturer's instructions in such a manner that the operation of the duct heater does not create a hazard to persons or property. Furthermore, duct heaters shall be located with respect to building construction and other equipment so as to permit access to the heater and the heater control. Sufficient clearance shall be maintained to permit replacement of controls and heating elements and for adjusting and cleaning of controls and other parts requiring such attention. See 110.26.

Informational Note: For additional installation information, see NFPA 90A-2015, Standard for the Installation of Air-Conditioning and Ventilating Systems, and NFPA 90B-2015, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

Part VII Resistance-Type Boilers

424.70 Scope

The provisions in Part VII of this article shall apply to boilers employing resistance-type heating elements. See Part VIII of this article for electrode-type boilers.

424.71 Identification

Resistance-type boilers shall be identified as suitable for the installation.

424.72 Overcurrent Protection

(A) Boiler Employing Resistance-Type Immersion Heating Elements in an ASME-Rated and Stamped Vessel

A boiler employing resistance-type immersion heating elements contained in an ASME-rated and stamped vessel shall have the heating elements protected at not more than 150 amperes. Such a boiler rated more than 120 amperes shall have the heating elements subdivided into loads not exceeding 120 amperes.

Where a subdivided load is less than 120 amperes, the rating of the overcurrent protective device shall comply with 424.4(B).

(B) Boiler Employing Resistance-Type Heating Elements Rated More Than 48 Amperes and Not Contained in an ASME-Rated and Stamped Vessel

A boiler employing resistance-type heating elements not contained in an ASME-rated and stamped vessel shall have the heating elements protected at not more than 60 amperes. Such a boiler rated more than 48 amperes shall have the heating elements subdivided into loads not exceeding 48 amperes.

Where a subdivided load is less than 48 amperes, the rating of the overcurrent protective device shall comply with 424.4(B).

(C) Supplementary Overcurrent Protective Devices

The supplementary overcurrent protective devices for the subdivided loads as required by 424.72(A) and (B) shall be as follows:

Factory-installed within or on the boiler enclosure or provided as a separate assembly by the boiler manufacturer

Accessible, but need not be readily accessible

Suitable for branch-circuit protection

Where cartridge fuses are used to provide this overcurrent protection, a single disconnecting means shall be permitted for the several subdivided circuits. See 240.40.

(D) Conductors Supplying Supplementary Overcurrent Protective Devices

The conductors supplying these supplementary overcurrent protective devices shall be considered branch-circuit conductors.

Where the heaters are rated 50 kW or more, the conductors supplying the overcurrent protective device specified in 424.72(C) shall be permitted to be sized at not less than 100 percent of the nameplate rating of the heater, provided all of the following conditions are met:

The heater is marked with a minimum conductor size and conductor insulation temperature rating.

The conductors are not smaller than the marked minimum size.

A temperature-or pressure-actuated device controls the cyclic operation of the equipment.

(E) Conductors for Subdivided Loads

Field-wired conductors between the heater and the supplementary overcurrent protective devices shall be sized at not less than 125 percent of the load served. The supplementary overcurrent protective devices specified in 424.72(C) shall protect these conductors in accordance with 240.4.

Where the heaters are rated 50 kW or more, the ampacity of field-wired conductors between the heater and the supplementary overcurrent protective devices shall be permitted to be not less than 100 percent of the load of their respective subdivided circuits, provided all of the following conditions are met:

The heater is marked with a minimum conductor size.

The conductors are not smaller than the marked minimum size.

A temperature-activated device controls the cyclic operation of the equipment.

424.73 Overtemperature Limit Control

Each boiler designed so that in normal operation there is no change in state of the heat transfer medium shall be equipped with a temperature-sensitive limiting means. It shall be installed to limit maximum liquid temperature and shall directly or indirectly disconnect all ungrounded conductors to the heating elements. Such means shall be in addition to a temperature-regulating system and other devices protecting the tank against excessive pressure.

424.74 Overpressure Limit Control

Each boiler designed so that in normal operation there is a change in state of the heat transfer medium from liquid to vapor shall be equipped with a pressure-sensitive limiting means. It shall be installed to limit maximum pressure and shall directly or indirectly disconnect all ungrounded conductors to the heating elements. Such means shall be in addition to a pressure-regulating system and other devices protecting the tank against excessive pressure.

Part VIII Electrode-Type Boilers

424.80 Scope

The provisions in Part VIII of this article shall apply to boilers for operation at 600 volts, nominal, or less, in which heat is generated by the passage of current between electrodes through the liquid being heated.

Informational Note: For over 600 volts, see Part V of Article 490.

424.81 Identification

Electrode-type boilers shall be identified as suitable for the installation.

424.82 Branch-Circuit Requirements

The size of branch-circuit conductors and overcurrent protective devices shall be calculated on the basis of 125 percent of the total load (motors not included). A contactor, relay, or other device, approved for continuous operation at 100 percent of its rating, shall be permitted to supply its full-rated load. See 210.19(A), Exception. The provisions of this section shall not apply to conductors that form an integral part of an approved boiler.

Where an electrode boiler is rated 50 kW or more, the conductors supplying the boiler electrode(s) shall be permitted to be sized at not less than 100 percent of the nameplate rating of the electrode boiler, provided all the following conditions are met:

The electrode boiler is marked with a minimum conductor size.

The conductors are not smaller than the marked minimum size.

A temperature-or pressure-actuated device controls the cyclic operation of the equipment.

424.83 Overtemperature Limit Control

Each boiler, designed so that in normal operation there is no change in state of the heat transfer medium, shall be equipped with a temperature-sensitive limiting means. It shall be installed to limit maximum liquid temperature and shall directly or indirectly interrupt all current flow through the electrodes. Such means shall be in addition to the temperature-regulating system and other devices protecting the tank against excessive pressure.

424.84 Overpressure Limit Control

Each boiler, designed so that in normal operation there is a change in state of the heat transfer medium from liquid to vapor, shall be equipped with a pressure-sensitive limiting means. It shall be installed to limit maximum pressure and shall directly or indirectly interrupt all current flow through the electrodes. Such means shall be in addition to a pressure-regulating system and other devices protecting the tank against excessive pressure.

424.85 Grounding

Boilers designed such that fault currents do not pass through the pressure vessel, and the pressure vessel is electrically isolated from the electrodes, all exposed non—current-carrying metal parts, including the pressure vessel, supply, and return connecting piping, shall be connected to an equipment grounding conductor.

For all other designs, the pressure vessel containing the electrodes shall be isolated and electrically insulated from ground.

424.86 Markings

All electrode-type boilers shall be marked to show the following:

The manufacturer's name.

The rating in volts, amperes, and kilowatts.

The electrical supply required specifying frequency, number of phases, and number of wires.

The marking "Electrode-Type Boiler."

A warning marking, "All Power Supplies Shall Be Disconnected Before Servicing, Including Servicing the Pressure Vessel."

A field-applied warning marking or label shall comply with 110.21(B). The nameplate shall be located so as to be visible after installation.

Part IX Electric Radiant Heating Panels and Heating Panel Sets

424.90 Scope

The provisions of Part IX of this article shall apply to radiant heating panels and heating panel sets.

424.92 Markings

(A) Location

Markings shall be permanent and in a location that is visible prior to application of panel finish.

(B) Identified as Suitable

Each unit shall be identified as suitable for the installation.

(C) Required Markings

Each unit shall be marked with the identifying name or identification symbol, catalog number, and rating in volts and watts or in volts and amperes.

424.93 Installation

(A) General

(1) Manufacturer's Instructions

Heating panels and heating panel sets shall be installed in accordance with the manufacturer's instructions.

(2) Locations Not Permitted

The heating portion shall not be installed as follows:

In or behind surfaces where subject to physical damage

Run through or above walls, partitions, cupboards, or similar portions of structures that extend to the ceiling

Run in or through thermal insulation, but shall be permitted to be in contact with the surface of thermal insulation

(3) Separation From Outlets for Luminaires

Edges of panels and panel sets shall be separated by not less than 200 mm (8 in.) from the edges of any outlet boxes and junction boxes that are to be used for mounting surface luminaires. A clearance of not less than 50 mm (2 in.) shall be provided from recessed luminaires and their trims, ventilating openings, and other such openings in room surfaces, unless the heating panels and panel sets are listed and marked for lesser clearances, in which case they shall be permitted to be installed at the marked clearances. Sufficient area shall be provided to ensure that no heating panel or heating panel set is to be covered by any surface-mounted equipment.

(4) Surfaces Covering Heating Panels

After the heating panels or heating panel sets are installed and inspected, it shall be permitted to install a surface that has been identified by the manufacturer's instructions as being suitable for the installation. The surface shall be secured so that the nails or other fastenings do not pierce the heating panels or heating panel sets.

(5) Surface Coverings

Surfaces permitted by 424.93(A)(4) shall be permitted to be covered with paint, wallpaper, or other approved surfaces identified in the manufacturer's instructions as being suitable.

(B) Heating Panel Sets

(1) Mounting Location

Heating panel sets shall be permitted to be secured to the lower face of joists or mounted in between joists, headers, or nailing strips.

(2) Parallel to Joists or Nailing Strips

Heating panel sets shall be installed parallel to joists or nailing strips.

(3) Installation of Nails, Staples, or Other Fasteners

Nailing or stapling of heating panel sets shall be done only through the unheated portions provided for this purpose. Heating panel sets shall not be cut through or nailed through any point closer than 6 mm (1/4 in.) to the element. Nails, staples, or other fasteners shall not be used where they penetrate current-carrying parts.

(4) Installed as Complete Unit

Heating panel sets shall be installed as complete units unless identified as suitable for field cutting in an approved manner.

424.94 Clearances of Wiring in Ceilings

Wiring located above heated ceilings shall be spaced not less than 50 mm (2 in.) above the heated ceiling. The ampacity shall be calculated on the basis of an assumed ambient temperature of not less than 50°C (122°F), applying the correction factors in accordance with 310.15(B)(1). If this wiring is located above thermal insulation having a minimum thickness of 50 mm (2 in.), it shall be subject to the ambient correction in accordance with 310.15(B)(1).

424.95 Location of Branch-Circuit and Feeder Wiring in Walls

(A) Exterior Walls

Wiring methods shall comply with 310.14(A)(3).

(B) Interior Walls

The ampacity of any wiring behind heating panels or heating panel sets located in interior walls or partitions shall be calculated on the basis of an assumed ambient temperature of 40°C (104°F), applying the correction factors in accordance with 310.15(B)(1).

424.96 Connection to Branch-Circuit Conductors

(A) General

Heating panels or heating panel sets assembled together in the field to form a heating installation in one room or area shall be connected in accordance with the manufacturer's instructions.

(B) Heating Panels

Heating panels shall be connected to branch-circuit wiring by an approved wiring method.

(C) Heating Panel Sets

(1) Connection to Branch-Circuit Wiring

Heating panel sets shall be connected to branch-circuit wiring by a method identified as being suitable for the purpose.

(2) Panel Sets With Terminal Junction Assembly

A heating panel set provided with terminal junction assembly shall be permitted to have the nonheating leads attached at the time of installation in accordance with the manufacturer's instructions.

424.97 Nonheating Leads

Excess nonheating leads of heating panels or heating panel sets shall be permitted to be cut to the required length as indicated in the manufacturer's installation instructions. Nonheating leads that are an integral part of a heating panel or heating panel set, either attached or provided by the manufacturer as part of a terminal junction assembly, shall not be subjected to the ampacity requirements of 424.4(B) for branch circuits.

424.98 Installation in Concrete or Poured Masonry

(A) Secured in Place and Identified as Suitable

Heating panels or heating panel sets shall be secured in place by means specified in the manufacturer's instructions and identified as suitable for the installation.

(B) Expansion Joints

Heating panels or heating panel sets shall not be installed where they bridge expansion joints unless provision is made for expansion and contraction.

(C) Spacings

Spacings shall be maintained between heating panels or heating panel sets and metal embedded in the floor. Grounded metal-clad heating panels shall be permitted to be in contact with metal embedded in the floor.

(D) Protection of Leads

Leads shall be protected where they leave the floor by rigid metal conduit, intermediate metal conduit, rigid nonmetallic conduit, or electrical metallic tubing, or by other approved means.

(E) Bushings or Fittings Required

Bushings or approved fittings shall be used where the leads emerge within the floor slabs.

424.99 Installation Under Floor Covering

(A) Identification

Heating panels or heating panel sets for installation under floor covering shall be identified as suitable for installation under floor covering.

(B) Installation

Listed heating panels or panel sets, if installed under floor covering, shall be installed on surfaces that are smooth and flat in accordance with the manufacturer's instructions and shall also comply with 424.99(B)(1) through (B)(6).

(1) Expansion Joints

Heating panels or heating panel sets shall not be installed where they bridge expansion joints unless protected from expansion and contraction.

(2) Connection to Conductors

Heating panels and heating panel sets shall be connected to branch-circuit and supply wiring by wiring methods recognized in Chapter 3.

(3) Anchoring

Heating panels and heating panel sets shall be firmly anchored to the floor using an adhesive or anchoring system identified for this use.

(4) Coverings

After heating panels or heating panel sets are installed and inspected, they shall be permitted to be covered by a floor covering that has been identified by the heater manufacturer as being suitable for the installation.

(5) GFCI Protection

In addition to the requirements in 210.8, branch circuits supplying the heating panel or heating panel sets shall have ground-fault circuit-interrupter protection for personnel.

(6) Grounding Braid or Sheath

Excluding nonheating leads, grounding means, such as copper braid, metal sheath, or other approved means, shall be provided with or as an integral part of the heating panel or heating panel set.

Part X Low-Voltage Fixed Electric Space-Heating Equipment

424.100 Scope

Low-voltage fixed electric space-heating equipment shall consist of an isolating power supply, low-voltage heaters, and associated equipment that are all identified for use in dry locations.

424.101 Energy Source

(A) Power Unit

The power unit shall be an isolating type with a rated output not exceeding 25 amperes, 30 volts (42.4 volts peak) ac, or 60 volts dc under all load conditions.

(B) Alternate Energy Sources

Listed low-voltage fixed electric space-heating equipment shall be permitted to be supplied directly from an alternate energy source such as solar photovoltaic (PV) or wind power. When supplied from such a source, the source and any power conversion equipment between the source and the heating equipment and its supply shall be listed and comply with the applicable section of the NEC for the source used. The output of the source shall meet the limits of 424.101(A).

424.102 Listed Equipment

Low-voltage fixed electric space-heating equipment shall be listed as a complete system.

424.103 Installation

(A) General

Equipment shall be installed per the manufacturer's installation instructions.

(B) Ground

Secondary circuits shall not be grounded.

(C) Ground-Fault Protection

Ground-fault protection shall not be required.

424.104 Branch Circuit

(A)

Equipment shall be permitted to be supplied from branch circuits rated not over 30 amperes.

(B)

The equipment shall be considered a continuous duty load.

Article 425 Fixed Resistance and Electrode Industrial Process Heating Equipment

Part I General

425.1 Scope

This article covers fixed industrial process heating employing electric resistance or electrode heating technology. For the purpose of this article, heating equipment includes boilers, electrode boilers, duct heaters, strip heaters, immersion heaters, process air heaters, or other fixed electric equipment used for industrial process heating. This article does not apply to heating and room air conditioning for personnel spaces covered by Article 424, fixed heating equipment for pipelines and vessels covered by Article 427, induction and dielectric heating equipment covered by Article 665, industrial furnaces incorporating silicon carbide, molybdenum, or graphite process heating elements, and electric resistance or electrode heating technology covered by 424.90.

425.2 Other Articles

Fixed industrial process heating equipment incorporating a hermetic refrigerant motor-compressor shall also comply with Article 440. Fixed industrial process heating equipment incorporating motors shall also comply with Article 430.

425.4 Branch Circuits

(A) Branch-Circuit Requirements

An individual branch circuit shall be permitted to supply any volt-ampere or wattage rating of fixed industrial process heating equipment for which the branch circuit is rated.

(B) Branch-Circuit Sizing

Fixed industrial process heating equipment and motors shall be considered continuous loads.

425.6 Listed Equipment

Fixed industrial process heating equipment shall be listed.

Part II Installation

425.8 General

(A) Location

Fixed industrial process heating equipment shall be accessible.

(B) Working Space

Working space about electrical enclosures for fixed industrial process heating equipment that require examination, adjustment, servicing, or maintenance while energized shall be accessible, and the work space for personnel shall comply with 110.26 and 110.34, based upon the utilization voltage to ground.

Exception: With special permission, in industrial establishments only, where conditions of maintenance and supervision ensure that only qualified persons will service the installation, working space less than that required in 110.26 or 110.34 shall be permitted.

(C) Above Grade Level, Floor, or Work Platform

Where the enclosure is located above grade, the floor, or a work platform, all of the following shall apply:

The enclosure shall be accessible.

The width of the working space shall be the width of the enclosure or a minimum of 762 mm (30 in.), whichever is greater.

The depth of the workspace shall comply with 110.26(A) or 110.34 based upon the voltage to ground.

All doors or hinged panels shall open to at least 90 degrees.

425.10 Special Permission

Fixed industrial process heating equipment and systems installed by methods other than covered by this article shall be permitted only by special permission.

425.11 Supply Conductors

Fixed industrial process heating equipment requiring supply conductors with over 60°C insulation shall be clearly and permanently marked. This marking shall be plainly visible after installation and shall be permitted to be adjacent to the field connection box.

425.12 Locations

(A) Exposed to Physical Damage

Where subject to physical damage, fixed industrial process heating equipment shall be protected in an approved manner.

(B) Damp or Wet Locations

Fixed industrial process heating equipment installed in damp or wet locations shall be listed for such locations and shall be constructed and installed so that water or other liquids cannot enter or accumulate in or on wired sections, electrical components, or ductwork.

Informational Note: See 110.11 for equipment exposed to deteriorating agents.

425.13 Spacing From Combustible Materials

Fixed industrial process heating equipment shall be installed to provide the required spacing between the equipment and adjacent combustible material, unless it is listed to be installed in direct contact with combustible material.

425.14 Infrared Lamp Industrial Heating Equipment

In industrial occupancies, infrared industrial process heating equipment lampholders shall be permitted to be operated in series on circuits of over 150 volts to ground, provided the voltage rating of the lampholders is not less than the circuit voltage.

Each section, panel, or strip carrying a number of infrared lampholders, including the terminal wiring of such section, panel, or strip, shall be considered as infrared industrial heating equipment. The terminal connection block of each assembly shall be considered an individual outlet.

Part III Control and Protection of Fixed Industrial Process Heating Equipment

425.19 Disconnecting Means

Means shall be provided to simultaneously disconnect the heater, motor controller(s), and supplementary overcurrent protective device(s) of all fixed industrial process heating equipment from all ungrounded conductors. Where heating equipment is supplied by more than one source, feeder, or branch circuit, the disconnecting means shall be grouped and identified as having multiple disconnecting means. Each disconnecting means shall simultaneously disconnect all ungrounded conductors that it controls. The disconnecting means specified in 425.19(A) and (B) shall have an ampere rating not less than 125 percent of the total load of the motors and the heaters and shall be capable of being locked in the open position in compliance with 110.25.

(A) Heating Equipment With Supplementary Overcurrent Protection

The disconnecting means for fixed industrial process heating equipment with supplementary overcurrent protection shall be within sight from the supplementary overcurrent protective device(s), on the supply side of these devices, if fuses, and, in addition, shall comply with either 425.19(A)(1) or (A)(2).

(1) Heater Containing No Motor Rated over 1/8 Horsepower

The disconnecting means specified in 425.19 or unit switches complying with 425.19(C) shall be permitted to serve as the required disconnecting means for both the motor controller(s) and heater under either of the following conditions:

The disconnecting means provided is also within sight from the motor controller(s) and the heater.

The disconnecting means is capable of being locked in the open position in compliance with 110.25.

(2) Heater Containing a Motor(s) Rated over 1/8 Horsepower

The disconnecting means required by 425.19(A)(1) shall be permitted to serve as the required disconnecting means for both the motor controller(s) and heater under either of the following conditions:

The disconnecting means is in sight from the motor controller(s) and the heater and complies with Part IX of Article 430.

Motor(s) of more than 1/8 hp and the heater are provided with disconnecting means. The disconnecting means shall be permitted to be out of sight from the motor controller and shall be capable of being locked in the open position in compliance with 110.25.

(B) Heating Equipment Without Supplementary Overcurrent Protection

(1) Without Motor or with Motor Not over 1/8 Horsepower

For fixed industrial process heating equipment without a motor rated over 1/8 hp, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means where the switch or circuit breaker is within sight from the heater, shall be permitted to be out of sight from the motor controller, and shall be capable of being locked in the open position in compliance with 110.25.

(2) Over 1/8 Horsepower

For motor-driven fixed industrial process heating equipment with a motor rated over 1/8 hp, a disconnecting means shall be located within sight from the motor controller or shall be permitted to be out of sight from the motor controller and shall be capable of being locked in the open position in compliance with 110.25.

(C) Unit Switch(es) as Disconnecting Means

A unit switch(es) with a marked "off" position that is part of a fixed heater and disconnects all ungrounded conductors shall be permitted as the disconnecting means required by this article. The branch circuit switch or circuit breaker, where readily accessible for servicing of the fixed heater, shall be permitted as the other disconnecting means.

425.21 Switch and Circuit Breaker to Be Indicating

Switches and circuit breakers used as disconnecting means shall be of the indicating type.

425.22

(A) Branch-Circuit Devices

Fixed industrial process heating equipment other than such motor-operated equipment as required by Articles 430 and 440 to have additional overcurrent protection shall be permitted to be protected against overcurrent where supplied by one of the branch circuits in Article 210.

(B) Resistance Elements

Resistance-type heating elements in fixed industrial process heating equipment shall be protected at not more than 60 amperes. Equipment rated more than 48 amperes and employing such elements shall have the heating elements subdivided, and each subdivided load shall not exceed 48 amperes.

Resistance-type heating elements in fixed industrial process heating equipment shall be permitted to be subdivided into circuits not exceeding 120 amperes and protected at not more than 150 amperes where one of the following is met:

Elements are integral with and enclosed within a process heating surface.

Elements are completely contained within an enclosure identified as suitable for this use.

Elements are contained within an ASME-rated and stamped vessel.

Where a subdivided load is less than 48 amperes, the rating of the supplementary overcurrent protective device shall comply with 425.4(B). A boiler employing resistance-type immersion heating elements contained in an ASME-rated and stamped vessel shall be permitted to comply with 425.72(A).

(C) Overcurrent Protective Devices

The supplementary overcurrent protective devices for the subdivided loads specified in 425.22(B) shall be (1) factory installed within or on the heater enclosure or supplied for use with the heater as a separate assembly by the heater manufacturer; (2) accessible, but shall not be required to be readily accessible; and (3) suitable for branch-circuit protection.

Informational Note No. 1: See 240.10. Where cartridge fuses are used to provide this overcurrent protection, a single disconnecting means shall be permitted to be used for the several subdivided loads.

Informational Note No. 2: For supplementary overcurrent protection, see 240.10.

Informational Note No. 3: Disconnecting means for cartridge fuses in circuits of any voltage, see 240.40.

(D) Supplying Supplementary Overcurrent Protective Devices

The conductors supplying the supplementary overcurrent protective devices shall be considered branch-circuit conductors.

Where the heaters are rated 50 kW or more, the conductors supplying the supplementary overcurrent protective devices specified in 425.22(C) shall be permitted to be sized at not less than 100 percent of the nameplate rating of the heater, provided all of the following conditions are met:

The heater is marked with a minimum conductor size.

The conductors are not smaller than the marked minimum size.

A temperature-actuated device controls the cyclic operation of the equipment.

(E) Conductors for Subdivided Loads

Field-wired conductors between the heater and the supplementary overcurrent protective devices for fixed industrial process heating equipment shall be sized at not less than 125 percent of the load served. The supplementary overcurrent protective devices specified in 425.22(C) shall protect these conductors in accordance with 240.4. Where the heaters are rated 50 kW or more, the ampacity of field-wired conductors between the heater and the supplementary overcurrent protective devices shall be permitted to be not less than 100 percent of the load of their respective subdivided circuits, provided all of the following conditions are met:

The heater is marked with a minimum conductor size.

The conductors are not smaller than the marked minimum size.

A temperature-activated device controls the cyclic operation of the equipment.

Part IV Marking of Heating Equipment

425.28 Nameplate

(A) Marking Required

Fixed industrial process heating equipment shall be provided with a nameplate identifying the manufacturer and the rating in volts and watts or in volts and amperes.

Fixed industrial process heating equipment intended for use on alternating current only, direct current only, or both shall be marked to so indicate. The marking of equipment consisting of motors over 1/8 hp and other loads shall specify the rating of the motor in volts, amperes, and frequency and the heating load in volts and watts or in volts and amperes.

(B) Location

This nameplate shall be located so as to be permanent and shall be visible or accessible after installation.

425.29 Marking of Heating Elements

All heating elements that are replaceable in the field and are part of industrial process heating equipment shall be legibly marked with the ratings in volts and watts or in volts and amperes.

425.45 Concealed Fixed Industrial Heating Equipment — Inspection

Concealed fixed industrial heating equipment installations shall be made with due care to prevent damage to the heating equipment and shall be inspected and approved before heating equipment is covered or concealed.

Part V Fixed Industrial Process Duct Heaters

425.57 General

Part V shall apply to any heater mounted in the airstream of a forced-air system where the air-moving unit is not provided as an integral part of the equipment.

425.58 Identification

Heaters installed in an air duct shall be identified as suitable for the installation.

425.59 Airflow

Means shall be provided to ensure uniform airflow over the face of the heater in accordance with the manufacturer's instructions.

Informational Note: Some heaters installed within 1.2 m (4 ft) of the outlet of an air-moving device, elbows, baffle plates, or other obstructions in ductwork use turning vanes, pressure plates, or other devices on the inlet side of the duct heater to ensure an even distribution of air over the face of the heater.

425.60 Elevated Inlet Temperature

Duct heaters intended for use with elevated inlet air temperature shall be identified as suitable for use at the elevated temperatures.

425.63 Fan Circuit Interlock

Means shall be provided to ensure that the fan circuit, where present, is energized when any heater circuit is energized. However, time-or temperature-controlled delay in energizing the fan motor shall be permitted.

425.64 Limit Controls

Each duct heater shall be provided with an integral, automatic-reset temperature-limiting control or controllers to de-energize the circuit or circuits. In addition, an integral independent supplementary control or controllers shall be provided in each duct heater that disconnects a sufficient number of conductors to interrupt heating element current flow. This device shall be manually resettable or replaceable.

425.65 Location of Disconnecting Means

Duct heater controller equipment shall be either accessible with the disconnecting means installed at or within sight from the controller or as permitted by 425.19(A).

Part VI Fixed Industrial Process Resistance-Type Boilers

425.70 Scope

The provisions in Part VI of this article shall apply to boilers employing resistance-type heating elements. Electrode-type boilers shall not be considered as employing resistance-type heating elements. See Part VII of this article.

425.71 Identification

Resistance-type boilers shall be identified as suitable for the installation.

425.72 Overcurrent Protection

(A) Boiler Employing Resistance-Type Immersion Heating Elements in an ASME-Rated and Stamped Vessel

A boiler employing resistance-type immersion heating elements contained in an ASME-rated and stamped vessel shall have the heating elements protected at not more than 150 amperes. Such a boiler rated more than 120 amperes shall have the heating elements subdivided into loads not exceeding 120 amperes. Where a subdivided load is less than 120 amperes, the rating of the overcurrent protective device shall comply with 425.4(B).

(B) Boiler Employing Resistance-Type Heating Elements Rated More Than 48 Amperes and Not Contained in an ASME-Rated and Stamped Vessel

A boiler employing resistance-type heating elements not contained in an ASME-rated and stamped vessel shall have the heating elements protected at not more than 60 amperes. Such a boiler rated more than 48 amperes shall have the heating elements subdivided into loads not exceeding 48 amperes. Where a subdivided load is less than 48 amperes, the rating of the overcurrent protective device shall comply with 425.4(B).

(C) Supplementary Overcurrent Protective Devices

The supplementary overcurrent protective devices for the subdivided loads as required by 425.72(A) and (B) shall be as follows:

Factory-installed within or on the boiler enclosure or provided as a separate assembly by the boiler manufacturer.

Accessible, but need not be readily accessible.

(D) Suitable for Branch-Circuit Protection

Where cartridge fuses are used to provide this overcurrent protection, a single disconnecting means shall be permitted for the several subdivided circuits. See 240.40.

(E) Conductors Supplying Supplementary Overcurrent Protective Devices

The conductors supplying these supplementary overcurrent protective devices shall be considered branch-circuit conductors. Where the heaters are rated 50 kW or more, the conductors supplying the overcurrent protective device specified in 424.72(C) shall be permitted to be sized at not less than 100 percent of the nameplate rating of the heater, provided all of the following conditions are met:

The heater is marked with a minimum conductor size.

The conductors are not smaller than the marked minimum size.

A temperature-or pressure-actuated device controls the cyclic operation of the equipment.

(F) Conductors for Subdivided Loads

Field-wired conductors between the heater and the supplementary overcurrent protective devices shall be sized at not less than 125 percent of the load served. The supplementary overcurrent protective devices specified in 425.72(C) shall protect these conductors in accordance with 240.4. Where the heaters are rated 50 kW or more, the ampacity of field-wired conductors between the heater and the supplementary overcurrent protective devices shall be permitted to be not less than 100 percent of the load of their respective subdivided circuits, provided all of the following conditions are met:

The heater is marked with a minimum conductor size.

The conductors are not smaller than the marked minimum size.

A temperature-activated device controls the cyclic operation of the equipment.

425.73 Overtemperature Limit Control

Each boiler designed so that in normal operation there is no change in state of the heat transfer medium shall be equipped with a temperature-sensitive limiting means. It shall be installed to limit maximum liquid temperature and shall directly or indirectly disconnect all ungrounded conductors to the heating elements. Such means shall be in addition to a temperature-regulating system and other devices protecting the tank against excessive pressure.

425.74 Overpressure Limit Control

Each boiler designed so that in normal operation there is a change in state of the heat transfer medium from liquid to vapor shall be equipped with a pressure-sensitive limiting means. It shall be installed to limit maximum pressure and shall directly or indirectly disconnect all ungrounded conductors to the heating elements. Such means shall be in addition to a pressure-regulating system and other devices protecting the tank against excessive pressure.

Part VII Fixed Industrial Process Electrode-Type Boilers

425.80 Scope

The provisions in Part VII of this article shall apply to boilers for operation at 600 volts, nominal, or less, in which heat is generated by the passage of current between electrodes through the liquid being heated.

425.81 Identification

Electrode-type boilers shall be identified as suitable for the installation.

425.82 Branch-Circuit Requirements

The size of branch-circuit conductors and overcurrent protective devices shall be calculated on the basis of 125 percent of the total load (motors not included). A contactor, relay, or other device, listed for continuous operation at 100 percent of its rating, shall be permitted to supply its full-rated load. See 210.19(A)(1)(a), Exception No. 1. This section shall not apply to conductors that form an integral part of an approved boiler.

Where an electrode boiler is rated 50 kW or more, the conductors supplying the boiler electrode(s) shall be permitted to be sized at not less than 100 percent of the nameplate rating of the electrode boiler, provided all the following conditions are met:

The electrode boiler is marked with a minimum conductor size.

The conductors are not smaller than the marked minimum size.

A temperature- or pressure-actuated switch controls the cyclic operation of the equipment.

425.83 Overtemperature Limit Control

Each boiler, designed so that in normal operation there is no change in state of the heat transfer medium, shall be equipped with a temperature-sensitive limiting means. It shall be installed to limit maximum liquid temperature and shall directly or indirectly interrupt all current flow through the electrodes. Such means shall be in addition to the temperature regulating system and other devices protecting the tank against excessive pressure.

425.84 Overpressure Limit Control

Each boiler, designed so that in normal operation there is a change in state of the heat transfer medium from liquid to vapor, shall be equipped with a pressure-sensitive limiting means. It shall be installed to limit maximum pressure and shall directly or indirectly interrupt all current flow through the electrodes. Such means shall be in addition to a pressure-regulating system and other devices protecting the tank against excessive pressure.

425.85 Grounding

Boilers designed such that fault currents do not pass through the pressure vessel, and the pressure vessel is electrically isolated from the electrodes, all exposed non—current-carrying metal parts, including the pressure vessel, supply, and return connecting piping, shall be connected to the equipment grounding conductor. For all other designs, the pressure vessel containing the electrodes shall be isolated and electrically insulated from ground.

425.86 Markings

All electrode-type boilers shall be marked to show the following:

The manufacturer's name.

The rating in volts, amperes, and kilowatts.

The electrical supply required specifying frequency, number of phases, and number of wires.

The marking "Electrode-Type Process Heating Boiler."

A warning marking, "All Power Supplies Shall Be Disconnected Before Servicing, Including Servicing the Pressure Vessel."

A field-applied warning marking or label shall comply with 110.21(B). The markings shall be permanent and located so as to be visible after installation.

Article 426 Fixed Outdoor Electric Deicing and Snow-Melting Equipment

Part I General

426.1 Scope

This article covers fixed outdoor electric deicing and snow-melting equipment and the installation of these systems.

(A) Embedded

Embedded in driveways, walks, steps, and other areas.

(B) Exposed

Exposed on drainage systems, bridge structures, roofs, and other structures.

Informational Note: For further information, see ANSI/IEEE 515.1—2012, Standard for the Testing, Design, Installation and Maintenance of Electrical Resistance Trace Heating for Commercial Applications. Also see applicable sections of the IEEE 844/CSA 293 series of standards for fixed outdoor electric deicing and snow-melting equipment.

426.2 Definitions

The definitions in this section shall apply only within this article.

Heating System. A complete system consisting of components such as heating elements, fastening devices, nonheating circuit wiring, leads, temperature controllers, safety signs, junction boxes, raceways, and fittings.

Impedance Heating System. A system in which heat is generated in an object, such as a pipe, rod, or combination of such objects serving as a heating element, by causing current to flow through such objects by direct connection to an ac voltage source from an isolating transformer. In some installations the object is embedded in the surface to be heated or constitutes the exposed component to be heated.

Resistance Heating Element. A specific separate element to generate heat that is embedded in or fastened to the surface to be heated.

Informational Note: Tubular heaters, strip heaters, heating cable, heating tape, and heating panels are examples of resistance heaters.

Skin-Effect Heating System. A system in which heat is generated on the inner surface of a ferromagnetic envelope embedded in or fastened to the surface to be heated.

Informational Note: Typically, an electrically insulated conductor is routed through and connected to the envelope at the other end. The envelope and the electrically insulated conductor are connected to an ac voltage source from an isolating transformer.

426.3 Application of Other Articles

Cord-and-plug-connected fixed outdoor electric deicing and snow-melting equipment intended for specific use and identified as suitable for this use shall be installed according to Article 422.

426.4 Continuous Load

Fixed outdoor electric deicing and snow-melting equipment shall be considered a continuous load.

Part II Installation

426.10 General

Equipment for outdoor electric deicing and snow melting shall be identified as suitable for the environment and installed in accordance with the manufacturer's instructions.

426.11 Use

Electric heating equipment shall be installed in such a manner as to be afforded protection from physical damage.

426.12 Thermal Protection

External surfaces of outdoor electric deicing and snow-melting equipment that operate at temperatures exceeding 60°C (140°F) shall be physically guarded, isolated, or thermally insulated to protect against contact by personnel in the area.

426.13 Identification

The presence of outdoor electric deicing and snow-melting equipment shall be evident by the posting of appropriate caution signs or markings where clearly visible.

426.14 Special Permission

Fixed outdoor deicing and snow-melting equipment employing methods of construction or installation other than covered by this article shall be permitted only by special permission.

Part III Resistance Heating Elements

426.20 Embedded Deicing and Snow-Melting Equipment

(A) Watt Density

Panels or units shall not exceed 1300 watts/m2 (120 watts/ft2) of heated area.

(B) Spacing

The spacing between adjacent cable runs is dependent upon the rating of the cable and shall be not less than 25 mm (1 in.) on centers.

(C) Cover

Units, panels, or cables shall be installed as follows:

On a substantial concrete, masonry, or asphalt base at least 50 mm (2 in.) thick and have at least 38 mm (11/2 in.) of concrete, masonry, or asphalt applied over the units, panels, or cables; or

They shall be permitted to be installed over other identified bases and embedded within 90 mm (31/2 in.) of concrete, masonry, or asphalt but not less than 38 mm (11/2 in.) from the top surface; or

Equipment that has been listed for other forms of installation shall be installed only in the manner for which it has been identified.

(D) Secured

Cables, units, and panels shall be secured in place by frames or spreaders or other approved means while the concrete, masonry, or asphalt finish is applied.

(E) Expansion and Contraction

Cables, units, and panels shall not be installed where they bridge expansion joints unless provision is made for expansion and contraction.

426.21 Exposed Deicing and Snow-Melting Equipment

(A) Secured

Heating element assemblies shall be secured to the surface being heated by identified means.

(B) Overtemperature

Where the heating element is not in direct contact with the surface being heated, the design of the heater assembly shall be such that its temperature limitations shall not be exceeded.

(C) Expansion and Contraction

Heating elements and assemblies shall not be installed where they bridge expansion joints unless provision is made for expansion and contraction.

(D) Flexural Capability

Where installed on flexible structures, the heating elements and assemblies shall have a flexural capability that is compatible with the structure.

426.22 Installation of Nonheating Leads for Embedded Equipment

(A) Grounding Sheath or Braid

Except as permitted under 426.22(B), nonheating leads installed in concrete, masonry, or asphalt shall be provided with a grounding sheath or braid in accordance with 426.27 or shall be enclosed in rigid metal conduit, electrical metallic tubing, intermediate metal conduit, or other metal raceways.

(B) Splice Connections

The splice connection between the nonheating lead and heating element, within concrete, masonry, or asphalt, shall be located no less than 25 mm (1 in.) and no more than 150 mm (6 in.) from the metal raceway. The length of the nonheating lead from the metal raceway to the splice assembly shall be permitted to be provided without a grounding sheath or braid. Grounding continuity shall be maintained.

(C) Bushings

Insulating bushings shall be used in the concrete, masonry, or asphalt where the leads enter a metal raceway.

(D) Expansion and Contraction

Leads shall be protected in expansion joints in accordance with 300.4(H) or installed in accordance with the manufacturer's instructions.

(E) Emerging From Grade

Exposed nonheating leads shall be protected by raceways or other identified means.

(F) Leads in Junction Boxes

Not less than 150 mm (6 in.) of free nonheating lead shall be within the junction box.

426.23 Installation of Nonheating Leads for Exposed Equipment

(A) Nonheating Leads

Power supply nonheating leads (cold leads) for resistance elements shall be identified for the temperature encountered. Not less than 150 mm (6 in.) of nonheating leads shall be provided within the junction box. Preassembled factory-supplied and field-assembled nonheating leads on approved heaters shall be permitted to be shortened if the markings specified in 426.25 are retained.

(B) Protection

Nonheating power supply leads shall be enclosed in a rigid conduit, intermediate metal conduit, electrical metallic tubing, or other approved means.

426.24 Electrical Connection

(A) Heating Element Connections

Electrical connections, other than factory connections of heating elements to nonheating elements embedded in concrete, masonry, or asphalt or on exposed surfaces, shall be made with insulated connectors identified for the use.

(B) Circuit Connections

Splices and terminations at the end of the nonheating leads, other than the heating element end, shall be installed in a box or fitting in accordance with 110.14 and 300.15.

426.25 Marking

Each factory-assembled heating unit shall be legibly marked within 75 mm (3 in.) of each end of the nonheating leads with the permanent identification symbol, catalog number, and ratings in volts and watts or in volts and amperes.

426.26 Corrosion Protection

Ferrous and nonferrous metal raceways, cable armor, cable sheaths, boxes, fittings, supports, and support hardware shall be permitted to be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences, where made of material suitable for the condition, or where provided with corrosion protection identified as suitable for the condition.

426.27 Grounding Braid or Sheath

Grounding means, such as copper braid, metal sheath, or other approved means, shall be provided as part of the heated section of the cable, panel, or unit.

426.28 Ground-Fault Protection of Equipment

Ground-fault protection of equipment shall be provided for fixed outdoor electric deicing and snow-melting equipment.

Part IV Impedance Heating

426.30 Personnel Protection

Exposed elements of impedance heating systems shall be physically guarded, isolated, or thermally insulated with a weatherproof jacket to protect against contact by personnel in the area.

426.31 Isolation Transformer

An isolation transformer with a grounded shield between the primary and secondary windings shall be used to isolate the distribution system from the heating system.

426.32 Voltage Limitations

The secondary winding of the isolation transformer connected to the impedance heating elements shall not have an output voltage greater than 30 volts ac.

426.33 Induced Currents

All current-carrying components shall be installed in accordance with 300.20.

Part V Skin-Effect Heating

426.40 Conductor Ampacity

The current through the electrically insulated conductor inside the ferromagnetic envelope shall be permitted to exceed the ampacity values shown in Table 310.16, provided it is identified as suitable for this use.

426.41 Pull Boxes

Where pull boxes are used, they shall be accessible without excavation by location in suitable vaults or abovegrade. Outdoor pull boxes shall be of watertight construction.

426.42 Single Conductor in Enclosure

The provisions of 300.20 shall not apply to the installation of a single conductor in a ferromagnetic envelope (metal enclosure).

426.43 Corrosion Protection

Ferromagnetic envelopes, ferrous or nonferrous metal raceways, boxes, fittings, supports, and support hardware shall be permitted to be installed in concrete or in direct contact with the earth, or in areas subjected to severe corrosive influences, where made of material suitable for the condition, or where provided with corrosion protection identified as suitable for the condition. Corrosion protection shall maintain the original wall thickness of the ferromagnetic envelope.

426.44 Equipment Grounding Conductor

The ferromagnetic envelope shall be connected to an equipment grounding conductor at both ends; and, in addition, it shall be permitted to be connected to an equipment grounding conductor at intermediate points as required by its design.

Section 250.30 shall not apply to the installation of skin-effect heating systems.

Part VI Control and Protection

426.50 Disconnecting Means

(A) Disconnection

All fixed outdoor deicing and snow-melting equipment shall be provided with a means for simultaneous disconnection from all ungrounded conductors. Where readily accessible to the user of the equipment, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means. The disconnecting means shall be of the indicating type and be capable of being locked in the open (off) position.

(B) Cord-and-Plug-Connected Equipment

The factory-installed attachment plug of cord-and-plug-connected equipment rated 20 amperes or less and 150 volts or less to ground shall be permitted to be the disconnecting means.

426.51 Controllers

(A) Temperature Controller With "Off" Position

Temperature-controlled switching devices that indicate an "off" position and that interrupt line current shall open all ungrounded conductors when the control device is in the "off" position. These devices shall not be permitted to serve as the disconnecting means unless they are capable of being locked in the open position in compliance with 110.25.

(B) Temperature Controller Without "Off" Position

Temperature controlled switching devices that do not have an "off" position shall not be required to open all ungrounded conductors and shall not be permitted to serve as the disconnecting means.

(C) Remote Temperature Controller

Remote controlled temperature-actuated devices shall not be required to meet the requirements of 426.51(A). These devices shall not be permitted to serve as the disconnecting means.

(D) Combined Switching Devices

Switching devices consisting of combined temperature-actuated devices and manually controlled switches that serve both as the controller and the disconnecting means shall comply with all of the following conditions:

Open all ungrounded conductors when manually placed in the "off" position

Be so designed that the circuit cannot be energized automatically if the device has been manually placed in the "off" position

Be capable of being locked in the open position in compliance with 110.25

426.54 Cord-and-Plug-Connected Deicing and Snow-Melting Equipment

Cord-and-plug-connected deicing and snow-melting equipment shall be listed.

Article 427 Fixed Electric Heating Equipment for Pipelines and Vessels

Part I General

427.1 Scope

This article covers electrically energized heating systems and the installation of these systems used with pipelines and vessels.

Informational Note: For further information, see ANSI/IEEE 515-2017, Standard for the Testing, Design, Installation and Maintenance of Electrical Resistance Trace Heating for Industrial Applications.

Also see applicable sections of the IEEE 844/CSA 293 series of standards for alternate technologies for fixed electric heating equipment for pipelines and vessels.

427.2 Definitions

The definitions in this section shall apply only within this article.

Impedance Heating System. A system in which heat is generated in a pipeline or vessel wall by causing current to flow through the pipeline or vessel wall by direct connection to an ac voltage source from a dual-winding transformer.

Induction Heating System. A system in which heat is generated in a pipeline or vessel wall by inducing current and hysteresis effect in the pipeline or vessel wall from an external isolated ac field source.

Pipeline. A length of pipe including pumps, valves, flanges, control devices, strainers, and/or similar equipment for conveying fluids.

Resistance Heating Element. A specific separate element to generate heat that is applied to the pipeline or vessel externally or internally.

Informational Note: Tubular heaters, strip heaters, heating cable, heating tape, heating blankets, and immersion heaters are examples of resistance heaters.

Skin-Effect Heating System. A system in which heat is generated on the inner surface of a ferromagnetic envelope attached to a pipeline or vessel, or both.

Informational Note: Typically, an electrically insulated conductor is routed through and connected to the envelope at the other end. The envelope and the electrically insulated conductor are connected to an ac voltage source from a dual-winding transformer.

Vessel. A container such as a barrel, drum, or tank for holding fluids or other material.

427.3 Application of Other Articles

Cord-connected pipe heating assemblies intended for specific use and identified as suitable for this use shall be installed according to Article 422.

427.4 Continuous Load

Fixed electric heating equipment for pipelines and vessels shall be considered continuous load.

Part II Installation

427.10 General

Equipment for pipeline and vessel electric heating shall be identified as being suitable for (1) the chemical, thermal, and physical environment and (2) installation in accordance with the manufacturer's drawings and instructions.

427.11 Use

Electric heating equipment shall be installed in such a manner as to be afforded protection from physical damage.

427.12 Thermal Protection

External surfaces of pipeline and vessel heating equipment that operate at temperatures exceeding 60°C (140°F) shall be physically guarded, isolated, or thermally insulated to protect against contact by personnel in the area.

427.13 Identification

The presence of electrically heated pipelines, vessels, or both, shall be evident by the posting of appropriate caution signs or markings at intervals not exceeding 6 m (20 ft) along the pipeline or vessel and on or adjacent to equipment in the piping system that requires periodic servicing.

Part III Resistance Heating Elements

427.14 Secured

Heating element assemblies shall be secured to the surface being heated by means other than the thermal insulation.

427.15 Not in Direct Contact

Where the heating element is not in direct contact with the pipeline or vessel being heated, means shall be provided to prevent overtemperature of the heating element unless the design of the heating assembly is such that its temperature limitations will not be exceeded.

427.16 Expansion and Contraction

Heating elements and assemblies shall not be installed where they bridge expansion joints unless provisions are made for expansion and contraction.

427.17 Flexural Capability

Where installed on flexible pipelines, the heating elements and assemblies shall have a flexural capability that is compatible with the pipeline.

427.18 Power Supply Leads

(A) Nonheating Leads

Power supply nonheating leads (cold leads) for resistance elements shall be suitable for the temperature encountered. Not less than 150 mm (6 in.) of nonheating leads shall be provided within the junction box. Preassembled factory-supplied and field-assembled nonheating leads on approved heaters shall be permitted to be shortened if the markings specified in 427.20 are retained.

(B) Power Supply Leads Protection

Nonheating power supply leads shall be protected where they emerge from electrically heated pipeline or vessel heating units by rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or other raceways identified as suitable for the application.

(C) Interconnecting Leads

Interconnecting nonheating leads connecting portions of the heating system shall be permitted to be covered by thermal insulation in the same manner as the heaters.

427.19 Electrical Connections

(A) Nonheating Interconnections

Nonheating interconnections, where required under thermal insulation, shall be made with insulated connectors identified as suitable for this use.

(B) Circuit Connections

Splices and terminations outside the thermal insulation shall be installed in a box or fitting in accordance with 110.14 and 300.15.

427.20 Marking

Each factory-assembled heating unit shall be legibly marked within 75 mm (3 in.) of the termination end of all nonheating leads with the permanent identification symbol, catalog number, and ratings in volts and watts or in volts and amperes.

427.22 Ground-Fault Protection of Equipment

Ground-fault protection of equipment shall be provided for electric heat tracing and heating panels. This requirement shall not apply in industrial establishments where there is alarm indication of ground faults and the following conditions apply:

Conditions of maintenance and supervision ensure that only qualified persons service the installed systems.

Continued circuit operation is necessary for safe operation of equipment or processes.

427.23 Grounded Conductive Covering

Electric heating equipment shall be listed and have a grounded conductive covering in accordance with 427.23(A) or (B). The conductive covering shall provide an effective ground-fault current path for operation of ground-fault protection equipment.

(A) Heating Wires or Cables

Heating wires or cables shall have a grounded conductive covering that surrounds the heating element and bus wires, if any, and their electrical insulation.

(B) Heating Panels

Heating panels shall have a grounded conductive covering over the heating element and its electrical insulation on the side opposite the side attached to the surface to be heated.

Part IV Impedance Heating

427.25 Personnel Protection

All accessible external surfaces of the pipeline, vessel, or both, being heated shall be physically guarded, isolated, or thermally insulated (with a weatherproof jacket for outside installations) to protect against contact by personnel in the area.

427.26 Isolation Transformer

A dual-winding transformer with a grounded shield between the primary and secondary windings shall be used to isolate the distribution system from the heating system.

427.27 Voltage Limitations

The secondary winding of the isolation transformer connected to the pipeline or vessel being heated shall not have an output voltage greater than 30 volts ac.

Exception No. 1: In industrial establishments, the isolation transformer connected to the pipeline or vessel being heated shall be permitted to have an output voltage greater than 30 but not more than 80 volts ac to ground where all of the following conditions apply:

Conditions of guarding, maintenance, and supervision ensure that only qualified persons have access to the installed systems.

Ground-fault protection of equipment is provided.

Exception No. 2: In industrial establishments, the isolation transformer connected to the pipeline or vessel being heated shall be permitted to have an output voltage not greater than 132 volts ac to ground where all of the following conditions apply:

Conditions of guarding, maintenance, and supervision ensure that only qualified persons service the installed systems.

Ground-fault protection of equipment is provided.

The pipeline or vessel being heated is completely enclosed in a grounded metal enclosure.

The transformer secondary connections to the pipeline or vessel being heated are completely enclosed in a grounded metal mesh or metal enclosure.

427.28 Induced Currents

All current-carrying components shall be installed in accordance with 300.20.

427.29 Grounding

The pipeline, vessel, or both, that is being heated and operating at a voltage greater than 30 but not more than 80 shall be grounded at designated points.

427.30 Secondary Conductor Sizing

The ampacity of the conductors connected to the secondary of the transformer shall be at least 100 percent of the total load of the heater.

Part V Induction Heating

427.35 Scope

This part covers the installation of line frequency induction heating equipment and accessories for pipelines and vessels.

Informational Note: See Article 665 for other applications.

427.36 Personnel Protection

Induction coils that operate or may operate at a voltage greater than 30 volts ac shall be enclosed in a nonmetallic or split metallic enclosure, isolated, or made inaccessible by location to protect personnel in the area.

427.37 Induced Current

Induction coils shall be prevented from inducing circulating currents in surrounding metallic equipment, supports, or structures by shielding, isolation, or insulation of the current paths. Stray current paths shall be bonded to prevent arcing.

Part VI Skin-Effect Heating

427.45 Conductor Ampacity

The ampacity of the electrically insulated conductor inside the ferromagnetic envelope shall be permitted to exceed the values given in Table 310.16, provided it is identified as suitable for this use.

427.46 Pull Boxes

Pull boxes for pulling the electrically insulated conductor in the ferromagnetic envelope shall be permitted to be buried under the thermal insulation, provided their locations are indicated by permanent markings on the insulation jacket surface and on drawings. For outdoor installations, pull boxes shall be of watertight construction.

427.47 Single Conductor in Enclosure

The provisions of 300.20 shall not apply to the installation of a single conductor in a ferromagnetic envelope (metal enclosure).

427.48 Grounding

The ferromagnetic envelope shall be grounded at both ends, and, in addition, it shall be permitted to be grounded at intermediate points as required by its design. The ferromagnetic envelope shall be bonded at all joints to ensure electrical continuity.

The provisions of 250.30 shall not apply to the installation of skin-effect heating systems.

Informational Note: See Article 250 for grounding methods.

Part VII Control and Protection

427.55 Disconnecting Means

(A) Switch or Circuit Breaker

Means shall be provided to simultaneously disconnect all fixed electric pipeline or vessel heating equipment from all ungrounded conductors. The branch-circuit switch or circuit breaker, where readily accessible to the user of the equipment, shall be permitted to serve as the disconnecting means. The disconnecting means shall be of the indicating type and shall be capable of being locked in the open (off) position. The disconnecting means shall be installed in accordance with 110.25.

(B) Cord-and-Plug-Connected Equipment

The factory-installed attachment plug of cord-and-plug-connected equipment rated 20 amperes or less and 150 volts or less to ground shall be permitted to be the disconnecting means.

427.56 Controls

(A) Temperature Control With "Off" Position

Temperature-controlled switching devices that indicate an "off" position and that interrupt line current shall open all ungrounded conductors when the control device is in this "off" position. These devices shall not be permitted to serve as the disconnecting means unless capable of being locked in the open position.

(B) Temperature Control Without "Off" Position

Temperature controlled switching devices that do not have an "off" position shall not be required to open all ungrounded conductors and shall not be permitted to serve as the disconnecting means.

(C) Remote Temperature Controller

Remote controlled temperature-actuated devices shall not be required to meet the requirements of 427.56(A) and (B). These devices shall not be permitted to serve as the disconnecting means.

(D) Combined Switching Devices

Switching devices consisting of combined temperature-actuated devices and manually controlled switches that serve both as the controllers and the disconnecting means shall comply with all the following conditions:

Open all ungrounded conductors when manually placed in the "off" position

Be designed so that the circuit cannot be energized automatically if the device has been manually placed in the "off" position

Be capable of being locked in the open position

427.57 Overcurrent Protection

Heating equipment shall be considered protected against overcurrent where supplied by a branch circuit as specified in 210.20 and 210.24.

Article 430 Motors, Motor Circuits, and Controllers

Part I General

430.1 Scope

This article covers motors, motor branch-circuit and feeder conductors and their protection, motor overload protection, motor control circuits, motor controllers, and motor control centers.

Informational Note No. 1: Installation requirements for motor control centers are covered in 110.26(E). Air-conditioning and refrigerating equipment are covered in Article 440.

Informational Note No. 2: Figure 430.1 is for information only.

General, 430.1 through 430.18 Part I

Motor Circuit Conductors, 430.21 through 430.29 Part II

Motor and Branch-Circuit Overload Protection, 430.31 through 430.44 Part III

Motor Branch-Circuit Short-Circuit and Ground-Fault Protection, 430.51 through 430.58 Part IV

Motor Feeder Short-Circuit and Ground-Fault Protection, 430.61 through 430.63 Part V

Motor Control Circuits, 430.71 through 430.75 Part VI

Motor Controllers, 430.81 through 430.90 Part VII

Motor Control Centers, 430.92 through 430.99 Part VIII

Disconnecting Means, 430.101 through 430.113 Part IX

Adjustable-Speed Drive Systems, 430.120 through 430.131 Part X

Over 1000 Volts, Nominal, 430.221 through 430.227 Part XI

Protection of Live Parts—All Voltages, 430.231 through 430.233 Part XII

Grounding—All Voltages, 430.241 through 430.246 Part XIII

Tables, Tables 430.247 through 430.252 Part XIV

FIGURE 430.1 Article 430 Contents.

430.2 Definitions

The definitions in this section shall apply only within this article.

Controller. Any switch or device that is normally used to start and stop a motor by making and breaking the motor circuit current.

Electronically Protected (as applied to motors). A motor that is provided with electronic control that is an integral part of the motor and protects the motor against dangerous overheating due to failure of the electronic control, overload and failure to start.

Part-Winding Motors. A part-winding start induction or synchronous motor is one that is arranged for starting by first energizing part of its primary (armature) winding and, subsequently, energizing the remainder of this winding in one or more steps. A standard part-winding start induction motor is arranged so that one-half of its primary winding can be energized initially, and, subsequently, the remaining half can be energized, both halves then carrying equal current.

Informational Note: A hermetic refrigerant motor-compressor is not considered a standard part-winding start induction motor.

System Isolation Equipment. A redundantly monitored, remotely operated contactor-isolating system, packaged to provide the disconnection/isolation function, capable of verifiable operation from multiple remote locations by means of lockout switches, each having the capability of being padlocked in the "off' (open) position.

Valve Actuator Motor (VAM) Assemblies. A manufactured assembly, used to operate a valve, consisting of an actuator motor and other components such as controllers, torque switches, limit switches, and overload protection.

Informational Note: VAMs typically have short-time duty and high-torque characteristics.

430.4 Part-Winding Motors

Where separate overload devices are used with a standard part-winding start induction motor, each half of the motor winding shall be individually protected in accordance with 430.32 and 430.37 with a trip current one-half that specified.

Each motor-winding connection shall have branch-circuit short-circuit and ground-fault protection rated at not more than one-half that specified by 430.52.

Exception: A short-circuit and ground-fault protective device shall be permitted for both windings if the device will allow the motor to start. Where time-delay (dual-element) fuses are used, they shall be permitted to have a rating not exceeding 150 percent of the motor full-load current.

430.5 Other Articles

Motors and controllers shall also comply with the applicable provisions of Table 430.5.

Table 430.5 Other Articles

Equipment/Occupancy Article Section

Air-conditioning and refrigerating equipment 440

Capacitors 460.8, 460.9

Commercial garages; aircraft hangars; motor fuel dispensing facilities; bulk storage plants; spray application, dipping, and coating processes; and inhalation anesthetizing locations 511, 513, 514, 515, 516, and 517 Part IV

Cranes and hoists 610

Electrically driven or controlled irrigation machines 675

Elevators, dumbwaiters, escalators, moving walks, wheelchair lifts, and stairway chair lifts 620

Fire pumps 695

Hazardous (classified) locations 500—503, 505, and 506

Industrial machinery 670

Motion picture projectors 540.11 and 540.20

Motion picture and television studios and similar locations 530

Resistors and reactors 470

Theaters, audience areas of motion picture and television studios, and similar locations 520.48

Transformers and transformer vaults 450

430.6 Ampacity and Motor Rating Determination

The size of conductors supplying equipment covered by Article 430 shall be selected from the ampacity tables in accordance with 310.15 or shall be calculated in accordance with 310.14(B). Where flexible cord is used, the size of the conductor shall be selected in accordance with 400.5. The required ampacity and motor ratings shall be determined as specified in 430.6(A), (B), (C), and (D).

(A) General Motor Applications

For general motor applications, current ratings shall be determined based on 430.6(A)(1) and (A)(2).

(1) Table Values

Other than for motors built for low speeds (less than 1200 RPM) or high torques, and for multispeed motors, the values given in Table 430.247, Table 430.248, Table 430.249, and Table 430.250 shall be used to determine the ampacity of conductors or ampere ratings of switches, branch-circuit short-circuit and ground-fault protection, instead of the actual current rating marked on the motor nameplate. Where a motor is marked in amperes, but not horsepower, the horsepower rating shall be assumed to be that corresponding to the value given in Table 430.247, Table 430.248, Table 430.249, and Table 430.250, interpolated if necessary. Motors built for low speeds (less than 1200 RPM) or high torques may have higher full-load currents, and multispeed motors will have full-load current varying with speed, in which case the nameplate current ratings shall be used.

Exception No. 1: Multispeed motors shall be in accordance with 430.22(B) and 430.52.

Exception No. 2: For equipment that employs a shaded-pole or permanent-split capacitor-type fan or blower motor that is marked with the motor type, the full load current for such motor marked on the nameplate of the equipment in which the fan or blower motor is employed shall be used instead of the horsepower rating to determine the ampacity or rating of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground-fault protection, and the separate overload protection. This marking on the equipment nameplate shall not be less than the current marked on the fan or blower motor nameplate.

Exception No. 3: For a listed motor-operated appliance that is marked with both motor horsepower and full-load current, the motor full-load current marked on the nameplate of the appliance shall be used instead of the horsepower rating on the appliance nameplate to determine the ampacity or rating of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground-fault protection, and any separate overload protection.

(2) Nameplate Values

Separate motor overload protection shall be based on the motor nameplate current rating.

(B) Torque Motors

For torque motors, the rated current shall be locked-rotor current, and this nameplate current shall be used to determine the ampacity of the branch-circuit conductors covered in 430.22 and 430.24, the ampere rating of the motor overload protection, and the ampere rating of motor branch-circuit short-circuit and ground-fault protection in accordance with 430.52(B).

Informational Note: For motor controllers and disconnecting means, see 430.83(D) and 430.110.

(C) Alternating-Current Adjustable Voltage Motors

For motors used in alternating-current, adjustable voltage, variable torque drive systems, the ampacity of conductors, or ampere ratings of switches, branch-circuit short-circuit and ground-fault protection, and so forth, shall be based on the maximum operating current marked on the motor or control nameplate, or both. If the maximum operating current does not appear on the nameplate, the ampacity determination shall be based on 150 percent of the values given in Table 430.249 and Table 430.250.

(D) Valve Actuator Motor Assemblies

For valve actuator motor assemblies (VAMs), the rated current shall be the nameplate full-load current, and this current shall be used to determine the maximum rating or setting of the motor branch-circuit short-circuit and ground-fault protective device and the ampacity of the conductors.

430.7 Marking on Motors and Multimotor Equipment

(A) Usual Motor Applications

A motor shall be marked with the following information:

Manufacturer's name.

Rated volts and full-load current. For a multispeed motor, full-load current for each speed, except shaded-pole and permanent-split capacitor motors where amperes are required only for maximum speed.

Rated frequency and number of phases if an ac motor.

Rated full-load speed.

Rated temperature rise or the insulation system class and rated ambient temperature.

Time rating. The time rating shall be 5, 15, 30, or 60 minutes, or continuous.

Rated horsepower if 1/8 hp or more. For a multispeed motor 1/8 hp or more, rated horsepower for each speed, except shaded-pole and permanent-split capacitor motors 1/8 hp or more where rated horsepower is required only for maximum speed. Motors of arc welders are not required to be marked with the horsepower rating.

Code letter or locked-rotor amperes if an alternating-current motor rated 1/2 hp or more. On polyphase wound-rotor motors, the code letter shall be omitted.

Informational Note: See 430.7(B).

Design letter for design B, C, or D motors.

Informational Note: Motor design letter definitions are found in ANSI/NEMA MG 1-1993, Motors and Generators, Part 1, Definitions, and in IEEE 100-1996, Standard Dictionary of Electrical and Electronic Terms.

Secondary volts and full-load current if a wound-rotor induction motor.

Field current and voltage for dc excited synchronous motors.

Winding — straight shunt, stabilized shunt, compound, or series, if a dc motor. Fractional horsepower dc motors 175 mm (7 in.) or less in diameter shall not be required to be marked.

A motor provided with a thermal protector complying with 430.32(A)(2) or (B)(2) shall be marked "thermally protected." Thermally protected motors rated 100 watts or less and complying with 430.32(B)(2) shall be permitted to use the abbreviated marking "T.P."

A motor complying with 430.32(B)(4) shall be marked "impedance protected." Impedance-protected motors rated 100 watts or less and complying with 430.32(B)(4) shall be permitted to use the abbreviated marking "Z.P."

Motors equipped with electrically powered condensation prevention heaters shall be marked with the rated heater voltage, number of phases, and the rated power in watts.

Motors that are electronically protected from overloads in accordance with 430.32(A)(2) and (B)(2) shall be marked "electronically protected" or "E.P."

(B) Locked-Rotor Indicating Code Letters

Code letters marked on motor nameplates to show motor input with locked rotor shall be in accordance with Table 430.7(B).

The code letter indicating motor input with locked rotor shall be in an individual block on the nameplate, properly designated.

Table 430.7(B) Locked-Rotor Indicating Code Letters

Code Letter Kilovolt-Amperes per Horsepower with Locked Rotor

A 0—3.14

B 3.15—3.54

C 3.55—3.99

D 4.0—4.49

E 4.5—4.99

F 5.0—5.59

G 5.6—6.29

H 6.3—7.09

J 7.1—7.99

K 8.0—8.99

L 9.0—9.99

M 10.0—11.19

N 11.2—12.49

P 12.5—13.99

R 14.0—15.99

S 16.0—17.99

T 18.0—19.99

U 20.0—22.39

V 22.4 and up

(1) Multispeed Motors

Multispeed motors shall be marked with the code letter designating the locked-rotor kilovolt-ampere (kVA) per horsepower (hp) for the highest speed at which the motor can be started.

Exception: Constant horsepower multispeed motors shall be marked with the code letter giving the highest locked-rotor kilovolt-ampere (kVA) per horsepower (hp).

(2) Single-Speed Motors

Single-speed motors starting on wye connection and running on delta connections shall be marked with a code letter corresponding to the locked-rotor kilovolt-ampere (kVA) per horsepower (hp) for the wye connection.

(3) Dual-Voltage Motors

Dual-voltage motors that have a different locked-rotor kilovolt-ampere (kVA) per horsepower (hp) on the two voltages shall be marked with the code letter for the voltage giving the highest locked-rotor kilovolt-ampere (kVA) per horsepower (hp).

(4) 50/60 Hz Motors

Motors with 50-and 60-Hz ratings shall be marked with a code letter designating the locked-rotor kilovolt-ampere (kVA) per horsepower (hp) on 60 Hz.

(5) Part-Winding Motors

Part-winding start motors shall be marked with a code letter designating the locked-rotor kilovoltampere (kVA) per horsepower (hp) that is based on the locked-rotor current for the full winding of the motor.

(C) Torque Motors

Torque motors are rated for operation at standstill and shall be marked in accordance with 430.7(A), except that locked-rotor torque shall replace horsepower.

(D) Multimotor and Combination-Load Equipment

(1) Factory-Wired

Multimotor and combination-load equipment shall be provided with a visible nameplate marked with the manufacturer's name, the rating in volts, frequency, number of phases, minimum supply circuit conductor ampacity, and the maximum ampere rating of the circuit short-circuit and ground-fault protective device. The conductor ampacity shall be calculated in accordance with 430.24 and counting all of the motors and other loads that will be operated at the same time. The short-circuit and ground-fault protective device rating shall not exceed the value calculated in accordance with 430.53. Multimotor equipment for use on two or more circuits shall be marked with the preceding information for each circuit.

(2) Not Factory-Wired

Where the equipment is not factory-wired and the individual nameplates of motors and other loads are visible after assembly of the equipment, the individual nameplates shall be permitted to serve as the required marking.

430.8 Marking on Controllers

A controller shall be marked with the manufacturer's name or identification, the voltage, the current or horsepower rating, the short-circuit current rating, and other necessary data to properly indicate the applications for which it is suitable.

Exception No. 1: The short-circuit current rating is not required for controllers applied in accordance with 430.81(A) or (B).

Exception No. 2: The short-circuit rating is not required to be marked on the controller when the short-circuit current rating of the controller is marked elsewhere on the assembly.

Exception No. 3: The short-circuit rating is not required to be marked on the controller when the assembly into which it is installed has a marked short-circuit current rating.

Exception No. 4: Short-circuit ratings are not required for controllers rated less than 2 hp at 300 V or less and listed exclusively for generalpurpose branch circuits.

A controller that includes motor overload protection suitable for group motor application shall be marked with the motor overload protection and the maximum branch-circuit short-circuit and ground-fault protection for such applications.

Combination controllers that employ adjustable instantaneous trip circuit breakers shall be clearly marked to indicate the ampere settings of the adjustable trip element.

Where a controller is built in as an integral part of a motor or of a motor-generator set, individual marking of the controller shall not be required if the necessary data are on the nameplate. For controllers that are an integral part of equipment approved as a unit, the above marking shall be permitted on the equipment nameplate.

Informational Note: See 110.10 for information on circuit impedance and other characteristics.

430.9 Terminals

(A) Markings

Terminals of motors and controllers shall be suitably marked or colored where necessary to indicate the proper connections.

(B) Conductors

Motor controllers and terminals of control circuit devices shall be connected with copper conductors unless identified for use with a different conductor.

(C) Torque Requirements

Control circuit devices with screw-type pressure terminals used with 14 AWG or smaller copper conductors shall be torqued to a minimum of 0.8 N•m (7 lb-in.) unless identified for a different torque value.

430.10 Wiring Space in Enclosures

(A) General

Enclosures for motor controllers and disconnecting means shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to the other apparatus unless designs are employed that provide adequate space for this purpose.

Informational Note: See 312.8 for switch and overcurrent-device enclosures.

(B) Wire-Bending Space in Enclosures

Minimum wirebending space within the enclosures for motor controllers shall be in accordance with Table 430.10(B) where measured in a straight line from the end of the lug or wire connector (in the direction the wire leaves the terminal) to the wall or barrier. Where alternate wire termination means are substituted for that supplied by the manufacturer of the controller, they shall be of a type identified by the manufacturer for use with the controller and shall not reduce the minimum wire-bending space.

Table 430.10(B) Minimum Wire-Bending Space at the Terminals of Enclosed Motor Controllers

Size of Wire (AWG or kcmil) Wires per Terminal\*

1 2

mm in. mm in.

10 and smaller Not specified — —

8—6 38 11/2 — —

4—3 50 2 — —

2 65 21/2 — —

1 75 3 — —

1/0 125 5 125 5

2/0 150 6 150 6

3/0—4/0 175 7 175 7

250 200 8 200 8

300 250 10 250 10

350—500 300 12 300 12

600—700 350 14 400 16

750—900 450 18 475 19

\*Where provision for three or more wires per terminal exists, the minimum wire-bending space shall be in accordance with the requirements of Article 312.

430.11 Protection Against Liquids

Suitable guards or enclosures shall be provided to protect exposed current-carrying parts of motors and the insulation of motor leads where installed directly under equipment, or in other locations where dripping or spraying oil, water, or other liquid is capable of occurring, unless the motor is designed for the existing conditions.

430.12 Motor Terminal Housings

(A) Material

Where motors are provided with terminal housings, the housings shall be of metal and of substantial construction.

Exception: In other than hazardous (classified) locations, substantial, nonmetallic, noncombustible housings shall be permitted, provided an internal grounding means between the motor frame and the equipment grounding connection is incorporated within the housing.

(B) Dimensions and Space — Wire-to-Wire Connections

Where these terminal housings enclose wire-to-wire connections, they shall have minimum dimensions and usable volumes in accordance with Table 430.12(B).

Table 430.12(B) Terminal Housings — Wire-to-Wire Connections

Motors 275 mm (11 in.) in Diameter or Less

Horsepower Cover Opening Minimum Dimension Usable Volume Minimum

mm in. cm3 in.3

1 and smallera 41 15/8 170 10.5

11/2, 2, and 3b 45 13/4 275 16.8

5 and 71/2 50 2 365 22.4

10 and 15 65 21/2 595 36.4

Motors Over 275 mm (11 in.) in Diameter — Alternating-Current Motors

Maximum Full Load Current for 3-Phase Motors with Maximum of 12 Leads (Amperes) Terminal Box Cover Opening Minimum Dimension Usable Volume Minimum Typical Maximum Horsepower 3-Phase

mm in. cm3 in.3 230 Volt 460 Volt

45 65 2.5 595 36.4 15 30

70 84 3.3 1,265 77 25 50

110 100 4.0 2,295 140 40 75

160 125 5.0 4,135 252 60 125

250 150 6.0 7,380 450 100 200

400 175 7.0 13,775 840 150 300

600 200 8.0 25,255 1540 250 500

Direct-Current Motors

Maximum Full-Load Current for Motors with Maximum of 6 Leads (Amperes) Terminal Box Minimum Dimensions Usable Volume Minimum

mm in. cm3 in.3

68 65 2.5 425 26

105 84 3.3 900 55

165 100 4.0 1,640 100

240 125 5.0 2,950 180

375 150 6.0 5,410 330

600 175 7.0 9,840 600

900 200 8.0 18,040 1,100

Note: Auxiliary leads for such items as brakes, thermostats, space heaters, and exciting fields shall be permitted to be neglected if their current-carrying area does not exceed 25 percent of the current-carrying area of the machine power leads.

aFor motors rated 1 hp and smaller, and with the terminal housing partially or wholly integral with the frame or end shield, the volume of the terminal housing shall not be less than 18.0 cm3 (1.1 in.3) per wire-to-wire connection. The minimum cover opening dimension is not specified.

bFor motors rated 11/2, 2, and 3 hp, and with the terminal housing partially or wholly integral with the frame or end shield, the volume of the terminal housing shall not be less than 23.0 cm3 (1.4 in.3) per wire-to-wire connection. The minimum cover opening dimension is not specified.

(C) Dimensions and Space — Fixed Terminal Connections

Where these terminal housings enclose rigidly mounted motor terminals, the terminal housing shall be of sufficient size to provide minimum terminal spacings and usable volumes in accordance with Table 430.12(C)(1) and Table 430.12(C)(2).

Table 430.12(C)(1) Terminal Spacings — Fixed Terminals

Nominal Volts Minimum Spacing

Between Line Terminals Between Line Terminals and Other Uninsulated Metal Parts

mm in. mm in.

250 or less 6 1/4 6 1/4

Over 250 — 1000 10 3/8 10 3/8

Table 430.12(C)(2) Usable Volumes — Fixed Terminals

Power-Supply Conductor Size (AWG) Minimum Usable Volume per Power-Supply Conductor

cm3 in.3

14 16 1

12 and 10 20 11/4

8 and 6 37 21/4

(D) Large Wire or Factory Connections

For motors with larger ratings, greater number of leads, or larger wire sizes, or where motors are installed as a part of factory-wired equipment, without additional connection being required at the motor terminal housing during equipment installation, the terminal housing shall be of ample size to make connections, but the foregoing provisions for the volumes of terminal housings shall not be considered applicable.

(E) Equipment Grounding Connections

A means for attachment of an equipment grounding conductor termination in accordance with 250.8 shall be provided at motor terminal housings for wire-to-wire connections or fixed terminal connections. The means for such connections shall be permitted to be located either inside or outside the motor terminal housing.

Exception: Where a motor is installed as a part of factory-wired equipment that is required to be grounded and without additional connection being required at the motor terminal housing during equipment installation, a separate means for motor grounding at the motor terminal housing shall not be required.

430.13 Bushing

Where wires pass through an opening in an enclosure, conduit box, or barrier, a bushing shall be used to protect the conductors from the edges of openings having sharp edges. The bushing shall have smooth, well-rounded surfaces where it may be in contact with the conductors. If used where oils, greases, or other contaminants may be present, the bushing shall be made of material not deleteriously affected.

Informational Note: For conductors exposed to deteriorating agents, see 310.10(F).

430.14 Location of Motors

(A) Ventilation and Maintenance

Motors shall be located so that adequate ventilation is provided and so that maintenance, such as lubrication of bearings and replacing of brushes, can be readily accomplished.

Exception: Ventilation shall not be required for submersible types of motors.

(B) Open Motors

Open motors that have commutators or collector rings shall be located or protected so that sparks cannot reach adjacent combustible material.

Exception: Installation of these motors on wooden floors or supports shall be permitted.

430.16 Exposure to Dust Accumulations

In locations where dust or flying material collects on or in motors in such quantities as to seriously interfere with the ventilation or cooling of motors and thereby cause dangerous temperatures, suitable types of enclosed motors that do not overheat under the prevailing conditions shall be used.

Informational Note: Especially severe conditions may require the use of enclosed pipe-ventilated motors, or enclosure in separate dusttight rooms, properly ventilated from a source of clean air.

430.17 Highest Rated or Smallest Rated Motor

In determining compliance with 430.24, 430.53(B), and 430.53(C), the highest rated or smallest rated motor shall be based on the rated full-load current as selected from Table 430.247, Table 430.248, Table 430.249, and Table 430.250.

430.18 Nominal Voltage of Rectifier Systems

The nominal value of the ac voltage being rectified shall be used to determine the voltage of a rectifier derived system.

Exception: The nominal dc voltage of the rectifier shall be used if it exceeds the peak value of the ac voltage being rectified.

Part II Motor Circuit Conductors

430.21 General

Part II specifies ampacities of conductors that are capable of carrying the motor current without overheating under the conditions specified.

Part II shall not apply to motor circuits rated over 1000 volts, nominal.

Informational Note: For over 1000 volts, nominal, see Part XI.

Articles 250, 300, and 310 shall not apply to conductors that form an integral part of equipment, such as motors, motor controllers, motor control centers, or other factory-assembled control equipment.

Informational Note: See 110.14(C) and 430.9(B) for equipment device terminal requirements.

430.22 Single Motor

Conductors that supply a single motor used in a continuous duty application shall have an ampacity of not less than 125 percent of the motor full-load current rating, as determined by 430.6(A)(1), or not less than specified in 430.22(A) through (G).

(A) Direct-Current Motor-Rectifier Supplied

For dc motors operating from a rectified power supply, the conductor ampacity on the input of the rectifier shall not be less than 125 percent of the rated input current to the rectifier. For dc motors operating from a rectified single-phase power supply, the conductors between the field wiring output terminals of the rectifier and the motor shall have an ampacity of not less than the following percentages of the motor full-load current rating:

Where a rectifier bridge of the single-phase, half-wave type is used, 190 percent.

Where a rectifier bridge of the single-phase, full-wave type is used, 150 percent.

(B) Multispeed Motor

For a multispeed motor, the selection of branch-circuit conductors on the line side of the controller shall be based on the highest of the full-load current ratings shown on the motor nameplate. The ampacity of the branch-circuit conductors between the controller and the motor shall not be less than 125 percent of the current rating of the winding(s) that the conductors energize.

(C) Wye-Start, Delta-Run Motor

For a wye-start, delta-run connected motor, the ampacity of the branch-circuit conductors on the line side of the controller shall not be less than 125 percent of the motor full-load current as determined by 430.6(A)(1). The ampacity of the conductors between the controller and the motor shall not be less than 72 percent of the motor full-load current rating as determined by 430.6(A)(1).

Informational Note: The individual motor circuit conductors of a wye-start, delta-run connected motor carry 58 percent of the rated load current. The multiplier of 72 percent is obtained by multiplying 58 percent by 1.25.

(D) Part-Winding Motor

For a part-winding connected motor, the ampacity of the branch-circuit conductors on the line side of the controller shall not be less than 125 percent of the motor full-load current as determined by 430.6(A)(1). The ampacity of the conductors between the controller and the motor shall not be less than 62.5 percent of the motor full-load current rating as determined by 430.6(A)(1).

Informational Note: The multiplier of 62.5 percent is obtained by multiplying 50 percent by 1.25.

(E) Other Than Continuous Duty

Conductors for a motor used in a short-time, intermittent, periodic, or varying duty application shall have an ampacity of not less than the percentage of the motor nameplate current rating shown in Table 430.22(E), unless the authority having jurisdiction grants special permission for conductors of lower ampacity.

Table 430.22(E) Duty-Cycle Service

Classification of Service Nameplate Current Rating Percentages

5-Minute Rated Motor 15-Minute Rated Motor 30- & 60-Minute Rated Motor Continuous Rated Motor

Short-time duty operating valves, raising or lowering rolls, etc. 110 120 150 —

Intermittent duty freight and passenger elevators, tool heads, pumps, drawbridges, turntables, etc. (for arc welders, see 630.11) 85 85 90 140

Periodic duty rolls, ore- and coal-handling machines, etc. 85 90 95 140

Varying duty 110 120 150 200

Note: Any motor application shall be considered as continuous duty unless the nature of the apparatus it drives is such that the motor will not operate continuously with load under any condition of use.

(F) Separate Terminal Enclosure

The conductors between a stationary motor rated 1 hp or less and the separate terminal enclosure permitted in 430.245(B) shall be permitted to be smaller than 14 AWG but not smaller than 18 AWG, provided they have an ampacity as specified in 430.22.

(G) Conductors for Small Motors

Conductors for small motors shall not be smaller than 14 AWG unless otherwise permitted in 430.22(G)(1) or (G)(2).

(1) 18 AWG Copper

18 AWG individual copper conductors installed in a cabinet or enclosure, copper conductors that are part of a jacketed multiconductor cable assembly, or copper conductors in a flexible cord shall be permitted, under either of the following sets of conditions:

The circuit supplies a motor with a full-load current rating, as determined by 430.6(A)(1), of greater than 3.5 amperes, and less than or equal to 5 amperes, and all the following conditions are met:

The circuit is protected in accordance with 430.52.

The circuit is provided with maximum Class 10 or Class 10A overload protection in accordance with 430.32.

Overcurrent protection is provided in accordance with 240.4(D)(1)(2).

The circuit supplies a motor with a full-load current rating, as determined by 430.6(A)(1), of 3.5 amperes or less, and all the following conditions are met:

The circuit is protected in accordance with 430.52.

The circuit is provided with maximum Class 20 overload protection in accordance with 430.32.

Overcurrent protection is provided in accordance with 240.4(D)(1)(2).

(2) 16 AWG Copper

16 AWG individual copper conductors installed in a cabinet or enclosure, copper conductors that are part of a jacketed multiconductor cable assembly, or copper conductors in a flexible cord shall be permitted under either of the following sets of conditions:

The circuit supplies a motor with a full-load current rating, as determined by 430.6(A)(1), of greater than 5.5 amperes, and less than or equal to 8 amperes, and all the following conditions are met:

The circuit is protected in accordance with 430.52.

The circuit is provided with maximum Class 10 or Class 10A overload protection in accordance with 430.32.

Overcurrent protection is provided in accordance with 240.4(D)(2)(2).

The circuit supplies a motor with a full-load current rating, as determined by 430.6(A)(1), of 5.5 amperes or less, and all the following conditions are met:

The circuit is protected in accordance with 430.52.

The circuit is provided with maximum Class 20 overload protection in accordance with 430.32.

Overcurrent protection is provided in accordance with 240.4(D)(2)(2).

430.23 Wound-Rotor Secondary

(A) Continuous Duty

For continuous duty, the conductors connecting the secondary of a wound-rotor ac motor to its controller shall have an ampacity not less than 125 percent of the full-load secondary current of the motor.

(B) Other Than Continuous Duty

For other than continuous duty, these conductors shall have an ampacity, in percent of full-load secondary current, not less than that specified in Table 430.22(E).

(C) Resistor Separate From Controller

Where the secondary resistor is separate from the controller, the ampacity of the conductors between controller and resistor shall not be less than that shown in Table 430.23(C).

Table 430.23(C) Secondary Conductor

Resistor Duty Classification Ampacity of Conductor in Percent of Full-Load Secondary Current

Light starting duty 35

Heavy starting duty 45

Extra-heavy starting duty 55

Light intermittent duty 65

Medium intermittent duty 75

Heavy intermittent duty 85

Continuous duty 110

430.24 Several Motors or a Motor(s) and Other Load(s)

Conductors supplying several motors, or a motor(s) and other load(s), shall have an ampacity not less than the sum of each of the following:

125 percent of the full-load current rating of the highest rated motor, as determined by 430.6(A)

Sum of the full-load current ratings of all the other motors in the group, as determined by 430.6(A)

100 percent of the noncontinuous non-motor load

125 percent of the continuous non-motor load.

Informational Note: See Informative Annex D, Example No. D8.

Exception No. 1: Where one or more of the motors of the group are used for short-time, intermittent, periodic, or varying duty, the ampere rating of such motors to be used in the summation shall be determined in accordance with 430.22(E). For the highest rated motor, the greater of either the ampere rating from 430.22(E) or the largest continuous duty motor full-load current multiplied by 1.25 shall be used in the summation.

Exception No. 2: The ampacity of conductors supplying motor-operated fixed electric space-heating equipment shall comply with 424.4(B).

Exception No. 3: Where the circuitry is interlocked so as to prevent simultaneous operation of selected motors or other loads, the conductor ampacity shall be permitted to be based on the summation of the currents of the motors and other loads to be operated simultaneously that results in the highest total current.

430.25 Multimotor and Combination-Load Equipment

The ampacity of the conductors supplying multimotor and combination-load equipment shall not be less than the minimum circuit ampacity marked on the equipment in accordance with 430.7(D). Where the equipment is not factory-wired and the individual nameplates are visible in accordance with 430.7(D)(2), the conductor ampacity shall be determined in accordance with 430.24.

430.26 Feeder Demand Factor

Where reduced heating of the conductors results from motors operating on duty-cycle, intermittently, or from all motors not operating at one time, the authority having jurisdiction may grant permission for feeder conductors to have an ampacity less than specified in 430.24, provided the conductors have sufficient ampacity for the maximum load determined in accordance with the sizes and number of motors supplied and the character of their loads and duties.

Informational Note: Demand factors determined in the design of new facilities can often be validated against actual historical experience from similar installations.

430.27 Capacitors With Motors

Where capacitors are installed in motor circuits, conductors shall comply with 460.8 and 460.9.

430.28 Feeder Taps

Feeder tap conductors shall have an ampacity not less than that required by Part II, shall terminate in a branch-circuit protective device, and, in addition, shall meet one of the following requirements:

Be enclosed either by an enclosed controller or by a raceway, be not more than 3.0 m (10 ft) in length, and, for field installation, be protected by an overcurrent device on the line side of the tap conductor, the rating or setting of which shall not exceed 1000 percent of the tap conductor ampacity

Have an ampacity of at least one-third that of the feeder conductors, be suitably protected from physical damage or enclosed in a raceway, and be not more than 7.5 m (25 ft) in length

Have an ampacity not less than the feeder conductors

Exception: Feeder taps over 7.5 m (25 ft) long. In high-bay manufacturing buildings [over 11 m (35 ft) high at walls], where conditions of maintenance and supervision ensure that only qualified persons service the systems, conductors tapped to a feeder shall be permitted to be not over 7.5 m (25 ft) long horizontally and not over 30.0 m (100 ft) in total length where all of the following conditions are met:

The ampacity of the tap conductors is not less than one-third that of the feeder conductors.

The tap conductors terminate with a single circuit breaker or a single set of fuses complying with (1) Part IV, where the load-side conductors are a branch circuit, or (2) Part V, where the load-side conductors are a feeder.

The tap conductors are suitably protected from physical damage and are installed in raceways.

The tap conductors are continuous from end-to-end and contain no splices.

The tap conductors shall be 6 AWG copper or 4 AWG aluminum or larger.

The tap conductors shall not penetrate walls, floors, or ceilings.

The tap shall not be made less than 9.0 m (30 ft) from the floor.

430.29 Constant Voltage Direct-Current Motors — Power Resistors

Conductors connecting the motor controller to separately mounted power accelerating and dynamic braking resistors in the armature circuit shall have an ampacity not less than the value calculated from Table 430.29 using motor full-load current. If an armature shunt resistor is used, the power accelerating resistor conductor ampacity shall be calculated using the total of motor full-load current and armature shunt resistor current.

Armature shunt resistor conductors shall have an ampacity of not less than that calculated from Table 430.29 using rated shunt resistor current as full-load current.

Table 430.29 Conductor Rating Factors for Power Resistors

Time in Seconds Ampacity of Conductor in Percent of Full-Load Current

On Off

5 75 35

10 70 45

15 75 55

15 45 65

15 30 75

15 15 85

Continuous Duty 110

Part III Motor and Branch-Circuit Overload Protection

430.31 General

Part III specifies overload devices intended to protect motors, motor-control apparatus, and motor branch-circuit conductors against excessive heating due to motor overloads and failure to start.

Informational Note No. 1: See Informative Annex D, Example No. D8.

Informational Note No. 2: See the definition of Overload in Article 100.

These provisions shall not require overload protection where a power loss would cause a hazard, such as in the case of fire pumps.

Informational Note: For protection of fire pump supply conductors, see 695.7.

Part III shall not apply to motor circuits rated over 1000 volts, nominal.

Informational Note: For over 1000 volts, nominal, see Part XI.

430.32 Continuous-Duty Motors

(A) More Than 1 Horsepower

Each motor used in a continuous duty application and rated more than 1 hp shall be protected against overload by one of the means in 430.32(A)(1) through (A)(4).

(1) Separate Overload Device

A separate overload device that is responsive to motor current. This device shall be selected to trip or shall be rated at no more than the following percent of the motor nameplate full-load current rating:

Motors with a marked service factor 1.15 or greater 125%

Motors with a marked temperature rise 40°C or less 125%

All other motors 115%

Modification of this value shall be permitted as provided in 430.32(C). For a multispeed motor, each winding connection shall be considered separately.

Where a separate motor overload device is connected so that it does not carry the total current designated on the motor nameplate, such as for wye-delta starting, the proper percentage of nameplate current applying to the selection or setting of the overload device shall be clearly designated on the equipment, or the manufacturer's selection table shall take this into account.

Informational Note: Where power factor correction capacitors are installed on the load side of the motor overload device, see 460.9.

(2) Thermal Protector or Electronically Protected

A thermal protector integral with the motor shall be approved for use with the motor it protects on the basis that it will prevent dangerous overheating of the motor due to overload and failure to start. An electronically protected motor shall be approved for use on the basis that it will prevent dangerous overheating due to the failure of the electronic control, overload, or failure to start the motor. The ultimate trip current of a thermally or electronically protected motor shall not exceed the following percentage of motor full-load current given in Table 430.248, Table 430.249, and Table 430.250:

Motor full-load current 9 amperes or less 170%

Motor full-load current from 9.1 to, and including, 20 amperes 156%

Motor full-load current greater than 20 amperes 140%

If the motor current-interrupting device is separate from the motor and its control circuit is operated by a protective device integral with the motor, it shall be arranged so that the opening of the control circuit will result in interruption of current to the motor.

(3) Integral With Motor

A protective device integral with a motor that will protect the motor against damage due to failure to start shall be permitted if the motor is part of an approved assembly that does not normally subject the motor to overloads.

(4) Larger Than 1500 Horsepower

For motors larger than 1500 hp, a protective device having embedded temperature detectors that cause current to the motor to be interrupted when the motor attains a temperature rise greater than marked on the nameplate in an ambient temperature of 40°C.

(B) One Horsepower or Less, Automatically Started

Any motor of 1 hp or less that is started automatically shall be protected against overload by one of the following means.

(1) Separate Overload Device

By a separate overload device following the requirements of 430.32(A)(1).

For a multispeed motor, each winding connection shall be considered separately. Modification of this value shall be permitted as provided in 430.32(C).

(2) Thermal Protector or Electronically Protected

A thermal protector integral with the motor shall be approved for use with the motor that it protects on the basis that it will prevent dangerous overheating of the motor due to overload and failure to start. An electronically protected motor shall be approved for use on the basis that it will prevent dangerous overheating due to the failure of the electronic control, overload, or failure to start the motor. Where the motor current-interrupting device is separate from the motor and its control circuit is operated by a protective device integral with the motor, it shall be arranged so that the opening of the control circuit results in interruption of current to the motor.

(3) Integral With Motor

A protective device integral with a motor that protects the motor against damage due to failure to start shall be permitted (1) if the motor is part of an approved assembly that does not subject the motor to overloads, or (2) if the assembly is also equipped with other safety controls (such as the safety combustion controls on a domestic oil burner) that protect the motor against damage due to failure to start. Where the assembly has safety controls that protect the motor, it shall be so indicated on the nameplate of the assembly where it will be visible after installation.

(4) Impedance-Protected

If the impedance of the motor windings is sufficient to prevent overheating due to failure to start, the motor shall be permitted to be protected as specified in 430.32(D)(2)(a) for manually started motors if the motor is part of an approved assembly in which the motor will limit itself so that it will not be dangerously overheated.

Informational Note: Many ac motors of less than 1/20 hp, such as clock motors, series motors, and so forth, and also some larger motors such as torque motors, come within this classification. It does not include split-phase motors having automatic switches that disconnect the starting windings.

(C) Selection of Overload Device

Where the sensing element or setting or sizing of the overload device selected in accordance with 430.32(A)(1) and 430.32(B)(1) is not sufficient to start the motor or to carry the load, higher size sensing elements or incremental settings or sizing shall be permitted to be used, provided the trip current of the overload device does not exceed the following percentage of motor nameplate full-load current rating:

Motors with marked service factor 1.15 or greater 140%

Motors with a marked temperature rise 40°C or less 140%

All other motors 130%

If not shunted during the starting period of the motor as provided in 430.35, the overload device shall have sufficient time delay to permit the motor to start and accelerate its load.

Informational Note: A Class 20 overload relay will provide a longer motor acceleration time than a Class 10 or Class 10A overload relay. A Class 30 overload relay will provide a longer motor acceleration time than a Class 20 overload relay. Use of a higher class overload relay may preclude the need for selection of a higher trip current.

(D) One Horsepower or Less, Nonautomatically Started

(1) Permanently Installed

Overload protection shall be in accordance with 430.32(B).

(2) Not Permanently Installed

(a) Within Sight from Controller. Overload protection shall be permitted to be furnished by the branch-circuit short-circuit and ground-fault protective device; such device, however, shall not be larger than that specified in Part IV of Article 430.

Exception: Any such motor shall be permitted on a nominal 120-volt branch circuit protected at not over 20 amperes.

(b) Not Within Sight from Controller. Overload protection shall be in accordance with 430.32(B).

(E) Wound-Rotor Secondaries

The secondary circuits of wound-rotor ac motors, including conductors, controllers, resistors, and so forth, shall be permitted to be protected against overload by the motor-overload device.

430.33 Intermittent and Similar Duty

A motor used for a condition of service that is inherently short-time, intermittent, periodic, or varying duty, as illustrated by Table 430.22(E), shall be permitted to be protected against overload by the branch-circuit short-circuit and ground-fault protective device, provided the protective device rating or setting does not exceed that specified in Table 430.52.

Any motor application shall be considered to be for continuous duty unless the nature of the apparatus it drives is such that the motor cannot operate continuously with load under any condition of use.

430.35 Shunting During Starting Period

(A) Nonautomatically Started

For a nonautomatically started motor, the overload protection shall be permitted to be shunted or cut out of the circuit during the starting period of the motor if the device by which the overload protection is shunted or cut out cannot be left in the starting position and if fuses or inverse time circuit breakers rated or set at not over 400 percent of the full-load current of the motor are located in the circuit so as to be operative during the starting period of the motor.

(B) Automatically Started

The motor overload protection shall not be shunted or cut out during the starting period if the motor is automatically started.

Exception: The motor overload protection shall be permitted to be shunted or cut out during the starting period on an automatically started motor where the following apply:

The motor starting period exceeds the time delay of available motor overload protective devices, and

Listed means are provided to perform the following:

Sense motor rotation and automatically prevent the shunting or cutout in the event that the motor fails to start, and

Limit the time of overload protection shunting or cutout to less than the locked rotor time rating of the protected motor, and

Provide for shutdown and manual restart if motor running condition is not reached.

430.36 Fuses — In Which Conductor

Where fuses are used for motor overload protection, a fuse shall be inserted in each ungrounded conductor and also in the grounded conductor if the supply system is 3-wire, 3-phase ac with one conductor grounded.

430.37 Devices Other Than Fuses — In Which Conductor

Where devices other than fuses are used for motor overload protection, Table 430.37 shall govern the minimum allowable number and location of overload units such as trip coils or relays.

Table 430.37 Overload Units

Kind of Motor Supply System Number and Location of Overload Units, Such as Trip Coils or Relays

1-phase ac or dc 2-wire, 1-phase ac or dc ungrounded 1 in either conductor

1-phase ac or dc 2-wire, 1-phase ac or dc, one conductor grounded 1 in ungrounded conductor

1-phase ac or dc 3-wire, 1-phase ac or dc, grounded neutral conductor 1 in either ungrounded conductor

1-phase ac Any 3-phase 1 in ungrounded conductor

2-phase ac 3-wire, 2-phase ac, ungrounded 2, one in each phase

2-phase ac 3-wire, 2-phase ac, one conductor grounded 2 in ungrounded conductors

2-phase ac 4-wire, 2-phase ac, grounded or ungrounded 2, one for each phase in ungrounded conductors

2-phase ac Grounded neutral or 5-wire, 2-phase ac, ungrounded 2, one for each phase in any ungrounded phase wire

3-phase ac Any 3-phase 3, one in each phase\*

\*Exception: An overload unit in each phase shall not be required where overload protection is provided by other approved means.

430.38 Number of Conductors Opened by Overload Device

Motor overload devices, other than fuses or thermal protectors, shall simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

430.39 Motor Controller as Overload Protection

A motor controller shall also be permitted to serve as an overload device if the number of overload units complies with Table 430.37 and if these units are operative in both the starting and running position in the case of a dc motor, and in the running position in the case of an ac motor.

430.40 Overload Relays

Overload relays and other devices for motor overload protection that are not capable of opening short circuits or ground faults shall be protected by fuses or circuit breakers with ratings or settings in accordance with 430.52 or by a motor short-circuit protector in accordance with 430.52.

Exception: Where approved for group installation and marked to indicate the maximum size of fuse or inverse time circuit breaker by which they must be protected, the overload devices shall be protected in accordance with this marking.

430.42 Motors on General-Purpose Branch Circuits

Overload protection for motors used on general-purpose branch circuits as permitted in Article 210 shall be provided as specified in 430.42(A), (B), (C), or (D).

(A) Not Over 1 Horsepower

One or more motors without individual overload protection shall be permitted to be connected to a general-purpose branch circuit only where the installation complies with the limiting conditions specified in 430.32(B) and 430.32(D) and 430.53(A)(1) and (A)(2).

(B) Over 1 Horsepower

Motors of ratings larger than specified in 430.53(A) shall be permitted to be connected to general-purpose branch circuits only where each motor is protected by overload protection selected to protect the motor as specified in 430.32. Both the controller and the motor overload device shall be approved for group installation with the short-circuit and ground-fault protective device selected in accordance with 430.53.

(C) Cord-and Plug-Connected

Where a motor is connected to a branch circuit by means of an attachment plug and a receptacle or a cord connector, and individual overload protection is omitted as provided in 430.42(A), the rating of the attachment plug and receptacle or cord connector shall not exceed 15 amperes at 125 volts or 250 volts. Where individual overload protection is required as provided in 430.42(B) for a motor or motor-operated appliance that is attached to the branch circuit through an attachment plug and a receptacle or a cord connector, the overload device shall be an integral part of the motor or of the appliance. The rating of the attachment plug and receptacle or the cord connector shall determine the rating of the circuit to which the motor may be connected, as provided in 210.21(B).

(D) Time Delay

The branch-circuit short-circuit and ground-fault protective device protecting a circuit to which a motor or motor-operated appliance is connected shall have sufficient time delay to permit the motor to start and accelerate its load.

430.43 Automatic Restarting

A motor overload device that can restart a motor automatically after overload tripping shall not be installed unless approved for use with the motor it protects. A motor overload device that can restart a motor automatically after overload tripping shall not be installed if automatic restarting of the motor can result in injury to persons.

430.44 Orderly Shutdown

If immediate automatic shutdown of a motor by a motor overload protective device(s) would introduce additional or increased hazard(s) to a person(s) and continued motor operation is necessary for safe shutdown of equipment or process, a motor overload sensing device(s) complying with Part III of this article shall be permitted to be connected to a supervised alarm instead of causing immediate interruption of the motor circuit, so that corrective action or an orderly shutdown can be initiated.

Part IV Motor Branch-Circuit Short-Circuit and Ground-Fault Protection

430.51 General

Part IV specifies devices intended to protect the motor branch-circuit conductors, the motor control apparatus, and the motors against overcurrent due to short circuits or ground faults. These rules add to or amend Article 240. The devices specified in Part IV do not include the types of devices required by 210.8, 230.95, and 590.6.

Informational Note: See Informative Annex D, Example D8.

Part IV shall not apply to motor circuits rated over 1000 volts, nominal.

Informational Note: For over 1000 volts, nominal, see Part XI.

430.52 Rating or Setting for Individual Motor Circuit

Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices

Type of Motor Percentage of Full-Load Current

Nontime Delay Fuse1 Dual Element (Time-Delay) Fuse1 Instantaneous Trip Breaker Inverse Time Breaker2

Single-phase motors 300 175 800 250

AC polyphase motors other than wound-rotor 300 175 800 250

Squirrel cage — other than Design B energy-efficient 300 175 800 250

Design B energy-efficient 300 175 1100 250

Synchronous3 300 175 800 250

Wound-rotor 150 150 800 150

DC (constant voltage) 150 150 250 150

Note: For certain exceptions to the values specified, see 430.54.

1The values in the Nontime Delay Fuse column apply to time-delay Class CC fuses.

2The values given in the last column also cover the ratings of nonadjustable inverse time types of circuit breakers that may be modified as in 430.52(C)(1), Exceptions No. 1 and No. 2.

3Synchronous motors of the low-torque, low-speed type (usually 450 rpm or lower), such as are used to drive reciprocating compressors, pumps, and so forth, that start unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 percent of full-load current.

(A) General

The motor branch-circuit short-circuit and ground-fault protective device shall comply with 430.52(B) and either 430.52(C) or (D), as applicable.

(B) All Motors

The motor branch-circuit short-circuit and ground-fault protective device shall be capable of carrying the starting current of the motor.

(C) Rating or Setting

(1) In Accordance With Table 430.52

A protective device that has a rating or setting not exceeding the value calculated according to the values given in Table 430.52 shall be used.

Exception No. 1: Where the values for branch-circuit short-circuit and ground-fault protective devices determined by Table 430.52 do not correspond to the standard sizes or ratings of fuses, nonadjustable circuit breakers, thermal protective devices, or possible settings of adjustable circuit breakers, a higher size, rating, or possible setting that does not exceed the next higher standard ampere rating shall be permitted.

Exception No. 2: Where the rating specified in Table 430.52, or the rating modified by Exception No. 1, is not sufficient for the starting current of the motor:

The rating of a nontime-delay fuse not exceeding 600 amperes or a time-delay Class CC fuse shall be permitted to be increased but shall in no case exceed 400 percent of the full-load current.

The rating of a time-delay (dual-element) fuse shall be permitted to be increased but shall in no case exceed 225 percent of the full-load current.

The rating of an inverse time circuit breaker shall be permitted to be increased but shall in no case exceed 400 percent for full-load currents of 100 amperes or less or 300 percent for full-load currents greater than 100 amperes.

The rating of a fuse of 601—6000 ampere classification shall be permitted to be increased but shall in no case exceed 300 percent of the full-load current.

Informational Note: See Informative Annex D, Example D8, and Figure 430.1.

(2) Overload Relay Table

Where maximum branch-circuit short-circuit and ground-fault protective device ratings are shown in the manufacturer's overload relay table for use with a motor controller or are otherwise marked on the equipment, they shall not be exceeded even if higher values are allowed as shown above.

(3) Instantaneous Trip Circuit Breaker

An instantaneous trip circuit breaker shall be used only if adjustable and if part of a listed combination motor controller having coordinated motor overload and short-circuit and ground-fault protection in each conductor, and the setting is adjusted to no more than the value specified in Table 430.52.

Informational Note No. 1: Instantaneous trip circuit breakers are also known as motor-circuit protectors (MCPs).

Informational Note No. 2: For the purpose of this article, instantaneous trip circuit breakers may include a damping means to accommodate a transient motor inrush current without nuisance tripping of the circuit breaker.

Exception No. 1: Where the setting specified in Table 430.52 is not sufficient for the starting current of the motor, the setting of an instantaneous trip circuit breaker shall be permitted to be increased but shall in no case exceed 1300 percent of the motor full-load current for other than Design B energy-efficient motors and no more than 1700 percent of motor full-load current for Design B energy-efficient motors. Trip settings above 800 percent for other than Design B energy-efficient motors and above 1100 percent for Design B energy-efficient motors shall be permitted where the need has been demonstrated by engineering evaluation. In such cases, it shall not be necessary to first apply an instantaneous-trip circuit breaker at 800 percent or 1100 percent.

Informational Note: For additional information on the requirements for a motor to be classified "energy efficient," see NEMA MG 1-2016, Motors and Generators, Part 12.59.

Exception No. 2: Where the motor full-load current is 8 amperes or less, the setting of the instantaneous-trip circuit breaker with a continuous current rating of 15 amperes or less in a listed combination motor controller that provides coordinated motor branch-circuit overload and short-circuit and ground-fault protection shall be permitted to be increased to the value marked on the controller.

(4) Multispeed Motor

For a multispeed motor, a single short-circuit and ground-fault protective device shall be permitted for two or more windings of the motor, provided the rating of the protective device does not exceed the above applicable percentage of the nameplate rating of the smallest winding protected.

Exception: For a multispeed motor, a single short-circuit and ground-fault protective device shall be permitted to be used and sized according to the full-load current of the highest current winding, where all of the following conditions are met:

Each winding is equipped with individual overload protection sized according to its full-load current.

The branch-circuit conductors supplying each winding are sized according to the full-load current of the highest full-load current winding.

The controller for each winding has a horsepower rating not less than that required for the winding having the highest horsepower rating.

(5) Power Electronic Devices

Semiconductor fuses intended for the protection of electronic devices shall be permitted in lieu of devices listed in Table 430.52 for power electronic devices, associated electromechanical devices (such as bypass contactors and isolation contactors), and conductors in a solid-state motor controller system, provided that the marking for replacement fuses is provided adjacent to the fuses.

(6) Self-Protected Combination Controller

A listed self-protected combination controller shall be permitted in lieu of the devices specified in Table 430.52. Adjustable instantaneous-trip settings shall not exceed 1300 percent of full-load motor current for other than Design B energy-efficient motors and not more than 1700 percent of full-load motor current for Design B energy-efficient motors.

Informational Note: Proper application of self-protected combination controllers on 3-phase systems, other than solidly grounded wye, particularly on corner grounded delta systems, considers the self-protected combination controllers' individual pole-interrupting capability.

(7) Motor Short-Circuit Protector

A motor short-circuit protector shall be permitted in lieu of devices listed in Table 430.52 if the motor short-circuit protector is part of a listed combination motor controller having coordinated motor overload protection and short-circuit and ground-fault protection in each conductor and it will open the circuit at currents exceeding 1300 percent of motor full-load current for other than Design B energy-efficient motors and 1700 percent of motor full-load motor current for Design B energy-efficient motors.

Informational Note: A motor short-circuit protector, as used in this section, is a fused device and is not an instantaneous trip circuit breaker.

(D) Torque Motors

Torque motor branch circuits shall be protected at the motor nameplate current rating in accordance with 240.4(B).

430.53 Several Motors or Loads on One Branch Circuit

Two or more motors or one or more motors and other loads shall be permitted to be connected to the same branch circuit under conditions specified in 430.53(D) and in 430.53(A), (B), or (C). The branch-circuit protective device shall be fuses or inverse time circuit breakers.

(A) Not Over 1 Horsepower

Several motors, each not exceeding 1 hp in rating, shall be permitted on a nominal 120-volt branch circuit protected at not over 20 amperes or a branch circuit of 1000 volts, nominal, or less, protected at not over 15 amperes, if all of the following conditions are met:

The full-load rating of each motor does not exceed 6 amperes.

The rating of the branch-circuit short-circuit and ground-fault protective device marked on any of the controllers is not exceeded.

Individual overload protection conforms to 430.32.

(B) If Smallest Rated Motor Protected

If the branch-circuit short-circuit and ground-fault protective device is selected not to exceed that allowed by 430.52 for the smallest rated motor, two or more motors or one or more motors and other load(s), with each motor having individual overload protection, shall be permitted to be connected to a branch circuit where it can be determined that the branch-circuit short-circuit and ground-fault protective device will not open under the most severe normal conditions of service that might be encountered.

(C) Other Group Installations

Two or more motors of any rating or one or more motors and other load(s), with each motor having individual overload protection, shall be permitted to be connected to one branch circuit where the motor controller(s) and overload device(s) are (1) installed as a listed factory assembly and the motor branch-circuit short-circuit and ground-fault protective device either is provided as part of the assembly or is specified by a marking on the assembly, or (2) the motor branch-circuit short-circuit and ground-fault protective device, the motor controller(s), and overload device(s) are field-installed as separate assemblies listed for such use and provided with manufacturers' instructions for use with each other, and (3) all of the following conditions are complied with:

Each motor overload device is either (a) listed for group installation with a specified maximum rating of fuse, inverse time circuit breaker, or both, or (b) selected such that the ampere rating of the motor-branch short-circuit and ground-fault protective device does not exceed that permitted by 430.52 for that individual motor overload device and corresponding motor load.

Each motor controller is either (a) listed for group installation with a specified maximum rating of fuse, circuit breaker, or both, or (b) selected such that the ampere rating of the motor-branch short-circuit and ground-fault protective device does not exceed that permitted by 430.52 for that individual controller and corresponding motor load.

Each circuit breaker is listed and is of the inverse time type.

The branch circuit shall be protected by fuses or inverse time circuit breakers having a rating not exceeding that specified in 430.52 for the highest rated motor connected to the branch circuit plus an amount equal to the sum of the full-load current ratings of all other motors and the ratings of other loads connected to the circuit. Where this calculation results in a rating less than the ampacity of the branch-circuit conductors, it shall be permitted to increase the maximum rating of the fuses or circuit breaker to a value not exceeding that permitted by 240.4(B).

The branch-circuit fuses or inverse time circuit breakers are not larger than allowed by 430.40 for the overload relay protecting the smallest rated motor of the group.

Overcurrent protection for loads other than motor loads shall be in accordance with Parts I through VII of Article 240.

Informational Note: See 110.10 for circuit impedance and other characteristics.

(D) Single Motor Taps

For group installations described above, the conductors of any tap supplying a single motor shall not be required to have an individual branch-circuit short-circuit and ground-fault protective device, provided they comply with one of the following:

No conductor to the motor shall have an ampacity less than that of the branch-circuit conductors.

No conductor to the motor shall have an ampacity less than one-third that of the branch-circuit conductors, with a minimum in accordance with 430.22. The conductors from the point of the tap to the motor overload device shall be not more than 7.5 m (25 ft) long and be protected from physical damage by being enclosed in an approved raceway or by use of other approved means.

Conductors from the point of the tap from the branch circuit to a listed manual motor controller additionally marked "Suitable for Tap Conductor Protection in Group Installations," or to a branch-circuit protective device, shall be permitted to have an ampacity not less than one-tenth the rating or setting of the branch-circuit short-circuit and ground-fault protective device. The conductors from the controller to the motor shall have an ampacity in accordance with 430.22. The conductors from the point of the tap to the controller(s) shall (1) be suitably protected from physical damage and enclosed either by an enclosed controller or by a raceway and be not more than 3 m (10 ft) long or (2) have an ampacity not less than that of the branch-circuit conductors.

Conductors from the point of the tap from the branch circuit to a listed manual motor controller additionally marked "Suitable for Tap Conductor Protection in Group Installations," or to a branch-circuit protective device, shall be permitted to have an ampacity not less than one-third that of the branch-circuit conductors. The conductors from the controller to the motor shall have an ampacity in accordance with 430.22. The conductors from the point of the tap to the controller(s) shall (1) be suitably protected from physical damage and enclosed either by an enclosed controller or by a raceway and be not more than 7.5 m (25 ft) long or (2) have an ampacity not less than that of the branch-circuit conductors.

430.54 Multimotor and Combination-Load Equipment

The rating of the branch-circuit short-circuit and ground-fault protective device for multimotor and combination-load equipment shall not exceed the rating marked on the equipment in accordance with 430.7(D).

430.55 Combined Overcurrent Protection

Motor branch-circuit short-circuit and ground-fault protection and motor overload protection shall be permitted to be combined in a single protective device where the rating or setting of the device provides the overload protection specified in 430.32.

430.56 Branch-Circuit Protective Devices — In Which Conductor

Branch-circuit protective devices shall comply with 240.15.

430.57 Size of Fuseholder

Where fuses are used for motor branch-circuit short-circuit and ground-fault protection, the fuseholders shall not be of a smaller size than required to accommodate the fuses specified by Table 430.52.

Exception: Where fuses having time delay appropriate for the starting characteristics of the motor are used, it shall be permitted to use fuseholders sized to fit the fuses that are used.

430.58 Rating of Circuit Breaker

A circuit breaker for motor branch-circuit short-circuit and ground-fault protection shall have a current rating in accordance with 430.52 and 430.110.

Part V Motor Feeder Short-Circuit and Ground-Fault Protection

430.61 General

Part V specifies protective devices intended to protect feeder conductors supplying motors against overcurrents due to short circuits or grounds.

Informational Note: See Informative Annex D, Example D8.

430.62 Rating or Setting — Motor Load

(A) Specific Load

A feeder supplying a specific fixed motor load(s) and consisting of conductor sizes based on 430.24 shall be provided with a protective device having a rating or setting not greater than the largest rating or setting of the branch-circuit short-circuit and ground-fault protective device for any motor supplied by the feeder [based on the maximum permitted value for the specific type of a protective device in accordance with 430.52, or 440.22(A) for hermetic refrigerant motor-compressors], plus the sum of the full-load currents of the other motors of the group.

Where the same rating or setting of the branch-circuit short-circuit and ground-fault protective device is used on two or more of the branch circuits supplied by the feeder, one of the protective devices shall be considered the largest for the above calculations.

Exception No. 1: Where one or more instantaneous trip circuit breakers or motor short-circuit protectors are used for motor branch-circuit short-circuit and ground-fault protection as permitted in 430.52(C), the procedure provided above for determining the maximum rating of the feeder protective device shall apply with the following provision: For the purpose of the calculation, each instantaneous trip circuit breaker or motor short-circuit protector shall be assumed to have a rating not exceeding the maximum percentage of motor full-load current permitted by Table 430.52 for the type of feeder protective device employed.

Exception No. 2: Where the feeder overcurrent protective device also provides overcurrent protection for a motor control center, the provisions of 430.94 shall apply.

Informational Note: See Informative Annex D, Example D8.

(B) Other Installations

Where feeder conductors have an ampacity greater than required by 430.24, the rating or setting of the feeder overcurrent protective device shall be permitted to be based on the ampacity of the feeder conductors.

430.63 Rating or Setting — Motor Load and Other Load(s)

Where a feeder supplies a motor load and other load(s), the feeder protective device shall have a rating not less than that required for the sum of the other load(s) plus the following:

For a single motor, the rating permitted by 430.52

For a single hermetic refrigerant motor-compressor, the rating permitted by 440.22

For two or more motors, the rating permitted by 430.62

Exception: Where the feeder overcurrent device provides the overcurrent protection for a motor control center, the provisions of 430.94 shall apply.

Part VI Motor Control Circuits

430.71 General

Part VI contains modifications of the general requirements and applies to the particular conditions of motor control circuits.

430.72 Overcurrent Protection

(A) General

A motor control circuit tapped from the load side of a motor branch-circuit short-circuit and ground-fault protective device(s) and functioning to control the motor(s) connected to that branch circuit shall be protected against overcurrent in accordance with 430.72. Such a tapped control circuit shall not be considered to be a branch circuit and shall be permitted to be protected by either a supplementary or branch-circuit overcurrent protective device(s). A motor control circuit other than such a tapped control circuit shall be protected against overcurrent in accordance with 725.43 or the notes to Table 11(A) and Table 11(B) in Chapter 9, as applicable.

(B) Conductor Protection

The overcurrent protection for conductors shall be provided as specified in 430.72(B)(1) or (B)(2).

Exception No. 1: Where the opening of the control circuit would create a hazard as, for example, the control circuit of a fire pump motor, and the like, conductors of control circuits shall require only short-circuit and ground-fault protection and shall be permitted to be protected by the motor branch-circuit short-circuit and ground-fault protective device(s).

Exception No. 2: Conductors supplied by the secondary side of a single-phase transformer having only a two-wire (single-voltage) secondary shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection does not exceed the value determined by multiplying the appropriate maximum rating of the overcurrent device for the secondary conductor from Table 430.72(B) by the secondary-to-primary voltage ratio. Transformer secondary conductors (other than two-wire) shall not be considered to be protected by the primary overcurrent protection.

Table 430.72(B) Maximum Rating of Overcurrent Protective Device in Amperes

Control Circuit Conductor Size (AWG) Column A Separate Protection Provided Protection Provided by Motor Branch-Circuit Protective Device(s)

Column B Conductors Within Enclosure Column C Conductors Extend Beyond Enclosure

Copper Aluminum or Copper-Clad Aluminum Copper Aluminum or Copper-Clad Aluminum Copper Aluminum or Copper-Clad Aluminum

18 7 — 25 — 7 —

16 10 — 40 — 10 —

14 (Note 1) — 100 — 45 —

12 (Note 1) (Note 1) 120 100 60 45

10 (Note 1) (Note 1) 160 140 90 75

Larger than 10 (Note 1) (Note 1) (Note 2) (Note 2) (Note 3) (Note 3)

Notes:

1. Value specified in 310.15 as applicable.

2. 400 percent of value specified in Table 310.17 for 60°C conductors.

3. 300 percent of value specified in Table 310.16 for 60°C conductors.

(1) Separate Overcurrent Protection

Where the motor branch-circuit short-circuit and ground-fault protective device does not provide protection in accordance with 430.72(B)(2), separate overcurrent protection shall be provided. The over-current protection shall not exceed the values specified in Column A of Table 430.72(B).

(2) Branch-Circuit Overcurrent Protective Device

Conductors shall be permitted to be protected by the motor branch-circuit short-circuit and ground-fault protective device and shall require only short-circuit and ground-fault protection. Where the conductors do not extend beyond the motor control equipment enclosure, the rating of the protective device(s) shall not exceed the value specified in Column B of Table 430.72(B). Where the conductors extend beyond the motor control equipment enclosure, the rating of the protective device(s) shall not exceed the value specified in Column C of Table 430.72(B).

(C) Control Circuit Transformer

Where a motor control circuit transformer is provided, the transformer shall be protected in accordance with 430.72(C)(1), (C)(2), (C)(3), (C)(4), or (C)(5).

Exception: Overcurrent protection shall be omitted where the opening of the control circuit would create a hazard as, for example, the control circuit of a fire pump motor and the like.

(1) Compliance With Article 725

Where the transformer supplies a Class 1 power-limited circuit, Class 2, or Class 3 remote-control circuit complying with the requirements of Article 725, protection shall comply with Article 725.

(2) Compliance With Article 450

Protection shall be permitted to be provided in accordance with 450.3.

(3) Less Than 50 Volt-Amperes

Control circuit transformers rated less than 50 volt-amperes (VA) and that are an integral part of the motor controller and located within the motor controller enclosure shall be permitted to be protected by primary overcurrent devices, impedance limiting means, or other inherent protective means.

(4) Primary Less Than 2 Amperes

Where the control circuit transformer rated primary current is less than 2 amperes, an overcurrent device rated or set at not more than 500 percent of the rated primary current shall be permitted in the primary circuit.

(5) Other Means

Protection shall be permitted to be provided by other approved means.

430.73 Protection of Conductors From Physical Damage

Where damage to a motor control circuit would constitute a hazard, all conductors of such a remote motor control circuit that are outside the control device itself shall be installed in a raceway or be otherwise protected from physical damage.

430.74 Electrical Arrangement of Control Circuits

Where one conductor of the motor control circuit is grounded, the motor control circuit shall be arranged so that a ground fault in the control circuit remote from the motor controller will (1) not start the motor and (2) not bypass manually operated shutdown devices or automatic safety shutdown devices.

430.75 Disconnection

(A) General

Motor control circuits shall be arranged so that they will be disconnected from all sources of supply when the disconnecting means is in the open position. The disconnecting means shall be permitted to consist of two or more separate devices, one of which disconnects the motor and the controller from the source(s) of power supply for the motor, and the other(s), the motor control circuit(s) from its power supply. Where separate devices are used, they shall be located immediately adjacent to each other.

Exception No. 1: Where more than 12 motor control circuit conductors are required to be disconnected, the disconnecting means shall be permitted to be located other than immediately adjacent to each other where all of the following conditions are complied with:

Access to energized parts is limited to qualified persons in accordance with Part XII of this article.

A warning sign is permanently located on the outside of each equipment enclosure door or cover permitting access to the live parts in the motor control circuit(s), warning that motor control circuit disconnecting means are remotely located and specifying the location and identification of each disconnect. Where energized parts are not in an equipment enclosure as permitted by 430.232 and 430.233, an additional warning sign(s) shall be located where visible to persons who may be working in the area of the energized parts.

Exception No. 2: The motor control circuit disconnecting means shall be permitted to be remote from the motor controller power supply disconnecting means where the opening of one or more motor control circuit disconnecting means is capable of resulting in potentially unsafe conditions for personnel or property and the conditions of items (1) and (2) of Exception No. 1 are complied with.

(B) Control Transformer in Controller Enclosure

Where a transformer or other device is used to obtain a reduced voltage for the motor control circuit and is located in the controller enclosure, such transformer or other device shall be connected to the load side of the disconnecting means for the motor control circuit.

Part VII Motor Controllers

430.81 General

Part VII is intended to require suitable controllers for all motors.

(A) Stationary Motor of 1/8 Horsepower or Less

For a stationary motor rated at 1/8 hp or less that is normally left running and is constructed so that it cannot be damaged by overload or failure to start, such as clock motors and the like, the branch-circuit disconnecting means shall be permitted to serve as the controller.

(B) Portable Motor of 1/3 Horsepower or Less

For a portable motor rated at 1/3 hp or less, the controller shall be permitted to be an attachment plug and receptacle or cord connector.

430.82 Controller Design

(A) Starting and Stopping

Each controller shall be capable of starting and stopping the motor it controls and shall be capable of interrupting the locked-rotor current of the motor.

(B) Autotransformer

An autotransformer starter shall provide an "off" position, a running position, and at least one starting position. It shall be designed so that it cannot rest in the starting position or in any position that will render the overload device in the circuit inoperative.

(C) Rheostats

Rheostats shall be in compliance with the following:

Motor-starting rheostats shall be designed so that the contact arm cannot be left on intermediate segments. The point or plate on which the arm rests when in the starting position shall have no electrical connection with the resistor.

Motor-starting rheostats for dc motors operated from a constant voltage supply shall be equipped with automatic devices that will interrupt the supply before the speed of the motor has fallen to less than one-third its normal rate.

430.83 Ratings

The controller shall have a rating as specified in 430.83(A), unless otherwise permitted in 430.83(B) or (C), or as specified in (D), under the conditions specified.

(A) General

(1) Horsepower Ratings

Controllers, other than inverse time circuit breakers and molded case switches, shall have horsepower ratings at the application voltage not lower than the horsepower rating of the motor.

(2) Circuit Breaker

A branch-circuit inverse time circuit breaker rated in amperes shall be permitted as a controller for all motors. Where this circuit breaker is also used for overload protection, it shall conform to the appropriate provisions of this article governing overload protection.

(3) Molded Case Switch

A molded case switch rated in amperes shall be permitted as a controller for all motors.

(B) Small Motors

Devices as specified in 430.81(A) and (B) shall be permitted as a controller.

(C) Stationary Motors of 2 Horsepower or Less

For stationary motors rated at 2 hp or less and 300 volts or less, the controller shall be permitted to be either of the following:

A general-use switch having an ampere rating not less than twice the full-load current rating of the motor

On ac circuits, a general-use snap switch suitable only for use on ac (not general-use ac-dc snap switches) where the motor full-load current rating is not more than 80 percent of the ampere rating of the switch

(D) Torque Motors

For torque motors, the controller shall have a continuous-duty, full-load current rating not less than the nameplate current rating of the motor. For a motor controller rated in horsepower but not marked with the foregoing current rating, the equivalent current rating shall be determined from the horsepower rating by using Table 430.247, Table 430.248, Table 430.249, or Table 430.250.

(E) Voltage Rating

A controller with a straight voltage rating, for example, 240 volts or 480 volts, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the controller's voltage rating. A controller with a slash rating, for example, 120/240 volts or 480Y/277 volts, shall only be applied in a solidly grounded circuit in which the nominal voltage to ground from any conductor does not exceed the lower of the two values of the controller's voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the controller's voltage rating.

430.84 Need Not Open All Conductors

The controller shall not be required to open all conductors to the motor.

Exception: Where the controller serves also as a disconnecting means, it shall open all ungrounded conductors to the motor as provided in 430.111.

430.85 In Grounded Conductors

One pole of the controller shall be permitted to be placed in a permanently grounded conductor, provided the controller is designed so that the pole in the grounded conductor cannot be opened without simultaneously opening all conductors of the circuit.

430.87 Number of Motors Served by Each Controller

Each motor shall be provided with an individual controller.

Exception No. 1: For motors rated 1000 volts or less, a single controller rated at not less than the equivalent horsepower, as determined in accordance with 430.110(C)(1), of all the motors in the group shall be permitted to serve the group under any of the following conditions:

Where a number of motors drive several parts of a single machine or piece of apparatus, such as metal and woodworking machines, cranes, hoists, and similar apparatus

Where a group of motors is under the protection of one overcurrent device as permitted in 430.53(A)

Where a group of motors is located in a single room within sight from the controller location

Exception No. 2: A branch-circuit disconnecting means serving as the controller as allowed in 430.81(A) shall be permitted to serve more than one motor.

430.88 Adjustable-Speed Motors

Adjustable-speed motors that are controlled by means of field regulation shall be equipped and connected so that they cannot be started under a weakened field.

Exception: Starting under a weakened field shall be permitted where the motor is designed for such starting.

430.89 Speed Limitation

Machines of the following types shall be provided with speed-limiting devices or other speed-limiting means:

Separately excited dc motors

Series motors

Motor-generators and converters that can be driven at excessive speed from the dc end, as by a reversal of current or decrease in load

Exception: Separate speed-limiting devices or means shall not be required under either of the following conditions:

Where the inherent characteristics of the machines, the system, or the load and the mechanical connection thereto are such as to safely limit the speed

Where the machine is always under the manual control of a qualified operator

430.90 Combination Fuseholder and Switch as Controller

The rating of a combination fuseholder and switch used as a motor controller shall be such that the fuseholder will accommodate the size of the fuse specified in Part III of this article for motor overload protection.

Exception: Where fuses having time delay appropriate for the starting characteristics of the motor are used, fuseholders of smaller size than specified in Part III of this article shall be permitted.

Part VIII Motor Control Centers

430.92 General

Part VIII covers motor control centers installed for the control of motors, lighting, and power circuits.

430.94 Overcurrent Protection

Motor control centers shall be provided with overcurrent protection in accordance with Parts I, II, and VIII of Article 240. The ampere rating or setting of the overcurrent protective device shall not exceed the rating of the common power bus. This protection shall be provided by (1) an overcurrent protective device located ahead of the motor control center or (2) a main overcurrent protective device located within the motor control center.

430.95 Service Equipment

Where used as service equipment, each motor control center shall be provided with a single main disconnecting means to disconnect all ungrounded service conductors.

Exception: A second service disconnect shall be permitted to supply additional equipment.

Where a grounded conductor is provided, the motor control center shall be provided with a main bonding jumper, sized in accordance with 250.28(D), within one of the sections for connecting the grounded conductor, on its supply side, to the motor control center equipment ground bus.

Exception: High-impedance grounded neutral systems shall be permitted to be connected as provided in 250.36.

430.96 Grounding

Multisection motor control centers shall be connected together with an equipment grounding conductor or an equivalent equipment grounding bus sized in accordance with Table 250.122. Equipment grounding conductors shall be connected to this equipment grounding bus or to a grounding termination point provided in a single-section motor control center.

430.97 Busbars and Conductors

(A) Support and Arrangement

Busbars shall be protected from physical damage and be held firmly in place. Other than for required interconnections and control wiring, only those conductors that are intended for termination in a vertical section shall be located in that section.

Exception: Conductors shall be permitted to travel horizontally through vertical sections where such conductors are isolated from the busbars by a barrier.

(B) Phase Arrangement

The phase arrangement on 3-phase horizontal common power and vertical buses shall be A, B, C from front to back, top to bottom, or left to right, as viewed from the front of the motor control center. The B phase shall be that phase having the higher voltage to ground on 3-phase, 4-wire, delta-connected systems. Other busbar arrangements shall be permitted for additions to existing installations and shall be marked.

Exception: Rear-mounted units connected to a vertical bus that is common to front-mounted units shall be permitted to have a C, B, A phase arrangement where properly identified.

(C) Minimum Wire-Bending Space

The minimum wire-bending space at the motor control center terminals and minimum gutter space shall be as required in Article 312.

(D) Spacings

Spacings between motor control center bus terminals and other bare metal parts shall not be less than specified in Table 430.97(D).

Table 430.97(D) Minimum Spacing Between Bare Metal Parts

Nominal Voltage Opposite Polarity Where Mounted on the Same Surface Opposite Polarity Where Held Free in Air Live Parts to Ground

mm in. mm in. mm in.

Not over 125 volts, nominal 19.1 3/4 12.7 1/2 12.7 1/2

Not over 250 volts, nominal 31.8 11/4 19.1 3/4 12.7 1/2

Not over 600 volts, nominal 50.8 2 25.4 1 25.4 1

(E) Barriers

Barriers shall be placed in all service-entrance motor control centers to isolate service busbars and terminals from the remainder of the motor control center.

430.98 Marking

(A) Motor Control Centers

Motor control centers shall be marked according to 110.21, and the marking shall be plainly visible after installation. Marking shall also include common power bus current rating and motor control center short-circuit current rating.

(B) Motor Control Units

Motor control units in a motor control center shall comply with 430.8.

430.99 Available Fault Current

The available fault current at the motor control center and the date the available fault current calculation was performed shall be documented and made available to those authorized to inspect, install, or maintain the installation.

Part IX Disconnecting Means

430.101 General

Part IX is intended to require disconnecting means capable of disconnecting motors and controllers from the circuit.

430.102 Location

(A) Controller

An individual disconnecting means shall be provided for each controller and shall disconnect the controller. The disconnecting means shall be located in sight from the controller location.

Exception No. 1: For motor circuits over 1000 volts, nominal, a controller disconnecting means lockable in accordance with 110.25 shall be permitted to be out of sight of the controller, provided that the controller is marked with a warning label giving the location of the disconnecting means.

Exception No. 2: A single disconnecting means shall be permitted for a group of coordinated controllers that drive several parts of a single machine or piece of apparatus. The disconnecting means shall be located in sight from the controllers, and both the disconnecting means and the controllers shall be located in sight from the machine or apparatus.

Exception No. 3: The disconnecting means shall not be required to be in sight from valve actuator motor (VAM) assemblies containing the controller where such a location introduces additional or increased hazards to persons or property and conditions (1) and (2) are met.

The valve actuator motor assembly is marked with a warning label giving the location of the disconnecting means.

The disconnecting means is lockable in accordance with 110.25.

(B) Motor

A disconnecting means shall be provided for a motor in accordance with 430.102(B)(1) or (B)(2).

(1) Separate Motor Disconnect

A disconnecting means for the motor shall be located in sight from the motor location and the driven machinery location.

(2) Controller Disconnect

The controller disconnecting means required in accordance with 430.102(A) shall be permitted to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.

Exception to (1) and (2): The disconnecting means for the motor shall not be required under either condition (1) or condition (2), which follow, provided that the controller disconnecting means required in 430.102(A) is lockable in accordance with 110.25.

Where such a location of the disconnecting means for the motor is impracticable or introduces additional or increased hazards to persons or property

Informational Note: Some examples of increased or additional hazards include, but are not limited to, motors rated in excess of 100 hp, multimotor equipment, submersible motors, motors associated with adjustable speed drives, and motors located in hazardous (classified) locations.

In industrial installations, with written safety procedures, where conditions of maintenance and supervision ensure that only qualified persons service the equipment

Informational Note: For information on lockout/tagout procedures, see NFPA 70E-2015, Standard for Electrical Safety in the Workplace.

430.103 Operation

The disconnecting means shall open all ungrounded supply conductors and shall be designed so that no pole can be operated independently. The disconnecting means shall be permitted in the same enclosure with the controller. The disconnecting means shall be designed so that it cannot be closed automatically.

Informational Note: See 430.113 for equipment receiving energy from more than one source.

430.104 To Be Indicating

The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

430.105 Grounded Conductors

One pole of the disconnecting means shall be permitted to disconnect a permanently grounded conductor, provided the disconnecting means is designed so that the pole in the grounded conductor cannot be opened without simultaneously disconnecting all conductors of the circuit.

430.107 Readily Accessible

At least one of the disconnecting means shall be readily accessible.

430.108 Every Disconnecting Means

Every disconnecting means in the motor circuit between the point of attachment to the feeder or branch circuit and the point of connection to the motor shall comply with the requirements of 430.109 and 430.110.

430.109 Type

The disconnecting means shall be a type specified in 430.109(A), unless otherwise permitted in 430.109(B) through (G), under the conditions specified.

(A) General

(1) Motor Circuit Switch

A listed motor-circuit switch rated in horsepower.

(2) Molded Case Circuit Breaker

A listed molded case circuit breaker.

(3) Molded Case Switch

A listed molded case switch.

(4) Instantaneous Trip Circuit Breaker

An instantaneous trip circuit breaker that is part of a listed combination motor controller.

(5) Self-Protected Combination Controller

Listed self-protected combination controller.

(6) Manual Motor Controller

Listed manual motor controllers additionally marked "Suitable as Motor Disconnect" shall be permitted as a disconnecting means where installed between the final motor branch-circuit short-circuit protective device and the motor. Listed manual motor controllers additionally marked "Suitable as Motor Disconnect" shall be permitted as disconnecting means on the line side of the fuses permitted in 430.52(C)(5). In this case, the fuses permitted in 430.52(C)(5) shall be considered supplementary fuses, and suitable branch-circuit short-circuit and ground-fault protective devices shall be installed on the line side of the manual motor controller additionally marked "Suitable as Motor Disconnect."

(7) System Isolation Equipment

System isolation equipment shall be listed for disconnection purposes. System isolation equipment shall be installed on the load side of the overcurrent protection and its disconnecting means. The disconnecting means shall be one of the types permitted by 430.109(A)(1) through (A)(3).

(B) Stationary Motors of 1/8 Horsepower or Less

For stationary motors of 1/8 hp or less, the branch-circuit overcurrent device shall be permitted to serve as the disconnecting means.

(C) Stationary Motors of 2 Horsepower or Less

For stationary motors rated at 2 hp or less and 300 volts or less, the disconnecting means shall be permitted to be one of the devices specified in (1), (2), or (3):

A general-use switch having an ampere rating not less than twice the full-load current rating of the motor

On ac circuits, a general-use snap switch suitable only for use on ac (not general-use ac—dc snap switches) where the motor full-load current rating is not more than 80 percent of the ampere rating of the switch

A listed manual motor controller having a horsepower rating not less than the rating of the motor and marked "Suitable as Motor Disconnect"

(D) Autotransformer-Type Controlled Motors

For motors of over 2 hp to and including 100 hp, the separate disconnecting means required for a motor with an autotransformer-type controller shall be permitted to be a general-use switch where all of the following provisions are met:

The motor drives a generator that is provided with overload protection.

The controller is capable of interrupting the locked-rotor current of the motors, is provided with a no voltage release, and is provided with running overload protection not exceeding 125 percent of the motor full-load current rating.

Separate fuses or an inverse time circuit breaker rated or set at not more than 150 percent of the motor full-load current is provided in the motor branch circuit.

(E) Isolating Switches

For stationary motors rated at more than 40 hp dc or 100 hp ac, the disconnecting means shall be permitted to be a general-use or isolating switch where plainly marked "Do not operate under load."

(F) Cord-and-Plug-Connected Motors

For a cord-and-plug-connected motor, a horsepower-rated attachment plug and receptacle, flanged surface inlet and cord connector, or attachment plug and cord connector having ratings no less than the motor ratings shall be permitted to serve as the disconnecting means. Horsepower-rated attachment plugs, flanged surface inlets, receptacles, or cord connectors shall not be required for cord-and-plug-connected appliances in accordance with 422.33, room air conditioners in accordance with 440.63, or portable motors rated 1/3 hp or less.

(G) Torque Motors

For torque motors, the disconnecting means shall be permitted to be a general-use switch.

430.110 Ampere Rating and Interrupting Capacity

(A) General

The disconnecting means for motor circuits rated 1000 volts, nominal, or less shall have an ampere rating not less than 115 percent of the full-load current rating of the motor.

Exception: A listed unfused motor-circuit switch having a horsepower rating not less than the motor horsepower shall be permitted to have an ampere rating less than 115 percent of the full-load current rating of the motor.

(B) For Torque Motors

Disconnecting means for a torque motor shall have an ampere rating of at least 115 percent of the motor nameplate current.

(C) For Combination Loads

Where two or more motors are used together or where one or more motors are used in combination with other loads, such as resistance heaters, and where the combined load may be simultaneous on a single disconnecting means, the ampere and horsepower ratings of the combined load shall be determined as follows.

(1) Horsepower Rating

The rating of the disconnecting means shall be determined from the sum of all currents, including resistance loads, at the full-load condition and also at the locked-rotor condition. The combined full-load current and the combined locked-rotor current so obtained shall be considered as a single motor for the purpose of this requirement as follows.

The full-load current equivalent to the horsepower rating of each motor shall be selected from Table 430.247, Table 430.248, Table 430.249, or Table 430.250. These full-load currents shall be added to the rating in amperes of other loads to obtain an equivalent full-load current for the combined load.

The locked-rotor current equivalent to the horsepower rating of each motor shall be selected from Table 430.251(A) or Table 430.251(B). The locked-rotor currents shall be added to the rating in amperes of other loads to obtain an equivalent locked-rotor current for the combined load. Where two or more motors or other loads cannot be started simultaneously, the largest sum of locked-rotor currents of a motor or group of motors that can be started simultaneously and the full-load currents of other concurrent loads shall be permitted to be used to determine the equivalent locked-rotor current for the simultaneous combined loads. In cases where different current ratings are obtained when applying these tables, the largest value obtained shall be used.

Exception: Where part of the concurrent load is resistance load, and where the disconnecting means is a switch rated in horsepower and amperes, the switch used shall be permitted to have a horsepower rating that is not less than the combined load of the motor(s), if the ampere rating of the switch is not less than the locked-rotor current of the motor(s) plus the resistance load.

(2) Ampere Rating

The ampere rating of the disconnecting means shall not be less than 115 percent of the sum of all currents at the full-load condition determined in accordance with 430.110(C)(1).

Exception: A listed nonfused motor-circuit switch having a horsepower rating equal to or greater than the equivalent horsepower of the combined loads, determined in accordance with 430.110(C)(1), shall be permitted to have an ampere rating less than 115 percent of the sum of all currents at the full-load condition.

(3) Small Motors

For small motors not covered by Table 430.247, Table 430.248, Table 430.249, or Table 430.250, the locked-rotor current shall be assumed to be six times the full-load current.

430.111 Switch or Circuit Breaker as Both Controller and Disconnecting Means

A switch or circuit breaker shall be permitted to be used as both the controller and disconnecting means if it complies with 430.111(A) and is one of the types specified in 430.111(B).

(A) General

The switch or circuit breaker complies with the requirements for controllers specified in 430.83, opens all ungrounded conductors to the motor, and is protected by an overcurrent device in each ungrounded conductor (which shall be permitted to be the branch-circuit fuses). The overcurrent device protecting the controller shall be permitted to be part of the controller assembly or shall be permitted to be separate. An autotransformer-type controller shall be provided with a separate disconnecting means.

(B) Type

The device shall be one of the types specified in 430.111(B)(1), (B)(2), or (B)(3).

(1) Air-Break Switch

An air-break switch, operable directly by applying the hand to a lever or handle.

(2) Inverse Time Circuit Breaker

An inverse time circuit breaker operable directly by applying the hand to a lever or handle. The circuit breaker shall be permitted to be both power and manually operable.

(3) Oil Switch

An oil switch used on a circuit whose rating does not exceed 1000 volts or 100 amperes, or by special permission on a circuit exceeding this capacity where under expert supervision. The oil switch shall be permitted to be both power and manually operable.

430.112 Motors Served by Single Disconnecting Means

Each motor shall be provided with an individual disconnecting means.

Exception: A single disconnecting means shall be permitted to serve a group of motors under any one of the conditions of (1), (2), and (3). The single disconnecting means shall be rated in accordance with 430.110(C).

Where a number of motors drive several parts of a single machine or piece of apparatus, such as metal-and woodworking machines, cranes, and hoists.

Where a group of motors is under the protection of one set of branch-circuit protective devices as permitted by 430.53(A).

Where a group of motors is in a single room within sight from the location of the disconnecting means.

430.113 Energy From More Than One Source

Motor and motor-operated equipment receiving electric energy from more than one source shall be provided with disconnecting means from each source of electric energy immediately adjacent to the equipment served. Each source shall be permitted to have a separate disconnecting means. Where multiple disconnecting means are provided, a permanent warning sign shall be provided on or adjacent to each disconnecting means.

Exception No. 1: Where a motor receives electric energy from more than one source, the disconnecting means for the main power supply to the motor shall not be required to be immediately adjacent to the motor, provided that the controller disconnecting means is lockable in accordance with 110.25.

Exception No. 2: A separate disconnecting means shall not be required for a Class 2 remote-control circuit conforming with Article 725, rated not more than 30 volts, and isolated and ungrounded.

Part X Adjustable-Speed Drive Systems

430.120 General

The installation provisions of Part I through Part IX are applicable unless modified or supplemented by Part X.

430.122 Conductors — Minimum Size and Ampacity

(A) Branch/Feeder Circuit Conductors

Circuit conductors supplying power conversion equipment included as part of an adjustable-speed drive system shall have an ampacity not less than 125 percent of the rated input current to the power conversion equipment.

Informational Note No. 1: Power conversion equipment can have multiple power ratings and corresponding input currents.

Informational Note No. 2: Circuit conductors on the output of an adjustable-speed drive system are susceptible to breakdown under certain conditions due to the characteristics of the output waveform of the drive. Factors affecting the conductors include but are not limited to the output voltage, frequency, and current, the length of the conductors, the spacing between the conductors, and the dielectric strength of the conductor insulation. Methods to mitigate breakdown include consideration of one or more of these factors.

(B) Output Conductors

The conductors between the power conversion equipment and the motor shall have an ampacity equal to or larger than 125 percent of the motor full-load current as determined by 430.6(A) or (B).

Exception: If the power conversion equipment is listed and marked as "Suitable for Output Motor Conductor Protection," the conductor between the power conversion equipment and the motor shall have an ampacity equal to or greater than the larger of:

125 percent of the motor full load current as determined by 430.6(A) or (B)

The ampacity of the minimum conductor size marked on the power conversion equipment

Informational Note: The minimum ampacity required of output conductors is often different than that of the conductors supplying the power conversion equipment. See 430.130 and 430.131 for branch circuit protection requirements.

(C) Bypass Device

For an adjustable-speed drive system that utilizes a bypass device, the conductor ampacity shall not be less than required by 430.6. The ampacity of circuit conductors supplying power conversion equipment included as part of an adjustable-speed drive system that utilizes a bypass device shall be the larger of either of the following:

125 percent of the rated input current to the power conversion equipment

125 percent of the motor full-load current rating as determined by 430.6

(D) Several Motors or a Motor and Other Loads

Conductors supplying several motors or a motor and other loads, including power conversion equipment, shall have ampacity in accordance with 430.24, using the rated input current of the power conversion equipment for purposes of calculating ampacity.

430.124 Overload Protection

Overload protection of the motor shall be provided.

(A) Included in Power Conversion Equipment

Where the power conversion equipment is marked to indicate that motor overload protection is included, additional overload protection shall not be required.

(B) Bypass Circuits

For adjustable-speed drive systems that utilize a bypass device to allow motor operation at rated full-load speed, motor overload protection as described in Article 430, Part III, shall be provided in the bypass circuit.

(C) Multiple Motor Applications

For multiple motor application, individual motor overload protection shall be provided in accordance with Article 430, Part III.

430.126 Motor Overtemperature Protection

(A) General

Adjustable-speed drive systems shall protect against motor overtemperature conditions where the motor is not rated to operate at the nameplate rated current over the speed range required by the application. This protection shall be provided in addition to the conductor protection required in 430.32. Protection shall be provided by one of the following means.

Motor thermal protector in accordance with 430.32

Adjustable-speed drive system with load and speed-sensitive overload protection and thermal memory retention upon shutdown or power loss

Exception to (2): Thermal memory retention upon shutdown or power loss is not required for continuous duty loads.

Overtemperature protection relay utilizing thermal sensors embedded in the motor and meeting the requirements of 430.126(A)(2)

Thermal sensor embedded in the motor whose communications are received and acted upon by an adjustable-speed drive system

Informational Note: The relationship between motor current and motor temperature changes when the motor is operated by an adjustable-speed drive. In certain applications, overheating of motors can occur when operated at reduced speed, even at current levels less than a motor's rated full-load current. The overheating can be the result of reduced motor cooling when its shaft-mounted fan is operating less than rated nameplate RPM. As part of the analysis to determine whether overheating will occur, it is necessary to consider the continuous torque capability curves for the motor given the application requirements. This will assist in determining whether the motor overload protection will be able, on its own, to provide protection against overheating. These overheating protection requirements are only intended to apply to applications where an adjustable-speed drive, as defined in Article 100, is used.

For motors that utilize external forced air or liquid cooling systems, overtemperature can occur if the cooling system is not operating. Although this issue is not unique to adjustable speed applications, externally cooled motors are most often encountered with such applications. In these instances, overtemperature protection using direct temperature sensing is recommended [i.e., 430.126(A)(1), (A)(3), or (A)(4)], or additional means should be provided to ensure that the cooling system is operating (flow or pressure sensing, interlocking of adjustable-speed drive system and cooling system, etc.).

(B) Multiple Motor Applications

For multiple motor applications, individual motor overtemperature protection shall be provided as required in 430.126(A).

(C) Automatic Restarting and Orderly Shutdown

430.43 and 430.44 shall apply to the motor overtemperature protection means.

430.128 Disconnecting Means

The disconnecting means shall be permitted to be in the incoming line to the conversion equipment and shall have a rating not less than 115 percent of the rated input current of the conversion unit.

430.130 Branch-Circuit Short-Circuit and Ground-Fault Protection for Single Motor Circuits Containing Power Conversion Equipment

(A) Circuits Containing Power Conversion Equipment

Circuits containing power conversion equipment shall be protected by a branch circuit short-circuit and ground-fault protective device in accordance with all of the following:

The rating and type of protection shall be determined by 430.52(C)(1), (C)(3), (C)(5), or (C)(6), using the full-load current rating of the motor load as determined by 430.6(A) or (B).

Exception to 1: The rating and type of protection shall be permitted to be determined by Table 430.52 using the power conversion equipment's rated input current where the power conversion equipment is listed and marked "Suitable for Output Motor Conductor Protection."

Informational Note No. 1: Motor conductor branch circuit short-circuit and ground-fault protection from the power conversion equipment to the motor is provided by power conversion equipment that is listed and marked "Suitable for Output Motor Conductor Protection."

Informational Note No. 2: A motor branch circuit using power conversion equipment, including equipment listed and marked "Suitable for Output Motor Conductor Protection," includes the input circuit to the power conversion equipment.

Where maximum branch circuit short-circuit and ground-fault protective ratings are stipulated for specific device types in the manufacturer's instructions for the power conversion equipment or are otherwise marked on the equipment, they shall not be exceeded even if higher values are permitted by 430.130 (A) (1).

A self-protected combination controller shall only be permitted where specifically identified in the manufacturer's instructions for the power conversion equipment or if otherwise marked on the equipment.

Informational Note: The type of protective device, its rating, and its setting are often marked on or provided with the power conversion equipment.

Where an instantaneous trip circuit breaker or semiconductor fuses are permitted in accordance with the drive manufacturer's instructions for use as the branch circuit short-circuit and ground-fault protective device for listed power conversion equipment, they shall be provided as an integral part of a single listed assembly incorporating both the protective device and power conversion equipment.

(B) Bypass Circuit/Device

Branch-circuit short-circuit and ground-fault protection shall also be provided for a bypass circuit/device(s). Where a single branch-circuit short-circuit and ground-fault protective device is provided for circuits containing both power conversion equipment and a bypass circuit, the branch-circuit protective device type and its rating or setting shall be in accordance with those determined for the power conversion equipment and for the bypass circuit/device(s) equipment.

430.131 Several Motors or Loads on One Branch Circuit Including Power Conversion Equipment

For installations meeting all the requirements of 430.53 that include one or more power converters, the branch-circuit short-circuit and ground-fault protective fuses or inverse time circuit breakers shall be of a type and rating or setting permitted for use with the power conversion equipment using the full-load current rating of the connected motor load in accordance with 430.53. For the purposes of 430.53 and 430.131, power conversion equipment shall be considered to be a motor controller.

Part XI Over 1000 Volts, Nominal

430.221 General

Part XI recognizes the additional hazard due to the use of higher voltages. It adds to or amends the other provisions of this article.

430.222 Marking on Controllers

In addition to the marking required by 430.8, a controller shall be marked with the control voltage.

430.223 Raceway Connection to Motors

Flexible metal conduit or liquidtight flexible metal conduit not exceeding 1.8 m (6 ft) in length shall be permitted to be employed for raceway connection to a motor terminal enclosure.

430.224 Size of Conductors

Conductors supplying motors shall have an ampacity not less than the current at which the motor overload protective device(s) is selected to trip.

430.225 Motor-Circuit Overcurrent Protection

(A) General

Each motor circuit shall include coordinated protection to automatically interrupt overload and fault currents in the motor, the motor-circuit conductors, and the motor control apparatus.

Exception: Where a motor is critical to an operation and the motor should operate to failure if necessary to prevent a greater hazard to persons, the sensing device(s) shall be permitted to be connected to a supervised annunciator or alarm instead of interrupting the motor circuit.

(B) Overload Protection

(1) Type of Overload Device

Each motor shall be protected against dangerous heating due to motor overloads and failure to start by a thermal protector integral with the motor or external current-sensing devices, or both. Protective device settings for each motor circuit shall be determined under engineering supervision.

(2) Wound-Rotor Alternating-Current Motors

The secondary circuits of wound-rotor ac motors, including conductors, controllers, and resistors rated for the application, shall be considered as protected against overcurrent by the motor overload protection means.

(3) Operation

Operation of the overload interrupting device shall simultaneously disconnect all ungrounded conductors.

(4) Automatic Reset

Overload sensing devices shall not automatically reset after trip unless resetting of the overload sensing device does not cause automatic restarting of the motor or there is no hazard to persons created by automatic restarting of the motor and its connected machinery.

(C) Fault-Current Protection

(1) Type of Protection

Fault-current protection shall be provided in each motor circuit as specified by either 430.225(C)(1)(a) or (C)(1)(b).

(a) A circuit breaker of suitable type and rating arranged so that it can be serviced without hazard. The circuit breaker shall simultaneously disconnect all ungrounded conductors. The circuit breaker shall be permitted to sense the fault current by means of integral or external sensing elements.

(b) Fuses of a suitable type and rating placed in each ungrounded conductor. Fuses shall be used with suitable disconnecting means, or they shall be of a type that can also serve as the disconnecting means. They shall be arranged so that they cannot be serviced while they are energized.

(2) Reclosing

Fault-current interrupting devices shall not automatically reclose the circuit.

Exception: Automatic reclosing of a circuit shall be permitted where the circuit is exposed to transient faults and where such automatic reclosing does not create a hazard to persons.

(3) Combination Protection

Overload protection and fault-current protection shall be permitted to be provided by the same device.

430.226 Rating of Motor Control Apparatus

The ultimate trip current of overcurrent (overload) relays or other motor-protective devices used shall not exceed 115 percent of the controller's continuous current rating. Where the motor branch-circuit disconnecting means is separate from the controller, the disconnecting means current rating shall not be less than the ultimate trip setting of the overcurrent relays in the circuit.

430.227 Disconnecting Means

The controller disconnecting means shall be lockable in accordance with 110.25.

Part XII Protection of Live Parts — All Voltages

430.231 General

Part XII specifies that live parts shall be protected in an approved manner for the hazard involved.

430.232 Where Required

Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded against accidental contact by enclosure or by location as follows:

By installation in a room or enclosure that is accessible only to qualified persons

By installation on a suitable balcony, gallery, or platform, elevated and arranged so as to exclude unqualified persons

By elevation 2.5 m (8 ft) or more above the floor

Exception: Live parts of motors operating at more than 50 volts between terminals shall not require additional guarding for stationary motors that have commutators, collectors, and brush rigging located inside of motor-end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground.

430.233 Guards for Attendants

Where live parts of motors or controllers operating at over 50 volts to ground are guarded against accidental contact only by location as specified in 430.232, and where adjustment or other attendance may be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

Informational Note: For working space, see 110.26 and 110.34.

Part XIII Grounding — All Voltages

430.241 General

Part XIII specifies the grounding of exposed non—current-carrying metal parts, likely to become energized, of motor and controller frames to prevent a voltage aboveground in the event of accidental contact between energized parts and frames. Insulation, isolation, or guarding are suitable alternatives to grounding of motors under certain conditions.

430.242 Stationary Motors

The frames of stationary motors shall be grounded under any of the following conditions:

Where supplied by metal-enclosed wiring

Where in a wet location and not isolated or guarded

If in a hazardous (classified) location

If the motor operates with any terminal at over 150 volts to ground

Where the frame of the motor is not grounded, it shall be permanently and effectively insulated from the ground.

430.243 Portable Motors

The frames of portable motors that operate over 150 volts to ground shall be guarded or grounded.

Informational Note No. 1: See 250.114(4) for grounding of portable appliances in other than residential occupancies.

Informational Note No. 2: See 250.119(C) for color of equipment grounding conductor.

Exception No. 1: Listed motor-operated tools, listed motor-operated appliances, and listed motor-operated equipment shall not be required to be grounded where protected by a system of double insulation or its equivalent. Double-insulated equipment shall be distinctively marked.

Exception No. 2: Listed motor-operated tools, listed motor-operated appliances, and listed motor-operated equipment connected by a cord and attachment plug other than those required to be grounded in accordance with 250.114.

430.244 Controllers

Controller enclosures shall be connected to the equipment grounding conductor regardless of voltage. Controller enclosures shall have means for attachment of an equipment grounding conductor termination in accordance with 250.8.

Exception: Enclosures attached to ungrounded portable equipment shall not be required to be grounded.

430.245 Method of Grounding

Connection to the equipment grounding conductor shall be done in the manner specified in Part VI of Article 250.

(A) Grounding Through Terminal Housings

Where the wiring to motors is metal-enclosed cable or in metal raceways, junction boxes to house motor terminals shall be provided, and the armor of the cable or the metal raceways shall be connected to them in the manner specified in 250.96(A) and 250.97.

(B) Separation of Junction Box From Motor

The junction box required by 430.245(A) shall be permitted to be separated from the motor by not more than 1.8 m (6 ft), provided the leads to the motor are stranded conductors within Type AC cable, interlocked metal tape Type MC cable where listed and identified in accordance with 250.118(10)(a), or armored cord or are stranded leads enclosed in liquidtight flexible metal conduit, flexible metal conduit, intermediate metal conduit, rigid metal conduit, or electrical metallic tubing not smaller than metric designator 12 (trade size 3/8), the armor or raceway being connected both to the motor and to the box.

Liquidtight flexible nonmetallic conduit and rigid nonmetallic conduit shall be permitted to enclose the leads to the motor, provided the leads are stranded and the required equipment grounding conductor is connected to both the motor and to the box.

Where stranded leads are used, protected as specified above, each strand within the conductor shall be not larger than 10 AWG and shall comply with other requirements of this Code for conductors to be used in raceways.

(C) Grounding of Controller-Mounted Devices

Instrument transformer secondaries and exposed non—current-carrying metal or other conductive parts or cases of instrument transformers, meters, instruments, and relays shall be grounded as specified in 250.170 through 250.178.

Part XIV Tables

Table 430.247 Full-Load Current in Amperes, Direct-Current Motors

The following values of full-load currents\* are for motors running at base speed.

Horsepower Armature Voltage Rating\*

90 Volts 120 Volts 180 Volts 240 Volts 500 Volts 550 Volts

1/4 4.0 3.1 2.0 1.6 — —

1/3 5.2 4.1 2.6 2.0 — —

1/2 6.8 5.4 3.4 2.7 — —

3/4 9.6 7.6 4.8 3.8 — —

1 12.2 9.5 6.1 4.7 — —

11/2 — 13.2 8.3 6.6 — —

2 — 17 10.8 8.5 — —

3 — 25 16 12.2 — —

5 — 40 27 20 — —

71/2 — 58 — 29 13.6 12.2

10 — 76 — 38 18 16

15 — — — 55 27 24

20 — — — 72 34 31

25 — — — 89 43 38

30 — — — 106 51 46

40 — — — 140 67 61

50 — — — 173 83 75

60 — — — 206 99 90

75 — — — 255 123 111

100 — — — 341 164 148

125 — — — 425 205 185

150 — — — 506 246 222

200 — — — 675 330 294

\*These are average dc quantities.

Table 430.248 Full-Load Currents in Amperes, Single-Phase Alternating-Current Motors

The following values of full-load currents are for motors running at usual speeds and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120 and 220 to 240 volts.

Horsepower 115 Volts 200 Volts 208 Volts 230 Volts

1/6 4.4 2.5 2.4 2.2

1/4 5.8 3.3 3.2 2.9

1/3 7.2 4.1 4.0 3.6

1/2 9.8 5.6 5.4 4.9

3/4 13.8 7.9 7.6 6.9

1 16 9.2 8.8 8.0

11/2 20 11.5 11.0 10

2 24 13.8 13.2 12

3 34 19.6 18.7 17

5 56 32.2 30.8 28

71/2 80 46.0 44.0 40

10 100 57.5 55.0 50

Table 430.249 Full-Load Current, Two-Phase Alternating-Current Motors (4-Wire)

The following values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Current in the common conductor of a 2-phase, 3-wire system will be 1.41 times the value given. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

Horsepower Induction-Type Squirrel Cage and Wound Rotor (Amperes)

115 Volts 230 Volts 460 Volts 575 Volts 2300 Volts

1/2 4.0 2.0 1.0 0.8 —

3/4 4.8 2.4 1.2 1.0 —

1 6.4 3.2 1.6 1.3 —

11/2 9.0 4.5 2.3 1.8 —

2 11.8 5.9 3.0 2.4 —

3 — 8.3 4.2 3.3 —

5 — 13.2 6.6 5.3 —

71/2 — 19 9.0 8.0 —

10 — 24 12 10 —

15 — 36 18 14 —

20 — 47 23 19 —

25 — 59 29 24 —

30 — 69 35 28 —

40 — 90 45 36 —

50 — 113 56 45 —

60 — 133 67 53 14

75 — 166 83 66 18

100 — 218 109 87 23

125 — 270 135 108 28

150 — 312 156 125 32

200 — 416 208 167 43

Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors

The following values of full-load currents are typical for motors running at speeds usual for belted motors and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

Horsepower Induction-Type Squirrel Cage and Wound Rotor (Amperes) Synchronous-Type Unity Power Factor\* (Amperes)

115 Volts 200 Volts 208 Volts 230 Volts 460 Volts 575 Volts 2300 Volts 230 Volts 460 Volts 575 Volts 2300 Volts

1/2 4.4 2.5 2.4 2.2 1.1 0.9 — — — — —

3/4 6.4 3.7 3.5 3.2 1.6 1.3 — — — — —

1 8.4 4.8 4.6 4.2 2.1 1.7 — — — — —

11/2 12.0 6.9 6.6 6.0 3.0 2.4 — — — — —

2 13.6 7.8 7.5 6.8 3.4 2.7 — — — — —

3 — 11.0 10.6 9.6 4.8 3.9 — — — — —

5 — 17.5 16.7 15.2 7.6 6.1 — — — — —

71/2 — 25.3 24.2 22 11 9 — — — — —

10 — 32.2 30.8 28 14 11 — — — — —

15 — 48.3 46.2 42 21 17 — — — — —

20 — 62.1 59.4 54 27 22 — — — — —

25 — 78.2 74.8 68 34 27 — 53 26 21 —

30 — 92 88 80 40 32 — 63 32 26 —

40 — 120 114 104 52 41 — 83 41 33 —

50 — 150 143 130 65 52 — 104 52 42 —

60 — 177 169 154 77 62 16 123 61 49 12

75 — 221 211 192 96 77 20 155 78 62 15

100 — 285 273 248 124 99 26 202 101 81 20

125 — 359 343 312 156 125 31 253 126 101 25

150 — 414 396 360 180 144 37 302 151 121 30

200 — 552 528 480 240 192 49 400 201 161 40

250 — — — — 302 242 60 — — — —

300 — — — — 361 289 72 — — — —

350 — — — — 414 336 83 — — — —

400 — — — — 477 382 95 — — — —

450 — — — — 515 412 103 — — — —

500 — — — — 590 472 118 — — — —

\*For 90 and 80 percent power factor, the figures shall be multiplied by 1.1 and 1.25, respectively.

Table 430.251(A) Conversion Table of Single-Phase Locked-Rotor Currents for Selection of Disconnecting Means and Controllers as Determined from Horsepower and Voltage Rating

For use only with 430.110, 440.12, 440.41, and 455.8(C).

Rated Horsepower Maximum Locked-Rotor Current in Amperes, Single Phase

115 Volts 208 Volts 230 Volts

1/2 58.8 32.5 29.4

3/4 82.8 45.8 41.4

1 96 53 48

11/2 120 66 60

2 144 80 72

3 204 113 102

5 336 186 168

71/2 480 265 240

10 1000 332 300

Table 430.251(B) Conversion Table of Polyphase Design B, C, and D Maximum Locked-Rotor Currents for Selection of Disconnecting Means and Controllers as Determined from Horsepower and Voltage Rating and Design Letter

For use only with 430.110, 440.12, 440.41, and 455.8(C).

Rated Horsepower Maximum Motor Locked-Rotor Current in Amperes, Two-and Three-Phase, Design B, C, and D\*

115 Volts 200 Volts 208 Volts 230 Volts 460 Volts 575 Volts

B, C, D B, C, D B, C, D B, C, D B, C, D B, C, D

1/2 40 23 22.1 20 10 8

3/4 50 28.8 27.6 25 12.5 10

1 60 34.5 33 30 15 12

11/2 80 46 44 40 20 16

2 100 57.5 55 50 25 20

3 — 73.6 71 64 32 25.6

5 — 105.8 102 92 46 36.8

71/2 — 146 140 127 63.5 50.8

10 — 186.3 179 162 81 64.8

15 — 267 257 232 116 93

20 — 334 321 290 145 116

25 — 420 404 365 183 146

30 — 500 481 435 218 174

40 — 667 641 580 290 232

50 — 834 802 725 363 290

60 — 1001 962 870 435 348

75 — 1248 1200 1085 543 434

100 — 1668 1603 1450 725 580

125 — 2087 2007 1815 908 726

150 — 2496 2400 2170 1085 868

200 — 3335 3207 2900 1450 1160

250 — — — — 1825 1460

300 — — — — 2200 1760

350 — — — — 2550 2040

400 — — — — 2900 2320

450 — — — — 3250 2600

500 — — — — 3625 2900

\*Design A motors are not limited to a maximum starting current or locked rotor current.

Article 440 Air-Conditioning and Refrigerating Equipment

Part I General

440.1 Scope

This article applies to electric motor-driven air-conditioning and refrigerating equipment and to the branch circuits and controllers for such equipment. It provides for the special considerations necessary for circuits supplying hermetic refrigerant motor-compressors and for any air-conditioning or refrigerating equipment that is supplied from a branch circuit that supplies a hermetic refrigerant motor-compressor.

440.2 Definitions

The definitions in this section shall apply only within this article.

Branch-Circuit Selection Current. The value in amperes to be used instead of the rated-load current in determining the ratings of motor branch-circuit conductors, disconnecting means, controllers, and branch-circuit short-circuit and ground-fault protective devices wherever the running overload protective device permits a sustained current greater than the specified percentage of the rated-load current. The value of branch-circuit selection current will always be equal to or greater than the marked rated-load current.

Leakage-Current Detector-Interrupter (LCDI). A device provided in a power supply cord or cord set that senses leakage current flowing between or from the cord conductors and interrupts the circuit at a predetermined level of leakage current.

Rated-Load Current. The current of a hermetic refrigerant motor-compressor resulting when it is operated at the rated load, rated voltage, and rated frequency of the equipment it serves.

440.3 Other Articles

(A) Article 430

These provisions are in addition to, or amendatory of, the provisions of Article 430 and other articles in this Code, which apply except as modified in this article.

(B) Articles 422, 424, or 430

The rules of Articles 422, 424, or 430, as applicable, shall apply to air-conditioning and refrigerating equipment that does not incorporate a hermetic refrigerant motor-compressor. This equipment includes devices that employ refrigeration compressors driven by conventional motors, furnaces with air-conditioning evaporator coils installed, fan-coil units, remote forced air-cooled condensers, remote commercial refrigerators, and so forth.

(C) Article 422

Equipment such as room air conditioners, household refrigerators and freezers, drinking water coolers, and beverage dispensers shall be considered appliances, and Article 422 shall also apply.

(D) Other Applicable Articles

Hermetic refrigerant motor-compressors, circuits, controllers, and equipment shall also comply with the applicable provisions of Table 440.3(D).

Table 440.3(D) Other Articles

Equipment /Occupancy Article Section

Capacitors 460.9

Commercial garages, aircraft hangars, motor fuel dispensing facilities, bulk storage plants, spray application, dipping, and coating processes, and inhalation anesthetizing locations 511, 513, 514, 515, 516, and 517 Part IV

Hazardous (classified) locations 500—503, 505, and 506

Motion picture and television studios and similar locations 530

Resistors and reactors 470

440.4 Marking on Hermetic Refrigerant Motor-Compressors and Equipment

(A) Hermetic Refrigerant Motor-Compressor Nameplate

A hermetic refrigerant motor-compressor shall be provided with a nameplate that shall indicate the manufacturer's name, trademark, or symbol; identifying designation; phase; voltage; and frequency. The rated-load current in amperes of the motor-compressor shall be marked by the equipment manufacturer on either or both the motor-compressor nameplate and the nameplate of the equipment in which the motor-compressor is used. The locked-rotor current of each single-phase motor-compressor having a rated-load current of more than 9 amperes at 115 volts, or more than 4.5 amperes at 230 volts, and each polyphase motor-compressor shall be marked on the motor-compressor nameplate. Where a thermal protector complying with 440.52(A)(2) and (B)(2) is used, the motor-compressor nameplate or the equipment nameplate shall be marked with the words "thermally protected." Where a protective system complying with 440.52(A)(4) and (B)(4) is used and is furnished with the equipment, the equipment nameplate shall be marked with the words, "thermally protected system." Where a protective system complying with 440.52(A)(4) and (B)(4) is specified, the equipment nameplate shall be appropriately marked.

(B) Multimotor and Combination-Load Equipment

Multimotor and combination-load equipment shall be provided with a visible nameplate marked with the maker's name, the rating in volts, frequency and number of phases, minimum supply circuit conductor ampacity, the maximum rating of the branch-circuit short-circuit and ground-fault protective device, and the short-circuit current rating of the motor controllers or industrial control panel. The ampacity shall be calculated by using Part IV and counting all the motors and other loads that will be operated at the same time. The branch-circuit short-circuit and ground-fault protective device rating shall not exceed the value calculated by using Part III. Multimotor or combination-load equipment for use on two or more circuits shall be marked with the above information for each circuit.

Exception No. 1: Multimotor and combination-load equipment that is suitable under the provisions of this article for connection to a single 15- or 20-ampere, 120-volt, or a 15-ampere, 208- or 240-volt, single-phase branch circuit shall be permitted to be marked as a single load.

Exception No. 2: The minimum supply circuit conductor ampacity and the maximum rating of the branch-circuit short-circuit and ground-fault protective device shall not be required to be marked on a room air conditioner complying with 440.62(A).

Exception No. 3: Multimotor and combination-load equipment used in one-and two-family dwellings or cord-and-attachment-plug-connected equipment shall not be required to be marked with a short-circuit current rating.

(C) Branch-Circuit Selection Current

A hermetic refrigerant motor-compressor, or equipment containing such a compressor, having a protection system that is approved for use with the motor-compressor that it protects and that permits continuous current in excess of the specified percentage of nameplate rated-load current given in 440.52(B)(2) or (B)(4) shall also be marked with a branch-circuit selection current that complies with 440.52(B)(2) or (B)(4). This marking shall be provided by the equipment manufacturer and shall be on the nameplate(s) where the rated-load current(s) appears.

440.5 Marking on Controllers

A controller shall be marked with the manufacturer's name, trademark, or symbol; identifying designation; voltage; phase; full-load and locked-rotor current (or horsepower) rating; and other data as may be needed to properly indicate the motor-compressor for which it is suitable.

440.6 Ampacity and Rating

The size of conductors for equipment covered by this article shall be selected from Table 310.16 through Table 310.19 or calculated in accordance with 310.14 as applicable. The required ampacity of conductors and rating of equipment shall be determined according to 440.6(A) and 440.6(B).

(A) Hermetic Refrigerant Motor-Compressor

For a hermetic refrigerant motor-compressor, the rated-load current marked on the nameplate of the equipment in which the motor-compressor is employed shall be used in determining the rating or ampacity of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground-fault protection, and the separate motor overload protection. Where no rated-load current is shown on the equipment nameplate, the rated-load current shown on the compressor nameplate shall be used.

Exception No. 1: Where so marked, the branch-circuit selection current shall be used instead of the rated-load current to determine the rating or ampacity of the disconnecting means, the branch-circuit conductors, the controller, and the branch-circuit short-circuit and ground-fault protection.

Exception No. 2: For cord-and-plug-connected equipment, the nameplate marking shall be used in accordance with 440.22(B), Exception No. 2.

(B) Multimotor Equipment

For multimotor equipment employing a shaded-pole or permanent split-capacitor-type fan or blower motor, the full-load current for such motor marked on the nameplate of the equipment in which the fan or blower motor is employed shall be used instead of the horsepower rating to determine the ampacity or rating of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground-fault protection, and the separate overload protection. This marking on the equipment nameplate shall not be less than the current marked on the fan or blower motor nameplate.

440.7 Highest Rated (Largest) Motor

In determining compliance with this article and with 430.24, 430.53(B) and 430.53(C), and 430.62(A), the highest rated (largest) motor shall be considered to be the motor that has the highest rated-load current. Where two or more motors have the same highest rated-load current, only one of them shall be considered as the highest rated (largest) motor. For other than hermetic refrigerant motor-compressors, and fan or blower motors as covered in 440.6(B), the full-load current used to determine the highest rated motor shall be the equivalent value corresponding to the motor horsepower rating selected from Table 430.248, Table 430.249, or Table 430.250.

Exception: Where so marked, the branch-circuit selection current shall be used instead of the rated-load current in determining the highest rated (largest) motor-compressor.

440.8 Single Machine

An air-conditioning or refrigerating system shall be considered to be a single machine under the provisions of 430.87, Exception No. 1, and 430.112, Exception. The motors shall be permitted to be located remotely from each other.

440.9 Grounding and Bonding

Where equipment is installed outdoors on a roof, an equipment grounding conductor of the wire type shall be installed in outdoor portions of metallic raceway systems that use compression-type fittings.

440.10 Short-Circuit Current Rating

(A) Installation

Motor controllers or industrial control panels of multimotor and combination-load equipment shall not be installed where the available fault current exceeds its short-circuit current rating as marked in accordance with 440.4(B).

(B) Documentation

When motor controllers or industrial control panels of multimotor and combination-load equipment are required to be marked with a short circuit current rating, the available fault current and the date the available fault current calculation was performed shall be documented and made available to those authorized to inspect, install, or maintain the installation.

Part II Disconnecting Means

440.11 General

Part II is intended to require disconnecting means capable of disconnecting air-conditioning and refrigerating equipment, including motor-compressors and controllers from the circuit conductors.

440.12 Rating and Interrupting Capacity

(A) Hermetic Refrigerant Motor-Compressor

A disconnecting means serving a hermetic refrigerant motor-compressor shall be selected on the basis of the nameplate rated-load current or branch-circuit selection current, whichever is greater, and locked-rotor current, respectively, of the motor-compressor as follows.

(1) Ampere Rating

The ampere rating shall be at least 115 percent of the nameplate rated-load current or branch-circuit selection current, whichever is greater.

Exception: A listed unfused motor circuit switch, without fuseholders, having a horsepower rating not less than the equivalent horsepower determined in accordance with 440.12(A)(2) shall be permitted to have an ampere rating less than 115 percent of the specified current.

(2) Equivalent Horsepower

To determine the equivalent horsepower in complying with the requirements of 430.109, the horsepower rating shall be selected from Table 430.248, Table 430.249, or Table 430.250 corresponding to the rated-load current or branch-circuit selection current, whichever is greater, and also the horsepower rating from Table 430.251(A) or Table 430.251(B) corresponding to the locked-rotor current. In case the nameplate rated-load current or branch-circuit selection current and locked-rotor current do not correspond to the currents shown in Table 430.248, Table 430.249, Table 430.250, Table 430.251(A), or Table 430.251(B), the horsepower rating corresponding to the next higher value shall be selected. In case different horsepower ratings are obtained when applying these tables, a horsepower rating at least equal to the larger of the values obtained shall be selected.

(B) Combination Loads

Where the combined load of two or more hermetic refrigerant motor-compressors or one or more hermetic refrigerant motor-compressor with other motors or loads may be simultaneous on a single disconnecting means, the rating for the disconnecting means shall be determined in accordance with 440.12(B)(1) and (B)(2).

(1) Horsepower Rating

The horsepower rating of the disconnecting means shall be determined from the sum of all currents, including resistance loads, at the rated-load condition and also at the locked-rotor condition. The combined rated-load current and the combined locked-rotor current so obtained shall be considered as a single motor for the purpose of this requirement as required by 440.12(B)(1)(a) and (B)(1)(b).

(a) The full-load current equivalent to the horsepower rating of each motor, other than a hermetic refrigerant motor-compressor, and fan or blower motors as covered in 440.6(B) shall be selected from Table 430.248, Table 430.249, or Table 430.250. These full-load currents shall be added to the motor-compressor rated-load current(s) or branch-circuit selection current(s), whichever is greater, and to the rating in amperes of other loads to obtain an equivalent full-load current for the combined load.

(b) The locked-rotor current equivalent to the horsepower rating of each motor, other than a hermetic refrigerant motor-compressor, shall be selected from Table 430.251(A) or Table 430.251(B), and, for fan and blower motors of the shaded-pole or permanent split-capacitor type marked with the locked-rotor current, the marked value shall be used. The locked-rotor currents shall be added to the motor-compressor locked-rotor current(s) and to the rating in amperes of other loads to obtain an equivalent locked-rotor current for the combined load. Where two or more motors or other loads such as resistance heaters, or both, cannot be started simultaneously, appropriate combinations of locked-rotor and rated-load current or branch-circuit selection current, whichever is greater, shall be an acceptable means of determining the equivalent locked-rotor current for the simultaneous combined load.

Exception: Where part of the concurrent load is a resistance load and the disconnecting means is a switch rated in horsepower and amperes, the switch used shall be permitted to have a horsepower rating not less than the combined load to the motor-compressor(s) and other motor(s) at the locked-rotor condition, if the ampere rating of the switch is not less than this locked-rotor load plus the resistance load.

(2) Full-Load Current Equivalent

The ampere rating of the disconnecting means shall be at least 115 percent of the sum of all currents at the rated-load condition determined in accordance with 440.12(B)(1).

Exception: A listed unfused motor circuit switch, without fuseholders, having a horsepower rating not less than the equivalent horsepower determined by 440.12(B)(1) shall be permitted to have an ampere rating less than 115 percent of the sum of all currents.

(C) Small Motor-Compressors

For small motor-compressors not having the locked-rotor current marked on the nameplate, or for small motors not covered by Table 430.247, Table 430.248, Table 430.249, or Table 430.250, the locked-rotor current shall be assumed to be six times the rated-load current.

(D) Disconnecting Means

Every disconnecting means in the refrigerant motor-compressor circuit between the point of attachment to the feeder and the point of connection to the refrigerant motor-compressor shall comply with the requirements of 440.12.

(E) Disconnecting Means Rated in Excess of 100 Horsepower

Where the rated-load or locked-rotor current as determined above would indicate a disconnecting means rated in excess of 100 hp, 430.109(E) shall apply.

440.13 Cord-Connected Equipment

For cord-connected equipment such as room air conditioners, household refrigerators and freezers, drinking water coolers, and beverage dispensers, a separable connector or an attachment plug and receptacle shall be permitted to serve as the disconnecting means.

Informational Note: For room air conditioners, see 440.63.

440.14 Location

Disconnecting means shall be located within sight from, and readily accessible from the air-conditioning or refrigerating equipment. The disconnecting means shall be permitted to be installed on or within the air-conditioning or refrigerating equipment.

The disconnecting means shall not be located on panels that are designed to allow access to the air-conditioning or refrigeration equipment or to obscure the equipment nameplate(s).

Exception No. 1: Where the disconnecting means provided in accordance with 430.102(A) is lockable in accordance with 110.25 and the refrigerating or air-conditioning equipment is essential to an industrial process in a facility with written safety procedures, and where the conditions of maintenance and supervision ensure that only qualified persons service the equipment, a disconnecting means within sight from the equipment shall not be required.

Exception No. 2: Where an attachment plug and receptacle serve as the disconnecting means in accordance with 440.13, their location shall be accessible but shall not be required to be readily accessible.

Informational Note No. 1: See Parts VII and IX of Article 430 for additional requirements.

Informational Note No. 2: See 110.26.

Part III Branch-Circuit Short-Circuit and Ground-Fault Protection

440.21 General

Part III specifies devices intended to protect the branch-circuit conductors, control apparatus, and motors in circuits supplying hermetic refrigerant motor-compressors against overcurrent due to short circuits and ground faults. They are in addition to or amendatory of Article 240.

440.22 Application and Selection

(A) Rating or Setting for Individual Motor-Compressor

The motor-compressor branch-circuit short-circuit and ground-fault protective device shall be capable of carrying the starting current of the motor. A protective device having a rating or setting not exceeding 175 percent of the motor-compressor rated-load current or branch-circuit selection current, whichever is greater, shall be permitted, provided that, where the protection specified is not sufficient for the starting current of the motor, the rating or setting shall be permitted to be increased but shall not exceed 225 percent of the motor rated-load current or branch-circuit selection current, whichever is greater.

Exception: The rating of the branch-circuit short-circuit and ground-fault protective device shall not be required to be less than 15 amperes.

(B) Rating or Setting for Equipment

The equipment branch-circuit short-circuit and ground-fault protective device shall be capable of carrying the starting current of the equipment. Where the hermetic refrigerant motor-compressor is the only load on the circuit, the protection shall comply with 440.22(A). Where the equipment incorporates more than one hermetic refrigerant motor-compressor or a hermetic refrigerant motor-compressor and other motors or other loads, the equipment short-circuit and ground-fault protection shall comply with 430.53 and 440.22(B)(1) and (B)(2).

(1) Motor-Compressor Largest Load

Where a hermetic refrigerant motor-compressor is the largest load connected to the circuit, the rating or setting of the branch-circuit short-circuit and ground-fault protective device shall not exceed the value specified in 440.22(A) for the largest motor-compressor plus the sum of the rated-load current or branch-circuit selection current, whichever is greater, of the other motor-compressor(s) and the ratings of the other loads supplied.

(2) Motor-Compressor Not Largest Load

Where a hermetic refrigerant motor-compressor is not the largest load connected to the circuit, the rating or setting of the branch-circuit short-circuit and ground-fault protective device shall not exceed a value equal to the sum of the rated-load current or branch-circuit selection current, whichever is greater, rating(s) for the motor-compressor(s) plus the value specified in 430.53(C)(4) where other motor loads are supplied, or the value specified in 240.4 where only nonmotor loads are supplied in addition to the motor-compressor(s).

Exception No. 1: Equipment that starts and operates on a 15- or 20-ampere 120-volt, or 15-ampere 208- or 240-volt single-phase branch circuit, shall be permitted to be protected by the 15- or 20-ampere overcurrent device protecting the branch circuit, but if the maximum branch-circuit short-circuit and ground-fault protective device rating marked on the equipment is less than these values, the circuit protective device shall not exceed the value marked on the equipment nameplate.

Exception No. 2: The nameplate marking of cord-and-plug-connected equipment rated not greater than 250 volts, single-phase, such as household refrigerators and freezers, drinking water coolers, and beverage dispensers, shall be used in determining the branch-circuit requirements, and each unit shall be considered as a single motor unless the nameplate is marked otherwise.

(C) Protective Device Rating Not to Exceed the Manufacturer's Values

Where maximum protective device ratings shown on a manufacturer's overload relay table for use with a motor controller are less than the rating or setting selected in accordance with 440.22(A) and (B), the protective device rating shall not exceed the manufacturer's values marked on the equipment.

Part IV Branch-Circuit Conductors

440.31 General

Part IV and Article 310 specify ampacities of conductors required to carry the motor current without overheating under the conditions specified, except as modified in 440.6(A), Exception No. 1.

These articles shall not apply to integral conductors of motors, to motor controllers and the like, or to conductors that form an integral part of approved equipment.

440.32 Single Motor-Compressor

Branch-circuit conductors supplying a single motor-compressor shall have an ampacity not less than the greater of:

125 percent of the motor-compressor rated-load current

125 percent of the branch-circuit selection current

For a wye-start, delta-run connected motor-compressor, the selection of branch-circuit conductors between the controller and the motor-compressor shall be permitted to be based on 72 percent of either the motor-compressor rated-load current or the branch-circuit selection current, whichever is greater.

Informational Note: The individual motor circuit conductors of wye-start, delta-run connected motor-compressors carry 58 percent of the rated load current. The multiplier of 72 percent is obtained by multiplying 58 percent by 1.25.

440.33 Motor-Compressor(s) With or Without Additional Motor Loads

Conductors supplying one or more motor-compressor(s) with or without an additional motor load(s) shall have an ampacity not less than the sum of each of the following:

The sum of the rated-load or branch-circuit selection current, whichever is greater, of all motor-compressor(s)

The sum of the full-load current rating of all other motors

25 percent of the highest motor-compressor or motor full load current in the group

Exception No. 1: Where the circuitry is interlocked so as to prevent the starting and running of a second motor-compressor or group of motor-compressors, the conductor size shall be determined from the largest motor-compressor or group of motor-compressors that is to be operated at a given time.

Exception No. 2: The branch-circuit conductors for room air conditioners shall be in accordance with Part VII of Article 440.

440.34 Combination Load

Conductors supplying a motor-compressor load in addition to other load(s) as calculated from Article 220 and other applicable articles shall have an ampacity sufficient for the other load(s) plus the required ampacity for the motor-compressor load determined in accordance with 440.33 or, for a single motor-compressor, in accordance with 440.32.

Exception: Where the circuitry is interlocked so as to prevent simultaneous operation of the motor-compressor(s) and all other loads connected, the conductor size shall be determined from the largest size required for the motor-compressor(s) and other loads to be operated at a given time.

440.35 Multimotor and Combination-Load Equipment

The ampacity of the conductors supplying multimotor and combination-load equipment shall not be less than the minimum circuit ampacity marked on the equipment in accordance with 440.4(B).

Part V Controllers for Motor-Compressors

440.41 Rating

(A) Motor-Compressor Controller

A motor-compressor controller shall have both a continuous-duty full-load current rating and a locked-rotor current rating not less than the nameplate rated-load current or branch-circuit selection current, whichever is greater, and locked-rotor current, respectively, of the compressor. In case the motor controller is rated in horsepower but is without one or both of the foregoing current ratings, equivalent currents shall be determined from the ratings as follows. Table 430.248, Table 430.249, and Table 430.250 shall be used to determine the equivalent full-load current rating. Table 430.251(A) and Table 430.251(B) shall be used to determine the equivalent locked-rotor current ratings.

(B) Controller Serving More Than One Load

A controller serving more than one motor-compressor or a motor-compressor and other loads shall have a continuous-duty full-load current rating and a locked-rotor current rating not less than the combined load as determined in accordance with 440.12(B).

Part VI Motor-Compressor and Branch-Circuit Overload Protection

440.51 General

Part VI specifies devices intended to protect the motor-compressor, the motor-control apparatus, and the branch-circuit conductors against excessive heating due to motor overload and failure to start.

Informational Note: See 240.4(G) for application of Parts III and VI of Article 440.

440.52 Application and Selection

(A) Protection of Motor-Compressor

Each motor-compressor shall be protected against overload and failure to start by one of the following means:

A separate overload relay that is responsive to motor-compressor current. This device shall be selected to trip at not more than 140 percent of the motor-compressor rated-load current.

A thermal protector integral with the motor-compressor, approved for use with the motor-compressor that it protects on the basis that it will prevent dangerous overheating of the motor-compressor due to overload and failure to start. If the current-interrupting device is separate from the motor-compressor and its control circuit is operated by a protective device integral with the motor-compressor, it shall be arranged so that the opening of the control circuit will result in interruption of current to the motor-compressor.

A fuse or inverse time circuit breaker responsive to motor current, which shall also be permitted to serve as the branch-circuit short-circuit and ground-fault protective device. This device shall be rated at not more than 125 percent of the motor-compressor rated-load current. It shall have sufficient time delay to permit the motor-compressor to start and accelerate its load. The equipment or the motor-compressor shall be marked with this maximum branch-circuit fuse or inverse time circuit breaker rating.

A protective system, furnished or specified and approved for use with the motor-compressor that it protects on the basis that it will prevent dangerous overheating of the motor-compressor due to overload and failure to start. If the current-interrupting device is separate from the motor-compressor and its control circuit is operated by a protective device that is not integral with the current-interrupting device, it shall be arranged so that the opening of the control circuit will result in interruption of current to the motor-compressor.

(B) Protection of Motor-Compressor Control Apparatus and Branch-Circuit Conductors

The motor-compressor controller(s), the disconnecting means, and the branch-circuit conductors shall be protected against overcurrent due to motor overload and failure to start by one of the following means, which shall be permitted to be the same device or system protecting the motor-compressor in accordance with 440.52(A):

Exception: Overload protection of motor-compressors and equipment on 15- and 20-ampere, single-phase, branch circuits shall be permitted to be in accordance with 440.54 and 440.55.

An overload relay selected in accordance with 440.52(A)(1)

A thermal protector applied in accordance with 440.52(A)(2), that will not permit a continuous current in excess of 156 percent of the marked rated-load current or branch-circuit selection current

A fuse or inverse time circuit breaker selected in accordance with 440.52(A)(3)

A protective system, in accordance with 440.52(A)(4), that will not permit a continuous current in excess of 156 percent of the marked rated-load current or branch-circuit selection current

440.53 Overload Relays

Overload relays and other devices for motor overload protection that are not capable of opening short circuits shall be protected by fuses or inverse time circuit breakers with ratings or settings in accordance with Part III unless identified for group installation or for part-winding motors and marked to indicate the maximum size of fuse or inverse time circuit breaker by which they shall be protected.

Exception: The fuse or inverse time circuit breaker size marking shall be permitted on the nameplate of the equipment in which the overload relay or other overload device is used.

440.54 Motor-Compressors and Equipment on 15- or 20-Ampere Branch Circuits — Not Cord- And Attachment-Plug-Connected

Overload protection for motor-compressors and equipment used on 15- or 20-ampere 120-volt, or 15-ampere 208- or 240-volt single-phase branch circuits as permitted in Article 210 shall be permitted as indicated in 440.54(A) and 440.54(B).

(A) Overload Protection

The motor-compressor shall be provided with overload protection selected as specified in 440.52(A). Both the controller and motor overload protective device shall be identified for installation with the short-circuit and ground-fault protective device for the branch circuit to which the equipment is connected.

(B) Time Delay

The short-circuit and ground-fault protective device protecting the branch circuit shall have sufficient time delay to permit the motor-compressor and other motors to start and accelerate their loads.

440.55 Cord- And Attachment-Plug-Connected Motor-Compressors and Equipment on 15- or 20-Ampere Branch Circuits

Overload protection for motor-compressors and equipment that are cord-and attachment-plug-connected and used on 15- or 20-ampere 120-volt, or 15-ampere 208- or 240-volt, single-phase branch circuits as permitted in Article 210 shall be permitted as indicated in 440.55(A), (B), and (C).

(A) Overload Protection

The motor-compressor shall be provided with overload protection as specified in 440.52(A). Both the controller and the motor overload protective device shall be identified for installation with the short-circuit and ground-fault protective device for the branch circuit to which the equipment is connected.

(B) Attachment Plug and Receptacle or Cord Connector Rating

The rating of the attachment plug and receptacle or cord connector shall not exceed 20 amperes at 125 volts or 15 amperes at 250 volts.

(C) Time Delay

The short-circuit and ground-fault protective device protecting the branch circuit shall have sufficient time delay to permit the motor-compressor and other motors to start and accelerate their loads.

Part VII Provisions for Room Air Conditioners

440.60 General

Part VII shall apply to electrically energized room air conditioners that control temperature and humidity. For the purpose of Part VII, a room air conditioner (with or without provisions for heating) shall be considered as an ac appliance of the air-cooled window, console, or in-wall type that is installed in the conditioned room and that incorporates a hermetic refrigerant motor-compressor(s). Part VII covers equipment rated not over 250 volts, single phase, and the equipment shall be permitted to be cord-and attachment-plug-connected.

A room air conditioner that is rated 3-phase or rated over 250 volts shall be directly connected to a wiring method recognized in Chapter 3, and Part VII shall not apply.

440.61 Grounding

The enclosures of room air conditioners shall be connected to the equipment grounding conductor in accordance with 250.110, 250.112, and 250.114.

440.62 Branch-Circuit Requirements

(A) Room Air Conditioner as a Single Motor Unit

A room air conditioner shall be considered as a single motor unit in determining its branch-circuit requirements where all the following conditions are met:

It is cord-and attachment-plug-connected.

Its rating is not more than 40 amperes and 250 volts, single phase.

Total rated-load current is shown on the room air-conditioner nameplate rather than individual motor currents.

The rating of the branch-circuit short-circuit and ground-fault protective device does not exceed the ampacity of the branch-circuit conductors or the rating of the receptacle, whichever is less.

(B) Where No Other Loads Are Supplied

The total marked rating of a cord-and attachment-plug-connected room air conditioner shall not exceed 80 percent of the rating of a branch circuit where no other loads are supplied.

(C) Where Lighting Units or Other Appliances Are Also Supplied

The total marked rating of a cord-and attachment-plug-connected room air conditioner shall not exceed 50 percent of the rating of a branch circuit where lighting outlets, other appliances, or general-use receptacles are also supplied. Where the circuitry is interlocked to prevent simultaneous operation of the room air conditioner and energization of other outlets on the same branch circuit, a cord-and attachment-plug-connected room air conditioner shall not exceed 80 percent of the branch-circuit rating.

440.63 Disconnecting Means

An attachment plug and receptacle or cord connector shall be permitted to serve as the disconnecting means for a single-phase room air conditioner rated 250 volts or less if (1) the manual controls on the room air conditioner are readily accessible and located within 1.8 m (6 ft) of the floor, or (2) an approved manually operable disconnecting means is installed in a readily accessible location within sight from the room air conditioner.

440.64 Supply Cords

Where a flexible cord is used to supply a room air conditioner, the length of such cord shall not exceed 3.0 m (10 ft) for a nominal, 120-volt rating or 1.8 m (6 ft) for a nominal, 208- or 240-volt rating.

440.65 Protection Devices

Single-phase cord-and plug-connected room air conditioners shall be provided with one of the following factory-installed devices:

Leakage-current detector-interrupter (LCDI)

Arc-fault circuit interrupter (AFCI)

Heat detecting circuit interrupter (HDCI)

The protection device shall be an integral part of the attachment plug or be located in the power supply cord within 300 mm (12 in.) of the attachment plug.

Article 445 Generators

445.1 Scope

This article contains installation and other requirements for generators.

445.6 Listing

Stationary generators 600 volts and less shall be listed.

Exception: One of a kind or custom manufactured generators shall be permitted to be field labeled by a field evaluation body.

Informational Note: For additional information, see UL 2200, Standard for Stationary Engine Generator Assemblies.

445.10 Location

Generators shall be of a type suitable for the locations in which they are installed. They shall also meet the requirements for motors in 430.14.

Informational Note: See NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, for information on the location of generator exhaust.

445.11 Marking

Each generator shall be provided with a nameplate giving the manufacturer's name, the rated frequency, the number of phases if ac, the rating in kilowatts or kilovolt-amperes, the power factor, the normal volts and amperes corresponding to the rating, and the rated ambient temperature.

Nameplates or manufacturer's instructions shall provide the following information for all stationary generators and portable generators rated more than 15 kW:

Subtransient, transient, synchronous, and zero sequence reactances

Power rating category

Temperature rise at rated load and insulation system class

Indication if the generator is protected against overload by inherent design, an overcurrent protective relay, a circuit breaker, or a fuse

Available fault current for inverter-based generators, in lieu of the synchronous, subtransient, and transient reactances

Marking shall be provided by the manufacturer to indicate whether or not the generator neutral is bonded to its frame. Where the bonding is modified in the field, additional marking shall be required to indicate whether the neutral is bonded to the frame.

445.12 Overcurrent Protection

(A) Constant-Voltage Generators

Constant-voltage generators, except ac generator exciters, shall be protected from overload by inherent design, circuit breakers, fuses, protective relays, or other identified overcurrent protective means suitable for the conditions of use.

(B) Two-Wire Generators

Two-wire, dc generators shall be permitted to have overcurrent protection in one conductor only if the overcurrent device is actuated by the entire current generated other than the current in the shunt field. The overcurrent device shall not open the shunt field.

(C) 65 Volts or Less

Generators operating at 65 volts or less and driven by individual motors shall be considered as protected by the overcurrent device protecting the motor if these devices will operate when the generators are delivering not more than 150 percent of their full-load rated current.

(D) Balancer Sets

Two-wire, dc generators used in conjunction with balancer sets to obtain neutral points for 3-wire systems shall be equipped with overcurrent devices that disconnect the 3-wire system in case of excessive unbalancing of voltages or currents.

(E) Three-Wire, Direct-Current Generators

Three-wire, dc generators, whether compound or shunt wound, shall be equipped with overcurrent devices, one in each armature lead, and connected so as to be actuated by the entire current from the armature. Such overcurrent devices shall consist either of a double-pole, double-coil circuit breaker or of a 4-pole circuit breaker connected in the main and equalizer leads and tripped by two overcurrent devices, one in each armature lead. Such protective devices shall be interlocked so that no one pole can be opened without simultaneously disconnecting both leads of the armature from the system.

Exception to (A) through (E): Where deemed by the authority having jurisdiction that a generator is vital to the operation of an electrical system and the generator should operate to failure to prevent a greater hazard to persons, the overload sensing device(s) shall be permitted to be connected to an annunciator or alarm supervised by authorized personnel instead of interrupting the generator circuit.

445.13 Ampacity of Conductors

(A) General

The ampacity of the conductors from the generator output terminals to the first distribution device(s) containing overcurrent protection shall not be less than 115 percent of the nameplate current rating of the generator. It shall be permitted to size the neutral conductors in accordance with 220.61. Conductors that must carry ground-fault currents shall not be smaller than required by 250.30(A). Neutral conductors of dc generators that must carry ground-fault currents shall not be smaller than the minimum required size of the largest conductor.

Exception: Where the design and operation of the generator prevent overloading, the ampacity of the conductors shall not be less than 100 percent of the nameplate current rating of the generator.

(B) Overcurrent Protection Provided

Where the generator set is equipped with a listed overcurrent protective device or a combination of a current transformer and overcurrent relay, conductors shall be permitted to be tapped from the load side of the protected terminals in accordance with 240.21(B).

Tapped conductors shall not be permitted for portable generators rated 15 kW or less where field wiring connection terminals are not accessible.

445.14 Protection of Live Parts

Live parts of generators operated at more than 50 volts ac or 60 volts dc to ground shall not be exposed to accidental contact where accessible to unqualified persons.

445.15 Guards for Attendants

Where necessary for the safety of attendants, the requirements of 430.233 shall apply.

445.16 Bushings

Where field-installed wiring passes through an opening in an enclosure, a conduit box, or a barrier, a bushing shall be used to protect the conductors from the edges of an opening having sharp edges. The bushing shall have smooth, well-rounded surfaces where it may be in contact with the conductors. If used where oils, grease, or other contaminants may be present, the bushing shall be made of a material not deleteriously affected.

445.17 Generator Terminal Housings

Generator terminal housings shall comply with 430.12. Where a horsepower rating is required to determine the required minimum size of the generator terminal housing, the full-load current of the generator shall be compared with comparable motors in Table 430.247 through Table 430.250. The higher horsepower rating of Table 430.247 and Table 430.250 shall be used whenever the generator selection is between two ratings.

Exception: This section shall not apply to generators rated over 600 volts.

445.18 Disconnecting Means and Emergency Shutdown

(A) Disconnecting Means

Generators other than cord-and-plug-connected portable generators shall have one or more disconnecting means. Each disconnecting means shall simultaneously open all associated ungrounded conductors. Each disconnecting means shall be lockable open in accordance with 110.25.

(B) Emergency Shutdown of Prime Mover

Generators shall have provisions to shut down the prime mover. The means of shutdown shall comply with all of the following:

Be equipped with provisions to disable all prime mover start control circuits to render the prime mover incapable of starting

Initiate a shutdown mechanism that requires a mechanical reset

The provisions to shut down the prime mover shall be permitted to satisfy the requirements of 445.18(A) where it is capable of being locked in the open position in accordance with 110.25.

(C) Remote Emergency Shutdown

Generators with greater than 15 kW rating shall be provided with a remote emergency stop switch to shut down the prime mover. The remote emergency stop switch shall be located outside the equipment room or generator enclosure and shall also meet the requirements of 445.18(B)(1) and (B)(2).

(D) Emergency Shutdown in One- And Two-Family Dwelling Units

For other than cord-and-plug-connected portable generators, an emergency shutdown device shall be located outside the dwelling unit at a readily accessible location.

(E) Generators Installed in Parallel

Where a generator is installed in parallel with other generators, the provisions of 445.18(A) shall be capable of isolating the generator output terminals from the paralleling equipment. The disconnecting means shall not be required to be located at the generator.

445.20 Ground-Fault Circuit-Interrupter Protection for Receptacles on 15-kW or Smaller Portable Generators

Receptacle outlets that are a part of a 15-kW or smaller portable generator shall have listed ground-fault circuit-interrupter protection (GFCI) for personnel integral to the generator or receptacle as indicated in either (A) or (B):

(A) Unbonded (Floating Neutral) Generators

Unbonded generators with both 125-volt and 125/250-volt receptacle outlets shall have listed GFCI protection for personnel integral to the generator or receptacle on all 125-volt, 15- and 20-ampere receptacle outlets.

Exception: GFCI protection shall not be required where the 125-volt receptacle outlets(s) is interlocked such that it is not available for use when any 125/250-volt receptacle(s) is in use.

(B) Bonded Neutral Generators

Bonded generators shall be provided with GFCI protection on all 125-volt, 15- and 20-ampere receptacle outlets.

Informational Note: Refer to 590.6(A)(3) for GFCI requirements for 15-kW or smaller portable generators used for temporary electric power and lighting.

Exception to (A) and (B): If the generator was manufactured or remanufactured prior to January 1, 2015, listed cord sets or devices incorporating listed GFCI protection for personnel identified for portable use shall be permitted.

Article 450 Transformers and Transformer Vaults (Including Secondary Ties)

Part I General Provisions

450.1 Scope

This article covers the installation of all transformers.

Exception No. 1: Current transformers.

Exception No. 2: Dry-type transformers that constitute a component part of other apparatus and comply with the requirements for such apparatus.

Exception No. 3: Transformers that are an integral part of an X-ray, high-frequency, or electrostatic-coating apparatus.

Exception No. 4: Transformers used with Class 2 and Class 3 circuits that comply with Article 725.

Exception No. 5: Transformers for sign and outline lighting that comply with Article 600.

Exception No. 6: Transformers for electric-discharge lighting that comply with Article 410.

Exception No. 7: Transformers used for power-limited fire alarm circuits that comply with Part III of Article 760.

Exception No. 8: Transformers used for research, development, or testing, where effective arrangements are provided to safeguard persons from contacting energized parts.

This article covers the installation of transformers dedicated to supplying power to a fire pump installation as modified by Article 695.

This article also covers the installation of transformers in hazardous (classified) locations as modified by Articles 501 through 504.

450.2 Definition

The definitions in this section shall apply only within this article.

Transformer. An individual transformer, single-or polyphase, identified by a single nameplate, unless otherwise indicated in this article.

450.3 Overcurrent Protection

Overcurrent protection of transformers shall comply with 450.3(A), (B), or (C). As used in this section, the word transformer shall mean a transformer or polyphase bank of two or more single-phase transformers operating as a unit.

Informational Note No. 1: See 240.4, 240.21, 240.100, and 240.101 for overcurrent protection of conductors.

Informational Note No. 2: Nonlinear loads can increase heat in a transformer without operating its overcurrent protective device.

(A) Transformers Over 1000 Volts, Nominal

Overcurrent protection shall be provided in accordance with Table 450.3(A).

Table 450.3(A) Maximum Rating or Setting of Overcurrent Protection for Transformers Over 1000 Volts (as a Percentage of Transformer-Rated Current)

Location Limitations Transformer Rated Impedance Primary Protection over 1000 Volts Secondary Protection (See Note 2.)

Over 1000 Volts 1000 Volts or Less

Circuit Breaker (See Note 4.) Fuse Rating Circuit Breaker (See Note 4.) Fuse Rating Circuit Breaker or Fuse Rating

Any location Not more than 6% 600%

(See Note 1.) 300%

(See Note 1.) 300%

(See Note 1.) 250%

(See Note 1.) 125%

(See Note 1.)

More than 6% and not more than 10% 400%

(See Note 1.) 300%

(See Note 1.) 250%

(See Note 1.) 225%

(See Note 1.) 125%

(See Note 1.)

Supervised locations only (See Note 3.) Any 300%

(See Note 1.) 250%

(See Note 1.) Not required Not required Not required

Not more than 6%

600%

300%

300%

(See Note 5.) 250%

(See Note 5.) 250%

(See Note 5.)

More than 6% and not more than 10%

400%

300%

250%

(See Note 5.)

225%

(See Note 5.)

250%

(See Note 5.)

Notes:

1. Where the required fuse rating or circuit breaker setting does not correspond to a standard rating or setting, a higher rating or setting that does not exceed the following shall be permitted:

a. The next higher standard rating or setting for fuses and circuit breakers 1000 volts and below, or

b. The next higher commercially available rating or setting for fuses and circuit breakers above 1000 volts.

2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped in one location. Where multiple overcurrent devices are utilized, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device. If both circuit breakers and fuses are used as the overcurrent device, the total of the device ratings shall not exceed that allowed for fuses.

3. A supervised location is a location where conditions of maintenance and supervision ensure that only qualified persons monitor and service the transformer installation.

4. Electronically actuated fuses that may be set to open at a specific current shall be set in accordance with settings for circuit breakers.

5. A transformer equipped with a coordinated thermal overload protection by the manufacturer shall be permitted to have separate secondary protection omitted.

(B) Transformers 1000 Volts, Nominal, or Less

Overcurrent protection shall be provided in accordance with Table 450.3(B).

Exception: Where the transformer is installed as a motor control circuit transformer in accordance with 430. 72(C)(1) through (C)(5).

Table 450.3(B) Maximum Rating or Setting of Overcurrent Protection for Transformers 1000 Volts and Less (as a Percentage of Transformer-Rated Current)

Protection Method Primary Protection Secondary Protection (See Note 2.)

Currents of 9 Amperes or More Currents Less Than 9 Amperes Currents Less Than 2 Amperes Currents of 9 Amperes or More Currents Less Than 9 Amperes

Primary only protection 125% (See Note 1.) 167% 300% Not required Not required

Primary and secondary protection 250% (See Note 3.) 250% (See Note 3.) 250% (See Note 3.) 125% (See Note 1.) 167%

Notes:

1. Where 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, a higher rating that does not exceed the next higher standard rating shall be permitted.

2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped in one location. Where multiple overcurrent devices are utilized, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device.

3. A transformer equipped with coordinated thermal overload protection by the manufacturer and arranged to interrupt the primary current shall be permitted to have primary overcurrent protection rated or set at a current value that is not more than six times the rated current of the transformer for transformers having not more than 6 percent impedance and not more than four times the rated current of the transformer for transformers having more than 6 percent but not more than 10 percent impedance.

(C) Voltage (Potential) Transformers

Voltage (potential) transformers installed indoors or enclosed shall be protected with primary fuses.

Informational Note: For protection of instrument circuits including voltage transformers, see 408.52.

450.4 Autotransformers 1000 Volts, Nominal, or Less

(A) Overcurrent Protection

Each autotransformer 1000 volts, nominal, or less shall be protected by an individual overcurrent device installed in series with each ungrounded input conductor. Such overcurrent device shall be rated or set at not more than 125 percent of the rated full-load input current of the autotransformer. Where this calculation does not correspond to a standard rating of a fuse or nonadjustable circuit breaker and the rated input current is 9 amperes or more, the next higher standard rating described in 240.6 shall be permitted. An overcurrent device shall not be installed in series with the shunt winding (the winding common to both the input and the output circuits) of the autotransformer between Points A and B as shown in Figure 450.4(A).

Exception: Where the rated input current of the autotransformer is less than 9 amperes, an overcurrent device rated or set at not more than 167 percent of the input current shall be permitted.

FIGURE 450.4(A) Autotransformer.

(B) Transformer Field-Connected as an Autotransformer

A transformer field-connected as an autotransformer shall be identified for use at elevated voltage.

Informational Note: For information on permitted uses of autotransformers, see 210.9 and 215.11.

450.5 Grounding Autotransformers

Grounding autotransformers covered in this section are zigzag or T-connected transformers connected to 3-phase, 3-wire ungrounded systems for the purpose of creating a 3-phase, 4-wire distribution system or providing a neutral point for grounding purposes. Such transformers shall have a continuous per-phase current rating and a continuous neutral current rating. Zigzag-connected transformers shall not be installed on the load side of any system grounding connection, including those made in accordance with 250.24(B), 250.30(A)(1), or 250.32(B), Exception No. 1.

Informational Note: The phase current in a grounding autotransformer is one-third the neutral current.

(A) Three-Phase, 4-Wire System

A grounding autotransformer used to create a 3-phase, 4-wire distribution system from a 3-phase, 3-wire ungrounded system shall conform to 450.5(A)(1) through (A)(4).

(1) Connections

The transformer shall be directly connected to the ungrounded phase conductors and shall not be switched or provided with overcurrent protection that is independent of the main switch and common-trip overcurrent protection for the 3-phase, 4-wire system.

(2) Overcurrent Protection

An overcurrent sensing device shall be provided that will cause the main switch or common-trip overcurrent protection referred to in 450.5(A)(1) to open if the load on the autotransformer reaches or exceeds 125 percent of its continuous current per-phase or neutral rating. Delayed tripping for temporary overcurrents sensed at the autotransformer overcurrent device shall be permitted for the purpose of allowing proper operation of branch or feeder protective devices on the 4-wire system.

(3) Transformer Fault Sensing

A fault-sensing system that causes the opening of a main switch or common-trip overcurrent device for the 3-phase, 4-wire system shall be provided to guard against single-phasing or internal faults.

Informational Note: This can be accomplished by the use of two subtractive-connected donut-type current transformers installed to sense and signal when an unbalance occurs in the line current to the autotransformer of 50 percent or more of rated current.

(4) Rating

The autotransformer shall have a continuous neutral-current rating that is not less than the maximum possible neutral unbalanced load current of the 4-wire system.

(B) Ground Reference for Fault Protection Devices

A grounding autotransformer used to make available a specified magnitude of ground-fault current for operation of a ground-responsive protective device on a 3-phase, 3-wire ungrounded system shall conform to 450.5(B)(1) and (B)(2).

(1) Rating

The autotransformer shall have a continuous neutral-current rating not less than the specified ground-fault current.

(2) Overcurrent Protection

Overcurrent protection shall comply with 450.5(B)(2)(a) and (B)(2)(b).

(a) Operation and Interrupting Rating. An overcurrent protective device having an interrupting rating in compliance with 110.9 and that will open simultaneously all ungrounded conductors when it operates shall be applied in the grounding autotransformer branch circuit.

(b) Ampere Rating. The overcurrent protection shall be rated or set at a current not exceeding 125 percent of the autotransformer continuous per-phase current rating or 42 percent of the continuous-current rating of any series-connected devices in the autotransformer neutral connection. Delayed tripping for temporary overcurrents to permit the proper operation of ground-responsive tripping devices on the main system shall be permitted but shall not exceed values that would be more than the short-time current rating of the grounding autotransformer or any series connected devices in the neutral connection thereto.

Exception: For high-impedance grounded systems covered in 250.36, where the maximum ground-fault current is designed to be not more than 10 amperes, and where the grounding autotransformer and the grounding impedance are rated for continuous duty, an overcurrent device rated not more than 20 amperes that will simultaneously open all ungrounded conductors shall be permitted to be installed on the line side of the grounding autotransformer.

(C) Ground Reference for Damping Transitory Overvoltages

A grounding autotransformer used to limit transitory overvoltages shall be of suitable rating and connected in accordance with 450.5(A)(1).

450.6 Secondary Ties

As used in this article, a secondary tie is a circuit operating at 1000 volts, nominal, or less between phases that connects two power sources or power supply points, such as the secondaries of two transformers. The tie shall be permitted to consist of one or more conductors per phase or neutral. Conductors connecting the secondaries of transformers in accordance with 450.7 shall not be considered secondary ties.

As used in this section, the word transformer means a transformer or a bank of transformers operating as a unit.

(A) Tie Circuits

Tie circuits shall be provided with overcurrent protection at each end as required in Parts I, II, and VIII of Article 240.

Under the conditions described in 450.6(A)(1) and 450.6(A)(2), the overcurrent protection shall be permitted to be in accordance with 450.6(A)(3).

(1) Loads at Transformer Supply Points Only

Where all loads are connected at the transformer supply points at each end of the tie and overcurrent protection is not provided in accordance with Parts I, II, and VIII of Article 240, the ampacity of the tie shall not be less than 67 percent of the rated secondary current of the highest rated transformer supplying the secondary tie system.

(2) Loads Connected Between Transformer Supply Points

Where load is connected to the tie at any point between transformer supply points and overcurrent protection is not provided in accordance with Parts I, II, and VIII of Article 240, the ampacity of the tie shall not be less than 100 percent of the rated secondary current of the highest rated transformer supplying the secondary tie system.

Exception: Tie circuits comprised of multiple conductors per phase shall be permitted to be sized and protected in accordance with 450.6(A)(4).

(3) Tie Circuit Protection

Under the conditions described in 450.6(A)(1) and (A)(2), both supply ends of each ungrounded tie conductor shall be equipped with a protective device that opens at a predetermined temperature of the tie conductor under short-circuit conditions. This protection shall consist of one of the following: (1) a fusible link cable connector, terminal, or lug, commonly known as a limiter, each being of a size corresponding with that of the conductor and of construction and characteristics according to the operating voltage and the type of insulation on the tie conductors or (2) automatic circuit breakers actuated by devices having comparable time-current characteristics.

(4) Interconnection of Phase Conductors Between Transformer Supply Points

Where the tie consists of more than one conductor per phase or neutral, the conductors of each phase or neutral shall comply with 450.6(A)(4)(a) or (A)(4)(b).

(a) Interconnected. The conductors shall be interconnected in order to establish a load supply point, and the protective device specified in 450.6(A)(3) shall be provided in each ungrounded tie conductor at this point on both sides of the interconnection. The means of interconnection shall have an ampacity not less than the load to be served.

(b) Not Interconnected. The loads shall be connected to one or more individual conductors of a paralleled conductor tie without interconnecting the conductors of each phase or neutral and without the protection specified in 450.6(A)(3) at load connection points. Where this is done, the tie conductors of each phase or neutral shall have a combined capacity ampacity of not less than 133 percent of the rated secondary current of the highest rated transformer supplying the secondary tie system, the total load of such taps shall not exceed the rated secondary current of the highest rated transformer, and the loads shall be equally divided on each phase and on the individual conductors of each phase as far as practicable.

(5) Tie Circuit Control

Where the operating voltage exceeds 150 volts to ground, secondary ties provided with limiters shall have a switch at each end that, when open, de-energizes the associated tie conductors and limiters. The current rating of the switch shall not be less than the rated current ampacity of the conductors connected to the switch. It shall be capable of interrupting its rated current, and it shall be constructed so that it will not open under the magnetic forces resulting from short-circuit current.

(B) Overcurrent Protection for Secondary Connections

Where secondary ties are used, an overcurrent device rated or set at not more than 250 percent of the rated secondary current of the transformers shall be provided in the secondary connections of each transformer supplying the tie system. In addition, an automatic circuit breaker actuated by a reverse-current relay set to open the circuit at not more than the rated secondary current of the transformer shall be provided in the secondary connection of each transformer.

(C) Grounding

Where the secondary tie system is grounded, each transformer secondary supplying the tie system shall be grounded in accordance with the requirements of 250.30 for separately derived systems.

450.7 Parallel Operation

Transformers shall be permitted to be operated in parallel and switched as a unit, provided the overcurrent protection for each transformer meets the requirements of 450.3(A) for primary and secondary protective devices over 1000 volts, or 450.3(B) for primary and secondary protective devices 1000 volts or less.

450.8 Guarding

Transformers shall be guarded as specified in 450.8(A) through (D).

(A) Mechanical Protection

Appropriate provisions shall be made to minimize the possibility of damage to transformers from external causes where the transformers are exposed to physical damage.

(B) Case or Enclosure

Dry-type transformers shall be provided with a noncombustible moisture-resistant case or enclosure that provides protection against the accidental insertion of foreign objects.

(C) Exposed Energized Parts

Switches or other equipment operating at 1000 volts, nominal, or less and serving only equipment within a transformer enclosure shall be permitted to be installed in the transformer enclosure if accessible to qualified persons only. All energized parts shall be guarded in accordance with 110.27 and 110.34.

(D) Voltage Warning

The operating voltage of exposed live parts of transformer installations shall be indicated by signs or visible markings on the equipment or structures.

450.9 Ventilation

The ventilation shall dispose of the transformer full-load heat losses without creating a temperature rise that is in excess of the transformer rating.

Informational Note No. 1: See IEEE C57.12.00-2015, General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers, and IEEE C57.12.01-2015, General Requirements for Dry-Type Distribution and Power Transformers.

Informational Note No. 2: Additional losses occur in some transformers where nonsinusoidal currents are present, resulting in increased heat in the transformer above its rating. See IEEE C57.110-2008, Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents, where transformers are utilized with nonlinear loads.

Transformers with ventilating openings shall be installed so that the ventilating openings are not blocked by walls or other obstructions. The required clearances shall be clearly marked on the transformer. Transformer top surfaces that are horizontal and readily accessible shall be marked to prohibit storage.

450.10 Grounding

(A) Dry-Type Transformer Enclosures

Where separate equipment grounding conductors and supply-side bonding jumpers are installed, a terminal bar for all grounding and bonding conductor connections shall be secured inside the transformer enclosure. The terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any vented portion of the enclosure.

Exception: Where a dry-type transformer is equipped with wire-type connections (leads), the grounding and bonding connections shall be permitted to be connected together using any of the methods in 250.8 and shall be bonded to the enclosure if of metal.

(B) Other Metal Parts

Exposed non—current-carrying metal parts of transformer installations, including fences, guards, and so forth, shall be grounded and bonded under the conditions and in the manner specified for electrical equipment and other exposed metal parts in Parts V, VI, and VII of Article 250.

450.11 Marking

(A) General

Each transformer shall be provided with a nameplate giving the following information:

Name of manufacturer

Rated kilovolt-amperes

Frequency

Primary and secondary voltage

Impedance of transformers 25 kVA and larger

Required clearances for transformers with ventilating openings

Amount and kind of insulating liquid where used

For dry-type transformers, temperature class for the insulation system

(B) Source Marking

A transformer shall be permitted to be supplied at the marked secondary voltage, provided that the installation is in accordance with the manufacturer's instructions.

450.12 Terminal Wiring Space

The minimum wire-bending space at fixed, 1000-volt and below terminals of transformer line and load connections shall be as required in 312.6. Wiring space for pigtail connections shall conform to Table 314.16(B).

450.13 Accessibility

All transformers and transformer vaults shall be readily accessible to qualified personnel for inspection and maintenance or shall meet the requirements of 450.13(A) or 450.13(B).

(A) Open Installations

Dry-type transformers 1000 volts, nominal, or less, located in the open on walls, columns, or structures, shall not be required to be readily accessible.

(B) Hollow Space Installations

Dry-type transformers 1000 volts, nominal, or less and not exceeding 50 kVA shall be permitted in hollow spaces of buildings not permanently closed in by structure, provided they meet the ventilation requirements of 450.9 and separation from combustible materials requirements of 450.21(A). Transformers so installed shall not be required to be readily accessible.

450.14 Disconnecting Means

Transformers, other than Class 2 or Class 3 transformers, shall have a disconnecting means located either in sight of the transformer or in a remote location. Where located in a remote location, the disconnecting means shall be lockable open in accordance with 110.25, and its location shall be field marked on the transformer.

Part II Specific Provisions Applicable to Different Types of Transformers

450.21 Dry-Type Transformers Installed Indoors

(A) Not Over 1121/2 kVA

Dry-type transformers installed indoors and rated 1121/2 kVA or less shall have a separation of at least 300 mm (12 in.) from combustible material unless separated from the combustible material by a fire-resistant, heat-insulated barrier.

Exception: This rule shall not apply to transformers rated for 1000 volts, nominal, or less that are completely enclosed, except for ventilating openings.

(B) Over 1121/2 kVA

Individual dry-type transformers of more than 1121/2 kVA rating shall be installed in a transformer room of fire-resistant construction having a minimum fire rating of 1 hour.

Exception No. 1: Transformers with Class 155 or higher insulation systems and separated from combustible material by a fire-resistant, heat-insulating barrier or by not less than 1.83 m (6 ft) horizontally and 3.7 m (12 ft) vertically.

Exception No. 2: Transformers with Class 155 or higher insulation systems and completely enclosed except for ventilating openings.

Informational Note: See ASTM E119—18a, Standard Test Methods for Fire Tests of Building Construction and Materials.

(C) Over 35,000 Volts

Dry-type transformers rated over 35,000 volts shall be installed in a vault complying with Part III of this article.

450.22 Dry-Type Transformers Installed Outdoors

Dry-type transformers installed outdoors shall have a weatherproof enclosure.

Transformers exceeding 1121/2 kVA shall not be located within 300 mm (12 in.) of combustible materials of buildings unless the transformer has Class 155 insulation systems or higher and is completely enclosed except for ventilating openings.

450.23 Less-Flammable Liquid-Insulated Transformers

Transformers insulated with listed less-flammable liquids that have a fire point of not less than 300°C shall be permitted to be installed in accordance with 450.23(A) or 450.23(B).

(A) Indoor Installations

Indoor installations shall be permitted in accordance with one of the following:

In Type I or Type II buildings, in areas where all of the following requirements are met:

The transformer is rated 35,000 volts or less.

No combustible materials are stored.

A liquid confinement area is provided.

The installation complies with all the restrictions provided for in the listing of the liquid.

Informational Note: Such restrictions can include, but are not limited to, maximum pressure of the tank, use of a pressure relief valve, appropriate fuse types, and proper sizing of overcurrent protection.

If an automatic fire extinguishing system and a liquid confinement area is present, provided the transformer is rated 35,000 volts or less

If the installation complies with 450.26

(B) Outdoor Installations

Less-flammable liquid-filled transformers shall be permitted to be installed outdoors, attached to, adjacent to, or on the roof of buildings, if installed in accordance with (1) or (2).

For Type I and Type II buildings, the installation shall comply with all the restrictions provided for in the listing of the liquid.

Informational Note No. 1: Installations adjacent to combustible material, fire escapes, or door and window openings can require additional safeguards such as those listed in 450.27.

Informational Note No. 2: Such restrictions can include, but are not limited to: maximum pressure of the tank, use of a pressure relief valve, appropriate fuse types, and proper sizing of overcurrent protection.

In accordance with 450.27.

Informational Note No. 1: As used in this section, Type I and Type II buildings refers to Type I and Type II building construction as defined in NFPA 220-2018, Standard on Types of Building Construction. Combustible materials refers to those materials not classified as noncombustible or limited-combustible as defined in NFPA 220-2018, Standard on Types of Building Construction.

Informational Note No. 2: See definition of Listed in Article 100.

450.24 Nonflammable Fluid-Insulated Transformers

Transformers insulated with a dielectric fluid identified as nonflammable shall be permitted to be installed indoors or outdoors. Such transformers installed indoors and rated over 35,000 volts shall be installed in a vault. Such transformers installed indoors shall be furnished with a liquid confinement area and a pressure-relief vent. The transformers shall be furnished with a means for absorbing any gases generated by arcing inside the tank, or the pressure-relief vent shall be connected to a chimney or flue that will carry such gases to an environmentally safe area.

Informational Note: Safety may be increased if fire hazard analyses are performed for such transformer installations.

For the purposes of this section, a nonflammable dielectric fluid is one that does not have a flash point or fire point and is not flammable in air.

450.25 Askarel-Insulated Transformers Installed Indoors

Askarel-insulated transformers installed indoors and rated over 25 kVA shall be furnished with a pressure-relief vent. Where installed in a poorly ventilated place, they shall be furnished with a means for absorbing any gases generated by arcing inside the case, or the pressure-relief vent shall be connected to a chimney or flue that carries such gases outside the building. Askarel-insulated transformers rated over 35,000 volts shall be installed in a vault.

450.26 Oil-Insulated Transformers Installed Indoors

Oil-insulated transformers installed indoors shall be installed in a vault constructed as specified in Part III of this article.

Exception No. 1: Where the total capacity does not exceed 1121/2 kVA, the vault specified in Part III of this article shall be permitted to be constructed of reinforced concrete that is not less than 100 mm (4 in.) thick.

Exception No. 2: Where the nominal voltage does not exceed 1000, a vault shall not be required if suitable arrangements are made to prevent a transformer oil fire from igniting other materials and the total capacity in one location does not exceed 10 kVA in a section of the building classified as combustible or 75 kVA where the surrounding structure is classified as fire-resistant construction.

Exception No. 3: Electric furnace transformers that have a total rating not exceeding 75 kVA shall be permitted to be installed without a vault in a building or room of fire-resistant construction, provided suitable arrangements are made to prevent a transformer oil fire from spreading to other combustible material.

Exception No. 4: A transformer that has a total rating not exceeding 75 kVA and a supply voltage of 1000 volts or less that is an integral part of charged-particle-accelerating equipment shall be permitted to be installed without a vault in a building or room of noncombustible or fire-resistant construction, provided suitable arrangements are made to prevent a transformer oil fire from spreading to other combustible material.

Exception No. 5: Transformers shall be permitted to be installed in a detached building that does not comply with Part III of this article if neither the building nor its contents present a fire hazard to any other building or property, and if the building is used only in supplying electric service and the interior is accessible only to qualified persons.

Exception No. 6: Oil-insulated transformers shall be permitted to be used without a vault in portable and mobile surface mining equipment (such as electric excavators) if each of the following conditions is met:

Provision is made for draining leaking fluid to the ground.

Safe egress is provided for personnel.

A minimum 6-mm (1/4-in.) steel barrier is provided for personnel protection.

450.27 Oil-Insulated Transformers Installed Outdoors

Combustible material, combustible buildings, and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on roofs, attached to or adjacent to a building or combustible material.

In cases where the transformer installation presents a fire hazard, one or more of the following safeguards shall be applied according to the degree of hazard involved:

Space separations

Fire-resistant barriers

Automatic fire suppression systems

Enclosures that confine the oil of a ruptured transformer tank

Oil enclosures shall be permitted to consist of fire-resistant dikes, curbed areas or basins, or trenches filled with coarse, crushed stone. Oil enclosures shall be provided with trapped drains where the exposure and the quantity of oil involved are such that removal of oil is important.

Informational Note: For additional information on transformers installed on poles or structures or under ground, see ANSI/IEEE C2—2017, National Electrical Safety Code.

450.28 Modification of Transformers

When modifications are made to a transformer in an existing installation that change the type of the transformer with respect to Part II of this article, such transformer shall be marked to show the type of insulating liquid installed, and the modified transformer installation shall comply with the applicable requirements for that type of transformer.

Part III Transformer Vaults

450.41 Location

Vaults shall be located where they can be ventilated to the outside air without using flues or ducts wherever such an arrangement is practicable.

450.42 Walls, Roofs, and Floors

The walls and roofs of vaults shall be constructed of materials that have approved structural strength for the conditions with a minimum fire resistance of 3 hours. The floors of vaults in contact with the earth shall be of concrete that is not less than 100 mm (4 in.) thick, but, where the vault is constructed with a vacant space or other stories below it, the floor shall have approved structural strength for the load imposed thereon and a minimum fire resistance of 3 hours. For the purposes of this section, studs and wallboard construction shall not be permitted.

Exception: Where transformers are protected with automatic sprinkler, water spray, carbon dioxide, or halon, construction of 1-hour rating shall be permitted.

Informational Note No. 1: For additional information, see ASTM E119-18a, Methods for Fire Tests of Building Construction and Materials.

Informational Note No. 2: A typical 3-hour construction is 150 mm (6 in.) thick reinforced concrete.

450.43 Doorways

Vault doorways shall be protected in accordance with 450.43(A), (B), and (C).

(A) Type of Door

Each doorway leading into a vault from the building interior shall be provided with a tight-fitting door that has a minimum fire rating of 3 hours. The authority having jurisdiction shall be permitted to require such a door for an exterior wall opening where conditions warrant.

Exception: Where transformers are protected with automatic sprinkler, water spray, carbon dioxide, or halon, construction of 1-hour rating shall be permitted.

Informational Note: For additional information, see NFPA 80-2016, Standard for Fire Doors and Other Opening Protectives.

(B) Sills

A door sill or curb that is of an approved height that will confine the oil from the largest transformer within the vault shall be provided, and in no case shall the height be less than 100 mm (4 in.).

(C) Locks

Doors shall be equipped with locks, and doors shall be kept locked, with access being allowed only to qualified persons. Personnel doors shall open in the direction of egress and be equipped with listed fire exit hardware.

450.45 Ventilation Openings

Where required by 450.9, openings for ventilation shall be provided in accordance with 450.45(A) through (F).

(A) Location

Ventilation openings shall be located as far as possible from doors, windows, fire escapes, and combustible material.

(B) Arrangement

A vault ventilated by natural circulation of air shall be permitted to have roughly half of the total area of openings required for ventilation in one or more openings near the floor and the remainder in one or more openings in the roof or in the sidewalls near the roof, or all of the area required for ventilation shall be permitted in one or more openings in or near the roof.

(C) Size

For a vault ventilated by natural circulation of air to an outdoor area, the combined net area of all ventilating openings, after deducting the area occupied by screens, gratings, or louvers, shall not be less than 1900 mm2 (3 in.2) per kVA of transformer capacity in service, and in no case shall the net area be less than 0.1 m2 (1 ft2) for any capacity under 50 kVA.

(D) Covering

Ventilation openings shall be covered with durable gratings, screens, or louvers, according to the treatment required in order to avoid unsafe conditions.

(E) Dampers

All ventilation openings to the indoors shall be provided with automatic closing fire dampers that operate in response to a vault fire. Such dampers shall possess a standard fire rating of not less than 11/2 hours.

Informational Note: See ANSI/UL 555-2016, Standard for Fire Dampers.

(F) Ducts

Ventilating ducts shall be constructed of fire-resistant material.

450.46 Drainage

Where practicable, vaults containing more than 100 kVA transformer capacity shall be provided with a drain or other means that will carry off any accumulation of oil or water in the vault unless local conditions make this impracticable. The floor shall be pitched to the drain where provided.

450.47 Water Pipes and Accessories

Any pipe or duct system foreign to the electrical installation shall not enter or pass through a transformer vault. Piping or other facilities provided for vault fire protection, or for transformer cooling, shall not be considered foreign to the electrical installation.

450.48 Storage in Vaults

Materials shall not be stored in transformer vaults.

Article 455 Phase Converters

Part I General

455.1 Scope

This article covers the installation and use of phase converters.

455.2 Definitions

Manufactured Phase. This definition shall apply within this article and throughout the Code.

The phase that originates at the phase converter and is not solidly connected to either of the single-phase input conductors.

Phase Converter. This definition shall apply within this article and throughout the Code.

An electrical device that converts single-phase power to 3-phase electric power.

Informational Note: Phase converters have characteristics that modify the starting torque and locked-rotor current of motors served, and consideration is required in selecting a phase converter for a specific load.

Rotary-Phase Converter. This definition shall apply only within this article.

A device that consists of a rotary transformer and capacitor panel(s) that permits the operation of 3-phase loads from a single-phase supply.

Static-Phase Converter. This definition shall apply only within this article.

A device without rotating parts, sized for a given 3-phase load to permit operation from a single-phase supply.

455.3 Other Articles

Phase converters shall comply with this article and with the applicable provisions of other articles of this Code.

455.4 Marking

Each phase converter shall be provided with a permanent nameplate indicating the following:

Manufacturer's name

Rated input and output voltages

Frequency

Rated single-phase input full-load amperes

Rated minimum and maximum single load in kilovoltamperes (kVA) or horsepower

Maximum total load in kilovolt-amperes (kVA) or horsepower

For a rotary-phase converter, 3-phase amperes at full load

455.5 Equipment Grounding Connection

A means for attachment of an equipment grounding conductor termination in accordance with 250.8 shall be provided.

455.6 Conductors

(A) Ampacity

The ampacity of the single-phase supply conductors shall be determined by 455.6(A)(1) or (A)(2).

Informational Note: Single-phase conductors sized to prevent a voltage drop not exceeding 3 percent from the source of supply to the phase converter may help ensure proper starting and operation of motor loads.

(1) Variable Loads

Where the loads to be supplied are variable, the conductor ampacity shall not be less than 125 percent of the phase converter nameplate single-phase input full-load amperes.

(2) Fixed Loads

Where the phase converter supplies specific fixed loads, and the conductor ampacity is less than 125 percent of the phase converter nameplate single-phase input full-load amperes, the conductors shall have an ampacity not less than 250 percent of the sum of the full-load, 3-phase current rating of the motors and other loads served where the input and output voltages of the phase converter are identical. Where the input and output voltages of the phase converter are different, the current as determined by this section shall be multiplied by the ratio of output to input voltage.

(B) Manufactured Phase Marking

The manufactured phase conductors shall be identified in all accessible locations with a distinctive marking. The marking shall be consistent throughout the system and premises.

455.7 Overcurrent Protection

The single-phase supply conductors and phase converter shall be protected from overcurrent by 455.7(A) or (B). Where the required fuse or nonadjustable circuit breaker rating or settings of adjustable circuit breakers do not correspond to a standard rating or setting, a higher rating or setting that does not exceed the next higher standard rating shall be permitted.

(A) Variable Loads

Where the loads to be supplied are variable, overcurrent protection shall be set at not more than 125 percent of the phase converter nameplate single-phase input full-load amperes.

(B) Fixed Loads

Where the phase converter supplies specific fixed loads and the conductors are sized in accordance with 455.6(A)(2), the conductors shall be protected in accordance with their ampacity. The overcurrent protection determined from this section shall not exceed 125 percent of the phase converter nameplate single-phase input amperes.

455.8 Disconnecting Means

Means shall be provided to disconnect simultaneously all ungrounded single-phase supply conductors to the phase converter.

(A) Location

The disconnecting means shall be readily accessible and located in sight from the phase converter.

(B) Type

The disconnecting means shall be a switch rated in horsepower, a circuit breaker, or a molded-case switch. Where only nonmotor loads are served, an ampere-rated switch shall be permitted.

(C) Rating

The ampere rating of the disconnecting means shall not be less than 115 percent of the rated maximum single-phase input full-load amperes or, for specific fixed loads, shall be permitted to be selected from 455.8(C)(1) or (C)(2).

(1) Current Rated Disconnect

The disconnecting means shall be a circuit breaker or molded-case switch with an ampere rating not less than 250 percent of the sum of the following:

Full-load, 3-phase current ratings of the motors

Other loads served

(2) Horsepower Rated Disconnect

The disconnecting means shall be a switch with a horsepower rating. The equivalent locked rotor current of the horsepower rating of the switch shall not be less than 200 percent of the sum of the following:

Nonmotor loads

The 3-phase, locked-rotor current of the largest motor as determined from Table 430.251(B)

The full-load current of all other 3-phase motors operating at the same time

(D) Voltage Ratios

The calculations in 455.8(C) shall apply directly where the input and output voltages of the phase converter are identical. Where the input and output voltages of the phase converter are different, the current shall be multiplied by the ratio of the output to input voltage.

455.9 Connection of Single-Phase Loads

Where single-phase loads are connected on the load side of a phase converter, they shall not be connected to the manufactured phase.

455.10 Terminal Housings

A terminal housing in accordance with the provisions of 430.12 shall be provided on a phase converter.

Part II Specific Provisions Applicable to Different Types of Phase Converters

455.20 Disconnecting Means

The single-phase disconnecting means for the input of a static phase converter shall be permitted to serve as the disconnecting means for the phase converter and a single load if the load is within sight of the disconnecting means.

455.21 Start-Up

Power to the utilization equipment shall not be supplied until the rotary-phase converter has been started.

455.22 Power Interruption

Utilization equipment supplied by a rotary-phase converter shall be controlled in such a manner that power to the equipment will be disconnected in the event of a power interruption.

Informational Note: Magnetic motor starters, magnetic contactors, and similar devices, with manual or time delay restarting for the load, provide restarting after power interruption.

455.23 Capacitors

Capacitors that are not an integral part of the rotary-phase conversion system but are installed for a motor load shall be connected to the line side of that motor overload protective device.

Article 460 Capacitors

460.1 Scope

This article covers the installation of capacitors on electrical circuits.

Surge capacitors or capacitors included as a component part of other apparatus and conforming with the requirements of such apparatus are excluded from these requirements.

This article also covers the installation of capacitors in hazardous (classified) locations as modified by Articles 501 through 503.

460.2 Definitions

The definition in this section shall apply only within this article.

Safe Zone. Low probability of damage other than a slight swelling of the capacitor case, as identified by the case rupture curve of the capacitor.

460.3 Enclosing and Guarding

(A) Containing More Than 11 L (3 Gal) of Flammable Liquid

Capacitors containing more than 11 L (3 gal) of flammable liquid shall be enclosed in vaults or outdoor fenced enclosures complying with Article 110, Part III. This limit shall apply to any single unit in an installation of capacitors.

(B) Accidental Contact

Where capacitors are accessible to unauthorized and unqualified persons, they shall be enclosed, located, or guarded so that persons cannot come into accidental contact or bring conducting materials into accidental contact with exposed energized parts, terminals, or buses associated with them. However, no additional guarding is required for enclosures accessible only to authorized and qualified persons.

Part I 1000 Volts, Nominal, and Under

460.6 Discharge of Stored Energy

Capacitors shall be provided with a means of discharging stored energy.

(A) Time of Discharge

The residual voltage of a capacitor shall be reduced to 50 volts, nominal, or less within 1 minute after the capacitor is disconnected from the source of supply.

(B) Means of Discharge

The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank or provided with automatic means of connecting it to the terminals of the capacitor bank on removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used.

460.8 Conductors

(A) Ampacity

The ampacity of capacitor circuit conductors shall not be less than 135 percent of the rated current of the capacitor. The ampacity of conductors that connect a capacitor to the terminals of a motor or to motor circuit conductors shall not be less than one-third the ampacity of the motor circuit conductors and in no case less than 135 percent of the rated current of the capacitor.

(B) Overcurrent Protection

An overcurrent device shall be provided in each ungrounded conductor for each capacitor bank. The rating or setting of the overcurrent device shall be as low as practicable.

Exception: A separate overcurrent device shall not be required for a capacitor connected on the load side of a motor overload protective device.

(C) Disconnecting Means

A disconnecting means shall be provided in each ungrounded conductor for each capacitor bank and shall meet the following requirements:

The disconnecting means shall open all ungrounded conductors simultaneously.

The disconnecting means shall be permitted to disconnect the capacitor from the line as a regular operating procedure.

The rating of the disconnecting means shall not be less than 135 percent of the rated current of the capacitor.

Exception: A separate disconnecting means shall not be required where a capacitor is connected on the load side of a motor controller.

460.9 Rating or Setting of Motor Overload Device

Where a motor installation includes a capacitor connected on the load side of the motor overload device, the rating or setting of the motor overload device shall be based on the improved power factor of the motor circuit.

The effect of the capacitor shall be disregarded in determining the motor circuit conductor rating in accordance with 430.22.

460.10 Grounding

Capacitor cases shall be connected to the equipment grounding conductor.

Exception: Capacitor cases shall not be connected to the equipment grounding conductor where the capacitor units are supported on a structure designed to operate at other than ground potential.

460.12 Marking

Each capacitor shall be provided with a nameplate giving the name of the manufacturer, rated voltage, frequency, kilovar or amperes, number of phases, and, if filled with a combustible liquid, the volume of liquid. Where filled with a nonflammable liquid, the nameplate shall so state. The nameplate shall also indicate whether a capacitor has a discharge device inside the case.

Part II Over 1000 Volts, Nominal

460.24 Switching

(A) Load Current

Group-operated switches shall be used for capacitor switching and shall be capable of the following:

Carrying continuously not less than 135 percent of the rated current of the capacitor installation

Interrupting the maximum continuous load current of each capacitor, capacitor bank, or capacitor installation that will be switched as a unit

Withstanding the maximum inrush current, including contributions from adjacent capacitor installations

Carrying currents due to faults on capacitor side of switch

(B) Isolation

(1) General

A means shall be installed to isolate from all sources of voltage each capacitor, capacitor bank, or capacitor installation that will be removed from service as a unit. The isolating means shall provide a visible gap in the electrical circuit adequate for the operating voltage.

(2) Isolating or Disconnecting Switches With No Interrupting Rating

Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load-interrupting device or shall be provided with prominently displayed caution signs in accordance with 490.22 to prevent switching load current.

(C) Additional Requirements for Series Capacitors

The proper switching sequence shall be ensured by use of one of the following:

Mechanically sequenced isolating and bypass switches

Interlocks

Switching procedure prominently displayed at the switching location

460.25 Overcurrent Protection

(A) Provided to Detect and Interrupt Fault Current

A means shall be provided to detect and interrupt fault current likely to cause dangerous pressure within an individual capacitor.

(B) Single Pole or Multipole Devices

Single-pole or multipole devices shall be permitted for this purpose.

(C) Protected Individually or in Groups

Capacitors shall be permitted to be protected individually or in groups.

(D) Protective Devices Rated or Adjusted

Protective devices for capacitors or capacitor equipment shall be rated or adjusted to operate within the limits of the safe zone for individual capacitors.

460.26 Identification

Each capacitor shall be provided with a permanent nameplate giving the manufacturer's name, rated voltage, frequency, kilovar or amperes, number of phases, and the volume of liquid identified as flammable, if such is the case.

460.27 Grounding

Capacitor cases shall be connected to the equipment grounding conductor. If the capacitor neutral point is connected to a grounding electrode conductor, the connection shall be made in accordance with Part III of Article 250.

Exception: Capacitor cases shall not be connected to the equipment grounding conductor where the capacitor units are supported on a structure designed to operate at other than ground potential.

460.28 Means for Discharge

(A) Means to Reduce the Residual Voltage

A means shall be provided to reduce the residual voltage of a capacitor to 50 volts or less within 5 minutes after the capacitor is disconnected from the source of supply.

(B) Connection to Terminals

A discharge circuit shall be either permanently connected to the terminals of the capacitor or provided with automatic means of connecting it to the terminals of the capacitor bank after disconnection of the capacitor from the source of supply. The windings of motors, transformers, or other equipment directly connected to capacitors without a switch or overcurrent device interposed shall meet the requirements of 460.28(A).

Article 470 Resistors and Reactors

Part I 1000 Volts, Nominal, and Under

470.1 Scope

This article covers the installation of separate resistors and reactors on electrical circuits.

Exception: Resistors and reactors that are component parts of other apparatus.

This article also covers the installation of resistors and reactors in hazardous (classified) locations as modified by Articles 501 through 504.

470.2 Location

Resistors and reactors shall not be placed where exposed to physical damage.

470.3 Space Separation

A thermal barrier shall be required if the space between the resistors and reactors and any combustible material is less than 305 mm (12 in.).

470.4 Conductor Insulation

Insulated conductors used for connections between resistance elements and controllers shall be suitable for an operating temperature of not less than 90°C (194°F).

Exception: Other conductor insulations shall be permitted for motor starting service.

Part II Over 1000 Volts, Nominal

470.18 General

(A) Protected Against Physical Damage

Resistors and reactors shall be protected against physical damage.

(B) Isolated by Enclosure or Elevation

Resistors and reactors shall be isolated by enclosure or elevation to protect personnel from accidental contact with energized parts.

(C) Combustible Materials

Resistors and reactors shall not be installed in close enough proximity to combustible materials to constitute a fire hazard and shall have a clearance of not less than 305 mm (12 in.) from combustible materials.

(D) Clearances

Clearances from resistors and reactors to grounded surfaces shall be adequate for the voltage involved.

(E) Temperature Rise From Induced Circulating Currents

Metallic enclosures of reactors and adjacent metal parts shall be installed so that the temperature rise from induced circulating currents is not hazardous to personnel or does not constitute a fire hazard.

470.19 Grounding

Resistor and reactor cases or enclosures shall be connected to the equipment grounding conductor.

Exception: Resistor or reactor cases or enclosures supported on a structure designed to operate at other than ground potential shall not be connected to the equipment grounding conductor.

470.20 Oil-Filled Reactors

Installation of oil-filled reactors, in addition to the above requirements, shall comply with applicable requirements of Article 450.

Article 480 Storage Batteries

480.1 Scope

This article applies to all stationary installations of storage batteries.

Informational Note: The following standards are frequently referenced for the installation of stationary batteries:

IEEE 484, Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications

IEEE 485, Recommended Practice for Sizing Vented Lead-Acid Storage Batteries for Stationary Applications

IEEE 1145, Recommended Practice for Installation and Maintenance of Nickel-Cadmium Batteries for Photovoltaic (PV) Systems

IEEE 1187, Recommended Practice for Installation Design, and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications

IEEE 1375, IEEE Guide for the Protection of Stationary Battery Systems

IEEE 1578, Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management

IEEE 1635/ASHRAE 21, Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications

UL 1973, Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail (LER) Applications

UL Subject 2436, Outline of Investigation for Spill Containment for Stationary Lead Acid Battery Systems

UL 1989, Standard for Standby Batteries

UL Subject 1974, Standard for Evaluation of Repurposed Batteries

480.2 Definitions

The definitions in this section shall apply only within this article.

Cell. The basic electrochemical unit, characterized by an anode and a cathode, used to receive, store, and deliver electrical energy.

Container. A vessel that holds the plates, electrolyte, and other elements of a single unit in a battery.

Informational Note: A container may be single-cell or multi-cell and is sometimes referred to in the industry as a "jar."

Electrolyte. The medium that provides the ion transport mechanism between the positive and negative electrodes of a cell.

Intercell Connector. An electrically conductive bar or cable used to connect adjacent cells.

Intertier Connector. An electrical conductor used to connect two cells on different tiers of the same rack or different shelves of the same rack.

Nominal Voltage (Battery or Cell). The value assigned to a cell or battery of a given voltage class for the purpose of convenient designation. The operating voltage of the cell or battery may vary above or below this value.

Informational Note: The most common nominal cell voltages are 2 volts per cell for the lead-acid systems, 1.2 volts per cell for alkali systems, and 3.6 to 3.8 volts per cell for Li-ion systems. Nominal voltages might vary with different chemistries.

Sealed Cell or Battery. A cell or battery that has no provision for the routine addition of water or electrolyte or for external measurement of electrolyte specific gravity and might contain pressure relief venting.

Storage Battery (Battery). A single or group of rechargeable cells connected together electrically in series, in parallel, or a combination of both, and comprised of lead-acid, nickel-cadmium, or other rechargeable electrochemical types.

Terminal. That part of a cell, container, or battery to which an external connection is made (commonly identified as post, pillar, pole, or terminal post).

480.3 Equipment

Storage batteries and battery management equipment shall be listed. This requirement shall not apply to lead-acid batteries.

480.4 Battery and Cell Terminations

(A) Corrosion Prevention

Where mating dissimilar metals, antioxidant material suitable for the battery connection shall be used where recommended by the battery manufacturer.

Informational Note: The battery manufacturer's installation and instruction manual can be used for guidance for acceptable materials.

(B) Intercell and Intertier Conductors and Connections

The ampacity of field-assembled intercell and intertier connectors and conductors shall be of such cross-sectional area that the temperature rise under maximum load conditions and at maximum ambient temperature shall not exceed the safe operating temperature of the conductor insulation or of the material of the conductor supports.

Informational Note: Conductors sized to prevent a voltage drop exceeding 3 percent of maximum anticipated load, and where the maximum total voltage drop to the furthest point of connection does not exceed 5 percent, may not be appropriate for all battery applications. IEEE 1375-2003, Guide for the Protection of Stationary Battery Systems, provides guidance for overcurrent protection and associated cable sizing.

(C) Battery Terminals

Electrical connections to the battery, and the cable(s) between cells on separate levels or racks, shall not put mechanical strain on the battery terminals. Terminal plates shall be used where practicable.

Informational Note: Conductors are commonly pre-formed to eliminate stress on battery terminations. Fine stranded cables may also eliminate the stress on battery terminations. See the manufacturer's instructions for guidance.

(D) Accessibility

The terminals of all cells or multicell units shall be readily accessible for readings, inspections, and cleaning where required by the equipment design. One side of transparent battery containers shall be readily accessible for inspection of the internal components.

480.5 Wiring and Equipment Supplied From Batteries

Wiring and equipment supplied from storage batteries shall be subject to the applicable provisions of this Code applying to wiring and equipment operating at the same voltage, unless otherwise permitted by 480.6.

480.6 Overcurrent Protection for Prime Movers

Overcurrent protection shall not be required for conductors from a battery with a voltage of 60 volts dc or less if the battery provides power for starting, ignition, or control of prime movers. Section 300.3 shall not apply to these conductors.

480.7 DC Disconnect Methods

(A) Disconnecting Means

A disconnecting means shall be provided for all ungrounded conductors derived from a stationary battery system with a voltage over 60 volts dc. A disconnecting means shall be readily accessible and located within sight of the battery system.

Informational Note: See 240.21(H) for information on the location of the overcurrent device for battery conductors.

(B) Emergency Disconnect

For one-family and two-family dwellings, a disconnecting means or its remote control for a stationary battery system shall be located at a readily accessible location outside the building for emergency use. The disconnect shall be labeled "EMERGENCY DISCONNECT".

(C) Disconnection of Series Battery Circuits

Battery circuits exceeding 240 volts dc nominal between conductors or to ground and subject to field servicing shall have provisions to disconnect the series-connected strings into segments not exceeding 240 volts dc nominal for maintenance by qualified persons. Non-load-break bolted or plug-in disconnects shall be permitted.

(D) Remote Actuation

Where a disconnecting means, located in accordance with 480.7(A), is provided with remote controls to activate the disconnecting means and the controls for the disconnecting means are not located within sight of the stationary battery system, the disconnecting means shall be capable of being locked in the open position, in accordance with 110.25, and the location of the controls shall be field marked on the disconnecting means.

(E) Busway

Where a dc busway system is installed, the disconnecting means shall be permitted to be incorporated into the busway.

(F) Notification

The disconnecting means shall be legibly marked in the field. A label with the marking shall be placed in a conspicuous location near the battery if a disconnecting means is not provided. The marking shall be of sufficient durability to withstand the environment involved and shall include the following:

Nominal battery voltage

Available fault current derived from the stationary battery system

Informational Note: Battery equipment suppliers can provide information about available fault current on any particular battery model.

An arc flash label in accordance with acceptable industry practice

Informational Note: NFPA 70E-2018, Standard for Electrical Safety in the Workplace, provides assistance in determining the severity of potential exposure, planning safe work practices, arc flash labeling, and selecting personal protective equipment.

Date the calculation was performed

Exception: List items (2), (3), and (4) shall not apply to one-and two-family dwellings.

(G) Identification of Power Sources

Battery systems shall be indicated by 480.7(G)(1) and (G)(2).

(1) Facilities With Utility Services and Battery Systems

Plaques or directories shall be installed in accordance with 705.10 and 712.10.

Exception: This requirement does not apply where a disconnect in 480.7(A) is not required.

(2) Facilities With Stand-Alone Systems

A permanent plaque or directory shall be installed in accordance with 710.10.

480.8 Insulation of Batteries

Batteries constructed of an electrically conductive container shall have insulating support if a voltage is present between the container and ground.

480.9 Battery Support Systems

For battery chemistries with corrosive electrolyte, the structure that supports the battery shall be resistant to deteriorating action by the electrolyte. Metallic structures shall be provided with nonconducting support members for the cells, or shall be constructed with a continuous insulating material. Paint alone shall not be considered as an insulating material.

480.10 Battery Locations

Battery locations shall conform to 480.10(A) through (G).

(A) Ventilation

Provisions appropriate to the battery technology shall be made for sufficient diffusion and ventilation of gases from the battery, if present, to prevent the accumulation of an explosive mixture.

Informational Note No. 1: See NFPA 1-2018, Fire Code, Chapter 52, for ventilation considerations for specific battery chemistries.

Informational Note No. 2: Some battery technologies do not require ventilation.

Informational Note No. 3: For additional information on the ventilation of stationary battery systems, see IEEE Std 1635-2012/ASHRAE Guideline 21-2012 Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications.

(B) Live Parts

Guarding of live parts shall comply with 110.27.

(C) Spaces About Battery Systems

Spaces about battery systems shall comply with 110.26 and 110.34. Working space shall be measured from the edge of the battery cabinet, racks, or trays.

For battery racks, there shall be a minimum clearance of 25 mm (1 in.) between a cell container and any wall or structure on the side not requiring access for maintenance. Battery stands shall be permitted to contact adjacent walls or structures, provided that the battery shelf has a free air space for not less than 90 percent of its length.

Informational Note: Additional space is often needed to accommodate battery hoisting equipment, tray removal, or spill containment.

(D) Top Terminal Batteries

Where top terminal batteries are installed on tiered racks or on shelves of battery cabinets, working space in accordance with the battery manufacturer's instructions shall be provided between the highest point on a cell and the row, shelf, or ceiling above that point.

Informational Note: IEEE 1187-2013, IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications, provides guidance for top clearance of valve-regulated lead-acid batteries, which are commonly used in battery cabinets.

(E) Egress

Personnel doors intended for entrance to, and egress from, rooms designated as battery rooms shall open in the direction of egress and shall be equipped with listed panic or listed fire exit hardware.

(F) Piping in Battery Rooms

Gas piping shall not be permitted in dedicated battery rooms.

(G) Illumination

Illumination shall be provided for working spaces containing battery systems. The lighting outlets shall not be controlled by automatic means only. Additional lighting outlets shall not be required where the work space is illuminated by an adjacent light source. The location of luminaires shall not:

Expose personnel to energized battery components while performing maintenance on the luminaires in the battery space; or

Create a hazard to the battery upon failure of the luminaire.

480.11 Vents

(A) Vented Cells

Each vented cell shall be equipped with a flame arrester.

Informational Note: A flame arrester prevents destruction of the cell due to ignition of gases within the cell by an external spark or flame.

(B) Sealed Cells

Where the battery is constructed such that an excessive accumulation of pressure could occur within the cell during operation, a pressure-release vent shall be provided.

480.12 Battery Interconnections

Flexible cables, as identified in Article 400, in sizes 2/0 AWG and larger shall be permitted within the battery enclosure from battery terminals to a nearby junction box where they shall be connected to an approved wiring method. Flexible battery cables shall also be permitted between batteries and cells within the battery enclosure. Such cables shall be listed and identified for the environmental conditions. Flexible, fine-stranded cables shall only be used with terminals, lugs, devices, or connectors in accordance with 110.14.

480.13 Ground-Fault Detection

Battery circuits exceeding 100 volts between the conductors or to ground shall be permitted to operate with ungrounded conductors, provided a ground-fault detector and indicator is installed to monitor for ground faults.

Article 490 Equipment Over 1000 Volts, Nominal

Part I General

490.1 Scope

This article covers the general requirements for equipment operating at more than 1000 volts, nominal.

Informational Note No. 1: See NFPA 70E-2018, Standard for Electrical Safety in the Workplace, for electrical safety requirements for employee workplaces.

Informational Note No. 2: For further information on hazard signs and labels, see ANSI Z535.4-2011, Product Signs and Safety Labels.

Informational Note No. 3: For information regarding power distribution apparatus, see IEEE 3001.5-2013, Recommended Practice for the Application of Power Distribution Apparatus in Industrial and Commercial Power Systems.

490.2 Definition

The definition in this section shall apply only within this article.

High Voltage. A potential difference of more than 1000 volts, nominal.

490.3 Other Articles

(A) Oil-Filled Equipment

Installation of electrical equipment, other than transformers covered in Article 450, containing more than 38 L (10 gal) of flammable oil per unit shall meet the requirements of Parts II and III of Article 450.

(B) Enclosures in Damp or Wet Locations

Enclosures in damp or wet locations shall meet the requirements of 312.2.

Part II Equipment — Specific Provisions

490.21 Circuit-Interrupting Devices

(A) Circuit Breakers

(1) Location

(a) Circuit breakers installed indoors shall be mounted either in metal-enclosed units or fire-resistant cell-mounted units, or they shall be permitted to be open-mounted in locations accessible to qualified persons only.

(b) Circuit breakers used to control oil-filled transformers in a vault shall either be located outside the transformer vault or be capable of operation from outside the vault.

(c) Oil circuit breakers shall be arranged or located so that adjacent readily combustible structures or materials are safeguarded in an approved manner.

(2) Operating Characteristics

Circuit breakers shall have the following equipment or operating characteristics:

An accessible mechanical or other identified means for manual tripping, independent of control power

Be release free (trip free)

If capable of being opened or closed manually while energized, main contacts that operate independently of the speed of the manual operation

A mechanical position indicator at the circuit breaker to show the open or closed position of the main contacts

A means of indicating the open and closed position of the breaker at the point(s) from which they may be operated

(3) Nameplate

A circuit breaker shall have a permanent and legible nameplate showing manufacturer's name or trademark, manufacturer's type or identification number, continuous current rating, interrupting rating in megavolt-amperes (MVA) or amperes, and maximum voltage rating. Modification of a circuit breaker affecting its rating(s) shall be accompanied by an appropriate change of nameplate information.

(4) Rating

Circuit breakers shall have the following ratings:

The continuous current rating of a circuit breaker shall not be less than the maximum continuous current through the circuit breaker.

The interrupting rating of a circuit breaker shall not be less than the available fault current the circuit breaker will be required to interrupt, including contributions from all connected sources of energy.

The closing rating of a circuit breaker shall not be less than the maximum asymmetrical fault current into which the circuit breaker can be closed.

The momentary rating of a circuit breaker shall not be less than the maximum asymmetrical fault current at the point of installation.

The rated maximum voltage of a circuit breaker shall not be less than the maximum circuit voltage.

(5) Retrofit Trip Units

Retrofit trip units shall be listed for use with the specific circuit breaker with which it is installed.

(B) Power Fuses and Fuseholders

(1) Use

Where fuses are used to protect conductors and equipment, a fuse shall be placed in each ungrounded conductor. Two power fuses shall be permitted to be used in parallel to protect the same load if both fuses have identical ratings and both fuses are installed in an identified common mounting with electrical connections that divide the current equally. Power fuses of the vented type shall not be used indoors, underground, or in metal enclosures unless identified for the use.

(2) Interrupting Rating

The interrupting rating of power fuses shall not be less than the available fault current the fuse is required to interrupt, including contributions from all connected sources of energy.

(3) Voltage Rating

The maximum voltage rating of power fuses shall not be less than the maximum circuit voltage. Fuses having a minimum recommended operating voltage shall not be applied below this voltage.

(4) Identification of Fuse Mountings and Fuse Units

Fuse mountings and fuse units shall have permanent and legible nameplates showing the manufacturer's type or designation, continuous current rating, interrupting current rating, and maximum voltage rating.

(5) Fuses

Fuses that expel flame in opening the circuit shall be designed or arranged so that they function properly without hazard to persons or property.

(6) Fuseholders

Fuseholders shall be designed or installed so that they are de-energized while a fuse is being replaced. A field-applied permanent and legible sign, in accordance with 110.21(B), shall be installed immediately adjacent to the fuseholders and shall be worded as follows:

DANGER — DISCONNECT CIRCUIT BEFORE REPLACING FUSES.

Exception: Fuses and fuseholders designed to permit fuse replacement by qualified persons using identified equipment without de-energizing the fuseholder shall be permitted.

(7) High-Voltage Fuses

Switchgear and substations that utilize high-voltage fuses shall be provided with a gang-operated disconnecting switch. Isolation of the fuses from the circuit shall be provided by either connecting a switch between the source and the fuses or providing roll-out switch and fuse-type construction. The switch shall be of the load-interrupter type, unless mechanically or electrically interlocked with a load-interrupting device arranged to reduce the load to the interrupting capability of the switch.

Exception: More than one switch shall be permitted as the disconnecting means for one set of fuses where the switches are installed to provide connection to more than one set of supply conductors. The switches shall be mechanically or electrically interlocked to permit access to the fuses only when all switches are open. A conspicuous sign shall be placed at the fuses identifying the presence of more than one. source.

(C) Distribution Cutouts and Fuse Links — Expulsion Type

(1) Installation

Cutouts shall be located so that they may be readily and safely operated and re-fused, and so that the exhaust of the fuses does not endanger persons. Distribution cutouts shall not be used indoors, underground, or in metal enclosures.

(2) Operation

Where fused cutouts are not suitable to interrupt the circuit manually while carrying full load, an approved means shall be installed to interrupt the entire load. Unless the fused cutouts are interlocked with the switch to prevent opening of the cutouts under load, a conspicuous sign shall be placed at such cutouts identifying that they shall not be operated under load.

(3) Interrupting Rating

The interrupting rating of distribution cutouts shall not be less than the available fault current the cutout is required to interrupt, including contributions from all connected sources of energy.

(4) Voltage Rating

The maximum voltage rating of cutouts shall not be less than the maximum circuit voltage.

(5) Identification

Distribution cutouts shall have on their body, door, or fuse tube a permanent and legible nameplate or identification showing the manufacturer's type or designation, continuous current rating, maximum voltage rating, and interrupting rating.

(6) Fuse Links

Fuse links shall have a permanent and legible identification showing continuous current rating and type.

(7) Structure Mounted Outdoors

The height of cutouts mounted outdoors on structures shall provide safe clearance between lowest energized parts (open or closed position) and standing surfaces, in accordance with 110.34(E).

(D) Oil-Filled Cutouts

(1) Continuous Current Rating

The continuous current rating of oil-filled cutouts shall not be less than the maximum continuous current through the cutout.

(2) Interrupting Rating

The interrupting rating of oil-filled cutouts shall not be less than the available fault current the oil-filled cutout is required to interrupt, including contributions from all connected sources of energy.

(3) Voltage Rating

The maximum voltage rating of oil-filled cutouts shall not be less than the maximum circuit voltage.

(4) Fault Closing Rating

Oil-filled cutouts shall have a fault closing rating not less than the maximum asymmetrical fault current that can occur at the cutout location, unless suitable interlocks or operating procedures preclude the possibility of closing into a fault.

(5) Identification

Oil-filled cutouts shall have a permanent and legible nameplate showing the rated continuous current, rated maximum voltage, and rated interrupting current.

(6) Fuse Links

Fuse links shall have a permanent and legible identification showing the rated continuous current.

(7) Location

Cutouts shall be located so that they are readily and safely accessible for re-fusing, with the top of the cutout not over 1.5 m (5 ft) above the floor or platform.

(8) Enclosure

Suitable barriers or enclosures shall be provided to prevent contact with nonshielded cables or energized parts of oil-filled cutouts.

(E) Load Interrupters

Load-interrupter switches shall be permitted if suitable fuses or circuit breakers are used in conjunction with these devices to interrupt available fault currents. Where these devices are used in combination, they shall be coordinated electrically so that they will safely withstand the effects of closing, carrying, or interrupting all possible currents up to the assigned maximum short-circuit rating.

Where more than one switch is installed with interconnected load terminals to provide for alternate connection to different supply conductors, each switch shall be provided with a warning sign identifying the presence of more than one source. Each warning sign or label shall comply with 110.21.

(1) Continuous Current Rating

The continuous current rating of interrupter switches shall equal or exceed the maximum continuous current at the point of installation.

(2) Voltage Rating

The maximum voltage rating of interrupter switches shall equal or exceed the maximum circuit voltage.

(3) Identification

Interrupter switches shall have a permanent and legible nameplate including the following information: manufacturer's type or designation, continuous current rating, interrupting current rating, fault closing rating, maximum voltage rating.

(4) Switching of Conductors

The switching mechanism 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. Switches shall be arranged to be locked in the open position. Metal-enclosed switches shall be operable from outside the enclosure.

(5) Stored Energy for Opening

The stored-energy operator shall be permitted to be left in the uncharged position after the switch has been closed if a single movement of the operating handle charges the operator and opens the switch.

(6) Supply Terminals

The supply terminals of fused interrupter switches shall be installed at the top of the switch enclosure, or, if the terminals are located elsewhere, the equipment shall have barriers installed so as to prevent persons from accidentally contacting energized parts or dropping tools or fuses into energized parts.

490.22 Isolating Means

Means shall be provided to completely isolate an item of equipment from all ungrounded conductors. The use of isolating switches shall not be required where there are other ways of de-energizing the equipment for inspection and repairs, such as draw-out-type switchgear units and removable truck panels.

Isolating switches not interlocked with an approved circuit-interrupting device shall be provided with a sign warning against opening them under load. The warning sign(s) or label(s) shall comply with 110.21(B).

An identified fuseholder and fuse shall be permitted as an isolating switch.

490.23 Voltage Regulators

Proper switching sequence for regulators shall be ensured by use of one of the following:

Mechanically sequenced regulator bypass switch(es)

Mechanical interlocks

Switching procedure prominently displayed at the switching location

490.24 Minimum Space Separation

In field-fabricated installations, the minimum air separation between bare live conductors and between such conductors and adjacent grounded surfaces shall not be less than the values given in Table 490.24. These values shall not apply to interior portions or exterior terminals of equipment designed, manufactured, and tested in accordance with accepted national standards.

Table 490.24 Minimum Clearance of Live Parts

Nominal Voltage Rating (kV) Impulse Withstand, Basic Impulse Level B.I.L (kV) Minimum Clearance of Live Parts

Phase-to-Phase Phase-to-Ground

Indoors Outdoors Indoors Outdoors

Indoors Outdoors mm in. mm in. mm in. mm in.

2.4—4.16 60 95 115 4.5 180 7 80 3.0 155 6

7.2 75 95 140 5.5 180 7 105 4.0 155 6

13.8 95 110 195 7.5 305 12 130 5.0 180 7

14.4 110 110 230 9.0 305 12 170 6.5 180 7

23 125 150 270 10.5 385 15 190 7.5 255 10

34.5 150 150 320 12.5 385 15 245 9.5 255 10

200 200 460 18.0 460 18 335 13.0 335 13

46 — 200 — — 460 18 — — 335 13

— 250 — — 535 21 — — 435 17

69 — 250 — — 535 21 — — 435 17

— 350 — — 790 31 — — 635 25

115 — 550 — — 1350 53 — — 1070 42

138 — 550 — — 1350 53 — — 1070 42

— 650 — — 1605 63 — — 1270 50

161 — 650 — — 1605 63 — — 1270 50

— 750 — — 1830 72 — — 1475 58

230 — 750 — — 1830 72 — — 1475 58

— 900 — — 2265 89 — — 1805 71

— 1050 — — 2670 105 — — 2110 83

Note: The values given are the minimum clearance for rigid parts and bare conductors under favorable service conditions. They shall be increased for conductor movement or under unfavorable service conditions or wherever space limitations permit. The selection of the associated impulse withstand voltage for a particular system voltage is determined by the characteristics of the surge protective equipment.

490.25 Backfeed

Installations where the possibility of backfeed exists shall comply with 490.25(A) and (B), which follow.

(A) Sign

A permanent sign in accordance with 110.21(B) shall be installed on the disconnecting means enclosure or immediately adjacent to open disconnecting means with the following words or equivalent: DANGER — CONTACTS ON EITHER SIDE OF THIS DEVICE MAY BE ENERGIZED BY BACKFEED.

(B) Diagram

A permanent and legible single-line diagram of the local switching arrangement, clearly identifying each point of connection to the high-voltage section, shall be provided within sight of each point of connection.

Part III Equipment — Switchgear and Industrial Control Assemblies

490.30 General

Part III covers assemblies of switchgear and industrial control equipment including, but not limited to, switches and interrupting devices and their control, metering, protection, and regulating equipment where they are an integral part of the assembly, with associated interconnections and supporting structures.

490.31 Arrangement of Devices in Assemblies

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

490.32 Guarding of High-Voltage Energized Parts Within a Compartment

Where access for other than visual inspection is required to a compartment that contains energized highvoltage parts, barriers shall be provided to prevent accidental contact by persons, tools, or other equipment with energized parts. Exposed live parts shall only be permitted in compartments accessible to qualified persons. Fuses and fuseholders designed to enable future replacement without de-energizing the fuseholder shall only be permitted for use by qualified persons.

490.33 Guarding of Energized Parts Operating at 1000 Volts, Nominal, or Less Within Compartments

Energized bare parts mounted on doors shall be guarded where the door must be opened for maintenance of equipment or removal of draw-out equipment.

490.34 Clearance for Cable Conductors Entering Enclosure

The unobstructed space opposite terminals or opposite raceways or cables entering a switchgear or control assembly shall be approved for the type of conductor and method of termination.

490.35 Accessibility of Energized Parts

(A) High-Voltage Equipment

Doors that would provide unqualified persons access to high-voltage energized parts shall be locked. Permanent signs in accordance with 110.21(B) shall be installed on panels or doors that provide access to live parts over 1000 volts and shall read DANGER — HIGH VOLTAGE — KEEP OUT.

(B) Control Equipment

Where operating at 1000 volts, nominal, or less, control equipment, relays, motors, and the like shall not be installed in compartments with high-voltage parts or high-voltage wiring, unless:

The access means is interlocked with the high-voltage switch or disconnecting means to prevent the access means from being opened or removed when the high-voltage switch is in the closed position or a withdrawable disconnecting means is in the connected position, and

All high-voltage parts or high-voltage wiring in the compartment that remain energized when a fixed mounted high-voltage switch is in the open position or a withdrawable disconnecting means is in the isolating (fully withdrawn) position are protected by insulating or grounded metal barriers to prevent accidental contact with energized high-voltage parts or wiring.

(C) High-Voltage Instruments or Control Transformers and Space Heaters

High-voltage instrument or control transformers and space heaters shall be permitted to be installed in the high-voltage compartment without access restrictions beyond those that apply to the high-voltage compartment generally.

490.36 Grounding

Frames of switchgear and control assemblies shall be connected to an equipment grounding conductor or, where permitted, the grounded conductor.

490.37 Grounding of Devices

The metal cases or frames, or both, such as those of instruments, relays, meters, and instrument and control transformers, located in or on switchgear or control assemblies, shall be connected to an equipment grounding conductor or, where permitted, the grounded conductor.

490.38 Door Stops and Cover Plates

External hinged doors or covers shall be provided with stops to hold them in the open position. Cover plates intended to be removed for inspection of energized parts or wiring shall be equipped with lifting handles and shall not exceed 1.1 m2 (12 ft2) in area or 27 kg (60 lb) in weight, unless they are hinged and bolted or locked.

490.39 Gas Discharge From Interrupting Devices

Gas discharged during operating of interrupting devices shall be directed so as not to endanger personnel.

490.40 Visual Inspection Windows

Windows intended for visual inspection of disconnecting switches or other devices shall be of suitable transparent material.

490.41 Location of Industrial Control Equipment

Routinely operated industrial control equipment shall meet the requirements of 490.41(A) unless infrequently operated, as covered in 490.41(B).

(A) Control and Instrument Transfer Switch Handles or Push Buttons

Control and instrument transfer switch handles or push buttons shall be in a readily accessible location at an elevation of not over 2.0 m (6 ft 7 in.).

Exception: Operating handles requiring more than 23 kg (50 lb) of force shall be located no higher than 1.7 m (66 in.) in either the open or closed position.

(B) Infrequently Operated Devices

Where operating handles for such devices as draw-out fuses, fused potential or control transformers and their primary disconnects, and bus transfer and isolating switches are only operated infrequently, the handles shall be permitted to be located where they are safely operable and serviceable from a portable platform.

490.42 Interlocks — Interrupter Switches

Interrupter switches equipped with stored energy mechanisms shall have mechanical interlocks to prevent access to the switch compartment unless the stored energy mechanism is in the discharged or blocked position.

490.43 Stored Energy for Opening

The stored energy operator shall be permitted to be left in the uncharged position after the switch has been closed if a single movement of the operating handle charges the operator and opens the switch.

490.44 Fused Interrupter Switches

(A) Supply Terminals

The supply terminals of fused interrupter switches shall be installed at the top of the switch enclosure or, if the terminals are located elsewhere, the equipment shall have barriers installed so as to prevent persons from accidentally contacting energized parts or dropping tools or fuses into energized parts.

(B) Backfeed

Where fuses can be energized by backfeed, a sign shall be placed on the enclosure door identifying this hazard.

(C) Switching Mechanism

The switching mechanism shall be arranged to be operated from a location outside the enclosure 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. Switches shall be lockable open in accordance with 110.25.

490.45 Circuit Breakers — Interlocks

(A) Circuit Breakers

Circuit breakers equipped with stored energy mechanisms shall be designed to prevent the release of the stored energy unless the mechanism has been fully charged.

(B) Mechanical Interlocks

Mechanical interlocks shall be provided in the housing to prevent the complete withdrawal of the circuit breaker from the housing when the stored energy mechanism is in the fully charged position, unless a suitable device is provided to block the closing function of the circuit breaker before complete withdrawal.

490.46 Circuit Breaker Locking

Circuit breakers shall be capable of being locked in the open position or, if they are installed in a drawout mechanism, that mechanism shall be capable of being locked in such a position that the mechanism cannot be moved into the connected position. In either case, the provision for locking shall be lockable open in accordance with 110.25.

490.47 Switchgear Used as Service Equipment

Switchgear installed as high-voltage service equipment shall include a ground bus for the connection of service cable shields and to facilitate the attachment of safety grounds for personnel protection. This bus shall be extended into the compartment where the service conductors are terminated. Where the compartment door or panel provides access to parts that can only be de-energized and visibly isolated by the serving utility, the warning sign required by 490.35(A) shall include a notice that access is limited to the serving utility or is permitted only following an authorization of the serving utility.

490.48 Substation Design, Documentation, and Required Diagram

(A) Design and Documentation

Substations shall be designed by a qualified licensed professional engineer. Where components or the entirety of the substation are listed by a qualified electrical testing laboratory, documentation of internal design features subject to the listing investigation shall not be required. The design shall address but not be limited to the following topics, and the documentation of this design shall be made available to the authority having jurisdiction:

Clearances and exits

Electrical enclosures

Securing and support of electrical equipment

Fire protection

Safety ground connection provisions

Guarding live parts

Transformers and voltage regulation equipment

Conductor insulation, electrical and mechanical protection, isolation, and terminations

Application, arrangement, and disconnection of circuit breakers, switches, and fuses

Provisions for oil filled equipment

Switchgear

Surge arresters

(B) Diagram

A permanent, single-line diagram of the switchgear shall be provided in a readily visible location within the same room or enclosed area with the switchgear, and this diagram shall clearly identify interlocks, isolation means, and all possible sources of voltage to the installation under normal or emergency conditions, and the marking on the switchgear shall cross-reference the diagram.

Exception: Where the equipment consists solely of a single cubicle or metal-enclosed substation containing only one high-voltage switching device, diagrams shall not be required.

490.49 Reconditioned Switchgear

Switchgear, or sections of switchgear, within the scope of this article shall be permitted to be reconditioned. The reconditioning process shall use design qualified parts verified under applicable standards and be performed in accordance with any instructions provided by the manufacturer. Reconditioned switchgear shall be listed or field labeled as reconditioned, and previously applied listing marks, if any, within the portions reconditioned shall be removed. If equipment has been damaged by fire, products of combustion, or water, it shall be specifically evaluated by its manufacturer or a qualified testing laboratory prior to being returned to service.

Part IV Mobile and Portable Equipment

490.51 General

(A) Covered

The provisions of this part shall apply to installations and use of high-voltage power distribution and utilization equipment that is portable, mobile, or both, such as substations and switch houses mounted on skids, trailers, or cars; mobile shovels; draglines; cranes; hoists; drills; dredges; compressors; pumps; conveyors; underground excavators; and the like.

(B) Other Requirements

The requirements of this part shall be additional to, or amendatory of, those prescribed in Articles 100 through 725 of this Code. Special attention shall be paid to Article 250.

(C) Protection

Approved enclosures or guarding, or both, shall be provided to protect portable and mobile equipment from physical damage.

(D) Disconnecting Means

Disconnecting means shall be installed for mobile and portable high-voltage equipment according to the requirements of Part VIII of Article 230 and shall disconnect all ungrounded conductors.

490.52 Overcurrent Protection

Motors driving single or multiple dc generators supplying a system operating on a cyclic load basis do not require overload protection, provided that the thermal rating of the ac drive motor cannot be exceeded under any operating condition. The branch-circuit protective device(s) shall provide short-circuit and locked-rotor protection and shall be permitted to be external to the equipment.

490.53 Enclosures

All energized switching and control parts shall be enclosed in grounded metal cabinets or enclosures. These cabinets or enclosures shall be marked DANGER — HIGH VOLTAGE — KEEP OUT and shall be locked so that only authorized and qualified persons can enter. The danger marking(s) or label(s) shall comply with 110.21(B). Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosure so these units can be reset without opening locked doors. With doors closed, safe access for normal operation of these units shall be provided.

490.54 Collector Rings

The collector ring assemblies on revolving-type machines (shovels, draglines, etc.) shall be guarded to prevent accidental contact with energized parts by personnel on or off the machine.

490.55 Power Cable Connections to Mobile Machines

A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include terminal connections to the machine frame for the equipment grounding conductor. Ungrounded conductors shall be attached to insulators or be terminated in approved high-voltage cable couplers (which include equipment grounding conductor connectors) of proper voltage and ampere rating. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so that only authorized and qualified persons may open it and shall be marked as follows:

DANGER — HIGH VOLTAGE — KEEP OUT.

The danger marking(s) or label(s) shall comply with 110.21(B).

490.56 High-Voltage Portable Cable for Main Power Supply

Flexible high-voltage cable supplying power to portable or mobile equipment shall comply with Article 250 and Article 400, Part III.

Part V Electrode-Type Boilers

490.70 General

The provisions of Part V shall apply to boilers operating over 1000 volts, nominal, in which heat is generated by the passage of current between electrodes through the liquid being heated.

490.71 Electrical Supply System

Electrode-type boilers shall be supplied only from a 3-phase, 4-wire solidly grounded wye system, or from isolating transformers arranged to provide such a system. Control circuit voltages shall not exceed 150 volts, shall be supplied from a grounded system, and shall have the controls in the ungrounded conductor.

490.72 Branch-Circuit Requirements

(A) Rating

Each boiler shall be supplied from an individual branch circuit rated not less than 100 percent of the total load.

(B) Common-Trip Fault-Interrupting Device

The circuit shall be protected by a 3-phase, common-trip fault-interrupting device, which shall be permitted to automatically reclose the circuit upon removal of an overload condition but shall not reclose after a fault condition.

(C) Phase-Fault Protection

Phase-fault protection shall be provided in each phase, consisting of a separate phase-overcurrent relay connected to a separate current transformer in the phase.

(D) Ground Current Detection

Means shall be provided for detection of the sum of the neutral conductor and equipment grounding conductor currents and shall trip the circuit-interrupting device if the sum of those currents exceeds the greater of 5 amperes or 71/2 percent of the boiler full-load current for 10 seconds or exceeds an instantaneous value of 25 percent of the boiler full-load current.

(E) Grounded Neutral Conductor

The grounded neutral conductor shall be as follows:

Connected to the pressure vessel containing the electrodes

Insulated for not less than 1000 volts

Have not less than the ampacity of the largest ungrounded branch-circuit conductor

Installed with the ungrounded conductors in the same raceway, cable, or cable tray, or, where installed as open conductors, in close proximity to the ungrounded conductors

Not used for any other circuit

490.73 Pressure and Temperature Limit Control

All exposed non—current-carrying metal parts of the boiler and associated exposed metal structures or equipment shall be bonded to the pressure vessel or to the neutral conductor to which the vessel is connected in accordance with 250.102, except the ampacity of the bonding jumper shall not be less than the ampacity of the neutral conductor.

