Chapter 6

EQUIPMENT FOR GENERAL USE

FLEXIBLE CORDS AND CABLES

FLEXIBLE CORDS AND CABLES

4.0.1.1 Scope

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

4.0.1.2 Other Articles

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

4.0.1.3 Suitability

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

4.0.1.4 Types

Flexible cords and flexible cables shall conform to the description in Table 4.0.1.4

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4.0.1.5 Ampacities for Flexible Cords and Cables.

(a.) Ampacity Tables

Table 4.0.1.5(A)(1) provides the allowable ampacities, and Table 4.0.1.5(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, the temperature correction factors from Table 3.10.2.6(B)(2)(a) that correspond to the temperature rating of the cord or cable shall be applied to the ampacity from Table 4.0.1.5(A)(1) and Table 4.0.1.5(A)(2).

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4.0.1.5 Ampacities for Flexible Cords and Cables.

Cords and cables rated 105% shall use correction factors in the 90°C column of table 3.10.2.6(B)(2)(a) for temperature correction. Where the number of current-carrying conductors exceeds three, the allowable ampacity or ampacity of each conductor shall be reduced from the three-conductor rating as shown in Table 4.0.1.5(A)(3).

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.

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4.0.1.5 Ampacities for Flexible Cords and Cables.

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 current-carrying conductor.

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4.0.1.5 Ampacities for Flexible Cords and Cables.

An equipment grounding conductors shall not be considered 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 2.50.7.11 for electric ranges and electric clothes dryers, it shall not be considered as a current-carrying conductor.

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4.0.1.5 Ampacities for Flexible Cords and Cables.

(b.) Ultimate Insulation temperature

In no case shall conductors be associated together in such a way with respect in 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 3.10.2.6(C).

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4.0.1.6 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 3.10.3.17(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 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.

FLEXIBLE CORDS AND CABLES

4.0.1.6 Markings

(B) Optional Markings. Flexible cords and flexible cable types listed in Table 4.0.1.4 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.

Table 4.0.1.4 Flexible Cords and Flexible Cables

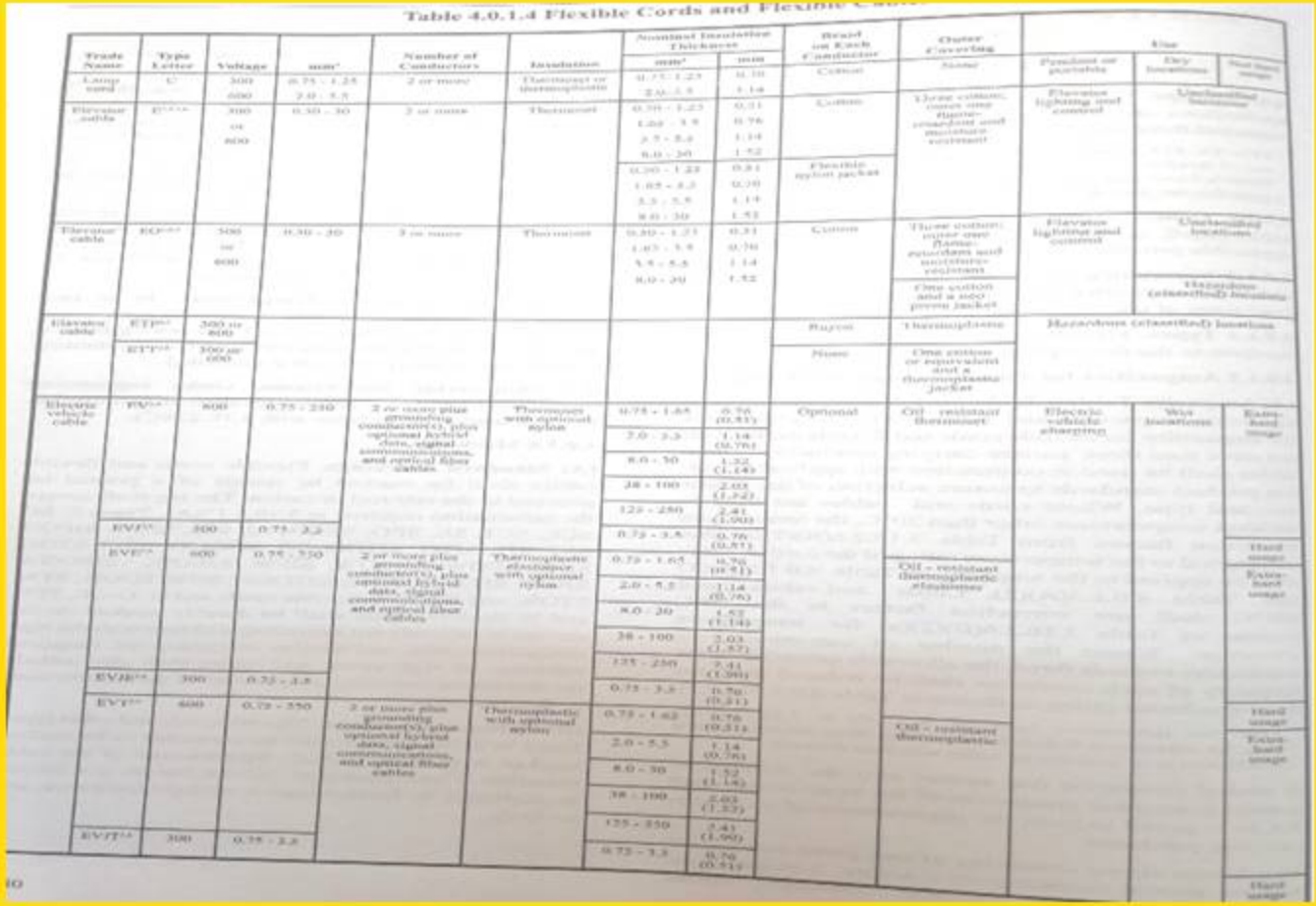
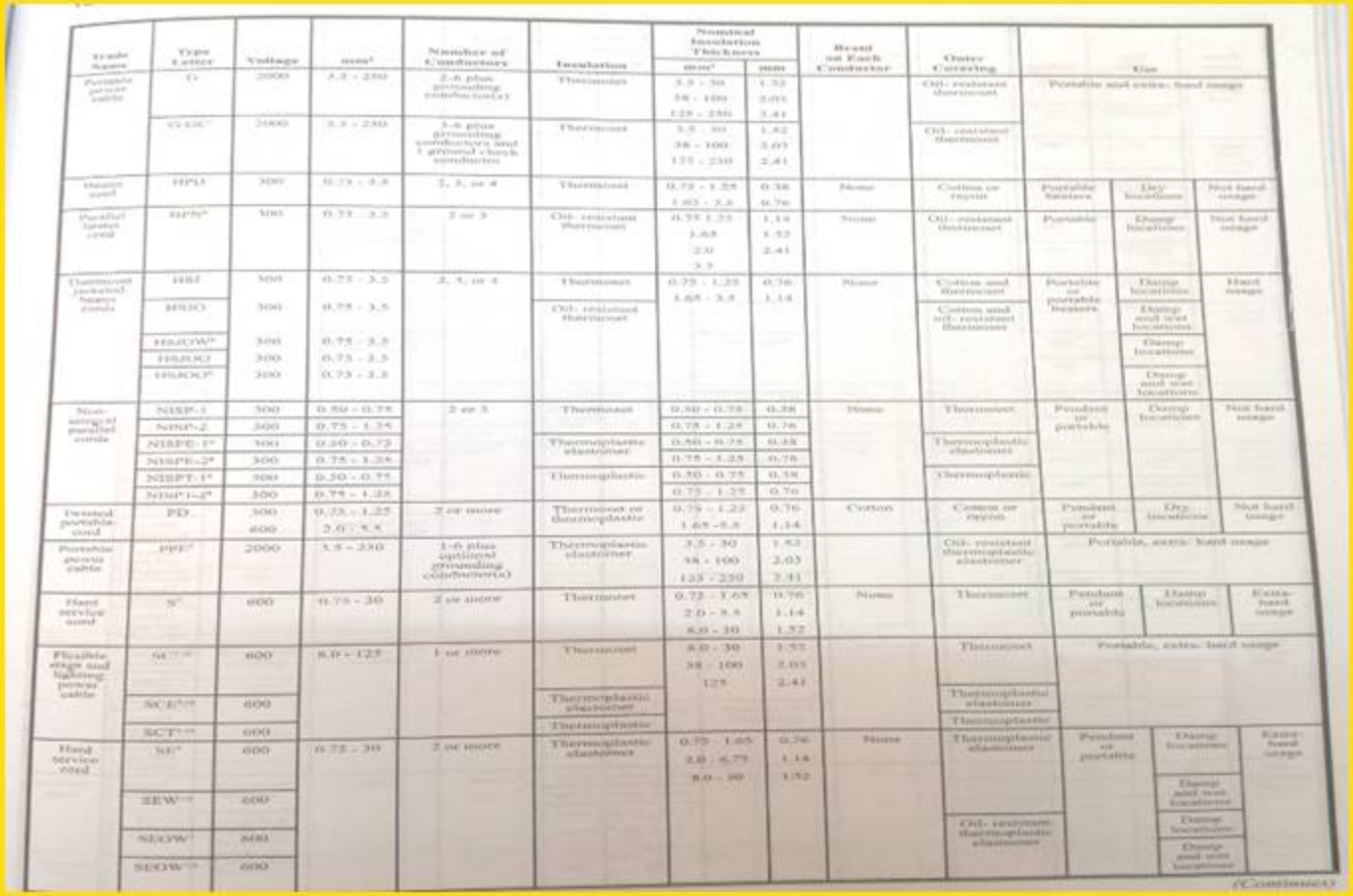


Table 4.0.1.4 Flexible Cords and Flexible Cables

Trade Name	Type Letter	Voltage	mm²	Number of Conductors	Insulation	Nominal Insulation Thickness mm²	Nominal Insulation Thickness mm	Braid on Each Conductor	Outer Covering	Use		
										Pendant or portable	Dry locations	Wet locations
Junior cord	C	300/500	0.75 - 1.25 / 2.0 - 5.5	2 or more	Thermoset or thermoplastic	0.77 - 1.25 / 2.0 - 5.5	0.38 / 1.14	Cotton				
Service cable	E*****	300 or 600	0.50 - 30	3 or more	Thermoset	0.50 - 1.25 / 1.65 - 3.9 / 5.5 - 8.0 / 8.0 - 30	0.51 / 0.76 / 1.14 / 1.52	Cotton	Three cotton, cotton and flame-resistant and moisture-resistant	Elevator lighting and control	Unclassified locations	
						0.50 - 1.25 / 1.65 - 3.9 / 5.5 - 8.0 / 8.0 - 30	0.51 / 0.76 / 1.14 / 1.52	Flexible nylon jacket				
Elevator cable	ECT**	300 or 600	0.50 - 30	3 or more	Thermoset	0.50 - 1.25 / 1.65 - 3.9 / 5.5 - 8.0 / 8.0 - 30	0.51 / 0.76 / 1.14 / 1.52	Cotton	Three cotton, nylon and flame-resistant and moisture-resistant	Elevator lighting and control	Unclassified locations	
									One cotton and a nylon jacket		Hazardous (classified) locations	
Elevator cable	ET**	300 or 600						Rayon	Thermoplastic	Hazardous (classified) locations		
	ETT**	300 or 600						Nylon	One cotton or equivalent and a thermoplastic jacket			
Electric vehicle cable	EV**	600	0.75 - 250	2 or more plus grounding conductor(s), plus optional hybrid data, signal communications, and optical fiber cables	Thermoset with optional nylon	0.75 - 1.65 / 2.0 - 5.5 / 8.0 - 50 / 38 - 100 / 125 - 250	0.76 (0.51) / 1.14 (0.76) / 1.52 (1.14) / 2.03 (1.52) / 2.41 (1.90)	Optional	Oil - resistant thermoset	Electric vehicle charging	Wet locations	Extra-hard usage
	EVJ**	300	0.75 - 2.5			0.75 - 2.5	0.76 (0.51)					
	EVE**	600	0.75 - 350	2 or more plus grounding conductor(s), plus optional hybrid data, signal communications, and optical fiber cables	Thermoplastic elastomer with optional nylon	0.75 - 1.65 / 2.0 - 5.5 / 8.0 - 50 / 38 - 100 / 125 - 250	0.76 (0.51) / 1.14 (0.76) / 1.52 (1.14) / 2.03 (1.52) / 2.41 (1.90)		Oil - resistant thermoplastic elastomer			Hard usage
	EVJE**	300	0.75 - 2.5			0.75 - 2.5	0.76 (0.51)					Extra-hard usage
	EVT**	600	0.75 - 350	2 or more plus grounding conductor(s), plus optional hybrid data, signal communications, and optical fiber cables	Thermoplastic with optional nylon	0.75 - 1.65 / 2.0 - 5.5 / 8.0 - 50 / 38 - 100 / 125 - 250	0.76 (0.51) / 1.14 (0.76) / 1.52 (1.14) / 2.03 (1.52) / 2.41 (1.90)		Oil - resistant thermoplastic			Hard usage
	EVJT**	300	0.75 - 2.5			0.75 - 2.5	0.76 (0.51)					Extra-hard usage

Table 4.0.1.4 Flexible Cords and Flexible Cables



Trade Name	Type Letter	Voltage	mm²	Number of Conductors	Insulation	Nominal Insulation Thickness mm²	Nominal Insulation Thickness mm	Braid on Each Conductor	Outer Covering	Use		
Portable power cable	G	2000	3.5 - 250	2-6 plus grounding conductor(s)	Thermoset	3.5 - 30 38 - 100 125 - 250	1.52 2.03 2.41		Oil- resistant thermoset	Portable and extra- hard usage		
	G-GC	2000	3.5 - 250	3-6 plus grounding conductors and 1 ground check conductor	Thermoset	3.5 - 30 38 - 100 125 - 250	1.52 2.03 2.41		Oil- resistant thermoset			
Heater cord	HPN	300	0.75 - 2.5	2, 3, or 4	Thermoset	0.75 - 1.25 1.65 - 2.5	0.38 0.76	None	Cotton or nylon	Portable heaters	Dry locations	Not hard usage
Parallel jacketed cord	SPT*	300	0.75 - 2.5	2 or 3	Oil- resistant thermoset	0.75 1.25 1.65 2.0 2.5	1.14 1.52 2.41	None	Oil- resistant thermoset	Portable	Damp locations	Not hard usage
Common jacketed heavy cords	HBJ	300	0.75 - 2.5	2, 3, or 4	Thermoset	0.75 - 1.25 1.65 - 2.5	0.76 1.14	None	Cotton and thermoset	Portable or portable heaters	Damp locations	Hard usage
	HSJO	300	0.75 - 2.5		Oil- resistant thermoset				Cotton and oil- resistant thermoset		Damp and wet locations	
	HSJOW*	300	0.75 - 2.5								Damp locations	
	HSJOU	300	0.75 - 2.5								Damp and wet locations	
	HSJOCP	300	0.75 - 2.5									
Non-integral parallel cords	NISP-1	300	0.50 - 0.75	2 or 3	Thermoset	0.50 - 0.75	0.38	None	Thermoset	Pendant or portable	Damp locations	Not hard usage
	NISP-2	300	0.75 - 1.25			0.75 - 1.25	0.76					
	NISPE-1*	300	0.50 - 0.75		Thermoplastic elastomer	0.50 - 0.75	0.38		Thermoplastic elastomer			
	NISPE-2*	300	0.75 - 1.25			0.75 - 1.25	0.76					
	NISPT-1*	300	0.50 - 0.75		Thermoplastic	0.50 - 0.75	0.38		Thermoplastic			
	NISPT-2*	300	0.75 - 1.25			0.75 - 1.25	0.76					
Twisted portable cord	PD	300 600	0.75 - 1.25 2.0 - 5.5	2 or more	Thermoset or thermoplastic	0.75 - 1.25 1.65 - 5.5	0.76 1.14	Cotton	Cotton or nylon	Pendant or portable	Dry locations	Not hard usage
Portable power cable	PPE*	2000	3.5 - 250	1-6 plus optional grounding conductors)	Thermoplastic elastomer	3.5 - 30 38 - 100 125 - 250	1.52 2.03 2.41		Oil- resistant thermoplastic elastomer	Portable, extra- hard usage		
Hard service cord	S*	600	0.75 - 30	2 or more	Thermoset	0.75 - 1.65 2.0 - 5.5 8.0 - 30	0.76 1.14 1.52	None	Thermoset	Pendant or portable	Damp locations	Extra- hard usage
Flexible stage and lighting power cable	SC**	600	8.0 - 125	1 or more	Thermoset	8.0 - 30 38 - 100 125	1.52 2.03 2.41		Thermoset	Portable, extra- hard usage		
	SCE**	600			Thermoplastic elastomer				Thermoplastic elastomer			
	SCT**	600			Thermoplastic				Thermoplastic			
Hard service cord	SE*	600	0.75 - 30	2 or more	Thermoplastic elastomer	0.75 - 1.65 2.0 - 5.75 8.0 - 30	0.76 1.14 1.52	None	Thermoplastic elastomer	Pendant or portable	Damp locations	Extra- hard usage
	SEW**	600									Damp and wet locations	
	SEOW*	600							Oil- resistant thermoplastic elastomer		Damp locations	
	SEOW**	600									Damp and wet locations	

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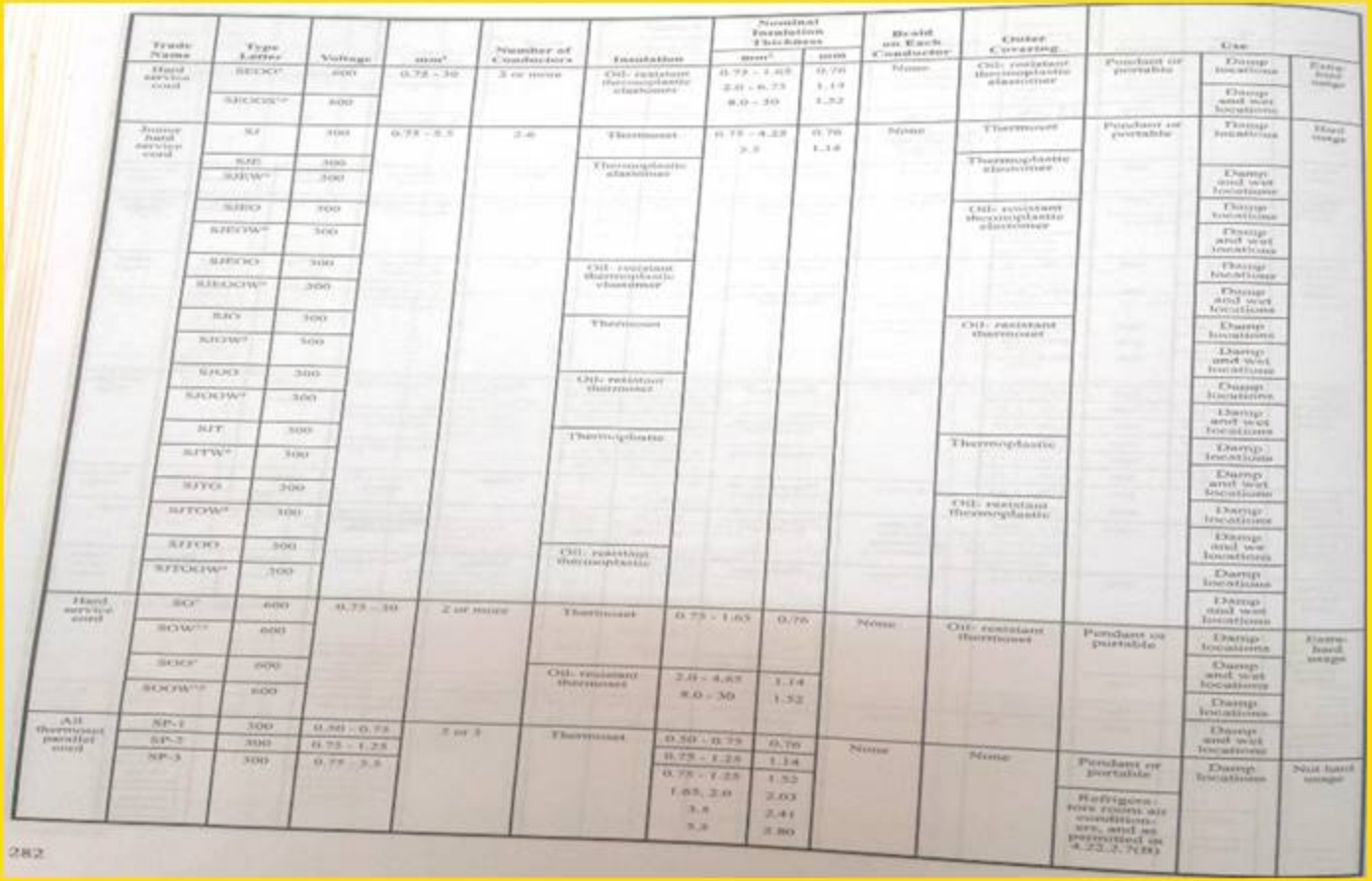
Table 4.0.1.4 Flexible Cords and Flexible Cables



Trade Name	Type Letter	Voltage	mm²	Number of Conductors	Insulation	Nominal Insulation Thickness mm²	Nominal Insulation Thickness mm	Braid on Each Conductor	Outer Covering	Use		
Hard service cord	SEOO*	600	0.75 – 30	3 or more	Oil- resistant thermoplastic elastomer	0.75 – 1.65 2.0 – 6.75 8.0 – 30	0.76 1.14 1.52	None	Oil- resistant thermoplastic elastomer	Pendant or portable	Damp locations Damp and wet locations	Fixed and range
	SJOOS*†	600										
Junior hard service cord	SJ	300	0.75 – 2.5	2-6	Thermoset	0.75 – 4.23 > 5	0.76 1.14	None	Thermoset	Pendant or portable	Damp locations	Hard range
	SJE	300			Thermoplastic elastomer				Thermoplastic elastomer		Damp and wet locations	
	SJEW*	300									Damp locations	
	SJEO	300							Oil- resistant thermoplastic elastomer		Damp and wet locations	
	SJEOW*	300									Damp locations	
	SJEOO	300			Oil- resistant thermoplastic elastomer						Damp and wet locations	
	SJEOOW*	300									Damp locations	
	SJO	300			Thermoset				Oil- resistant thermoset		Damp and wet locations	
	SJOW*	300									Damp locations	
	SJOO	300			Oil- resistant thermoset						Damp and wet locations	
	SJOOW*	300									Damp locations	
	SJT	300			Thermoplastic				Thermoplastic		Damp and wet locations	
	SJTW*	300									Damp locations	
	SJTO	300							Oil- resistant thermoplastic		Damp and wet locations	
	SJTOW*	300									Damp locations	
	SJTOO	300			Oil- resistant thermoplastic						Damp and wet locations	
	SJTOOW*	300									Damp locations	
Hard service cord	SO	600	0.75 – 30	2 or more	Thermoset	0.75 – 1.65	0.76	None	Oil- resistant thermoset	Pendant or portable	Damp locations	Fixed and range
	SOW*	600									Damp and wet locations	
	SOO	600			Oil- resistant thermoset	2.0 – 4.65 8.0 – 30	1.14 1.52				Damp locations	
	SOOW*	600									Damp and wet locations	
All thermoset parallel cord	SP-1	300	0.50 – 0.75	2 or 3	Thermoset	0.50 – 0.75	0.76	None	None	Pendant or portable Refrigerator rooms air conditioners, and as permitted in 4.22.3.7(B)	Damp locations	Not hard range
	SP-2	300	0.75 – 1.25			0.75 – 1.25	1.14					
	SP-3	300	0.75 – 3.5			0.75 – 1.25 1.65, 2.0 3.5 5.5	1.52 2.03 2.41 2.80					

Table 4.0.1.4 Flexible Cords and Flexible Cables

Trade Name	Type Letter	Voltage	mm²	Number of Conductors	Insulation	Nominal Insulation Thickness mm²	Nominal Insulation Thickness mm	Braid on Each Conductor	Outer Covering	Use		
All elastomer (thermoplastic) parallel cord	SPE-1*	300	0.30 - 0.75	2 or 3	Thermoplastic elastomer	0.30 - 0.75	0.76	None	None	Pendant or portable	Damp locations	Not hard usage
	SPE-2*	300	0.75 - 1.25			0.75 - 1.25	1.14			Refrigerator room air conditioners, and as permitted in 4.32.2.7(B)		
	SPE-3*	300	0.75 - 2.5			0.75 - 1.25	1.52					
						1.65	2.03					
						2.0	2.41					
						2.5	2.8					
						3.5						
All thermoplastic parallel cord	SPT - 1	300	0.50 - 0.75	2 or 3	Thermoplastic	0.50 - 0.75	0.76	None	None	Pendant or portable	Damp locations	Not hard usage
	SPT-1W*	300		3							Damp and wet locations	
	SPT - 2	300	0.75 - 1.25	2 or 3		0.75 - 1.25	1.14				Damp locations	
	SPT - 2W*	300		2							Damp and wet locations	
	SPT - 3	300	0.75 - 2.5	2 or 3		0.75 - 1.25	1.52			Refrigerator room air conditioners, and as permitted in 4.32.2.7(B)	Damp locations	Not hard usage
						1.65	2.03					
						2.0	2.41					
						2.5	2.8					
						3.5						
Range, dryer cable	SRD	300	5.5 - 22	3 or 4	Thermoset	5.5 - 22	1.14	None	Thermoset	Portable	Damp locations	Ranges, dryers
	SRDE	300	5.5 - 22	3 or 4	Thermoplastic elastomer			None	Thermoplastic elastomer			
	SRDT	300	5.5 - 22	3 or 4	Thermoplastic			None	Thermoplastic			
Hard service cord	ST*	600	0.75 - 30	2 or more	Thermoplastic	0.75 - 1.65	0.76	None	Thermoplastic	Pendant or portable	Damp locations	Extra-hard usage
	STW**	600				2.0 - 4.65	1.14				Damp and wet locations	
	STO*	600				8.0 - 30	1.52		Oil- resistant thermoplastic		Damp locations	
	STOW**	600									Damp and wet locations	
	STOO*	600			Oil- resistant thermoplastic						Damp locations	
	STOOW**	600									Damp and wet locations	
Vacuum cleaner cord	SV	300	0.75 - 1.25	2 or 3	Thermoset	0.75 - 1.25	0.38	None	Thermoset	Pendant or portable	Damp location	Not hard usage
	SVE	300			Thermoplastic elastomer				Thermoplastic elastomer			
	SVEO	300			Oil- resistant thermoplastic elastomer				Oil- resistant thermoplastic elastomer			
	SVEOO	300			Oil- resistant thermoset				Oil- resistant thermoset			
	SVO	300			Oil- resistant thermoset				Oil- resistant thermoset			
	SVOO	300			Thermoplastic				Thermoplastic			
	SVT	300			Thermoplastic				Oil-resistant thermoplastic			
	SVTO	300			Oil-resistant thermoplastic							
	SVTOO	300										
Parallel tinsel cord	TPT**	300	0.129	2	Thermoplastic	0.129	0.76	None	Thermoplastic	Attached to an appliance	Damp location	Not hard usage

(Continued)

Table 4.0.1.4 Flexible Cords and Flexible Cables

Trade Name	Type Letter	Voltage	mm²	Number of Conductors	Insulation	Nominal Insulation Thickness		Braid on Each Conductor	Outer Covering	Use		
						mm²	mm					
Jacketed tinsel cord	TST[1]	300	0.125	2	Thermoplastic	0.125	0.38	None	Thermoplatic	Attached to an appliance	Damp locations	Not hard usage
Portable power cable	W[7]	2000	3.5 - 250 251 - 500	1 - 6 1	Thermoset	3.5 - 30 38 - 100 125 - 250 251 - 500	1.52 2.03 2.41 2.80		Oil- resistant thermoset	Portable, extra- hard usage		

Notes:

Table 4.0.1.5(A)(1) Allowable Ampacity for Flexible Cords and Flexible Cables Based on Ambient Temperature of 30°C

		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	
		Thermoplastic Types ETP, ETT, NISPE-1, NISPE-2, NISPT-1, NISPT-2, SE, SEW, SEO, SEOO, SEOW, SEOOW, SJE, SJEW, SJEO, SJEOO, SJEOW, SJEOOW	Types HPD,

Table 4.0.1.5(A)(3A) Adjustment Factors for More Than Three Current-Carrying Conductors in a Flexible Cord or Flexible Cable

Number of Conductors	Percent of Value in Table 4.0.1.5(A)(1) and Table 4.0.1.5(A)(2)
4 - 6	80
7 - 9	70
10 - 20	50
21 - 30	45
31 - 40	40
41 and Above	35

FLEXIBLE CORDS AND CABLES

4.0.1.10 Uses Permitted

(A) Uses. Flexible cords and flexible cables shall be used only for the following:

(1) Pendants (2) Wiring of luminaires

(3) Connection of portable luminaries, portable and mobile signs, or appliances

(4) Elevator cables (5) Wiring of cranes and hoists

(6) Connection of utilization equipment to facilitate frequent interchange

(7) Prevention of the transmission of noise or vibration

(8) 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

(9) Connection of moving parts

(10) Where specifically permitted elsewhere in this Code

FLEXIBLE CORDS AND CABLES

4.0.1.10 Uses Permitted

(B) **Attachment Plugs.** Where used as permitted in 4.0.1.10(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.

4.0.1.12 Uses Not Permitted

Unless specifically permitted in 4.0.1.10, flexible cables, flexible cords sets, and power supply cords shall not be used for the following:

(1) As a substitute for the fixed wiring of a structure

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

(3) Where run through doorways, windows, or similar openings

FLEXIBLE CORDS AND CABLES

4.0.1.12 Uses Not Permitted

(4) 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 the provisions of 3.68.2.47(b)

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

Exception to (5): Flexible cord and flexible cable shall be permitted if contained within on enclosure for use in Other Spaces Used for Environmental Air as Permitted by 3.01.22(c)(3)

(6) Where installed in raceways, except as otherwise permitted in this Code

(7) Where subject to physical damage

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4.0.1.13 Splices

Flexible cord shall be used only in continuous lengths without splice or tap where initially installed in applications permitted by 4.0.1.10(A). The repair of hard-service cord and junior hard-service cord (see Trade Name column in Table 4.0.1.4) 2.0 mm2 (1.6 mm dia.) and larger shall be permitted if conductors are spliced in accordance with 1.10.1.14(B) and the completed splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

4.0.1.14 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.

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4.0.1.15 In Show Windows and Showcases

Flexible cords used in show windows and show cases shall be Type 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

4.0.1.16 Overcurrent Protection

Flexible cords not smaller than 0.75 mm2, and tinsel cords or cords having equivalent characteristics of smaller size approved for use with specific appliances, shall be considered as protected against overcurrent by the overcurrent devices described in 2.40.1.5.

FLEXIBLE CORDS AND CABLES

4.0.1.17 Protection From Damage

Flexible cords and 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 person service the installation, flexible cords and flexible cables shall be permitted to be installed in aboveground raceways that are no longer than 15000 mm to protect the flexible cord or flexible cable from physical damage. Where more than three current-carrying conductors are installed within the raceway, the allowable ampacity shall be reduced in accordance with Table 4.0.1.5(A)(3).

4.0.2 Construction Specification

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

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4.0.2.2 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 4.0.1.4

(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 4.0.1.4

4.0.2.3 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 4.0.2.3(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.

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4.0.2.2 Construction

(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.

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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.

FLEXIBLE CORDS AND CABLES

(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.

4.0.2.4 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 without a nonintegral grounding conductor shall be permitted to be green. The identifying marker shall consist of one of the methods in 4.0.2.4(A) or (B).

FLEXIBLE CORDS AND CABLES

4.0.2.4 Equipment Grounding Conductor Identification.

(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.

4.0.2.5 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 2.50.7.9(A) and (B).

FLEXIBLE CORDS AND CABLES

4.0.3 Portable Cables Over 600 Volts, Nominal

4.0.3.1 Scope. Part 4.0.1 applies to single and multiconductor portable cables used to connect mobile equipment and machinery.

4.0.3.2 Construction

(A) Conductors. The conductors shall be 3.5 mm2 (2.0 mm dia.) 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 2.50.6.13.

FLEXIBLE CORDS AND CABLES

4.0.3.3 Shielding. All shields shall be connected to an equipment grounding conductor.

4.0.3.4 Equipment Grounding Conductors. Equipment grounding conductors shall be connected in accordance with Parts 2.50.6 and 2.50.7

4.0.3.5 Minimum Bending Radii. The minimum bending radii for portable cables during insulation and bending in service shall be adequate to prevent damage to the cable.

4.0.3.6 Fittings. Connectors used to connect lengths of cable in a run shall be of a type that lock 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.

4.0.3.7 Splices and Terminations. Portable cables shall not contain splices unless the splices are of the permanent molded, vulcanized types in accordance with 1.10.1.14(B). Terminations on portable cables rated over 600 volts, nominal, shall be accessible only to authorized and qualified personnel.

FIXTURE WIRES

FIXTURE WIRES

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

Allowable Ampacities For Fixture Wires. No conductor shall be used under such conditions that its operating temperature exceeds the temperature specified for the type of insulation involved.

Minimum Size. Fixture wires shall not be smaller than 0.75mm^2 (1.0 mm dia.)

Number of Conductors in Conduit or Tubing. The number of fixture wires permitted in a single conduit or tubing shall not exceed the percentage filled in specification method.

Grounded Conductor Identification. Fixture wires that are intended to be used as grounded conductors shall be identified by one or more continuous white stripes or other than green insulation or by the means described.

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

Optional Marking. Fixture wire types shall be permitted to be surface marked indicate special characteristics of the cable materials.

Uses Permitted. Fixture wires shall be permitted

a.) for installation in luminaires and in similar equipment where enclosed or protected and not subject to bending or twisting in use.

b.) for connecting luminaires to the branch circuit conductors supplying luminaires.

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

Overcurrent Protection. Overcurrent protection for fixture wires shall be as specified in this code.

SWITCHES

SWITCHES

Scope. The provisions of this article apply to all switches devices, and circuit breaker used as switches operating at 1 000 volts and below, unless specifically referenced elsewhere in this Code for higher voltages.

Switch Connections

Three-Way and Four-Way Switches. Three-way and four-way switches shall be wired so that all switching is done only in the underground circuit conductor.

Exception: Switch Loops shall not require a grounded conductor.

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.*

Switches Controlling Lighting Loads. The grounded circuit conductor for the controlled lighting circuit shall be installed at the location where switches control lighting loads.

Location under any of the following conditions

a.) Where conductors enter the box enclosing the switch through a raceway, provided that the raceway is large enough for all contained conductors.

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

c.) Where lighting in the area is controlled by automatic means.
d.) 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.

Exception: *The connection requirement shall be effective on January 1, 2020. Where the grounded conductor cannot be extended without removing the finish materials.*

Enclosure. In general the switches and circuit breakers shall be of the externally operable type mounted in an enclosure listed for the intended use.

Exception 1: *Pendant and surface type snap switches and knife switches mounted on an open-face switchboard or panel board shall be permitted without enclosure.*

Exception 2: *Switches and circuit breakers installed shall be permitted without enclosures.*

Used as a Raceway. Enclosures shall not be used as a junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices.

Damp or Wet Locations

Surface-mounted switch or Circuit Breaker. A surface-mounted switch or circuit breaker shall be enclosed in weatherproof enclosure or cabinet.

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

Switches in Tub or Shower Spaces. Switches shall not be installed within tubs or shower spaces unless installed as part of a listed tub or shower assembly.

Time Switches, Flashers, and similar devices. Time switches, flushers ,and similar devices shall be of the enclose type or shall be mounted in cabinets or boxes or equipment enclosures. Energize 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 energize parts within 152mm of the manual adjustment or switch are covered by suitable barriers.

Position and Connection of Switches

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

Double-throw knife Switches. Double-throw knife Switches shall be permitted to be mounted so that the throw is either vertical or horizontal.

Connection of Switches. Single throw knife switches and switches with butt contacts shall be connected.

Accessibility and Grouping

Location. All switches and circuit breakers used as switches shall be located so that they maybe operated from a readily accessible place.

Voltage Between adjacent Devices. A snap switch shall not be group 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.

Multi-pole Snap Switches. A general use snap switch shall not be permitted to be feed from more than a single circuit unless its is listed and marked as a two circuit.

Provisions for General Use Snap Switches

Face-Plates. Face plates provided for snap switches mounted in boxes and other enclosure shall be installed so as to completely cover the opening and, where the switch is flush mounted , seat against the finish surface.

Grounding. Snap switches, including dimmer and similar control switches, shall be connected to an equipment grounding conductor and shall provide a means to connect metal face plates.

Construction. Metal face plates shall be of ferrous metal not less than 0.76mm in thickness or of nonferrous metal not less than 1.02mm in thickness.

Mounting of snap Switches

Surface type. Snap switches used with open wiring on insulators shall be mounted on insulating materials that separates the conductors at least 13mm from the surface wired over.

Box Mounted. Flush type snap switches mounted in boxes that are set back of the finish surface as permitted shall be installed so that the extension plaster ears are seated against the surface.

Circuit Breakers as Switches. A hand operable circuit breaker equip with a lever or handle, or a power operated circuit breaker capable of being opened by hand in the event of a power failure.

Grounding Enclosures. Metal enclosures for switches or circuit breakers shall be connected to an equipment grounding conductor as specified. Metal enclosures for switches used as service equipment shall comply with the provisions.

Knife Switches

Isolating Switches. Knife switches rated at over 1200 Amperes at 250 Volts or less, and at over 1000A at 251V to 1000V shall be used only as isolating switches and shall not be opened under load.

To interrupt Current. To interrupt current over 1200A at 250V, or over 600A at 251V to 600V, a circuit breaker or a switch of a special design listed for such purpose shall be used.

General Used Switches. Knife switches of ratings less than on the specified table shall be considered general used switches.

Motor Circuit Switches. Shall be permitted to be of the knife switch type.

Rating and Used of snap Switches. Shall be used within their ratings and as indicated in :

FPN 1: For Switches on signs and outline lighting.
FPN 2: For switches controller motors.

Alternating-Current or Direct-Current General Use Snap Switch. A form of General-use snap switch suitable for use on either ac or dc circuits for controlling the FF:

a.) Resistive loads not exceeding the ampere rating of the switch at the voltage applied.
b.) Inductive loads not exceeding 50 percent of the ampere rating of the switch at the applied voltage.
c.)Tungsten-filament lamp loads not exceeding the ampere rating of the switch at the applied voltage if T-rated.

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

Alternating-Current Specific-Use Snap Switches Rated for 347 Volts. Snap switches rated 347 Volts ac shall be used only for controlling the loads permitted by (D)(I) and (D) (2).

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

Inductive Loads. Inductive loads not exceeding the ampere and voltage ratings of the switch.

Dimmer 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.

Cord and Plug-Connected Loads. Where a snap switch or control devices is used to control cord and plug connected equipment on a general purpose branch circuit.

FPN: 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.*

Construction Specification

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

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.

Electronic Lighting Control Switches. Electronic Lighting control switches shall not introduce current on the equipment grounding conductor during normal operation.

Exception: *Electronic lighting control switches that introduce current on the equipment grounding conductor shall be permitted for applications covered.*

Knife Switches Rated 600V to 1000V. Auxiliary contacts of a renewable or quick-break type or the equivalent shall be provided on all knife switches on this rating designed for use in breaking current over 200A.

Fused Switches. Fused switch shall not have fuses in parallel except as permitted.

Wire-Bending Space. The wire-bending space required shall meet spacing to the enclosure wall opposite the line and load terminals.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

Definitions:

Child Care Facility

- A bldg. or structure, or position thereof, for educational, supervisory, or personal care services for more than four children 7 years old or less.

Outlet Box Hood

- 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.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

Receptacle Rating and Type

A. Receptacles

- Shall be listed and marked with the manufacturer's name or identification and voltage and ampere rating.

B. Rating

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

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

C. Receptacles for Aluminum Conductors

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

D. Isolated Ground Receptacles

- Shall be identified by an orange triangle located on the face of the receptacle.

1. Isolated equipment grounding conductor required - shall be used only with equipment grounding conductors.

2. Installation in nonmetallic boxes – shall be covered with nonmetallic faceplate.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

E. Controlled Receptacle Marking

- All nonlocking-type, 125 or 250V, 15 and 20A receptacles that are controlled by an automatic device, shall be permanently marked with the symbol and the word "controlled".

E. Receptacle with USB Charger

- A 125 or 250V, 15 or 20A receptacle shall be listed and constructed such that the class 2 circuitry is integral with the receptacle.

CONTROLLED RECEPTACLE MARKING SYMBOL

General Installation Requirements

A. Grounding Type

- Shall be installed only on circuits of the voltage class and current for which they are rated.

B. To be Grounded

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

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

E. Cord- and Plug-Connected Equipment

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

F. Noninterchangeable Type

- 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.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

Receptacle Mounting

- Shall be mounted in identified boxes or assemblies.

A. Boxes that are Set Back

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

A. Receptacles Mounted on Covers

- 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.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

D. Position of Receptacle Faces

- After installation, receptacle faces shall be flush with or project from faceplates insulating material shall project a minimum of 0/4mm from the metal faceplates.

E. Receptacles in Countertops

- Shall be listed for countertop application.

F. Receptacles in Work Surfaces

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

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

G. Receptacle Orientation

- receptacles shall not be installed in a face-up position.

H. Receptacles in Seating Areas and Other Similar Surfaces

- In setting areas or similar surfaces, receptacles shall not be installed in a face-up position.

I. Exposed Terminal

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

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

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 V between adjacent devices does not exceed 300V.

Receptacle Faceplates (Cover Plates)

- Shall be installed so as to completely cover the opening and seat against the mounting surface.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

A. Thickness of Metal Faceplates

- shall not be of ferrous metal not less than 0.76mm in thickness or of nonferrous not less than 1.02mm in thickness.

B. Grounding

- Metal faceplates shall be grounded.

C. Faceplates of Insulating Material

- Faceplates of insulating material shall not be combustible and not less than 2.54mm in thickness.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

Attachment Plugs, Cord Connectors, and Ranged Surface Devices

- All attachment plugs, cord connectors, and flanged surface devices shall be listed and marked with the manufacturer's name or identification and voltage and ampere ratings.

A. Construction of Attachment Plugs and Cord Connectors

- Shall be constructed so that there are no exposed current-carrying parts except the prongs, blades, or pins.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

B. Connection of Attachment Plugs

- Shall be installed so that their prongs, blades or pins are not energized unless inserted into an energized receptacle.

C. Attachment Plug Ejector Mechanism

- Shall not adversely affect engagement of blades of the attachment plug with contacts of receptacle.

D. Flanged Surface Inlet

- A flanged surface inlet shall be installed such that the prongs, blades, or pins are nit energized.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

Noninterchangeability

- Receptacles, cord, connectors, and attachment plugs shall be constructed such that the receptacle or cord connectors do not accept an attachment plug with different voltage or current rating from that for which the device is intended.

Receptacles Damp or in Wet Locations

A. Damp Locations

- Shall have an enclosure for the receptacle that is weatherproof.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

B. Wet Locations

- Shall be installed so that their prongs, blades or pins are not energized unless inserted into an energized receptacle.

1. Receptacles of 15 or 20A in a wet location

- Shall have an enclosure that is weather proof. An outlet box hood installed for this purpose shall be listed and shall be identified as *"extra duty"*.

C. Bathrub and Shower Space

- A receptacle shall not be installed within or directly over a bathrub or shower space.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

D. Protection for Floor Receptacles

- Standpipes of floor receptacles shall allow floor-cleaning equipment.

Grounding-type Receptacles, Adapters, Cord Connectors, and Attachment Plugs

A. Grounding Poles

- The grounding contacting pole shall be permitted to be of moveable, self-restoring type on circuits operating not over 150V.

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

B. Grounding Pole Indication

- Shall have a means for connection of an equipment grounding conductor to the grounding pole.

C. Grounding Terminal Use

- A grounding terminal shall not be used for purposes other than grounding.

D. Grounding-Pole Requirements

- Shall be designed such that the equipment grounding connection is made before the current-carrying connections.

E. Use

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

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

Tamper-resistant Receptacles

- All 15 and 20A, 125 and 250V nonlocking-type receptacles in the areas specified shall be listed tamper-resistant receptacles.

1. Dwelling Units
2. Guest Rooms and suites
3. Childcare facilities
4. Preschools and elementary education facilities.
5. Business offices, corridors, waiting rooms and the like in clinics, medical and dental offices and outpatient facilities.
6. Dormitories

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Support and Arrangement of Busbars and Conductors:

(a) Conductors and Busbars on a Switchboard or Panelboard. Conductors and busbars on a switchboard or panelboard shall comply with 4.8.1.3(a)(1), (a)(2), and (a)(3) 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) Service Switchboards. Barriers shall be placed in all service switchboards such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Support and Arrangement of Busbars and Conductors:

(3) 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 shall be located in that section.

(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 or panelboard, if used as service equipment, shall be provided with a main bonding jumper sized in accordance with 2.50.2.9

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Support and Arrangement of Busbars and Conductors:

(d) Terminals. In switchboards and panelboards, load terminals for field wiring, including grounded circuit conductor load terminals and connections to the ground bus for load equipment grounding conductors, shall be so located that it is not necessary to reach across or beyond an uninsulated ungrounded line bus in order to make connections.

(e) Phase Arrangement. The 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 or panelboard.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Support and Arrangement of Busbars and Conductors:

(f) Minimum Wire-Bending Space. The minimum wire-bending space at terminals and minimum gutter space provided in panelboards and switchboards shall be as required in 3.12.1.6.

Circuit Directory or Circuit Identification

- Every circuit and circuit modification shall be legibly identified as to its clear, evident, and specific purpose or use.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Clearance for Conductor Entering Bus Enclosures

- Where conduits or other raceways enter a switchboard, floor-standing panelboard, or similar enclosure at the bottom, sufficient space shall be provided to permit installation of conductors in the enclosure.

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.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Switchboards

Switchboards in Damp or Wet Locations.

- Switchboards in damp or wet locations shall be installed in accordance with 3.12.1.2(a).

Location Relative to Easily Ignitable Material.

- Switchboards 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.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Clearances

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

(b) Around Switchboards. Clearances around switchboards shall comply with the provisions of 1.10.2.1.

Conductor Insulation

- An insulated conductor used within a switchboard 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 in contact.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Location of Switchboards

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

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

- Instruments, relays, meters, and instrument transformers located on switchboards shall be grounded as specified in 2.50.9.1 through 2.50.9.9.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Panelboards

General. All panelboards shall have a rating not less than the minimum feeder capacity required for the load calculated. Panelboards shall be durably marked by the manufacturer with the voltage and the current rating and the number of phases 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.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Classification of Panelboards

- Panelboards shall be classified for the purposes of this article as either lighting and appliance branch circuit panelboards or power panelboards, based on their content. A lighting and appliance branch circuit is a branch circuit that has a connection to the neutral of the panelboard and that has overcurrent protection of 30 amperes or less in one or more conductors.

(a) Lighting and Appliance Branch-Circuit Panelboard. A lighting and appliance branch-circuit panelboard is one having more than 10 percent of its overcurrent devices protecting lighting and appliance branch circuits.

(b) Power Panelboard. A power panelboard is one having 10 percent or fewer of its overcurrent devices protecting lighting and appliance branch circuits.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Number of Overcurrent Devices on One Panelboard

- Not more than 42 overcurrent devices (other than those provided for in the mains) of a lighting and appliance branch-circuit panelboard shall be installed in any one cabinet or cutout box.

Overcurrent Protection.

(a) Lighting and Appliance Branch-Circuit Panelboard Individually Protected. Each lighting and appliance branch-circuit panelboard shall be individually protected on the supply side by not more than two main circuit breakers or two sets of fuses having a combined rating not greater than that of the panelboard.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Overcurrent Protection.

(b) 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.

(c) Supplied Through a Transformer. Where a panelboard is supplied through a transformer, the overcurrent protection required by 4.8.3.7(a), (b), and (c) shall be located on the secondary side of the transformer.

(d) 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.

(e) 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

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Power Panelboard Protection

- In addition to the requirements of 4.8.3.1, a power panelboard with supply conductors that include a neutral and having more than 10 percent of its overcurrent devices protecting branch circuits rated 30 amperes or less, 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.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Panelboards in Damp or Wet Locations

- Panelboards in damp or wet locations shall be installed to comply with 3.12.1.2(a).

Enclosure. Panelboards shall be mounted in cabinets, cutout boxes, or enclosures designed for the purpose and shall be dead-front.

Grounding of Panelboards

- Panelboard cabinets and panelboard frames, if of metal, shall be in physical contact with each other and shall be grounded.

Grounded Conductor Terminations

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

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Construction Specifications

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

Busbars. Insulated or bare busbars shall be rigidly mounted.

Protection of Instrument Circuits. Instruments, pilot lights, potential transformers, and other switchboard devices with potential coils shall be supplied by a circuit that is protected by standard overcurrent devices rated 15 amperes or less.

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Component Parts. Switches, fuses, and fuseholders used on panelboards shall comply with the applicable requirements of Articles 2.40 and 4.4.

Wire-Bending Space in Panelboards. The enclosure for a panelboard shall have the top and bottom wire-bending space sized in accordance with Table 3.12.1.6(b) for the largest conductor entering or leaving the enclosure

SWITCHBOARDS, SWITCHGEAR AND PANELBOARDS

Minimum Spacings. The distance between bare metal parts, busbars, and so forth shall not be less than specified in Table 4.8.4.7

INDUSTRIAL CONTROL PANEL

INDUSTRIAL CONTROL PANEL

Scope. This article covers industrial control panels intended for general use and operating at 600 volts or less.

Definitions.

Industrial Control Panel. An assembly of a systematic and standard arrangement of two or more components such as motor controllers, overload relays, fused disconnect switches, and circuit breakers and related control devices such as pushbutton stations, selector switches, timers, switches, control relays, and the like with associated wiring, terminal blocks, pilot lights, and similar components. The industrial control panel does not include the controlled equipment.

INDUSTRIAL CONTROL PANEL

Installation

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 resistance 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.

INDUSTRIAL CONTROL PANEL

Overcurrent Protection.

(a) General. Industrial control panels shall be provided with overcurrent protection in accordance with Parts 2.40.1, 2.40.2, and 2.40.9.

(b) Location. This protection shall be provided by either of the following:

(1) An overcurrent protective device located ahead of the industrial control panel.
(2) 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 2.40.2.2.

INDUSTRIAL CONTROL PANEL

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

INDUSTRIAL CONTROL PANEL

Busbars and Conductors.

Industrial control panels utilizing busbars shall comply with 4.9.3.3(a) and 4.9.3.3(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.

INDUSTRIAL CONTROL PANEL

Wiring Space in Industrial Control Panels.

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, unless adequate space for this purpose is provided.

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

LUMINAIRES, LAMPHOLDERS, AND LAMPS

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Live Parts. Luminaires (fixtures), 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 (fixture) canopies or in open bases of portable table or floor lamps.

Exception: Cleat-type lampholders located at least 2 400 mm above the floor shall be permitted to have exposed terminals

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Luminaire (Fixture)

Luminaires (Fixtures) in Specific Locations.

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

(b) Corrosive Locations. Luminaires (fixtures) installed in corrosive locations shall be of a type suitable for such locations.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Luminaire (Fixture)

Luminaires (Fixtures) in Specific Locations.

(c) In Ducts or Hoods. Luminaires (fixtures) shall be permitted to be installed in commercial cooking hoods.

(d) Bathtub and Shower Areas. No parts of cord-connected luminaires (fixtures), chain-, cable-, or cord-suspended-luminaires (fixtures), lighting track, pendants, or ceiling-suspended (paddle) fans shall be located within a zone measured 900 mm horizontally and 2 400 mm vertically from the top of the bathtub rim or shower stall threshold.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

(e) Luminaires (Fixtures) in Indoor Sports, Mixed-Use, and All-purpose Facilities. Luminaires (fixtures) 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 (fixtures) shall be permitted to have an additional guard.

Luminaires (Fixtures) Near Combustible Material. Luminaires (fixtures) 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).

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Luminaires (Fixtures) in Clothes Closets.

(a) Definition.

Storage Space. The volume bounded by the sides and back closet walls and planes extending from the closet floor vertically to a height of 1 800 mm or to the highest clothes-hanging rod and parallel to the walls at a horizontal distance of 600 mm 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 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 on either side of the rod on a plane horizontal to the floor extending the entire length of the rod.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Luminaires (Fixtures) in Clothes Closets.

b) Luminaire (Fixture) Types Permitted. Listed luminaires (fixtures) of the following types shall be permitted to be installed in a closet:

(1) A surface-mounted or recessed incandescent luminaire (fixture) with a completely enclosed lamp
(2) A surface-mounted or recessed fluorescent luminaire (fixture)

(c) Luminaire (Fixture) Types Not Permitted. Incandescent luminaires (fixtures) with open or partially enclosed lamps and pendant luminaires (fixtures) or lampholders shall not be permitted.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Luminaires (Fixtures) in Clothes Closets.

(d) Location. Luminaires (fixtures) in clothes closets shall be permitted to be installed as follows:

(1) Surface-mounted incandescent luminaires (fixtures) installed on the wall above the door or on the ceiling, provided there is a minimum clearance of 300 mm between the luminaire (fixture) and the nearest point of a storage space

(2) Surface-mounted fluorescent luminaires (fixtures) installed on the wall above the door or on the ceiling, provided there is a minimum clearance of 150 mm between the luminaire (fixture) and the nearest point of a storage space

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

(3) Recessed incandescent luminaires (fixtures) with a completely enclosed lamp installed in the wall or the ceiling, provided there is a minimum clearance of 150 mm between the luminaire (fixture) and the nearest point of a storage space

(4) Recessed fluorescent luminaires (fixtures) installed in the wall or the ceiling, provided there is a minimum clearance of 150 mm between the luminaire (fixture) and the nearest point of a storage space

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

Provisions at Luminaire (Fixture) Outlet Boxes, Canopies, and Pans

Space for Conductors. Canopies and outlet boxes taken together shall provide adequate space so that luminaire (fixture) conductors and their connecting devices can be properly installed.

Temperature Limit of Conductors in Outlet Boxes. Luminaires (fixtures) 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.

Connection of Electric-Discharge Luminaires (Lighting Fixtures)

(a) Independent of the Outlet Box. Electric-discharge luminaires (lighting fixtures) supported independently of the outlet box shall be connected to the branch circuit.

(b) Access to Boxes. Electric-discharge luminaires (fixtures) 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 (fixture) to provide access to the wiring in the box.

Luminaire (Fixture) Supports

(a) General. Luminaires (fixtures) and lampholders shall be securely supported. A luminaire (fixture) that weighs more than 3 kg (6 lb) or exceeds 410 mm in any dimension shall not be supported by the screw shell of a lampholder.

(b) Metal or Nonmetallic Poles Supporting Luminaires (Lighting Fixtures). Metal or nonmetallic poles shall be permitted to be used to support luminaires (lighting fixtures) and as a raceway to enclose supply conductors, provided the following conditions are met:

(1) A pole shall have a handhole not less than 50 mm × 100 mm with a raintight cover to provide access to the supply terminations within the pole or pole base.

(2) 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.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Grounding

General. Luminaires (fixtures) and lighting equipment shall be grounded as required in Part 2.50.5.

Exposed Luminaire (Fixture) Parts.

(a) Exposed Conductive Parts. Exposed metal parts shall be grounded or insulated from ground and other conducting surfaces or be inaccessible to unqualified personnel.

(b) Made of Insulating Material. Luminaires (fixtures) directly wired or attached to outlets supplied by a wiring method that does not provide a ready means for grounding shall be made of insulating material and shall have no exposed conductive parts.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Wiring of Luminaires (Fixtures)

Luminaire (Fixture) Wiring — *General.* Wiring on or within fixtures shall be neatly arranged and shall not be exposed to physical damage.

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

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

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 2.0 mm2 (1.6 mm dia.) for mogulbase 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 shall be twisted together where not cabled in a listed assembly.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

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 (Fixture) Stems. Splices and taps shall not be located within luminaire (fixture) arms or stems.

(d) Splices and Taps. No unnecessary splices or taps shall be made within or on a luminaire (fixture).

(e) Stranding. Stranded conductors shall be used for wiring on luminaire (fixture) chains and on other movable or flexible parts.

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

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Cord-Connected Lampholders and Luminaires (Fixtures).

(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) 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.

(b) Adjustable Luminaires (Fixtures). Luminaires (fixtures) 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 of the hard-usage or extra-hard-usage type and is not longer than that required for maximum adjustment. The cord shall not be subject to strain or physical damage.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Branch Circuit Conductors and Ballasts. Branch-circuit conductors within 75 mm of a ballast shall have an insulation temperature rating not lower than 90°C (194°F) unless supplying a luminaire (fixture) listed and marked as suitable for a different insulation temperature.

Construction of Luminaires (Fixtures)

Combustible Shades and Enclosures. Adequate airspace shall be provided between lamps and shades or other enclosures of combustible material.

Luminaire (Fixture) Rating.

(a) Marking. All luminaires (fixtures) shall be marked with the maximum lamp wattage or electrical rating, manufacturer's name, trademark, or other suitable means of identification.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Mechanical Strength

(a) Tubing for Arms. Tubing used for arms and stems where provided with cut threads shall not be less than 1.00 mm in thickness and, where provided with rolled (pressed) threads, shall not be less than 0.65 mm in thickness.

(b) Metal Canopies. Metal canopies supporting lampholders, shades, and so forth exceeding 4 kg (8 lb), or incorporating attachment plug receptacles, shall not be less than 0.50 mm in thickness. Other canopies shall not be less than 0.40 mm if made of steel and not less than 0.50 mm if of other metals.

(c) Canopy Switches. Pull-type canopy switches shall not be inserted in the rims of metal canopies that are less than 0.65 mm in thickness, unless the rims are reinforced by the turning of a bead or the equivalent. Pull-type canopy switches, whether mounted in the rims or elsewhere in sheet metal canopies, shall not be located more than 90 mm from the center of the canopy.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Portable Lamps.

(a) General. Portable lamps shall be wired with flexible cord recognized by 4.0.1.4 and an attachment plug of the polarized or grounding type. Where 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.

(b) Portable Handlamps. In addition to the provisions of 4.10.7.9(a), portable handlamps shall comply with the following:

(1) Metal shell, paper-lined lampholders shall not be used.
(2) Handlamps shall be equipped with a handle of molded composition or other insulating material.
(3) Handlamps shall be equipped with a substantial guard attached to the lampholder or handle

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Installation of Lampholders

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.

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.

Lampholders in Wet or Damp Locations. Lampholders installed in wet or damp locations shall be of the weatherproof type.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

Construction of Lampholders

Insulation. The outer metal shell and the cap shall be lined with insulating material that prevents the shell and cap from becoming a part of the circuit. The lining shall not extend beyond the metal shell more than 3 mm but shall prevent any current-carrying part of the lamp base from being exposed when a lamp is in the lampholding device.

Switched Lampholders. Switched lampholders shall be of such construction that the switching mechanism interrupts the electrical connection to the center contact

Special Provisions for Flush and Recessed Luminaires (Fixtures)

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

(b) **Fire-Resistant Construction.** Where a luminaire (fixture) is recessed in fire-resistant material in a building of fire-resistant construction, a temperature higher than 90°C (194°F) but not higher than 150°C (302°F) shall be considered acceptable if the luminaire (fixture) is plainly marked that it is listed for that service.

(c) **Recessed Incandescent Luminaires (Fixtures).** Incandescent luminaires (fixtures) shall have thermal protection and shall be identified as thermally protected

Construction of Flush and Recessed Luminaires (Fixtures)

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

Lamp Wattage Marking. Incandescent lamp luminaires (fixtures) shall be marked to indicate the maximum allowable wattage of lamps.

Solder Prohibited. No solder shall be used in the construction of a luminaire (fixture) box.

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

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

General.

(a) **Open-Circuit Voltage of 1 000 Volts or Less.** Equipment for use with electric-discharge lighting systems and designed for an open circuit voltage of 1 000 volts or less shall be of a type intended 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 (lighting fixtures), such equipment shall comply with Part 4.10.13.

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

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 1 000 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 (lighting fixtures), such equipment shall comply with Part 4.10.14.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

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 7 500 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 7 500 volts, and not more than 300 mA if the open-circuit voltage rating is 7 500 volts or less. (d) Secondary Connections. Secondary circuit outputs shall not be connected in parallel or in series.

LUMINAIRES (LIGHTING FIXTURES), LAMPHOLDERS, AND LAMPS

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).

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

Marking. Each luminaire (fixture) or each secondary circuit of tubing having an open-circuit voltage of over 1 000 volts shall have a clearly legible marking in letters not less than 6 mm high reading "Caution ____ volts." The voltage indicated shall be the rated open circuit voltage.

LOW-VOLTAGE LIGHTING

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Scope

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

General

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 25 A maximum under all load conditions.

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Listing Required

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 form the listed parts shall be permitted: *a.) Low-voltage luminaires b.) Power supply c.) Low-voltage luminaire fittings d.) Suitably rate cord, cable, conductors in conduit, or other fixed Chapter 3 wiring method for the secondary circuit.*

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Specific Location Requirements

A) Walls, Floors and Ceilings

B) Pools, Spas, Fountains and Similar Location

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.

D) **Insulated Conductors**. It should be in the said type under the specifications in the code.

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Branch Circuits

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

Hazardous (Classified) Locations

Installed in hazardous locations, these systems shall conform with articles 5.0 through 5.17 in addition to this article.

APPLIANCES

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Live Parts

Appliances shall have no live parts normally exposed to contact other than those parts functioning as open-resistance.

Ground-Fault Circuit-Interrupter (GFCI) Protection for Personnel

GENERAL Appliances identified in 4.22.1.5(A)(1) through (5) rated 250 V or less and 60 A or less, single- or 3-phase, shall be provided with GFCI protection for personnel.

1. Automotive vacuum machines provided for public use
2. Drinking water coolers
3. High-pressure spray washing machines---- cord and plug connected
4. Tire inflation machines provided for public use
5. Vending machines

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

TYPE. The GCFI shall be readily accessible, listed, and located in one or more of the following locations:

1. Within the branch circuit overcurrent device
2. A device or outlet within the supply circuit
3. An integral part of the attachment plug
4. Within the supply cord not more than 300mm from the attachment plug
5. Factory installed within the appliances

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Installation

Branch-Circuit Rating

The ratings of the branch circuits capable of carrying appliance current without overheating under the conditions specified.

Individual Circuits. The rating shall not be less than the marked rating of the appliances or marked rating of an appliance having combined loads

Circuit Supplying Two or More Loads. The rating shall be determined in accordance 2.10.2.1(A)(3)

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Over current protection

- ✓ **Branch-Circuit Overcurrent Protection**

  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.

- ✓ **Household-Type Appliances with surface heating elements**

  Having a maximum demand of more than 60 A calculated with accordance in Table 2.20.3.16 shall have their power supply subdivided into two or more circuits.

- ✓ **Infrared Lamp Commercial and Industrial Heating appliances**

  Shall have overcurrent protection not exceeding 50 A.

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Over current protection

- ✓ **Open-Coil or Exposed Sheathed-Coil Types of Surface Heating Elements in commercial type heating appliances**

  Shall be protected by overcurrent devices rated at not over 50 A.

- ✓ **Single Non-Motor-Operated Appliance**

  The rating of the overcurrent device shall not exceed the marked rating on the appliance.

- ✓ **Electric heating appliances employing resistance-type heating elements rated more than 48 A**

  a. Electric Heating Appliances. The heating elements that were subdivided shall not exceed 48A and shall be protected at not more than 60 A.

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Over current protection

b. Commercial Kitchen and Cooking Appliances. Commercial kitchen and cooking appliances using sheathed type heating elements not covered in 4.22.2.2(D) shall be permitted to be subdivided into circuits not exceeding 120 A and protected not more than 150 A.

c. Water Heaters and Steam Boilers. Shall be permitted to be subdivided into circuits not exceeding 120 A and protected not more than 150 A.

✓ **Motor-operated appliances**

Hermetic refrigerant motor-compressors in air-conditioning or refrigerating equipment shall be provided with overload protection. Where appliance overcurrent protective devices that are separate from the appliance that are required, data for selection of these devices shall be marked on the appliance.

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Central Heating Equipment. Shall be supplied by an individual branch-circuit

EXCEPTION I : Auxilary 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 II : Permanently connected air-conditioning equipment shall be permitted to be connected to the same branch circuit.

Storage-Type Water Heaters. Having a capacity of 450 L or less shall be considered a continuous load for the purposes of sizing branch circuits.

Central Vacuum Assembly. Ampacity of the connecting conductors shall not be less than the ampacity of the branch circuit conductors to which they are connected.

LIGHTING SYSTEMS OPERATING AT 30 VOLTS OR LESS AND LIGHTING EQUIPMENT CONNECTED TO CLASS 2 POWER SOURCES

Flexible Cords

- ✓ ***Electrically Operated In-Sink Waste Disposers***

  The length of the cord shall not be less than 450 mm and not over 900 mm

- ✓ ***Built-In Dishwashers and Trash Compactors***

  Trash compactors, the length of the cord shall be 900mm to 1200 mm measured from the face of the attachment plug to the plane of the rear of the appliance

  Built-In Dishwasher, the length of the cord shall be 900 mm to 2000 mm measured from the face of the attachment plug to the plane of the rear of the appliance

- ✓ ***Wall-Mounted Ovens and Counter-Mounted Cooking Units***

  Shall be permitted to be permanently connected

- ✓ ***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.

Protection of Combustible Material. Electrically heated appliance that is intended by size, weight, and service not to be located in a fixed position shall be placed so as to provide ample protection between the appliance and adjacent combustible material.

Support of Ceiling-Suspended (Paddle) Fans. Ceiling suspended fans shall be supported with outlet box, locking support and mounting receptacle, and a compatible factory

Disconnecting Means

Disconnection of permanently connected appliances:

a. Rated at not over 300 VA or 1/8 Hp

b. Appliances rated over 300 VA

c. Motor-Operated Appliances rated over 1/8 Hp

Disconnection of cord-and-plug and plug-connected or attachment fitting-connected appliances

a. Separable connector or an attachment plug (or attachment fitting) and receptacle
b. Connection at the rear rating base of a range
c. Rating

Unit Switch(es) as Disconnecting Means

Multifamily Dwellings. Shall be within the dwelling unit or on the same floor in which the appliance is installed

Two-Family Dwellings. Shall be permitted either inside or outside of the dwelling unit in which the appliance is installed

One-Family Dwellings. The service disconnecting means shall be permitted to be other disconnecting means.

Other Occupancies. The branch-circuit switch of circuit breaker hall be permitted as the other disconnecting means.

Cord- and Plug-Connected Immersion Heaters. This type shall be constructed and installed so that current-carrying parts are effectively insulated form electrical contact with the substance in which they are immersed

Stands for Cord- and Plug-Connected Appliances. Electrically heated appliances shall be equipped with an approved stand of which shall be permitted to be a separate piece of the appliance.

Flatirons. It shall be equipped with an identified temperature-limiting means.

Water Heater Controls. Shall be equipped with a temperature-limiting means to sense maximum water temperature.

Infrared Lamp Industrial heating appliances. With the 300W or less, lampholders of the medium base shall be permitted while over 300W screw shell lampholders shall not be used with infrared lamps.

Cord- and Plug-Connected Pipe Heating Appliances. Are intended to prevent freezing of piping shall be listed.

Marking

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.

The markings :

- Should be visible
- Should have the marking of heating elements
- With the horsepower markings

Alternate Marking Method. Shall be permitted to specify the rating of the largest motor in volts and amperes, and the additional loads in volts and amperes or volts and watts in addition to the marking required in 4.22.5.1.

FIXED ELECTRIC SPACE-HEATING EQUIPMENT

FIXED ELECTRIC SPACE-HEATING EQUIPMENT

The purpose of this article, heating equipment shall include heating cable, unit heaters, boilers central systems or other fixed electric space-heating equipment.

Branch-Circuit Requirements. Shall be permitted to supply any volt-ampere or wattage rating of fixed electric space heating equipment for which they are used.

Supply Conductors. Fixed electric space heating equipment requiring supply conductors with 60°C insulation shall be clearly and permanently marked.

FIXED ELECTRIC SPACE-HEATING EQUIPMENT

Locations

a. Exposed to Physical Damage
b. Damp or wet locations

Control and Protection of Fixed Electric Space heating Equipment

Disconnecting Means

- ✓ Heater equipment with supplementary overcurrent protection
- ✓ Heater equipment without supplementary overcurrent protection
- ✓ Unit switches as disconnecting means

FIXED ELECTRIC SPACE-HEATING EQUIPMENT

Thermostatically Controlled Switching Devices

a. Serving as both Controllers and Disconnecting Means

b. Thermostats that do not directly interrupt ungrounded conductors

Overcurrent Protection

- Branch-Circuit Devices
- Resistance Elements
- Overcurrent Protective Devices
- Branch-Circuit Conductors
- Conductors for Subdivided Loads

Electric Space-Heating Cables

Heating Cable Construction. Factory assembles non-heating leads of heating cables, if any, shall be at least 2100mm in length.

Marking of Heating Cables. Each unit shall be marked with the identifying name, symbols, catalog number and ratings.

Clearances of Wiring in Ceilings. Wiring above heated ceiling shall be spaced not less than 50mm above the heated ceiling.

Ceiling Installations of Heating Cables on Dryboard, In Plaster, and on Concrete Ceilings

- In walls
- Adjacent runs
- Surfaces to be Applied
- Splices
- Ceiling Surface
- Secured
- Dry Board Installations
- Free form contact with conductive surfaces
- Joists
- Crossing Joints

Considerations of:

Installation of Cables in Concrete or Poured Masonry

- Adjacent runs
- Leads protected
- Bushing or approved fittings
- Ground-Fault Circuit-Interruptor Protection

Installations of Cables under Floor coverings

- Identification
- Expansion Joints
- Connection to Conductors
- Anchoring
- GFCI Protection
- Grounding Braid or Sheath

FIXED ELECTRIC SPACE-HEATING EQUIPMENT

Duct Heaters

This part of the article 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.

Airflow. Shall be provided to ensure the uniform airflow over the face of the heater in accordance with the manufacturer's instruction.

Elevated Inlet Temperature. Shall be identified as suitable for use at the elevated temperatures.

Condensations. Condensation of moisture shall be identified as suitable for use with air conditioner.

Fan Circuit Interlock. Shall provide to ensure that the fan circuit is energized when any heater circuit is energized.

Limit Controls. It disconnects a sufficient number of conductors to interrupt the current flow.

Location of Disconnecting Means. Shall be either accessible with the disconnecting means installed at or within sight form the controller or as permitted by 4.24.3.1(a).

FIXED ELECTRIC SPACE-HEATING EQUIPMENT

Resistance Type Boilers. Contained in an ASME-rated and stamped vessel shall have the heating elements protected at not more than 150 A.

Electrode Type Boilers. Shall apply to boilers for operation at 600V, nominal, or les, in which heat is generated by the passage of current between electrodes thorugh the liquid being heated.

FIXED ELECTRIC SPACE-HEATING EQUIPMENT

Electric Radiant Heating Panels and Heating Panel Sets

Heating Panel. A complete assembly provided with a junction box or length of flexible conduit for connection to a branch circuit.

Heating Panel Set. A rigid or non rigid assembly provided with non-heating leads or a terminal junction assembly identified as being suitable for connection to a wiring system.

Separation from Outlets for Luminaires. Edges of panels and panel sets shall be separated by not less than 200mm form the edges of any outlet boxes and junction boxes that are used for mounting surface luminaires.

Clearances of Wiring In Ceilings. Shall be spaced not less than 50mm above the heated ceiling.

FIXED RESISTANCE AND ELECTRODE INDUSTRIAL PROCESS HEATING EQUIPMENT

FIXED RESISTANCE AND ELECTRODE INDUSTRIAL PROCESS HEATING EQUIPMENT

This article covers fixed industrial process heating employing electric resistance or electrode heating technology.

Fixed Industrial Process Duct Heaters. The air-moving unit is not provided as an integral part of the equipment.

Fixed Industrial Process Resistance-Type Boilers. Electrode type boilers shall not be considered as employing resistance type heating elements.

Fixed Industrial Process Electrode-Type Boilers. The provisions in 4.25.7 shall apply to boilers at 600 V, nominal, or less, in which heat is generated by the passage of current between electrodes through the liquid being heated.

FIXED ELECTRIC HEATING EQUIPMENT FOR PIPELINES AND VESSELS

Definitions

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.

Integrated Heating System- a complete system consisting of components such as pipelines, vessels, heating elements, heat transfer medium, thermal insulation, moisture barrier, non-heating leads, temperature controllers, safety signs, junction boxes, raceways, and fittings.

Pipeline- a length of pipe including pumps, valves, flanges, control devices, strainers, and/or similar equipment for conveying fluids.

Definitions

Resistance Heating Element- specific separate element to generate heat that is applied to the pipeline or vessel externally or internally.

FPN: 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.

FPN: 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.

Installation

General: Equipment for pipeline and vessel electrical 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.

Use: Electrical heating equipment shall be installed in such a manner as to be afforded protection from physical damage.

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.

Identification: The presence of electrically heated pipelines, vessels, or both, shall be evident by the posting of appropriate caution signs or markings at frequent intervals along the pipeline or vessel.

Resistance Heating Elements

Secured: Heating element assemblies shall be secured to the surface being heated by means other than the thermal insulation.

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 over temperature of the heating element unless the design of the heater assembly is such that its temperature limitations will not be exceeded.

Expansion and Contraction: Heating elements and assemblies shall not be installed where they bridge expansion joints unless provisions are made for expansion and contraction.

Flexural Capability: Where installed on flexible pipelines, the heating elements and assemblies shall have a flexural capability that is compatible with the pipeline

FIXED ELECTRIC HEATING EQUIPMENT FOR PIPELINES AND VESSELS

Electrical Connections.

(a) Non heating Interconnections- Non heating 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 1.10.1.14 and 3.0.1.15.

Marking- Each factory-assembled heating unit shall be legibly marked within 75 mm 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.

FIXED ELECTRIC HEATING EQUIPMENT FOR PIPELINES AND VESSELS

Equipment Protection- 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:

(1) Conditions of maintenance and supervision ensure that only licensed electrical practitioner or non licensed electrical practitioner under the supervision of a licensed electrical practitioner service the installed systems.

(2) Continued circuit operation is necessary for safe operation of equipment or processes.

FIXED ELECTRIC HEATING EQUIPMENT FOR PIPELINES AND VESSELS

Grounded Conductive Covering- Electric heating equipment shall be listed and have a grounded conductive covering in accordance with 4.27.3.10(a) or 4.27.3.10(b). The conductive covering provide an effective ground path for equipment protection.

(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.

Impedance Heating

Personnel Protection- external surfaces of the pipeline, vessel, or both, being heated shall be physically guarded, isolated, or thermally insulated

Isolation Transformer- A dual-winding transformer used to isolate the distribution system from the heating system.

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 but not more than 80 volts as permitted.

Induction Heating

Personnel Protection- Induction coils that operate or may operate at a voltage greater than 30 volts ac shall be enclosed in a non metallic or split metallic enclosure, isolated, or made inaccessible by location to protect personnel in the area.

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.

Skin-Effect Heating

Conductor Ampacity- The ampacity of the electrically insulated conductor inside the ferromagnetic envelope shall be permitted to exceed the values given in Article 3.10, provided it is identified as suitable for this use.

Pull Boxes- For outdoor installations, pull boxes shall be of water tigh construction.

Single Conductor in Enclosure- The provisions of 3.0.1.20 shall not apply to the installation of a single conductor in a ferromagnetic envelope (metal enclosure).

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.

Control and Protection

Disconnecting Means.

(a) Switch or Circuit Breaker- 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 provided with a positive lockout in the "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.

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 provided with a positive lockout in the "off" 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.

Controls

(c) Remote Temperature Controller- Remote controlled temperature-actuated devices shall not be required to meet the requirements of 4.27.7.2(a) and 4.27.7.2(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:

(1) Open all ungrounded conductors when manually placed in the "off" position (2) Be designed so that the circuit cannot be energized automatically if the device has been manually placed in the "off" position (3) Be provided with a positive lockout in the "off" position

Overcurrent Protection- Heating equipment shall be considered as protected against overcurrent where supplied by a branch circuit as specified in 2.10.1.3 and 2.10.2.4.

MOTORS, MOTOR CIRCUITS, AND CONTROLLERS

Definitions

Adjustable Speed Drive- A combination of the power converter, motor, and motor mounted auxiliary devices such as encoders, tachometers, thermal switches and detectors, air blowers, heaters, and vibration sensors.

Adjustable-Speed Drive System - An interconnected combination of equipment that provides a means of adjusting the speed of a mechanical load coupled to a motor. A drive system typically consists of an adjustable speed drive and auxiliary electrical apparatus.

Controller- For the purpose of this article, a controller is any switch or device that is normally used to start and stop a motor by making and breaking the motor circuit current.

Definitions

Motor Control Circuit- The circuit of a control apparatus or system that carries the electric signals directing the performance of the controller but does not carry the main power current.

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.

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.

Marking on Motors and Multimotor Equipment

(a) Usual Motor Applications- A motor shall be marked with the following information.

(1) Manufacturer's name.

(2) Rated volts and full-load current

(3) Rated frequency and number of phases if an ac motor.

(4) Rated full-load speed.

(5) Rated temperature rise or the insulation system class and rate ambient temperature.

(6) Time rating. The time rating shall be 5, 15, 30, or 60 minutes, or continuous.

(7) Rated horsepower if 1/8 hp or more

(8) Code letter or locked-rotor amperes if an alternating- current motor rated ½ hp or more. On polyphase wound-rotor motors, the code letter shall be omitted.

Marking on Motors and Multimotor Equipment

(9) Design letter for design B, C, or D motors.

(10) Secondary volts and full-load current if a wound-rotor induction motor.

(11) Field current and voltage for dc excited synchronous motors.

(12) Winding — straight shunt, stabilized shunt, compound, or series, if a dc motor. Fractional horsepower dc motors 180 mm or less in diameter shall not be required to be marked.

(13) Thermally Protected marking, abbreviated as "T.P."

(14) Impedance Protected marking, abbreviated as "Z.P."

(15) 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.

(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 4.30.1.7(b). The code letter indicating motor input with locked rotor shall be in an individual block on the nameplate, properly designated.

(1) Multispeed Motors

(2) Single-Speed Motors

(3) Dual-Voltage Motors

(4) 50/60 Hz Motors

(5) Part Winding Motors

The code letter indicating motor input with locked rotor shall be in an individual block on the nameplate, properly designated.

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 2.0 mm2 (1.6 mm dia.) or smaller copper conductors shall be torqued to a minimum of 0.8 Nm (7 lb-in.) unless identified for a different torque value.

Motor Terminal Housings

(a) Material- the housings shall be of metal and of substantial construction.

(b) Dimensions and Space — Wire-to-Wire Connections

(c) Dimensions and Space — Fixed Terminal Connections- terminal housing shall be of sufficient size

(d) Large Wire or Factory Connections- terminal housing shall be of ample size

(e) Equipment Grounding Connections

For 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.

For motors rated 1½, 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.

4.30.1.15 Location of Motors.

(a)Ventilation and Maintenance.

(b) Open Motors

4.30.1.16 Exposure to Dust Accumulations

FPN: 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.

4.30.1.17 Highest Rated or Smallest Rated Motor.

4.30.1.18 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.

4.30.2 Motor Circuit Conductors

The provisions of Part II shall not apply to motor circuits rated over 600 volts, nominal

4.30.2.2 Single Motor

(a) General

(b) Multi-speed Motor

(c) Wye-Start, Delta-Run Motor

(d) Part-Winding Motor

(e) Other Than Continuous Duty

(f) Separate Terminal Enclosure

4.30.2.3 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 4.30.2.2(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 4.30.2.3(c).

(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 4.30.2.3(c).

Feeder Taps

Feeder tap conductors shall have an ampacity not less than that required by Part II and shall meet one of the following

requirements:

(1) Be enclosed either by an enclosed controller or by a raceway, be not more than 3 000 mm in length, the rating or setting of which shall not exceed 1000 percent of the tap conductor ampacity

(2) 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

(3) Have an ampacity not less than the feeder conductors

Motor and Branch-Circuit Overload Protection

Overload in electrical apparatus is an operating overcurrent that, when it persists for a sufficient length of time, would cause damage or dangerous overheating of the apparatus. It does not include short circuits or ground faults.

Exception: An overload unit in each phase shall not be required where overload protection is provided by other approved means.

Rating or Setting for Individual Motor Circuit

All Motors- The motor branch-circuit short-circuit and groundfault protective device shall be capable of carrying the starting current of the motor.

Rating or Setting.

(1) A protective device that has a rating or setting not exceeding the value calculated according to Table 4.30.4.2 shall be used.

(2) Overload Relay Table

(3) Instantaneous Trip Circuit Breaker

(4) Multispeed Motor

(5) Power Electronic Devices

(6) Self-Protected Combination Controller

(7) Motor Short-Circuit Protector

Over 600 Volts, Nominal

4.30.11.5 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.

(b) Overload Protection.

(1) Type of Overload Device

(2) Wound-Rotor AC Motors

(3) Operation

(4) Automatic Reset

(c) Fault-Current Protection

(1) Type of Protection

a. A circuit breaker of suitable type and rating arranged so that it can be serviced without hazard.

b. Fuses of a suitable type and rating placed in each ungrounded conductor.

(2) Reclosing - Fault-current interrupting devices shall not automatically reclose the circuit.

(3) Combination Protection- Overload protection and fault-current protection shall be permitted to be provided by the same device.

Protection of Live Parts — All Voltages

General- Live parts shall be protected in a manner judged adequate for the hazard involved.

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:

(1) By installation in a room or enclosure that is accessible only to licensed electrical practitioner or non licensed electrical practitioner under the supervision of a licensed electrical practitioner

(2) By installation on a suitable balcony, gallery, or platform, elevated and arranged so as to exclude unqualified persons

(3) By elevation 2 400 mm or more above the floor

Guards for Attendants- Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact.

AIR-CONDITIONING AND REFRIGERATING EQUIPMENT

AIR-CONDITIONING AND REFRIGERATING EQUIPMENT

Definitions:

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 protection devices. The value of branch-circuit selection current will always be equal to or greater than the marked rated-load 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.

Marking on Hermetic Refrigerant Motor-Compressors and Equipment

a. **HMRC Nameplate-** nameplate shall indicate the manufacturer's name, trademark or symbol, identifying designation, phase voltage and frequency. 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 and it should be "**thermally protected**" according to 4.40.6.2A4.

Marking on Hermetic Refrigerant Motor-Compressors and Equipment

b. **Multimotor and Combination-Load Equipment-** MCLE shall be provided with a visible nameplate marked with the makers name, rating in volts, frequency, and number of phase, minimum supply circuit conductor ampacity, maximum rating, ground fault protection devices, and the short circuit current rating of the motor controllers or industrial control panel.

c. **Branch Circuit Selection Current-** a HRMC or equipment containing such a compressor, having a protection system that is approved for used and has permits continuous current in excess of the specified percentage of nameplate rated-load current given in 4.40.6.2(B)(2) shall also be marked with a BCSC that complies the above provision.

Ampacity and Rating

a. Hermetic Refrigerant Motor-Compressor- For a HRMC, the rated-load current marked on the nameplate of the equipment shall be used in determining the rating or ampacity of the disconnecting means, BCC, controllers, GFP, BCSC, and 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.

b. Multimotor Equipment- for ME employing a shaded-pole or permanent magnet split capacitor type fan or blower motor, the full-load current for such motor marked on the nameplate of the equipment in which motor is employ shall be used instead of the horsepower rating to be determine the ampacity or rating of the disconnecting means, controller, BCC, GFP, BCSC, and overload protection

Single Machine

An air-conditioning or refrigerating system shall be considered to be a single machine under the provisions of 4.30. 7.7, exception number 1,and 4.30.9.12, the motors shall be permitted to be located remotely from each other.

Short-Circuit Current Rating (SCCR)

(A) Installation: Motor controllers of multimotor and combination load equipment shall not be installed where the available short-circuit current exceeds its short-circuit current rating as marked in accordance with 4.40.1.4b

(B) Documentation: The available short-circuit current and the date that short-circuit current calculations was performed shall be documented and made available to those authorized to inspect the installation.

Disconnecting Means

Rating and Interrupting Capacity

(A). **Hermetic Refrigerant Motor-Compressor-** a disconnecting means serving a HRMC shall be selected on the basis of the nameplate rated-load current, whichever is greater, and locked-rotor current respectively, of the motor compressor as follows.

B) Combination Loads- where the combined load of two or more HRMC or one or more HRMC 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 4.40.2.2b1 and b2.

Disconnecting Means

(1) **Horsepower Rating-** the HP rating of the disconnecting means shall be determined from the sum of all currents, resistance, rated-load condition, and locked-rotor condition.

(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 4.40.2.2b1

Disconnecting Means

(C) **Small Motor Compressor-** for SMC not having the locked rotor current marked on the nameplate, the locked-rotor current shall be assumed to be **six (6) times the rated load current.**

(D) **Disconnecting Means-** every DM 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 4.40.2.2.

(E) **DM Rated in Excess of 100 Hp-** where the rated-load current as determine above would indicate a DM rated in 100 hp, the provisions Of 4.30.9.9E shall apply.

Disconnecting Means

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.

Location of Disconnecting Means

Disconnecting Means shall be located within the sight from and readily accessible from the air-conditioning or refrigerating equipment. The DM shall be permitted to be installed on or within the air-conditioning or refrigerating equipment. DM shall not be located on panels that are designed to allow access to the air-conditioning or refrigerating equipment or to obscure the equipment nameplates.

Branch-Circuit Short Circuit and Ground Fault Protection

Application and Selection

(a) **Rating or setting for individual motor-compressor -** a protective device having a rating not exceeding 175 percent of the motor-compressor rated load current where the starting current is not sufficient for the motor, setting shall be permitted to be increase but not exceed 225 percent of the motor rated load current.

Branch-Circuit Short Circuit and Ground Fault Protection

(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 conform with 4.40.3.2(a).

Branch-Circuit Short Circuit and Ground Fault Protection

(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 4.40.3.2(a) and 4.40.3.2(b), the protective device rating shall not exceed the manufacturer's values marked on the equipment.

Single Motor Compressor

Branch circuit conductors supplying a SMC shall have an ampacity not less than 125 percent of either MC rated-load current or branch circuit selection current.

For a wye-start, delta-run connected motor compressor, the selection of branch-circuit conductors between the controller and the motorcompressor 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.

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 4. 40.1.4B

Controllers for Motor-Compressors

Rating :

(A)Motor-Compressor controller- a MCC shall have both continuous duty full-load current rating and a locked-rotor current rating not less than the nameplate rated-load current of the compressor.

(B)Controller Serving More than one Load- 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 4.40.2.2B

Motor-Compressor and Branch-Circuit Overload Protection

Application and selection: Each motor-compressor shall be protected against overload and failure to start by one of the following means:

(1)A separate overload relay- it shall be selected to trip at not more than 140 percent of the motor compressor rate load current

(2) A thermal protector integral with the motor compressor- prevent dangerous overheating of the motor-compressor.

(3) A fuse or inverse time circuit breaker- shall be rated at not more than 125 percent of the motor-compressor RLC. It shall have sufficient time delay to permit the motor-compressor to start and accelerate its load.

(4) A protective system approved for use with motor compressor to prevent overheating due to overload and failure to start.

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 4.40.6.5(a), (b), and (c).

Cord-and-Attachment-Plug-Connected Motor Compressors and Equipment on 15- or 20-Ampere Branch Circuits

(a) Overload Protection. The motor-compressor shall be provided with overload protection as specified in 4.40.6.2(a). Both the controller and the motor overload protective device shall be approved 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 Rating. The rating of the attachment plug and receptacle 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.

Provisions for Room Air-Conditioners

General : A room air conditioners shall be consider as an ac appliance of the air-cooled window, console, or in wall type is installed in the conditioned room and it incorporates with HRMCs. This provision covers equipment rated not over 250 volts, single phase, and the equipment shall be permitted to be cord-attachment plug-connected.

Grounding : the enclosures of the RAC shall be connected to the equipment grounding conductor on accordance with 2.50.6.1, 2.50.6.3, and 2.50.6.5

Provisions for Room Air-Conditioners

(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:

(1) It is cord-and-attachment-plug-connected.

(2) Its rating is not more than 40 amperes and 250 volts, single phase.

(3) Total rated-load current is shown on the room air conditioner nameplate rather than individual motor currents.

(4) 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.

Provisions for Room Air-Conditioners

(B) Where no other Loads are Supplied- total marked rating of cord and attachment shall not exceed 80 percent of rating of the branch circuit.

(C) Lighting Units or other Appliances also Supplied- the total marked rating of cord and attachment shall not exceed 50 percent of rating of the branch circuit where lighting outlets, other appliances, or general use receptacles are also supplied.

Provisions for Room Air-Conditioners

Disconnecting Means- for a single phase room air-conditioned rated 250 volts or less (1) Manual controls shall be accessible and located within 18000 mm or 1.8 m of the floor. (2) approved disconnecting means shall be located within the sight from the RAC

Supply Cords- where a flexible cord is used to supply a RAC, the length of such cord shall not exceed 3000 mm for a nominal 115 volt rating or 1800 mm for nominal, 208 or 230-volt rating.

GENERATORS

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 4.30.1.1.4

Marking:

Each generator shall be provided with a nameplate with manufacturers name, rated frequency, number of phase if ac, rating (kW or kVA), power factor, normal volts and amperes corresponding to the rating, rated ambient temperature, and rated temperature rise.

Nameplates shall provide the information for all stationary generators and portable rated more than 15kW:

(1) Subtransient, transient, synchronous, and zero sequence reactance.
(2) Power rating category
(3) Insulation system class
(4)Indication of the generator is protected against overload by inherent design, overcurrent protective relay, circuit breaker, or fuse
(5) Maximum short-circuit current for inverter-based generators, in lieu of synchronous, subtransient, and transient reactance

Overcurrent Protection

(A)Constant-Voltage Generators- shall be protected from overload, circuit breakers, fuses protective relays and other protective means suitable for the conditions of use. (except ac generators)

(B)Two-Wire Generators- DC generators shall permitted to have overcurrent protection in one conductor only.

(C)65 Volts or Less- Generators operating at 65 volts or less and driven by individual motors shall be considered as protected by overcurrent device.

(D)Balancer Sets- two-wire, dc generators used in conjunction with balancer sets to obtain neutral ppoints for 3-wire system shall be equipped with overcurrent devices due to excessive unbalancing of voltages or currents.

Ampacity of Conductors

(A) General: the ampacity of the conductors from the generator output terminals to the first distribution devices containing overcurrent protection shall not be less than 115 % of the nameplate current rating of the generator

(**B) Overcurrent Protection Provided-** conductors shall be permitted to be tapped from the load side of the protected terminals in accordance with 2.40.2.1B. Tapped conductors shall not be permitted for portable generators rated 15kW or less where field wiring connection terminals are not accessible.

Protection of Live Parts- operates at more than 50 volts ac or 60 volts dc to ground shall not be accessible to unqualified person

Guards for Attendance- where necessary for the safety of attendants, the requirements of 4.30.12.3 shall apply.

Bushings- a bushing shall be used to protect the conductors from the edges of a opening having sharp edges.

Generator Terminal Housing- GTH shall comply with 4.30.1.12. Where a horsepower rating is required to determine the required minimum size of the GTH the full-load current of the generator shall be compared with comparable motors in table 4.30.14.1

Disconnecting Means and Shutdown of Prime Mover

(A)Disconnecting Means- generators other than cord and plug connected portable shall have one or more disconnecting means.

(B) Shutdown of Prime Mover- the means of shut down shall comply:(1) be equipped with provisions to disable all prime mover start control circuits to render the prime mover incapable of starting,(2) initiate a shutdown mechanism that requires a mechanical reset

(C) Generators installed in Parallel- installed in parallel with other generators, the provisions of 4.45.1.18A 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.

Ground Fault Circuit Interrupter Protection and Receptacles on 15000 W or Smaller Portable Generators- Receptacle outlets that are a part of a 15000 W or SPG shall have listed GFCI protection for personnel integral to the generator or receptacle as indicated in either (A) or (B)

(A) Unbonded Generators (Floating Neutral)- UG 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 25- ampere receptacle outlets.

(B) Bonded Neutral Generators- BG shall be provided with GFCI protection on all 125 and 250-volt, 15 and 20-ampere receptacle outlets.

TRANSFORMERS AND TRANSFORMER VAULTS (INCLUDING SECONDARY TIES)

DEFINITION

Transformer

- An individual transformer, single- or polyphase, identified by a single nameplate, unless otherwise indicated in this article.

OVERCURRENT PROTECTION

Overcurrent protection of transformers shall comply with 4.50.1.3(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.

(A) TRANSFORMERS OVER 1000 VOLTS, NOMINAL

- Overcurrent protection shall be provided in accordance with Table 4.50.1.3(A).

OVERCURRENT PROTECTION

Table 4.50.1.3(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.)

OVERCURRENT PROTECTION

(B) TRANSFORMERS 1000 VOLTS, NOMINAL, OR LESS

- Overcurrent protection shall be provided in accordance with Table 4.50.1.3(B).

(C) VOLTAGE (POTENTIAL) TRANSFORMERS

- Voltage (potential) transformers installed indoors or enclosed shall be protected with primary fuses.

OVERCURRENT PROTECTION

Table 4.50.1.3(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 3.)	167%

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.

AUTOTRANSFORMERS 1000 VOLTS, NOMINAL, OR LESS

- 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 2.40.1.6 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 4.50.1.4(A).

AUTOTRANSFORMERS 1000 VOLTS, NOMINAL, OR LESS

(B) TRANSFORMER FIELD-CONNECTED AS AN AUTOTRANSFORMER

- A transformer field-connected as an autotransformer shall be identified for use at elevated voltage.

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 neutral point for grounding purposes.
- Such transformers shall have 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.

GROUNDING AUTOTRANSFORMERS

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 4.50.1.5(A)(1) through (A)(4).

1 Connections

2 Overcurrent Protection

3 Transformer Fault Sensing

4 Rating

THREE-PHASE, 4-WIRE SYSTEM

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.

THREE-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 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 overcurrent 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.

THREE-PHASE, 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.

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.

GROUNDING AUTOTRANSFORMERS

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 protected device on a 3-phase, 3-wire ungrounded system shall conform to 4.50.1.5(B)(1) and (B)(2).

1 **Rating**

2 **Overcurrent Protection**

GROUND REFERENCE FOR FAULT PROTECTION DEVICES

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 (a) and (b).

GROUND REFERENCE FOR FAULT PROTECTION DEVICES

2 Overcurrent Protection

(a) Operation and Interrupting Rating

- An overcurrent protective device having an interrupting rating in compliance with 1.10.1.9 and that will open simultaneously all ungrounded conductors when it operates shall be applied in the grounding autotransformer branch circuit.

GROUND REFERENCE FOR FAULT PROTECTION DEVICES

2 Overcurrent Protection

(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.

GROUND REFERENCE FOR FAULT PROTECTION DEVICES

2 Overcurrent Protection

(b) Ampere Rating

- Delayed tripping for temporary overcurrent 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.

GROUNDING AUTOTRANSFORMERS

GROUND REFERENCE FOR DAMPING TRANSITORY OVER-VOLTAGES

A grounding autotransformer used to limit transitory overvoltages shall be of suitable rating and connected in accordance with 4.50.1.5(A)(1).

SECONDARY TIES

- 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 4.50.1.7 shall not be considered secondary ties.

SECONDARY TIES

(A) Tie Circuits

- Shall be provided with overcurrent protection at each end.

(1) Loads at Transformer Supply Points Only

- Where all loads are connected at the transformer supply points at each end of the tie and the overcurrent protection is not provided.
- The rated 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.

SECONDARY TIES

(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.
- The rated 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.

(3) Tie Circuit Protection

- 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.

SECONDARY TIES

(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 one of the following provisions:

  - ✓ **Interconnected** – The conductors shall be interconnected in order to establish a load supply point, and the protective device 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.

SECONDARY TIES

- ✓ **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 at load connection points.

(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.

SECONDARY TIES

(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.

(C) Grounding

- Where the secondary tie system is grounded, each transformer secondary supplying the tie system shall be grounded for separately derived systems.

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 4.50.1.3(A) for primary and secondary protective devices over 1000 volts or 4.50.1.3(B) for primary and secondary protective devices 1000 volts or less.

GUARDING

- **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.
- **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.

GUARDING

- **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.
- **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.

VENTILATION

- Shall dispose of the transformer full-load heat losses without creating a temperature rise that is in excess of the transformer rating.
  - 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.

GROUNDING

- **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 and shall not be installed on or over any vented portion of the enclosure.

- **Other Metal Parts**
  - Where grounded, exposed non-current-carrying metal parts of transformer installations, including fences, guards, and so forth, shall be grounded and bonded.

MARKING

- Each transformer shall be provided with a nameplate giving the following information:

1. Name of Manufacturer
2. Rated kilovolt-amperes
3. Frequency
4. Primary and secondary voltage
5. Impedance of transformers 25 kVA and larger
6. Required clearances for transformers with ventilating openings
7. Amount and kind of insulating liquid where used
8. For dry-type transformers, temperature class for the insulation system

MARKING

- ***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.

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 3.12.1.6

ACCESSIBILITY

- All transformers and transformer vaults shall be readily accessible to qualified personnel for inspection and maintenance.
  - **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 accessible.
  - **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 4.50.1.9 and separation from combustible materials requirements of 4.50.2.1(A).

SPECIFIC PROVISIONS APPLICABLE TO DIFFERENT TYPES OF TRANSFORMERS

DRY-TYPE TRANSFORMERS INSTALLED INDOORS

- **Not Over 112 $\frac{1}{2}$ kVA:** Dry-type transformers installed indoors and rated 112 $\frac{1}{2}$ kVA or less shall have a separation of at least 300 mm from combustible material unless separated from the combustible material by a fire-resistant, heat-insulated barrier.
- **Over 112 $\frac{1}{2}$ kVA:** Individual dry-type transformers of more than 112 $\frac{1}{2}$ kVA rating shall be installed in a transformer room of fire-resistant construction
- **Over 35000 Volts:** Dry-type transformers rated over 35000 volts shall be installed in a vault.

SPECIFIC PROVISIONS APPLICABLE TO DIFFERENT TYPES OF TRANSFORMERS

LESS-FLAMMABLE LIQUID-INSULATED TRANSFORMERS

- **INDOOR INSTALLATIONS:** Shall be permitted in accordance with one of the following

  (1) In Type I or Type II buildings, in areas where all of the following requirements are met:

  - ✓ The transformer is rated 35000 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.
  - ✓ With an automatic fire extinguishing system and liquid confinement area, provided the transformer is rated 35000 volts or less.

SPECIFIC PROVISIONS APPLICABLE TO DIFFERENT TYPES OF TRANSFORMERS

- **LESS-FLAMMABLE LIQUID-INSULATED TRANSFORMERS**
  - **OUTDOOR INSTALLATIONS:** Shall be permitted to be installed outdoors, attached to, adjacent to, or on the roof of buildings.
- **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 35000 volts shall be installed in a vault, and furnished with a liquid confinement area and a pressure-relief vent.

SPECIFIC PROVISIONS APPLICABLE TO DIFFERENT TYPES OF TRANSFORMERS

- **ASKAREL-INSULATED TRANSFORMERS INSTALLED INDOORS**
  - Rated over 25 kVA; shall be furnished with a pressure-relief vent.
  - Askarel-insulated transformers rated over 35000 volts shall be installed in a vault.
- **OIL-INSULATED TRANSFORMERS INSTALLED INDOORS**
  - Shall be installed in a vault constructed as specified in Part 4.50.3.
- **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.

TRANSFORMER VAULTS

LOCATION

- Shall be located where they can be ventilated to the outside air without using flues or ducts wherever such an arrangement is practicable.

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 concrete that is not less than 100 mm 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.

TRANSFORMER VAULTS

DOORWAYS

- ❑ Vault doorways shall be protected.
  - ✓ Type of Door
  - ✓ Sills
  - ✓ Locks

VENTILATION OPENINGS

- ✓ Location
- ✓ Arrangement
- ✓ Size
- ✓ Covering
- ✓ Dampers
- ✓ Ducts

DRAINAGE

- ❑ 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.

WATER PIPES AND ACCESSORIES

- ❑ Any pipe or duct foreign to the electrical installation shall not enter or pass through a transformer vault.

STORAGE IN VAULTS

- ❑ Materials shall not be stored in transformer vaults.

PHASE CONVERTERS

PHASE CONVERTER

- **Manufactured Phase:** The manufactured or derived phase originates at the phase converter and is not solidly connected to either of the single-phase input conductors.
- **Phase Converter:** An electrical device that converts single-phase power to 3-phase electric power.

PHASE CONVERTER

- **Rotary-Phase Converter:** 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:** A device without rotating parts, sized for a given 3-phase load to permit operation from a single-phase supply.

PHASE CONVERTER

CONDUCTORS

- Ampacity
  - ✓ *Variable Loads*
  - ✓ *Fixed Loads*
- Manufactured Phase Marking

DISCONNECTING MEANS

- Location: Readily accessible and located in sign from the phase converter.
- Type: Shall be a switch rated in hp, a circuit breaker, or a molded-case switch.
- Rating: Ampere 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: (1) *Current Rated Disconnect* (2) *Horsepower Rated Disconnect*
- Voltage Ratios

CAPACITORS

CAPACITOR

- **ENCLOSING AND GUARDING**
  - Containing More Than 11 L of Flammable Liquid: Shall be enclosed in vaults or outdoor fenced enclosures.
  - 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.

CAPACITOR

1000 VOLTS, NOMINAL, AND UNDER

- Discharge of Stored Energy: Capacitors shall be provided with a means of discharging stored energy.
  - ✓ Time of Discharge: The residual voltage shall be reduced to 50 volts, nominal, or less within 1 minute after the capacitor is disconnected from the source of supply.
  - ✓ 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.

CAPACITOR

- **1000 VOLTS, NOMINAL, AND UNDER**
  - 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 motor overload device shall be based in the improved power factor of the motor circuit.
  - Grounding: Capacitor cases shall be connected to the equipment grounding conductor.
  - Marking

CAPACITOR

OVER 1000 VOLTS, NOMINAL

- Load Current: Group-operated switches shall be used for capacitor switching.
- Isolation: 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.
- 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

CAPACITOR

- **OVER 1000 VOLTS, NOMINAL**
  - Overcurrent Protection
    - ✓ Provided to Detect and Interrupt Fault Current
    - ✓ Single Pole or Multiple Devices
    - ✓ Protected Individually or in Groups
    - ✓ Protective Devices Rated or Adjusted
  - Means for Discharge
    - ✓ Means to Reduce the Residual Voltage
    - ✓ Connection to Terminals

RESISTORS AND REACTORS

RESISTORS AND REACTORS

- 1000 VOLTS, NOMINAL, AND UNDER
  - Location: Shall not be placed where exposed to physical damage.
  - Space Separation: A thermal barrier shall be required if the space between the resistors and reactors and any combustible material is less than 300 mm.
  - 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.

RESISTORS AND REACTORS

- **OVER 1000 VOLTS, NOMINAL**
  - Protected Against Physical Damage: Shall be protected against physical damage.
  - Isolated by Enclosure or Elevations: Shall be isolated by enclosure or elevation to protect personnel from accidental contact with energized parts.
  - Combustible Materials: 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 300 mm from combustible materials.

RESISTORS AND REACTORS

- **OVER 1000 VOLTS, NOMINAL**
  - Clearances: Clearances from resistors and reactors to grounded surfaces shall be adequate for the voltage involved.
  - Temperature Rise from Inducted 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.

RESISTORS AND REACTORS

- OVER 1000 VOLTS, NOMINAL
  - Grounding: Resistor and reactor cases or enclosures shall be connected to the equipment grounding conductor.
  - Oil-Filled Reactors: Installation of oil-filled reactors, in addition to the above requirements, shall comply with applicable requirements of Article 4.50.

STORAGE BATTERIES

Storage Batteries

Definitions

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.

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.

Storage Batteries

Nominal Voltage (Battery or Cell). The value assigned to a cell or battery of a given voltage class for the purpose of convenient designation.

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. A battery comprised of one or more rechargeable cells of the 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.

Storage Batteries

Battery and Cell Terminations

a) **Corrosion Prevention.** Where mating dissimilar metals, antioxidants material suitable for the battery connection shall be used where recommended by the battery manufacturer.

b) **Intercell and Intertier Conductors and Connection.** 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.

c) **Battery Terminals.** Electrical connections to the battery, and the cable(s) between cell on separate levels or racks, shall not put mechanical strain on the battery terminals.

Storage Batteries

DC Disconnects Methods

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.

Remote actuation. Remote controls to activate the disconnecting means and the controls for the disconnecting means are not located within the sight of the stationary battery system.

Busway. Where a dc busway system is installed, the disconnecting means shall be permitted to be incorporated into the busway.

Storage Batteries

DC Disconnects Methods

Notification. A label with the marking shall be placed in a conspicuous location near the battery if a disconnecting means is not provided.

1. Nominal battery voltage
2. Maximum available short-circuit current derived from the stationary battery system
3. Date the calculation was performed

Storage Batteries

Battery Locations

Battery Locations shall conform to (A), (B), (C).

A. Ventilation. Shall be made for sufficient diffusion and ventilation of gases from the battery to prevent the accumulation of an explosive mixture.

B. Live Parts. Guarding of live parts shall comply with 1.10.2.2.

C. Spaces About Battery Systems. Working space shall be measured from the edge of the battery cabinet, racks, or trays.

Storage Batteries

Vents

A. Vented Cells. Each vented cell shall be equipped with a flame arrester.

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.

EQUIPMENT OVER 1,000 VOLTS NOMINAL

Equipment: Circuit-Interrupting Devices

Circuit Breakers

1. **Locations**

Indoors: mounted either metal-enclosed units or fire-resistant cell-mounted units.

Used to control oil-filled transformer in a vault: either outside the transformer vault or be capable of operation from outside the vault.

Oil circuit breakers: arranged or located so that adjacent readily combustible structures or materials are safeguarded in an approved manner.

Equipment: Circuit-Interrupting Devices

Circuit Breakers

2. 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 main contacts
- A means of indicating the open and closed position of the breaker at the at the point(s) from which they may be operated.

Equipment: Circuit-Interrupting Devices

Circuit Breaker

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.

Equipment: Circuit-Interrupting Devices

Circuit Breaker

4. Rating

- **Continuous current rating**: shall not be less than the maximum continuous current through the circuit breaker.
- **Interrupting rating**: shall not be less than the maximum fault current the circuit breaker will be required to interrupt, including contributions from all connected sources of energy.
- **Closing rating**: shall not be less than the maximum asymmetrical fault current into which the circuit breaker can be closed.
- **Momentary rating**: shall not be less than the maximum asymmetrical fault current at the point of installation.
- **Rated maximum voltage**: shall not be less than the maximum circuit voltage.

Equipment: Circuit-Interrupting Devices

Power Fuses and Fuseholders

1. **Use**
   - fuses are used to protect conductors and equipment
   - Power fuses of the vented type shall not be used indoors, underground, or in metal enclosures identified for the use.
2. **Interrupting Rating**
   - power fuses shall not be less than the maximum fault current the fuse is required to interrupt, including contributions from all connected sources of energy.

Equipment: Circuit-Interrupting Devices

Power Fuses and Fuseholders

3. Voltage Rating

- maximum voltage rating of power fuses shall not be lthe ess 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

- manufacturer's type or designation,
- continuous current rating,
- interrupting current rating, and
- maximum voltage rating.

Equipment: Circuit-Interrupting Devices

Power Fuses and Fuseholders

4. 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.

5. Fuseholders

- shall be designed or installed so that they are de-energized while a fuse is being replaced.

DANGER - DISCONNECT CIRCUIT BEFORE REPLACING FUSES

Equipment: Circuit-Interrupting Devices

Power Fuses and Fuseholders

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 source and the fuses
  - roll-out switch and fuse-type construction

Equipment: Circuit-Interrupting Devices

Load Interrupters. Load interrupters switches shall be permitted if suitable fuses or circuit breakers are used in conjunction with these devices to interrupt fault currents.

1. **Continuous Current Rating**
   - shall equal or exceed the maximum continuous current at the point of installation.
2. **Voltage Rating**
   - shall equal or exceed the maximum circuit voltage.

Equipment: Circuit-Interrupting Devices

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

- shall be arranged to be operated from a location where the operator is not exposed to energized parts
- shall be arranged to open all grounded conductors of the circuit simultaneously with one operation.

Equipment: Circuit-Interrupting Devices

4. Stored Energy for Opening

- 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.

5. Supply Terminals

- 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.

EQUIPMENT OVER 1,000 VOLTS NOMINAL

Voltage Regulators

Proper switching sequence for regulators shall be ensured by use of one of the following:

1. Mechanically sequenced regulator bypass switch(es)
2. Mechanical interlocks
3. Switching procedure prominently displayed at the switching location

EQUIPMENT OVER 1,000 VOLTS NOMINAL

Backfeed

Installations where the possibility of backfeed exist shall comply with:

- A permanent sign in accordance with 1.10.1.21 (B)

DANGER – CONTACTS ON EITHER SIDE OF THIS DEVICE MAY BE ENERGIZE BY BACKFEED

- A permanent and legible single-line diagram of local switching arrangement

Minimum Space Operation

Table 4.90.2.4 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	mm	mm	mm
2.4 - 4.16	60	95	115	180	80	155
7.2	75	95	140	180	105	155
13.8	95	110	195	305	130	180
14.4	110	110	230	305	170	180
23	125	150	270	385	190	255
34.5	150	150	320	385	245	255
	200	200	460	460	335	335
46	-	200	-	460	-	335
	-	250	-	535	-	435
69	-	250	-	535	-	435
	-	350	-	790	-	635
115	-	550	-	1350	-	1070
138	-	550	-	1350	-	1070
	-	650	-	1605	-	1270
161	-	650	-	1605	-	1270
	-	750	-	1830	-	1475
230	-	750	-	1830	-	1475
	-	900	-	2265	-	1805
	-	1050	-	2670	-	2110

Note: The value ... for rigid parts and bare conductors under favorable service conditions. They shall be increased for conductor ... permit. The selection of the associated impulse withstand voltage for a particular

Equipment: Switchgear and Industrial Control Assemblies

General

Switches and interrupting devices and their control, metering, protection, and regulating equipment where they are an integral part of the assembly, with associated interconnections structures.

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.

Equipment: Switchgear and Industrial Control Assemblies

Guarding of High-Voltage Energized Parts Within a Compartment

Exposed live parts shall only be permitted in compartments accessible to qualified persons.

Guarding of Energized Parts Operating at 1000 Volts, Nominal, or Less Within Compartment

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.

Equipment: Switchgear and Industrial Control Assemblies

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.

Accessibility of Energized Parts

A. High-Voltage Equipment

- Doors that would provide unqualified persons access to high-voltage energized parts shall be locked.

DANGER – HIGH VOLTAGE – KEEP OUT

Equipment: Switchgear and Industrial Control Assemblies

Accessibility of Energized Parts

B. Control Equipment. Where operating 1000 volts, nominal, or less, control equipment, relays, motors, and the like shall not be installed in compartments with exposed high-voltage energized parts or high-voltage wiring, unless of the following condition met:

1. The access means is interlocked with the high-voltage switch or disconnecting means to prevent the access means from being opened or removed.
2. The high-voltage switch or disconnecting means is in isolating position.

Equipment: Switchgear and Industrial Control Assemblies

Accessibility of Energized Parts

C. High-Voltage Instrument or Control Transformer 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.

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 discharged or blocked position.

Equipment: Switchgear and Industrial Control Assemblies

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.

Fused Interrupter Switches

A. **Supply Terminal**. Shall be installed at the top of the switch enclosure.
B. **Backfeed.** Where fuses can be energized by backfeed. A sign shall be placed on the enclosure door identifying the hazard.
C. **Switching Mechanism.** Shall be arranged to be operated from a location outside the enclosure where the operator is not exposed to energized parts.

Equipment: Switchgear and Industrial Control Assemblies

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 charge.

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.

Substation Design, Documentation, and Required Diagram

A. **Documentation.** Substations shall be designed by a licensed electrical practitioner. The design shall address but not be limited to the following topics and the documentation of this design shall be made available to the Office of the Building Official/EE.

1. Clearances and exits
2. Electrical enclosures
3. Securing and support of electrical equipment
4. Fire protection
5. Safety ground connection provisions
6. Guarding live parts
7. Transformers and voltage regulation equipment
8. Conductor insulation, electrical and mechanical protection, isolation, and terminations
9. Applications, arrangement, and disconnection of circuit breakers, switches, and fuses
10. Provisions for oil-filled equipment
11. Switchgear
12. Surge arrestors

Substation Design, Documentation, and Required Diagram

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
- 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 unit substation containing only one set of high-voltage switching devices, diagrams shall not be required.

Mobile and Portable Equipment

Covered

The provision 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:

1. Substations and switch houses mounted on skids, trailer, or car
2. Mobile shovels
3. Draglines
4. Cranes
5. Hoists
6. Drills
7. Dredges
8. Compressors
9. Pumps
10. Conveyors
11. Underground excavators

Mobile and Portable Equipment

Protection

Approved enclosures or guarding, or both, shall be provided to protect portable and mobile equipment from physical damage.

Disconnecting Means

Shall be installed for mobile and portable high-voltage equipment according to the requirements of Part 2.30.8 and shall disconnect all ungrounded conductors.

Mobile and Portable Equipment

Overcurrent Protection. The branch-circuit protective device(s) shall provide short-circuit and locked-rotor protection and shall be permitted to be external to the equipment.

Enclosures. All energized switching and control parts shall be enclosed in grounded metal cabinets or enclosures.

DANGER – HIGH VOLTAGE – KEEP OUT

Mobile and Portable Equipment

Collector Rings. The collector rings 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.

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 method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections.

DANGER – HIGH VOLTAGE – KEEP OUT

Electrode-Type Boilers

Branch-Circuit Requirements

Rating. Each boiler shall be supplied from an individual branch circuit rated not less than 100 percent of the total load.

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.

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.

Electrode-Type Boilers

Branch-Circuit Requirements

Ground Neutral 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 7 ½ percent of the boiler full-load current for 10 seconds or exceeds an instantaneous value of 25 percent of the boiler full-load current.

Grounded Neutral Conductor

1. Connected to the pressure vessel containing the electrodes
2. Insulated for not less than 100 volts

Electrode-Type Boilers

Branch-Circuit Requirements

3. Have not less than the ampacity of the largest ungrounded branch-circuit conductor
4. Installed with the undergrounded conductors in the same raceway, cable, or cable tray, or, where installed as open conductors, in close proximity to the ungrounded conductors
5. Not used for any other circuit

Pressure and Temperature Limit Control

Each boiler shall be equipped with a means to limit the maximum temperature, pressure, or both, by directly or indirectly interrupting all current flow through the electrodes.

Electrode-Type Boilers

Bonding

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 the neutral conductor to which the vessel is connected, except the ampacity of the bonding jumper shall not be less than the ampacity of the neutral conductor.

Thank You!