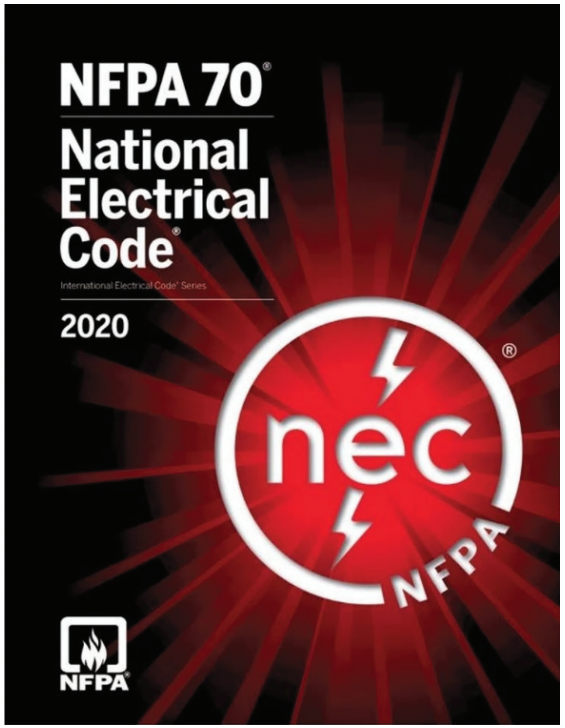
2020 NATIONAL ELECTRICAL CODE CHANGES TO COMMERCIAL AND INDUSTRIAL RULES



PRESENTED BY
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Kiewit Chief Electrical Engineer
Kiewit Engineering Group

Kiewit

Thank you for providing this great facility for our seminar.

Thank all of you for supporting our local IEEE chapter.

Thanks to Saed Kurd, Kiewit Director of Engineering for the printed slide handouts.

CORE VALUE MOMENT : EXCELLENCE

IT IS THE KIEWIT WAY TO DO OUR WORK WITH **EXCELLENCE**.

SUPERIOR ENGINEERING, STATE-OF-THE-ART SPECIFIED EQUIPMENT, EXCELLENT INSTALLATION, AND THOROUGH COMMISSIONING ALL WORK TOGETHER TO CONTINUALLY ESTABLISH KIEWIT AS THE EPC FIRM OF CHOICE.

BEFORE WE CONSIDER WHAT HAS CHANGED, LET'S CONSIDER WHAT CONTINUES UNCHANGED (1 of 4)

- The purpose of the code. (90.1)
- The layout of NEC chapters (9 CHAPTERS)
- What is written early in the book is defined and limited by what is written later (except Ch 8)
- The first part of each chapter is LV; and the final part of each chapter is MV or HV. Whatever rules that are not talked about in the final part remain in effect even though they were initially written for LV.

BEFORE WE CONSIDER WHAT HAS CHANGED, LET'S CONSIDER WHAT CONTINUES UNCHANGED (2 of 4)

- The layout of the 9 NEC chapters
- Ch 1 – General Definitions and Rules
- Ch 2- Branch Circuits and Feeders
- Ch 3 – The Electrician's Chapter
- Chapter 4 – Eqpt for General Use, Cords, Appliances, Luminaires, Motors…)
- Chapter 5 –Special Occupancies (Hazloc)
- Chapter 6 –Special Equipment (Welders, Fire Pumps…)
- Chapter 7 – Dealing with Special Conditions (Emergency)
- Chapter 8 – Communications (more stand-alone)
- Chapter 9 – Reference Tables

BEFORE WE CONSIDER WHAT HAS CHANGED, LET'S CONSIDER WHAT CONTINUES UNCHANGED (3 of 4)

- 90.1 – "This code is not intended as a design specification or an instruction manual for untrained persons."
- But
- The NEC serves both (1)electricians who generally work without engineering calculations, and it serves (2)engineers who generally work with engineering calculations – as is exemplified in:

(1) Art 310 & 311 wire ampacity look-up tables in Sec. 310.14(A), or (2) Sec. 310.14(B) Engineering Supervision

BEFORE WE CONSIDER WHAT HAS CHANGED, LET'S CONSIDER WHAT CONTINUES UNCHANGED (4 of 4)

- Definitions of terms that occur in 2 or more NEC chapters are included in Ch 1
- Definitions of terms that only occur in one NEC chapter are included within that chapter

As we review each of the changes made to the 2020 NEC, please consider them in terms of

SAFETY :

a) To persons

b) To electrical equipment

PROPOSED REVISIONS FROM THE 2017 NEC

- 3700 Public inputs
- 1900 comments

RESULT OF THESE INPUTS:

- Hundreds of updates
- Three all-new articles
  - -242 Overvoltage Protection
  - -311 MV Cables
  - -337 Type P Cable

FINDING WHAT HAS CHANGED

- Revisions in text are shaded
- A △before a section number indicates that words within that section were changed,
- A △ to the left of a table or figure number indicates a revision to it.
- When a chapter was heavily revised, the entire chapter is marked throughout with the △ symbol.
- Where one or more sections were deleted, a • is placed between the remaining sections.
- Chapters, annexes, sections, figures, and tables that are new are marked with an "N"

WHILE WE WILL NOT FOCUS ON RESIDENTIAL CHANGES, GENERAL KNOWLEDGE DEMANDS THAT WE TAKE NOTE OF TWO LONG-OVERDUE CHANGES HERE:

Sec 230.67(A) now requires SPD at residential service equipment, and

Ref. Art 242 for SPD details

An Exterior emergency service disconnecting means is now required at each residential service to improve safety for emergency responders.

SOME NEW KEY DEFINITIONS

REVISED DEFINITION: **ACCESSIBLE** (AS APPLIED TO EQUIPMENT)

- **NEW DEF: "CAPABLE OF BEING REACHED FOR OPERATION, RENEWAL, AND INSPECTION"**
- *OLD DEF: ADMITTING CLOSE APPROACH, NOT GUARDED BY LOCKED DOORS, ELEVATION, OR OTHER EFFECTIVE MEANS*

Note that 110.26(F) states that " Electrical equipment rooms or enclosures housing electrical apparatus that are controlled by a lock(s) shall be considered accessible to qualified persons.

NOTE THAT THE FOLLOWING SIMILAR EXISTING DEFINITIONS WERE NOT CHANGED:

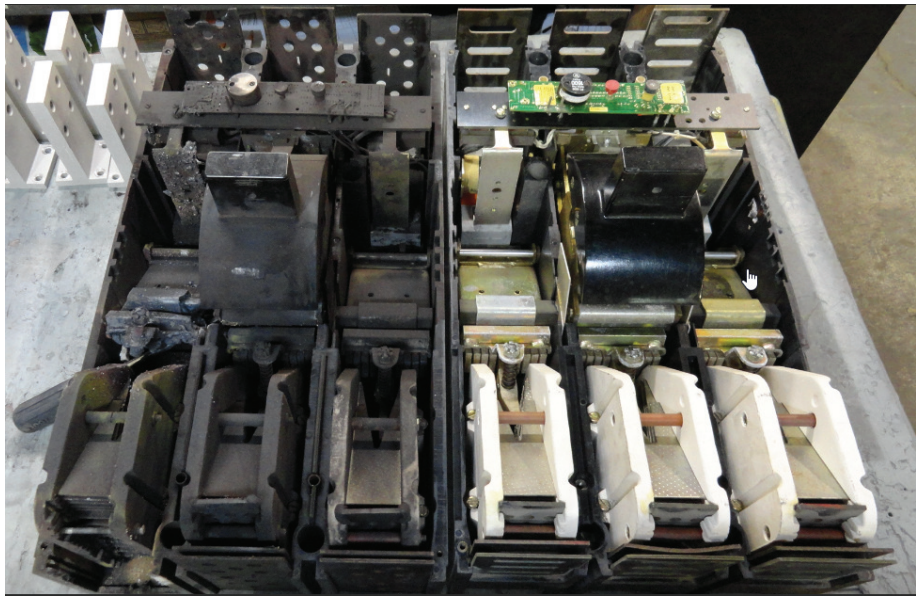
-ACCESSIBLE (AS APPLIED TO WIRING)

-READILY ACCESSIBLE

UNFORTUNATELY , THE DEFINITION OF A CIRCUIT BREAKER (A LIE)

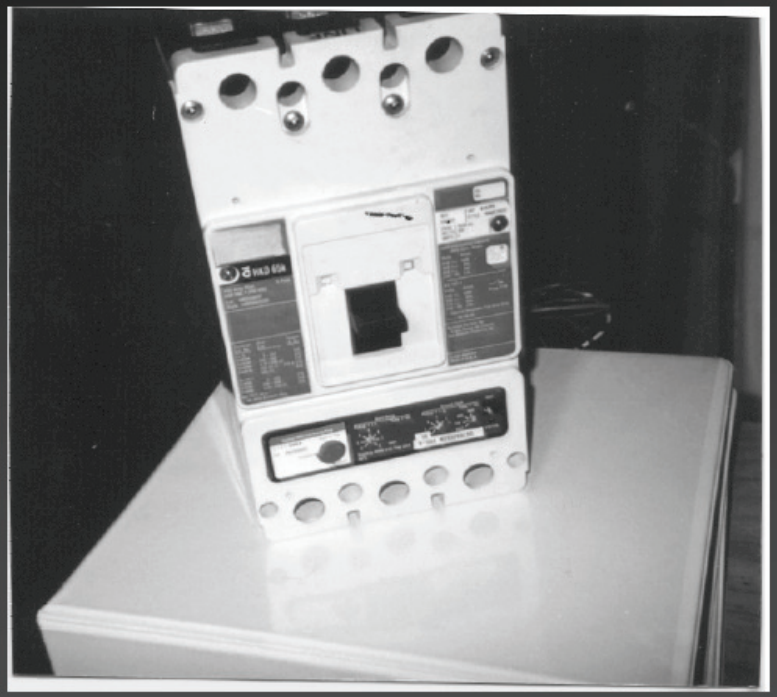
DID NOT CHANGE

(ALTHOUGH THE CB IS STILL DAMAGED IF IT INTERRUPTS ITS RATED SHORT CIRCUIT CURRENT)



"A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a pre-determined overcurrent without damaged to itself when properly applied within its rating."

OSHA 1910.334(b)(2), RECLOSING MOLDED CASE CIRCUIT BREAKER AFTER DEVICE OPERATION:

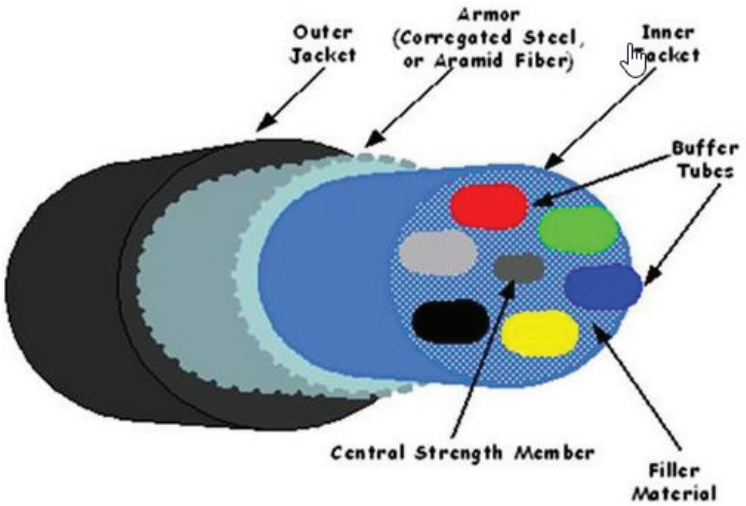


"After a circuit is de-energized by a circuit protective device, the circuit may NOT be manually reenergized until it has been determined that the equipment and circuit can be safely reenergized. The repetitive manual reclosing of circuit breakers…is prohibited."

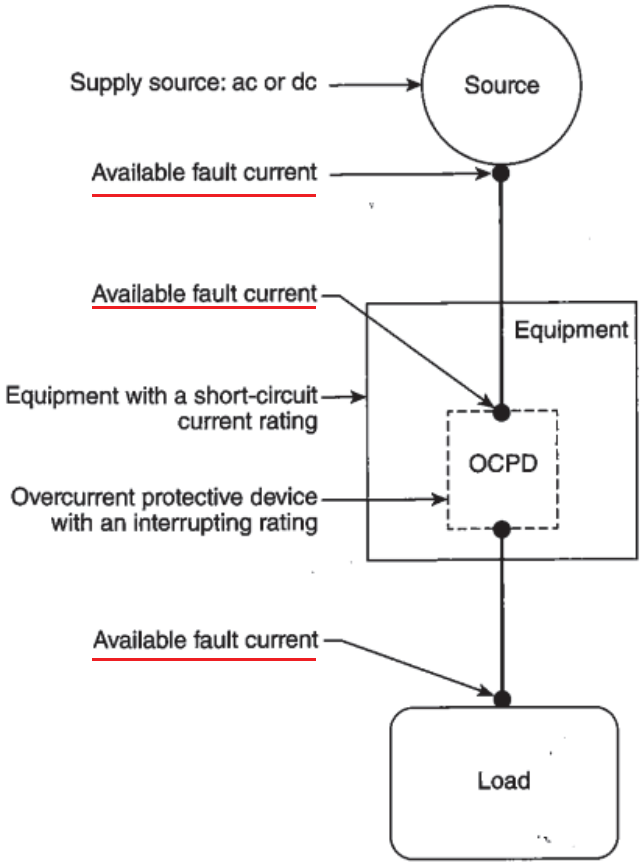
NEW DEFINITIONS REGARDING FIBER OPTIC CABLE

- COMPOSITE OPTICAL FIBER CABLE
- CONDUCTIVE OPTICAL FIBER CABLE
- NONCONDUCTIVE OPTICAL FIBER CABLE

Fiber-optic Cable:- A fiber-optic cable is made of glass or plastic and transmits signals in the form of light



NEW FAULT CURRENT DEFINITIONS



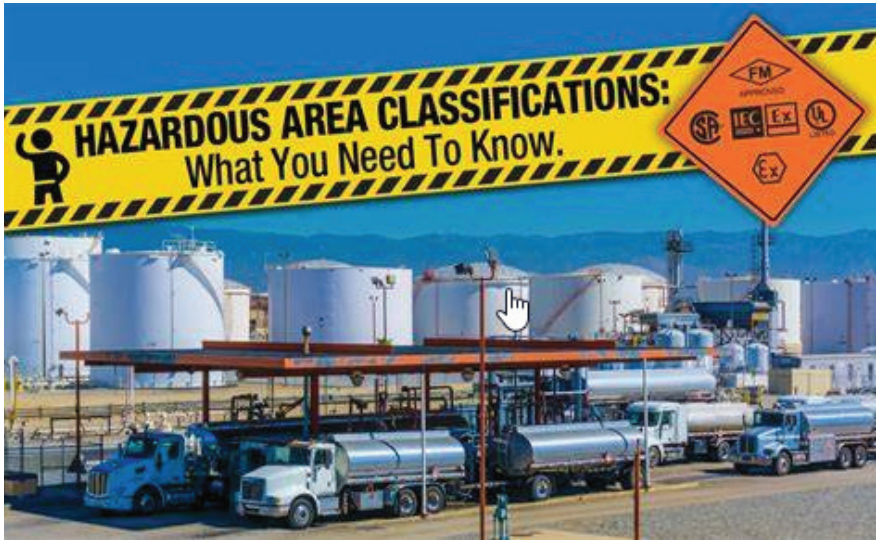
N Informational Note Figure 100.1 Available Fault Current.

Fault Current: The current delivered at a point on the system during a short-circuit condition.

Fault Current, Available: The largest amount of current capable of being delivered at a point on the system during short circuit conditions.

NEW PART III DEFINITIONS

HAZARDOUS CLASSIFIED LOCATIONS

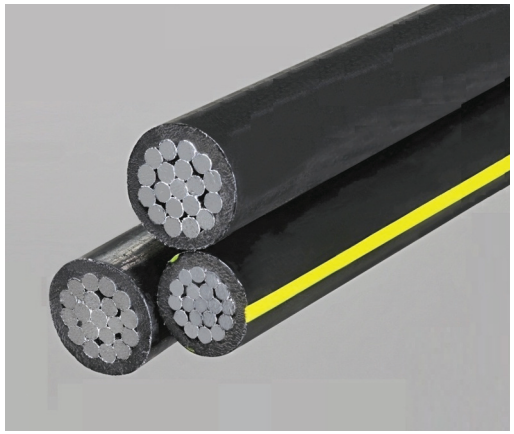


-FOUR PAGES OF NEW HAZARDOUS AREA DEFINITIONS

(2020 NEC pp 42-46)

110.5 – COPPER CLAD ALUMINUM CONDUCTORS

- In addition to copper and aluminum conductors, the NEC now also recognizes copper clad aluminum conductors.



110.21(A)(2) LABEL ON **RECONDITIONED** EQUIPMENT

Remove the original label, and **apply the new label** (except for Owner-supplied maintenance)

Note that Sec 210.15 NEC **prohibits some equipment from being reconditioned**; and instead must be replaced with new equipment, including:

1. Equipment that provides ground fault circuit interrupter protection for personnel.
2. Equipment that provides arc-fault circuit-interrupter protection.
3. Equipment that provides ground fault protection of equipment.
4. Sec 240.62 that prohibits fuseholders from being reconditioned
5. Sec 406.3 now prohibits receptacle devices from being reconditioned
6. Sec 411.4 now prohibits LV luminaires from being reconditioned
7. Sec 406.7 now prohibits attachment plugs and cord connectors from being reconditioned
8. Sec 240.88 now prohibits molded case LV circuit breakers from being reconditioned.
9. Sec 695.10 now prohibits fire pump controllers and transfer switches from being reconditioned.
10. Sec 700.5 & 702.5 now prohibit emergency transfer switches from being reconditioned.

490.49 RECONDITIONED SWITCHGEAR

N 490.49 Reconditioned Switchgear. Switchgear, or sections of switchgear, within the scope of this article shall be permitted to be reconditioned. The reconditioning process shall use design qualified parts verified under applicable standards and be performed in accordance with any instructions provided by the manufacturer. Reconditioned switchgear shall be listed or field labeled as *reconditioned*, and previously applied listing marks, if any, within the portions reconditioned shall be removed. If equipment has been damaged by fire, products of combustion, or water, it shall be specifically evaluated by its manufacturer or a qualified testing laboratory prior to being returned to service.

110.22(A) LABEL FOR DISCONNECTING MEANS

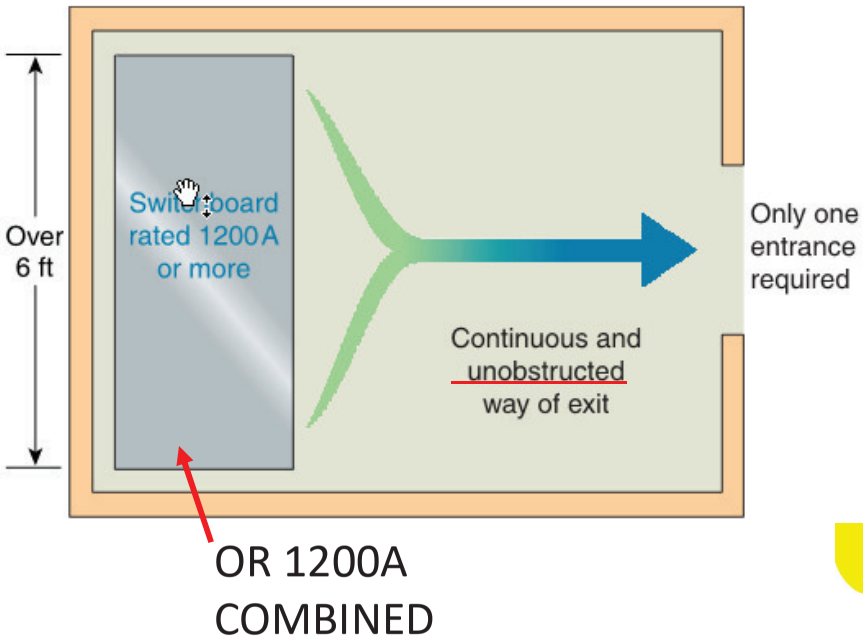
In addition to the marking to indicate the purpose of the disconnect, the disconnecting means must feature a label showing the source of the circuit feeding the disconnect.

DISCONNECT FOR PM-2755
FED FROM PANEL DHA-37

SIDE NOTE: The maximum kA rating for non-fused LV disconnect switches is 10kA. Beyond 10kA requires the use of current limiting fuses.

110.26(C) REGARDING ENTRANCE SPACE TO ELECTRICAL EQUIPMENT

- Used to say: ”For equipment rated 1200 amperes or more and over 6-feet wide…”
- The 2020 NEC says:



(C) Entrance to and Egress from Working Space.

(1) Minimum Required. At least one entrance of sufficient area shall be provided to give access to and egress from working space about electrical equipment.

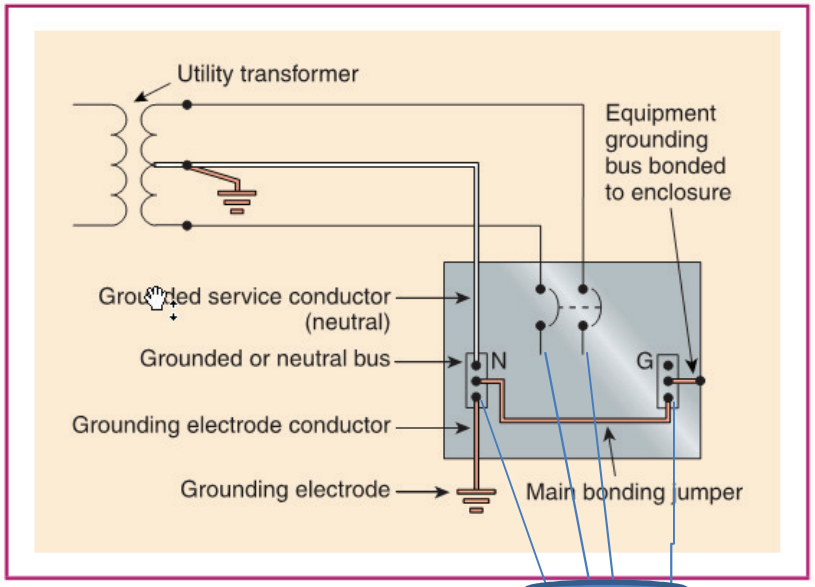
(2) Large Equipment. For large equipment that contains overcurrent devices, switching devices, or control devices, there shall be one entrance to and egress from the required working space not less than 610 mm (24 in.) wide and 2.0 m (6½ ft) high at each end of the working space. This requirement shall apply to either of the following conditions:

(1) For equipment rated 1200 amperes or more and over 1.8 m (6 ft) wide
(2) For service disconnecting means installed in accordance with 230.71 where the combined ampere rating is 1200 amperes or more and over 1.8 m (6 ft) wide

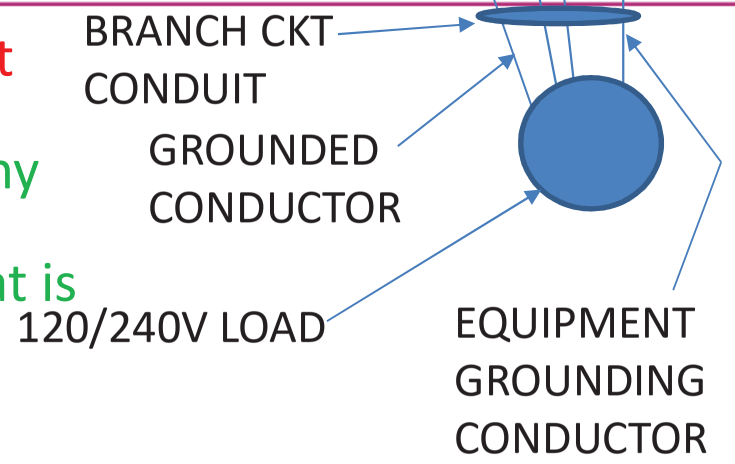
Open equipment doors shall not impede the entry to or egress from the working space.

200.3 CONNECTION TO GROUNDED SYSTEM

- 2020 NEC States: “Grounded conductors of premises wiring systems shall be electrically connected to the supply system grounded conductor…”

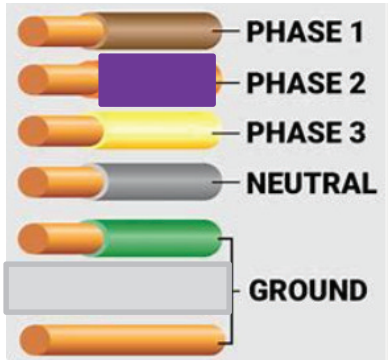


- 2017 Stated: “Premises wiring shall not be electrically connected to a supply system unless the latter contains for any grounded conductor of the interior system, a corresponding conductor that is grounded.”



210.5 (C)(1) IDENTIFICATION OF BRANCH CIRCUIT [CONDUCTORS]

- 2020 Simplifies conductor color coding. NEC Says:



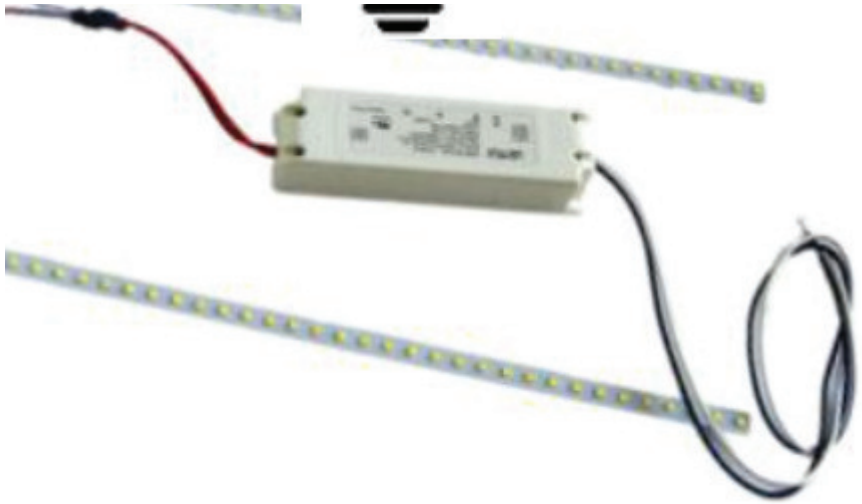
(1) Branch Circuits Supplied from More Than One Nominal Voltage System. Where the premises wiring system has branch circuits supplied from more than one nominal voltage system, each ungrounded conductor of a branch circuit shall be identified by phase or line and by system voltage class at all termination, connection, and splice points in compliance with 210.5(C)(1)(a) and (b). Different systems within the same premises that have the same system voltage class shall be permitted to use the same identification.

- "2017 NEC said:

(1) Branch Circuits Supplied from More Than One Nominal Voltage System. Where the premises wiring system has branch circuits supplied from more than one nominal voltage system, each ungrounded conductor of a branch circuit shall be identified by phase or line and system at all termination, connection, and splice points in compliance with 210.5(C)(1)(a) and (b).

Note that Sec. 215.12 still requires that feeders of different MV systems be identified by phase AND SYSTEM at all terminations & splices points.

210.6(B) LUMINAIRES WITH LISTED LED CONVERSION KITS CAN NOW BE SERVED AT 277 VOLTS



GFI RECEPTACLE OUTLETS

210.8(F) “All outdoor outlets for dwellings, and most in commercial and industrial occupancies that are supplied by single-phase branch circuits rated 150-volts to ground or less, 50-amperes or less, shall have ground-fault circuit interrupter protection for personnel. “

(Note that Art. 110 definitions requires these GFI receptacles to operate between 4ma and 6 ma.)

Sec 215.9 permits the GFI protection to be located in “a readily accessible location” in lieu of devices on the branch circuits.

422.5(A) The following appliances shall be served through GFI protection:

1. Automotive vacuum machines, 2. Drinking water coolers & refill stations,3. Cord & plug connected spray washers, 4. Tire inflators, 5. Vending machines 6. Sump pumps, 7. Dishwashers

210.65 RECEPTACLES IN 1000 SQ.FT. MEETING ROOMS (NEW SECTION)

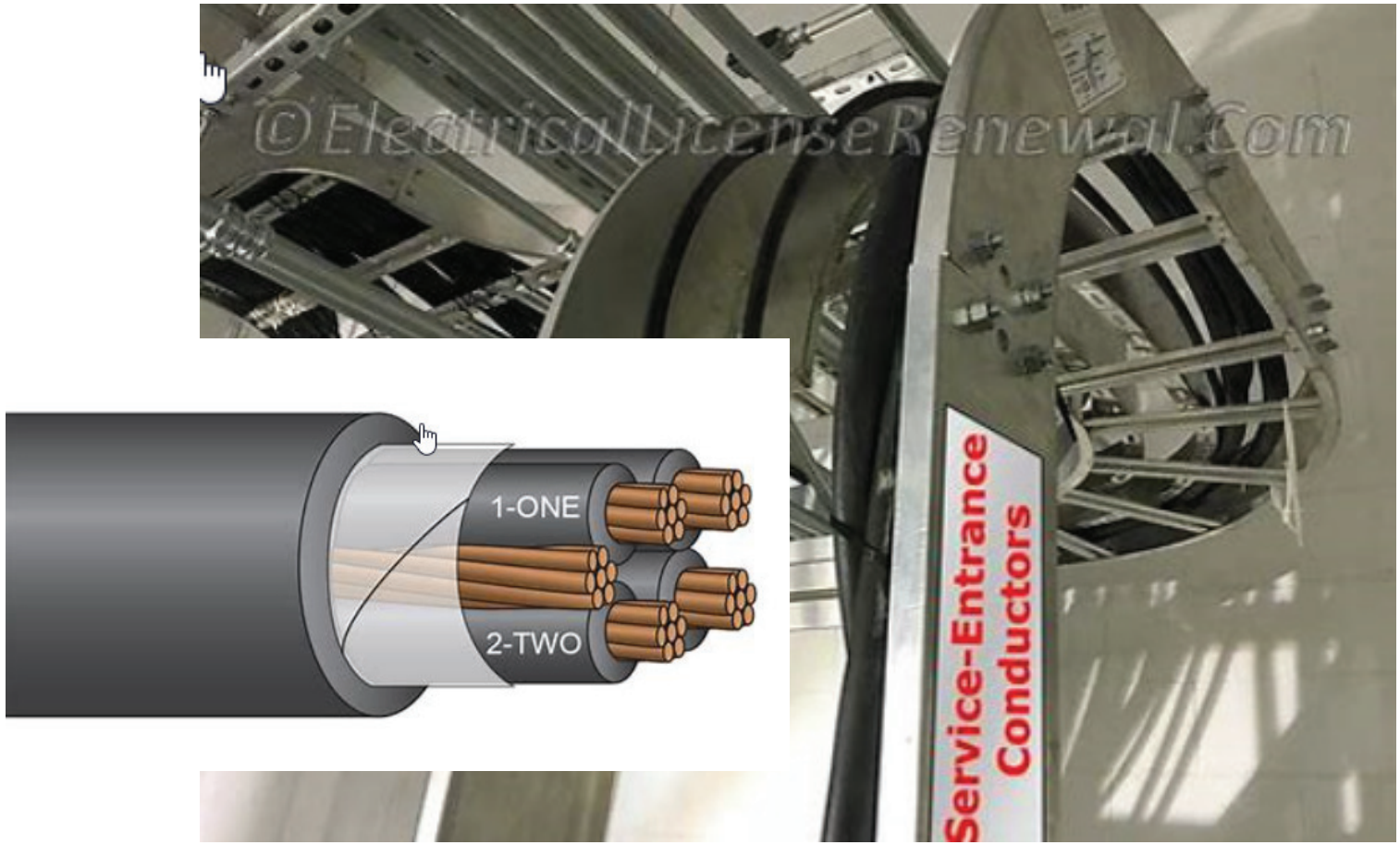
This section requires receptacle outlets:

1. As required for residential walls (210.52) and small appliances,
2. As required for movable partitions, and
3. Floor outlets as follow:

   One receptacle per 215 sq. ft. of floor space, with the outlet(s) located not closer than 6-ft from walls

CONSIDERING 230.43 & 230.44 TOGETHER: THERE IS A NEW ADDITIONAL WIRING METHOD FOR ART. 230 SERVICES OF UP TO 1KV AND LESS:

Type TC-ER cable in Cable Tray

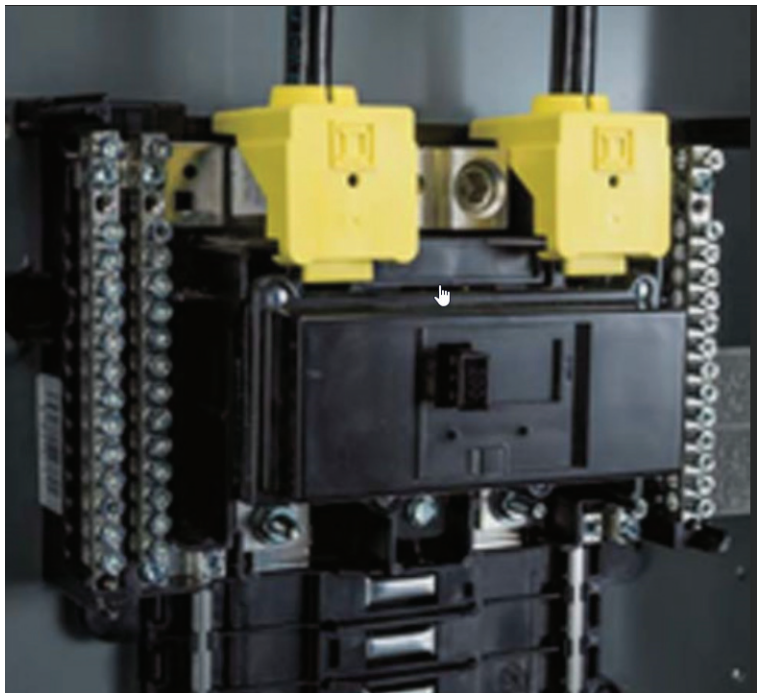


Remember: Incident Energy is proportional to I^2 x t

230.46 IN SERVICE ENTRANCE, POWER DISTRIBUTION BLOCKS, PRESSURE CONNECTORS, AND DEVICES FOR SPLICES AND TAPS MUST BE MARKED “SUITABLE FOR USE ON THE LINE SIDE OF THE SERVICE EQUIPMENT.”

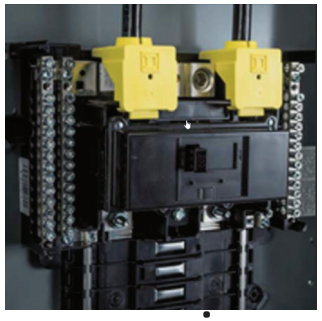
NEW 230.62(C)

- All service equipment is now required to be provided with barriers to prevent line-side inadvertent contact. This includes, but is not limited to, panelboards, switchboards, switchgear, motor control centers, individual circuit breaker enclosures, transfer switches, and fused disconnects that are suitable for use as service equipment.

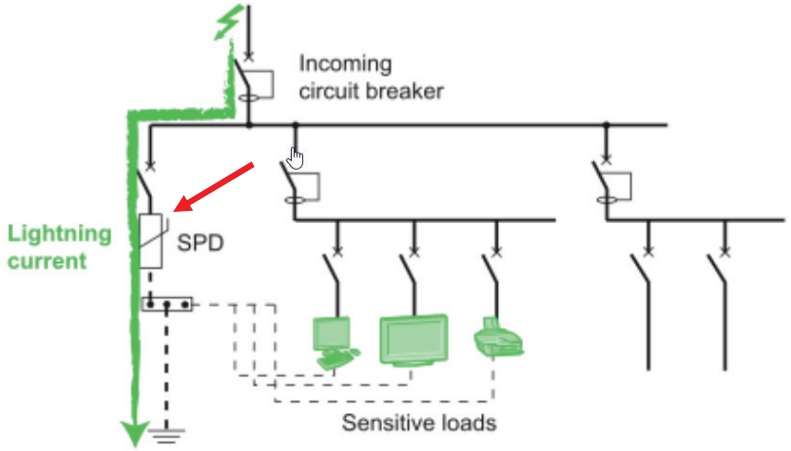


NEW ART 230, PART V RULES

- 230.66(A): Barriers shall be placed in service equipment to prevent inadvertent contact by persons while servicing load terminations.



- 230.67(D): When service equipment is replaced, all of the requirements for SPD in this new 2020 code will apply.



NOTE: SPDs protect GFI receptacle devices

230.71 NEW RULES FOR THE 2 TO 6 SERVICE DISCONNECTING MEANS

Δ **(B) Two to Six Service Disconnecting Means.** Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

(1) Separate enclosures with a main service disconnecting means in each enclosure
(2) Panelboards with a main service disconnecting means in each panelboard enclosure
(3) Switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section
(4) Service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment

This re-written rule eliminated the haphazard use of multiple different types of single enclosure disconnecting means.

240.6(C) RESTRICTED ACCESS ADJUSTABLE-TRIP CBs

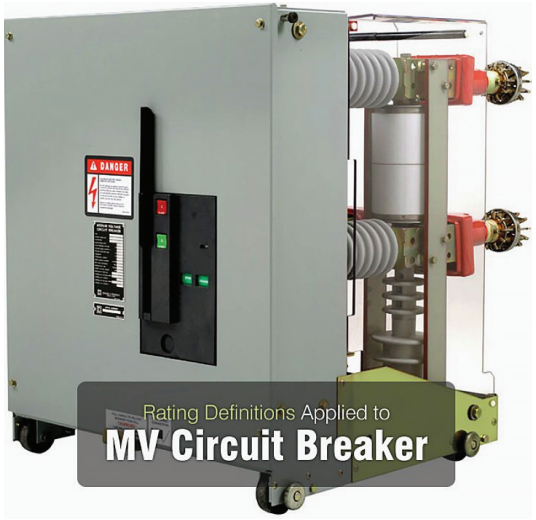
- Restricted access can now be achieved by permission of the 2020 NEC by the additional means of password protection

240.33 ENCLOSURES FOR OVERCURRENT DEVICES SHALL BE MOUNTED IN A VERTICAL POSITION. PERMISSION TO INSTALL THEM HORIZONTALLY IS NO LONGER PERMITTED EXCEPT FOR WITHIN PANELBOARDS.

240.88(A) RECONDITIONED CIRCUIT BREAKERS

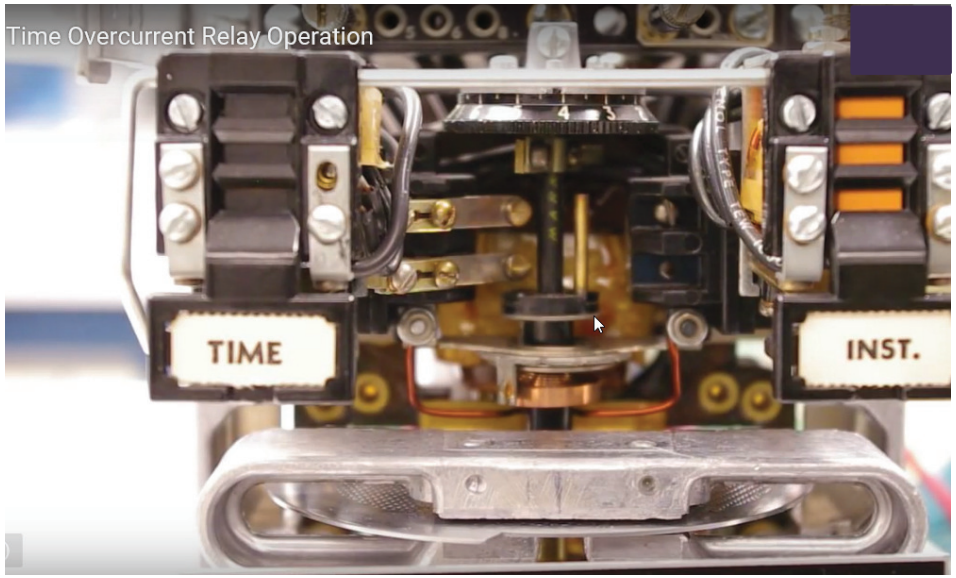
1. Molded case circuit breakers shall not be permitted to be reconditioned.

2. MV and HV CBs shall be permitted to be reconditioned



240.88(B) RECONDITIONING OF LV CB TRIP UNITS

- Low voltage power circuit breaker electronic trip units shall not be permitted to be reconditioned
- Electromechanical protective relays and current transformers shall be permitted to be reconditioned



NEW ART 242
OVERVOLTAGE PROTECTION

- This new article provides the general requirements, installation requirements, and connection requirements for overvoltage protection and overvoltage protective devices.
- Part II covers surge –protective devices (SPDs)permanently installed on premises wiring systems of not more than 1000 volts.
- Part III covers surge arresters permanently installed on premises wiring systems over 1000 volts.

242.6 LV SPD SHALL NOT BE INSTALLED:

1. Circuits over 1000 volts
2. On ungrounded systems*
3. On corner-grounded systems*
4. On impedance-grounded systems*
5. Where the voltage rating of the SPD is less than the maximum continuous phase-to-ground voltage at the power frequency available at the SPD installation point!

* (unless the SPD is specifically listed for that type of system)

Info:

1. The primary function of the SPD is to eliminate short duration voltage spikes by diverting the excess electrons and their innate voltage to ground.
2. SPDs are marked with a Voltage Protection Rating (VPR). If possible, specify the SPD to incorporate fuses for fault current protection.
3. SPDs are marked with a nominal discharge current rating
4. SPDs are marked with an SPD "Type" that indicates where the SPD can be installed in the electrical system.

242.8 THE SPD MUST BE LISTED

(i.e. The SPD must meet all of the requirements of UL 1449.

242.10 SPD SHORT-CIRCUIT RATING

The SPD shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating.

Receptacles need not be marked with a short-circuit rating.

(FPN SLIDE)

TWO STATIONARY TYPES OF SPD

Type1:

Permanently connected, hard-wired SPDs which can be installed between the secondary side of the utility service transformer and the line side of the main service equipment overcurrent protective device, as well as the load side of the main service equipment.

Type2:

SPDs intended for installation on the load side of the main service equipment overcurrent protective device ONLY. These SPDs may also be installed at the service entrance point, but must be installed on the load side of the main service overcurrent protective device.

TYPE 1

TYPE 2

242.14 SPD CONNECTION POINT

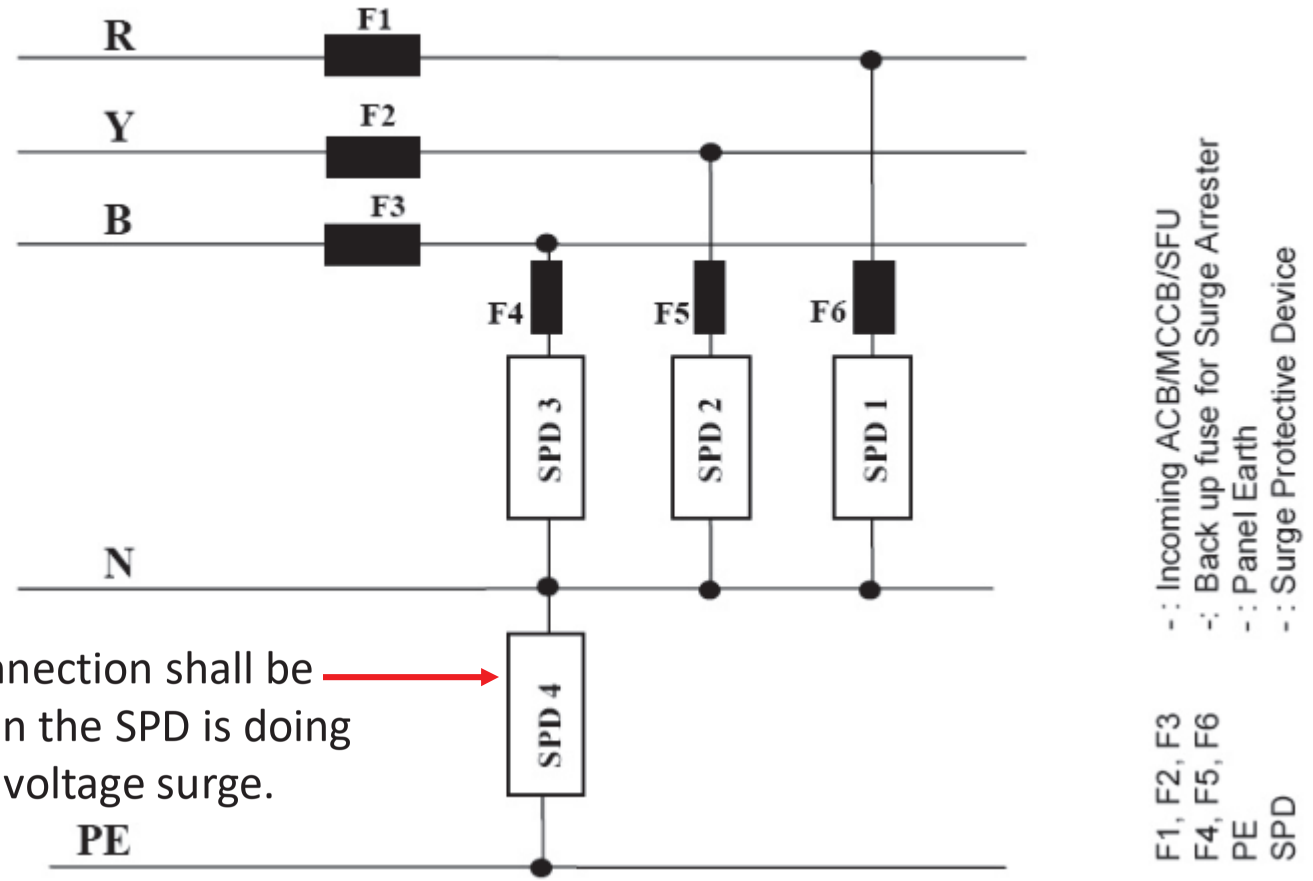
Connect Type 2 SPD on load side of Service Overcurrent Device, at a point that is inaccessible to unqualified persons.

bussmann spp40sp3480wyg surge protection device, type 2, 40ka, 3p

(FPN SLIDE)

SPD WIRING DIAGRAM

Connection diagram for 3 phase 4 wire network SPD



242.30 This connection shall be made only when the SPD is doing its job during a voltage surge.

240.20 Where used, an SPD shall be connected to each ungrounded conductor.

(FPN SLIDE)

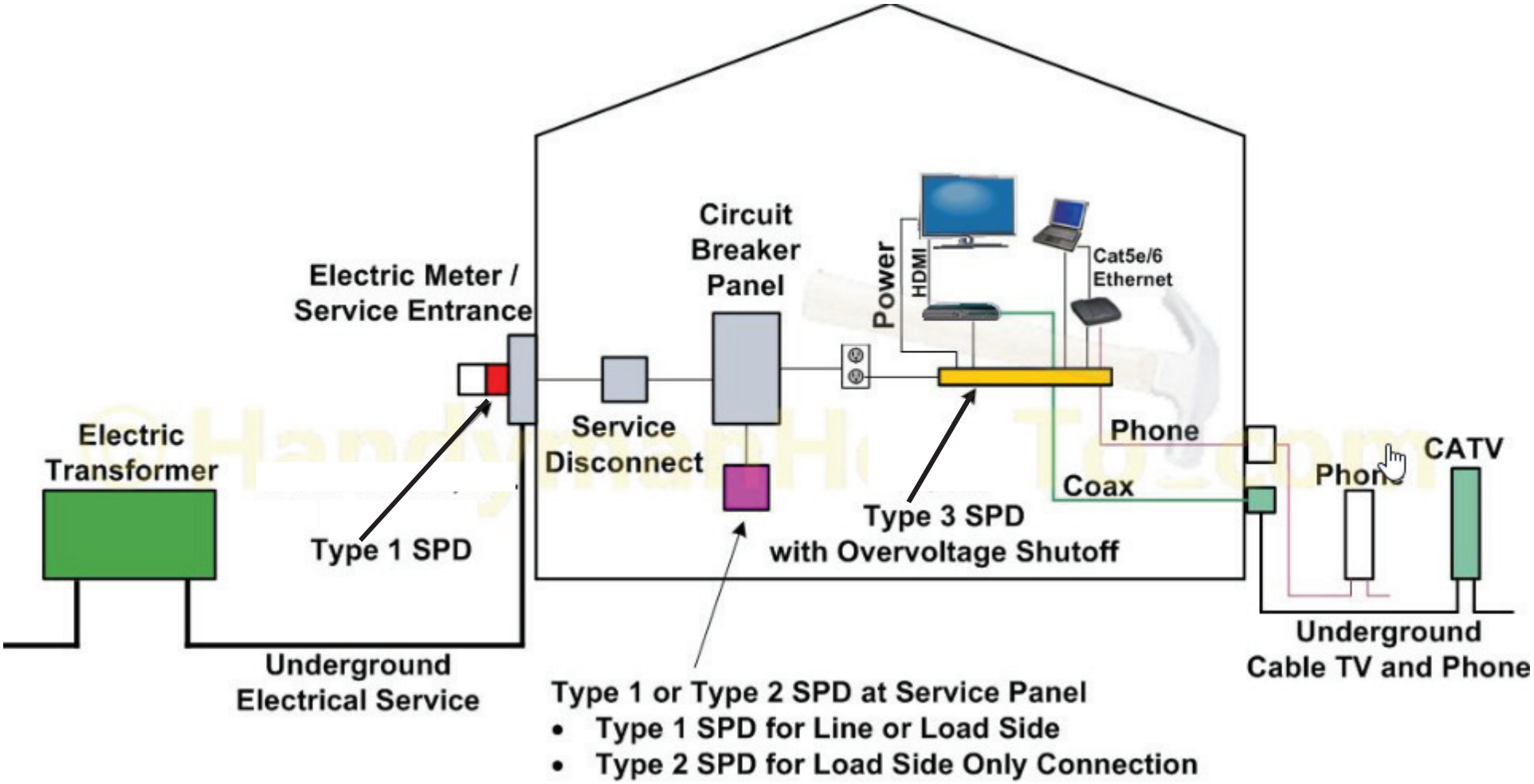
TYPE 3 SPD

- Type 3 Surge Protection Devices are often called “power strips”

Install on load side of branch circuit OCD, with a maximum of 30lf between the SPD and OCD.

(FPN SLIDE)

SPD WIRING DIAGRAM



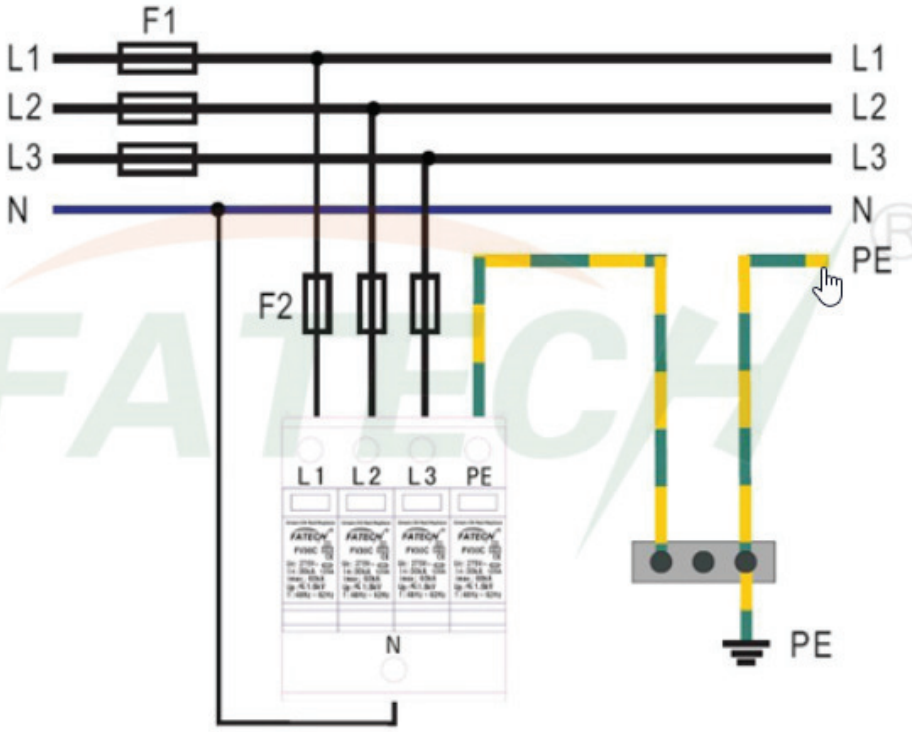
242.42(B) SPD VOLTAGE RATING FOR OVER 1000V WHEN SPD IS SILICON CARBIDE TYPE

- THE VOLTAGE RATING OF SILICON CARBIDE TYPE SPD MUST BE AT LEAST **25%** OVER THE SYSTEM VOLTAGE.

242.50 SURGE ARRESTOR GROUND CONNECTION

The arrestor shall be connected to at least one of the following:

1. Grounded service conductor
2. Grounding electrode conductor
3. Grounding electrode for the service
4. Equipment grounding terminal within the service equipment

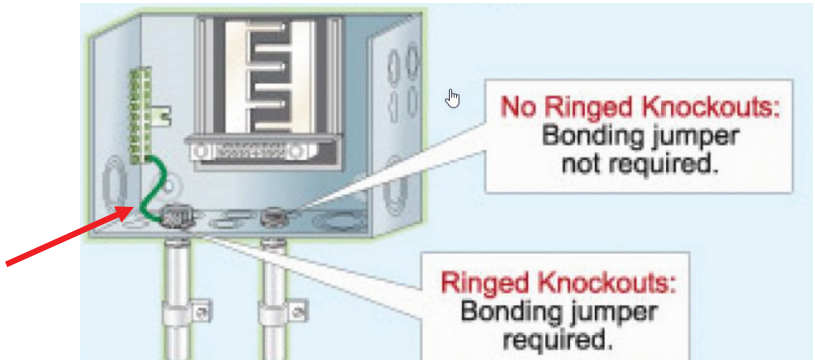


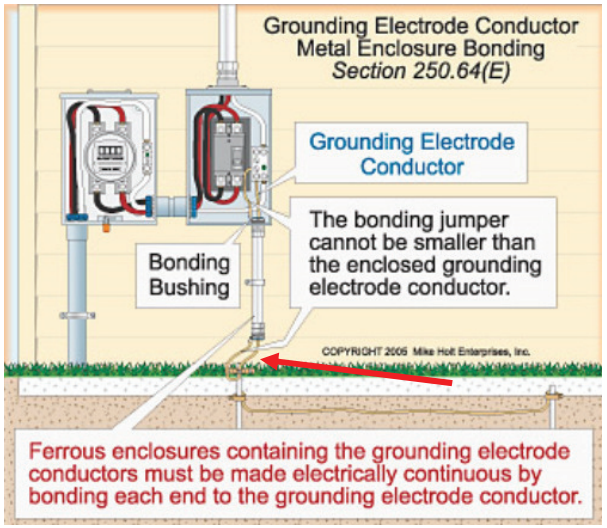
250.53(C) BONDING JUMPER BETWEEN GROUNDING ELECTRODES

- REBAR SHALL NOT BE USED AS A CONDUCTOR TO INTERCONNECT THE ELECTRODES OF GROUNDING ELECTRODE SYSTEMS

250.64(E)(3)

- When the grounding electrode conductor (GEC) is routed through a raceway, the bonding jumper from the GEC to the raceway end must be at least as large as the GEC.



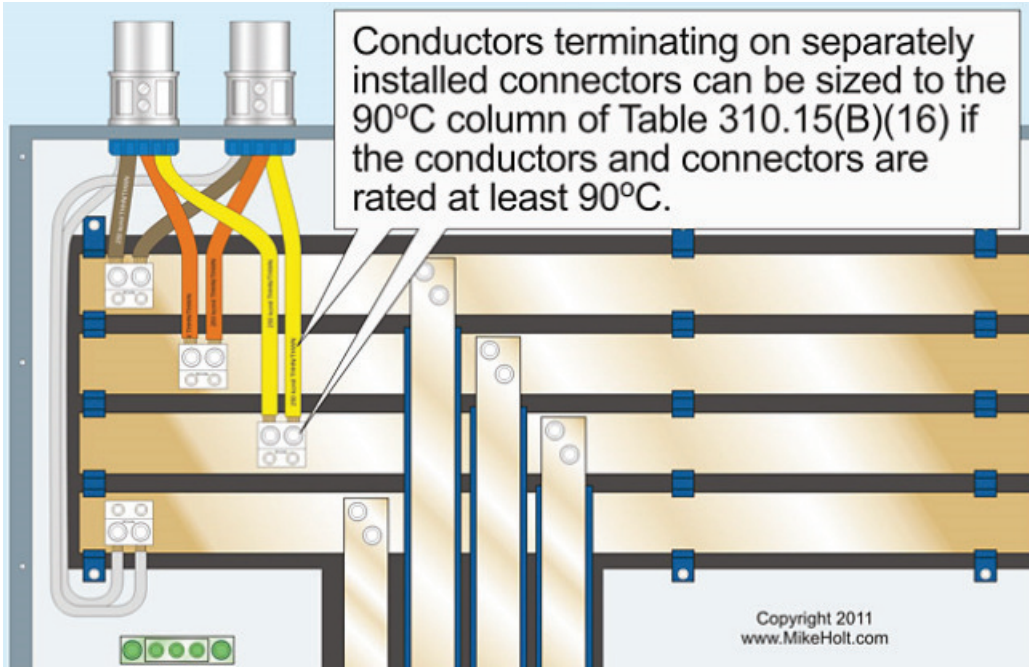


250.98 BONDING AT EXPANSION JOINTS AND AT DEFLECTION FITTINGS

- Expansion, expansion-deflection, or deflection fittings and telescoping sections of metal raceways shall be made electrically continuous by equipment bonding jumpers sized per Table 250.102(C)(1).

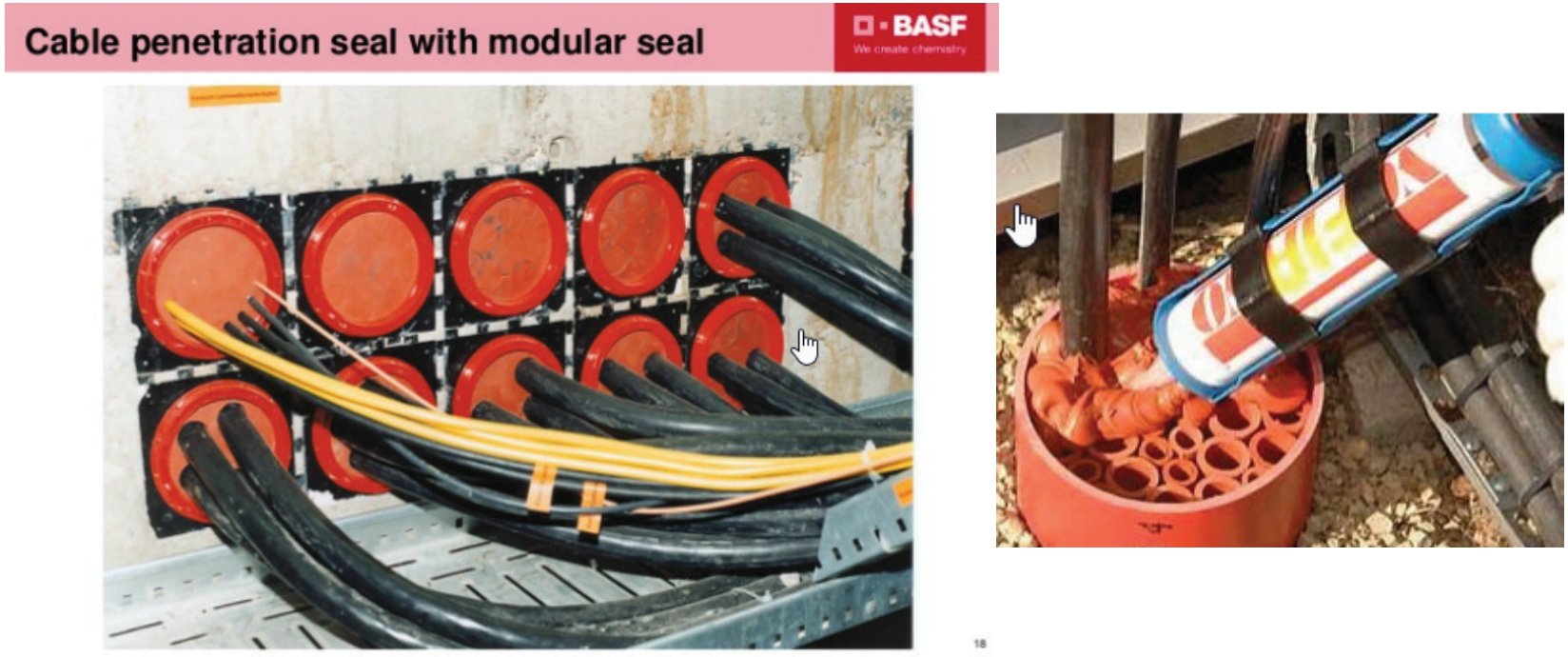
300.3(B)(1) CONDUCTORS INSTALLED IN PARALLEL

- "Connections, taps, or extensions made from paralleled conductors shall connect to all conductors of the paralleled set, grounded and ungrounded."



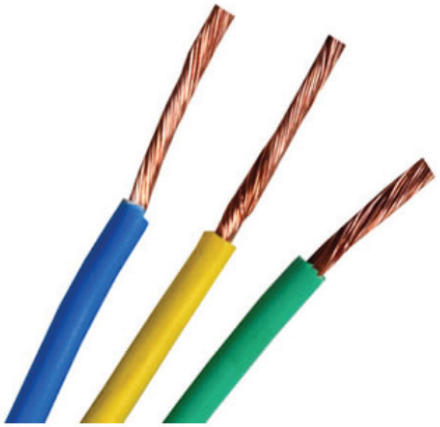
300.7 SEALANT AROUND CONDUCTORS PREVENTING AIR PASSAGE

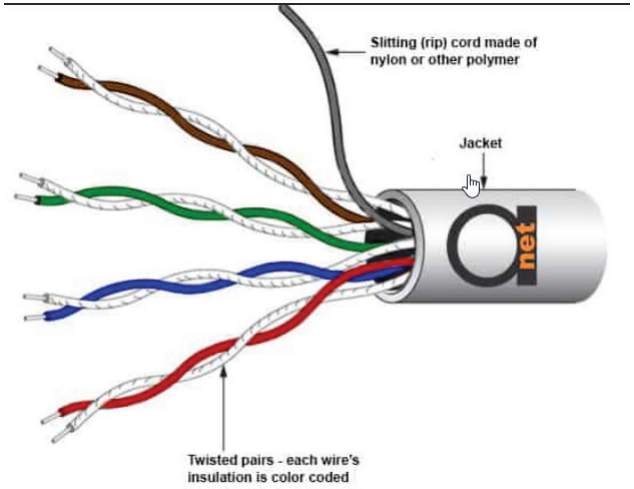
- The sealant shall be identified for use with the cable insulation, the conductor insulation, the conductor shield, and other cable parts.



NEW 310.3 MINIMUM CONDUCTOR SIZE

The minimum size of conductor shall be #14 AWG for 0-2000 volts, except where specified elsewhere in the code (such as new Sec. 312.8(B)(3) that permits 22 AWG, and even 26 AWG for specific applications).





NEW TABLE 310.4(B) INSULATION THICKNESS

Δ Table 310.4(B) Thickness of Insulation for Nonshielded Types RHH and RHW Solid Dielectric Insulated Conductors Rated 2000 Volts

Conductor Size (AWG or kcmil)	Column A[1]		Column B[2]	
	mm	mils	mm	mils
14–10	2.03	80	1.52	60
8	2.03	80	1.78	70
6–2	2.41	95	1.78	70
1–2/0	2.79	110	2.29	90
3/0–4/0	2.79	110	2.29	90
213–500	3.18	125	2.67	105
501–1000	3.56	140	3.05	120
1001–2000	3.56	140	3.56	140

[1]Column A insulations shall be limited to natural, SBR, and butyl rubbers.
[2]Column B insulations shall be materials such as cross-linked polyethylene, ethylene propylene rubber, and composites thereof.

NOTE! IMPORTANT!

Be the first to write a review...

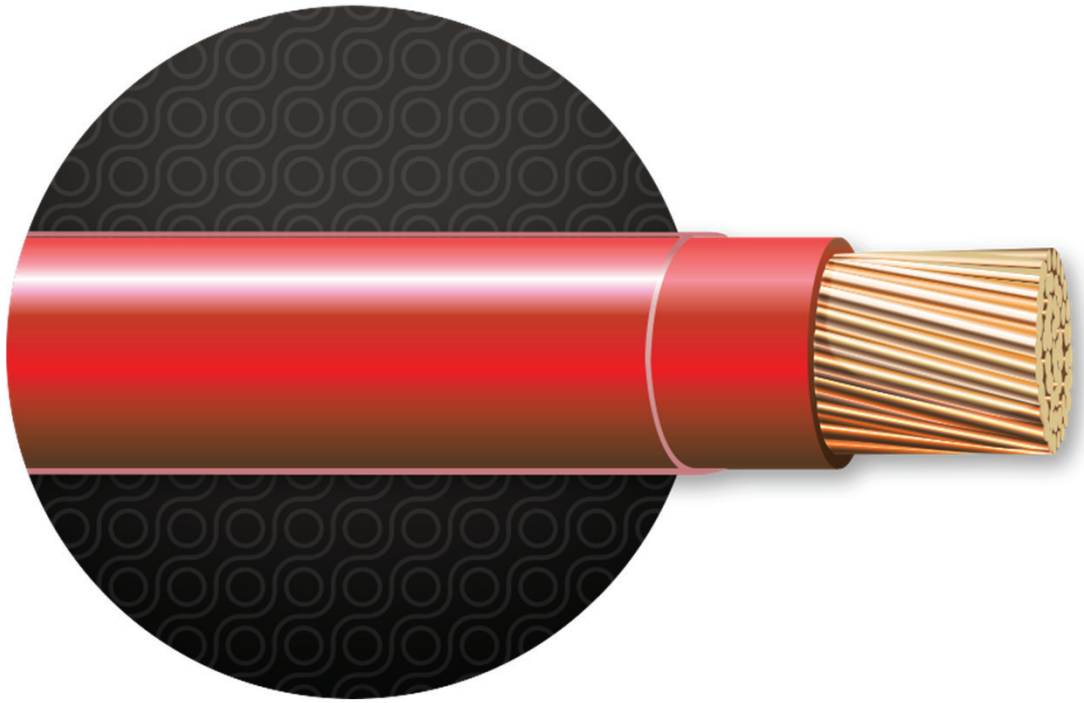
NEW!

Southwire DLO, RHH, RHW-2 heavy duty flexible power cable, single conductor, 2 AWG, EPDM thermoset rubber conductor insulation material, black, unshielded, CPE thermoset rubber jacket, black, cut to length.

SEC. 310.120 **MARKING** HAS BEEN CHANGED TO SEC 310.8, BUT NO SUBSTANCE HAS CHANGED

310.10(B) & (C)

- New wire insulation type: XHWN, & XHWN-2

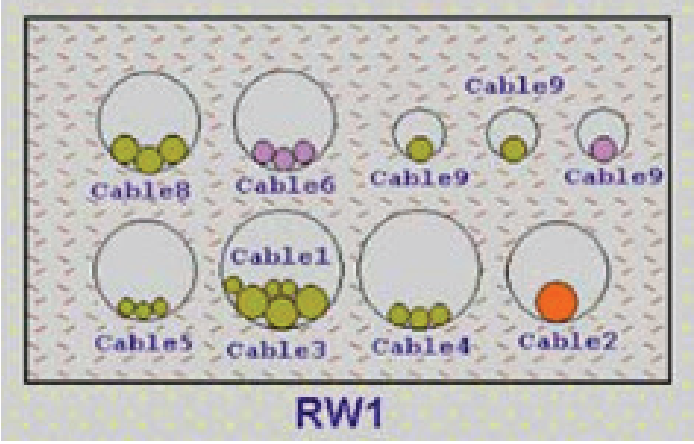


RULES AND PERMISSIONS FOR **CONDUCTOR SIZING** BY ENGINEERING CALCULATIONS ARE NOW IN SEC. 310.14 INSTEAD OF 310.15.

310.14 Ampacities for Conductors Rated 0 Volts – 2000 Volts.

(A) General.

Δ **(1) Tables or Engineering Supervision.** Ampacities for conductors shall be permitted to be determined by tables as provided in 310.15 or under engineering supervision, as provided in 310.14(B).



(B) Engineering Supervision. Under engineering supervision, conductor ampacities shall be permitted to be calculated by means of Equation 310.14(B).

[310.14(B)]

$$I = \sqrt{\frac{T_c - T_a}{R_{dc}(1+Y_c)R_{ca}}} \times 10^3 \text{ amperes}$$

where:

T_c = conductor temperature in degrees Celsius (°C)
T_a = ambient temperature in degrees Celsius (°C)
R_{dc} = dc resistance of 305 mm (1 ft) of conductor in micro-ohms at temperature, T_c
Y_c = component ac resistance resulting from skin effect and proximity effect
R_{ca} = effective thermal resistance between conductor and surrounding ambient

TABLE 310.15(B)(2)b, AMBIENT TEMPERATURE CORRECTION FACTORS BASED ON 40 C IS NOW REPLACED AND AUGMENTED WITH TWO NEW TABLES BASED ON 30 C AND 40 C:
310.15(B)(1) AND 310.15(B)(2)

Δ Table 310.15(B)(1) Ambient Temperature Correction Factors Based on 30°C (86°F)

For ambient temperatures other than 30°C (86°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	Temperature Rating of Conductor			Ambient Temperature (°F)
	60°C	75°C	90°C	
10 or less	1.29	1.20	1.15	50 or less
11–15	1.22	1.15	1.12	51–59
16–20	1.15	1.11	1.08	60–68
21–25	1.08	1.05	1.04	69–77
26–30	1.00	1.00	1.00	78–86
31–35	0.91	0.94	0.96	87–95
36–40	0.82	0.88	0.91	96–104
41–45	0.71	0.82	0.87	105–113
46–50	0.58	0.75	0.82	114–122
51–55	0.41	0.67	0.76	123–131
56–60	—	0.58	0.71	132–140
61–65	—	0.47	0.65	141–149
66–70	—	0.33	0.58	150–158
71–75	—	—	0.50	159–167
76–80	—	—	0.41	168–176
81–85	—	—	0.29	177–185

Δ Table 310.15(B)(2) Ambient Temperature Correction Factors Based on 40°C (104°F)

For ambient temperatures other than 40°C (104°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	Temperature Rating of Conductor						Ambient Temperature (°F)
	60°C	75°C	90°C	150°C	200°C	250°C	
10 or less	1.58	1.36	1.26	1.13	1.09	1.07	50 or less
11–15	1.50	1.31	1.22	1.11	1.08	1.06	51–59
16–20	1.41	1.25	1.18	1.09	1.06	1.05	60–68
21–25	1.32	1.2	1.14	1.07	1.05	1.04	69–77
26–30	1.22	1.13	1.10	1.04	1.03	1.02	78–86
31–35	1.12	1.07	1.05	1.02	1.02	1.01	87–95
36–40	1.00	1.00	1.00	1.00	1.00	1.00	96–104
41–45	0.87	0.93	0.95	0.98	0.98	0.99	105–113
46–50	0.71	0.85	0.89	0.95	0.97	0.98	114–122
51–55	0.50	0.76	0.84	0.93	0.95	0.96	123–131
56–60	—	0.65	0.77	0.90	0.94	0.95	132–140
61–65	—	0.53	0.71	0.88	0.92	0.94	141–149
66–70	—	0.38	0.63	0.85	0.90	0.93	150–158
71–75	—	—	0.55	0.83	0.88	0.91	159–167
76–80	—	—	0.45	0.80	0.87	0.90	168–176
81–90	—	—	—	0.74	0.83	0.87	177–194
91–100	—	—	—	0.67	0.79	0.85	195–212
101–110	—	—	—	0.60	0.75	0.82	213–230
111–120	—	—	—	0.52	0.71	0.79	231–248
121–130	—	—	—	0.43	0.66	0.76	249–266
131–140	—	—	—	0.30	0.61	0.72	267–284
141–160	—	—	—	—	0.50	0.65	285–320
161–180	—	—	—	—	0.35	0.58	321–356
181–200	—	—	—	—	—	0.49	357–392
201–225	—	—	—	—	—	0.35	393–437

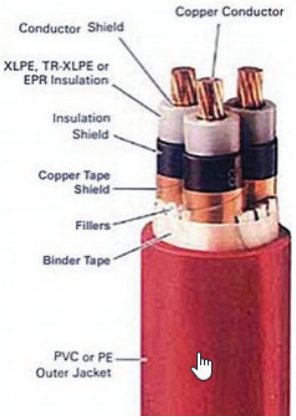
NEW ART. 311 MEDIUM VOLTAGE CONDUCTORS AND CABLE

- Art 311 is an entirely new article, and it deals exclusively with MV cables.

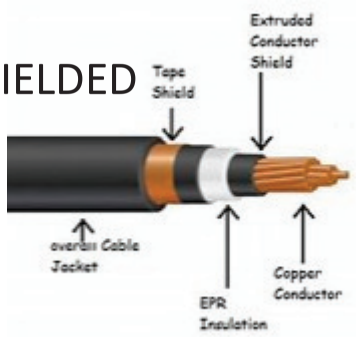
- Note that Art 310 now deals only with LV cables.

311.2 Definition of MV cable: A SINGLE OR MULTI-CONDUCTOR SOLID DIELECTRIC INSULATED CABLE RATED 2001 VOLTS, OR UP TO 35KV.

NONSHIELDED



SHIELDED



NEW ART 311 MEDIUM VOLTAGE CONDUCTORS AND CABLE

- This new article covers the use, installation, construction specifications, and ampacities for Type MV medium voltage conductors and cable that is rated 2001 – 35,000 volts.

311.10(B) MV CABLE INSULATION THICKNESS FOR NON-SHIELDED CABLE SEE TABLE 311.10(B)

Table 311.10(B) Thickness of Insulation and Jacket for Nonshielded Solid Dielectric Insulated Conductors Rated 2001 Volts to 5000 Volts

Conductor Size (AWG or kcmil)	Dry Locations, Single Conductor						Wet or Dry Locations					
	Without Jacket Insulation		With Jacket				Single Conductor				Multiconductor Insulation*	
			Insulation		Jacket		Insulation		Jacket			
	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils
8	2.79	110	2.29	90	0.76	30	3.18	125	2.03	80	2.29	90
6	2.79	110	2.29	90	0.76	30	3.18	125	2.03	80	2.29	90
4–2	2.79	110	2.29	90	1.14	45	3.18	125	2.03	80	2.29	90
1–2/0	2.79	110	2.29	90	1.14	45	3.18	125	2.03	80	2.29	90
3/0–4/0	2.79	110	2.29	90	1.65	65	3.18	125	2.41	95	2.29	90
213–500	3.05	120	2.29	90	1.65	65	3.56	140	2.79	110	2.29	90
501–750	3.30	130	2.29	90	1.65	65	3.94	155	3.18	125	2.29	90
751–1000	3.30	130	2.29	90	1.65	65	3.94	155	3.18	125	2.29	90
1001–1250	3.56	140	2.92	115	1.65	65	4.32	170	3.56	140	2.92	115
1251–1500	3.56	140	2.92	115	2.03	80	4.32	170	3.56	140	2.92	115
1501–2000	3.56	140	2.92	115	2.03	80	4.32	170	3.94	155	3.56	140

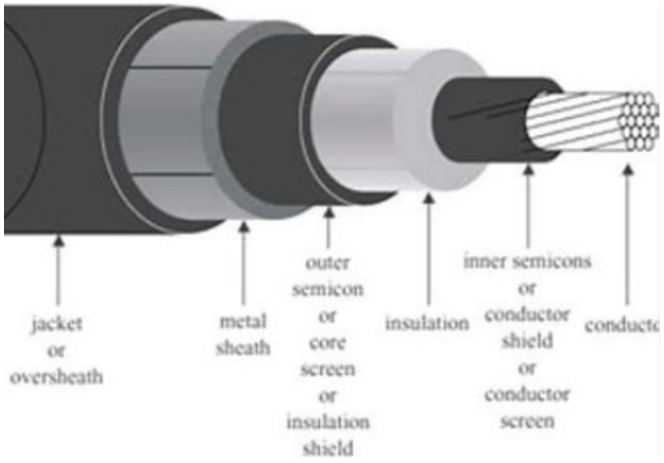
*Under a common overall covering such as a jacket, sheath, or armor.

311.10(C) MV CABLE INSULATION THICKNESS OF SHIELDED CABLE SEE TABLE 311.10(C)

Table 311.10(C) Thickness of Insulation for Shielded Solid Dielectric Insulated Conductors Rated 2001 Volts to 35,000 Volts

Conductor Size (AWG or kcmil)	2001–5000 Volts		5001–8000 Volts						8001–15,000 Volts						15,001–25,000 Volts					
	100 Percent Insulation Level		100 Percent Insulation Level		133 Percent Insulation Level		173 Percent Insulation Level		100 Percent Insulation Level		133 Percent Insulation Level		173 Percent Insulation Level		100 Percent Insulation Level		133 Percent Insulation Level		173 Percent Insulation Level	
	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils
8	2.29	90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6–4	2.29	90	2.92	115	3.56	140	4.45	175	—	—	—	—	—	—	—	—	—	—	—	—
2	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	—	—	—	—	—	—
1	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	6.60	260	8.13	320	10.67	420
1/0–2000	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	6.60	260	8.13	320	10.67	420

Conductor Size (AWG or kcmil)	25,001–28,000 Volts						28,001–35,000 Volts					
	100 Percent Insulation Level		133 Percent Insulation Level		173 Percent Insulation Level		100 Percent Insulation Level		133 Percent Insulation Level		173 Percent Insulation Level	
	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils
1	7.11	280	8.76	345	11.30	445	—	—	—	—	—	—
1/0–2000	7.11	280	8.76	345	11.30	445	8.76	345	10.67	420	14.73	580



311.10(C)(1) & (2) 100% INSULATION LEVEL AND 133% INSULATION LEVEL

N **(1) 100 Percent Insulation Level.** Cables shall be permitted to be applied where the system is provided with relay protection such that ground faults will be cleared as rapidly as possible but, in any case, within 1 minute. These cables are applicable to cable installations that are on grounded systems and shall be permitted to be used on other systems provided the above clearing requirements are met in completely de-energizing the faulted section.

N **(2) 133 Percent Insulation Level.** Cables shall be permitted to be applied in situations where the clearing time requirements of the 100 percent level category cannot be met and the faulted section will be de-energized in a time not exceeding 1 hour. Cable shall be permitted to be used in 100 percent insulation level applications where the installation requires additional insulation.

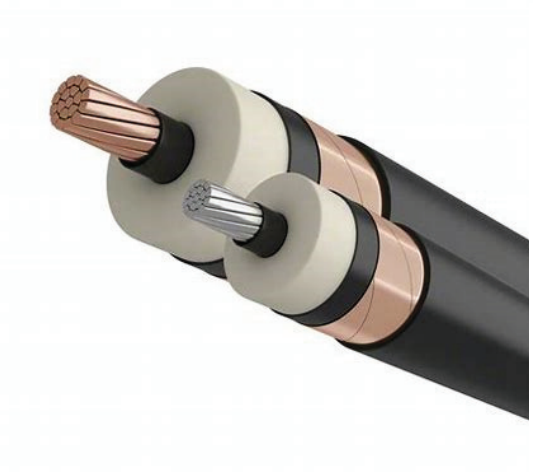
311.10(C)(3) 173% INSULATION LEVEL

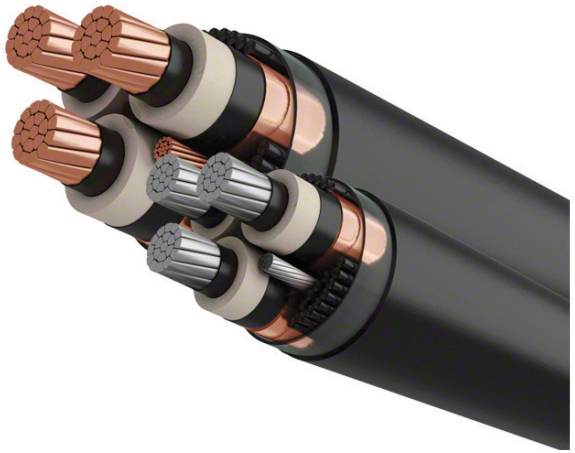
- FOR USE WHERE THE CLEARING TIME OF 133% CABLE CANNOT BE MET, SUCH AS WHEN AN ORDERLY SHUTDOWN IS NEEDED REQUIRING LONG DURATION BEFORE CLEARING A FAULT.

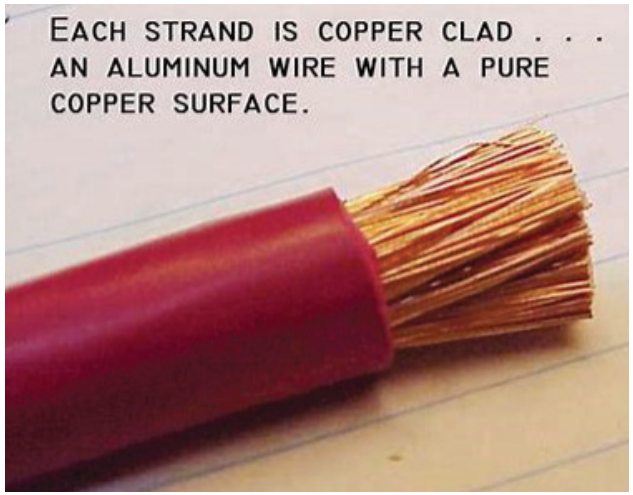
TABLE 311.12(A)

- VOLTAGE MIN. SIZE CONDUCTOR
- 2,001-5,000 8AWG*
- 5,001-8,000 6AWG*
- 8,001-15,000 2AWG*
- 15,001-28,000 1AWG*
- 28,001-35,000 1/0*

* THIS MIN. CONDUCTOR SIZE CAN BE CU, AL, OR COPPER-COATED ALUMINUM

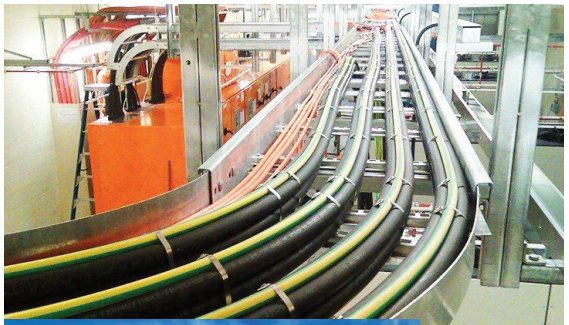




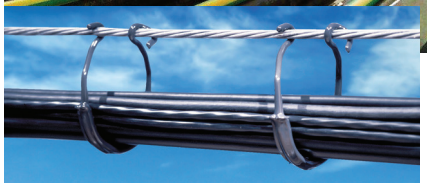


311.32 USES PERMITTED FOR MV CABLE

- In wet or dry locations*
- In raceways
- In cable trays



- Messenger-supported wiring



- As exposed runs per Sec 300.37 (such as airfield buried lighting circuit cable)
- Corrosive conditions when the conductor and insulation are of a type not attacked by the conditions (chemicals, termites, bacteria)
- Conductors in parallel
- Direct-burial (when shielded, identified for direct burial, and installed in accordance with Table 300.50)

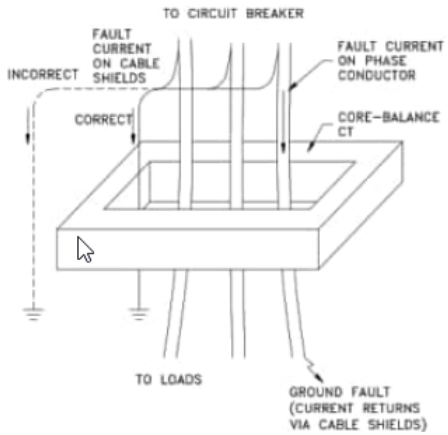
*Note that Type MV cables that are exposed to direct sunlight shall be identified for this use

311.44 SHIELDING

- Nonshielded, ozone-resistant insulated conductors with a maximum phase-to-phase voltage of 5000 volts shall be permitted in industrial establishments where provided with qualified maintenance.

- Solid dielectric insulated conductors operated above 2kV in non-industrial establishments shall be shielded.

- All metallic insulation shields shall be connected to a grounding electrode conductor and grounding electrode system



311.60 MV CABLE AMPACITIY

- Permitted to use Tables 311.60(B) & (C)*, or
- Engineering Supervision (IEEE 835, ICEA 46-466, or ETAP UG Module or similar engineering software)

*Note: Where different ampacities apply to portions of a circuit, the higher ampacity shall be permitted to be used if the total portion of the circuit with the lower ampacity does not exceed the lesser of:

1) 10-ft, or

2) 10% of overall circuit length

Ignore mutual heating in the last few feet where conductors come closer together in order to terminate.

Table 311.60(C)(67) AMPACITIES OF NONSHIELDED & SHIELDED MV CABLE

-Table 311.60(C)69 1/C CU 15kV in air #2-90°C-195 Amp

-Table 311.60(C)67 1/C CU 15kV Triplexed in air #2-90°C-170 Amp

-Table 311.60(C)71 3/C CU 15kV in air #2-90°C-165 Amp

-Table 311.60(C)73 1/C CU 15kV in conduit #2-90°C-150 Amp

-Table 311.60(C)75 3/C CU 15kV in conduit in air #2-90°C-145 Amp

1/C CU 15kV in air

311.60(F) AMPACITY OF U.G. CABLES

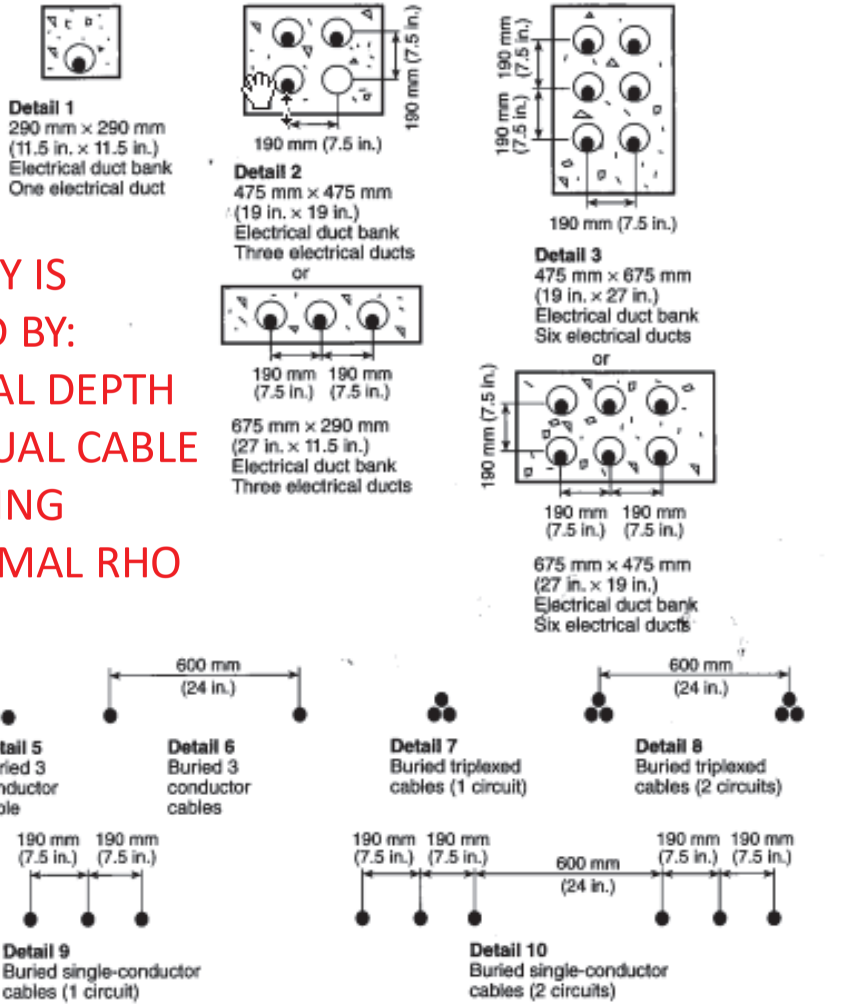
N **(F) Ampacity in Underground Electrical Ducts and Direct Buried in Earth.** Ampacities for conductors and cables in underground electrical ducts and direct buried in earth shall be as specified in Table 311.60(C)(77) through Table 311.60(C)(86). Ampacities shall be based on the following:

(1) Ambient earth temperature of 20°C (68°F)
(2) Arrangement in accordance with Figure 311.60(D)(3)
(3) 100 percent load factor
(4) Thermal resistance (Rho) of 90
(5) Conductor temperatures 90°C (194°F) and 105°C (221°F)
(6) Minimum burial depths to the top electrical ducts or cables shall be in accordance with 300.50.
(7) Maximum depth to the top of electrical duct banks shall be 750 mm (30 in.), and maximum depth to the top of direct-buried cables shall be 900 mm (36 in.).

MV UNDERGROUND CABLES

AMPACITY IS REDUCED BY:

1. BURIAL DEPTH
2. MUTUAL CABLE HEATING
3. THERMAL RHO



Note: Minimum burial depths to top electrical ducts or cables shall be in accordance with 300.50. Maximum depth to the top of electrical duct banks shall be 750 mm (30 in.) and maximum depth to the top of direct-buried cables shall be 900 mm (36 in.).

Δ FIGURE 311.60(D)(3) Cable Installation Dimensions for Use with Table 311.60(C)(77) Through Table 311.60(C)(86).

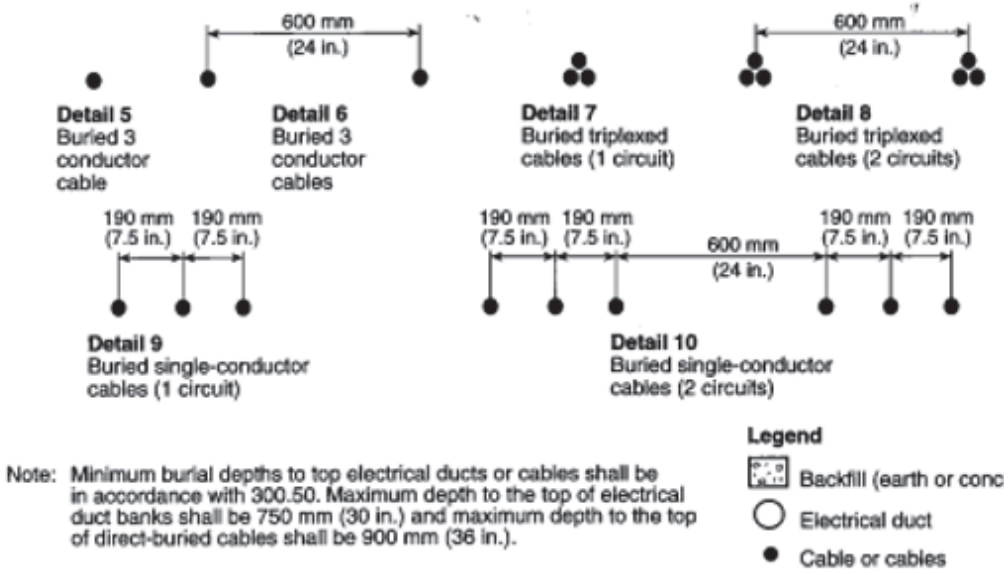
Δ Table 311.60(C)(77) Ampacities of Three Single-Insulated Copper Conductors in Underground Electrical Ducts (Three Conductors per Electrical Duct)

Conductor Size (AWG or kcmil)	Temperature Rating of Conductor: 2001–5000 Volts Ampacity 90°C (194°F) Type MV-90	2001–5000 Volts Ampacity 105°C (221°F) Type MV-105	5001–35,000 Volts Ampacity 90°C (194°F) Type MV	5001–35,000 Volts Ampacity 105°C (221°F) Type MV-105
One Circuit [See Figure 311.60(D)(3), Detail 1.]				
8	64	69	—	—
6	85	92	90	97
4	110	120	115	125
2	145	155	155	166 ←
1	170	180	175	185
1/0	195	210	200	215
2/0	220	235	230	245
3/0	250	270	260	275
4/0	290	310	295	315
250	320	345	325	345
350	385	415	390	415
500	470	505	465	500
750	585	650	565	610
1000	670	720	640	690
Three Circuits [See Figure 311.60(D)(3), Detail 2.]				
8	56	60	—	—
6	75	79	77	83
4	95	100	99	105
2	125	130	130	135 ←
1	140	150	145	155
1/0	160	175	165	175
2/0	185	195	185	200
3/0	210	225	210	225
4/0	235	255	240	255
250	260	280	260	280
350	315	335	310	330
500	375	405	370	395
750	460	495	440	475
1000	525	565	495	535
Six Circuits [See Figure 311.60(D)(3), Detail 3.]				
8	48	52	—	—
6	62	67	64	68
4	80	86	82	88
2	105	110	105	115 ←
1	115	125	120	125
1/0	135	145	135	145
2/0	150	160	150	165
3/0	170	185	170	185
4/0	195	210	190	205
250	210	225	210	225
350	250	270	245	265
500	300	325	290	310
750	365	395	350	375
1000	410	445	390	415

Note: Refer to 311.60(F) for basis of ampacities and Table 311.10(A) for the temperature rating of the conductor.

SEC. 311.60(D)(2)(a) & (b)

- "Where the burial depth of direct burial or electrical duct bank circuits is modified from the values shown in a figure or table, ampacities shall be permitted to be modified as indicated in 311.60(D)(2)(a) & (b). No ampacity adjustments shall be required where the burial depth is decreased."



Δ FIGURE 311.60(D)(3) Cable Installation Dimensions for Use with Table 311.60(C)(77) Through Table 311.60(C)(86).

Table 300.50 Minimum Cover[a] Requirements

	General Conditions (not otherwise specified)						Special Conditions (use if applicable)					
	Column 1		Column 2		Column 3		Column 4		Column 5		Column 6	
	Direct-Buried Cables[b]		RTRC, PVC, and HDPE Conduit[c]		Rigid Metal Conduit and Intermediate Metal Conduit		Raceways Under Buildings or Exterior Concrete Slabs, 100 mm (4 in.) Minimum Thickness[d]		Cables in Airport Runways or Adjacent Areas Where Trespass Is Prohibited		Areas Subject to Vehicular Traffic, Such as Thoroughfares and Commercial Parking Areas	
Circuit Voltage	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.
Over 1000 V through 22 kV	750	30	450	18	150	6	100	4	450	18	600	24
Over 22 kV through 40 kV	900	36	600	24	150	6	100	4	450	18	600	24
Over 40 kV	1000	42	750	30	150	6	100	4	450	18	600	24

311.60(F) AMPACITIES OF U.G. CABLES BURIED IN CONDUIT IN THE EARTH

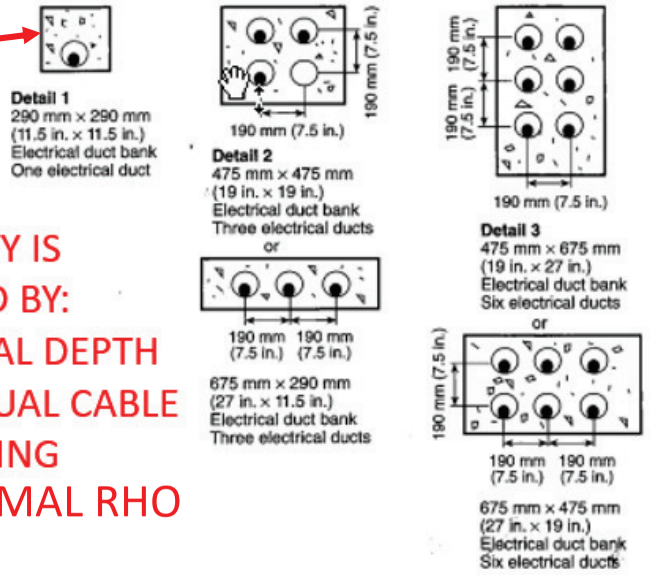
-Table 311.60(C)77 3-1/C CU 15kV UG Det 1 #2-90°C-155 Amp

-Table 311.60(C)77 3-1/C CU 15kV UG Det 2 #2-90°C-130 Amp

-Table 311.60(C)77 3-1/C CU 15kV UG Det 3 #2-90°C-105 Amp

- Table 311.60(C)79 3-1/C CU/SH 15kV/DUCT UG Det 1 #2-90°C-150A
- Table 311.60(C)79 3-1/C CU/SH 15kV/DUCT UG Det 2 #2-90°C-125A
- Table 311.60(C)79 3-1/C CU/SH 15kV/DUCT UG Det 3 #2-90°C-105A

(OPTIMUM)



AMPACITY IS REDUCED BY:

1. BURIAL DEPTH
2. MUTUAL CABLE HEATING
3. THERMAL RHO

311.60(C) AMPACITIES OF MV U.G. CABLES BURIED IN THE EARTH

-Table 311.60(C)(81) ONE CIRCUIT, 3-1/C CU 15kV UG DIRECT BURIAL Det 9 #2-90°C-210A

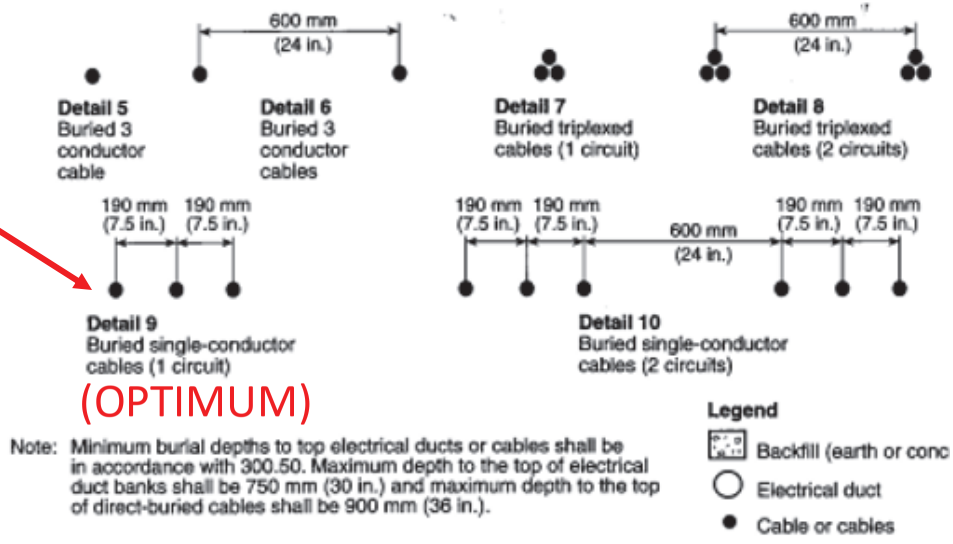
-Table 311.60(C)(81) TWO CIRCUITS, 6-1/C CU 15kV UG DIRECT BURIAL Det 10 #2-90°C-195A

-Table 311.60(C)(83) ONE CIRCUIT, ONE 3/C CU SH 15kV UG DIRECT BURIAL Det 5 #2-90°C-185A

-Table 311.60(C)(83) TWO CIRCUITS, TWO 3/C CU SH 15kV UG DIRECT BURIAL Det 6 #2-90°C-170A

-Table 311.60(C)(85) ONE CIRCUIT, ONE TRIPLEXED 3/C CU 15kV UG DIRECT BURIAL Det 7 #2-90°C-190A

-Table 311.60(C)(85) TWO CIRCUITS, TWO TRIPLEXED 3/C CU 15kV UG DIRECT BURIAL Det 8 #2-90°C-175A



(OPTIMUM)

Note: Minimum burial depths to top electrical ducts or cables shall be in accordance with 300.50. Maximum depth to the top of electrical duct banks shall be 750 mm (30 in.) and maximum depth to the top of direct-buried cables shall be 900 mm (36 in.).

Δ FIGURE 311.60(D)(3) Cable Installation Dimensions for Use with Table 311.60(C)(77) Through Table 311.60(C)(86).

TABLE 311.60(D)(4) AMBIENT TEMPERATURE CORRECTION FACTORS

(4) Ambient Temperature Correction. Ampacities for ambient temperatures other than those specified in the ampacity tables shall be corrected in accordance with Table 311.60(D)(4) or shall be permitted to be calculated using the following equation:

[311.60(D)(4)]

$$I' = I\sqrt{\frac{T_c - T_a'}{T_c - T_a}}$$

where:

I' = ampacity corrected for ambient temperature
I = ampacity shown in the table for T_c and T_a
T_c = temperature rating of conductor (°C)
T_a' = new ambient temperature (°C)
T_a = ambient temperature used in the table (°C)

Table 311.60(D)(4) Ambient Temperature Correction Factors

For ambient temperatures other than 40°C (104°F), multiply the allowable ampacities specified in the ampacity tables by the appropriate factor shown below.

Ambient Temperature (°C)	Temperature Rating of Conductor		Ambient Temperature (°F)
	90°C	105°C	
10 or less	1.26	1.21	50 or less
11–15	1.22	1.18	51–59
16–20	1.18	1.14	60–68
21–25	1.14	1.11	69–77
26–30	1.10	1.07	78–86
31–35	1.05	1.04	87–95
36–40	1.00	1.00	96–104
41–45	0.95	0.96	105–113
46–50	0.89	0.92	114–122
51–55	0.84	0.88	123–131
56–60	0.77	0.83	132–140
61–65	0.71	0.78	141–149
66–70	0.63	0.73	150–158
71–75	0.55	0.68	159–167
76–80	0.45	0.62	168–176
81–85	0.32	0.55	177–185
86–90	—	0.48	186–194
91–95	—	0.39	195–203
96–100	—	0.28	204–212

314.23(H)(2) LISTED SWIVEL HANGERS

- “For stems longer than 18”, the stems shall be connected to the wiring system with listed swivel hangers suitable for the location.”

Ball

336.10 TYPE TC-ER CABLE

- Sec 336.104 the Type TC-ER cable must contain an equipment grounding conductor.
- For control and signaling conductors, the minimum conductor permitted shall be #18, copper or nickel-coated copper, #14 #AWG copper-clad aluminum, or #12 AWG aluminum.

336.130 TYPE TC-ER-HL

336.130 Hazardous (Classified) Location Cable. Cable listed and marked Type TC-ER-HL shall comply with the following:

(1) The overall nonmetallic jacket shall be suitable for the environment.

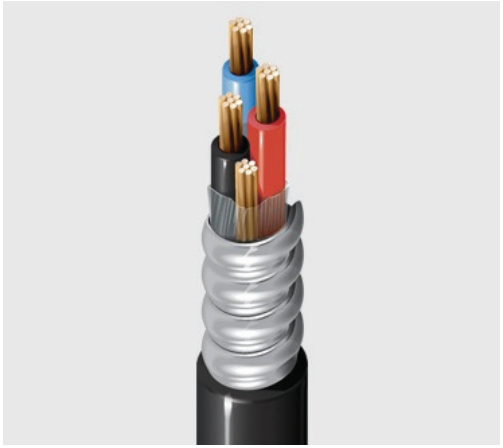
(2) The overall cable construction shall be essentially circular in cross-section.

(3) The overall nonmetallic jacket shall be continuous and gas/vapor tight.

(4) For construction greater than 25.4 mm (1 in.) in diameter, the following shall apply:

a. The equipment grounding conductor shall be bare.

b. A metallic shield shall be included over all conductors under the outer jacket.



NEW ART. 337 TYPE P CABLE

FLEXIBLE
STRANDING

Type P cable is a factory assembly of one or more insulated flexible tinned copper conductors, with associated equipment grounding conductors, with or without a braided metallic armor, with an overall nonmetallic jacket.

337.1 TYPE P CABLE VOLTAGE

- Type P cable can be 0-volts through 2000-volts.

337.10 TYPE P CABLE

- Type P cable is permitted for use as follows:
  - Under engineering supervision in industrial installations where conditions of maintenance and supervision ensure that only qualified persons monitor and service the cable system
  - In C1D1 or C1D2 locations

Note: Listed fittings are required

337.104 THROUGH 337.120 Type P Cable Features

- Tinned fine-strand conductors
- EGC per Table 250.122 shall be included
- Synthetic rubber cross-linked insulation
- Non-metallic moisture-resistant jacket that is sunlight resistant
- Braided basket –weave armor made of commercial bronze

Note that the basket-weave armor shall not be utilized as the equipment grounding conductor.

337.80 Type P Cable Ampacity

The ampacity of Type P cable shall be:

a. Per 310.14(A) or 310.14(B), just like most other cables, or
b. For 18AWG and 16AWG, use Table 402.5
c. When the Type P cable is installed in cable tray, refer to 392.80(A), just like most other cables

342.10(E) IMC CAN BE INSTALLED WHERE SUBJECT TO PHYSICAL DAMAGE

342.14 IMC OF DISSIMILAR METALS

Δ **342.14 Dissimilar Metals.** Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

Stainless steel and aluminum fittings and enclosures shall be permitted to be used with galvanized steel IMC where not subject to severe corrosive influences.

Stainless steel IMC shall only be used with the following:

(1) Stainless steel fittings
(2) Stainless steel boxes and enclosures
(3) Steel (galvanized, painted, powder or PVC coated, and so forth) boxes and enclosures when not subject to severe corrosive influences
(4) Stainless steel, nonmetallic, or approved accessories

344.10(A)(1) Rigid Metal Conduit, RMC

- Besides galvanized steel and stainless steel, the 2020 NEC permits RMC to be made of Red Brass
- The 2020 NEC contains the following rules regarding dissimilar metals:

344.14 Dissimilar Metals. Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action. Stainless steel and aluminum fittings and enclosures shall be permitted to be used with galvanized steel RMC, and galvanized steel fittings and enclosures shall be permitted to be used with aluminum RMC where not subject to severe corrosive influences. Stainless steel rigid conduit shall only be used with the following:

(1) Stainless steel fittings
(2) Stainless steel boxes and enclosures
(3) Steel (galvanized, painted, powder or PVC coated, and so forth) boxes and enclosures when not subject to severe corrosive influences
(4) Stainless steel, nonmetallic, or approved accessories

Art 350.10(4) Liquidtight Flexible Metallic Conduit Type:LFMC

"Conductors or cables rated at a temperature higher than the listed temperature rating of LFMC conduit shall be permitted to be installed in LFMC, provided the conductors or cables are not operated at a temperature higher than the listed temperature rating of the LFMC per 110.14(C).

Temperature Rating

- 105°C (221°F) DRY
- 60°C (140°F) WET
- 70°C (158°F) OIL RESISTANT
- -55°C (-67°F) LOW TEMPERATURE

Applications

Suitable for use in:

- NEC® 350 Liquidtight Flexible Metal Conduit Type LFMC Machine tool wiring applications
- Wet Locations
- Direct Burial in earth

NOT FOR USE WHERE SUBJECT TO PHYSICAL DAMAGE

350.30(A) Securing & Supporting LFMC

"LFMC shall be securely fastened in place by an approved means within 12-in. of each box, cabinet, conduit body, and other conduit termination and shall be supported and secured at intervals not to exceed 4.5-ft…"