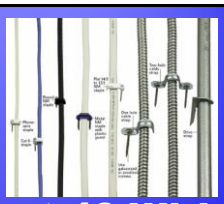
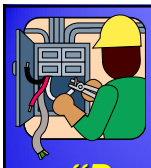
Western Section

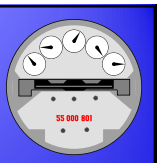
"2011 NEC Electrical Wiring Methods"

Properly Selecting
and
Installing Wiring Methods"



There are about 40 Wiring Methods to choose from each have an application that will assure user satisfaction





"Design Considerations for Selecting and Installing Wiring Methods in accordance with the 2011 NEC".

Basic Design Factors

- Safety
- Capacity
- Flexibility
- Resistance to the spread of fire
- Voltage selection
- EMF-Harmonics

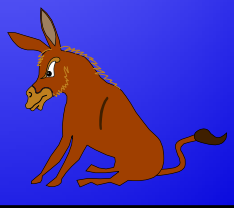
NEC Compliance

A New Code Again !

NEC Usability

- The code continues to be more user friendly?

FOR SOME OF US



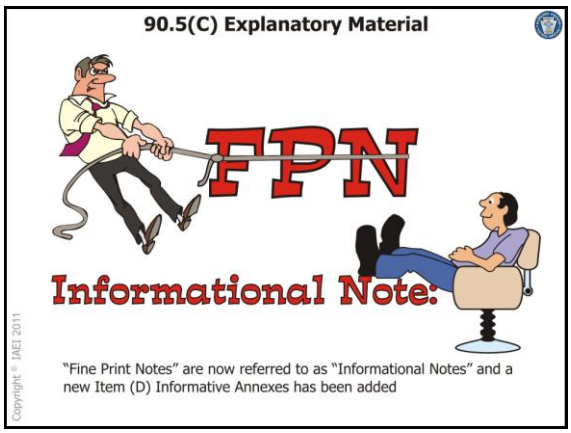
Let's look at how the NEC impacts our choice of a wiring method

Code-Wide Changes

- **There were approximately 5,016 proposals and 2,910 public comments submitted for modifications to the 2011 edition of the *NEC***
- **The term "grounding conductor" was replaced with the term "grounding electrode conductor," "Equipment Grounding conductor", "bonding jumper," or "bonding conductor" throughout the *NEC*.**
- ***We have also added terms like "connected to"***

Code-Wide Changes (cont.)

- Three new articles added to the 2011 *NEC*
  - **Article 399 -** Outdoor, Overhead Conductors, Over 600 Volts
  - **Article 694 -** Small Wind Electric Systems
  - **Article 840 -** Premises-Powered Broadband Communications Systems



90.5(D) Informative Annexes

- "New subdivision (D) (Informative Annexes) has been added referencing the informational annexes contained in the *NEC*
- Nonmandatory information relative to the use of the *NEC* is provided in informative annexes

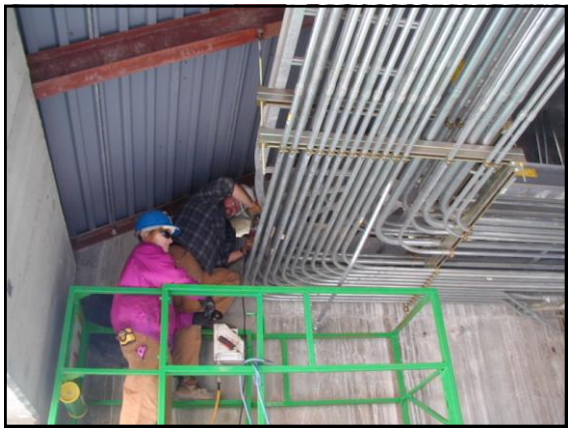
Article 90

- **90-7 IF Listed**
  The wiring or the construction of equipment need not be inspected at the time of installation except to detect alterations or damage, if the equipment is listed and suitable for installation in accordance with this Code.
- ***90-8.* Wiring Planning**
  It is the Designer who must plan for future expansion and convenience.
  And the number of circuits in enclosures.

Article 100 Definitions

Qualified Worker;

One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved.



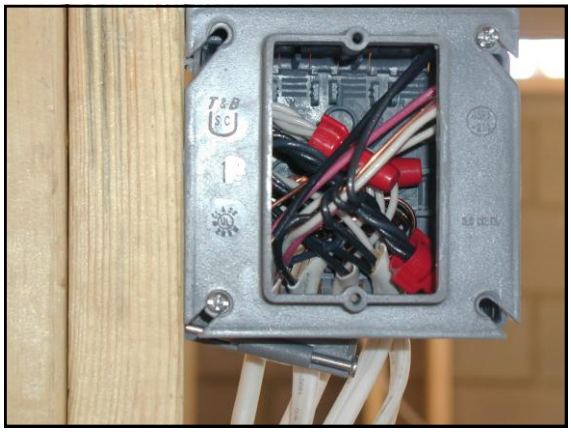
Article 110

- Part A (I)General
- Part B (II) Requirements for 0 to 600 volts
- Part C (III) High Voltage (above 600 volts)
- Part. D (IV) Tunnels over 600 volts

110.3
Examination, Identification, Installation, and Use of Equipment

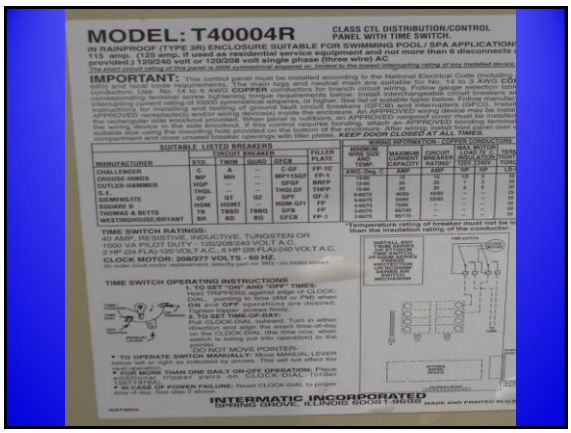
- Suitability for installation
- Conformity to the Code
- Adequacy of the protection
- Practical safeguarding of persons

Cont.



Installation and Use.

Listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling.



MODEL: T40004R

CLASS CTL DISTRIBUTION/CONTROL PANEL WITH TIME SWITCH.

IN RAINPROOF (TYPE 3R) ENCLOSURE SUITABLE FOR SWIMMING POOL / SPA APPLICATION

115 amp. (125 amp. if used as residential service equipment and not more than 6 disconnects

provided.) 120/240 volt or 120/208 volt single phase (three wire) AC

IMPORTANT:

SUITABLE LISTED BREAKERS

MANUFACTURER	CIRCUIT BREAKER STD	TWIN	QUAD	GFCB	FILLER PLATE
CHALLENGER	C	A	--	C-GF	FP-1C
CROUSE-HINDS	MP	MH	--	MP115GF	FP-1
CUTLER-HAMMER	HGP	--	--	GFGF	BRFP
G.E.	THGL	--	--	THQLGF	THFP
SIEMENS/ITE	QP	QT	QU	QPF	QF-3
SQUARE D	HOM	HOMT	--	HOM-GFI	FP
THOMAS & BETTS	TB	TBBD	TBBQ	GFB	FP
WESTINGHOUSE/BRYANT	BR	BD	BQ	GFCB	FP-1

TIME SWITCH RATINGS:

40 AMP. RESISTIVE, INDUCTIVE, TUNGSTEN OR 1000 VA PILOT DUTY - 120/208/240 VOLT A.C. 2 HP @ FLA-120 VOLT A.C., 5 HP @ 208 FLA-240 VOLT A.C.

CLOCK MOTOR: 208/277 VOLTS - 60 HZ.

TIME SWITCH OPERATING INSTRUCTIONS

1. TO SET "ON" AND "OFF" TIMES:
2. TO SET TIME-OF-DAY:

INTERMATIC INCORPORATED

DANVERS GROVE, ILLINOIS 60031-9698

110.12
Mechanical Execution of Work.

- Electrical equipment shall be installed in a neat and workmanlike manner.
- (B) Integrity of Electrical Equipment and Connections. Internal parts of electrical equipment, including busbars, wiring terminals, insulators, and other surfaces, shall not be damaged or contaminated by foreign materials

110.16 Flash Hazard Warning.

Electrical equipment such as switchboards, panelboards, industrial control panels, meter scoke enclosures and motor control centers that are in other than dwelling units and are likely to require examination, adjustment, servicing, or maintenance while energized shall be field marked to warn qualified persons of potential electric arc flash hazards. The marking shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

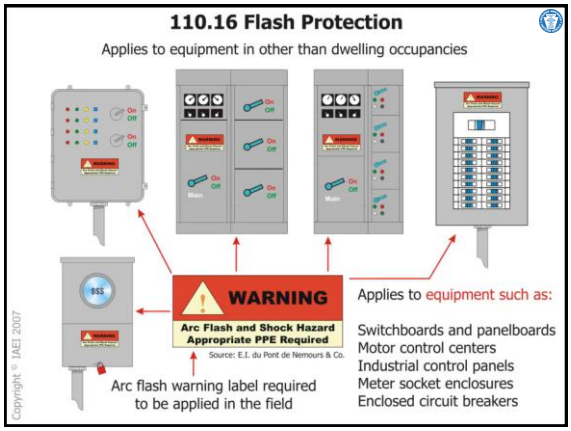
Additional information provided

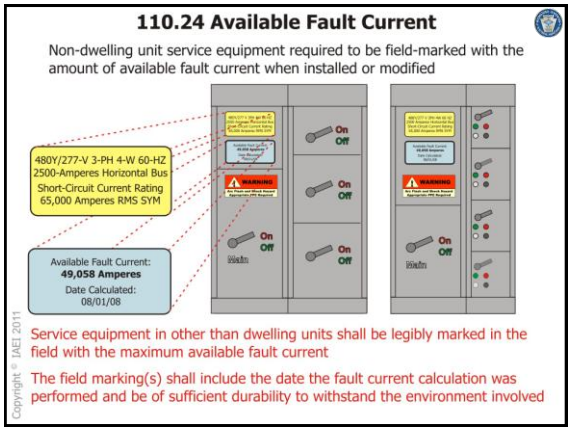
110.16 Flash Protection.

continued

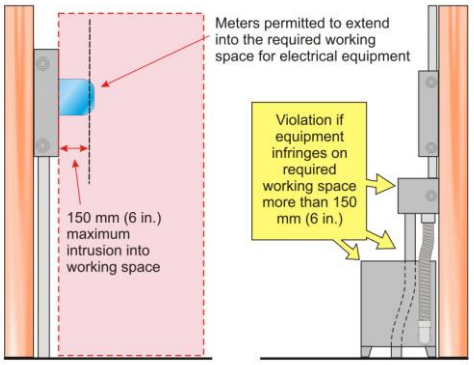
FPN No. 1: NFPA 70E-2009, Electrical Safety Requirements for Employee Workplaces, provides assistance in determining severity of potential exposure, planning safe work practices, and selecting personal protective equipment.

FPN No. 2: ANSI Z535.4-1998, Product Safety Signs and Labels, provides guidelines for the design of safety signs and labels for application to products.



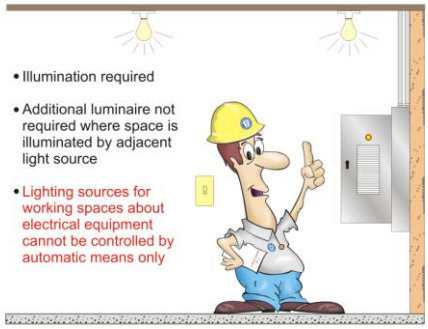


110.26(A)(3), Ex. No. 2 Height of Working Space



110.26(D) Illumination About Electrical Equipment

- Illumination required
- Additional luminaire not required where space is illuminated by adjacent light source
- Lighting sources for working spaces about electrical equipment cannot be controlled by automatic means only



Illumination shall be provided for all working spaces about service equipment, switchboards, panelboards, or motor control centers installed indoors

110.26(E) Compliance

Violation 110.26(E)(1)(a) & (b)

110.26(E) (1)(b)

- Dedicated foot print now 6 feet above the top of the equipment.
- Foreign Systems above may be permitted if a drip pan is installed over the equipment.
- Sprinklers are still permitted in this area.

110.28 Enclosure Types

- List of items that are required to be marked with an enclosure-type number from Table 110.28 have been expanded
- Enclosures of switchboards, panelboards, industrial control panels, motor control centers, meter sockets, enclosed switches, transfer switches, power outlets, circuit breakers, adjustable-speed drive systems, pullout switches, portable power distribution equipment, termination boxes, general purpose transformers, fire pump controllers, fire pump motors, and motor controllers shall be marked with an enclosure-type number as shown in Table 110.28

110.28 Enclosure Types

For Outdoor Use

Provides a degree of protection against the following environmental conditions	Enclosure Type Number									
	3	3R	3S	3X	3RX	3SX	4	4X	6	6P
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Rain, snow, and sleet	X	X	X	X	X	X	X	X	X	X
Sleet*	-	-	X	-	-	X	-	-	-	-
Windblown dust	X	-	X	X	-	X	X	X	X	X
Hose-down	-	-	-	-	-	-	X	X	X	X
corrosive agents	-	-	-	X	X	X	-	X	X	X
Temporary submersion	-	-	-	-	-	-	-	-	X	X
Prolonged submersion	-	-	-	-	-	-	-	-	-	X

For Indoor Use

Provides a degree of protection against the following environmental conditions	Enclosure Type Number									
	1	2	4	4X	5	6	6P	12	12K	13
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X	X	X	X
Falling liquids and light splashing	-	X	X	X	X	X	X	X	X	X
Circulating dust, lint, fibers, and flyings	-	-	X	X	-	X	X	X	X	X
Settling airborne dust, lint, fibers and flyings	-	-	X	X	X	X	X	X	X	X
Hose-down and splashing water	-	-	X	X	-	X	X	-	-	-
Oil and coolant seepage	-	-	-	-	-	-	-	X	X	X
Oil or coolant spraying and splashing	-	-	-	-	-	-	-	-	-	X
Corrosive agents	-	-	-	X	-	-	X	-	-	-
Temporary submersion	-	-	-	-	-	X	X	-	-	-
Prolonged submersion	-	-	-	-	-	-	X	-	-	-

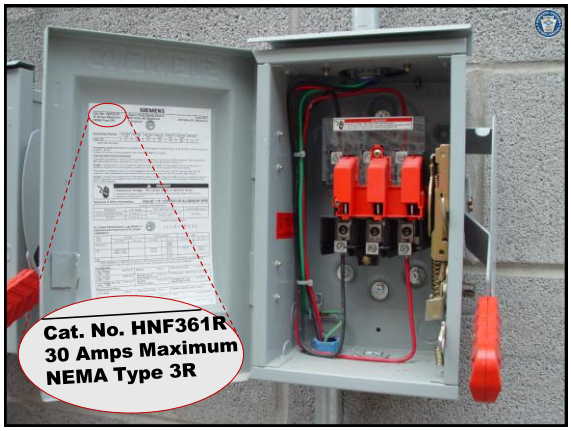
Reproduction of Table 110.28 (part)

*Mechanism shall be operable when ice covered.

Typical enclosures

Table 110.20 has been relocated to section 110.28

Enclosure type designations apply to electrical enclosures beyond those for motor controller enclosures and those enclosures shall be marked.



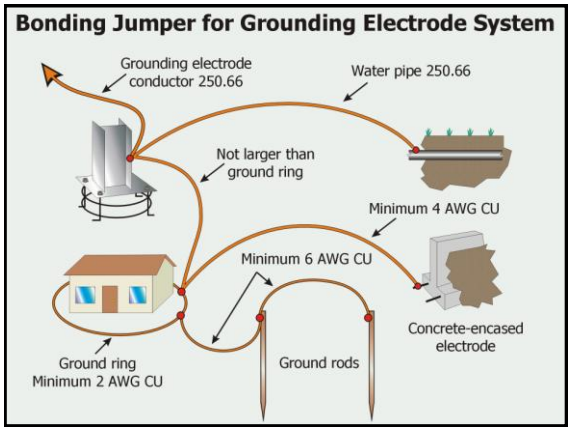
Grounding & Bonding is Paramount to a good installation

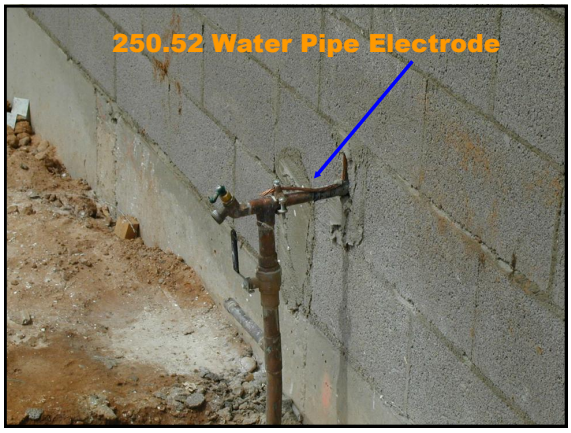
Protection against;

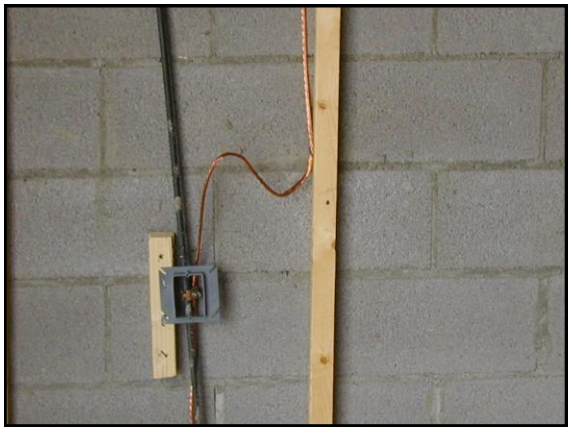
- Lightning & Voltage Surges
- Short Circuits
- Ground Faults
- Limit Fire & Shock Hazards

Grounding Electrode System

- Underground Water Piping
- Effectively Grounded Building Steel
- Concrete Encased Electrode
- Ground Ring
- Other made Electrodes







Bonding Part V

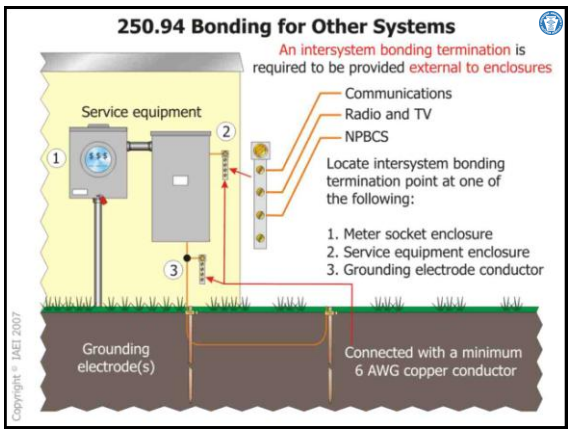
- 250.90 - General
- 250.92 – Services
- 250.94 – Other Systems
- 250.96 – Other Enclosures
- 250.97 – Over 250 Volts
- 250.98 – Loose Joints
- 250.100 – Hazardous Locations
- 250.102 – Equipment Jumpers
- 250.104 – Piping Systems and Exposed Structural Steel

250.8 Connections

- Listed pressure connectors
- Terminal bars
- Listed pressure connectors as grounding and bonding equipment
- Exothermic Welding process
- Machine screw type fasteners (2 threads or secured with a nut)
- Thread forming screws (min. 2 threads)
- Part of a listed assembly
- Other listed means

250.92(B) Method of Bonding at Service

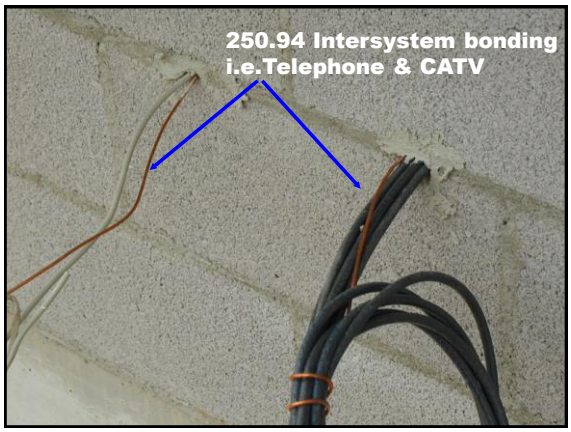
- Bonding requirements were added for bonding around reducer washers at raceways containing service conductors
- Bonding jumpers must be used around impaired connections such as reducing washers or oversized, concentric, or eccentric knockouts
- Standard locknuts or bushings cannot be the only means for the bonding at services but permitted to be installed to make a mechanical connection of the raceway(s)
- Electrical continuity at service equipment, service raceways, and service conductor enclosures shall be ensured by bonding equipment to the grounded service conductor, threaded couplings or threaded hubs, bonding-type locknuts, bonding bushings, etc.



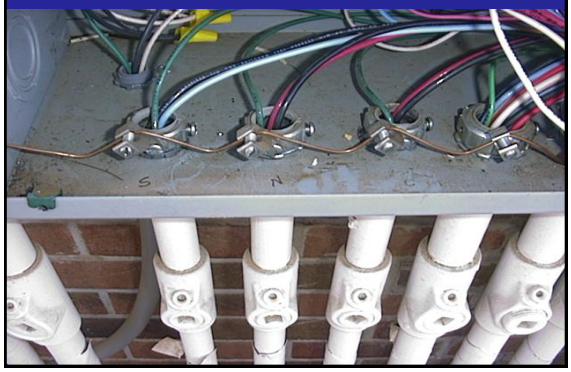
Bonding Fittings

Bonding Locknut - Used where no concentric or eccentric knockouts remain. Standard locknut opposite side.

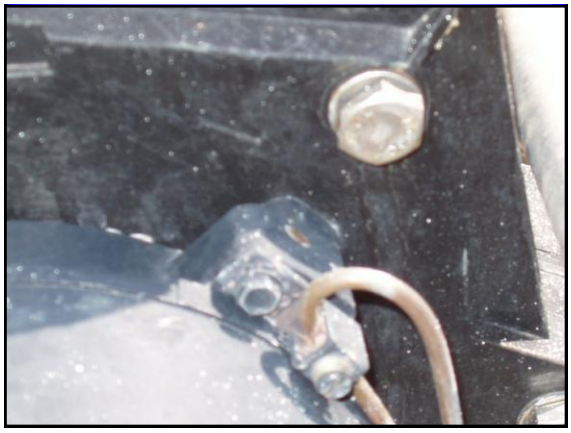
Bonding Wedge - Use with bonding jumper around concentric or eccentric knockouts; with or without bonding jumper where no concentric or eccentric knockouts. Standard locknut opposite side.



Bonding as Required by 250.100



250.104(B)



Wiring Methods are Grounding Conductors or They must contain an Equipment Grounding Conductor *Generally*

NEC 250.4(A)(5)

Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a permanent, low-impedance circuit capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source. The earth shall not be used as the sole equipment grounding conductor or effective ground-fault current path.

250.118 EGC

- Conductors; copper, aluminum, or copper-clad aluminum conductor.
- RMC, IMC & EMT
- FMC where both the conduit and fittings are listed for grounding.
- Listed FMC conduit that is not listed for grounding, *
- Listed LFMC meeting all the following conditions: **
- Other electrically continuous metal raceways and auxiliary gutters listed for grounding.

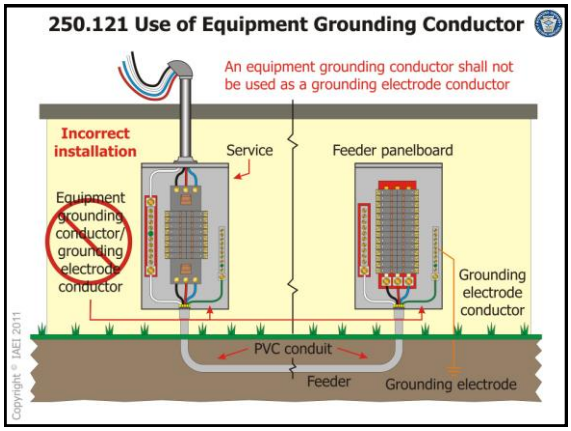


Table 250.122

- Sizing requirements for wire type equipment grounding conductors is governed by 250.122 and Table 250.122
- Revision with the deletion of the "30" and "40" amperes rows in Table 250.122
- The heading above the ampere column in the table states "Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)"
- The "30" and "40" ampere figures were redundant and not needed

Table 250.122 (in part)

Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
15	14	12
20	12	10
~~30~~	~~10~~	~~8~~
~~40~~	~~10~~	~~8~~
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0

Note: Where necessary to comply with 250.4(A)(5) or 250.4(B)(4), the equipment grounding conductor shall be sized larger than given in this table.

Table 250.122

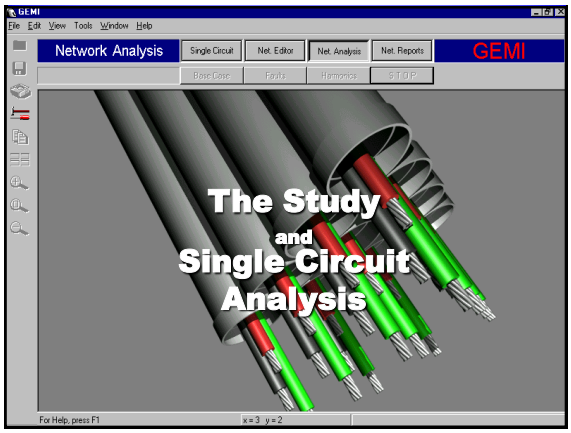
- **The sizing requirement of an aluminum equipment grounding conductor for circuit conductors protected by a 4000-ampere rated overcurrent device was revised**
- **The minimum size for this aluminum equipment grounding conductor was changed from 800 kcmil to 750 kcmil**
- **A 500 kcmil copper conductor and a 750 kcmil aluminum conductor with equivalent insulation are equally capable of carrying the same fault current**
- **750 kcmil aluminum conductors are a more common industry standard size than 800 kcmil**

Table 250.122 (in part)

Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	750
5000	700	1200
6000	800	1200

Note: Where necessary to comply with 250.4(A)(5) or 250.4(B)(4), the equipment grounding conductor shall be sized larger than given in this table.



More Information

1. GEMI Software (Free)
   www.steelconduit.org
2. Q&A (lots of great answers)
3. Steel Conduit & EMT Installation guide (Free)
4. Articles & White Papers
5. Case Studies
6. Manufacturer's contact info
7. And Lots More!

Examples of Maximum Length Equipment Grounding Conductor (Steel EMT, IMC, GRC, and Copper, Copperclad or Aluminum Wire)
Computed As A Safe Return Fault Path To Overcurrent Device
Based on 1994 Georgia Tech Software (GEMI windows 1.1)
With an Arc Voltage of 40 and 4 IP at 25° C Ambient
120 Volts to Ground

Overcurren Device Rating Amperes (75° C)	400% (4IP) Overcurren Device Rating Amperes	Circuit Conductor Size AWG-kcmil Copper or Aluminum	EMT, IMC GRC Trade Size	(1) Equipment Grounding Conductor Size Copper or Aluminum	Length of EMT Run Computed Maximum (In Feet)	Length of IMC Run Computed Maximum (In Feet)	Length of GRC Run Computed Maximum (In Feet)	(1) Copper Grounding Conductor Max Run (In Feet)	(1) Aluminum or Copperclad Grounding Conductor Max Run (In Feet)
20	80	12	1/2	---	395	398	384	---	---
20	80	12	---	12	---	---	---	300	---
20	80	10 AL	---	10 AL	---	---	---	---	293
30	120	10	1/2	---	---	383	---	---	---
30	120	10	3/4	---	404	399	386	---	---
30	120	10	---	10	---	---	---	319	---
30	120	8 AL	---	8 AL	---	---	---	---	310
40	160	8	3/4	---	---	414	---	---	---
40	160	8	1	---	447	431	418	---	---
40	160	8	---	10	---	---	---	294	---
40	160	8 AL	---	8 AL	---	---	---	---	232
60	240	6	1	---	404	400	382	---	---
60	240	6	---	10	---	---	---	228	---
60	240	4 AL	---	8 AL	---	---	---	---	221
100	400	3	1 1/4	---	402	397	373	---	---
100	400	3	---	8	---	---	---	229	---
100	400	1 AL	---	6 AL	---	---	---	---	222
200	800	3/0	2	---	390	389	363	---	---
200	800	3/0	---	6	---	---	---	201	---
200	800	250 AL	---	4 AL	---	---	---	---	195

(1) Per NEC Table 250-95.
Applicable to non-metallic conduit runs.

* NEC Wire Fill Table Permits Sr

Note: Software is not limited to

Examples of Maximum Length Equipment Grounding Conductor (Steel EMT, IMC, GRC, and Copper, Copperclad or Aluminum w
Computed As A Safe Return Fault Path To Overcurrent Device
Based on 1994 Georgia Tech Software (GEMI 2.3)
With an Arc Voltage of 40 and 4 IP at 25° C Ambient
277 Volts to Ground

Overcurrent Device Rating Amperes (75° C)	400% (4IP) Overcurrent Device Rating Amperes	Circuit Conductor Size AWG-kcmil Copper or Aluminum	EMT, IMC GRC Trade Size	(1) Equipment Grounding Conductor Size Copper or Aluminum	Length of EMT Run Computed Maximum (In Feet)	Length of IMC Run Computed Maximum (In Feet)	Length of GRC Run Computed Maximum (In Feet)	(1) Copper Grounding Conductor Max Run (In Feet)	(1) Aluminum or Copperclad Grounding Conductor Max Run (In Feet)
20	80	12	1/2	---	1170	1179	1140	---	---
20	80	12	---	12	---	---	---	890	---
20	80	10 AL	---	10 AL	---	---	---	---	870
30	120	10	1/2	---	---	1135	---	---	---
30	120	10	3/4	---	1199	1182	1143	---	---
30	120	10	---	10	---	---	---	946	---
30	120	8 AL	---	8 AL	---	---	---	---	920
40	160	8	3/4	---	---	1228	---	---	---
40	160	8	1	---	1326	1276	1239	---	---
40	160	8	---	10	---	---	---	871	---
40	160	8 AL	---	8 AL	---	---	---	---	690
60	240	6	1	---	1197	1186	1131	---	---
60	240	6	---	10	---	---	---	676	---
60	240	4 AL	---	8 AL	---	---	---	---	657
100	400	3	1 1/4	---	1192	1176	1107	---	---
100	400	3	---	8	---	---	---	680	---
100	400	1 AL	---	6 AL	---	---	---	---	659
200	800	3/0	2	---	1157	1155	1077	---	---
200	800	3/0	---	6	---	---	---	598	---
200	800	250 AL	---	4 AL	---	---	---	---	578

(1) Per NEC Table 250.95.
Applicable to non-metallic conduit runs.

* NEC Wire Fill Table Permits Smaller Conduit Size

Note: Software is not limited to above examples

250.190 Grounding of Equipment 1 kV and Over (High Voltage)

250.190 Grounding of Equipment

(A) Equipment Grounding

(B) Grounding Electrode Conductor

(C) Equipment Grounding Conductor

(1) General

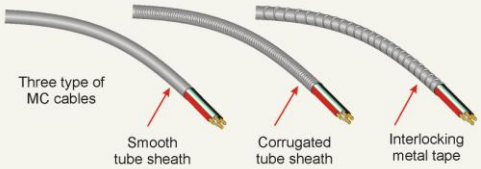
(2) Shielded Cables

(3) Sizing

- Requirements for grounding of equipment of systems and circuits of 1 kV and over (high voltage) have been revised and expanded

IMC Art. 342 and RMC Art. 344

250.118
Types of Equipment Grounding Conductors



MC cable listed and identified for grounding in accordance with the following:

a. The combined metallic sheath and grounding conductor of interlocked metal tape-type MC cable

b. The metallic sheath or the combined metallic sheath and grounding conductors of smooth or corrugated tube-type MC cable

Article 300

General Wiring Methods

Applicable to all wiring methods

Chapter 3 has Changed.

- Nonmetallic raceways have been split into four distinct Articles
- 352 PVC Schedule 40 and 80
- 353 HDPE Underground only
- 354 HDPE w. conductors Underground only
- 355 RTRC Fiber glass

Wiring Methods in Alphabetical Order

- The articles within each numbered group or range are arranged alphabetically.
- Cable methods Article 320 Type AC etc.
- Conduit Article 342 IMC etc
- Tubing Article 358 EMT etc.
- Other Article 366 Aux. Gutters etc.
- Article 392 Cable tray (not a wiring method a support system)

Chapter 3

- **Articles are divided into 7 groups according to material types covered.**
- **Articles 300 through 310 are general in nature.**
- **Articles 312 through 314 cover boxes and enclosures.**
- **Articles 320 through 340 include cables.**
- **Articles 342 through 356 cover conduits.**
- **Articles 358 through 362 cover tubings.**
- **Articles 366 through 390 cover other wiring methods.**
- **Articles 392 through 399 cover open wiring.**

Chapter 3 common Numbering

- XXX.1 SCOPE.
- XXX.2 DEFINITIONS
- XXX.6 LISTING REQUIREMENTS
- XXX.10 USES PERMITTED
- XXX.12 USES NOT PERMITTED
- XXX.30 SUPPORTS
- XXX.60 GROUNDING & BONDING
- XXX.100 CONSTRUCTION SPECIFICATIONS

300.4 (A) through (H)

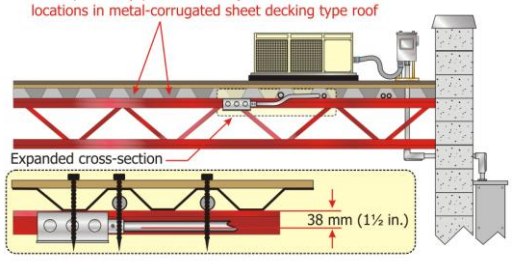
- Protection from physical damage
- (a) Protection through wooden bored holes
- (b) Protection through metal studs
- (c) Parallel to framing members
- (d) Behind spaces must be accessible and be supported
- (e) Shallow grooves
- (f) Bushing requirements
- (G) Insulated fittings
- (H) Structural Joints

Physical Protection

- **Article 332 Type MI Cable**
- **Article 342 IMC**
- **Article 344 RMC**
- **Article 352 RNC Schedule 80**
- **Article 355 RTRC XW**
- **Article 358 EMT (not Severe)**

300.4(E) Raceways, Boxes Under Roof Decking

Cables, raceways, or boxes not permitted to be installed in concealed locations in metal-corrugated sheet decking type roof



A cable, raceway, or box, installed in exposed or concealed locations under metal-corrugated sheet roof decking, shall be installed and supported so there is not less than 38 mm (1½ in.) measured from the lowest surface of the roof decking to the top of the cable, raceway, or box

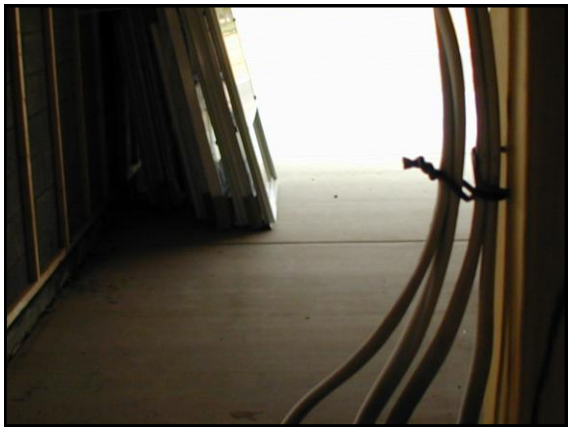
300.4(H) Structural Joints

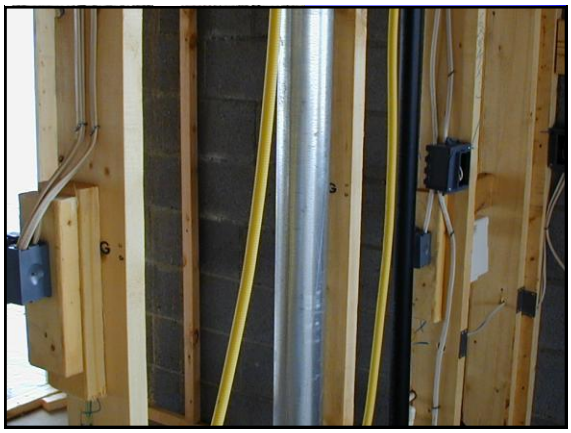
A new section (H) was added to 300.4 to cover expansion and deflection at a structural joint in a building or other structure

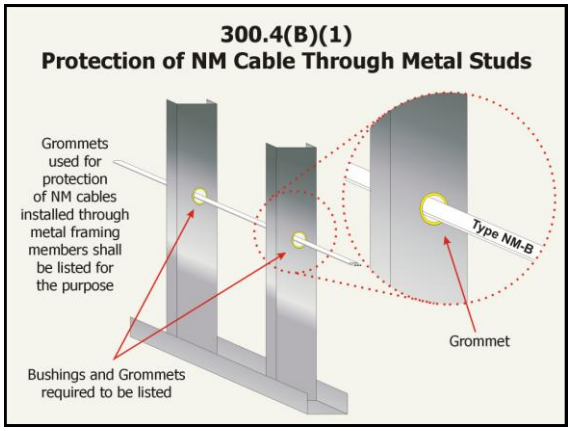
A listed expansion/deflection fitting or other approved means shall be used where a raceway crosses a structural joint intended for expansion, contraction or deflection, used in buildings, bridges, parking garages, or other structures

300.4 (H) Structural Joints

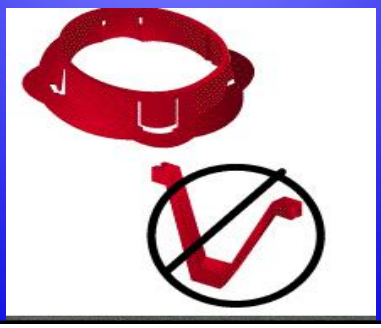
- **Expansion or Deflection fitting or other approved means Shall be used where a raceway crosses a structural joint intented for expansion, contraction or other deflection.**





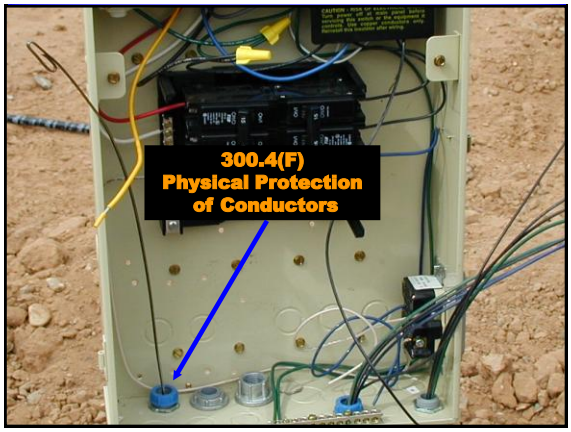

300.4(B)(1)
Protection of NM Cable Through Metal Studs
Grommets used for protection of NM cables installed through metal framing members shall be listed for the purpose
Type NM-B
Grommet
Bushings and Grommets required to be listed

300.4 (B)(1)




IEC Violations
hysical Damage 352.12(C)
ox Support 314.23

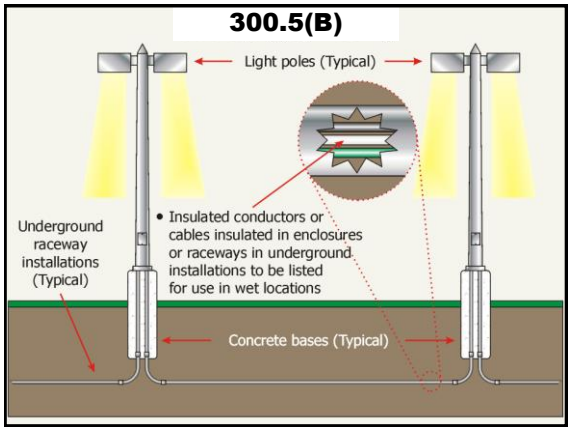

300.4(F)
Wire Protection

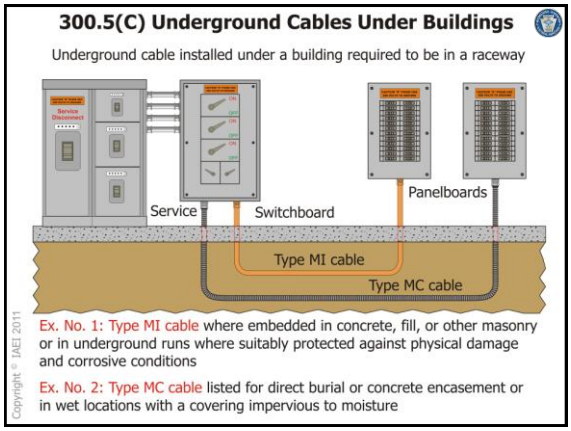


300.5

- Location of the wiring method
- Burial depths required Table 300.5
- Section 300.5 (A) through (K)
  - (A) Minimum cover
  - (B) wet Locations
  - (C) Under Buildings Installed in Raceways (NEW EX.
  - (D) Protection from Damage
  - (E) Splices & Taps
  - (F) Backfill material
  - (G) Seal equipment from moisture
  - (H) Bushings
  - (J) Ground Movement (bushing & S-loops)
  - (K) Directional Boring


Table 300.5
IMC and RMC
6 inches

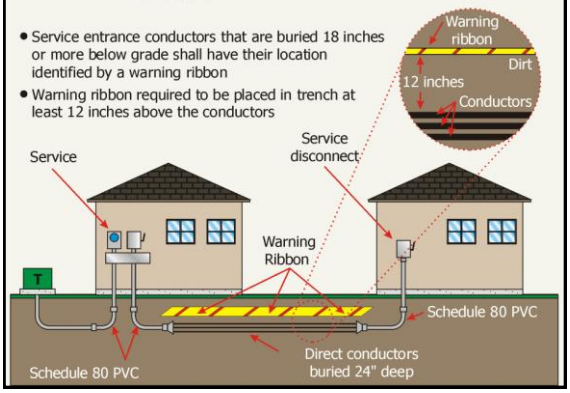

300.5(B)
Light poles (Typical)
Underground raceway installations (Typical)
• Insulated conductors or cables insulated in enclosures or raceways in underground installations to be listed for use in wet locations
Concrete bases (Typical)


300.5(C) Underground Cables Under Buildings
Underground cable installed under a building required to be in a raceway
Service
Switchboard
Panelboards
Type MI cable
Type MC cable
Ex. No. 1: Type MI cable where embedded in concrete, fill, or other masonry or in underground runs where suitably protected against physical damage and corrosive conditions
Ex. No. 2: Type MC cable listed for direct burial or concrete encasement or in wet locations with a covering impervious to moisture
Copyright © IAEI 2011


480 VOLTS
480 VOLTS
480 VOLTS

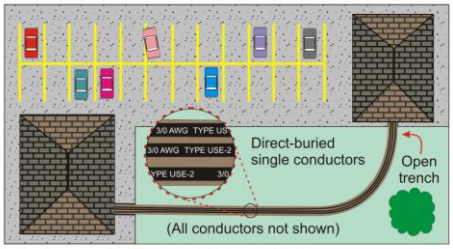
300.5(D)(3) Protection from Damage

- Service entrance conductors that are buried 18 inches or more below grade shall have their location identified by a warning ribbon
- Warning ribbon required to be placed in trench at least 12 inches above the conductors



300.5(I) Ex. No. 1 Underground Installations

All conductors of the same circuit typically required to be installed in the same raceway or cable or in close proximity in the same trench



Conductors permitted to be installed in parallel in raceways, multi-conductor cables, or direct-buried single-conductor cables

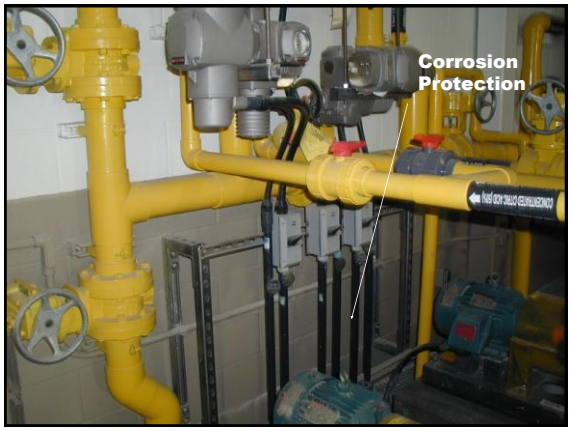
Each direct-buried single-conductor cable permitted in close proximity in a trench to the other single-conductor cables in the same parallel set of conductors in the circuit

Directional Boring Equipment

300.5(K)

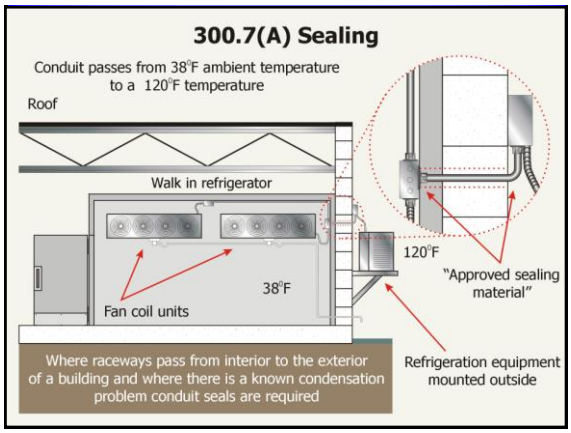
300.6 (A) - (C)

- Protection against Corrosion (all wiring methods)
- (a) General
- (b) in concrete or in direct contact with earth
- (c) indoor wet locations



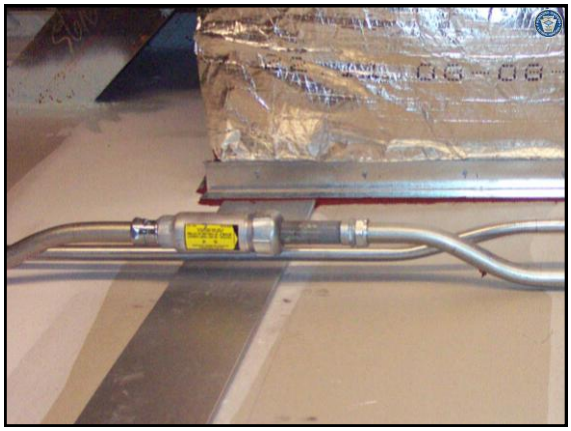
300.7

- Raceways exposed to different temperatures
- (a) Sealing
- (b) Expansion
  - 352.44
  - Tables 352.44(A) and (B)


300.7(A) Sealing
Conduit passes from 38°F ambient temperature to a 120°F temperature
Roof
Walk in refrigerator
120°F
"Approved sealing material"
38°F
Fan coil units
Where raceways pass from interior to the exterior of a building and where there is a known condensation problem conduit seals are required
Refrigeration equipment mounted outside


Seal required


Expansion Fittings

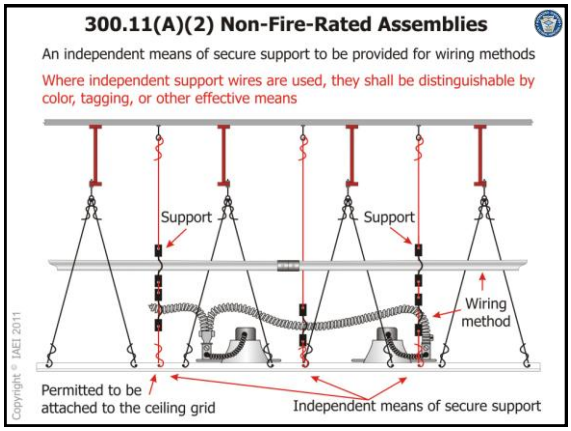


300.10. Electrical Continuity of Metal Raceways and Enclosures

Metallic wiring methods are also required to provide electrical continuity and bonded to available grounds to minimize shock hazard.

300.11(A)(2) Non-Fire-Rated Assemblies

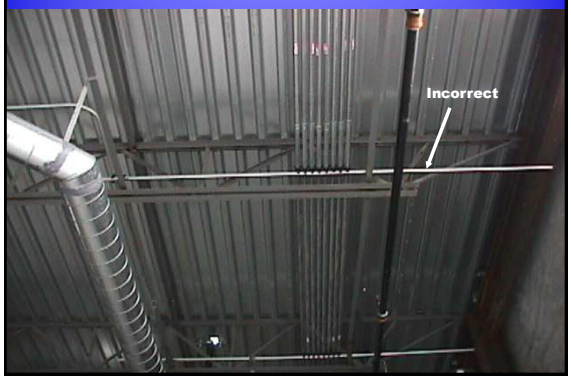
- New language was added requiring identification of independent wiring method support ceiling wires in non-fire-rated assemblies
- Previous language only required additional wiring method support wires to be distinguishably marked for fire-rated assemblies
- Acceptable identification methods could

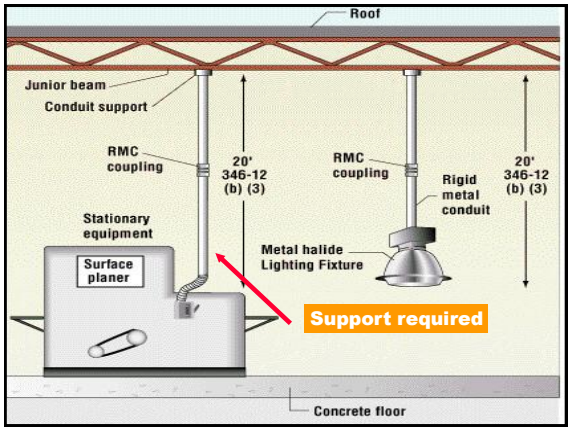


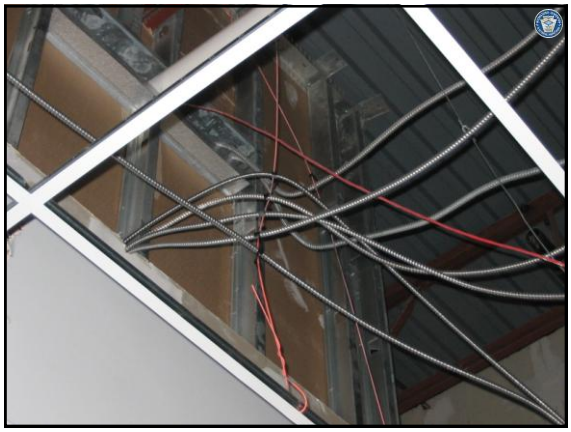
300.11. Securing and Supporting

Each wiring method contains specific support Requirements i.e. ART. 358 EMT requires within 3 Ft (900mm) of all terminations (boxes & conduit bodies) and every 10 ft (3.0m).

Not just support but Proper Support!







- ***300.12. Mechanical Continuity — Raceways and Cables Metallic and Nonmetallic***

The integrity of the system requires that all wiring methods be continuous and made-up properly to provide the conductors mechanically protection.

300.15.

Boxes, Conduit Bodies, or Fittings — at all splices and joints, where Required

300.17. Number and Size of Conductors in Raceway

The number and size of conductors in any raceway shall not be more than will permit dissipation of the heat and ready installation or withdrawal of the conductors without damage to the conductors or to their insulation.

300.18. Raceway Installations

(a) Complete Runs. Raceways, Ex. busways or exposed raceways having hinged or removable covers, shall be installed complete between outlet, junction, or splicing points Before installing conductors.

(b) Welding. Metal raceways shall not be welded designed to be or specifically permitted to be in this Code.

SP Products "Quick Pipe" block prevents roof damage

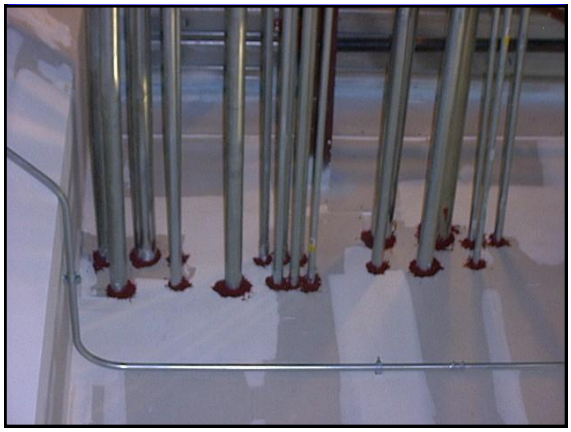
NEC 300.21

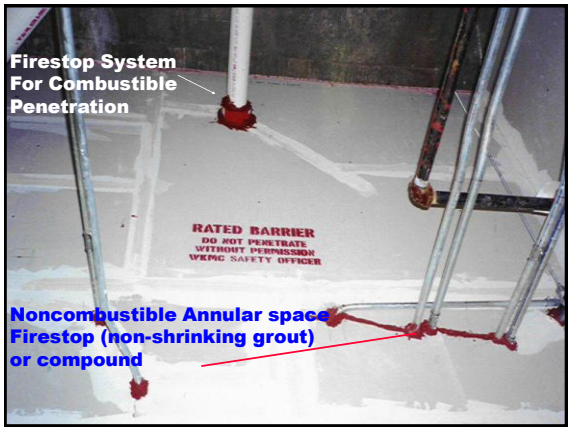
- **Spread of Fire and products of combustion**
- **Electrical installations in hollow spaces, vertical shafts, and ventilation or air-handling ducts shall be made so that the possible spread of fire or products of combustion will not be substantially increased. Openings around electrical penetrations through fire-resistant-rated walls, partitions, floors, or ceilings shall be firestopped using approved methods to maintain the fire resistance rating.**
- **FPN: Directories of electrical construction materials published by qualified testing laboratories contain many listing installation restrictions necessary to maintain the fire-resistive rating of assemblies where penetrations or openings are made. An example is the 24-in. (610-mm) minimum horizontal separation that usually applies between boxes on opposite sides of the wall. Assistance in complying with 300.21 can be found in these directories and product listings.**

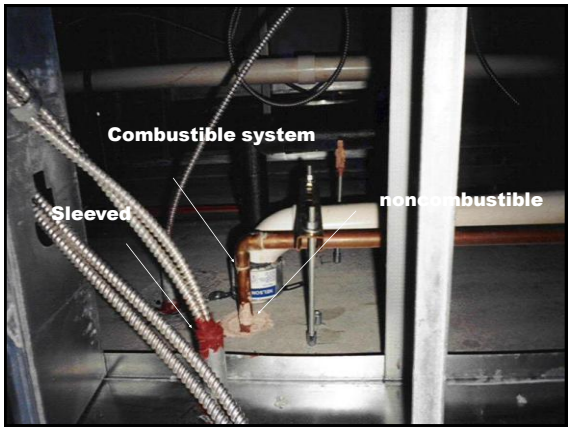
Installing Combustible Wiring Methods; Not so easy!

You Must Follow the NEC + Local Amendments + Building Codes + National Evaluation reports + Testing Laboratories Special Requirements, If you don't :

- **Increased Liability.**
- **Inspector Headaches.**
- **Even Finding Out The Rules Can Be Tough.**




Firestop System
For Combustible
Penetration
RATED BARRIER
DO NOT PENETRATE
WITHOUT PERMISSION
WRMC SAFETY OFFICER
Noncombustible Annular space
Firestop (non-shrinking grout)
or compound


Combustible system
Sleeved
noncombustible

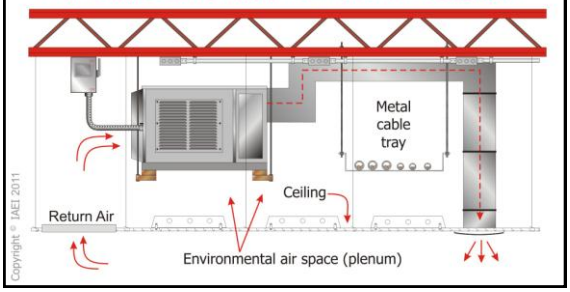
300.22(A) - (D)

- (A) ducts for dust loose stock or vapor removal
- (B) ducts for environmental air
- (C) other spaces used for environmental air
- (D) data processing

300.22 Wiring in Environmental Air Space

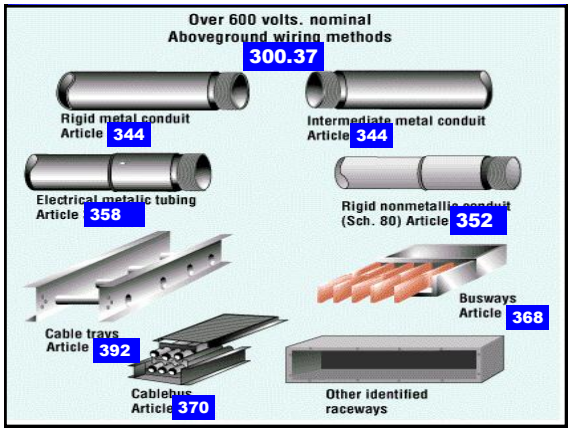
Section 300.22 was rewritten to simplify the requirements based on the areas of installation, and new 300.22(C)(2) was inserted to cover cable trays in other spaces for environmental air (plenums)

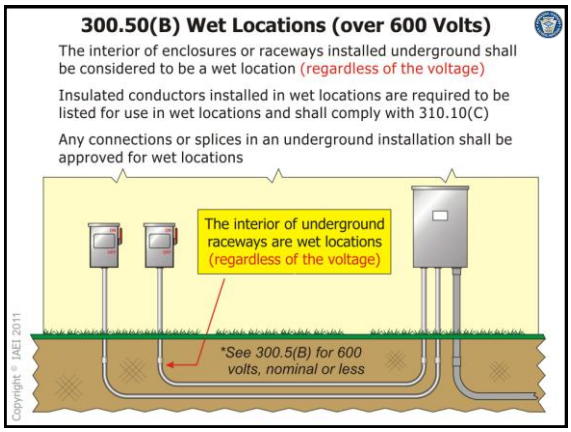
Metal cable trays permitted to support the wiring methods in 300.22(C)(1)



300 Part II

- **Wiring Method Requirements for over 600 volt installations**
- **300.37 Above ground**
- **300.50 Underground installations**



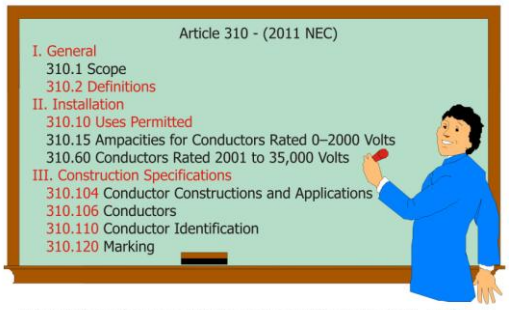


General Requirements

- Location
- Temperature
- Corrosion & Reagent
- Fire rated buildings
- Hazardous Locations

If we don't, we violate 90.7 & 110.3b

Article 310 - Conductors for General Wiring



Article 310 received and extensive reorganization for the 2011 *NEC* in an effort to comply with the *NEC* Style Manual and provide consistency with other *NEC* Chapter 3 articles

Article 310 Ampacity Tables

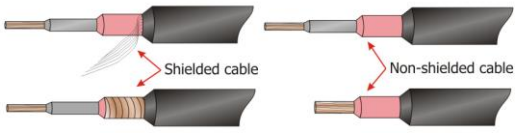
- All tables located within Article 310 were renumbered in the 2011 *NEC*
- Article 310 *(Conductors for General Wiring)* went through extensive reorganization for the 2011 *NEC*
- This reorganization had an extreme impact on the tables within the article as well
- This was an effort to bring the table numbering in line with the *NEC* Style

Article 310 Tables Comparison Chart

2008 NEC	Table Title	2011 NEC
310.15(B)(2)(a)	Adjustment Factors for More Than Three Current-Conductor in a Raceway or Cable	310.15(B)(3)(a)
310.15(B)(2)(c)	Ambient Temperature Adjustment for Conduits Exposed to Sunlight On or Above Rooftops	310.15(B)(3)(c)
310.15(B)(6)	Conductor Types and Sizes for 120/240-Volt, ~~3-Wire~~, Single-Phase Dwelling Services and Feeders	310.15(B)(7)
310.16	Allowable Ampacities of Insulated Conductors Rated Up to and Including 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)	310.15(B)(16)
310.16 *(bottom of Table)*	Ambient Temperature Correction Factors Based on 30°C (86°F)	310.15(B)(2)(a)
(Not in '08 NEC)	Ambient Temperature Correction Factors	310.60(C)(4)
310.68	Ampacities of Insulated Single Aluminum Conductor Cables Triplexed in Air Based on Conductor Temperatures of 90°C (194°F) and 105°C (221°F) and Ambient Air Temperature of 40°C (104°F)	310.60(C)(68)

Article 310 Table Comparison Chart (in part)

310.10(E) Shielding of Conductors



Shielded cable generally required for voltages greater than 2000 volts

Non-shielded, ozone-resistant insulated conductors permitted in Type MC cables
- Maximum phase-to-phase voltage of 5000 volts
- Industrial establishments only where the conditions of maintenance and supervision ensure that only qualified persons service the installation

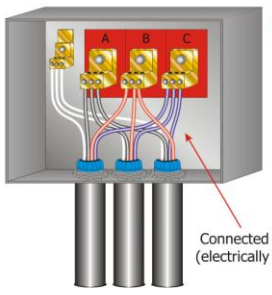
Non-shielded cable permitted for use with the following:
- Maximum 2400 volts listed by qualified testing laboratory (Ex. No. 1)
- Replacement of existing nonshielded conductors (up to 5000 volts with existing equipment in industrial establishments only) (Ex. No. 2)
- Airfield lighting cable (series circuits up to 5000 volts powered by regulators) (Ex. No. 3)

310.10(H)(1) Conductors in Parallel

- Revisions were made to the parallel conductors rules found at 310.10(H)(1) *[previously 310.4(A)]* pertaining to the minimum size conductors permitted to be run in parallel
- Previous language stated that conductors "1/0 AWG and larger shall be permitted" to be run in parallel
- The words "shall be permitted" did not act

310.10(H)(1) Conductors in Parallel

Only conductors in sizes 1/0 AWG and larger, comprising each phase, polarity, neutral, or grounded circuit conductor shall be connected in parallel



Where conductors of size 1/0 and larger are installed in parallel, must be installed as follows:

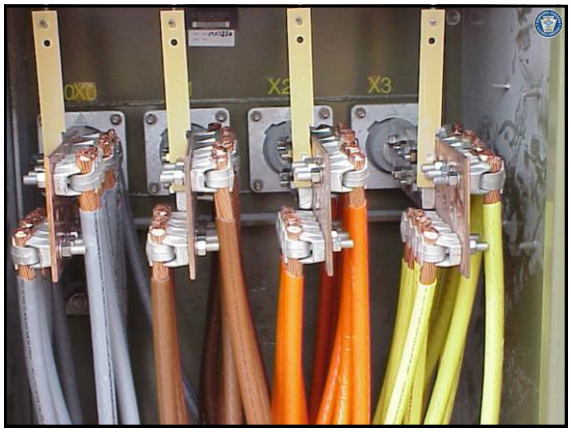
(1) Same length

(2) Consist of same conductor material

(3) Same circular mil area

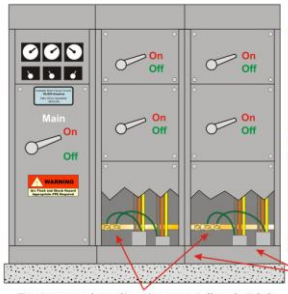
(4) Same insulation type

(5) Terminated in same manner



310.10(H)(6) EBJs Installed in Parallel

Where parallel equipment bonding jumpers are installed in raceways, they are required to be sized and installed in accordance with 250.102



Size supply-side bonding jumper for each raceway or cable from Table 250.66 based on size of ungrounded supply conductors in each raceway or cable [250.102(C)(1) and (C)(2)]

Size equipment bonding jumpers (load side) in accordance with 250.122 (overcurrent device ahead of equipment) [250.122(D)]

Feeders (installed in parallel)

Equipment bonding jumpers (load side)

Temperature Correction Factors Based on 30°C (86°F)

- The ambient temperature correction factor table has been relocated from the bottom of previous Table 310.16 to a new Table 310.15(B)(2)(a)
- Temperature correction factors needed and will now have there own table
- All temperature applications now at one location as the other temperature correction factor tables previously located at the bottom of the other allowable ampacity tables were relocated to new Table 310.15(B)(2)(b)

Table 310.15(B)(2)(a) Temperature Correction Factors

Ambient Temperature Correction Factors Based on 30°C (86°F)

For ambient temperatures other than 30°C (86°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)
	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

Factors for More Than Three Current-Carrying Conductors in a Raceway or Cable

- Table 310.15(B)(3)(a) [formally Table 310.15(B)(2)(a)] contains requirements for adjustment or derating of conductors where the number of current-carrying conductors in a raceway or cable exceeds three
- The first column heading has been changed from "Number of Current-Carrying Conductors" to "Number of Conductors"
- This will take into account "spare" conductors that might be installed in raceways for future

Table 310.15(B)(3)(a) Adjustment Factors for More Than Three Current-Carrying Conductors in a Raceway or Cable

Number of Conductors[1]	Percent of Values in Tables 310.15(B)(16) through 310.15(B)(19) as Adjusted for Ambient Temperature if Necessary
4-6	80
7-9	70
10-20	50
21-30	45
31-40	40
41 and above	35

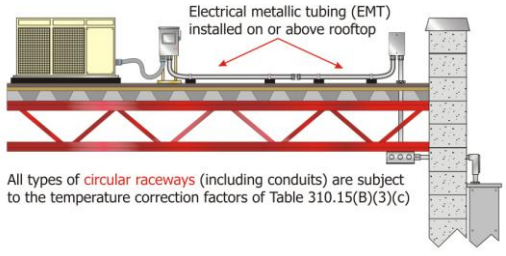
[1]Number of Conductors is the total number of conductors in the raceway or cable adjusted in accordance with 310.15(B)(5) and (6).

310.15(B)(3)(c) Circular Raceways Exposed to Sunlight on Rooftops

- Revisions were added to require all types of circular raceways to temperature correction factors of 310.15(B)(3)(c) *(not just conduits)*
- Previous language required conductors or cables installed in conduits exposed to direct sunlight on or above rooftops to be subject to these correction factors
- The term "conduit" was changed to "circular raceway" to indicate that all types of circular raceways are subject to these temperature correction factors

310.15(B)(3)(c) Circular Raceways on Rooftops

Conductors or cables installed in circular raceways exposed to direct sunlight on or above rooftops require adjustments shown in Table 310.15(B)(3)(c)



All types of circular raceways (including conduits) are subject to the temperature correction factors of Table 310.15(B)(3)(c)

Chapter 3
Wiring Methods

- **There are different wiring methods From Article 320 to 398**
- **Article 392 Cable Tray *Is not* a wiring method**

WIRING CATEGORIES

- **Residential**
- **Commercial**
- **Institutional**
- **Industrial**
- **Special Occupancies**

Residential

- **Nonmetallic sheath cable** Art. 334
- **Armor Cable (AC or BX)** Art. 320
- **Metalclad Cable (MC)** Art. 330
- **Electrical Metallic Tubing** Art. 358

And

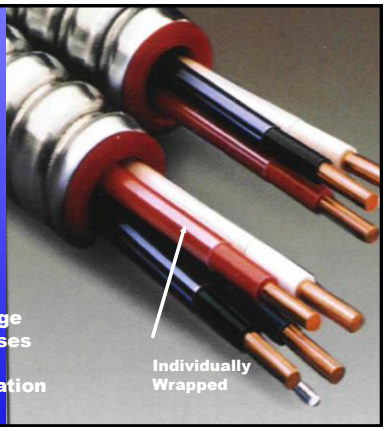
Other wiring methods 600 volt, i.e.

- Art. 344 Galv. Rigid - Mast
- Art. 340 Type UF cable outdoor underground
- Art. 348, 350, 351, 356 & 360 for flexible connections
- Art. 338 SER for feeders, range and dryer

Art. 320

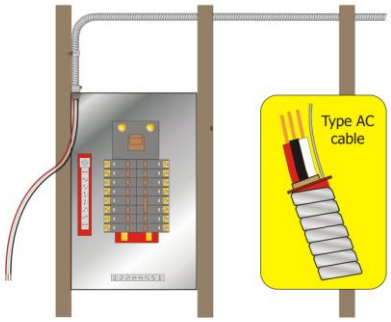
AC Cable

- Dry Locations
- Protect from Physical Damage & corrosive gases
- Limited application

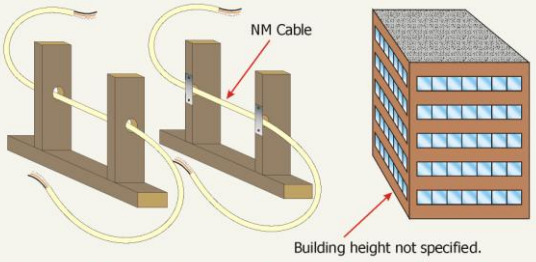


320.2 Definition: Type AC Cable

Armored Cable, Type AC - A fabricated assembly of insulated conductors in a flexible interlocked metallic armor (See 320.100)



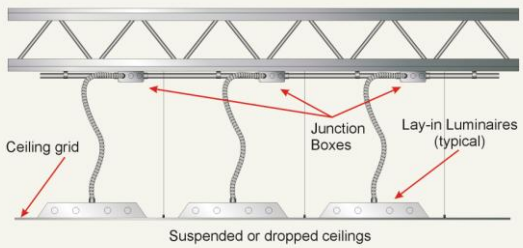
334.10 Uses Permitted
Uses Permitted for Nonmetallic Sheathed Cable



Permitted for multifamily dwellings of Types III, IV, and V construction except as prohibited by 334.12

Permitted in other buildings of Types III, IV, or V construction under certain conditions

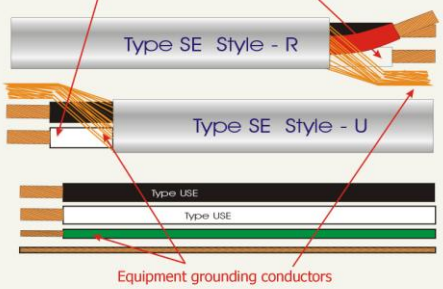
334.12(A)(1)
Uses Not Permitted for Nonmetallic Sheathed Cables



Nonmetallic sheathed cable not permitted as open runs in suspended or dropped ceilings in other than one- and two-family dwellings

338.10(B) Branch Circuits or Feeders

Grounded conductor required to be insulated unless permitted in accordance with 250.140

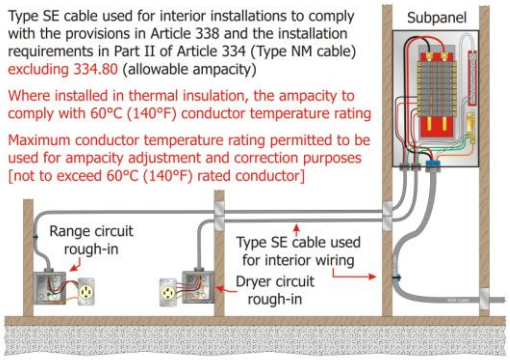


338.10(B)(4)(a) Uses Permitted - Type SE Cable

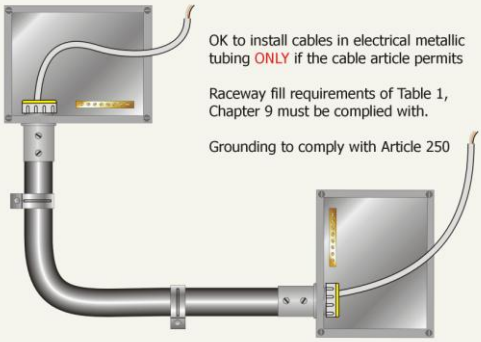
Type SE cable used for interior installations to comply with the provisions in Article 338 and the installation requirements in Part II of Article 334 (Type NM cable) excluding 334.80 (allowable ampacity)

Where installed in thermal insulation, the ampacity to comply with 60°C (140°F) conductor temperature rating

Maximum conductor temperature rating permitted to be used for ampacity adjustment and correction purposes [not to exceed 60°C (140°F) rated conductor]



358.22 Cables in Electrical Metallic Tubing



OK to install cables in electrical metallic tubing ONLY if the cable article permits

Raceway fill requirements of Table 1, Chapter 9 must be complied with.

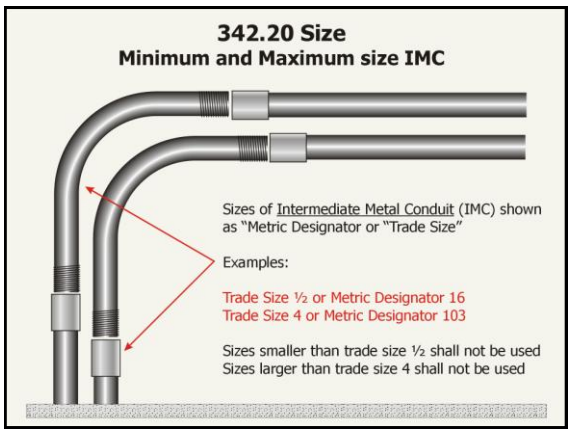
Grounding to comply with Article 250

Commercial – Institutional Industrial

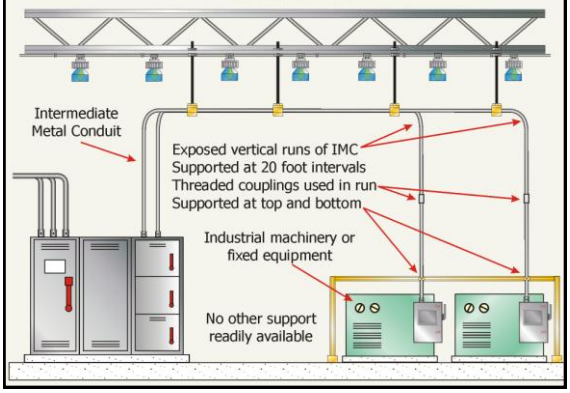
- All wiring methods above and below 600 volts.

328.14 Medium Voltage Cable: Type MV

- Type MV cable is now required to be installed, terminated and tested by qualified persons
- Type MV cable installations have typically been under the authority of licensed utilities (typically above 600 volts), and under the supervision of the engineering community
- New language should heighten the awareness to installers and AHJs



342.30(B)(3) Supports

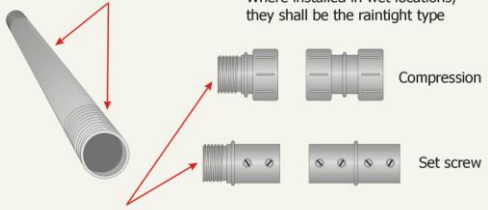


342.42(A) Threadless

Intermediate metal conduit with threads

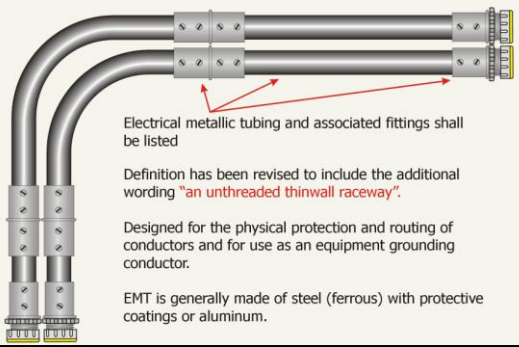
Where buried in masonry or concrete, they shall be the concretetight type

Where installed in wet locations, they shall be the raintight type



Threadless, threadless couplings and connectors shall not be used on threaded ends unless listed for the purpose.

358.2 Definition of EMT Electrical Metallic Tubing



Electrical metallic tubing and associated fittings shall be listed

Definition has been revised to include the additional wording "an unthreaded thinwall raceway".

Designed for the physical protection and routing of conductors and for use as an equipment grounding conductor.

EMT is generally made of steel (ferrous) with protective coatings or aluminum.

Art. 330 Type MC Cable

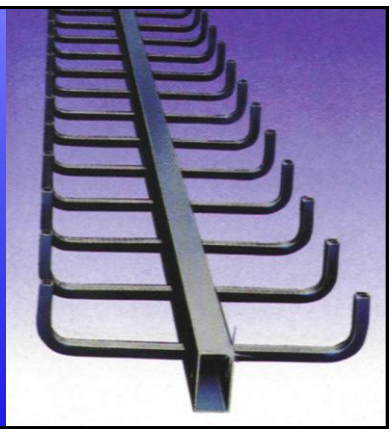
- There are many different products designed specifically for different applications
- generally not acceptable in Healthcare 517.13(B)

Art. 392 Cable Tray

- Not required to be listed
- Not a wiring Method – Designed for support

Art. 392 Cable Tray

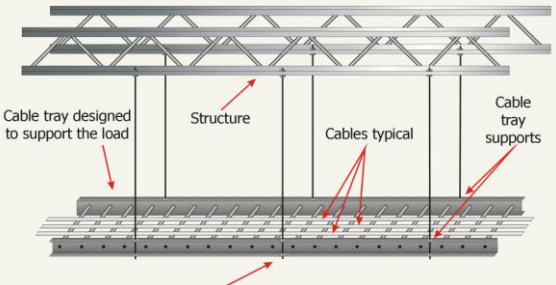
There are many Types designed for specific and Limited support Applications.



392.3 Uses Permitted

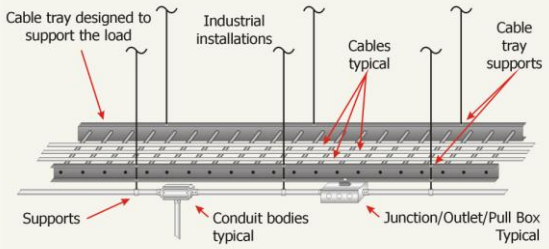
Cable tray and fittings identified for the intended use

392.6(C) Support for Cable Trays



Cable trays must be supported at intervals per the manufacturer's instructions

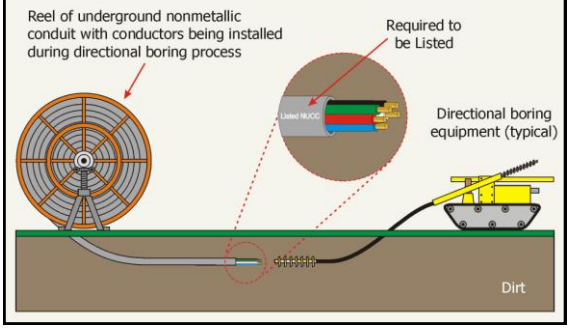
392.6(J)
Raceways, Cables and Boxes Supported from Cable Tray System



The change recognizes that boxes, outlet boxes, conduit bodies are permitted to be supported by properly supported cable tray. This eliminates the limitation to just outlet boxes.

354.100(B) Construction - Type - NUCC

- Underground nonmetallic conduit or underground nonmetallic conduit with conductors or cables shall be listed for the purpose.



Directional Boring Equipment

Flexible wiring Methods

- Article 348, 350 and Article 356
- Article 360 is special!

Special Occupancies

- Article 500 through 516 Hazardous (Classified)
- Article 517 Healthcare Facilities
- Article 518 Places of Assembly
- Article 520 Theaters
- Article 525 Carnivals
- Article 547 Agricultural Buildings
- Article 550 Manufactured Homes
- Article 555 Marinas & Boatyards
- Chapters 6 and 7 also contain special wiring method requirements

- *Thanks to those that contributed pictures and slides to make this presentation.*
- *IAEI (International Assn of Electrical Inspectors)*
- *IBEW LU 291 Boise Idaho*
- *Michael Johnston (NECA)*

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