Board of Building Standards

ELECTRICAL SAFETY INSPECTOR ADVISORY COMMITTEE
REQUEST FOR RECOMMENDATIONS

DATE: MARCH 15, 2024
TIME: 10:00 AM
LOCATION: NO MEETING THIS MONTH

Personnel Certification Applications

P-1 Benson, John - ESI
Certification ID: 96
Current Certifications: None
Staff notes - Additional information on electrical experience submitted, please review.
ESIAC Recommendations:
Committee Recommendation:

Continuing Education Applications for Review

ER-1 Appliances (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)
All certifications (4 hours)
Staff Notes: Number of slides is small for a four-hour course because of the math.
ESIAC Recommendations:
Committee Recommendation:

ER-2 Box Fill (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)
All certifications (4 hours)
Staff Notes:
ESIAC Recommendations:
Committee Recommendation:

ER-3 Conductor Types, Ampacities, and Correction Factors (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)
All certifications (4 hours)
Staff Notes:
ESIAC Recommendations:
Committee Recommendation:

ER-4 Dwelling Circuit Requirements (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)
All certifications (4 hours)
Staff Notes:
ESIAC Recommendations:
Committee Recommendation:

ER-5 Grounding and Bonding (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)
All certifications (4 hours)
Staff Notes:
ESIAC Recommendations:
Committee Recommendation:

ER-6 Practical NEC 2023 Training (Pool LLC)
All certifications (10 hours)
Staff Notes: Title amended with permission of the provider.
ESIAC Recommendations:
Committee Recommendation:

ER-7 Voltage Drop (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)
All certifications (4 hours)
Staff Notes: Number of slides is small for a four-hour course because of the math.
ESIAC Recommendations:
Committee Recommendation:

File Attachments for Item:

P-1 Benson, John - ESI

Certification ID: 96

Current Certifications: None

Staff notes - Additional information on electrical experience submitted, please review.

ESIAC Recommendations:

Committee Recommendation:

Board of Building Standards Application for Interim Certification, Building Department Personnel

Benson	John	96
Last Name	*First Name*	*BBS Certification ID*

SECTION 1: CHECK INTERIM CERTIFICATION(S) BEING REQUESTED

☒ Building Official RBO	☐ Master Plans Examiner	☐ Building Inspector	☒ Electrical Safety Inspector	☐ Fire Protection Inspector
☐ Building Plans Examiner	☐ Plumbing Plans Examiner	☐ Mechanical Plans Examiner	☐ Electrical Plans Examiner	☐ Fire Protection Plans Examiner
	☐ Plumbing Inspector	☐ Mechanical Inspector	☐ Non-Residential Industrial Unit Inspector	

SECTION 2: LIST ANY OHIO LICENSE, CERTIFICATE, OR REGISTRATION HELD
(Mark "T" If Trainee)

Description			Certificate Number	Date Received
Architectural Registration				
P.E. Registration				
Res	Non-Res			
☒	☐	Building Official Certification	96	2007 2018
☐	☐	Plans Examiner Certification		2010
☒	☒	Building Inspector Certification		
☐	☐	Mechanical Inspector Certification		
Building Plans Examiner Certification				
Mechanical Plans Examiner Certification				
Fire Protection Plans Examiner Certification				
Electrical Plans Examiner Certification				
Plumbing Plans Examiner Certification				
Fire Protection Inspector Certification				
Electrical Safety Inspector Certification				
Plumbing Inspector Certification				
Fire Safety Inspector Certification			96	1987
Fire Protection System Designer Certification				
~~Medical Gas Piping Inspector Certification~~			10553	2013

BACKFLOW CERTIFICATION

BENSON | JOHN | 96

Last Name | First Name | BBS Certification ID

SECTION 3: EMPLOYMENT/EDUCATION

Formal Education	Date Graduated
W M HIGH SCHOOL	76
LIBERTY UNIVERSITY	76 - 78
Related Vocational or Technical Training	**Years' Experience**
ELECTRICAL JOURNEYMAN VOC.	30 YEARS
BACKFLOW CERTIFICATION	10 YEARS
U.S. Military construction experience (MOS or other designation):	**Years' Experience**
Place of Employment:	**Years' Employed**
CITY OF ZANESVILLE	44 YEARS
PETRA CONSTRUCTION	28 YEARS

SECTION 4: APPLICANTS REQUESTING MEDICAL GAS INSPECTOR CERTIFICATION

Attach proof *of certification by an ASSE recognized third-party certifier in accordance with ASSE standard 6020.*

SECTION 5: OBC BUILDING INSPECTION EXPERIENCE PERFORMED FOR A BBS CERTIFIED BUILDING DEPARTMENT

BBS Certified Building Department	BBS Certified Position/Title	Duties	Date of Service, Length of Time (MM/DD/YY)
ZANESVILLE	BI X3	BACKUP FOR BI	2001 - 2021
ZFD	1	FIRE SAFETY INSP.	1998 - 2007

BENSON (Last Name) JOHN (First Name) 96 (BBS Certification ID)

SECTION 6: ELECTRICAL SAFETY INSPECTOR (ESI) - SPECIFIC EXPERIENCE QUALIFICATIONS

Applicants for Electrical Safety Inspector Only Must Complete This Item

Section 3783 of the Ohio Revised Code specifies that an applicant for a Certificate of Competency as an Electrical Safety Inspector must meet on of the following to qualify to take required examination. Please check the qualification that applies:

1. ☒ Have been a journeyman electrician or equivalent for four years, two of which were as an electrician foreman, and have had two years' experience as a building department electrical inspector trainee;
2. ☒ Have been a journeyman electrician or equivalent for four years and have had three years' experience as a building department electrical inspector trainee;
3. ☐ Have had for four years' experience as a building department electrical inspector trainee;
4. ☒ Have been a journeyman electrician or equivalent for six years;
5. ☐ Am a graduate electrical engineer and registered in the State of Ohio. Registration number: _____
6. ☐ Applicant authorizes all testing organizations including ICC to provide test results to the BBS.

SECTION 7: EXPERIENCE *(DO NOT SUBSTITUTE WITH OTHER RESUMES)*.

Refer to Experience Requirements Listed in O.A.C. 4101:7-3-01 and O.R.C. 3783

Below, list the specific projects you worked on, and the specific work you performed, your typical duties for each project, and dates of this work. You **must** demonstrate that you have the required number of months (years) of actual, practical experience for the certification requested (see matrix).

Provide letters from certified inspectors, employers, or contractors verifying your experience. Submit copies of any certificates, diplomas, or licenses. Remove all personal information.

SECTION 7 CONT.: EXPERIENCE

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
Example: *Children's Hospital, Toledo* *Structural steel work on addition*	*Homer Steel and Trade* *125 Anytown Street* *My City, OH, 45454* *(419)555-1212*	*July 2013-May 2014* *(10 months)*
ZANESVILLE FIRE DEPT	CITY OF ZANESVILLE 401 MARKET ST. ZANES. OH 43701	1981- 2007
PETRA CONST. CO CONSTRUCTION RESID + COMM.	PETRA CONST. CO P.O. BOX 611 ZANES. OH 43702	
Total Experience on This Page (In Months):		

Board of Building Standards Application for Interim Certification, Building Department Personnel

Last Name	First Name	BBS Certification ID
BENSON	JOHN	96

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
BUILDING MAINTENEE 28 BUILDINGS MAINTENANCE/ HVAC / ECECTAIC PLUMBING / BUILDING SUPERINTENDENT	CITY OF ZANESVILLE 401 MARKET ST ZANES OH 43701	1998 - 2013
BUILDING & CODE DEPARTMENT CODE OFFICER BUILDING INSP. RESIDENTIAL + Com	11 11	2013 TO PRESENT
	Total Experience on This Page (In Months):	

Last Name	First Name	BBS Certification ID
BENSON	JOHN	96

SECTION 8: PERSONAL HISTORY

1. Have you ever been convicted of any felony, or any crime involving moral turpitude? ☐ Yes ☒ No

   If you answered "Yes" please explain below:
2. Have you served in the U.S. armed services? (If No, skip question 3) ☐ Yes ☐ No
3. If YES, were you discharged under honorable conditions? ☐ Yes ☒ No

   If you answered "No" please explain below:

SECTION 9: CERTIFICATION

I certify the information contained in this application is true and complete, and I understand that providing false information may be grounds for not granting certification or for immediate termination of certification at any point in the future, if granted. I authorize the investigation of all statements contained herein and release all parties from all liability for any damage that may result from furnishing the same to Ohio Board of Building Standards. Falsification is a violation of section 2921.13 of the Ohio Revised Code and is punishable as a misdemeanor of the first degree.

Signature of Applicant: [signature]

Subscribed and duly sworn before me according to law, by the above named applicant this day 1st of February in the year 2024 at Muskingum, County of Muskingum and State of OHIO

Notary Public: Krista D Bonnett

SEAL

NOTARIAL SEAL STATE OF OHIO

KRISTA D. BONNETT
NOTARY PUBLIC
FOR THE
STATE OF OHIO
My Commission Expires
2/10/2025

ICC INTERNATIONAL CODE COUNCIL®

INTERNATIONAL CODE COUNCIL

JOHN BENSON

The International Code Council attests that the individual named on this certificate has satisfactorily demonstrated knowledge as required by the International Code Council by successfully completing the prescribed written examination based on codes and standards then in effect, and is hereby issued this certification as:

Commercial Building Inspector

Given this day April 29, 2023

Certificate No. 8417098

Stuart Tom, P.E., CBO, FIAE
President, Board of Directors

Dominic Sims, CBO
Chief Executive Officer

INTERNATIONAL CODE COUNCIL, INC. CERTIFIED

This certificate is the property of ICC and must be returned to ICC in the event of suspension or revocation of the certificate.

Jones, Amy

From: John Benson <John.Benson@coz.org>
Sent: Wednesday, February 28, 2024 10:13 AM
To: Jones, Amy
Subject: Emailing: certificate-B2-8417098
Attachments: certificate-B2-8417098.pdf

Amy,
We are currently renewing our Tyler Energov Data base and everything is mixed up as to locations in the system. Once we find numbers and certificates ,I will send them.
I thought I detailed my electrical experience but if not, a synopsis of my past is this: When I got out of college in 1978 I worked at Brockway Glass in the labor pool with Mill Rights. I was assigned to work with Electricians, Carpenters, Block layers, Machinists or wherever I was needed for the plant. I was hired by the city in 1981 at the fire department. I worked and operated a construction company on my days off with up to 14 employees and multiple Sub contractors and did custom homes and commercial work till 2001. I was the Building Department Superintendent for the City from 2001 till 2013. We maintained the 28 buildings for the city including all electrical systems. I got my Journeyman license in 2009 along with my NCCER certificate. I taught Electricity I & II for Adults at Mid-East Career and Technology Center here in Zanesville . I previously have had my Backflow Certification through the state. Once we are back online I will attempt to send your validation.

John Benson
City of Zanesville
Your message is ready to be sent with the following file or link attachments.

certificate-B2-8417098

NCCER

The Standard for Developing Craft Professionals

This is to certify that

John Benson

has fulfilled the requirements to serve as a

Electrical Instructor

in NCCER's standardized training curriculum
this Twenty-first day of September, 2012

The Standard for Developing Craft Professionals
Founded 1996

Donald E. Whyte

Donald E. Whyte
President, NCCER

THE CITY OF
Zanesville

401 Market Street • Zanesville, Ohio 43701
Phone (740) 455-0646 • Fax (740) 455-0642
E-mail • buildingcode@coz.org

Council-Mayor Government
Don Mason, Mayor

Department of Public Safety
Division of Building and Code Enforcement

License/Registration

This Certifies that JOHN BENSON
JOHN BENSON
5205 BELLVIEW DR
ZANESVILLE OH, 43701

Is granted a License/Registration to work in the City of Zanesville corporate limits as an
JOURNEYMAN ELECTRICIAN

For a period from 12/29/2023 to 12/31/2024, unless sooner revoked on proof of

cause. This License/Registration is not transferable.

12/29/2023

License or Registration #926

M. Nykiel

For Safety Director

Laminate for Wallet

CITY OF ZANESVILLE
LICENSE / REGISTRATION

JOHN BENSON
JOURNEYMAN ELECTRICIAN
LIC#926
EXPIRES: 12/31/2024

M Nykiel

FOR SAFETY DIRECTOR

ICC INTERNATIONAL CODE COUNCIL®

INTERNATIONAL CODE COUNCIL

JOHN BENSON

The International Code Council attests that the individual named on this certificate has satisfactorily demonstrated knowledge as required by the International Code Council by successfully completing the prescribed written examination based on codes and standards then in effect, and is hereby issued this certification as:

Commercial Building Inspector

Given this day April 29, 2023

Certificate No. 8417098

Michael Wich, CBO
President, Board of Directors

Dominic Sims, CBO
Chief Executive Officer

This certificate is the property of ICC and must be returned to ICC in the event of suspension or revocation of the certificate.

[redacted]

4/08/14

APPLICATION

FOR

CERTIFICATION OF BUILDING DEPARTMENT PERSONNEL

This application is hereby submitted to the Board of Building Standards pursuant to the provisions of Section 3781.10 of the Ohio Revised and Section 103 of the OBC.

Board of Building Standards
6606 Tussing Road, P.O. Box 4009
Reynoldsburg, Ohio 43068-9009
(614) 644-2613 Fax (614) 644-3147
dic bbs@com.state.oh.us
www.com.ohio.gov/dico/BBS.aspx

1. APPLICANT

Name: JOHN B BENSON

H[redacted]
Ci
Co
E-
De

2. SPECIFIC CERTIFICATE(S) BEING REQUESTED: (Please check appropriate box(s) for certification being sought.)

- ☐ Building Official
- ☐ Master Plans Examiner
- ☐ Master Plns. Ex. Trainee
- ☐ Electrical Plans Examiner
- ☐ Plumbing Plans Examiner
- ☒ Building Insp.
- ☐ Bldg. Insp. Trainee
- ☐ Mechanical Insp.
- ☐ Mech. Insp. Trainee
- ☐ Plumbing Insp.
- ☐ Plumbing Insp. Trainee
- ☐ Fire Protection Insp.
- ☐ Com. IU Inspector
- ☐ Electrical Safety Inspector
- ☐ Electrical Safety Inspector Trainee
- ☐ Medical Gas Inspector
- ☐ Interim App. on File; All Interim Reqmnts. Completed – Seek Full Certification (Complete Items 3, 9, 10, 11, and Code Academy and Exam. Results)

3. LIST ANY OHIO LICENSE, CERTIFICATE, OR REGISTRATION: (mark "T" if trainee):

Description	Certificate Number	Date Received
Architectural Registration		
P.E. Registration		
Building Official Cert.		
Master Plans Examiner Cert.		
Building Inspector Cert.	465	APRIL 25, 2008
Electrical Plans Examiner Cert.		
Plumbing Plans Examiner Cert.		
Fire Protection Inspector Cert.	503	APRIL 25, 2008
Mechanical Inspector Cert.		
Electrical Safety Inspector Cert.		
Plumbing Inspector Cert.		
Fire Safety Inspector Cert.		
Fire Protection Sys. Designer Cert.		
Medical Gas Piping Inspector		

4. EMPLOYMENT/EDUCATION: In the space below list the Certified Building Department(s) by which applicant is employed.

a. Formal Education:	Date Graduated
WEST MUSIC HIGH SCHOOL	1976
LIBERTY UNIV.	76 - 78
b. Related Vocational or Related Technical Training:	**Years Experience**
NCCER ELECTRICAL I & II	25
JOURNEYMAN CERT. THROUGH C.O.Z.	
c. OBC Building Code Experience (certified OBC enforcement/administration, etc.)	**Years Experience**
HAVE HELD INTERIM CERTS. IN YEARS PAST	15
d. Place of Employment CITY OF ZANESVILLE	**Years Employed**
Firm	33
Building Department	

5. - APPLICANTS REQUESTING BUILDING OFFICIAL, PLANS EXAMINER, OR INSPECTOR CERTIFICATIONS:
Attach proof of certification by one of the model code organizations or other agency approved by the Board of Building Standards.

- APPLICANTS REQUESTING MEDICAL GAS INSPECTOR CERTIFICATION:
Attach proof of certification by an ASSE recognized third-party certifier in accordance with ASSE standard 6020.

Form 1525

BBS 215180

Board of Building Standards

APPLICATION FOR CERTIFICATION OF BUILDING DEPARTMENT PERSONNEL

Page 3 (You may make additional copies of this page if necessary.)

8. EXPERIENCE (CONT.): Refer to Experience Requirements Listed in 4101:1-1-01 OAC and 3783 ORC **(DO NOT SUBSTITUTE WITH OTHER RESUMES).** **State the specific duties and type of work performed for each position listed. Give only information which relates directly to the information you provide. Provide letters from certified inspectors, employers, or contractors verifying your experience. Submit copies of any certificates, diplomas, or licenses received.**

List Each Construction Project AND Specific Type of Work Performed	OBC Group	Name of Employer, Address, Telephone Number	Project Time: From To (MM/DD/YY)
OWNER OPERATOR DBA PETRA CONST CO. DESIGN + BUILD LIGHT COMMERCIAL PROJECTS ALONG WITH CUSTOM HOMES MANAGEMENT OF ALL TRADES INCLUDE HVAC ELECTRICITY PLUMBING MASONRY CARPENTRY EXCAVATION TURN KEY CONTRACTOR AND MANAGER OF ALL SUB CONTRACTORS + SUPPLIERS OVER 20 CUSTOM HOMES 4 SPEC. HOMES		PETRA CONST CO 5205 BELLVIEW DR ZANES. OH 43701 SERVED AS PRESIDENT OF MUSKINGUM HOME BUILDERS ASSOC. 1987 TO 1994	1981 TO 2001
		TOTAL EXPERIENCE ON THIS PAGE (IN MONTHS):	240

NOTE: Only experience **DIRECTLY** related to buildings or structures within the scope of the groups regulated by the Ohio Building Codes shall be acceptable for credit for any certification, pursuant to rule 4101:1-1-01. **ONLY ELECTRICAL SAFETY INSPECTORS MAY LIST 1-, 2-, or 3-FAMILY EXPERIENCE.**

Board of Building Stands

APPLICATION FOR CERTIFICATION OF BUILDING DEPARTMENT PERSONNEL

9. OFFENSES:

Have you ever been convicted of any felony or crime involving moral turpitude? YES ☐ NO ☒
If you answered "Yes" above, please explain below:

10. CERTIFICATION:

I solemnly swear or affirm that the answers I have made to each and all of the questions in this application are complete and true to the best of my knowledge and belief. I hereby waive all provisions of law forbidding colleges or universities that I have attended, or past employers, from disclosing any knowledge or information which they thereby acquired relevant to my employment and I hereby consent that they may disclose such knowledge or information to the Board of Building Standards. Falsification is a violation of section 2921.13 of the Ohio Revised Code and is punishable as a misdemeanor of the first degree.

SIGNATURE OF APPLICANT: [signature]

Subscribed and duly sworn before me according to law, by the above named applicant this 6th day of March in the year 2014 at 401 Market St Zanesville, County of Muskingum and State of Ohio.

NOTARIAL SEAL STATE OF OHIO

Mari Nykile
Notary Public
Ohio
Muskingum County
My Commission Expires
May 20, 2017

Notary Public Mari Nykile

Form 1525

BBS 215180

Board of Building Standards

OHIO BUILDING CODE ACADEMY

Certificate of Completion

This is to certify that:

John B. Benson

SUCCESSFULLY COMPLETED THE REQUIREMENTS FOR THE OHIO BUILDING CODE ACADEMY ON APRIL 25, 2008, FOR THE BUILDING INSPECTOR CERTIFICATION

Gerald O Holland

GERALD O. HOLLAND
CHAIRMAN

CERTIFICATE # 465

Department of Commerce

Division of Industrial Compliance
Mike Dewine, Governor
Sheryl Maxfield, Director

JOHN B BENSON
[redacted]

Personnel ID #: **96**
2/28/2024

At its meeting on 2/28/2024, the Board of Building Standards approved your interim certification as indicated on the enclosed certification ID card below.

The expiration date(s) for your interim certification(s) is (are) as indicated below on the ID card.

You must complete the conditions of your interim certification during the interim certification period stated on your ID card. The specific examination and Ohio Building Code Academy, if applicable, requirements are summarized in the attached form and can also be found in Ohio Administrative Code Chapter 4101:1-1-01 for commercial certifications and Ohio Administrative Code Chapter 4101:8-1-01 for residential certifications.

Please refer to your personnel I.D. number (shown on the ID card below) on any correspondence and on all certificates of continuing education forwarded to the Board's office related to your certification. If you have any questions, please contact the Board for assistance at 614-644-2613.

Sincerely,
BOARD OF BUILDING STANDARDS

Regina S. Hanshaw
Executive Secretary

Personnel ID #: **96**
Residential Building Official-Int **2/28/2026**

Mike DeWine
GOVERNOR

Timothy Galvin
CHAIRMAN

BOARD OF BUILDING STANDARDS
This is to certify that: JOHN B BENSON has met the requirements of the OAC and is hereby certified as indicated.

Executive Secretary

Ohio Board of Building Standards
6606 Tussing Road
PO Box 4009
Reynoldsburg, OH 43068-9009 U.S.A.

Timothy Galvin, Chairman

An Equal Opportunity Employer and Service Provider

614 | 644 2613
Fax 614 | 644 3147
TTY/TDD 800 | 750 0750
www.com.ohio.gov

File Attachments for Item:

ER-1 Appliances (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)

All certifications (4 hours)

Staff Notes: Number of slides is small for a four-hour course because of the math.

ESIAC Recommendation:

Committee Recommendation:

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Kevin Collins

Organization: IEC of Greater Cincinnati

Address: 586 Kings Run Drive Cincinnati, OH 45232

E-mail: KCollins@iec-cincy.com Telephone: 513-542-0400

Website: iec-cincy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Appliances

Course instructor: Sean Clark

Course description: Review Article 422 of the NEC. We will cover requirements for dishwashers, disposals, water heaters, central vac systems, ranges + dryers. We will also calculate the load required to the service size.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: TBD- IEC of Greater Cincinnati

Special Content:

Code Administration: ☒
Existing Buildings: ☐
Electrical Instruction: ☒
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: ☐
Administrative Course, All Certifications: ☐

Commercial Certifications: ☒

Application materials included:

☐ Course Outline or Course Learning Objectives
☒ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☐ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Special Equipment Chapter 6

Appliances 422, 220

Special Equipment

- Chapter 6
- Equipment that are not your everyday items but you will come across from time to time
  - Not receptacles, switches, panels, light fixtures
- Not the structure themselves

Most sections are small (except pools)

Special Equipment

- Chapter 6 – not many questions
- Examples
  - Signs
  - Elevators
  - Welders
  - Pools

Use the index!

Special Equipment

A hot tub installed indoors shall have at least one 125-volt, 15 or 20 ampere receptacle on a general purpose branch circuit located not less than ____ feet from, and not exceeding ____ feet from, the inside wall of the hot tub:

A. 3, 8
B. 6,10
C. 6,12
D. 8,20

Special Equipment

A hot tub installed indoors shall have at least one 125-volt, 15 or 20 ampere receptacle on a general purpose branch circuit located not less than ____ feet from, and not exceeding ____ feet from, the inside wall of the hot tub.

A. 3, 8
B. 6,10
C. 6,12
D. 8,20

680.43(A)

Special Equipment

- Branch circuits that supply neon tubing installations shall be rated not to exceed ____ amps:

A. 15
B. 20
C. 30
D. 40

Special Equipment

Branch circuits that supply neon tubing installations shall be rated not to exceed _____ amps.

A. 15
B. 20
C. 30
D. 40

600.5 (B)(1)

Appliances

- 422
  - Infrared heating appliances (heat lamps)
  - Non motor appliance – water heater
  - Central Vac
  - Dishwasher
  - Trash compactor
  - Range hoods
- You won't find specific appliances in index!
- Not the big appliances – Ranges and Dryers

Appliances

- 424, 426, 427
  - Deals with heating equipment
    - Minimal questions

Appliances

- The length of cord of a trash compactor is allowed to be:

A. 2 feet
B. 3 feet
C. 6 feet
D. Any of these

Appliances

- The length of cord of a trash compactor is allowed to be:

A. 2 feet
B. 3 feet
C. 6 feet
D. Any of these

422.16 (B) (2) (2)

Table 220.54 Demand Factors for Household Electric Clothes Dryers

Number of Dryers	Demand Factor (Percent)
1–4	100%
5	85%
6	75%
7	65%
8	60%
9	55%
10	50%
11	47%
12–22	% = 47 – (number of dryers – 11)
23	35%
24–42	% = 35 – [0.5 × (number of dryers – 23)]
43 and over	25%

Dryer

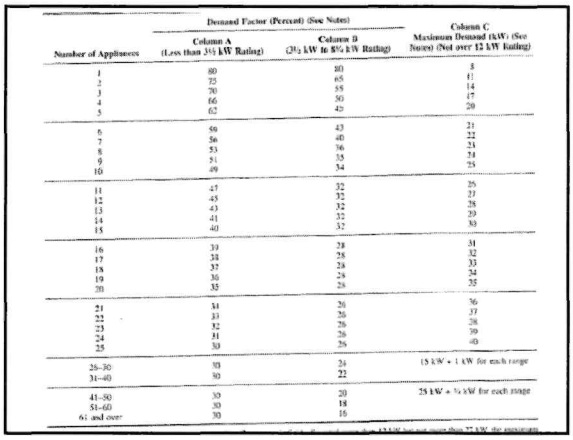
- Dryers are calculated at the greater of
  - 5,000 W
  - The nameplate rating

Demand factors can be applied from 220.54

Ex: I have 5 – 4,500 W Dryers, what is the service demand?

5,000 (minimum required) x 5 x .85 = 21,250 W

This is only for service,
branch is computed separately



Number of Appliances	Demand Factor (Percent) (See Notes)		Column C
	Column A (Less than 3½ kW Rating)	Column B (3½ kW to 8¾ kW Rating)	Maximum Demand (kW) (See Notes) (Not over 12 kW Rating)
1	80	80	8
2	75	65	11
3	70	55	14
4	66	50	17
5	62	45	20
6	59	43	21
7	56	40	22
8	53	36	23
9	51	35	24
10	49	34	25
11	47	32	26
12	45	32	27
13	43	32	28
14	41	32	29
15	40	32	30
16	39	28	31
17	38	28	32
18	37	28	33
19	36	28	34
20	35	28	35
21	34	26	36
22	33	26	37
23	32	26	38
24	31	26	39
25	30	26	40
26–30	30	24	15 kW + 1 kW for each range
31–40	30	22	
41–50	30	20	25 kW + ½ kW for each range
51–60	30	18	
61 and over	30	16	

Electric Ranges

- 220.55
- For dwelling with no additional information
  - Use 8,000 W
- If you know the kW use the appropriate column
- Column C is already in kW
- Column A and B are percentages

Electric Ranges

What is the demand factor for 6 – 10kW ranges?

Number of appliances = 6

The ranges would fall into Column C

21 kW would be the demand factor

Electric Ranges

What is the demand factor for 5 – 7 kW ranges?

5 x 7,000W (given) = 35,000W

35,000W x 45% = **15,750W**

If the ranges exceed 12 kW or if the ranges fall into different columns – see me later or D.6 in the examples in the back of the book

Electric Ranges

- What is the demand factor for 12 – 2kW ranges?
- What is the demand factor for 7 - 11 kW ranges?

Electric Ranges

- What is the demand factor for 12 –2kW ranges?
  - Use column A
    - Your percentage will be 45%
  - 12 x 2 kW = 24 kW
  - 24kW x 45% (.45) = 10.8 kW or 10,800W (VA)
- What's the demand factor for 7 -11 kW ranges?
  - Use column C
  - 22 kW

Ranges – article 220.55
Calculating the service load for range(s)

Dryers – article 220.54
Calculating the service load for dryer(s)

Article 422
In Sink Waste Disposals
Dishwashers
Range Hoods
Central Vacuums
Water Heaters

Sean Clark

901 Beechmeadow Ln. Cincinnati, Ohio 45238
(H)513/347-9054 (C)513/800-4450
sclark@ohiovalleyelectric.com

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A licensed electrician with over twenty years of experience in installing, maintaining, and repairing electrical wiring, equipment, and fixtures, ensuring that work is in accordance with relevant codes, fire alarm installations, electrical control systems, and high voltage terminations. A licensed electrician with three years teaching experience in first and second year electrical.

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- Diagnose malfunctioning systems, apparatus, and components, using test equipment and hand tools, to locate the cause of a breakdown and correct the problem.
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- Perform business management duties such as maintaining records and files, preparing reports and ordering supplies and equipment.

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Journeyman Electrician's License-Hamilton, Ohio

Fire Alarm License-State of Ohio

Certified in high voltage terminations and splices

Lift, Lull, Bobcat, and Boom/scissors lift licenses

OSHA-30 card

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Certified NCCER Core Curricula Instructor

Certified NCCER Electrical Instructor

Completed 4 year apprenticeship program

1 Year Pre-apprentice school (ABC)

High School Diploma (1991)

ARCH FLASH SAFETY TRAINING

PROJECTS-SUPERVISED

$4.5mil.-MASON HIGH SCHOOL ADDITION

$250.000-3CDC-5TH RACE PARKING GARAGE

$250.000-AVONEDALE APT. COMPLEX

$100.000-MAHOGANYS AT THE BANK-

1.2mil. -PATHEON CHEMICALS

$450.000- FED EX GROUND ADDITION

$250.000-LIBERTY WAY PROJECT

$500.000-GE AT THE BANKS

$100.000 - SYCAMORE SCHOOLS/POWER/CONTROL-

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$250.000- UC POWER PLANT ADDITION

$75.000 - 580BLD/ CHEMED, RETROFIT

$4.0mil - DHL- CONVEYERS/SHELL

$90.000- DOUBLE TREE AIRPORT

$2.5mil- TWIN LAKES OF MONTGOMERY

$45.000- STEINMART ANDERSON

And many small T&M jobs.

All on time and under budget

File Attachments for Item:

ER-2 Box Fill (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)

All certifications (4 hours)

Staff Notes:

ESIAC Recommendation:

Committee Recommendation:

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Kevin Collins

Organization: IEC of Greater Cincinnati

Address: 586 Kings Run Drive Cincinnati, OH 45232

E-mail: KCollins@iec-cincy.com Telephone: 513-542-0400

Website: iec-cincy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ *(i.e. BBS2018-429)*

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Box Fill

Course instructor: Sean Clark

Course description: Review Article 314 of the NEC. We will calculate the type of box as well as the minimum size required based on number of conductors, size of conductors and devices/ clamps contained in the box

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: TBD- IEC of Greater Cincinnati

Special Content:

Code Administration: ☒
Existing Buildings: ☐
Electrical Instruction: ☒
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: ☐
Administrative Course, All Certifications: ☐

Commercial Certifications: ☒

Application materials included:

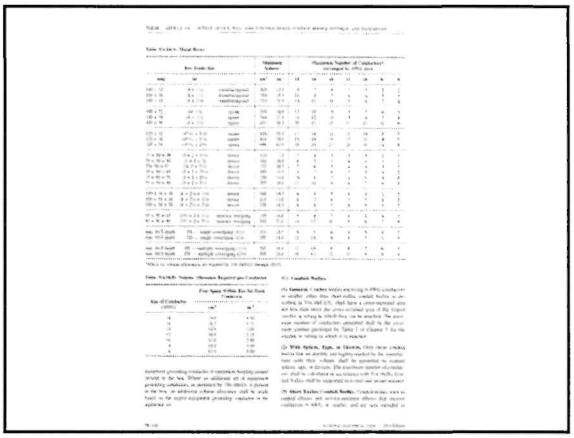
☐ Course Outline or Course Learning Objectives
☒ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☐ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Box Fill
314.16

Box Fill

- 314.16(A) & (B)



Box fill

- 314.16 (A) – simpler chart – metal boxes
- 314.16 (B) - needed when wire sizes are different and factors other than conductors are involved (clamps, devices)
- If conductors are #4 and larger shall also comply with 314.28 (see 314.16)
- 314.17 (C) Non metallic boxes
  - Exception – within 8" of the box

Box fill

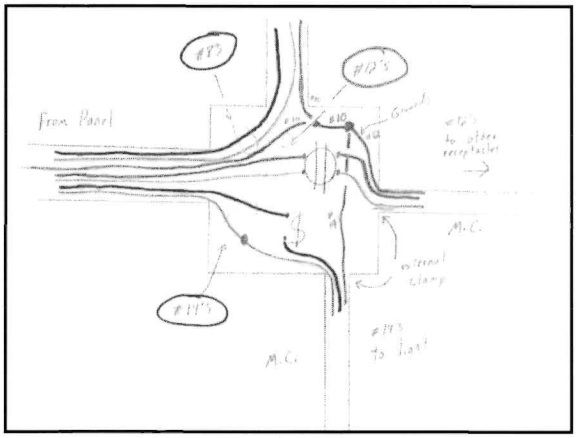
- How many #12 can fit into a 3x2x2 device box?
- How many #8 can fit into a 4 x 2 1/8 round box?

Box fill

- How many #12 can fit into a 3x2x2 device box?
  - **4**
- How many #8 can fit into a 4 x 2 1/8 round box?
  - **7**
    - Make sure boxes match exactly.

Box Fill – 314.16 (B)

- Wires passing through count once
- Fixture wires smaller than #14 do not count
- Internal clamp – counted once no matter how many – based on largest conductor in box
  - External connectors do not count
- Support fittings – counted once no matter how many – based on largest conductor size
- Devices or equipment yoke – count twice for each one based on largest wire size going to device
- Equipment grounds – No matter how many grounds, only 1 (based on largest ground) shall be counted
  - Equipment ground calculation has been revised in 2020.



Box Fill

I have a raceway coming from a panel and terminating into a box.

In the box I have

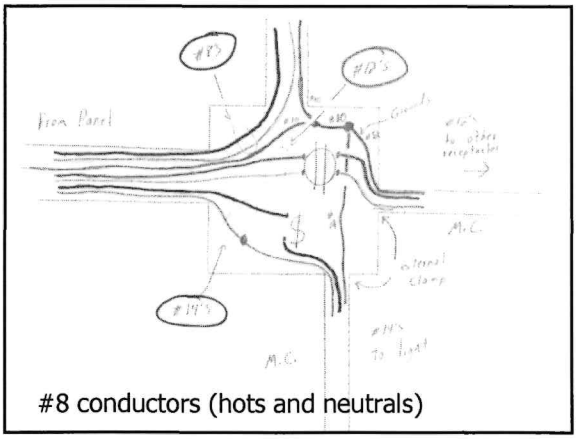
2 - #8's passing straight through

A #12 ungrounded and grounded conductor landing on a receptacle and then leaving the box to pick up other receptacles.

A #14 ungrounded and grounded conductor enter the box. The "hot" lands on the line side of a switch. A "hot" then leaves the switch heading toward a light. The neutral is spliced and heads towards the light.

A #10 ground enters the box. It is spliced with a #14 and #12. The #14 heads off toward the light, the #12 heads off to the other receptacles.

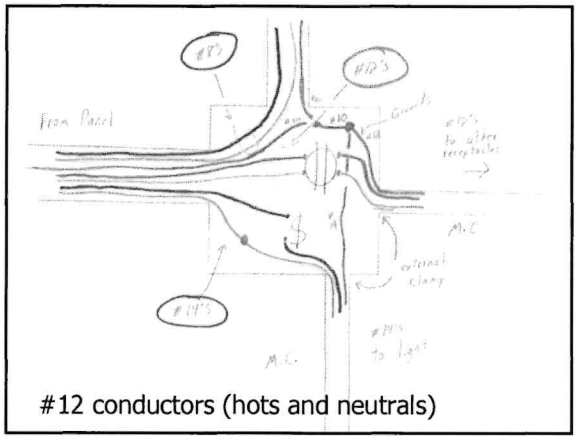
The cables heading toward the other receptacle and the lights have external clamps.



#8 conductors (hots and neutrals)

Box Fill

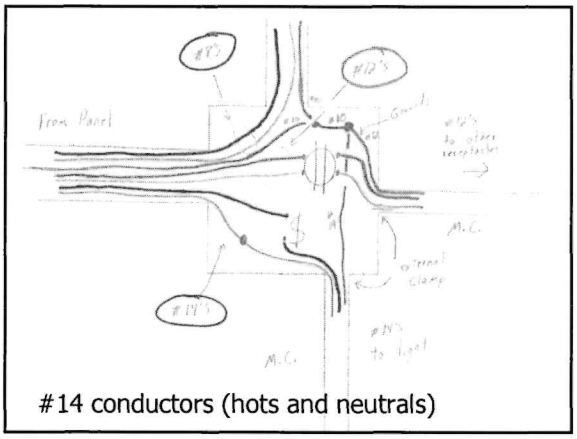
- 2 - #8's pass straight through
- The volume allowance for a #8 is 3 in cubed
- 2 x 3 = 6
  - This is your volume of your number #8's



#12 conductors (hots and neutrals)

Box Fill

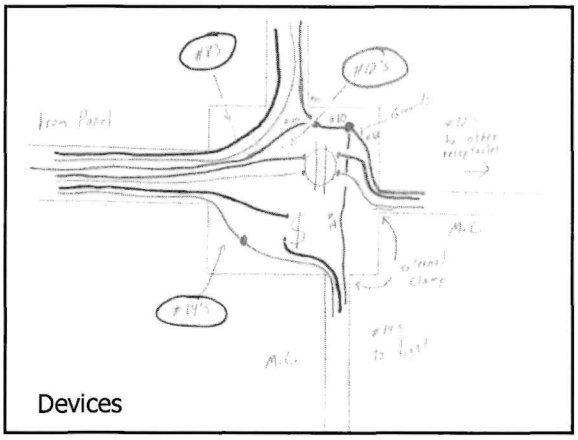
- 2 - #12's enter the box and 2 leave the box. This is not going straight through.
- Therefore you have 4 - #12 conductors
- Each #12 has a volume of 2.25 in. cubed
  - Therefore 4 x 2.25 = 9



#14 conductors (hots and neutrals)

Box Fill

- 2 - #14's enter the box and 2 leave the box. Since the neutral is spliced, this is not going straight through.
- You have 4 - #14 conductors
  - 4 x 2.00 = 8 inches cubed



Devices

Box Fill

- This takes care of your hots and neutrals.

Devices

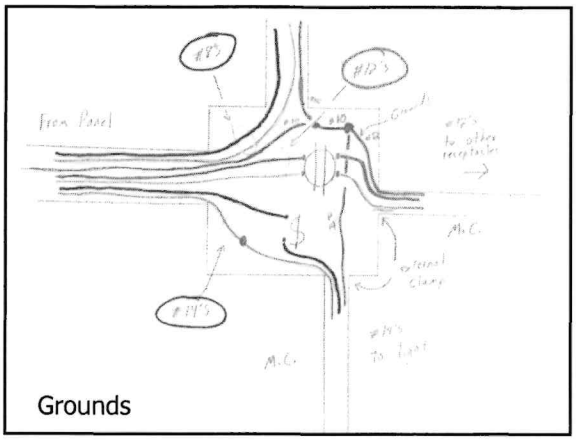
#12's land on the receptacle

For a device, you take double the allowance of the largest conductor landed on the devices

2 x 2.25 (#12) = 4.5

#14's land on the switch

2 x 2.00 (#14) = 4.0

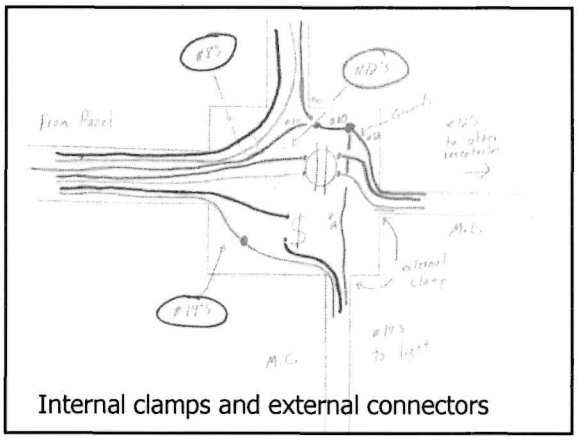


Grounds

Box Fill

- Grounds
  - You only need to take the largest size
  - There is 2 - #10's, 1 - #12 and 1 - #14

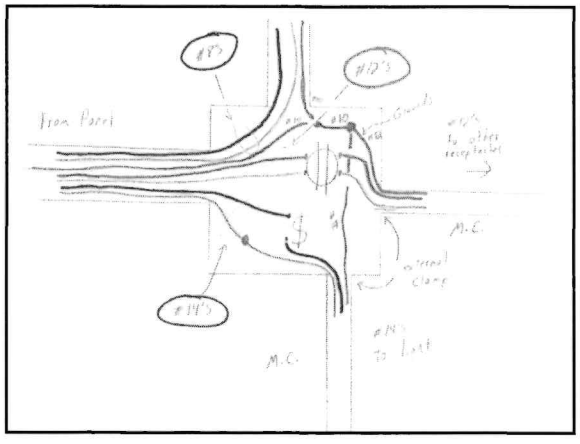
  1 x 2.5 (#10) = 2.5



Internal clamps and external connectors

Box Fill

- Clamps
- You have two external clamps
  - NO ALLOWANCE REQUIRED
- Had this been internal clamps you would have taken 1 x 3.00. No matter how many internal clamps you have, take 1 x the largest conductor in the box.



Box Fill

- Therefore

  6 (# 8's passing through)
  9 (#12's hots and neutrals on receptacle)
  8 (#14's hots and neutrals on switch)
  4.5 (receptacle - #12's on it)
  4 (switch - #14's on it)
  + 2.5 (grounds – based on 1 - #10)
  34

Box Fill

34 Cubic Inches are needed.

- You could legally have a 4 11/16 x 2 1/8 square box contain the conductors/devices.
- No 4 square is big enough – maxes at 30.3

Box fill

- What is the minimum size square box is needed for
- 4 - #14 phase conductors
- 3 - #12 phase conductors
- 2 - #10 phase conductors
- 2 - #10 equipment ground
- 2 - #12 equipment grounds
- 1 device attached to the #12
- 2 external clamps
- 2 internal clamps:

Box fill

- What is the minimum size square box is needed for
- 4 - #14 phase conductors = **4 x 2.00 = 8**
- 3 - #12 phase conductors = **3 x 2.25 = 6.75**
- 2 - #10 phase conductors = **2 x 2.50 = 5.00**
- 2 - #10 ground = **1 x 2.50 = 2.50 (only 1 needed)**
- 2 - #12 grounds = **0 (#10 ground accounted for)**
- 1 device = **2 x 2.25 = 4.50**
  - **(twice the largest conductor attached to device)**
- 2 external clamps = **0 = no allowance needed**
- 2 internal clamps = **1 x 2.50 = 2.50**

8.00 + 6.75 + 5.00 + 2.50 + 4.50 + 2.50 =**29.25**

Box fill

29.25 Cubic Inches

Go to box volume
make sure to look up correct box type
(round, square, device, masonry)

4 11/16 x 1 ½" has a 29.5 allowance.

4 11/16 x 2 1/8" and 4 x 2 1/8" would be legal but would not be correct

- Pick **minimum** size needed.
- Do not pick largest box so that you are covered.

Box fill

- If box has #4 or larger, use 314.28
  - Refers to this article in 314.16
    - Straight Pulls
    - Angle or U Pulls

If conductors are pulled straight through a box, multiply the largest raceway by 8. The product will be the minimum length of the box to the opposite wall.

Box fill

Ex: A 3" conduit contains #10, #8 and #2 conductors. There is a pull box in the middle of a straight run which has the 3" conduit entering and leaving on opposite walls would require at LEAST a 24"x24" box (3" x 8) across.

Box fill

- A box will angle or U bends
- (anything not straight through)
  - Take the largest conduit on ONE side and multiply it by 6.
  - Add any additional conduits ON THE SAME SIDE to it.
  - This is the minimum dimension to the opposite wall of the box.
  - Technically must be done to all 4 sides.

Box fill

Ex: A pull box contains 1/0, #3's and #12's has:

1 - 2", 3 – 1" and 2 – ¾" conduit on the left side.

1 – 2", 3 – 1" on the bottom.

2 – 1" on the right.

Box fill

1 - 2", 3 – 1" and 2 – ¾" conduit on the left side.
1 – 2", 3 – 1" on the bottom
2 – 1" on the right.

- Left side:

1 – 2" (largest size) = 2" x 6 = 12"

12" + 1" + 1" + 1" + ¾" + ¾" = 16 ½"

Box fill

1 - 2", 3 – 1" and 2 – ¾" conduit on the left side.
1 – 2", 3 – 1" on the bottom
2 – 1" on the right.

- Bottom:

1 – 2" (largest size) = 2" x 6 = 12"

12" + 1" + 1" + 1" + = 15"

Box fill

1 - 2", 3 – 1" and 2 – ¾" conduit on the left side.
1 – 2", 3 – 1" on the bottom
2 – 1" on the right.

- Right side:

1 – 1" (largest size) = 1" x 6 = 6"

6" + 1"= 7"

Box fill

- From Left side – 16 ½" across
- From Bottom – 12" up
- From Right side – 7" across

- Smallest pull box would be 16 ½".
  - If in field, would just round up.

Box Fill – 314.16 (A) and (B)

- Number of conductors of the same size in different boxes.
- Number of conductors of different sizes in different boxes.
- Other factors in determining box fill
  - Wire spliced/running straight through
  - Clamps
    - Internal/External
  - Devices
  - Grounds (Regular/Isolated)

Sean Clark

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$90.000- DOUBLE TREE AIRPORT

$2.5mil- TWIN LAKES OF MONTGOMERY

$45.000- STEINMART ANDERSON

And many small T&M jobs.

All on time and under budget

File Attachments for Item:

ER-3 Conductor Types, Ampacities, and Correction Factors (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)

All certifications (4 hours)

Staff Notes:

ESIAC Recommendation:

Committee Recommendation:

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Kevin Collins

Organization: IEC of Greater Cincinnati

Address: 586 Kings Run Drive Cincinnati, OH 45232

E-mail: kcollins@iec-cincy.com Telephone: 513-542-0400

Website: iec-cincy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ *(i.e. BBS2018-429)*

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Conductor types, ampacities & correction Factors

Course instructor: Sean Clark

Course description: Review article 310 of the NEC. We will discuss where different types of conductors are allowed & not allowed. We will calculate ampacities of a conductor based on ambient temperature and number of conductors in a conduit.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: TBD - IEC of Greater Cincinnati

Special Content:

Code Administration: ☒
Existing Buildings: ☐
Electrical Instruction: ☒
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

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Course applicable for the following certifications

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Administrative Course, All Certifications: ☐

Commercial Certifications: ☒

Application materials included:

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☒ Presentation Materials/Slides (not required for roundtable courses)
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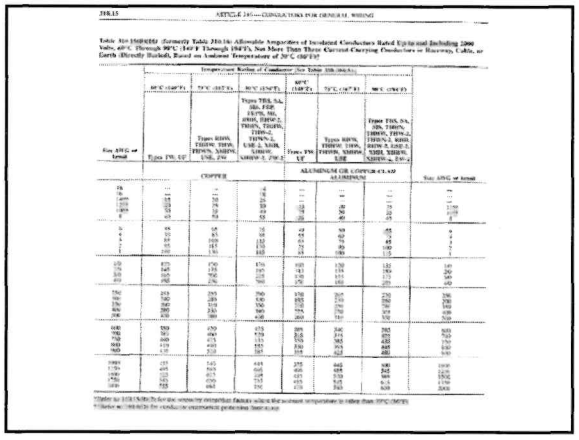
☐ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Ampacities
Article 310.15 & 16

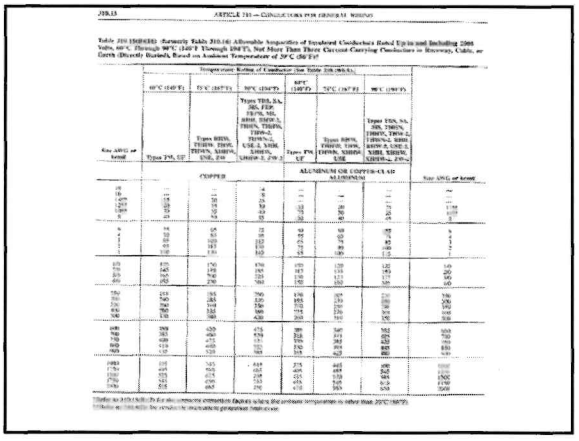
Ampacities

- 310.15(B)(16)



Ampacities

- How many amps is Al THW-2 #4 good for?
  - Go to right half of the chart (Aluminum conductors)
  - Find THW – 2 in the categories at the top
    - Use the 90 degree C column
  - Find #4 on the far right side
  - Find where that column and the #4 row cross.
  - 75 amps



Ampacities

- Copper vs. Aluminum
- Use wire insulations
- DON'T WORRY ABOUT LUG RATING

How many amps are each of the following good for:

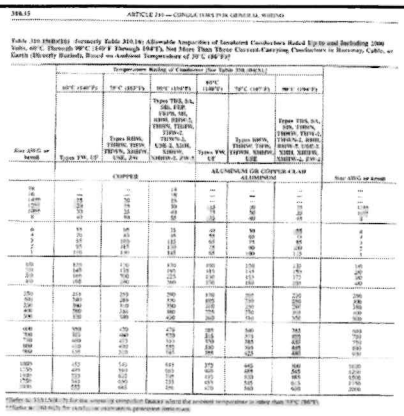
- 3/0 RHW AL
- #3 UF Cu
- 4/0 RHW-2 Cu

Ampacities

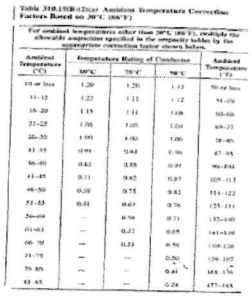
- Copper vs. Aluminum
- Use wire insulations
- DON'T WORRY ABOUT LUG RATING

How many amps are each of the following good for

- 3/0 RHW AL – **155**
- #3 UF Cu - **85**
- 4/0 RHW-2 Cu - **260**



Ambient temperature – 310.15(B)(2)(a)



Ambient temperature

- Outside temperature, this is different than temperature rating of wire
- Celsius on left – Fahrenheit on right
  - Make sure to answer in correct temperature
- Ex: Use the same example we had before
- Al THW-2 #4 in 77 degree C ambient temperature
  - Take your initial amps that you found (75 amps)
  - Apply the ambient temperature factor (.41)
    - It will be in the same column as the initial amp finding
    - Find the ambient temperature on the edge of the chart
    - Could be left side (C) or right side (F)
  - Multiply the amps by the ambient temperature correction factor
- 75 x .41 = 30.75 amps

Ambient temperature

- Determine the ampere rating for each of the following conductors:

- 3/0 RHW Al in 42 C ambient temperature
- #3 UF Cu in 90 F ambient temperature
- 4/0 RHW-2 Cu in 75 F ambient temperature

Ambient temperature

Determine the ampere rating for each of the following conductors

- 3/0 RHW Al in 42 C ambient temperature
  - **127.1 amps – correction factor of .82**
- #3 UF Cu in 90 F ambient temperature
  - **77.35 amps – correction factor of .91**
- 4/0 RHW-2 Cu in 75 F ambient temperature
  - **270.4 amps – correction factor of 1.04**

You can exceed the rating of 310.15(B)(16)

Adjustment factors - derating

- 310.15(B)(3)(a)

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 Table 310.15(B)(16) through Table 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).

Adjustment factors - derating

- Based on number of **current carrying** conductors
- HAS NOTHING TO DO WITH TYPE OR SIZE OF CONDUIT
  - 4 - #18 conductors in 6" Rigid would still be derated
- Ex: Use the same wire as before.
- What is the ampacity of 11 - Al THW-2 #4
- Take initial ampacity (75 amps)
- Use 310.15 (B)(3)(c) to apply the correction factor
- 10 – 20 has a factor of 50% (.5)
- 75 x .5 = 37.5 = **38 Amps**

Adjustment factors - derating

Determine the ampere rating for each of the following conductors:

- 5 - 3/0 RHW Al
- 21 - #3 UF Cu
- 8 - 4/0 RHW-2 Cu

Adjustment factors - derating

- Determine the ampere rating for each of the following conductors
- 5 - 3/0 RHW Al
  - **124 amps – derate at 80%**
- 21 - #3 UF Cu
  - **38.25 amps – derate at 45%**
    - Have to round down to 38 amps – decimal below .5
- 8 - 4/0 RHW-2 Cu
  - **182 amps – derate at 70%**

Combining factors for derating

- If taking into account ambient temperature and correction factor (derating) you must apply BOTH not the greatest of the two.
- Ex: 11 - Al THW-2 #4 in 77 degree C ambient temperature
  - 75 amps (off 310.15(B)(16))
  - .41 (ambient temp)
  - .5 (derating chart, 310.15 (B)(3)(a)
- 75 x .41 x .5 = 15.375 = 15 amps
- Each conductor is only good for 15 amps

Combining factors for derating

- Determine the ampere rating for each of the following conductors:
- 5 - 3/0 RHW Al in 42 C ambient temperature
- 21 - #3 UF Cu in 90 F ambient temperature
- 8 - 4/0 RHW-2 Cu in 75 F ambient temperature

Combining factors

- Determine the ampere rating for each of the following conductors
- 5 - 3/0 RHW Al in 42 C ambient temperature
  - 155 x .82 x .8 = 101.68 = **102 amps**
- 21 - #3 UF Cu in 90 F ambient temperature
  - 85 x .91 x .45 = 34.8075 = **35 amps**
- 8 - 4/0 RHW-2 Cu in 75 F ambient temperature
  - 260 x 1.04 x .7 = 189.28 = **189 amps**

Dwelling Service Chart 310.15(B)(7)

- 83% Rule
  - Only for dwelling purposes
  - 100 amps through 400 amps
  - Must feed entire load
  - Single phase or single phase from a 3 phase system

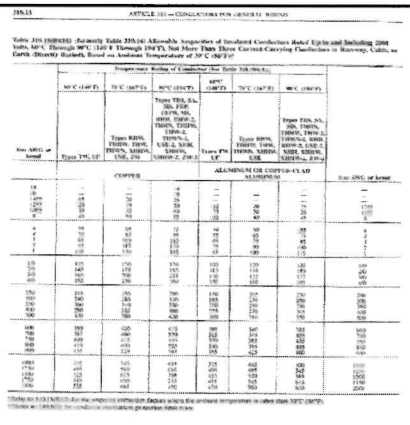
Rephrased – Same Values

- 83% Rule
- Take rating of service and multiply by .83 (83%)
- Ex. 200 amp service
  - 200 x .83 = 166
- Refer to 310.15(B)(16) – Main Ampacity Chart
- Find conductors rated for at least 166 amps
  - Unless noted, use 75 degree column and copper

Dwelling Service Chart 310.15(B)(7) – page 800

Table 310.15(B)(7) Conductor Types and Sizes for 120/240-Volt, 3-Wire, Single-Phase Dwelling Services and Feeders. Conductor Types RHH, RHW, RHW-2, THHN, THHW, THW, THW-2, THWN, THWN-2, XHHW, XHHW-2, SE, USE, USE-2

	Conductor (AWG or kcmil)	
Service or Feeder Rating (Amperes)	Copper	Aluminum or Copper-Clad Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600



Dwelling Service

What size copper conductors are needed for a 150 amp residential single phase service?

Dwelling Service

What size copper conductors are needed for a 150 amp residential single phase service?

150 x .83 = 124.5 amps

#1 is good for 130 amps

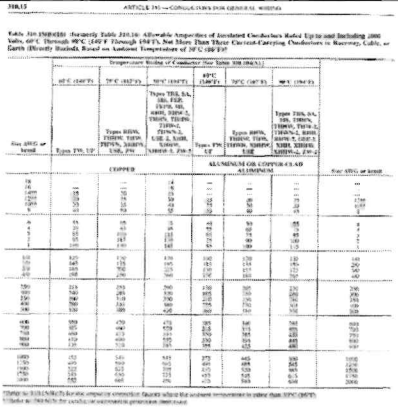


Table 310.15(B)(7) Conductor Types and Sizes for 120/240-Volt, 3-Wire, Single-Phase Dwelling Services and Feeders. Conductor Types RHH, RHW, RHW-2, THHN, THHW, THW, THW-2, THWN, THWN-2, XHHW, XHHW-2, SE, USE, USE-2

Service or Feeder Rating (Amperes)	Conductor (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600

Ampacities

- 310.15(B)(16) vs. 310.15 (B)(7)
  - 310.15 (B)(7) is for 120/240, 3 wire, single phase dwelling services and feeders
    - Ex. Houses, apartments
    - Feeders is a bit deceptive
  - Notice the difference in ampacities!
    - 200 amp Dwelling feeder is permitted to be 4/0 AL
    - On 310.16 if you needed 200 amps on Al wire, you would need 250 kcmil
- Only refer to 310.15 (B)(7) when all stipulations are given.

Conductor Properties

- 310.4 (A)
  - Gives trade name and type letter
  - Maximum operating temperature
    - Conductors may have different operating temperatures in different environments
      - See type ZW
  - Insulation
  - Outer covering

Conductor Properties

- 310.4 (A)
- Which conductor is good for switchboard and switchgear wiring only?

- A. ZW
- B. SA
- C. MTW
- D. TBS

Conductor Properties

- 310.4 (A)
- Which conductor is good for switchboard and switchgear wiring only?

- A. ZW
- B. SA
- C. MTW
- **D. TBS**

Box and conduit fill – derating
9/17/09
5-8 PM

5 P.M.
Box Fill

By applying 310.14, you need to know how many conductors you can legally fit in a metal or plastic box. Devices and supports can also affect your calculation

6 P.M.
Sizing conduits

By using tables 4 and 5 in the NEC you can calculate the total area of the conductors you are running as well as the allowable space inside of different types and sizes of conduits

7 P.M.
Derating ampacities

310.15 (b)(2) lessens the ampacity allowed for conductors once you have put more than 4 conductors in a raceway. We will look at common derating factors and apply them to normal construction applications.

Sean Clark

901 Beechmeadow Ln. Cincinnati, Ohio 45238
(H)513/347-9054 (C)513/800-4450
sclark@ohiovalleyelectric.com

••••••••••••••••••••••••••••

A licensed electrician with over twenty years of experience in installing, maintaining, and repairing electrical wiring, equipment, and fixtures, ensuring that work is in accordance with relevant codes, fire alarm installations, electrical control systems, and high voltage terminations. A licensed electrician with three years teaching experience in first and second year electrical.

Summary of Qualifications

- More than twenty years experience.
- Three years experience in teaching first and second year electrical.
- Thorough knowledge of electrical systems including planning additions and modifications on secondary circuits. Controls and low voltage wiring
- Able to read commercial electrical blueprints and apply NEC through the full range of commercial and industrial maintenance and construction work.
- Can use appropriate tools and diagnostic equipment to repair, install, replace, and test electrical circuits, equipment and appliances.
- Excellent ability to diagnose and repair electrical controls, industrial motor control centers, and programmable logic controllers.
- Strong desire to study and comprehend new technology.
- In-depth ability to make mathematical computations.
- Considerable ability to explain instructions and guidelines to others effectively.
- Able to assign work to employees., prioritize the work of others and organize and coordinate the work of the unit. For subs and Primes.

Professional Experience

Ohio Valley Electrical Services 2011-Present

ABC Electrical Teacher 2010-2013

Beacon Electrical Contractors 2007-2011

Ohio Valley Electrical Services 1993-2007

Electrical Superintendant/Foreman/Instructor

- First and Second year electrical instructor
- Supervision of all electrical installations of as many as 50 electricians to assure that work was done safely, efficiently, properly and within time allowed.
- Trained multiple employees in all aspects of electrical work to be able to identify an employee's strengths and weaknesses to better utilize their skills. Traced out short circuits in wiring, using test meter.
- Coordinated and implemented electrical projects within a variety of environments including plants, hospitals, schools, retail stores, public facilities, waste water treatment plants industrial buildings;

projects include both new construction and underground electrical wiring as well as renovation within existing buildings. Parking Garages and Fed Ex Ground Facilities.

- Assemble, install, test, and maintain electrical or electronic wiring, equipment, appliances, apparatus, and fixtures, using hand tools and power tools.
- Connect wires to circuit breakers, transformers, or other components.
- Construct and fabricate parts, using hand tools and specifications.
- Diagnose malfunctioning systems, apparatus, and components, using test equipment and hand tools, to locate the cause of a breakdown and correct the problem.
- Inspect electrical systems, equipment, and components to identify hazards, defects, and the need for adjustment or repair, and to ensure compliance with codes.
- Plan layout and installation of electrical wiring, equipment and fixtures, based on job specifications and local codes.
- Test electrical systems and continuity of circuits in electrical wiring, equipment, and fixtures, using testing devices such as ohmmeters, voltmeters, and oscilloscopes, to ensure compatibility and safety of system.
- Perform business management duties such as maintaining records and files, preparing reports and ordering supplies and equipment.

Education & Certifications

Master Electrician License-State of Kentucky

Journeyman Electrician's License-Hamilton, Ohio

Fire Alarm License-State of Ohio

Certified in high voltage terminations and splices

Lift, Lull, Bobcat, and Boom/scissors lift licenses

OSHA-30 card

Certified in first aid and CPR training

Certified NCCER Core Curricula Instructor

Certified NCCER Electrical Instructor

Completed 4 year apprenticeship program

1 Year Pre-apprentice school (ABC)

High School Diploma (1991)

ARCH FLASH SAFETY TRAINING

PROJECTS-SUPERVISED

$4.5mil.-MASON HIGH SCHOOL ADDITION

$250.000-3CDC-5TH RACE PARKING GARAGE

$250.000-AVONEDALE APT. COMPLEX

$100.000-MAHOGANYS AT THE BANK-

1.2mil. -PATHEON CHEMICALS

$450.000- FED EX GROUND ADDITION

$250.000-LIBERTY WAY PROJECT

$500.000-GE AT THE BANKS

$100.000 - SYCAMORE SCHOOLS/POWER/CONTROL-

$50.000 - NKU RETROFIT

$250.000- UC POWER PLANT ADDITION

$75.000 - 580BLD/ CHEMED, RETROFIT

$4.0mil - DHL- CONVEYERS/SHELL

$90.000- DOUBLE TREE AIRPORT

$2.5mil- TWIN LAKES OF MONTGOMERY

$45.000- STEINMART ANDERSON

And many small T&M jobs.

All on time and under budget

File Attachments for Item:

ER-4 Dwelling Circuit Requirements (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)

All certifications (4 hours)

Staff Notes:

ESIAC Recommendation:

Committee Recommendation:

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Kevin Collins

Organization: IEC of Greater Cincinnati

Address: 586 Kings Run Drive Cincinnati, OH 45232

E-mail: KCollins@iec-cincy.com Telephone: 513-542-0400

Website: iec-cincy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Dwelling Circuit Requirements

Course instructor: Sean Clark

Course description: Review Article 210 of the NEC. We will discuss receptacle & switch location requirements in a dwelling as well as required circuitry in a dwelling

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: 3/26/24 - IEC of Greater Cincinnati

Special Content:

Code Administration: ☒
Existing Buildings: ☐
Electrical Instruction: ☒
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: ☐
Administrative Course, All Certifications: ☐

Commercial Certifications: ☒

Application materials included:

☐ Course Outline or Course Learning Objectives
☒ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☐ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

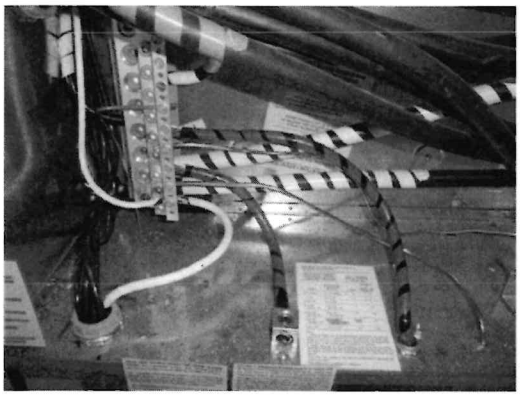
RESIDENTIAL N.E.C. REQUIREMENTS

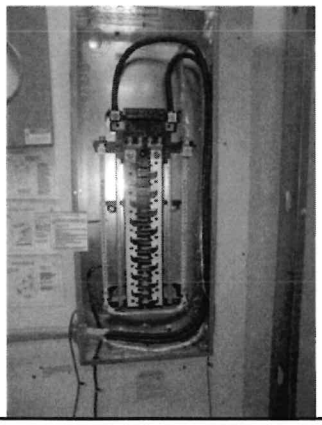
Services - general

- 230.2 – Only one service per building
  - Several exceptions – unlikely to apply to dwellings
    - Too large
    - Different voltages
    - Different rate schedules

Services - general

- Must be suitable for service entrance equipment
- Bonding ground and neutral
  - Only one time
- Main breaker must be secured in place
  - Wording is back fed devices – 408.36(D)
- Height of main breaker 6'7" to top – 404.8(A)





Services - Clearances

- 230.24 (B) Vertical Clearance
- Voltages are one phase to ground
  - 10 feet
    - Pedestrian only, 150 volts to ground
  - 12 feet
    - Not subject to truck traffic, 300 volts to ground
  - 15 feet
    - Same as 12, over 300 volts to ground
  - 18 feet
    - Over public streets, subject to truck traffic
  - 24 ½ feet
    - Over railroad tracks

(B) Vertical Clearance for Overhead Service Conductors. Overhead service conductors, where not in excess of 600 volts, nominal, shall have the following minimum clearance from final grade:

(1) 3.0 m (10 ft) — at the electrical service entrance to buildings, also at the lowest point of the drip loop of the building electrical entrance, and above areas or sidewalks accessible only to pedestrians, measured from final grade or other accessible surface only for overhead service conductors supported on and cabled together with a grounded bare messenger where the voltage does not exceed 150 volts to ground

(2) 3.7 m (12 ft) — over residential property and driveways, and those commercial areas not subject to truck traffic where the voltage does not exceed 300 volts to ground

(3) 4.5 m (15 ft) — for those areas listed in the 3.7-m (12-ft) classification where the voltage exceeds 300 volts to ground

(4) 5.5 m (18 ft) — over public streets, alleys, roads, parking areas subject to truck traffic, driveways on other than residential property, and other land such as cultivated, grazing, forest, and orchard

Services - Clearances

- 230.9 – Clearances on buildings
  - Open conductors – 3 feet from attainable locations
    - Exception – above a window
  - Vertical Clearance – platforms, etc.
  - Roofs
    - 8 feet – normal roofs – maintained for 3 feet in all directions
      - Exception 1 – pedestrian traffic (patio, etc.)
        - Then normal clearances
      - Exception 2 - only 3 feet needed
        - Less than 300 volts
        - 4/12 slope

Services – Conductor Installation

- 230.50 (1) – Underground protection against physical damage when emerging from grade
  - Rigid metal, IMC, Schedule 80 PVC, EMT

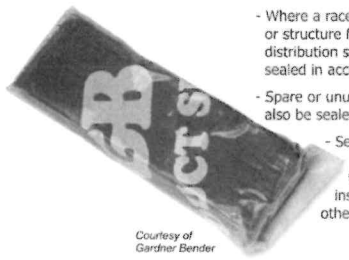
Services - Underground

- 300.5 Underground Installations
  - (D)(1) Emerging from grade
    - 8 feet above
    - 18 inches below
  - (D)(3) Service conductors
    - If not in concrete and buried 18 inches or more
      - Warning ribbon – 12 inches above conductors
  - (F) Backfill – clean
  - (J) Earth Movement – "S" loops

If conduit enters building from outside, it must be sealed

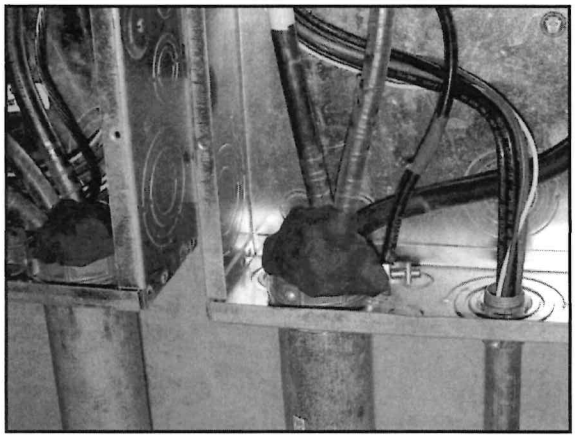
225.27 Raceway Seal

A raceway seal is required at outside underground branch circuit and feeder raceways entering a building



- Where a raceway enters a building or structure from an underground distribution system, it shall be sealed in accordance with 300.5(G)
- Spare or unused raceways shall also be sealed
- Sealants shall be identified for use with the cable insulation, shield or other components

Courtesy of Gardner Bender



Services – Conductor Installation

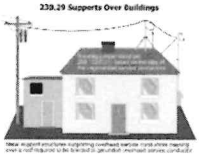
- Overhead conductors
- 230.51 (A) – mounting supports
  - 12" from "ends"
  - 30" intervals
- 230.54 (C)
  - Service heads above point of attachment
  - If impracticable – has to be less than 2 feet
- 230.54 (F)
  - Drip loops – Duke requires 3' minimum
  - Neutral needs to be bare – Duke requirement

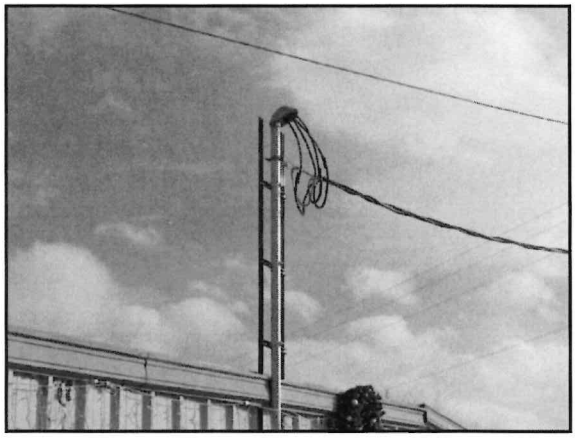
Services - Conductor Installation

- 225.17 (A) Mast Support -
- Hubs must be identified for use with service equipment.
- Can't attach conductors to a mast above a coupling if no support above it (floating coupling)
- Same in section 230 (services)

230.29 Supports over Buildings. Service conductors passing over a roof shall be securely supported by substantial structures. For a grounded system, where the substantial structure is metal, it shall be bonded by means of a bonding jumper and listed connector to the grounded overhead service conductor. Where practicable, such supports shall be independent of the building.

230.29 Supports Over Buildings





Service - size & metering

- 230.79 (C) - 100 amp for one family dwelling
- 230.79 (D) - 60 amp - others
- Meter must be placed outside unless approved by Duke
- Meter height 4 ½' - 5 ½' to center - Duke

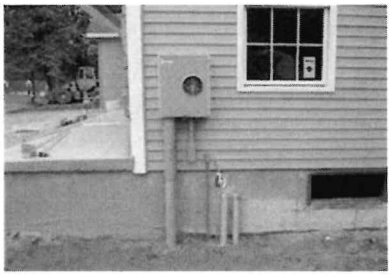


Table 310.15(B)(6) Conductor Types and Sizes for 120/240-Volt, 3-Wire, Single-Phase Dwelling Services and Feeders. Conductor Types RHH, RHW, RHW-2, THHN, THHW, THW, THW-2, THWN, THWN-2, XHHW, XHHW-2, SE, USE, USE-2

Conductor (AWG or kcmil)		
Copper	Aluminum or Copper-Clad Aluminum	Service or Feeder Rating (Amperes)
4	2	100
3	1	110
2	1/0	125
1	2/0	150
1/0	3/0	175
2/0	4/0	200
3/0	250	225
4/0	300	250
250	350	300
350	500	350
400	600	400

- After many cycles of debate, the provisions for sizing dwelling unit service (and main power feeder) was expanded to allow for 208Y/120-volt single-phase systems.
- Keep in mind this is only for the single-phase component of a three phase 208/120 volt system.
- Many users liked the simplified residential dwelling ampacity table and this was added back to the Annex D7. (Previous Table 310.15(B)(7) in 2014).
- Explanatory language added to address the permitted application of correction or adjustment factors required by 310.15(B)(2)(a) (Temperature Correction Factors) or 310.15(B)(3)(a) (More Than Three Current-Carrying Conductors) applied to the ampacity associated with the temperature rating of the conductors
- New informational note added with direction to 240.6(A) for service ratings based on standard ampacity ratings for application of 310.15(B)(7)

(7) ~~120/240-Volt,~~ Single-Phase Dwelling Services and Feeders.

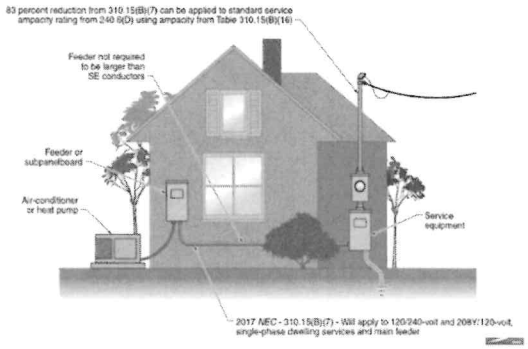
For one-family dwellings and the individual dwelling units of two-family and multifamily dwellings, service and feeder conductors supplied by a single-phase, 120/240-volt system shall be permitted to be sized in accordance with 310.15(B)(7)(1) through (4).

Single-phase feeders from a 208Y/120 volt system shall be permitted to use 310.15(B)(7)(1) through (4).

For a service rated 100 through 400 A amperes, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83 percent of the service rating...

Continued on next slide...

310.15(B)(7) Dwelling Unit Services and Feeders



Services - Disconnecting Means

- 230.70 (1) – Readily accessible location
  - Nearest point of entrance
  - No six foot rule
    - Service conductor protection
      - Not necessarily panel
  - Don't put in:
  - Bathrooms
  - 240.24(F)
    - Vicinity of easily ignitable material – clothes closets
    - Located above steps

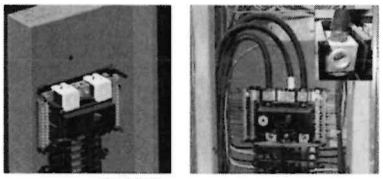
Services - Disconnecting Means

- 230.70 (1) – Readily accessible location
  - Working clearance
    - 3 feet depth – 120/240 volt – 110.26
    - Equipment may not extend 6" beyond the front
      - Be careful of trough
      - Meters are exempt
    - Width – panel width or 30"
      - Can infringe upon other panel space
    - Headroom – 6'6" or ceiling (whichever is greater)
      - Existing dwellings (service changes) exempt from 6'6" if panel is 200 amps or less
    - Door opens 90 degrees

- New requirement to provide barrier in all service panelboards such that no uninsulated, ungrounded service busbar or service terminal be exposed to inadvertent contact by persons
- Helps with arc-flash concern and lowers incident energy if energized work performed on load side of main.
- Requirement came from Canadian Electrical Code.
- An exception was also added eliminating the barriers at panelboards installed to comply with the requirements of 408.36, Ex. No. 1, 2, and 3
- Exceptions to 408.36 address the "six means of disconnect" rules and the old "split-bus" panelboards that could be present

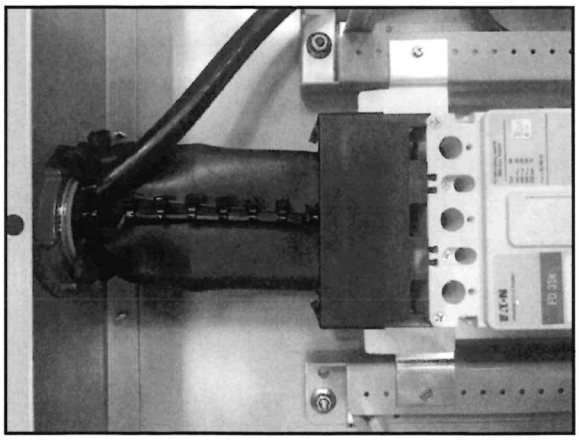
408.3(A)(2) Barriers at Service Panelboards

Barriers required in all service panelboards, switchboards, and switchgear such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations

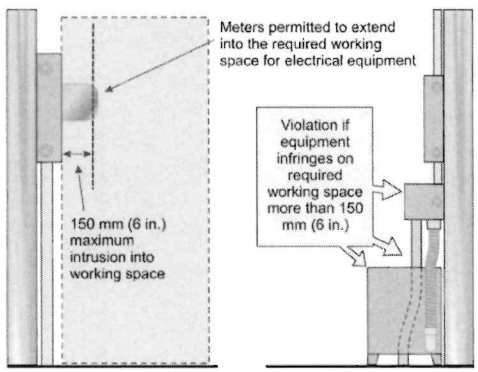


Schneider Electric

Exception: *This requirement shall not apply to service panelboards with provisions for more than one service disconnect within a single enclosure as permitted in 408.36, Exceptions No. 1, 2, and 3*



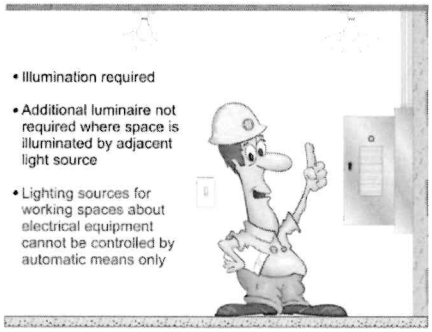
110.26(A)(3), Ex. No. 2 Height of Working Space



Services - Disconnecting Means

- 230.70 (1) - Readily accessible location
  - Illumination - must be lit
  - No automatic devices unless able to be overridden
  - Dedicated equipment space
    - 6 feet above equipment
    - Also applies outdoors
    - Up - On, Down - Off - 404.7

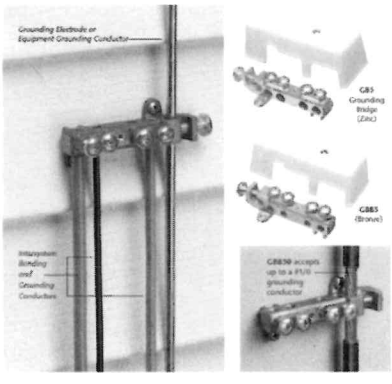
110.26(D) Illumination About Electrical Equipment

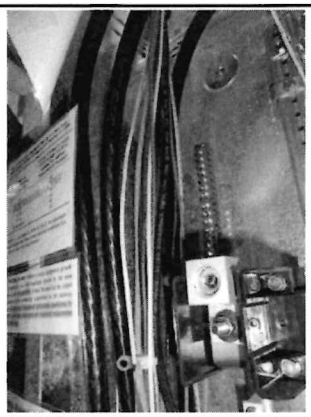


Illumination shall be provided for all working spaces about service equipment, switchboards, panelboards, or motor control centers installed indoors

Service - Panel

- 230.71
  - Six switch rule
  - Intersystem bonding
  - Marking of circuits - not arbitrary
  - Handle ties required on shared neutral
    - Red and black conductor in cable must have common trip.
  - Tie wrap neutral with circuit conductors
    - Not needed if you can tell in panel
      - same cable, distinct size, etc.





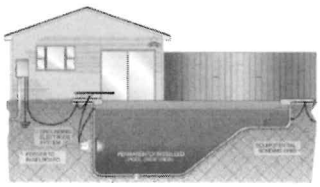
Grounding - 250.52

- Metal Frames of buildings
- Concrete Encased Electrodes - footer
  - 20 feet / #4
  - Listed connector
- Rod and Pipe
  - Supplemental - #6
  - You probably don't need it.
    - Only if metal underground water pipe
    - Only if no other means available
- Other Local metal underground systems
- **Do not ground metal underground gas piping systems**

- Third item added to the list of objects that are prohibited from being used as a grounding electrode at 250.52(B) (cont.)
- Items that shall not be used as a grounding electrode include:
  - Underground gas piping systems
  - An aluminum electrode
  - Structures and structural reinforcing steel of an in-ground swimming pool

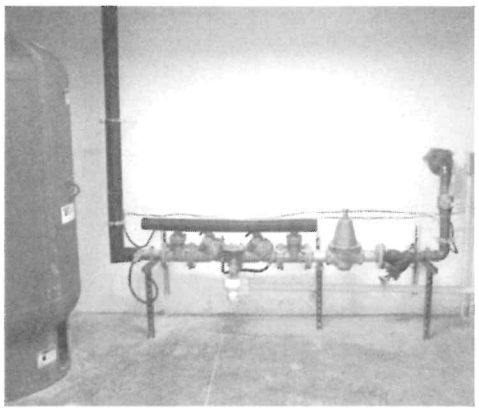
The provisions of 680.26 for equipotential bonding are to reduce voltage gradients *(difference of voltage potential between two conducting objects)*, not to establish a grounding electrode system for a building or structure

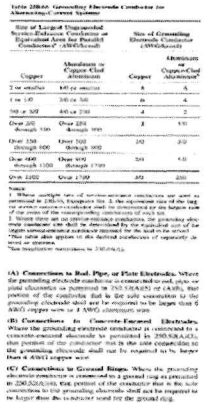
The structures and structural reinforcing steel of an in-ground swimming pool as described in 680.26(B)(1) and (B)(2) are prohibited from being used as a grounding electrode



Grounding - sizing

- 250.66
- Grounding electrode conductor (water pipe)
  - Contact with earth for at least 10 feet
  - Hit within 5 feet of entrance
  - Jump the meter
- Based on largest ungrounded conductor, not ampacity
- Typical – if pulling normal conductors
- 100 amp - #2 Al conductor - #8 Cu ground
- 150 amp – 2/0 Al conductor - #6 Cu ground
- 200 amp – 4/0 Al conductor - #4 Cu ground





Cables - Underground

- 300.5 Underground Installations
  - (B) Wet locations – Contains Letter W
  - (C) Under a building – raceway

  If conduit enters building from outside, it must be sealed
- Can't run Romex in conduit to enclosure
  - Sleeve OK
  - Must have a connector

- Low voltage lighting is at voltage levels at 50 volts or below which is less a safety hazard.
- Conflicts is resolved between manufacture instructions that in many cases allows for a reduced wiring depth on the secondary of a transformer than what is required in Table 300.5.
- Added new footnotes to Table 300.5 allowing reduced depths for listed low-voltage lighting system and for pool and spa lighting when included as part of a listed low-voltage lighting system.

Table 300.5 Minimum Cover Requirements, 0 to 1000 Volts, Nominal, Burial in Millimeters (Inches)

Location of Wiring Method or Circuit	Type of Wiring Method or Circuit									
	Column 1 Direct Burial Cables or Conductors		Column 2 Rigid Metal Conduit or Intermediate Metal Conduit		Column 3 Nonmetallic Raceways Listed for Direct Burial Without Concrete Encasement or Other Approved Raceways		Column 4 Residential Branch Circuits Rated 120 Volts or Less with GFCI Protection and Maximum Overcurrent Protection of 20 Amperes		Column 5 Circuits for Control of Irrigation and Landscape Lighting Limited to Not More than 30 volts and Installed with Type UF or in Other Identified Cable or Raceway	
	mm	in	mm	in	mm	in	mm	in	mm	in
All locations not specified below	600	24	150	6	450	18	300	12	150[a]	6[a]
In trench below 50 mm (2 in.) thick concrete or equivalent	150	18	150	6	300	12	150	6	150	6
Under a building	0	0	0	0	0	0	0	0	0	0
Under minimum of 102 mm (4 in) thick concrete exterior slab with no vehicular traffic and the slab extending not less than 152 mm (6 in) beyond the underground installation	450	18	100	4	100	4	150	6	150	6
							100	4	100	4
Under streets, highways, roads, alleys, driveways, and parking lots	600	24	600	24	600	24	600	24	600	24
One- and two-family dwelling driveways and outdoor parking areas, and used only for dwelling related purposes	450	18	450	18	450	18	300	12	450	18
In or under airport runways, including adjacent areas where trespassing prohibited	450	18	450	18	450	18	300	12	450	18

[a] A lesser depth shall be permitted where specified in the installation instructions of a listed low-voltage lighting system.
[b] A depth of 150 mm (6 in.) shall be permitted for pool, spa, and fountain lighting, installed in a nonmetallic raceway, limited to not more than 30 volts where part of a listed low-voltage lighting system.

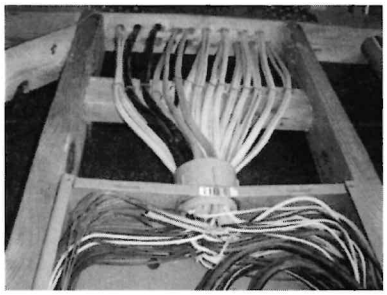
Cables - General

300.4 – Bored Holes
1 ¼" from edge
1/16" protector plate – also notched studs

300.4 – NM through metal framing members must have grommets completely around

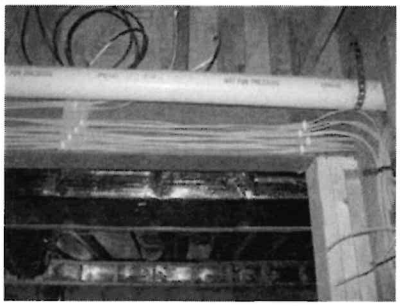
300.22 (B) – Plenums

Bundles of cables run through holes
derating



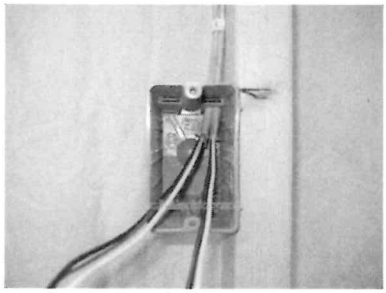
NM Cable

- 334.12 (B)(4) Uses not permitted
  - Wet or damp locations
  - Allowed to use in garages (attached and detached), accessory and storage buildings
- 334.15 (C) Unfinished basements under joists
  - Two - #6 AWG
  - Three - #8 AWG
  - Running boards or bored holes
- 334.30 Securing and supporting
  - 12" / 4 ½'



NM Cable Support

- 334.30 (A)
  - Horizontal Runs through Holes and Notches
- 314.17 (C) Nonmetallic boxes
  - ¼" sheath in box
  - 8" if cable not supported by box
- Unsupported Cables
  - Fishing
  - 4 ½' for fixture within an accessible ceiling



Boxes - general

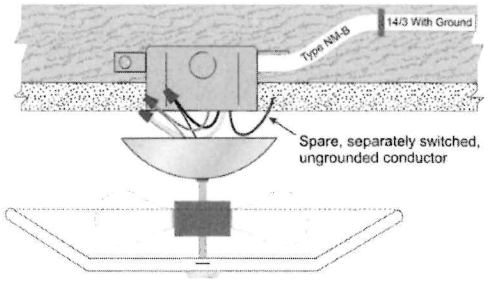
- Boxes must have backs for electrical
- Not needed but allowed for data
- Divider for double gang box
- Close all unused openings
- All boxes must have covers and be accessible
  - Doorbell transformers in basements
- Weatherproof boxes/bell boxes
  - Wet and damp locations

Boxes - fixtures

- Ceiling fan boxes must be listed
  - 70 lbs max
  - Must show max weight if above 35 lbs
  - Weight stamped inside of box - 2014
  - If running 3 wire to ceiling box it must be rated for a fan – if a fan is possible
- Vertical surface outlets (wall sconce)
  - 6 lbs. or less– can use device box
  - Not allowed for ceiling mount

314.27(C) Boxes at Ceiling Fan Outlets

At single or multi-family dwellings, spare, separately switched, ungrounded conductors at ceiling-mounted outlet boxes (in a location acceptable for a ceiling fan) require outlet box or system listed for sole support of a ceiling-suspended (paddle) fan



Circuits required

- Small appliance circuit – 20 amp
  - 2 for counters, can also hit dining room
  - No other receptacles
    - Not more than one kitchen is allowed
    - Definition of a kitchen
- Laundry circuit – 20 amp
  - Typically washing machine
- Bathroom circuit – 20 amp
  - All bath receptacles OR
  - All circuits in ONE bathroom
  - NOT BOTH

Circuits required

- Lighting and general purpose receptacles
  - All lighting
  - Bedroom receptacles
  - Living room/rec room/etc. receptacles
  - Hallway
  - Outdoor
  - Garage

N **(4) Garage Branch Circuits.** In addition to the number of branch circuits required by other parts of this section, at least one 120-volt, 20-ampere branch circuit shall be installed to supply receptacle outlets in attached garages an in detached garages with electric power. This circuit shall have no other outlets.

Exception: This circuit shall be permitted to supply readily accessible outdoor receptacle outlets.

IRC

Circuits required

- Take square footage of house
  - Measure on the outside
  - Do not include
    - Garages
    - Open porches/decks
    - Space not adaptable for future use /crawl spaces
- Multiply by 3 (VA)
- Divide by 120 (your voltage)
- Divide by breaker size (typically 15)

Circuits required

- 2,200 square foot house with 400 square foot room addition, 600 square foot garage.
- Total of 2,600 square feet (no garage)
- 2,600 x 3 = 7,800 VA
- You need 7,800 total volt amps of lighting, general receptacles
- 7,800 VA/120 V = 65 amps
- 65 amps/15 amp breakers = 4.3
- You would have to have AT LEAST 5 – 15amp breakers for lighting, general recepts. Etc.

Circuits required

- How many general purpose receptacles are you allowed to put on a 15 amp circuit?

Circuits required

- How many general purpose receptacles are you allowed to put on a 15 amp circuit?

No Limit

Required receptacles

- Kitchens (wall space), family rooms, dining rooms, parlor, bedroom, recreation room, etc.
  - 6 foot rule
  - 2 foot or wider wall sections
    - sections broken by doors, fireplaces, etc
  - Fixed door panels apply
  - Railings apply
    - Floor receptacles - less than 18" off the wall
    - Wall receptacles – less than 5 ½' above the floor

(2) Wall Space. As used in this section, a wall space shall include the following:

(1) Any space 600 mm (2 ft) or more in width (including space measured around corners) and unbroken along the floor line by doorways and similar openings, fireplaces, and fixed cabinets that do not have countertops or similar work surfaces

(2) The space occupied by fixed panels in walls, excluding sliding panels

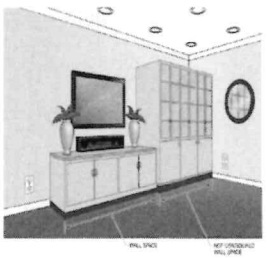
(3) The space afforded by fixed room dividers, such as free-standing bar-type counters or railings

Changes have been made to clarify that countertops must be included when calculating wall space.

Kitchen type cabinets, bar area countertops, and home office counters are all considered wall space.

Key term is "fixed cabinets".

At rough-in inspection, inspector should verify blueprints to see where cabinets are located to clarify areas that are not considered wall space.



Required receptacles

- Do not count as part of required receptacles
  - Part of a luminaire or appliance
  - Controlled by a wall switch
    - Unless half switched
  - In cabinets or cupboards

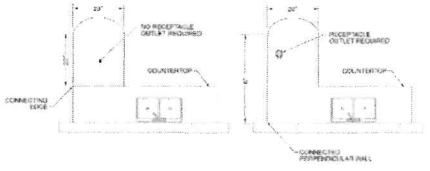
Required receptacles

- Kitchens countertops
  - 2′ rule
    - Spaces are broken by sinks, ranges, etc.
    - Does not apply if sink is:
      - Straight sink is more than 12″ off back wall
      - Corner sink is more than 18″ off back wall
  - Any space wider than 12″
  - Must be 20″ or less above countertop

Required receptacles

- Islands
  - At least one if greater than 24″ and 12″
  - Can count as two separate spaces is broken by sink, range, etc.
    - Not considered broken if more than 12″ of counter behind.
- Peninsula
  - At least one if greater than 24″ and 12″
    - Measured from wall
  - Same rules as islands

(3) Peninsular Countertop Spaces. At least one receptacle outlet shall be installed at each peninsular countertop long dimension space with a long dimension of 600 mm (24 in.) or greater and a short dimension of 300 mm (12 in.) or greater. A peninsular countertop is measured from the connected perpendicular wall.



2014 NEC
Peninsular countertop long dimension is measured from the "connecting edge"

2017 NEC
Peninsular countertop long dimension is measured from the "connected perpendicular wall"

Required receptacles

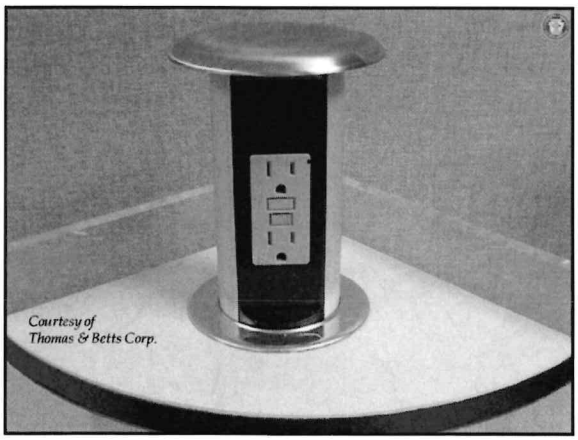
- Kitchens
  - For physically impaired or flat counter (no backsplash)
    - Can be located below counter if less than 12″
      - Doesn't apply if counter extends 6 or more inches over base
  - Kitchen counter receptacles can not face up
    - Not permitted anywhere

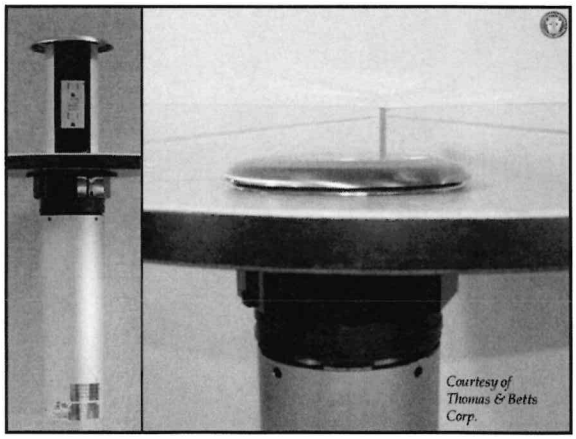
Required receptacles

- Appliance receptacles within 6′ of appliance
  - Laundry equipment
  - Refrigerator
- At least one receptacle in laundry
- Bathrooms
  - At least one – within 3′ of outer edge of each basin
  - Can be located not less than 12″ below counter.
  - Listed receptacles may be used (pop up)

210.52(C)(5) and 210.52(D)

- Dwelling Unit Receptacle Outlet Locations:
  - Listed receptacle outlet assemblies are now permitted to be installed on or in kitchen and bathroom countertops to serve as the required countertop receptacles
  - Receptacle outlets must be located on, or above the countertop
  - Applies to countertops in bathrooms, kitchens, pantries, breakfast rooms, dining rooms, and similar areas of dwelling units
  - Receptacles shall not be installed in a face-up position in countertops or similar work surfaces *[406.5(E)]*





Required receptacles

- Outdoors
  - One in front and back
    - Not more than 6 1/2' above grade
    - All covers in use covers
    - Extra Duty
      - Clear "bubble" covers no longer allowed
- Balconies, Decks, Porches
  - One required if
    - Accessible from inside the dwelling
    - Any size, 20 square foot reference removed in 2011
  - If required, it must be
    - Accessible from the balcony
    - Less than 6 ½' above surface

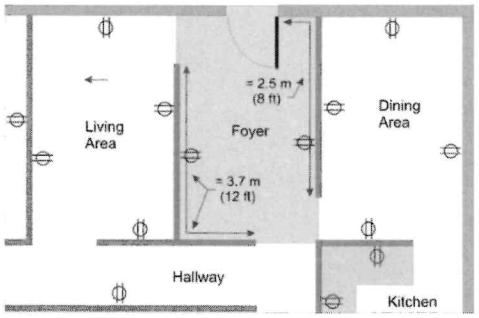
Required receptacles

- HVAC equipment
  - Within 25' of HVAC or refrigeration equipment
- Receptacles can perform double duty
- Receptacles must be readily accessible from grade level

Required receptacles

- Hallways
  - Need only one if hallway is 10' or longer
  - Passing through a door constitutes new area
- Foyers
  - Need at least one in each wall space 3 feet or wider
    - Does not fall under the 6 foot rule
  - Applies if foyer is 60 or more square feet

210.52(I) Foyers



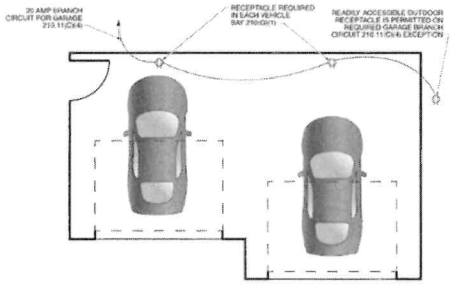
Foyers that are not part of a hallway having an area that is greater than 5.6 m² (60 ft²) are required to have a receptacle(s) located in each wall space 900 mm (3 ft) or more in width

Required receptacles

- Garage
  - Receptacles for specific equipment do not count towards required receptacles.
    - Central Vac , Garage door
  - Circuit must be dedicated in garage – 210.52 (G)(1)
    - Same rule applies for detached garage – if it has power
    - Separate circuit for attached and detached?
  - One receptacle for each car space - 210.52 (G)(1)
  - Vehicle charging circuit must be dedicated – 210.17
    - Only if installed.

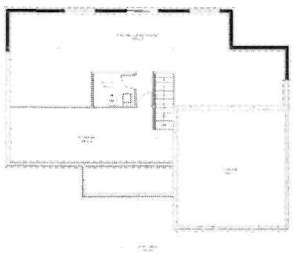
(G) Basements, Garages, and Accessory Buildings. For one- and two-family dwellings, at least one receptacle outlet shall be installed in the areas specified in 210.52(G) (1) through (3). These receptacles required for specific equipment.

(1) Garages. In each attached garage and in each detached garage with electric power, at least one receptacle outlet shall be installed in each vehicle bay and not more than 1.7 m (5-1/2 ft) above the floor.



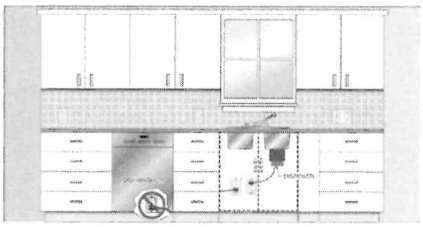
Required receptacles

- Basement
  - One receptacle needed in addition to receptacle required for specific equipment
    - Central Vac , Sump pump
  - Each separate section is required to have a receptacle
    - Storage room
    - Partially finished basement



- Built-in Dishwashers that are cord-and-plug-connected are now required to have receptacle outlet located in space adjacent to the space occupied by the dishwasher.
- Length of dishwasher cord was increased from 4 ft to 6.5 ft, "measured from the face of the attachment plug to the plane of the rear of the appliance".
- Trash compactor cord is still required to be between 3 and 4 ft.
- Trash compactor receptacle is required to be located in adjacent space as well.

422.16(B)(2) Built-in Dishwashers

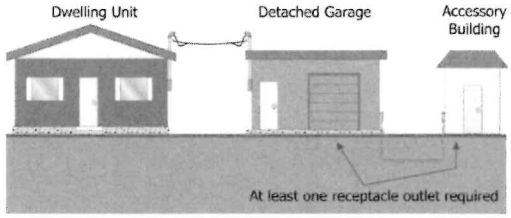


Receptacle outlet for cord-and-plug connected built-in dishwasher required to be located in the space adjacent to the space containing the dishwasher only with the length of a cord for a built-in dishwasher lengthened from 1.2 m (4 ft) to 2.0 m (6-1/2 ft)

Required receptacles

- Accessory Building(s) – (detached garage, shed, etc.)
  - Not required to run electric to any of these buildings
  - If you do run electric power, you must install a receptacle
    - Can't do lighting only
- Only 1 branch circuit allowed to be run to building
  - Multi-wire branch circuit counts as one circuit.
  - If more circuits are needed, run feeder to subpanel.

210.52(G) Accessory Buildings with Power



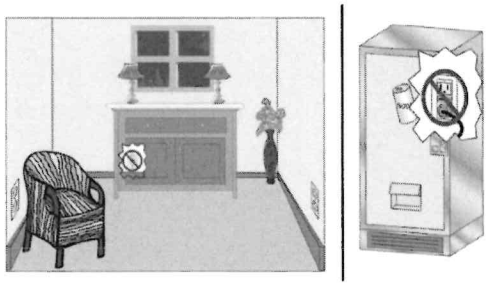
210.52(G) - Basements, Garages, and Accessory Buildings

At least one 125-volt, 15- and 20-ampere receptacle outlet, in addition to those for specific equipment, shall be installed in each basement, in each attached garage, and in each detached garage or accessory building with electric power

GFCI Receptacles

- Required
  - Dwelling Units – 15 and 20 amp, 120 volt
    - Bathrooms
    - Garages-*
    - Outdoors
    - Crawl spaces
    - Unfinished basements *
    - Kitchens – where the recepts are installed to serve countertops
    - Boathouses
    - Accessory buildings with floor at or below grade not intended as habitable (storage, work areas)
  - *Do not need if used for fire alarm and/or burglar alarm systems
  - **Must be READILY ACCESSIBLE**

210.8 Ground-Fault Circuit-Interrupters



- All GFCIs for personnel must be installed in a readily accessible location
- This applies to 210.8(A), (B), and (C)

GFCI Receptacles

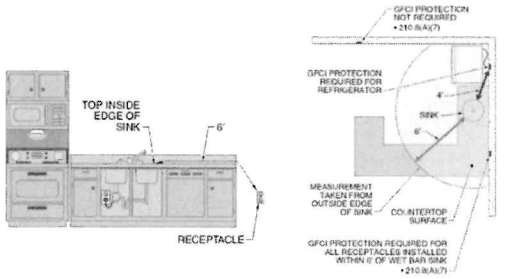
- Required
- Dwelling Units – 15 and 20 amp, 120 volt
  - **Within 6 feet of bathtub or shower stall**
    - Eliminated loop hole
  - **All sinks – took out kitchen sink reference**
    - Could affect disposals, microwave and fridge
  - **Laundry areas**
    - Define "area"
  - **Dishwashers – 210.8(D)**

210.8 Ground-Fault Circuit-Interrupter Protection for Personnel. Ground-fault circuit-interrupter protection for personnel shall be provided as required in 210.8(A) through (E). The ground-fault circuit interrupter shall be installed in a readily accessible location.

Informational Note No. 1: See 215.9 for ground-fault circuit-interrupter protection for personnel on feeders.

Informational Note No. 2: See 422.5(A) for GFCI requirements for appliances.

For the purposes of this section, when determining distance from receptacles the distance shall be measured as the shortest path the cord of an appliance connected to the receptacle would follow without piercing a floor, wall, ceiling, or fixed barrier, or passing through a door, doorway, or window.

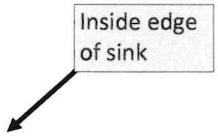


(A) Dwellings ...

(7) Sinks — where receptacles are installed within 1.8 m (6 ft) from the *top inside* edge of the bowl of the sink.....

(B) Other than Dwelling Units....

(5) Sinks — where receptacles are installed within 1.8 m (6 ft) from the top inside edge of the bowl of the sink....



N **(E) Crawl Space Lighting Outlets.** GFCI protection shall be provided for lighting outlets not exceeding 120 volts installed in crawl spaces.

Applies to **ALL crawl spaces**, BOTH dwelling unit and non-dwelling units alike!

Arc Fault Receptacles

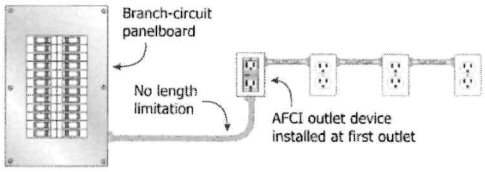
- Dwelling units – 15 and 20 amp, 120 volt
  - 210.12 (A)
  - Pretty much every place that doesn't require GFCI
- Locations that don't require arc fault protection
  - Bathroom
  - Outside
  - Unfinished basement
  - Garage

Arc Fault Receptacles

- Dwelling units – 15 and 20 amp, 120 volt
  - 210.12 (A)
- Verbiage includes the word "devices"
  - Could affect garage lighting, outdoor lighting
  - Can bypass breaker and use first outlet box if metal box and fed by metal raceway or cable.

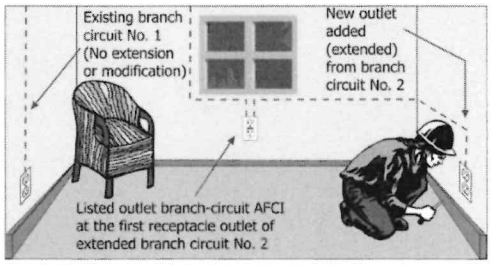
210.12(A) Ex. No. 1 Outlet Type AFCI

Main rule at 210.12(A) requires AFCI combination-type protection installed to provide protection of the entire branch circuit



Ex. No. 1: If RMC, IMC, EMT, Type MC or steel armored Type AC cables meeting the requirements of 250.118 and metal outlet and junction boxes are installed for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a outlet branch-circuit Type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.

210.12(B) AFCI - Extensions or Modifications



In any of the areas specified in 210.12(A), where branch-circuit wiring is modified, replaced or extended, the branch circuit shall be protected by:

(1) A listed combination AFCI located at the origin of the branch circuit, or

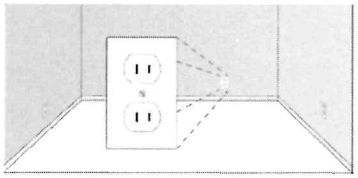
(2) A listed outlet branch-circuit AFCI located at the first receptacle outlet of the existing branch circuit

- Four exceptions were added to this section which covers replacement of receptacles in areas that 210.12(A) and (B) now requires to have AFCI protection.
  - AFCI is not required when replacing a non-grounding receptacle and no ground exists.
  - AFCI is not required when there is not equipment ground.
  - A listed combination type arc-fault circuit-interrupter circuit breaker is not commercially available.
  - GFCI/AFCI dual function receptacles are not commercially available.
- Exception to 210.12(B) permits existing branch circuit conductors to be modified or extended up to 1.8 m (6 ft) without AFCI protection where no additional outlets or devices are installed

- Arc Fault replaces are not necessary if the Exception to 210.12(B) applies.
- This exception permits existing branch circuit conductors to be modified or extended up to 1.8 m (6 ft) without AFCI protection where no additional outlets or devices are installed.

406.4(D)(4) Replacement Receptacles (AFCI)

Where a receptacle outlet is located in any areas specified in 210.12(A) or (B), a replacement receptacle at this outlet must be AFCI protected



Ex. No. 1: AFCI protection not required where all of the following apply:

(1) Replacement complies with 406.4(D)(2)(b) *(two-wire system-GFCI)*

(2) Impracticable to provide an EGC as provided by 250.130(C)

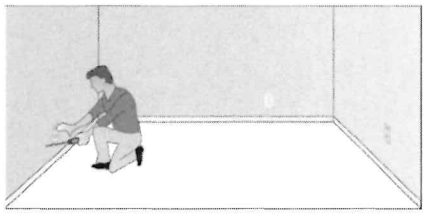
(3) Listed combination type AFCI circuit breaker not commercially available

(4) GCFI/AFCI dual function receptacles not commercially available

Ex. No. 2: Exception at 210.12(B) shall not apply to replacement of receptacles

406.4(D)(4) Replacement Receptacles (AFCI)

Where a receptacle outlet is located in any areas specified in 210.12(A) or (B), a replacement receptacle at this outlet must be AFCI protected



Ex. No. 2: Exception at 210.12(B) shall not apply to replacement of receptacles

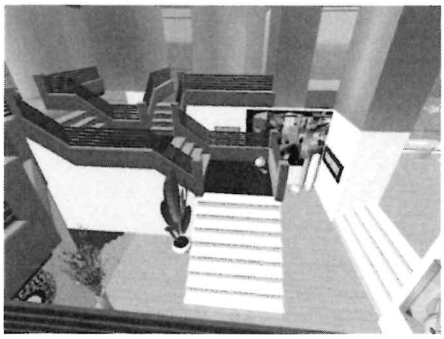
[210.12(B), Ex.: AFCI protection not required where the extension of the existing conductors is not more than 1.8 m (6 ft.) and does not include any additional outlets or devices]

Required switches

- At least one wall switch controlled lighting outlet in each habitable room
  - Outlet is not the same as a receptacle
    - Overhead light
    - Wall sconce
  - Sensors are allowed if manual override available
- It may be a receptacle instead of a lighting outlet (overhead light) except for
  - Kitchen
  - Bathroom
  - Garage

Required switches

- Hallways – at least one switch
- Storage or equipment spaces
  - Attics, under floor spaces, utility rooms, basements
  - At least one switch
    - Switch near point of entry
    - Lighting outlet near equipment needing servicing
- Stairs
  - One at each level if there are 6 or more risers
  - One at each level if it is an entryway
- Exterior of exterior doors with grade level access
  - Coach lights
  - Does not include a vehicle door (garage door)



Required switches

- 2011 required a neutral to be in most switch boxes
  - Hoped to reduce having ground used as conductor
- Rules loosened up a little in 2014
  - Neutral not needed if:
    - Switch does not serve a habitable room or bathroom
      - Hallway
      - Closets
    - Multiple switching (3 ways and 4 ways)
      - Only need where switch location covers the area
    - Integral switches
      - Door jam switch
- Also kept other exceptions:
  - Raceways
  - Access to switch box at later time

(C) Switches Controlling Lighting Loads. The grounded circuit conductor for the controlled lighting circuit shall be installed at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit serving bathrooms, hallways, stairways, or rooms suitable for human habitation or occupancy as defined in the applicable building code. Where multiple switch locations control the same lighting load such that the entire floor area of the room or space is visible from the single or combined switch locations, the grounded circuit conductor shall only be required at one location.

404.2(C) Grounded Conductor at Switch Locations

A grounded conductor is generally required to be installed and connected to the switching device at locations where switches control lighting loads that are supplied by a grounded general-purpose-branch circuit.

Grounded conductor is generally NOT required at the following locations:

Lighting controlled by automatic means

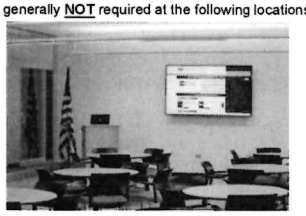
Where a switch controls a receptacle load

Switch for non-habitation type room or occupancies as defined by applicable building codes

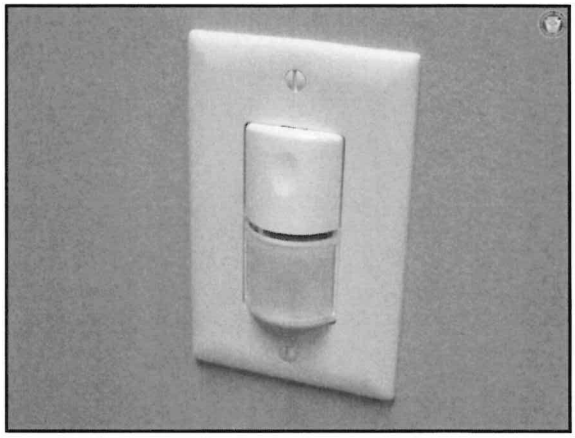
404.2(C) Grounded Conductor at Switch Locations

A grounded conductor is generally required to be installed and connected to the switching device at locations where switches control lighting loads that are supplied by a grounded general-purpose branch circuit

Grounded is generally **NOT** required at the following locations:



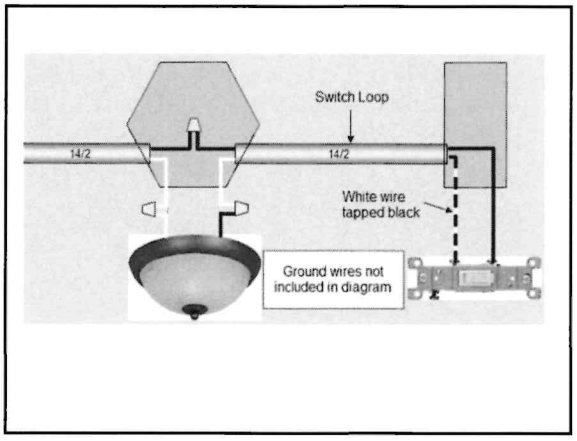
Where multiple switch locations control the same lighting load such that the entire floor area of the room or space is visible from the single or combined switch locations, the grounded circuit conductor shall only be required at one location



- All electronic lighting control switches are required to be listed. As of Jan. 1, 2020, electronic lighting control switches (with exceptions) will not be permitted to introduce current on the equipment-grounding conductor during normal operation.
- Manufacturers will only make devices that place current on the equipment-grounding conductor during normal operation for replacement/retrofit.
- New exception places limits to electronic switches to the following levels.
  - Branch circuit (5)
  - Or feeder (25)

Required switches

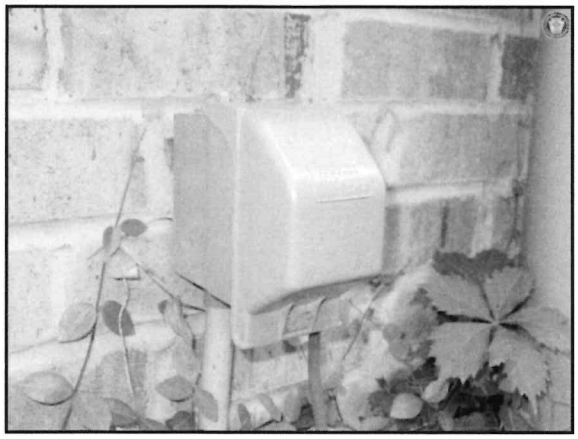
- Switch loops required to be:
  - Down on white
  - Back on black
- Must phase white conductor with phase color
  - Tape
  - Paint
  - Marker
- Not as relevant with neutral requirements

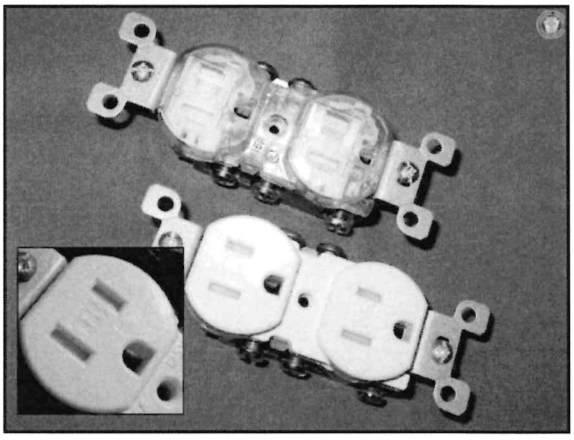


Devices- General

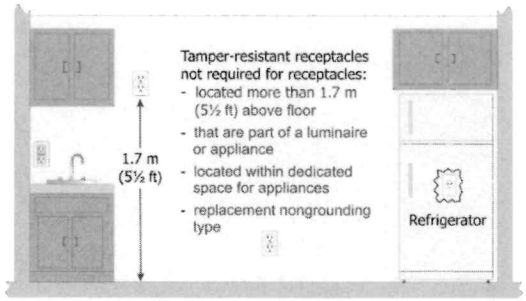
- Tamper resistant receptacles
  - Required for all 120 volt, 15 and 20 amp receptacles
    - Not required 5 ½ feet off the floor and below or dedicated for appliance.
- Weather resistant receptacles
  - Required for all outdoor receptacles
- **Extra Duty Covers**
  - Must be used in all wet locations
  - Can not be old gasket type
- CO/ALR
  - Listed for both copper and aluminum wire

Replacement receptacles must be brought up to code regarding tamper and weather resistant. There is also provisions for bringing the circuit up to arc fault standards.



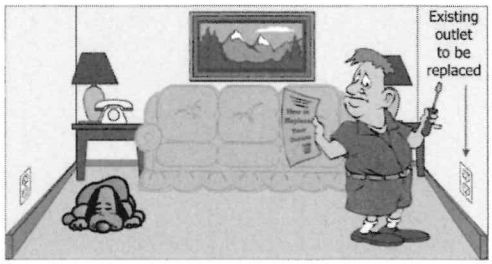


406.12 Tamper-Resistant Receptacles



In all areas specified in 210.52, all nonlocking type 125-volt, 15- and 20-ampere receptacles required to be listed tamper-resistant receptacles

406.4(D)(4) Receptacle Replacement (AFCI)



Arc-fault circuit-interrupter protection is required for replacement receptacle outlets where a receptacle outlet is supplied by a branch circuit that requires AFCI protection elsewhere in the *Code* *(effective date January 1, 2014)*

Replacement receptacle outlet can be protected by a listed outlet branch circuit type AFCI receptacle or a listed combination type AFCI circuit breaker

406.4(D)(5) Receptacle Replacement Tamper-Resistant Receptacles

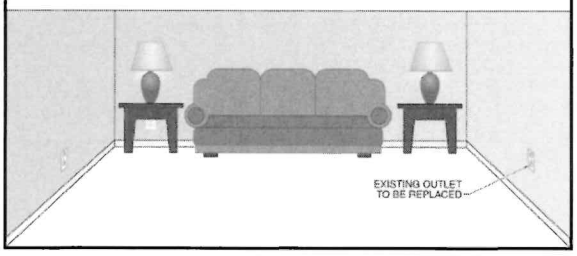
Listed tamper-resistant receptacles are required for replacement receptacle outlets where a receptacle outlet is required to be tamper-resistant elsewhere in the *Code*

See 406.12, 406.13, and 406.14 for tamper-resistant receptacle requirements

- Tamper-resistant receptacles are presently not manufactured in a nongrounding type, two-prong receptacle
- Therefore, when replacing receptacles, tamper-resistant receptacles are required for all replacements in those areas required by the code unless a non-grounding receptacle is replaced with another non-grounding receptacle type.

406.4(D)(5) Replacement with Tamper Resistant

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

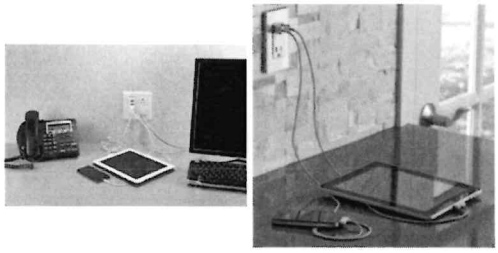


406.4(D)(6) Receptacle Replacement Weather-Resistant Receptacles

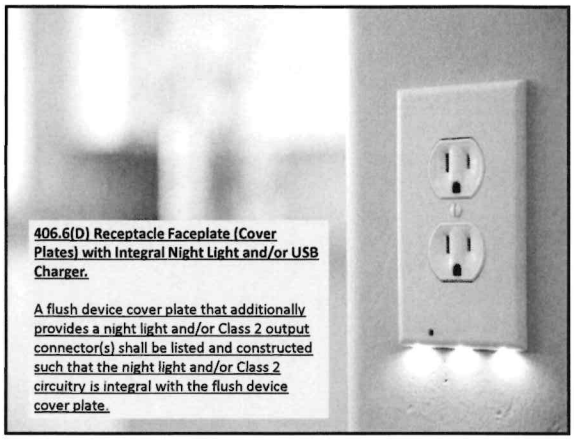
Listed weather-resistant receptacles are required for replacement receptacle outlets where a receptacle outlet is required to be weather-resistant elsewhere in the *Code*

See 406.9(A) and 406.9(B) for weather-resistant receptacle requirements

- New Text has been added to clarify the when USB Charging ports are integral to a 125-volt, 15- or 20- amp receptacle the Class 2 circuitry necessary for the USB charging is integral to the receptacle.
- Receptacle shall be listed.
- Certain Class 2 power supplies and output connector(s) are intended to be secured and directly connected to a duplex receptacle. This is not permitted according to the new text.

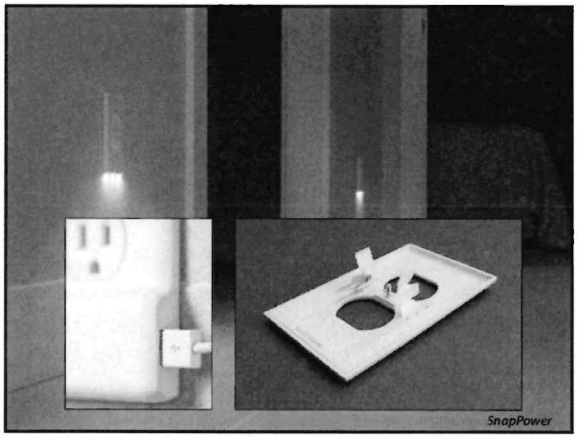


- New requirements were added pertaining to receptacle faceplates with integral night lights and/or USB chargers
- These faceplates must be listed and constructed such that the night light and/or Class 2 circuitry is "integral with the flush device cover plate"
- Plug-in night light/covers that is not "integral with the flush device cover plate," but simply designed to be plugged directly into a receptacle outlet presents a problem
- The ease in removing these night light-type covers from the receptacle outlet increases its safety hazard



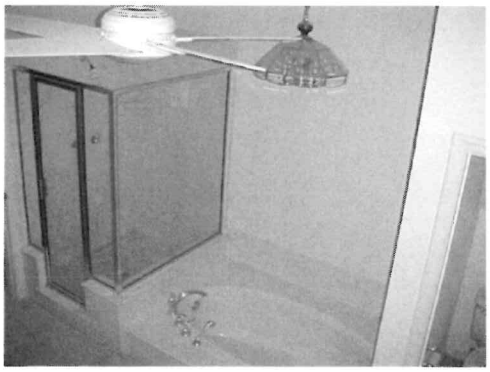
406.6(D) Receptacle Faceplate (Cover Plates) with Integral Night Light and/or USB Charger.

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



Required lighting

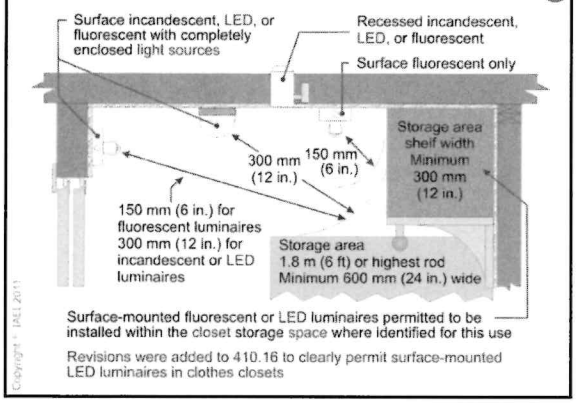
- Lighting fixtures
  - Bathtub and shower
    - No part of fixture shall be located within
      - 8' vertically from top of bathtub rim or shower thresh hold
      - 3' horizontally from edge of fixture
    - If located within this zone, must be marked for damp/wet location (can light, weatherproof trim)



Required lighting

- Clothes closets
  - Open lamps not allowed
- Zone extends from edge of shelf to ceiling
  - 12" clearance for surface mounted incandescent lamp completely enclosed
  - 6" clearance for surface mount fluorescent, or recessed light.
  - LED lights allowed if completely enclosed or listed for closets
- White can - 3" from insulation,
- Metal can - insulation can come in contact

410.16 Luminaires in Clothes Closets



Revisions were added to 410.16 to clearly permit surface-mounted LED luminaires in clothes closets

Disconnecting Means

- Needed for appliances/motors
  - In sight and within 50'
- Common disconnects
  - Furnace
  - Dishwasher
  - Oven
  - Central Vac
  - AC unit
  - Dryer
- Can be switch or receptacle
- AC unit does not have to be fused – if breaker is correct
- MUST SIMULTANEOUS DISCONNECT ALL PHASE CONDUCTORS OF AN APPLIANCE

Pools/Hot tubs/Jacuzzis

- Dwelling Pools
  - At least one receptacle located between 6'-20' from inside edge of pool shall be provided
  - Located 6'6" or less above grade level
  - Must be GFCI protected
  - Pool pump must be GFCI protected
    - 120 or 240 volt
  - Must have insulated ground throughout circuit for light fixtures
  - Receptacle for hydro massage tub must be within one foot of the opening of the access panel with its face in direct view.

Pools/Hot tubs/Jacuzzis

- Dwelling hot tub
  - Receptacle required between 6 and 10 feet
  - Must be GFCI protected
  - Power to hot tub must be GFCI protected
- Lighting outlets, paddle fans, etc.
  - If not GFCI protected
  - Located at least 12 feet above maximum water level
  - If GFCI protected
  - Located at least 7 foot 6 above maximum water level
- Specialty fixtures may be allowed lower clearance if GFCI protected.

Smoke Detectors

- Must have one on each floor
- If placed on ceiling, keep off wall by at least 12"
- If placed on wall, mount between 4" and 12" of ceiling
- Every bedroom and common hallway is required to have one
- Must be interconnected (3 wire)
- Do not place near kitchen, bathroom, garage, utility room unless it is rated for it. Could use rate of rise or heat detector instead
- Do not put near register vents or ceiling fans.

Dwelling requirements

Required receptacles

- 6 foot rule – no point along the wall may be more than 6 feet from a receptacle
- 2 foot walls – the minimum size wall that is required to have receptacles
- Kitchen countertops – no point along these walls can be more than 2 feet away from a receptacle
- Appliance receptacles – at least one within 6 feet.
- Bathrooms – one per bathroom required
- Outside – receptacles are required at the front and back of the house
- Hallways – 10 foot or more require receptacles
- Garages with power – at least one required

Services

- Minimum size
- Location

Lighting

- Switched outlets required

Clearances

- Underground burial depths
- Overhead conductor minimum heights

Sean Clark

901 Beechmeadow Ln. Cincinnati, Ohio 45238
(H)513/347-9054 (C)513/800-4450
sclark@ohiovalleyelectric.com

••••••••••••••••••••••••••••

A licensed electrician with over twenty years of experience in installing, maintaining, and repairing electrical wiring, equipment, and fixtures, ensuring that work is in accordance with relevant codes, fire alarm installations, electrical control systems, and high voltage terminations. A licensed electrician with three years teaching experience in first and second year electrical.

Summary of Qualifications

- More than twenty years experience.
- Three years experience in teaching first and second year electrical.
- Thorough knowledge of electrical systems including planning additions and modifications on secondary circuits. Controls and low voltage wiring
- Able to read commercial electrical blueprints and apply NEC through the full range of commercial and industrial maintenance and construction work.
- Can use appropriate tools and diagnostic equipment to repair, install, replace, and test electrical circuits, equipment and appliances.
- Excellent ability to diagnose and repair electrical controls, industrial motor control centers, and programmable logic controllers.
- Strong desire to study and comprehend new technology.
- In-depth ability to make mathematical computations.
- Considerable ability to explain instructions and guidelines to others effectively.
- Able to assign work to employees., prioritize the work of others and organize and coordinate the work of the unit. For subs and Primes.

Professional Experience

Ohio Valley Electrical Services 2011-Present

ABC Electrical Teacher 2010-2013

Beacon Electrical Contractors 2007-2011

Ohio Valley Electrical Services 1993-2007

Electrical Superintendant/Foreman/Instructor

- First and Second year electrical instructor
- Supervision of all electrical installations of as many as 50 electricians to assure that work was done safely, efficiently, properly and within time allowed.
- Trained multiple employees in all aspects of electrical work to be able to identify an employee's strengths and weaknesses to better utilize their skills. Traced out short circuits in wiring, using test meter.
- Coordinated and implemented electrical projects within a variety of environments including plants, hospitals, schools, retail stores, public facilities, waste water treatment plants industrial buildings;

projects include both new construction and underground electrical wiring as well as renovation within existing buildings. Parking Garages and Fed Ex Ground Facilities.

- Assemble, install, test, and maintain electrical or electronic wiring, equipment, appliances, apparatus, and fixtures, using hand tools and power tools.
- Connect wires to circuit breakers, transformers, or other components.
- Construct and fabricate parts, using hand tools and specifications.
- Diagnose malfunctioning systems, apparatus, and components, using test equipment and hand tools, to locate the cause of a breakdown and correct the problem.
- Inspect electrical systems, equipment, and components to identify hazards, defects, and the need for adjustment or repair, and to ensure compliance with codes.
- Plan layout and installation of electrical wiring, equipment and fixtures, based on job specifications and local codes.
- Test electrical systems and continuity of circuits in electrical wiring, equipment, and fixtures, using testing devices such as ohmmeters, voltmeters, and oscilloscopes, to ensure compatibility and safety of system.
- Perform business management duties such as maintaining records and files, preparing reports and ordering supplies and equipment.

Education & Certifications

Master Electrician License-State of Kentucky

Journeyman Electrician's License-Hamilton, Ohio

Fire Alarm License-State of Ohio

Certified in high voltage terminations and splices

Lift, Lull, Bobcat, and Boom/scissors lift licenses

OSHA-30 card

Certified in first aid and CPR training

Certified NCCER Core Curricula Instructor

Certified NCCER Electrical Instructor

Completed 4 year apprenticeship program

1 Year Pre-apprentice school (ABC)

High School Diploma (1991)

ARCH FLASH SAFETY TRAINING

PROJECTS-SUPERVISED

$4.5mil.-MASON HIGH SCHOOL ADDITION

$250.000-3CDC-5TH RACE PARKING GARAGE

$250.000-AVONEDALE APT. COMPLEX

$100.000-MAHOGANYS AT THE BANK-

1.2mil. -PATHEON CHEMICALS

$450.000- FED EX GROUND ADDITION

$250.000-LIBERTY WAY PROJECT

$500.000-GE AT THE BANKS

$100.000 - SYCAMORE SCHOOLS/POWER/CONTROL-

$50.000 - NKU RETROFIT

$250.000- UC POWER PLANT ADDITION

$75.000 - 580BLD/ CHEMED, RETROFIT

$4.0mil - DHL- CONVEYERS/SHELL

$90.000- DOUBLE TREE AIRPORT

$2.5mil- TWIN LAKES OF MONTGOMERY

$45.000- STEINMART ANDERSON

And many small T&M jobs.

All on time and under budget

File Attachments for Item:

ER-5 Grounding and Bonding (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)

All certifications (4 hours)

Staff Notes:

ESIAC Recommendation:

Committee Recommendation:

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Kevin Collins

Organization: IEC of Greater Cincinnati

Address: 586 Kings Run Drive Cincinnati, OH 45232

E-mail: KCollins@iec-cincy.com Telephone: 513-542-0400

Website: iec-cincy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Grounding & Bonding

Course instructor: Sean Clark

Course description: Review Article 250 of the NEC. We will discuss different grounding electrodes, what are required at different structures, sizing the GEC, different types of equipment grounding conductors, the location of the main bonding jumper and sizing.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: 3/12/24 - IEC of Greater Cincinnati

Special Content:

Code Administration: [X]
Existing Buildings: [ ]
Electrical Instruction: [X]
Plumbing Instruction: [ ]

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? [ ] **On Demand** [ ] **Webinar** [ ]

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: [ ]
Administrative Course, All Certifications: [ ]

Commercial Certifications: [X]

Application materials included:

- [ ] Course Outline or Course Learning Objectives
- [X] Presentation Materials/Slides (not required for roundtable courses)
- [ ] Assessment Materials (for online courses)
- [ ] Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Grounding

- 250.66
- 250.02(C)(1)
- 250.122

Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors* (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum†
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounded Conductor or Bonding Jumper* (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	See Notes	

Notes:
1. If the ungrounded supply conductors are larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded conductor or bonding jumper shall have an area not less than 12 ½ percent of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors. The grounded conductor or bonding jumper shall not be required to be larger than the largest ungrounded conductor or set of ungrounded conductors.

Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

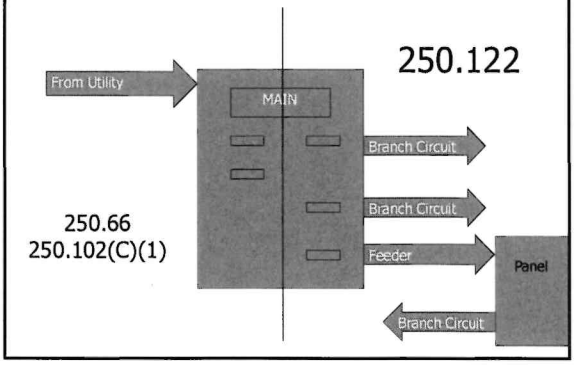
Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum*
15	14	12
20	12	10
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	750
5000	700	1250
6000	800	1200

Note: Where necessary to comply with 250.4(A)(5) or (B)(4), the equipment grounding conductor shall be sized larger than given in this table.
*See installation restrictions in 250.120.

Grounding

- 250.66/250.102(C)(1) vs. 250.122
  - .66 is before first overcurrent protection device. (SERVICE)
  - .122 based on the size of overcurrent protection device in circuit

Grounding



Grounding electrode(s)

- Based on 250.66
- Water pipe, steel, ground rod, footer ground (concrete encased electrode), ground ring, ground plate are all grounding electrodes. All are sized off this chart.
  - Additional code articles do not require ground rod conductor larger than 6, footer larger than 4 and ground ring larger than 2.
  - Could be smaller if you have a smaller service.
  - If you have it, you got to land it.
  - Ground rods are seldom needed.

Grounding electrode(s)

- Based on 250.66
- Grounding electrode conductors MAX OUT
  - 3/0 Cu or 250 Al is the largest required
- Based on size of TOTAL area of ONE phase
  - Add all of the conductors of the same phase (hots)
  - Has nothing to do with service size
  - Make sure to read chart carefully
    - 3/0, 350, 600 and 1100 appear twice
      - One row will say through
      - One row will say over

Grounding Electrode Conductor

- Example
  - I have 1 set of 3/0 Cu feeding a 200 amp service. Size the grounding electrode to the building steel, water pipe, ground rod and the concrete encased electrode:

Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors[a] (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum[b]
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

Grounding Electrode Conductor

- Example
  - I have 1 set of 3/0 Cu feeding a 200 amp service. Size the grounding electrode to the building steel, water pipe, ground rod and the concrete encased electrode
  - Find 3/0 on 250.66 – read across
  - Water pipe - **#4 Cu or #2 Al**
  - Steel - **#4 Cu or #2 Al**
  - Ground rod **#6**, Concrete encased **#4**

MAKE SURE TO ANSWER IN CORRECT CONDUCTOR TYPE

Grounding Electrode Conductor

- Example (parallel sets)
  - I have 4 sets of 350 kcmil Cu feeding a 1200 amp service. Size the grounding electrode to the building steel, water pipe, ground rod and the concrete encased electrode:

Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors[a] (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum[b]
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

Grounding Electrode Conductor

- Example (parallel sets)
  - I have 4 sets of 350 kcmil Cu feeding a 1200 amp service. Size the grounding electrode to the building steel, water pipe, ground rod and the concrete encased electrode
  - 4 x 350,000 = 1,400,000 or 1,400 kcmil
  - 1,400 kcmil exceeds 250.66
  - Water pipe – **3/0 Cu or 250 kcmil Al**
  - Steel – **3/0 Cu or 250 kcmil Al**
  - Rod - **#6**, Concrete encased - **#4**

Grounding Electrode Conductor

- Example
  - I have 2 sets of 250 kcmil Cu feeding a 500 amp service. Size the grounding electrode to the building steel, water pipe, ground rod and the concrete encased electrode:

Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors[a] (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum[b]
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

Grounding Electrode Conductor

- Example
  - I have 2 sets of 250 kcmil Cu feeding a 500 amp service. Size the grounding electrode to the building steel, water pipe, ground rod and the concrete encased electrode
  - 2 x 250,000 = 500,000 or 500 kcmil
  - Water pipe – **1/0 Cu or 3/0 kcmil Al**
  - Steel – **1/0 Cu or 3/0 kcmil Al**
  - Rod - **#6**, Concrete encased - **#4**

Grounding

- Main bonding jumper (MBJ)
  - New chart – 250.102(C)(1) – almost same as 250.66
  - Bonds the grounded conductor (neutral) to the grounding conductor (ground)
    - Only done once per service
    - Also transformers/treat like a new service
  - Size the same as grounding electrode
    - Only difference is it does not max out
    - Read directly off chart until you are over 1100 kcmil Cu or 250 Al.

Grounding electrode conductor and MBJ will be the same size unless conductors exceed 250.66.

Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

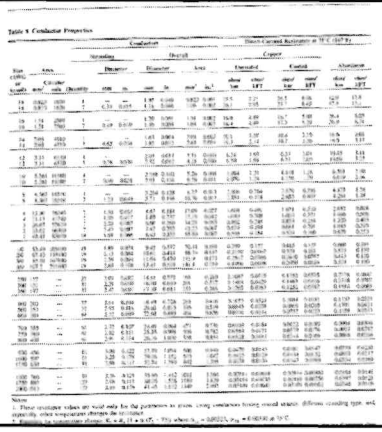
Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounded Conductor or Bonding Jumper* (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
1/0 or smaller		8	6
2 or smaller	smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	See Notes	

Notes:
1. If the ungrounded supply conductors are larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded conductor or bonding jumper shall have an area not less than 12 ½ percent of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors. The grounded conductor or bonding jumper shall not be required to be larger than the largest ungrounded conductor or set of ungrounded conductors.

Grounding - Main Bonding Jumper

- Once the total of a phase exceeds 250.102(C)(1) THEN use 12 ½%
- Take 12 ½% of kcmil and size it from Table 8 in back of code book

DO NOT USE 12 ½% AUTOMATICALLY ON THE MBJ

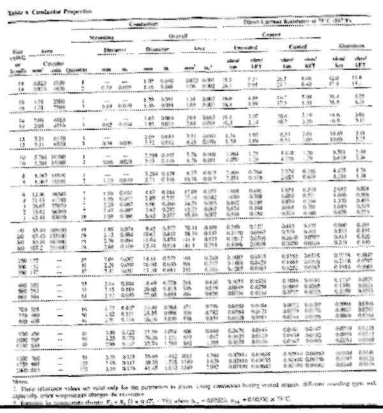


Grounding – Main Bonding Jumper

- Example
  - I have 4 sets of 350MCM Cu feeding a 1200 amp service. Size the Cu main bonding jumper.

Grounding – Main Bonding Jumper

- Example
  - I have 4 sets of 350 kcmil Cu feeding a 1200 amp service. Size the main bonding jumper.
  - 4 x 350,000 = 1,400,000 or 1,400 kcmil
  - 1400 kcmil exceeds chart
  - 1,400,000 x .125 (12 ½%) = 175,000.
  - The main bonding jumper must be AT LEAST 175,000 circular mills



Grounding – Main Bonding Jumper

- Refer to Table 8 conductor properties
  - 3/0 is 167,800 circular mills
  - 4/0 is 211,600 circular mills
    - Parallel 4/0 - sizing
- 4/0 Cu is the size of the main bonding jumper.
- You can not round this number up no matter how close it is.
- Conductors 250 kcmil and larger are already labeled in circular mill
  - Ex. If you needed 311,000 kcmil, you would need 350MCM.

Grounding – Main Bonding Jumper

- Example
  - I have 2 sets of 350MCM Cu feeding a 600 amp service. Size the Cu main bonding jumper:

Grounding – Main Bonding Jumper

- Example
  - I have 2 sets of 350 kcmil Cu feeding a 600 amp service. Size the main bonding jumper.
  - 2 x 350,000 = 700,000 or 700 kcmil
  - 700 kcmil does not exceed the chart
- The main bonding jumper is:
  - 2/0 Cu or 4/0 Al

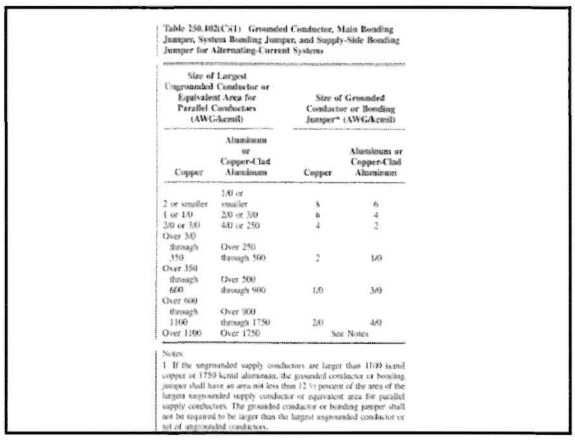


Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounded Conductor or Bonding Jumper* (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	See Notes	

Notes:
1. If the ungrounded supply conductors are larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded conductor or bonding jumper shall have an area not less than 12 ½ percent of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors. The grounded conductor or bonding jumper shall not be required to be larger than the largest ungrounded conductor or set of ungrounded conductors.

Grounding

- 250.122 – Equipment grounding conductor
  - Based on the size of overcurrent protection device in circuit

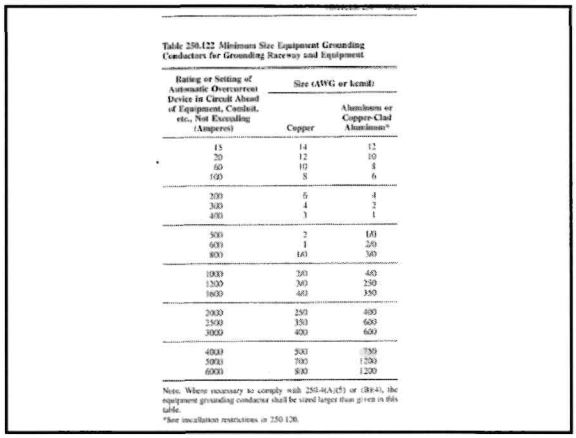


Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

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
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
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 (B)(4), the equipment grounding conductor shall be sized larger than given in this table.
*See installation restrictions in 250.120.

Grounding

- 250.122
  - Must go up if in between sizes
  - What size Cu is the equipment grounding conductor on a 60 amp circuit?
  - What size Cu is the equipment grounding conductor on a 90 amp circuit?

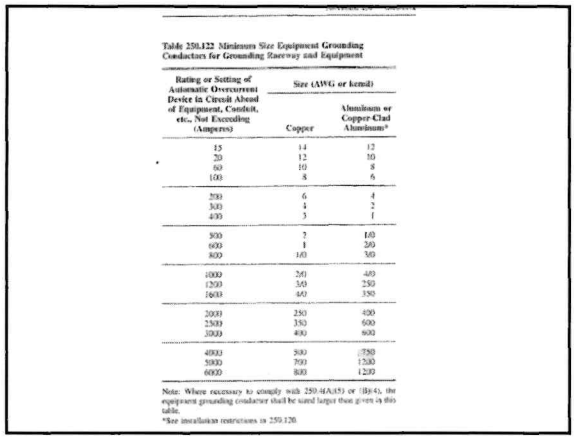


Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

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
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
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	1500
6000	800	1200

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

*See installation restrictions in 250.120.

Grounding

- 250.122
  - Must go up if in between sizes
  - What size Cu is the equipment grounding conductor on a 60 amp circuit? - **#10 Cu**
  - What size Cu is the equipment grounding conductor on a 90 amp circuit? - **#8 Cu**

Grounding

- 250.122
  - If you have multiple circuits in a raceway, you base it on the largest overcurrent device
  - Only one equipment ground needed in a raceway
    - Unless you have a isolated ground also.

Grounding

- 250.122
  - What size Cu is the equipment grounding conductor in a raceway that contains:
  - 2 – 40 amp circuits
  - 1 – 30 amp circuit
  - 3 – 20 amp circuits

Grounding

- 250.122
  - What size Cu is the equipment grounding conductor in a raceway that contains:
  - 2 – 40 amp circuits
  - 1 – 30 amp circuit
  - 3 – 20 amp circuits
- #10 – based on a 40 amp circuit

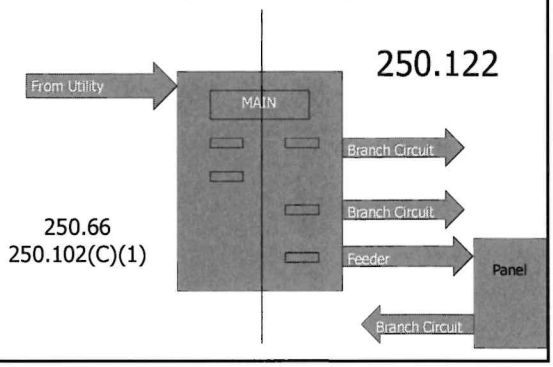
Grounding – Bonding Jumpers

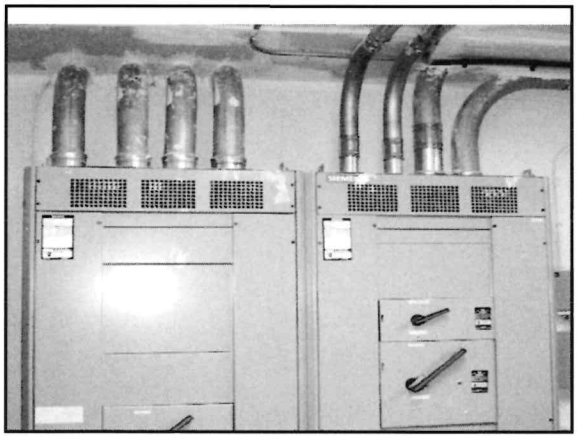
Load side

If you have multiple conduits for one circuit (parallel), you can not run the equipment grounding conductor in parallel.

The equipment grounding conductor must be sized in accordance with 250.122 in EACH conduit.

Grounding – Bonding Jumpers

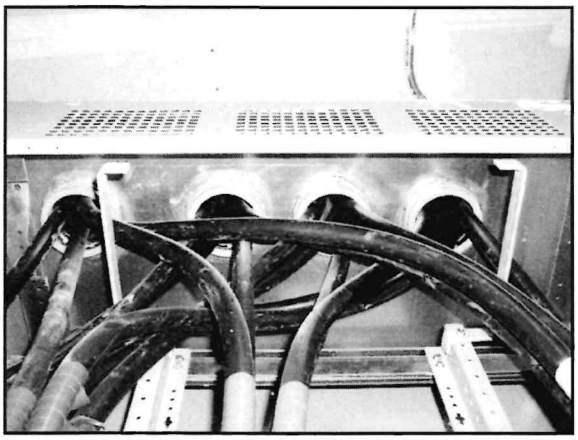




Grounding – Bonding Jumpers

Line side of service:

- Conduits must have bonding locknuts
- Conduits must have bonding bushings if holes are non-concentric



Grounding – Bonding Jumpers

Line side of service:

- If not using largest knock out or holes are too large, you must use bonding bushing.

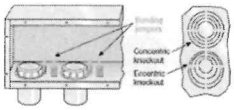
Sized in accordance with 250.102(C)(1)

- does not max out.

Grounding – Bonding Jumpers

Line side of service:

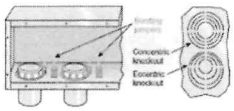
If individual jumpers are run from each conduit to ground bar, size per conductors in that ONE conduit.



Grounding – Bonding Jumpers

Line side of service:

Ex. Two sets of 500 kcmil Cu. Each conduit contains 500 kcmil. Table 250.102(C) – 1/0 Cu



Grounding – Bonding Jumpers

Line side of service:

If one jumper is used to run through all conduits, size per total of all conductors (one phase)

Grounding – Bonding Jumpers

Line side of service:

4 sets of 350 kcmil.

4 x 350 kcmil = 1,400,000 cmil

1,400 kcmil exceed chart

1,400 kcmil x .125 (12 ½ %) = 175,000 cmil

Go to table 8 – 4/0

Grounding – Bonding Jumpers

Line side of service:

6 conduits feed a service.

Each conduit contains 4/0 phase conductors.

The holes were drilled too large

Size the bonding jumper if run separate

Size the bonding jumper if run continuous through:

Grounding – Bonding Jumpers

Line side of service:

6 conduits feed a service.

Each conduit contains 4/0 phase conductors.

Separate

4/0 Cu – 250.102 (C) - #2

Grounding – Bonding Jumpers

Line side of service:

6 conduits feed a service.

Each conduit contains 4/0 phase conductors.

Continuous

4/0 Cu x 6 = 211,600 x 6 = 1,269,600 (1,269.6 kcmil)

Exceeds 1,100 kcmil

1,269,600 x .125 = 158,700 – 3/0

Grounding – Bonding Jumpers

Load side

Follow the rules of 250.122

A quazite box has two rigid 90's (in and out). The circuit running through the conduit is a 30 amp circuit.

Place bonding bushings on each conduit. Attach a #10 bonding jumper (250.122)

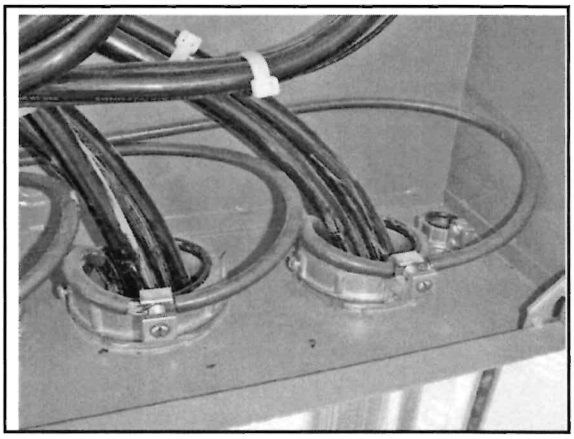
Grounding – Bonding Jumpers

Load side

If you have multiple conduits (parallel), the bonding jumper must be sized to the breaker.

If you run individual jumpers from the conduits to the ground bar or if you run one continuous through all the conduits, the size will BE THE SAME.

This is different than the load side.



Grounding

- 250.122
  - If you oversize phase conductors due to voltage drop, you also need to oversize ground proportionally
  - 250.122 (B)

Grounding

- 250.122 (B)
  - Oversizing conductors
    - Voltage Drop
      - Pole lights
      - Out buildings

Grounding

- Oversizing equipment grounding conductors

  You have a remote building with a 200 amp sub panel inside of it. Because of voltage drop, you will need to pull 350 kcmil conductors.

Grounding

- Oversizing equipment grounding conductors

  You need to set up a ratio with the following info:

  Size of ungrounded conductors (code)
  Size of equipment grounding conductor (code)
  Size of ungrounded conductors (field)

Grounding

- Oversizing equipment grounding conductors

  You have a remote building with a 200 amp sub panel inside of it. Because of voltage drop, you will need to pull 350 kcmil conductors.

  Size of ungrounded conductors (code)
  3/0 – 310.15(B)(16)

Grounding

- Oversizing equipment grounding conductors

  You have a remote building with a 200 amp sub panel inside of it. Because of voltage drop, you will need to pull 350 kcmil conductors.

  Size of equipment grounding conductor (code)
  #6 – 250.122

Grounding

- Oversizing equipment grounding conductors

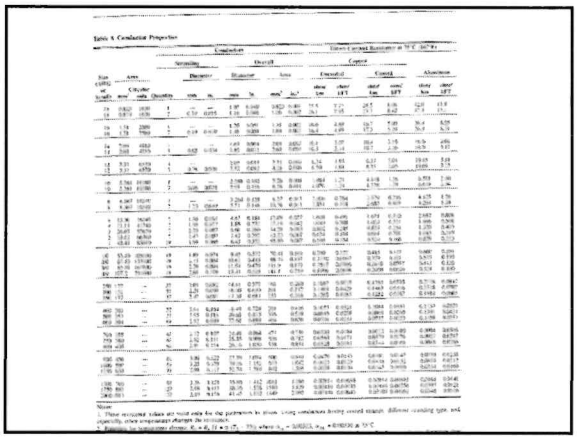
  You have a remote building with a 200 amp sub panel inside of it. Because of voltage drop, you will need to pull **350 kcmil** conductors.

  Size of ungrounded conductors (field)
  350 kcmil

Grounding

- Will need to use table 8

	Phase		Ground
Actual	350 kcmil	=	? .
Code	3/0		#6



Grounding

- Will need to use table 8

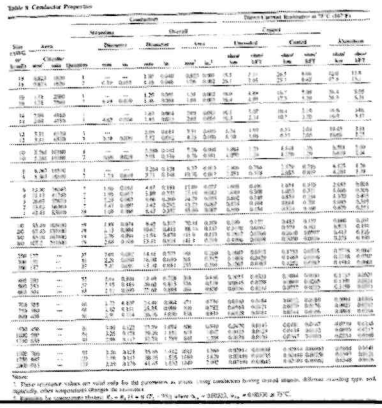
	Phase		Ground
Actual	350,000	=	? .
Code	167,800 (3/0)		26,240 (#6)

Grounding

350,000 x 26,240 = 167,800 x ?

? = 54,731.8

Go back to table 8



Grounding

350,000 x 26,240 = 167,800 x ?

? = 54,731.8

Go back to table 8

#2 (66,360)

Grounding

You have been cordially invited to Greg Hyland's palatial estate. His guard shack on the east wing (1 of 4) is located approximately 2,000 feet away from the main road. Head security officer Gil Hyland demanded that his guard shack be supplied with a 60 amp panel since he likes to smelt copper in his spare time. #1's were run to the guard shack. What size equipment ground?

Grounding

- Will need to use table 8

	Phase		Ground
Actual	#1	=	? .
Code	#6		#10

Grounding

- Will need to use table 8

	Phase		Ground
Actual	83,690 (#1)	=	? .
Code	26,240 (#6)		10,380 (#10)

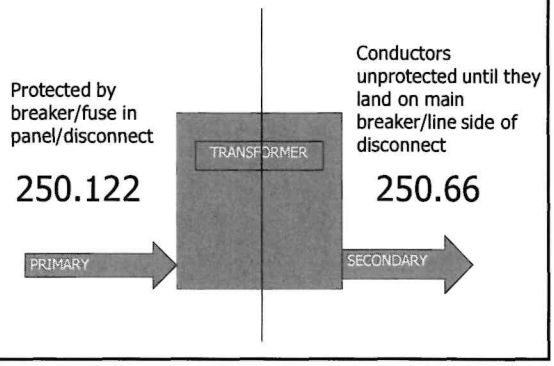
Grounding

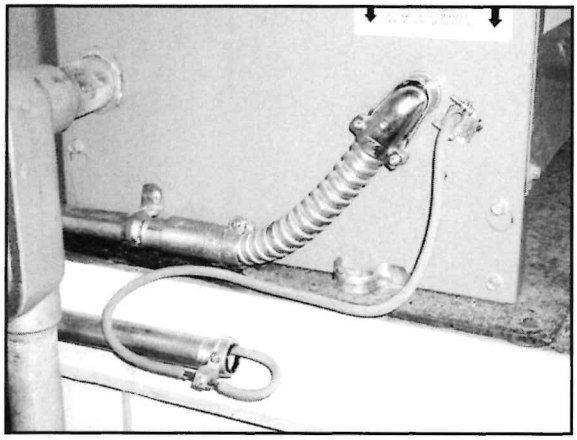
83,690 x 10,380 = 26,240 x ?

? = 33,143.9

#4 (41,470)

Grounding





Grounding

Purpose of Grounding
Grounding Terminology

Different Types of grounding electrodes
- Steel
- Water Pipe
- Ground Rod
- Concrete Encased Electrodes
- Ground Ring
- Ground Plates

Sizing the grounding electrode – 250.66

Sizing the Main bonding jumper – 250.102(C)(1)
- 12 ½% rule

Sizing the equipment ground – 250.122
- Sizing the equipment ground conductor when oversizing the phase conductors.

Bonding requirements – Both on line side and load side.

Sean Clark

901 Beechmeadow Ln. Cincinnati, Ohio 45238

(H)513/347-9054 (C)513/800-4450

sclark@ohiovalleyelectric.com

••••••••••••••••••••••••••••

A licensed electrician with over twenty years of experience in installing, maintaining, and repairing electrical wiring, equipment, and fixtures, ensuring that work is in accordance with relevant codes, fire alarm installations, electrical control systems, and high voltage terminations. A licensed electrician with three years teaching experience in first and second year electrical.

Summary of Qualifications

- More than twenty years experience.
- Three years experience in teaching first and second year electrical.
- Thorough knowledge of electrical systems including planning additions and modifications on secondary circuits. Controls and low voltage wiring
- Able to read commercial electrical blueprints and apply NEC through the full range of commercial and industrial maintenance and construction work.
- Can use appropriate tools and diagnostic equipment to repair, install, replace, and test electrical circuits, equipment and appliances.
- Excellent ability to diagnose and repair electrical controls, industrial motor control centers, and programmable logic controllers.
- Strong desire to study and comprehend new technology.
- In-depth ability to make mathematical computations.
- Considerable ability to explain instructions and guidelines to others effectively.
- Able to assign work to employees., prioritize the work of others and organize and coordinate the work of the unit. For subs and Primes.

Professional Experience

Ohio Valley Electrical Services 2011-Present

ABC Electrical Teacher 2010-2013

Beacon Electrical Contractors 2007-2011

Ohio Valley Electrical Services 1993-2007

Electrical Superintendant/Foreman/Instructor

- First and Second year electrical instructor
- Supervision of all electrical installations of as many as 50 electricians to assure that work was done safely, efficiently, properly and within time allowed.
- Trained multiple employees in all aspects of electrical work to be able to identify an employee's strengths and weaknesses to better utilize their skills. Traced out short circuits in wiring, using test meter.
- Coordinated and implemented electrical projects within a variety of environments including plants, hospitals, schools, retail stores, public facilities, waste water treatment plants industrial buildings;

projects include both new construction and underground electrical wiring as well as renovation within existing buildings. Parking Garages and Fed Ex Ground Facilities.

- Assemble, install, test, and maintain electrical or electronic wiring, equipment, appliances, apparatus, and fixtures, using hand tools and power tools.
- Connect wires to circuit breakers, transformers, or other components.
- Construct and fabricate parts, using hand tools and specifications.
- Diagnose malfunctioning systems, apparatus, and components, using test equipment and hand tools, to locate the cause of a breakdown and correct the problem.
- Inspect electrical systems, equipment, and components to identify hazards, defects, and the need for adjustment or repair, and to ensure compliance with codes.
- Plan layout and installation of electrical wiring, equipment and fixtures, based on job specifications and local codes.
- Test electrical systems and continuity of circuits in electrical wiring, equipment, and fixtures, using testing devices such as ohmmeters, voltmeters, and oscilloscopes, to ensure compatibility and safety of system.
- Perform business management duties such as maintaining records and files, preparing reports and ordering supplies and equipment.

Education & Certifications

Master Electrician License-State of Kentucky

Journeyman Electrician's License-Hamilton, Ohio

Fire Alarm License-State of Ohio

Certified in high voltage terminations and splices

Lift, Lull, Bobcat, and Boom/scissors lift licenses

OSHA-30 card

Certified in first aid and CPR training

Certified NCCER Core Curricula Instructor

Certified NCCER Electrical Instructor

Completed 4 year apprenticeship program

1 Year Pre-apprentice school (ABC)

High School Diploma (1991)

ARCH FLASH SAFETY TRAINING

PROJECTS-SUPERVISED

$4.5mil.-MASON HIGH SCHOOL ADDITION

$250.000-3CDC-5TH RACE PARKING GARAGE

$250.000-AVONEDALE APT. COMPLEX

$100.000-MAHOGANYS AT THE BANK-

1.2mil. -PATHEON CHEMICALS

$450.000- FED EX GROUND ADDITION

$250.000-LIBERTY WAY PROJECT

$500.000-GE AT THE BANKS

$100.000 - SYCAMORE SCHOOLS/POWER/CONTROL-

$50.000 - NKU RETROFIT

$250.000- UC POWER PLANT ADDITION

$75.000 - 580BLD/ CHEMED, RETROFIT

$4.0mil - DHL- CONVEYERS/SHELL

$90.000- DOUBLE TREE AIRPORT

$2.5mil- TWIN LAKES OF MONTGOMERY

$45.000- STEINMART ANDERSON

And many small T&M jobs.

All on time and under budget

File Attachments for Item:

ER-6 Practical NEC 2023 Training (Pool LLC)

All certifications (10 hours)

Staff Notes: Title amended with permission of the provider.

ESIAC Recommendation:

Committee Recommendation:

APPLICATION

FOR

Continuing Education Course Approval

Continuing education programs approved for education credit by the Ohio Board of Building Standards may be used for compliance with certification requirements related to code enforcement, plan review, and inspection responsibilities. The credit is to be used to renew the certifications issued by the Ohio Board of Building Standards pursuant to section 3781.10(E) ORC.

Board of Building Standards
6606 Tussing Road, P.O. Box 4009
Reynoldsburg, Ohio 43068-9009
(614) 644-2613 Fax: (614) 644-3147
dic.bbs@com.state.oh.us
www.com.state.oh.us/dic/dicbbs.htm

COURSE SUBMITTER: Timothy Pool, LLC

Course Submitter: Timothy Pool (Contact Name)

Organization: Timothy Pool, LLC (Organization/Company)

Address: 36605 Garretts Cove (Include Room Number, Suite, etc.)

City: Eastlake State: Ohio Zip: 44095

E-Mail: timpool@sbcglobal.net

Telephone: 440-477-8722 Fax:

Course Sponsor:

COURSE INFORMATION:

Course Title: Practical NEC 2024 Training

New Course Submittal: ☐ Update Course: ■ Prior Approval Number: BBS2023-074

Purpose and Objective: To provide practical National Electrical Code training necessary to ensure safety and compliance of electrical installations and to provide better inspection services by Building Officials and Safety Inspectors

Number of Instructional Contact Hours that can be obtained upon completion: 10 hours

If Multi-Session, Number of Instructional Contact Hours Per Session:

Program Applicable for the Following Participants:

Building Official ■ Master Plans Examiner ☐
Building Plans Exam. ☐
Plumbing Plans Exam. ☐
Electrical Plans Exam. ■
Mechanical Plans Exam. ☐
Fire Protect. Plans Exam. ☐

Building Inspector ■ Fire Protection Inspector ☐ Mechanical Inspector ☐
Plumbing Inspector ☐
Non-Res IU Inspector ☐

Res Building Official ☐ Res Plans Examiner ☐ Res Building Inspector ☐ Res Mechanical Inspector ☐ Res IU Inspector ☐

Electrical Safety Inspectors ☒

Location of ESI Course: 33851 Curtis Blvd #216, Eastlake, Ohio 44095 Date(s) of ESI Course(s): April 6, 2024

SUBMITTAL CHECKLIST: **Make Sure** all of the Following Information is **Submitted**:		Check Off
Course Submitter:	Name of contact person and their certification numbers, organization, address, fax, phone	X
	Organization sponsoring or requesting the program (if any)	X
Course Title:	Name of course (related to content)	X
Purpose/Objective:	Describe purpose and how course will improve competency of certification(s) listed	X
Contact Hours:	Indicate instructional time and credit requested in hours (e.g.: 0.5 hr, 1 hr, 3.5 hrs)	X
Participants:	Check off each certification for which credit is requested (for which course relates to certification)	X
Content of Program:	Include collated agenda, time schedule, course outline; list specific sections of code, references, and topics covered	X
Course Materials:	Collated workbooks, handouts, hard copy or electronic versions of program is available	X
Instructor(s) Info.:	Resume of professional/educational qualifications & teaching/training experience/BBS certifications	X
Test Materials:		N/A
Completed Application:		X

NOTE: The Board does NOT grant retroactive approval for courses presented prior to approval date.

RECEIVED
FEB 22 2024
BOARD OF BUILDING STANDARDS

Form: 1526

BBS 81028110

PRESENTER BIO: Timothy G Pool, PE, ESI, RCDD

- Principal
- Director of Engineering

Mr. Timothy Pool, PE has over 30 years' experience as an Electrical Engineer and Electrical Project Manager in total design of building electrical systems, information technology systems, and industrial/control systems design. As a Partner in the firm and the Director of Engineering for Tec, Inc. Engineering and Design, Mr. Pool is in responsible charge of all aspects of power distribution, short circuit and arc flash studies, commercial and industrial power and control systems, and quality control review.

Mr. Pool continues to serve as the Project Manager on many projects completing the electrical engineering design for many large companies including Avery Dennison, Lincoln Electric, First Energy, ODOT, and Lubrizol. As Project Manager his responsibility is to coordinate the engineering team effort with respect to the overall project goals, coordinate the schedule and budget, obtain, and disseminate pertinent project information and act as the coordination person for the other design team members.

Another outstanding asset is Mr. Pool's knowledge and instruction on the National Electrical Code, National Fire Alarm Code and Electrical Safety in the Workplace. Considered an expert in the industry, Mr. Pool provides class training and guidance to the electrical industry and many electrical contracting firms throughout Northeast Ohio. Mr. Pool's method of presentation and practical application of the material make him stand out as one of the premier presenters in the electrical industry.

PRACTICAL NEC 2023 TRAINING

Presented by

Timothy Pool, P.E.

Tec Inc, Engineering and Design
33851 Curtis Blvd #216, Eastlake, Ohio 44095

Instructor: Timothy Pool, P.E.
timpool@sbcglobal.net
440-477-8722

April 8, 2024
7:00 AM to 5:00 PM

Outline of Material to be Covered

Chapter 1: General (90 minutes)

- Definitions and Requirements of Electrical Installations (20 minutes)
- Temperature Limitations of Equipment and Terminations (25 minutes)
- Short Circuit Current Identification (10 minutes)
- Equipment space, Working space and guarding (25 minutes)
- Equipment Room Requirements (10 minutes)

Chapter 2: Wiring and Protection (135 minutes)

- Use and Identification of Grounded Neutral Conductors (15 minutes)
- GFCI Requirements (20 minutes)
- AFCI Outlet protection Requirements (15 minutes)
- Services (20 minutes)
- Arc Energy Reduction (15 minutes)
- Overcurrent Protection (30 minutes)
- Overvoltage Protection (20 minutes)

Chapter 3: Wiring Methods and Materials (85 minutes)

- Wiring Methods – Protection from Damage (15 Minutes)
- Cabinets and enclosures (25 minutes)
- Outlet, Device, Pull and Junction Boxes (25 minutes)
- Auxiliary Gutters (20 minutes)

Chapter 4: Equipment for General Use (80 minutes)

- Switches (15 minutes)
- Receptacles and Cord Connectors (30 minutes)
- Switchboards and Panelboards (15 minutes)
- Generators (20 minutes)

Chapter 5: Special Occupancies (70 minutes)

- Marinas, Boatyards and Commercial Docking Facilities (35 minutes)
- Temporary Installation changes (35 minutes)

(Outline Continued on next page)

Chapter 6: Special Equipment (70 minutes)

- Splash Pad and Pool Inspections (30 minutes)
- Fire Pumps (40 minutes)

Chapter 7: Special Conditions (70 minutes)

- Emergency Systems (Life Safety, Legally Required and Optional) (30 minutes)
- Wiring requirements (Transfer Switch) of emergency systems (15 minutes)
- Selective coordination of emergency systems (15 minutes)
- Emergency System Documentation (10 minutes)

Since all students are encouraged to ask questions and seek help in understanding the rules, the material shown and the schedule for its presentation may be altered to fit the time period available for each class session.

1

Practical National Electrical Code Training

New Class Location!

Tec, Inc Engineering and Design

Presented by
Mr. Timothy Pool

2

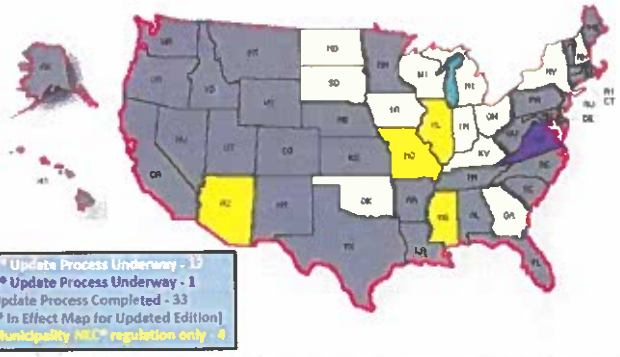
Intro and Code Update Status

3

NEC® in Effect 1/1/2024

4

NEC® Update Process In Progress 1/1/2024



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Summary

The Ohio Board of Building Standards meeting on January 26, 2024, approved adoption of the 2023 NEC for Commercial and Residential Construction effective March 1, 2024.

Any permit submitted after March 1, 2024, will need to comply with the 2023 National Electrical Code.

Inspections for projects started before March 1, 2024, will be on the 2017 NEC, projects started after March 1, 2024, will be on the 2023 NEC.

Ohio Residential Code Exceptions: 240-volt GFCI Protection

7

Update Status in Ohio

The Ohio Residential Code covers 1, 2 and 3 family dwellings.

Wherever the National Electrical Code references 1 and 2 family dwellings, the Ohio Residential Code also applies those rules to 3 family homes.

Is a building permit required to replace a circuit breaker in a dwelling unit if it is the same size and type?

1. Yes
2. No

9

Ohio Residential Code Section 3401

102.10 Electrical Work. Approval (Permitting) shall not be required for the following:

1. Listed cord-and-plug connected temporary decorative lighting.
2. Reinstallation of attachment plug receptacles but not the outlets thereof.
3. Replacement of branch circuit overcurrent devices of the required *capacity and type* in the same location.
4. Electrical wiring, devices, appliances, apparatus, or equipment operating at less than 25 volts and not capable of supplying more than 50 watts of energy.
5. Repairs and Maintenance: Approval shall not be required for minor repair work, including the replacement of lamps or the connection of approved portable electrical equipment to approved permanently installed receptacles.

10

Ohio Residential Code Section 3401

NEC 2024 Article 210.8(A) includes 240-volt receptacles.

However, see specific appliance Article 210.8(D) on Next Slide

1. **Modify Section 210.8(A) to read:**

(A) Dwelling units. All 125-volt, single phase, 15- and 20-ampere receptacles installed in locations specified in 210.8(A)(1) through (A)(12) are to have ground-fault circuit-interrupter protection for personnel.

11

Article 210.8(D) GFCI

Ohio did not exempt any of these items for residential.

Removed the ability to have factory installed integral GFCI protection. See old 422.5(B)

210.8(D) Specific Appliances.

GFCI protection shall be provided for the branch circuit or outlet supplying the following appliances rated 150 volts or less to ground and 60 amperes or less, single- or 3-phase:

(1) Automotive vacuum machines
(2) Drinking water coolers and bottle fill stations
(3) High-pressure spray washing machines
(4) Tire inflation machines
(5) Vending machines
(6) Sump pumps
(7) Dishwashers (Ohio Removed Exception)
(8) Electric ranges
(9) Wall-mounted ovens
(10) Counter-mounted cooking units
(11) Clothes dryers
(12) Microwave ovens

12

GFCI Requirements in Dwelling Units

13

Article 210.8 GFCI

Class A GFCI only works on 120 volts to ground. New Special purpose Class B works on higher than 150 volts to ground and 20 milliamps (SPGFCI) see definitions.

Article 210.52(C)(1)

210.8 Ground-Fault Circuit-Interrupter Protection for Personnel.

A listed Class A GFCI shall provide protection in accordance with 210.8(A) through (F). The GFCI shall be installed in a readily accessible location.

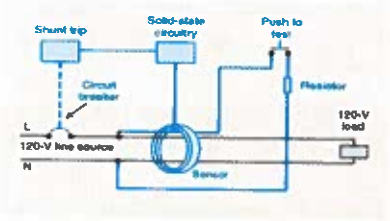
Informational Note: See 215.9 for GFCI protection on feeders.

For the purposes of this section, the distance from receptacles shall be measured as the shortest path the power supply cord connected to the receptacle would follow without piercing a floor, wall, ceiling, or fixed barrier.

14

Article 210.8 Ground-Fault Circuit-Interrupter Protection

The circuitry and components of a typical Class A GFCI.



Class A GFCI operates at 5 mA

15

Article 210.8 Ground-Fault Circuit-Interrupter Protection

Class B GFCI (Special Purpose) operates at 20 mA

16

Article 210.8 GFCI

Current level in milliamperes	Probable effect on the human body
1 mA	Tingling sensations and a change in perception levels.
5 mA	A subtle shock. The individual is able to let go of the object. Intense involuntary spasms might lead to injury.
6-16 mA	A painful shock. Loss of muscular control. Often referred to as a freezing current where the individual cannot separate from the electrical source.
17-99 mA	Extreme pain, lung failure, strong muscular contractions. Inability to separate from electrical source. Possibly fatal.
100-2000 mA	Severely abnormal heartbeat. Extreme muscular contractions and nerve damage occur. Likely resulting in death.
>2,000 mA	Heart stops beating, internal organs are severely damaged and extreme burns. Probable death.

17

Is a receptacle installed in a finished basement below grade required to be GFCI?

1. Yes
2. No

18

Article 210.8 GFCI

△ 210.8(A) Dwelling Units.

All 125-volt through 250-volt receptacles (Modified by Ohio to remove 250-volt receptacles) installed in the following locations and supplied by single-phase branch circuits rated 150 volts or less to ground shall have ground-fault circuit-interrupter protection for personnel.

1) Bathrooms
2) Garages and accessory buildings at or below grade non-habitable limited to storage areas, work areas and similar. (Modified by Ohio to remove garage door opener from GFCI requirement if single receptacle)
3) Outdoors
4) Crawl Spaces at or below grade
5) Basements (Modified by Ohio to remove exception and require Sump Pump on GFCI)

Spacing above a counter per Article 210.52(C)(1)

19

Article 210.8 GFCI

△ 210.8(A) GFCI Dwelling Units

Continued Locations include:

6) Kitchens – Removed only where installed to serve countertop surfaces – now implies all kitchen receptacles.
7) Areas with sinks and permanent provisions for food preparation, beverage preparation, or cooking.
8) Sinks - within 6 feet of the inside edge of the bowl
9) Boathouses
10) Bathtubs and shower stalls – where the receptacle is installed within 6' of the outside edge
11) Laundry areas - everywhere in the room (even the ceiling)
12) Indoor damp and wet locations (patios / mud rooms, etc.) (2020 NEC addition)

20

Ohio Residential Code Exception: Garage Door Opener GFCI Protection

21

Ohio Residential Code Section 3401

Garage Door Receptacle is not permitted to be duplex if it's not on a GFCI.

2. Modify Section **210.8(A)(2)** to read:

Garages, and also accessory buildings that have a floor located at or below grade level not intended as habitable rooms and limited to storage areas, work areas, and areas of similar use except for the receptacle located to serve a garage door opener when the device is a single receptacle and located in the ceiling. (Ohio added highlighted text)

2

Ohio Residential Code Removed Exception for Sump Pump and Dishwasher GFCI Protection

23

Ohio Residential Code Section 3401

Section **210.8(A)(5)** exceptions were removed!

1. Now 120-volt receptacles serving Sump Pumps in finished or unfinished basements are required to have GFCI protection.

2

Ohio Residential Code Section 3401

Section 210.8(D) was not removed from the residential code. This article requires GFCI on all dishwasher branch circuits (both hard-wired or cord and plug). Remember the GFCI must be readily accessible!

25

Ohio Residential Code Exception for Outdoor Outlet GFCI

26

Article 210.8(F)

What is an outlet vs. a receptacle?

3. **Modify Section 210.8(F) to read:**

(F) Outdoor Outlets. All outdoor outlets for dwellings, other than those covered in 210.8(A), Exception No. 1 (snow melting), *garages with floor level at or below grade, accessory buildings and boathouses, where the outlets are* supplied by single-phase branch circuits rated 150 volts or less to ground, *and* 50 amperes or less, *are to be* provided with *ground-fault circuit-interrupter protection for personnel.*

If equipment supplied by an outlet covered under the requirements of this section is replaced, the outlet is to be supplied with GFCI protection.

Exception No. 1: GFCI protection is not required on lighting outlets other than those covered in 210.8(C) (crawl space)

Exception No. 2: GFCI protection is not required for listed HVAC equipment.

27

Article 210.8(F)

2023 Code

The 2023 code recognized this issue and exempted HVAC GFCI till 2026.

210.8(F) Outdoor Outlets.

For dwellings, all outdoor outlets, other than those covered in 210.8(A), Exception No. 1 (snow melting), including outlets installed in the following locations, and supplied by single-phase branch circuits rated 150 volts or less to ground, 50 amperes or less, shall be provided with GFCI protection:

(1) Garages that have floors located at or below grade level

(2) Accessory buildings

(3) Boathouses

If equipment supplied by an outlet covered under the requirements of this section is replaced, the outlet shall be supplied with GFCI protection.

Exception No. 1: GFCI protection shall not be required on lighting outlets other than those covered in 210.8(C) (Crawl Spaces).

Exception No. 2: GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026.

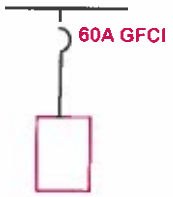
28

A contractor installed a 60 amp, 2 pole GFCI in the main panel to feed a sub-panel in the detached garage. Are GFCI type receptacles also required?

1. Yes
2. No

29

Article 215.9



All ckts in Sub Panel are considered GFCI protected

215.9 Ground-Fault Circuit-Interrupter Protection for Personnel.

Feeders shall be permitted to be protected by a listed ground-fault circuit interrupter installed in a readily accessible location in lieu of the provisions for such interrupters as specified in 210.8 and 590.6(A).

30

Ohio Residential Code Exception for Service and Feeder Surge Protection

31

Surge Protection

Ohio Removed the requirement and simply said where provided the surge protection must be installed in accordance with this section.

4. **Modify Section 215.18(A) to read:**

(A) Surge-Protection Device. *Where provided as part of feeder supplied distribution equipment, surge-protection devices (SPD) are to be installed in accordance with this section.*

5. Modify Section 230.67(A) to read:

(A) Surge-Protection Device. *Where provided as part of the service entrance equipment, surge-protection devices (SPD) are to be installed in accordance with this section.*

32

N Article 230.67 Surge Protection

Not Required in Ohio

***N* 230.67 Surge Protection.**

(A) Surge-Protective Device.

All services supplying the following occupancies shall be provided with a surge protection device (SPD)

(1) Dwelling units

(2) Dormitory units

(3) Guest rooms and guest suites of hotels and motels

(4) Areas of nursing homes and limited-care facilities used exclusively as patient sleeping rooms

Informational Note: See 517.10(B)(2)

33

Article 230.67

N **230.67(B) Location.** The SPD shall be an integral part of the service equipment of shall be located immediately adjacent thereto.

Exception: The SPD shall not be required to be located at the service equipment as required in 230.67(B) if located at each next level distribution equipment downstream toward the load.

Not Required in Ohio

34

Article 230.67

242.9 Indicating. There is also a new requirement that surge protective devices (SPDs) provide an indication that they are functioning properly.

230.67(C) Surge Protection.

Must be Type 1 or 2

230.67(D) Replacement. Where the service equipment is replaced, all of the requirements of this section shall apply.

230.67(E) Ratings.

SPDs shall have a nominal discharge current rating (In) of not less than 10kA.

Not Required in Ohio

35

Article 230.85
Emergency Disconnect on Residential Services

36

N Article 230 Services

New in 2023 NEC

230.85 Emergency Disconnects.

For one- and two-family dwelling units, an emergency disconnecting means shall be installed.

230.85(A) General.

230.85(A)(1) Location.

The disconnecting means shall be installed in a readily accessible outdoor location on or within sight of the dwelling unit.

Exception: Where the requirements of 225.41 (Feeder Emergency Disconnect) are met, this section shall not apply.

37

Article 230 Services

New in 2023 NEC

230.85(A)(2) Rating.

The disconnecting means shall have a short-circuit current rating equal to or greater than the available fault current.

230.85(A)(3) Grouping.

If more than one disconnecting means is provided, they shall be grouped.

38

Article 230 Services

230.85(B) Disconnects.

Each disconnect shall be one of the following:

(1) Service disconnect (fused)

(2) A meter disconnect integral to the meter mounting equipment not marked as suitable only for use as service equipment installed in accordance with 230.82

New in 2023 NEC

39

Article 230 Services

New in 2023 NEC

230.85(B) Disconnects.

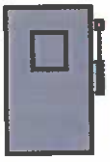
(3) Other listed disconnect switch or circuit breaker that is marked suitable for use as service equipment, but not marked as suitable only for use as service equipment, installed on the supply side of each service disconnect (non-fused)

Informational Note 1: Conductors between the emergency disconnect and the service disconnect in 230.85(2) and 230.85(3) are service conductors.

Informational Note 2: Equipment marked "Suitable only for use as service equipment" includes the factory marking "Service Disconnect".

4

Article 230 Services



New in 2023 NEC

230.85(C) Replacement.

Where service equipment is replaced, all of the requirements of this section shall apply.

Exception: Where only meter sockets, service entrance conductors, or related raceways and fittings are replaced, the requirements of this section shall not apply.

41

Article 230 Services

230.85(D) Identification of Other Isolation Disconnects.

Where equipment for isolation of other energy source systems is not located adjacent to the emergency disconnect required by this section, a plaque or directory identifying the location of all equipment for isolation of other energy sources shall be located adjacent to the disconnecting means required by this section.

New in 2023 NEC

Informational Note: See 445.18, 480.7, 705.20, and 706.15 for examples of other energy source system isolation means.

42

What color is the label on the emergency disconnect on a dwelling unit?

1. Black text on White Background
2. Red text on White Background
3. White text on Red Background

43

Article 230 Services

230.85(E) Marking.

230.85(E)(1) Marking Text.

The disconnecting means shall marked as follows:

(1) Service disconnect

EMERGENCY DISCONNECT, SERVICE DISCONNECT

(2) Meter disconnects installed in accordance with 230.82(3) and marked as follows:

EMERGENCY DISCONNECT, METER DISCONNECT, NOT SERVICE EQUIPMENT

New in 2023 NEC

44

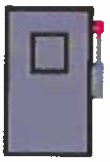
Article 230 Services

230.85(E) Marking.

230.85(E)(1) Marking Text.

(3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are marked suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT, NOT SERVICE EQUIPMENT



New in 2023 NEC

45

Article 230 Services

230.85(E)(2) Marking Location and Size.

Markings shall comply with 110.21(B) and both of the following:

(1) The marking or labels shall be located on the outside front of the disconnect enclosure with red background and white text.

(2) The letters shall be at least 13 mm ($1/2$ in.) high.

New in 2023 NEC

EMERGENCY DISCONNECT, NOT SERVICE EQUIPMENT

46

Article 210.11
Small Appliance Branch Circuits

47

210.11 Branch Circuits Required.

210.11 Branch Circuits Required.

(C) Dwelling Units. (1) Small-Appliance Branch Circuits. In addition to the number of branch circuits required by other parts of this section, two or more 20-ampere small-appliance branch circuits shall be provided for all receptacle outlets specified by 210.52(B). (Kitchen, pantry, breakfast room, dining room or similar area)

48

210.11 Branch Circuits Required.

210.11 Branch Circuits Required.

(C) Dwelling Units. (2) Laundry Branch Circuits. In addition to the number of branch circuits required by other parts of this section, at least one additional 20-ampere branch circuit shall be provided to supply the laundry receptacle outlet(s) required by 210.52(F). This circuit shall have no other outlets.

49

210.11 Branch Circuits Required.

210.11 Branch Circuits Required.

(C) Dwelling Units. (3) Bathroom Branch Circuits. In addition to the number of branch circuits required by other parts of this section, one or more 120-volt, 20-ampere branch circuit shall be provided to supply the bathroom(s) receptacle outlet(s) required by 210.52(D) and any countertop and similar work surface receptacle outlets. Such circuits shall have no other outlets.

50

The garage circuit can feed the dwelling unit outdoor GFCI receptacles.

1. True
2. False

51

210.11 Branch Circuits Required.

210.52(G)(1) requires one receptacle in each vehicle bay not more than 1.7 m (5 1/2 ft) above the floor. (Page 288)

210.11 Branch Circuits Required.

(C)(4) Garage Branch Circuits. In addition to the number of branch circuits required by other parts of this section, at least one 120-volt, 20-ampere branch circuit shall be installed to supply receptacle outlets required by 210.52(G)(1) for attached garages and in detached garages with electric power. This circuit shall have no other outlets.

Exception: This circuit shall be permitted to outdoor receptacle outlets.

Exception for other receptacles in single bay garage

52

Article 210.52 Dwelling Unit Receptacle Outlets

53

210.52 Dwelling Unit Receptacle Outlets.

210.52 Dwelling Unit Receptacle Outlets.

(A) General Provisions. In every kitchen, family room, dining room, living room, parlor, library, den, sunroom, bedroom, recreation room, or similar room or area of dwelling units, receptacle outlets shall be installed in accordance with the general provisions specified in 210.52(A)(1) through (A)(4).

(A)(1) Spacing. Receptacles shall be installed such that no point measured horizontally along the floor line of any wall space is more than 1.8 m (6 ft) from a receptacle outlet.

54

210.52 Dwelling Unit Receptacle Outlets.

210.52(A)(2) Wall Space. As used in this section, a wall space shall include the following:

(1) Any space 600 mm (2 ft) or more in width (including space measured around corners) and unbroken along the floor line by doorways and similar openings, fireplaces, and fixed cabinets that do not have countertops or similar work surfaces

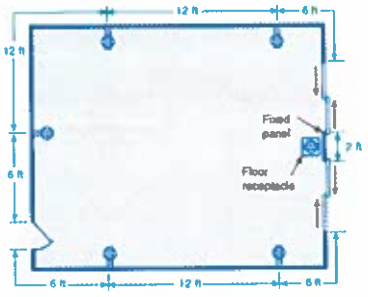
(2) The space occupied by fixed panels in walls, excluding sliding panels

(3) The space afforded by fixed room dividers, such as freestanding bar-type counters or railings

55

Article 210.52 Dwelling Unit Receptacle Outlets.

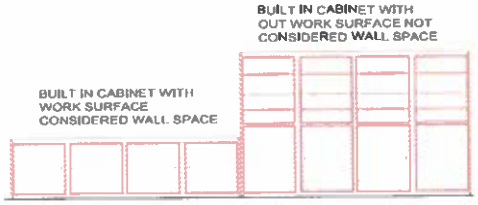
Typical room plan view of the location of dwelling unit receptacles meeting the requirements of 210.52(A).



5

Article 210.52 Dwelling Unit Receptacle Outlets

210.52(A)(2)(1) fixed cabinets that do not have countertops or similar work surfaces are not considered wall space.



210.52 Dwelling Unit Receptacle Outlets. 57

210.52(A)(3) Floor Receptacles. Receptacle outlets in or on floors shall not be counted as part of the required number of receptacle outlets unless located within 450 mm (18 in.) of the wall.

406.5 Receptacle Mounting

(B) Receptacles in Seating Areas and Other Similar Surfaces. In seating areas or similar surfaces, receptacles shall not be installed in a face-up position unless the receptacle is any of the following:

(1) Part of an assembly listed as a furniture power distribution unit
(2) Part of an assembly listed either as household furnishings or as commercial furnishings
(3) Listed either as a receptacle assembly for countertop applications or as a GFCI receptacle assembly for countertop applications
(4) Installed in a listed floor box

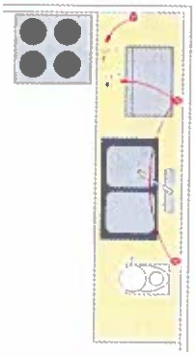
210.52 Dwelling Unit Receptacle Outlets. 58

210.52(B)(1) (B) Small Appliances.

(1) Receptacle Outlets Served. In the kitchen, pantry, breakfast room, dining room, or similar area of a dwelling unit, the two or more 20-ampere small-appliance branch circuits required by 210.11(C)(1) shall serve all wall and floor receptacle outlets covered by 210.52(A), all countertop outlets covered by 210.52(C), and receptacle outlets for refrigeration equipment.

(2) No Other Outlets. The two or more small-appliance branch circuits specified in 210.52(B)(1) shall have no other outlets.

Article 210.52 Dwelling Unit Receptacle Outlets 59



210.52(B)(3) Kitchen Receptacle Requirements. Receptacles installed in a kitchen to serve countertop surfaces shall be supplied by not fewer than two small-appliance branch circuits, either or both of which shall also be permitted to supply receptacle outlets in the same kitchen and in other rooms specified in 210.52(B)(1). (kitchen, pantry, breakfast room, dining room or similar). Additional small-appliance branch circuits shall be permitted to supply receptacle outlets in the kitchen and other rooms specified in 210.52(B)(1). No small-appliance branch circuit shall serve more than one kitchen.

Article 210.52 Dwelling Unit Receptacle Outlets 60

210.52(C) Countertops and Work Surfaces.

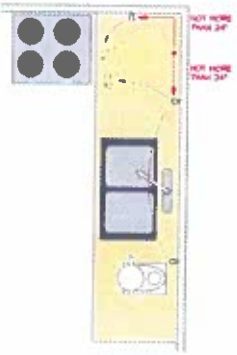
In kitchens, pantries, breakfast rooms, dining rooms, and similar areas of dwelling units, receptacle outlets for countertop and work surfaces that are 300 mm (12 in.) or wider shall be installed in accordance with 210.52(C)(1) through (C)(3) and shall not be considered as the receptacle outlets required by 210.52(A) (General).

For the purposes of this section, where using multioutlet assemblies, each 300 mm (12 in.) of multioutlet assembly containing two or more receptacles installed in individual or continuous lengths shall be considered to be one receptacle outlet.

Article 210.52 Dwelling Unit Receptacle Outlets 61

210.52(C) includes "Countertops and Work Surfaces" in Kitchen areas

Article 210.52 Dwelling Unit Receptacle Outlets 62

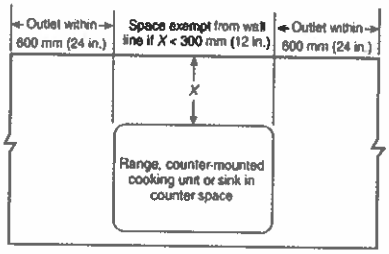


210.52(C)(1) Wall Spaces. Receptacle outlets shall be installed so that no point along the wall line is more than 600 mm (24 in.) measured horizontally from a receptacle in that space. The location of the receptacles shall be in accordance with 210.52(C)(3).

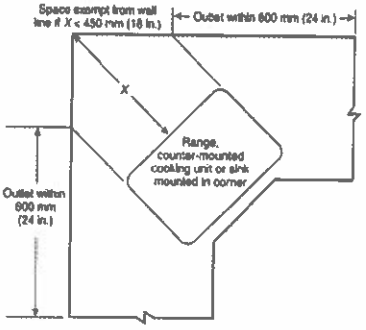
Exception No. 1: Receptacle outlets shall not be required directly behind a range, counter-mounted cooking unit, or sink in the installation described in Figure 210.52(C)(1).

Article 210.52 Dwelling Unit Receptacle Outlets 63

Figure 210.52(C)(1) Determination of Area Behind a Range, Counter-Mounted Cooking Unit, or Sink.



Article 210.52 Dwelling Unit Receptacle Outlets 64



65

According to the 2023 NEC, how many receptacles are required at an island countertop in a dwelling unit kitchen?

1. None
2. 1
3. 2
4. 3

66

Article 210.52 Dwelling Unit Receptacle Outlets

Changed in 2023 Code

No one is sure what a provision means?

210.52(C)(2) Island and Peninsular Countertops and Work Surfaces.

Receptacle outlets, if installed to serve an island or peninsular countertop or work surface, shall be installed in accordance with 210.52(C)(3). If a receptacle outlet is not provided to serve an island or peninsular countertop or work surface, provisions shall be provided at the island or peninsula for future addition of a receptacle outlet to serve the island or peninsular countertop or work surface.

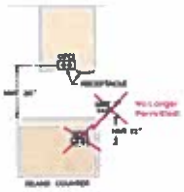
67

It is permitted to install a receptacle below a dwelling unit counter to serve the countertop surface.

1. True
2. False

68

Article 210.52 Dwelling Unit Receptacle Outlets



210.52(C)(3) Receptacle Outlet Location. Receptacle outlets shall be located in one or more of the following:

Receptacle outlets shall be located in one or more of the following:

(1) On or above, but not more than 500 mm (20 in.) above, a countertop or work surface

(2) In a countertop using receptacle outlet assemblies listed for use in countertops

(3) In a work surface using receptacle outlet assemblies listed for use in work surfaces or listed for use in countertops

69

Article 210.52 Dwelling Unit Receptacle Outlets

210.52(C)(3) Countertops and Work Surfaces.

Receptacle Outlets rendered not readily accessible by appliances fastened in place, appliance garages, sinks or range tops as covered in 210.52(C)(1), exception, or appliances occupying assigned spaces shall not be considered as these required outlets.

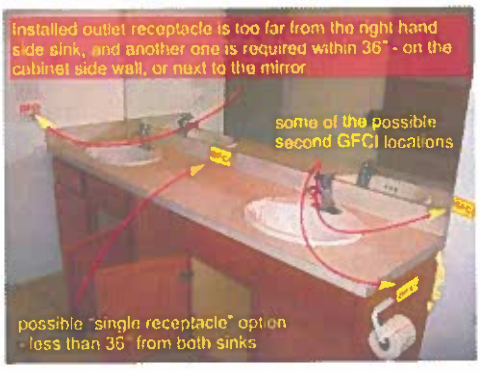
70

Article 210.52 Dwelling Unit Receptacle Outlets

210.52(D) Bathrooms. At least one receptacle outlet shall be installed in bathrooms within 900 mm (3 ft) of the outside edge of each basin. The receptacle outlet shall be located on a wall or partition that is adjacent to the basin or basin countertop, located on the countertop, or installed on the side or face of the basin cabinet. In no case shall the receptacle be located more than 300 mm (12 in.) below the top of the basin or basin countertop. Receptacle outlet assemblies listed for use in countertops shall be permitted to be installed in the countertop.

71

Article 210.52 Dwelling Unit Receptacle Outlets

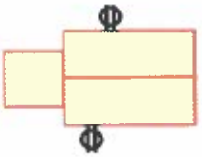


72

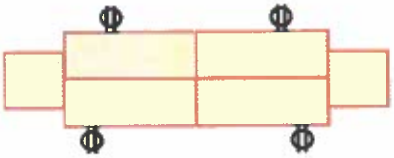
Article 210.52 Dwelling Unit Receptacle Outlets.

210.52(E)(1) One-Family and Two-Family Dwellings.

For a one-family dwelling and each unit of a two-family dwelling that is at grade level, at least one receptacle outlet readily accessible from grade and not more than 2.0 m (6½ ft) above grade level shall be installed at the front and back of the dwelling.



Single Family Dwelling

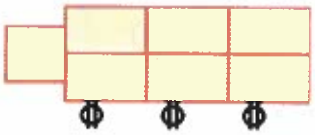


Two Family Dwelling

Article 210.52 Dwelling Unit Receptacle Outlets. 73

210.52(E)(2) Multifamily Dwellings.

For each dwelling unit of a multifamily dwelling where the dwelling unit is located at grade level and provided with individual exterior entrance/egress, at least one receptacle outlet readily accessible from grade and not more than 2.0 m (6½ ft) above grade level shall be installed.



Multi-family Dwelling

Article 210.52 Dwelling Unit Receptacle Outlets. 74

210.52(E)(3) Balconies, Decks, and Porches.

Balconies, decks, and porches that are within 102 mm (4 in.) horizontally of the dwelling unit shall have at least one receptacle outlet accessible from the balcony, deck, or porch. The receptacle outlet shall not be located more than 2.0 m (6½ ft) above the balcony, deck, or porch walking surface.

Article 210.52 Dwelling Unit Receptacle Outlets. 75

210.52(F) Laundry Areas.

In dwelling units, at least one receptacle outlet shall be installed in areas designated for the installation of laundry equipment.

Exception No. 1: A receptacle for laundry equipment shall not be required in a dwelling unit of a multifamily building where laundry facilities are provided on the premises for use by all building occupants.

Exception No. 2: A receptacle for laundry equipment shall not be required in other than one-family dwellings where laundry facilities are not to be installed or permitted.

Article 210.52 Dwelling Unit Receptacle Outlets. 76

(G) Basements, Garages, and Accessory Buildings. For one and two- family dwellings, and multi-family dwellings at least one receptacle outlet shall be installed in the areas specified in 210.52(G)(1) through (G)(3). These receptacles shall be in addition to receptacles required for specific equipment.

(1) Garages. In each attached garage and in each detached garage with electric power, at least one receptacle outlet shall be installed in each vehicle bay and not more than 1.7 m (5 1⁄2 ft) above the floor.

Article 210.52 Dwelling Unit Receptacle Outlets. 77

(G) Basements, Garages, and Accessory Buildings. At least one receptacle outlet in:

(2) Accessory Buildings. In each accessory building with electric power.

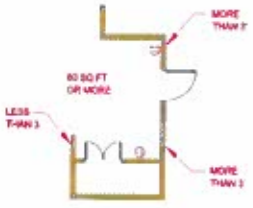
(3) Basements. In each separate unfinished portion of a basement.

Article 210.52 Dwelling Unit Receptacle Outlets. 78

(H) Hallways. In dwelling units, hallways of 3.0 m (10 ft) or more in length shall have at least one receptacle outlet.

As used in this subsection, the hallway length shall be considered the length along the centerline of the hallway without passing through a doorway.

Article 210.52 Dwelling Unit Receptacle Outlets. 79



(I) Foyers. Foyers that are not part of a hallway in accordance with 210.52(H) and that have an area that is greater than 5.6 m² (60 ft²) shall have a receptacle(s) located in each wall space 900 mm (3 ft) or more in width. Doorways, door-side windows that extend to the floor, and similar openings shall not be considered wall space.

Article 210.63 80

Remember - Must be GFCI per Article 210.8(E)

210.63 Equipment Requiring Servicing.

A 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed at an accessible location for the servicing of heating, air conditioning, and refrigeration equipment. The receptacle shall be located on the same level and within 7.5 m (25 ft) of the equipment as specified in 210.63(A) and (B).

(A) Heating, Air-conditioning, and Refrigeration equipment. The required receptacle outlet shall be located on the same level as the heating, air-conditioning and refrigeration equipment. The receptacle shall not be connected to the load side of the equipment disconnecting means.

81

Article 210.70
Lighting Outlets Required

82

Article 210.70 Lighting Outlets Required

Ex 1: Receptacles are permitted to be controlled

Ex 2: Occupancy Sensors if they have a manual override

210.70 Lighting Outlets Required. Lighting outlets shall be installed where specified in 210.70(A), (B) and (C).

(A) Dwelling units. In dwelling units, lighting outlets shall be installed in accordance with 210.70(A)(1), (A)(2) and (A)(3).

(1) Habitable Rooms. At least one lighting outlet controlled by a listed wall-mounted control device shall be installed in every habitable room, kitchen and bathroom. The wall-mounted control device shall be located near an entrance to the room on a wall.

83

Article 210.70 Lighting Outlets Required

Ex 1: Automatic lighting control permitted

210.70 Lighting Outlets Required.

(2) Additional locations. Additional Lighting outlets shall be installed in accordance with the following:

(1) At least one lighting outlet controlled by a listed wall-mounted control device shall be installed in hallways, stairways, attached garages, and detached garages with electric power.

84

Is an exterior light required at all exterior entrances of a dwelling unit?

1. Yes
2. No

85

Article 210.70 Lighting Outlets Required

Ex 1: Automatic lighting control permitted

210.70 Lighting Outlets Required.

(2) Additional locations.

(2) For dwelling units, attached garages, and detached garages with electric power, at least one lighting outlet controlled by a listed wall-mounted control device shall be installed to provide illumination on the exterior side of outdoor entrances or exits with grade-level access. A vehicle door in a garage shall not be considered as an outdoor entrance or exit.

86

Article 210.70 Lighting Outlets Required

Ex 1: Automatic lighting control permitted

210.70(A)(2) Additional locations.

(3) Where one or more lighting outlet(s) are installed for interior stairways, there shall be a listed wall-mounted control device at each floor level, and landing level that includes an entryway, to control the lighting outlet(s) where the stairway between floor levels has six risers or more.

Part (4) Does not allow dimming control unless you can dim full range from every location.

87

Article 210.70 Lighting Outlets Required

210.70 Lighting Outlets Required.

(C) All Occupancies. For attics and underfloor spaces, utility rooms, and basements, at least one lighting outlet containing a switch or controlled by a wall switch or listed wall-mounted control device shall be installed where these spaces are used for storage or contain equipment requiring servicing. A point of control shall be at each entry that permits access to the attic and underfloor space, utility room, or basement. Where a lighting outlet is installed for equipment requiring service, the lighting outlet shall be installed at or near the equipment.

88

Article 210.12
Arc Fault Circuit Interrupter Protection

89

Article 210.12 AFCI

AFCI is not needed on 240 volt or 120 volt - 30, 40, and 50 amp branch circuits!

210.12 Arc-Fault Circuit-Interrupter Protection.

Arc-fault circuit-interrupter (AFCI) protection shall be installed in accordance with 210.12(B) through (E) by any of the means described in 210.12(A)(1) through (A)(6) (AFCI Combo Breaker or Device and raceway). The AFCI shall be listed and installed in a readily accessible location.

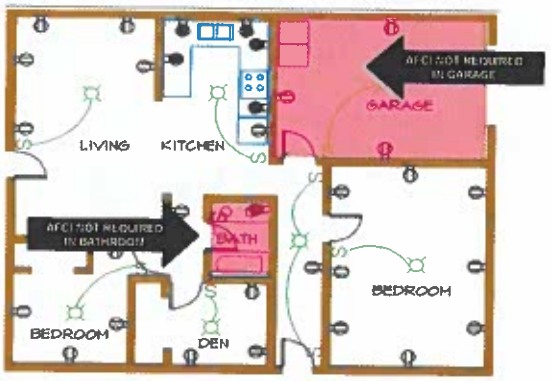
N **210.12(B) Dwelling Units.**

All 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets or devices installed in the following locations shall be protected by any of the means described in 210.12(A)(1) through (A)(6) (AFCI Breaker or Device):

1) Kitchens
2) Family rooms
3) Dining rooms
4) Living rooms
5) Parlors
6) Libraries
7) Dens
8) Bedrooms
9) Sunrooms
10) Recreation rooms
11) Closets
12) Hallways
13) Laundry areas
14) Similar areas

90

Article 210.12(B) Dwelling Units



91

Ohio Residential Code Section 3401

See page 270 in the Pocket Guide

2023 Ohio Residential Code removed the exception for AFCI protection only on the kitchen countertop circuits of a dwelling unit.

AFCI is now required on every branch circuit serving a kitchen per 210.12.

92

AFCI protection is not required if the existing branch circuit is extended not more than _____ feet and does not include additional outlets or devices.

1. 3'
2. 4'
3. 5'
4. 6'
5. 10'

93

Article 210.12 Arc-Fault Circuit-Interrupter Protection

Replace-ments: See 406.4(D)(4)

210.12 Arc-Fault Circuit-Interrupter Protection.

(D) Branch Circuit Extensions or Modifications – Dwelling Units, Dormitory Units and Guest Rooms and Guest Suites. Where branch-circuit wiring for any of the areas specified in 210.12(A), (B) or (C) is modified, replaced, or extended, the branch circuit shall be protected by one of the following:

(1) By any of the means described in 210.12(A)(1) through (A)(6)

(2) A listed outlet branch-circuit type AFCI located at the first receptacle outlet of the existing branch circuit

Exception: AFCI protection shall not be required where the extension of the existing branch circuit conductors is not more than 1.8 m (6 ft) and does not include any additional outlets or devices, other than splicing devices. This measurement shall not include the conductors inside an enclosure, cabinet, or junction box.

94

Article 210.18
Branch Circuit Ratings

95

Article 210.18 Ratings

210.18 Rating.

Branch circuits recognized by this article shall be rated in accordance with the maximum permitted ampere rating or setting of the overcurrent device. The rating for other than individual branch circuits shall be 10, 15, 20, 30, 40, and 50 amperes. Where conductors of higher ampacity are used for any reason, the ampere rating or setting of the specified overcurrent device shall determine the circuit rating.

Exception No. 1: Multioutlet branch circuits greater than 50 amperes shall be permitted to supply nonlighting outlet loads in locations where conditions of maintenance and supervision ensure that only qualified persons service the equipment.

Exception No. 2: Branch circuits rated 10 amperes shall not supply receptacle outlets.

96

Article 210.23 10- Amp Circuit

Permitted

210.23(A)(1) Loads Permitted for 10-Ampere Branch Circuits.

A 10-ampere branch circuit shall be permitted to supply one or more of the following:

1) Lighting outlets
2) Dwelling unit exhaust fans on bathroom or laundry room lighting circuits
3) A gas fireplace unit supplied by an individual branch circuit

Not Permitted

210.23(A)(2) Loads Not Permitted for 10-Ampere Branch Circuits.

A 10-ampere branch circuit shall not supply any of the following:

1) Receptacle outlets
2) Fixed appliances, except as permitted for individual branch circuits
3) Garage door openers
4) Laundry equipment

97

Article 210.18 Circuit Ratings

These articles make it sound like it would allow a 14 AWG aluminum wire on a 10-amp circuit breaker although see 310.3 still restricts the minimum size of aluminum conductor to 12 AWG.

310.3(A) Minimum Size of Conductors.

The minimum size of conductors for voltage ratings up to and including 2000 volts shall be 14 AWG copper or 12 AWG aluminum or copper-clad aluminum, except as permitted elsewhere in this *Code*.

98

Article 210.24(1) Summary

Table 210.24(1) Summary of Branch-Circuit Requirements — Copper Conductors

Circuit Rating	10 A	15 A	20 A	30 A	40 A	50 A
Conductors (min. size):						
Circuit wires	14	14	12	10	8	6
Taps	14	14	14	14	12	12
Fixture wires and cords			See 240.5.			
Overcurrent Protection	10 A	15 A	20 A	30 A	40 A	50 A
Outlet devices:						
Lampholders permitted	Any type	Any type	Any type	Heavy duty	Heavy duty	Heavy duty
Receptacle rating[1]	Not applicable[2]	15 max. A	15 A or 20 A	30 A	40 A or 50 A	50 A
Maximum Load	10 A	15 A	20 A	30 A	40 A	50 A
Permissible load	See 210.23(A).	See 210.23(B).	See 210.23(B).	See 210.23(C).	See 210.23(D).	See 210.23(D).

99

Article 210.24(2) Summary

New Table in 2023

Table 210.24(2) Summary of Branch-Circuit Requirements — Aluminum and Copper-Clad Aluminum Conductors

Circuit Rating	10 A	15 A	20 A	30 A	40 A	50 A
Conductors (min. size):						
Circuit wires	12	12	10	8	6	4
Taps	12	12	12	12	10	10
Fixture wires and cords				See 240.5.		
Overcurrent Protection	10 A	15 A	20 A	30 A	40 A	50 A
Outlet devices:						
Lampholders permitted	Any type	Any type	Any type	Heavy duty	Heavy duty	Heavy duty
Receptacle rating[1]	Not applicable[2]	15 max. A	15 A or 20 A	30 A	40 A or 50 A	50 A
Maximum Load	10 A	15 A	20 A	30 A	40 A	50 A
Permissible load	See 210.23(A).	See 210.23(B).	See 210.23(B).	See 210.23(C).	See 210.23(D).	See 210.23(D).

100

N Article 726 Class 4 Fault-Managed Power Systems

New Class Rating. *Class 4 cables allow the distribution of AC or DC power at higher-voltages (up to 450 volts). This type of circuit constantly monitors itself (intelligent wiring system) for faults and would shut power off simultaneously if a fault occurs. Capacity to deliver more power than Class I, II, or III systems.*

Class 4 power systems are extremely safe from potential fire or shock hazards. Aka Power Energy Transfer (PET), Fault Managed Power; {Built-In Fault Management} (FMP)

Smart Building Technology; 450v L-L / 225v to ground

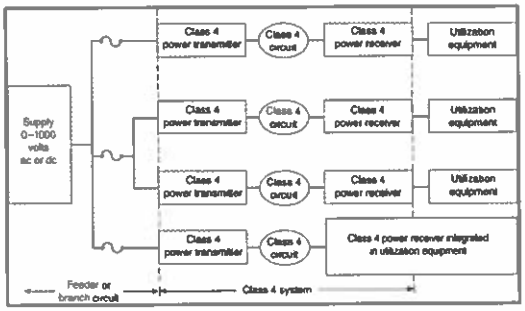
101

N Article 726 Fault Managed Power Systems

726.144 Ampacity. The ampacity of class 4 cables shall comply with 300.15 based on the temperature rating of the class 4 cable for conductors sized 16 AWG to 6 AWG. For conductors sized 24 AWG to 17 AWG, the class 4 cable shall be rated for the intended ampacity as evidenced by the marking FMP-XXA, where XX is the maximum allowable ampacity permitted.

10

N 726.121 Class 4 Circuits



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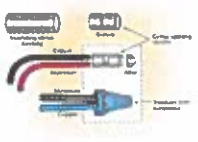
Article 110.14
Wire Ampacity Calculations and Lug Termination Temperature

10

ARTICLE 110
Requirements for Electrical Installation



110.14 Electrical Connections.

Because of different characteristics of dissimilar metals, devices such as pressure terminal or pressure splicing connectors and soldering lugs shall be identified for the material of the conductc and shall be properly installed and used. Conductors of dissimilar metals shall not be intermixed in a terminal or splicing connector where physical contact occurs between dissimilar conductors (such as copper and aluminum, copper and copper-clad aluminum, or aluminum and copper-clad aluminum), unless the device is identified for the purpose and conditions of use.

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Temperature Rating of Conductor [See Table 310.4(1)]

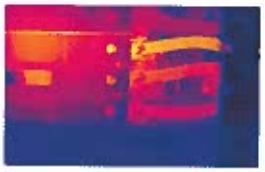
Size AWG or kcmil	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	Size AWG or kcmil
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600

ARTICLE 110

Requirements for Electrical Installations

110.14 Electrical Connections.

(C) Temperature Limitations.



The temperature rating associated with the ampacity of a conductor shall be selected and coordinated so as not to exceed the lowest temperature rating of any connected termination, conductor, or device. Conductors with temperature ratings higher than specified for terminations shall be permitted to be used for ampacity adjustment, correction, or both.

ARTICLE 110

Requirements for Electrical Installations

110.14(C)(1) Electrical Connections.

(1) Equipment Provisions. The determination of termination provisions of equipment shall be based on 110.14(C)(1)(a) or (C)(1)(b). Unless the equipment is listed and marked otherwise, conductor ampacities used in determining equipment termination provisions shall be based on Table 310.16 as appropriately modified by 310.12.

(a) Termination provisions of equipment for circuits rated 100 amperes or less, or marked for 14 AWG through 1 AWG conductors:

(1) Conductors rated 60°C (140°F)

(2) Conductors with higher temperature ratings provided the ampacity of such is determined based on the 60°C (140°F) ampacity of the conductor size used.

ARTICLE 110

Requirements for Electrical Installations

110.14(C)(1) Electrical Connections (Con't)

(b) Termination provisions of equipment for circuits rated over 100 amperes, or marked for conductors larger than 1 AWG, shall be used only for one of the following:

(1) Conductors rated 75°C (167°F)

(2) Conductors with higher temperature ratings provided the ampacity of such conductors does not exceed the 75°C (167°F) ampacity of the conductor size used, or up to their ampacity if the equipment is listed and identified for use with such conductors.

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Temperature Rating of Conductor [See Table 310.4(1)]

Size AWG or kcmil	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	Size AWG or kcmil
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600

* Over 100 amperes or larger than 1 AWG go to 75°C

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Temperature Rating of Conductor [See Table 310.4(1)]

Size AWG or kcmil	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	Size AWG or kcmil
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Temperature Rating of Conductor [See Table 310.4(1)]

Size AWG or kcmil	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	Size AWG or kcmil
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600

ARTICLE 110

Requirements for Electrical Installations

UL White Book General Information on electrical equipment directory says:

A 75 or 90°C temperature marking on a terminal does not in itself indicate that 75 or 90°C insulated wire can be used unless the equipment in which the terminals are installed is also marked for 75 or 90°C.

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ARTICLE 110
Requirements for Electrical Installations

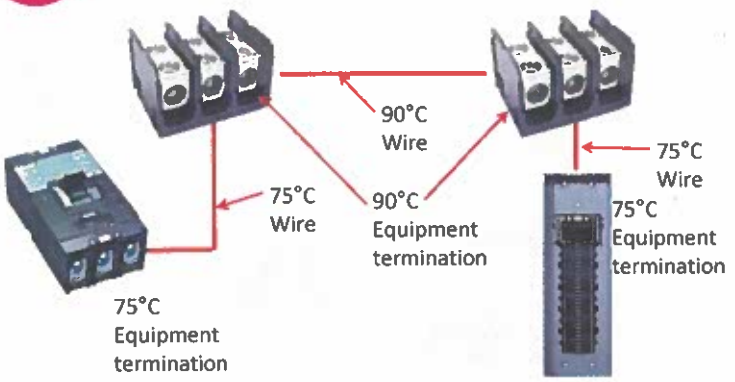

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Table 310.15(C)(1)

Table 310.15(C)(1) Adjustment Factors for More Than Three Current-Carrying Conductors

Number of Conductors*	Percent of Values in Table 310.16 Through Table 310.19 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

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Table 310.15(C)(1)

310.15(E) Neutral Conductor.

Neutral conductors **shall not** be considered current carrying when:

(1) Neutral carries only the unbalanced current from other conductors of the same circuit.

The neutral **shall** be considered current carrying when:

(1) Two phase conductors and the neutral conductor of a 4-wire, 3-phase, wye-connected system.

(2) Where the major portion of the load consists of nonlinear loads then harmonic currents are present in the neutral.

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Table 310.15(B)(1)(1)

Table 310.15(B)(1)(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 60°C	75°C	90°C	Ambient Temperature (°F)
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

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Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	60°C (140°F) Types TW, UF	75°C (167°F) Types RHW, THHW, THWN, XHHW, USE, ZW	90°C (194°F) Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2
	COPPER		
18*	–	–	14
16*	–	–	18
14*	15	20	25
12*	20	25	30
10*	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	115
2	95	115	130
1	110	130	145
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430

Example 1:

A 20-amp circuit breaker requires a 12 AWG conductor according to 240.4(D).

If I install nine 20/1 circuits with shared neutrals in a ¾" conduit, and assuming an ambient temperature of 86 degrees F, then the demand factor for number of current carrying conductors per table 310.15(C)(1) is 7-9 = 70%.

If the wire is THWN-2, then the ampacity of each conductor is 30 amps x 70% = 21 amps and still complies with code on a 20-amp CB.

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Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	60°C (140°F) Types TW, UF	75°C (167°F) Types RHW, THHW, THWN, XHHW, USE, ZW	90°C (194°F) Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2
	COPPER		
18*	–	–	14
16*	–	–	18
14*	15	20	25
12*	20	25	30
10*	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	115
2	95	115	130
1	110	130	145
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430

Example 2:

If the same wire is installed in an attic space with 120-degree F ambient temperature, an additional ambient temperature correction factor of .82 must be applied.

Therefore, 21 amps x .82 = 17.22 amps and a 20-amp CB cannot be used.

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Article 240.4
Overcurrent Protection Round Up Rule

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Article 240 Overcurrent Protection

So...When can I use the 90 degree C column for wiring?

Always begin de-rating using the highest ampacity column in Table 310.16 corresponding to the conductor's insulation temperature rating. Then follow the limitations for the terminations.

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Article 240 Overcurrent Protection

240.4 Protection of Conductors.

(B) Overcurrent Devices Rated 800 Amperes or Less. The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the following conditions are met:

(1) Not part of a multioutlet branch circuit supplying receptacles

(2) The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker

(3) The next higher standard rating selected does not exceed 800 amperes. (Art. 240.6)

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Article 240 Overcurrent Protection

240.4 Protection of Conductors.

(C) Overcurrent Devices Rated Over 800 Amperes. Where the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects shall be equal to or greater than the rating of the overcurrent device defined in 240.6.

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What is the next size higher standard overcurrent device above 100 amps.

1. 105
2. 110
3. 125

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Article 240 Overcurrent Protection

Table 240.6(A) Standard Ampere Ratings for Fuses and Inverse Time Circuit Breakers

Standard Ampere Ratings				
10	15	20	25	30
35	40	45	50	60
70	80	90	100	110
125	150	175	200	225
250	300	350	400	450
500	600	700	800	1000
1200	1600	2000	2500	3000
4000	5000	6000	—	—

Table 240.6(A) Standard Ampere Ratings (A) Fuses and Fixed-Trip Circuit Breakers. The standard ampere ratings for fuses and inverse time circuit breakers shall be considered as shown in Table 240.6(A). Additional standard ampere ratings for fuses shall be 1, 3, 6, 10, and 601. The use of fuses and inverse time circuit breakers with nonstandard ampere ratings shall be permitted.

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Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor (See Table 310.4(1)) 60°C (140°F) Types TW, UF	75°C (167°F) Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	90°C (194°F) Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2
	COPPER		
18*	—	—	14
16*	—	—	18
14*	15	20	25
12*	20	25	30
10*	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	115
2	95	115	130
1	110	130	145
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430

Example 1:

Is it permitted to install 2 sets of 3/0 AWG, copper, THWN-2 in a single conduit on a 400-amp breaker?

Lug Temp:

Per table 310.16, since we are over a #1 AWG, we can use the 75 degree C column, so each #3/0 AWG conductor is good for 200 amps (75°C) x 2 = 400-amp breaker.

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Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor (See Table 310.4(1)) 60°C (140°F) Types TW, UF	75°C (167°F) Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	90°C (194°F) Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2
	COPPER		
18*	—	—	14
16*	—	—	18
14*	15	20	25
12*	20	25	30
10*	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	115
2	95	115	130
1	110	130	145
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430

Example 1:

Is it permitted to install 2 sets of #3/0 AWG, copper, THWN-2 in a single conduit on a 400-amp breaker?

Derating:

Because there are 2 sets in a common raceway, the number of current carrying conductors is six (6) so the derating per table 310.15(C)(1) is 4-6 = 80%.

If I install THWN-2 wire, then the ampacity of each #3/0 is 225 amps x 80% = 180 amps x 2 = 360 amps, and I can still install on a 400-amp CB per 240.4(B) (Round up Rule).

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Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor (See Table 310.4(1)) 60°C (140°F) Types TW, UF	75°C (167°F) Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	90°C (194°F) Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2
	COPPER		
18*	—	—	14
16*	—	—	18
14*	15	20	25
12*	20	25	30
10*	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	115
2	95	115	130
1	110	130	145
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430

Example 2:

What is the breaker size permitted to be installed on 2 sets of 4-250 MCM, THWN-2 installed in two (2) conduits?

Per table 310.16, each 250 MCM conductor is good for 255 amps (75°C) x 2 = 510 Amp feeder.

The next standard size breaker is 600 amps per table 240.6(B).

If you have any derating factors, then you fall below the 500-amp breaker rating and can only round up to 500 amps.

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Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor (See Table 310.4(1)) 60°C (140°F) Types TW, UF	75°C (167°F) Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	90°C (194°F) Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2
	COPPER		
18*	—	—	14
16*	—	—	18
14*	15	20	25
12*	20	25	30
10*	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	115
2	95	115	130
1	110	130	145
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430
600	350	420	475
700	385	460	520

Example 3:

What is the THWN-2 wire size required on a 1200-amp breaker?

Per table 310.16, each 500 MCM conductor carries 380 amps (75°C) x 3 = 1140 amps.

You cannot round up because we are over 800 amps.

You must install 4 sets of 350 MCM or 3 sets of 600 MCM.

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Article 240.21(B) Feeder Taps

130

Article 240 Overcurrent Protection

240.21(B) Feeder Taps. Conductors shall be permitted to be tapped, without overcurrent protection at the tap, to a feeder as specified in 240.21(B)(1) through (B)(5). The tap shall be permitted at any point on the load side of the feeder overcurrent protective device. Section 240.4(B) shall not be permitted for tap conductors (next size higher).

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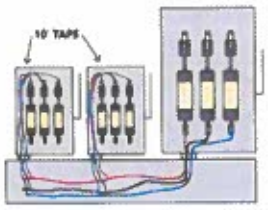
Article 240 Overcurrent Protection



240.21(B)(1) Feeder Taps Not over 3 m (10 ft) Long. If the length of the tap conductors does not exceed 3 m (10 ft) and the tap conductors comply with all of the following:

(1) The ampacity of the tap conductors is

a. Not less than the combined calculated loads on the circuits supplied by the tap conductors, and

b. Not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or not less than the rating of the overcurrent protective device at the termination of the tap conductors.

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Article 240 Overcurrent Protection

240.21(B)(1) Feeder Taps Not over 3 m (10 ft) Long.

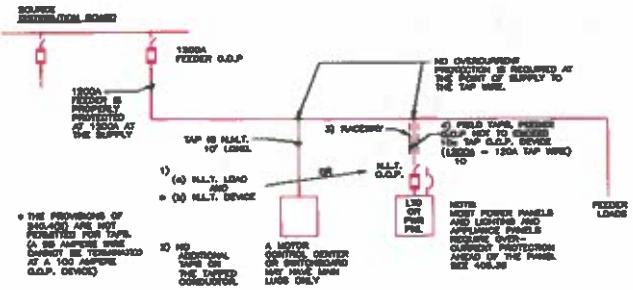
(2) The tap conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.

(3) Except at the point of connection to the feeder, the tap conductors are enclosed in a raceway, which extends from the tap to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices, or to the back of an open switchboard.

(4) For field installations, if the tap conductors leave the enclosure or vault in which the tap is made, the ampacity of the tap conductors is not less than **one-tenth** of the rating of the overcurrent device protecting the feeder conductors.

133

Article 240 Overcurrent Protection



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Article 240 Overcurrent Protection

240.21(B)(2) Taps Not over 7.5 m (25 ft) Long. Where the length of the tap conductors does not exceed 7.5 m (25 ft) and the tap conductors comply with all the following:

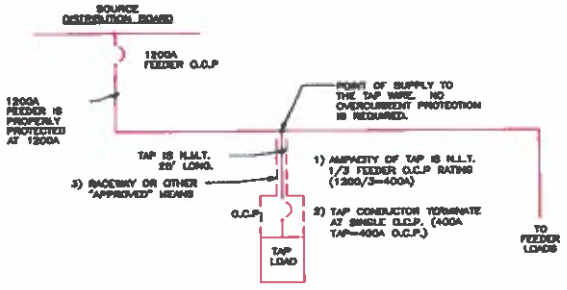
(1) The ampacity of the tap conductors is not less than one third o the rating of the overcurrent device protecting the feeder conductors.

(2) The tap conductors terminate in a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This device shall be permitted to supply any number of additional overcurrent devices on its load side.

(3) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

135

Article 240 Overcurrent Protection



13

Chapter 9 Conduit and Wire Fill

137

ARTICLE 90.9 Units of Measurement

Chapter 9 – Table 4
2" EMT Diameter:
2.067

2" Rigid Steel Diameter:
2.083

90.9 Units of Measurement.

(C) Permitted Uses of Soft Conversion. The cases given in 90.9(C)(1) through (C)(4) shall not be required to use hard conversion and shall be permitted to use soft conversion.

(1) Trade Sizes. Where the actual measured size of a product is not the same as the nominal size, trade size designators shall be used rather than dimensions. **Trade practices shall be followed in all cases.**

(2) Extracted Material (from another standard), (3) Industry Practice, (4) Safety

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Chapter 9 - Table 4 – Page 473

Article 358 — Electrical Metallic Tubing (EMT)

Metric Designator	Trade Size	Over 2 Wires 40% mm²	Over 2 Wires 40% in.²	60% mm²	60% in.²	1 Wire 53% mm²	1 Wire 53% in.²	2 Wires 31% mm²	2 Wires 31% in.²	Nominal Internal Diameter mm	Nominal Internal Diameter in.	Total Area 100% mm²	Total Area 100% in.²
16	1/2	78	0.122	118	0.182	104	0.161	61	0.094	15.8	0.622	196	0.304
21	3/4	137	0.213	206	0.320	182	0.283	106	0.165	20.9	0.824	343	0.533
27	1	222	0.346	333	0.519	295	0.458	172	0.268	26.6	1.049	556	0.864
35	1 1/4	387	0.598	581	0.897	513	0.793	300	0.464	35.1	1.380	968	1.496
41	1 1/2	526	0.814	788	1.221	696	1.079	407	0.631	40.9	1.610	1314	2.036
53	2	866	1.342	1299	2.013	1147	1.778	671	1.040	52.5	2.067	2165	3.356
63	2 1/2	1513	2.343	2270	3.515	2005	3.105	1173	1.816	69.4	2.731	3783	5.858
78	3	2280	3.538	3421	5.307	3022	4.688	1767	2.742	85.2	3.356	5701	8.846
91	3 1/2	2980	4.618	4471	6.927	3949	6.119	2310	3.579	97.4	3.834	7451	11.545
103	4	3808	5.901	5712	8.852	5046	7.819	2951	4 573	110.1	4.334	9521	14.753
129	5	5220	8.085	7830	12.127	6916	10.713	4045	6.266	128.9	5.073	13050	20.212
155	6	7528	11.663	11292	17.495	9975	15.454	5834	9.039	154.8	6.093	18821	29.158

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Chapter 9 - Table 4 – Page 479

Article 344 — Rigid Metal Conduit (RMC)

Metric Designator	Trade Size	Over 2 Wires 40% mm²	Over 2 Wires 40% in.²	60% mm²	60% in.²	1 Wire 53% mm²	1 Wire 53% in.²	2 Wires 31% mm²	2 Wires 31% in.²	Nominal Internal Diameter mm	Nominal Internal Diameter in.	Total Area 100% mm²	Total Area 100% in.²
12	3/8	—	—	—	—	—	—	—	—	—	—	—	—
16	1/2	81	0.125	122	0.188	108	0.166	63	0.097	16.1	0.632	204	0.314
21	3/4	141	0.220	212	0.329	187	0.291	109	0.170	21.2	0.836	353	0.549
27	1	229	0.355	344	0.532	303	0.470	177	0.275	27.0	1.063	573	0.887
35	1 1/4	394	0.610	591	0.916	522	0.809	305	0.473	35.4	1.394	984	1.526
41	1 1/2	533	0.829	800	1.243	707	1.098	413	0.642	41.2	1.624	1333	2.071
53	2	879	1.363	1319	2.045	1165	1.806	681	1.056	52.9	2.083	2198	3.408
63	2 1/2	1255	1.946	1882	2.919	1663	2.579	972	1.508	63.2	2.489	3137	4.866
78	3	1936	3.000	2904	4.499	2565	3.974	1500	2.325	78.5	3.090	4840	7.499
91	3 1/2	2584	4.004	3877	6.006	3424	5.305	2003	3.103	90.7	3.570	6461	10.010
103	4	3326	5.153	4990	7.729	4408	6.828	2578	3.994	102.9	4.050	8316	12.882
129	5	5220	8.085	7830	12.127	6916	10.713	4045	6.266	128.9	5.073	13050	20.212
155	6	7528	11.663	11292	17.495	9975	15.454	5834	9.039	154.8	6.093	18821	29.158

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Chapter 9 - Table 4 – Page 479

Article 352 — Rigid PVC Conduit (PVC), Schedule 80

Metric Designator	Trade Size	Over 2 Wires 40% mm²	Over 2 Wires 40% in.²	60% mm²	60% in.²	1 Wire 53% mm²	1 Wire 53% in.²	2 Wires 31% mm²	2 Wires 31% in.²	Nominal Internal Diameter mm	Nominal Internal Diameter in.	Total Area 100% mm²	Total Area 100% in.²
12	3/8	—	—	—	—	—	—	—	—	—	—	—	—
16	1/2	56	0.087	85	0.130	75	0.115	44	0.067	13.4	0.526	141	0.217
21	3/4	105	0.164	158	0.246	139	0.217	82	0.127	18.3	0.722	263	0.409
27	1	178	0.275	267	0.413	236	0.365	138	0.213	23.8	0.936	445	0.688
35	1 1/4	320	0.495	480	0.742	424	0.656	248	0.383	31.9	1.255	799	1.237
41	1 1/2	442	0.684	663	1.027	585	0.907	342	0.530	37.5	1.476	1104	1.711
53	2	742	1.150	1113	1.725	983	1.523	575	0.891	48.6	1.913	1855	2.874
63	2 1/2	1064	1.647	1596	2.471	1410	2.183	825	1.277	58.2	2.290	2660	4.119
78	3	1660	2.577	2491	3.865	2200	3.414	1287	1.997	72.7	2.864	4151	6.442
91	3 1/2	2243	3.475	3366	5.213	2972	4.605	1738	2.693	84.5	3.326	5608	8.688
103	4	2907	4.503	4361	6.755	3852	5.967	2253	3.490	96.2	3.786	7268	11.258
129	5	4607	7.142	6911	10.713	6105	9.463	3571	5.535	121.1	4.768	11518	17.855
155	6	6605	10.239	9908	15.359	8752	13.567	5119	7.935	145.0	5.709	16513	25.598

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Chapter 9 – Conductor and Cable Fill Page 470

Table 1 Percent of Cross Section of Conduit and Tubing for Conductors and Cables

Number of Conductors and/or Cables	Cross-Sectional Area (%)
1	53
2	31
Over 2	40

Summary: The fill percentage value is different for the type of raceway you are installing – the conductors might fit in RMC but may not fit in PVC Schedule 80.

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Chapter 9 – Conduit Wire Fill

Conduit nipples less than 24" long can be filled to 60% without de-rating!

Chapter 9 – Table 1

Table 1 is based on common conditions of proper cabling and alignment of conductors where the length of the pull and the number of bends are within reasonable limits. It should be recognized that, for certain conditions, a larger size conduit or a lesser conduit fill should be considered.

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Chapter 9 – Table 1 – Page 470

Note to Tables

(3) Equipment grounding or bonding conductors, where installed, shall be included when calculating conduit or tubing fill. The actual dimensions of the equipment grounding or bonding conductor (insulated or bare) shall be used in the calculation.

See also note 9 for Multi-conductor cables or elliptical cross-section.

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Chapter 9, Table 5

Example 1

4#2 AWG and 1#6 AWG ground. The wires are THHN/THWN. What size EMT must be used?

Total Conductor Area:
4 x 0.1158
+ 1 x 0.0507 =
0.5139

Type	Size (AWG or kcmil)	Approximate Area mm²	Approximate Area in.²	Approximate Diameter mm	Approximate Diameter in.
	10	13.61	0.0211	4.166	0.164
	8	23.61	0.0366	5.486	0.216
	6	32.71	0.0507	6.452	0.254
	4	53.16	0.0824	8.230	0.324
	3	62.77	0.0973	8.941	0.352
	2	74.71	0.1158	9.754	0.384
	1	100.8	0.1562	11.33	0.446

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Chapter 9, Table 4

Example 1

In Table 4 – find the value in the 40% column that is more than 0.5139:

Article 358 — Electrical Metallic Tubing (EMT)

Metric Designator	Trade Size	Over 2 Wires 40%		60%		1 Wire 53%		2 Wires 31%		Nominal Internal Diameter		Total Area 100%	
		mm²	in.²	mm²	in.²	mm²	in.²	mm²	in.²	mm	in.	mm²	in.²
16	1/2	78	0.122	118	0.182	104	0.161	61	0.094	15.8	0.622	196	0.304
21	3/4	137	0.213	206	0.320	182	0.283	106	0.165	20.9	0.824	343	0.533
27	1	222	0.346	333	0.519	295	0.458	172	0.268	26.6	1.049	556	0.864
35	1 1/4	387	0.596	581	0.897	513	0.793	300	0.464	35.1	1.380	968	1.496
41	1 1/2	526	0.814	788	1.221	696	1.079	407	0.631	40.9	1.610	1314	2.036
53	2	866	1.342	1299	2.013	1147	1.778	671	1.040	52.5	2.067	2165	3.356
63	2 1/2	1513	2.343	2270	3.515	2005	3.105	1173	1.816	69.4	2.731	3783	5.858
78	3	2280	3.538	3421	5.307	3022	4.688	1767	2.742	85.2	3.356	5701	8.846
91	3 1/2	2980	4.618	4471	6.927	3949	6.119	2310	3.579	97.4	3.834	7451	11.545
103	4	3808	5.901	5712	8.852	5046	7.819	2951	4.573	110.1	4.334	9521	14.753
129	5	5220	8.085	7830	12.127	6916	10.713	4045	6.266	128.9	5.073	13050	20.212
155	6	7528	11.663	11292	17.495	9975	15.454	5834	9.039	154.8	6.093	18821	29.158

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Example 1 - Answer

4#2 AWG and 1#6 AWG ground. The wires are THHN/THWN. What size EMT must be used?

1) A 1 1/4" EMT raceway has an area of 0.598 and is the minimum that can be used.

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Chapter 9, Table 5

Example 2

4#2/0 AWG and 1#4 AWG ground in an underground conduit. The wires are THHN/THWN. What size PVC Schedule 40 must be used?

Type	Size (AWG or kcmil)	Approximate Area mm²	Approximate Area in.²	Approximate Diameter mm	Approximate Diameter in.
	4	53.16	0.0824	8.230	0.324
	3	62.77	0.0973	8.941	0.352
	2	74.71	0.1158	9.754	0.384
	1	100.8	0.1562	11.33	0.446
	1/0	119.7	0.1855	12.34	0.486
	2/0	143.4	0.2223	13.51	0.532
	3/0	172.8	0.2679	14.83	0.584
	4/0	208.8	0.3237	16.31	0.642
	250	266.1	0.3970	18.06	0.711
	300	297.3	0.4608	19.46	0.766

Total Conductor Area:
4 x 0.2223
+ 1 x 0.0824 =
0.9716

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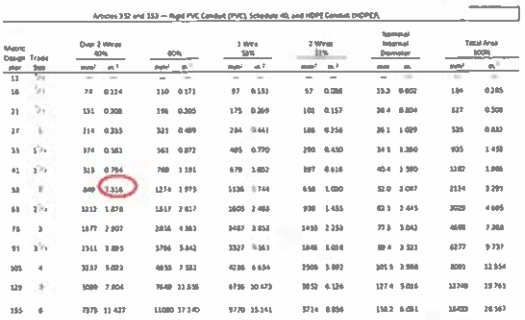
Chapter 9, Table 4

Example 2

In Table 4 – find the value in the 40% column that is more than 0.9716:



149

Example 2 - Answer

4#2/0 AWG and 1#4 AWG ground in an underground conduit. The wires are THHN/THWN. What size PVC Schedule 40 must be used?

1) A 2" PVC schedule 40 raceway has an area of 1.316 and is the minimum that can be used.

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Article 334
Type NM Cable

151

ARTICLE 334
Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

NFPA 220 and OBC have Standards for types of Building Construction
Also Annex E

334.10 Uses Permitted. Type NM, Type NMC, and Type NMS cables shall be permitted to be used in the following, except as prohibited in 334.12:

(1) One- and two-family dwellings and their attached or detached garages, and their storage buildings.

(2) Multi-family dwellings and their detached garages permitted to be of Types III, IV, and V construction.

(3) Other structures permitted to be of Types III, IV, and V construction. Cables shall be concealed within walls, floors, or ceilings that provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies.

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ARTICLE 334
Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.10(A) Type NM.

Type NM cable shall be permitted as follows:

(1) For both exposed and concealed work in normally dry locations except as prohibited in 334.10(3)

(2) To be installed or fished in air voids in masonry block or tile walls

ARTICLE 334 — 153

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.10(B) Type NMC. (Corrosion Resistant)

Type NMC cable shall be permitted as follows:

(1) For both exposed and concealed work in dry, wet, damp, or corrosive locations, except as prohibited by 334.10(3)

(2) In outside and inside walls of masonry block or tile

(3) In a shallow chase in masonry, concrete, or adobe protected against nails or screws by a steel plate at least 1.59 mm ($^{1}/_{16}$ in.) thick and covered with plaster, adobe, or similar finish

ARTICLE 334 — 154

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.12 Uses Not Permitted.

(A) Types NM, NMC, and NMS. Types NM, NMC, and NMS cables shall not be permitted as follows:

(1) In any dwelling or structure not specifically permitted in 334.10(1), (2), (3), and (5)

(2) Exposed within a dropped or suspended ceiling cavity in other than one- and two-family and multifamily dwellings

(3) As service-entrance cable

(4) In commercial garages having hazardous (classified) locations as defined in 511.3

(5) In theaters and similar locations, except where permitted in 518.4(B)

ARTICLE 334 — 155

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.12 Uses Not Permitted.

(6) In motion picture studios

(7) In storage battery rooms

(8) In hoistways or on elevators or escalators

(9) Embedded in poured cement, concrete, or aggregate

(10) In hazardous (classified) locations, except where specifically permitted by other articles in this *Code*

ARTICLE 334 — 156

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.15(A) To Follow Surface.

Cable shall closely follow the surface of the building finish or of running boards.

334.15(B) Protection from Physical Damage.

Cable shall be protected from physical damage where necessary by rigid metal conduit, intermediate metal conduit, electrical metallic tubing, Schedule 80 PVC conduit, RTRC marked with the suffix -XW, or other approved means. Where passing through a floor, the cable shall be enclosed in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, Schedule 80 PVC conduit, RTRC marked with the suffix -XW, or other approved means extending at least 150 mm (6 in.) above the floor. Conduit or tubing shall be provided with a bushing or adapter that provides protection from abrasion at the point the cable enters and exits the raceway.

ARTICLE 334 — 157

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.23 In Accessible Attics.

The installation of cable in accessible attics or roof spaces shall also comply with 320.23.

320.23(A) Where run across the top of framing members, or across the face of rafters or studding within 2.1 m (7 ft) of the floor or horizontal surface, the cable shall be protected by guard strips that are at least as high as the cable. Where this space is not accessible by permanently installed stairs or ladders, protection shall only be required within 1.8 m (6 ft) of the nearest edge of the scuttle hole or attic entrance

320.23(B) Where the cable is installed parallel to the sides of rafters, studs, or ceiling or floor joists, neither guard strips nor running boards shall be required, and the installation shall also comply with 300.4(D) (1 ¼" from edge of joist)

ARTICLE 334 — 158

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.30 Securing and Supporting. Nonmetallic-sheathed cable shall be supported and secured by staples; cable ties listed and identified for securement and support; or straps, hangers, or similar fittings designed and installed so as not to damage the cable, at intervals not exceeding 1.4 m (4 1/2 ft) and within 300 mm (12 in.) of every cable entry into enclosures such as outlet boxes, junction boxes, cabinets, or fittings. Flat cables shall not be stapled on edge.

Sections of cable protected from physical damage by raceway shall not be required to be secured within the raceway.

ARTICLE 334 — 159

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.40 Boxes and Fittings.

334.40(A) Boxes of Insulating Material.

Nonmetallic outlet boxes shall be permitted as provided by 314.3.

(only non-metallic with open wiring on insulators, concealed knob-and-tube wiring, cabled wiring methods with entirely nonmetallic sheaths, flexible cords, and nonmetallic raceways)

160

Can a self-contained and listed NM splice be installed where concealed in the wall?

1. Yes
2. No

ARTICLE 334 — 161

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.40(B) Devices of Insulating Material.

Self-contained switches, self-contained receptacles, and listed nonmetallic-sheathed cable interconnector devices of insulating material that are listed for use without a box shall be permitted to be used without boxes in exposed or concealed installations. Openings in such devices shall form a close fit around the outer covering of the cable, and the device shall fully enclose the part of the cable from which any part of the covering has been removed. Where connections to conductors are by binding-screw terminals, there shall be available as many terminals as conductors.

ARTICLE 334 — 162

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

334.80 Ampacity.

The ampacity of Types NM and NMC cable shall be determined in accordance with 310.14. The ampacity shall not exceed that of a 60°C (140°F) rated conductor. The 90°C (194°F) rating shall be permitted to be used for ampacity adjustment and correction calculations, provided the final calculated ampacity does not exceed that of a 60°C (140°F) rated conductor. The ampacity of Types NM and NMC cable installed in cable trays shall be determined in accordance with 392.80(A).

ARTICLE 334 — 163

Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

Table 310.15(C)(1) Adjustment Factors for More Than Three Current-Carrying Conductors

Number of Conductors*	Percent of Values in Table 310.16 Through Table 310.19 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

334.80 Ampacity.

Where more than two NM cables containing two or more current-carrying conductors are installed, without maintaining spacing between the cables, through the same opening in wood framing that is to be sealed with thermal insulation, caulk, or sealing foam, the ampacity of each conductor shall be adjusted in accordance with Table 310.15(C)(1) and 310.14(A)(2), Exception, shall not apply. (Higher ampacity of circuit wire permitted if less than 10' or 10% of the ckt length)

Where more than **two NM cables** containing two or more current-carrying conductors are installed in contact with thermal insulation without maintaining spacing between cables, the ampacity of each conductor shall be adjusted in accordance with Table 310.15(C)(1) and 310.14(A)(2), Exception shall not apply.

ARTICLE 334 — 164

Nonmetallic-Sheathed Cable: Types NM NMC, and NMS

The exception does not apply to Romex

310.14(A)(2) Selection of Ampacity.

Where more than one ampacity applies for a given circuit length, the lowest value shall be used.

Exception: Where different ampacities apply to portions of a circuit, the higher ampacity shall be permitted to be used if the total portion(s) of the circuit with lower ampacity does not exceed the lesser of 3.0 m (10 ft) or 10 percent of the total circuit.

Informational Note: See 110.14(C) for conductor temperature limitations due to termination provisions.

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Article 110.26
Working Space and Dedicated Equipment Space

ARTICLE 110.26 Spaces About Electrical Equipment — 166

2023 NEC

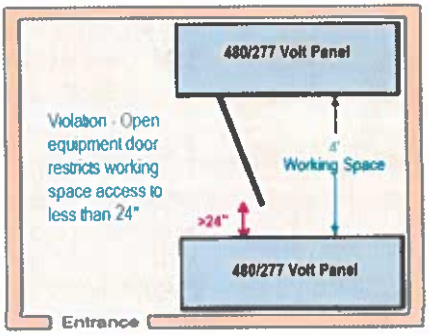
1.Note: See NFPA 70E-2018 for exposure and assessing risk.

110.26 Spaces About Electrical Equipment.

Working space, and access to and egress from working space, shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment. Open equipment doors shall not impede access to and egress from the working space. Access or egress is impeded if one or mon simultaneously opened equipment doors restrict working space access to be less than 610 mm (24 in.) wide and 2.0 m (6½ ft) high.

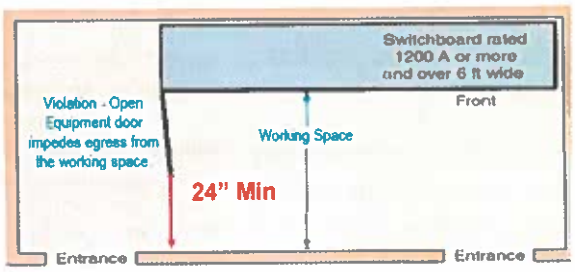
ARTICLE 110.26 Spaces About Electrical Equipment — 167

Clarified in 2023!



ARTICLE 110.26 Spaces About Electrical Equipment — 16

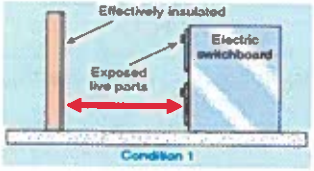
Clarified in 2023!



ARTICLE 110.26 Spaces About Electrical Equipment

169

110.26 Spaces About Electrical Equipment.



110.26(A)(1) Depth of Working Space. The depth of the working space in the direction of live parts shall not be less than that specified in Table 110.26(A)(1) unless the requirements of 110.26(A)(1)(a), (A)(1)(b), or (A)(1)(c) are met. Distances shall be measured from the exposed live parts or from the enclosure or opening if the live parts are enclosed.

ARTICLE 110.26 Spaces About Electrical Equipment

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Table 110.26(A)(1) Working Spaces

Nominal Voltage to Ground	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
0–150	900 mm (3 ft)	900 mm (3 ft)	900 mm (3 ft)
151–600	900 mm (3 ft)	1.0 m (3 ft 6 in.)	1.2 m (4 ft)
601–1000	900 mm (3 ft)	1.2 m (4 ft)	1.5 m (5 ft)

Distances are measured from the exposed live parts or from the enclosure or opening if the live parts are enclosed.

ARTICLE 100 - Definitions

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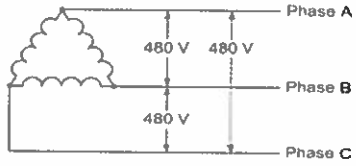

This system is 480 volts to ground

Voltage to Ground. For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit (CMP-1)

ARTICLE 110.26 Spaces About Electrical Equipment

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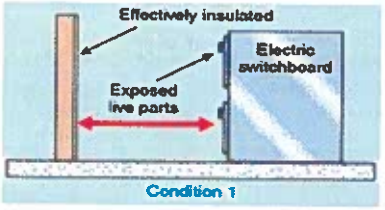
Condition 1 — Exposed live parts on one side of the working space and no live or grounded parts on the other side of the working space, or exposed live parts on both sides of the working space that are effectively guarded by insulating materials.



Nominal Voltage to Ground	Minimum Clear Distance
0–150	900 mm (3 ft)
151–600	900 mm (3 ft)
601–1000	900 mm (3 ft)

ARTICLE 110.26 Spaces About Electrical Equipment

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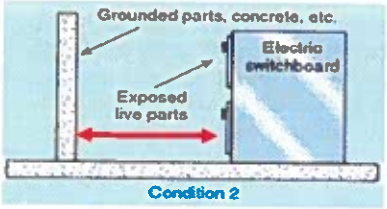
Condition 2 distances permitted between panels in existing buildings!

Condition 2 — Exposed live parts on one side of the working space and grounded parts on the other side of the working space. Concrete, brick, or tile walls shall be considered as grounded.



Nominal Voltage to Ground	Minimum Clear Distance
0–150	900 mm (3 ft)
151–600	1.0 m (3 ft 6 in.)
601–1000	1.2 m (4 ft)

ARTICLE 110.26 Spaces About Electrical Equipment

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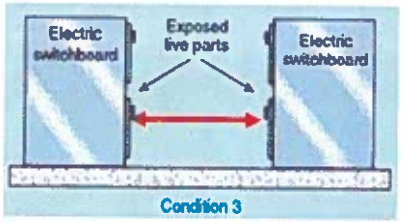
Condition 3 — Exposed live parts on both sides of the working space.



Nominal Voltage to Ground	Minimum Clear Distance
0–150	900 mm (3 ft)
151–600	1.2 m (4 ft)
601–1000	1.5 m (5 ft)

ARTICLE 110.26 Spaces About Electrical Equipment

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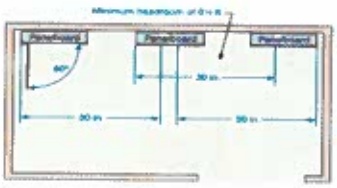
110.26 Spaces About Electrical Equipment.



(A) (2) Width of Working Space. The width of the working space in front of the electric equipment shall be the width of the equipment or 762 mm (30 in.), whichever is greater. In all cases, the workspace shall permit at least a 90-degree opening of equipment doors or hinged panels.

ARTICLE 110.26 Spaces About Electrical Equipment

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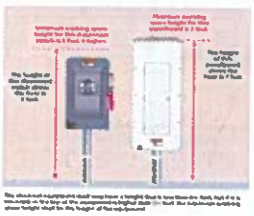

2020 NEC Change

110.26 Spaces About Electrical Equipment.

(A) (3) Height of Working Space. The workspace shall be clear and extend from the grade, floor, or platform to a height of **2.0 m (6 1/2')** or the height of the equipment, whichever is greater. Within the height, other equipment or support structures, such as concrete pads, associated with the electrical installation and is located above or below the electrical equipment shall be permitted to extend not more than 150 mm (6 in.) beyond the front of the electrical equipment.

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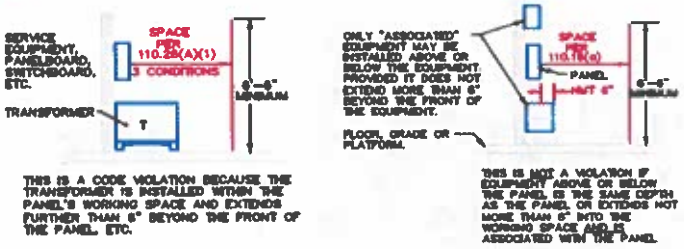
ARTICLE 110.26 Spaces About Electrical Equipment

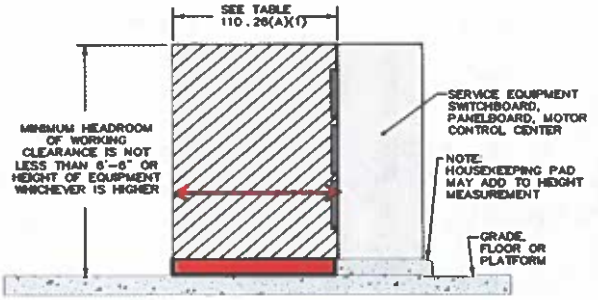


Elevation A
Not permitted

Elevation B
Permitted

178

ARTICLE 110.26 Spaces About Electrical Equipment



179

N 110.26(A)(6) Working Spaces

N **(A)(6) Grade level, Floor, or Working Platform**

The grade, floor, or platform in the required working space shall be kept clear, and the floor, grade, or platform in the working space shall be as level and flat as practicable for the entire required depth and width of the working space.

Raised sump pump covers in the working space would not be level

2023 NEC Change

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ARTICLE 110.26 Spaces About Electrical Equipment

110.26(C) Entrance to and Egress from Working Space.

110.26(C)(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.

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ARTICLE 110.26 Spaces About Electrical Equipment

110.26(C) Entrance to Working Space

(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 (6 1/2 ft) high at each end of the working space. This requirement shall apply to either of the following conditions:

2020 Change

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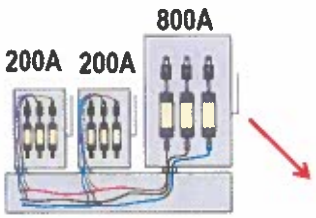
ARTICLE 110.26 Spaces About Electrical Equipment

110.26(C) Entrance to Working Space

(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(B where the combined ampere rating is 1200 amperes or more and where the combined width is over 1.8 m (6 ft).



2023 Change

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Article 210.8 Ground Fault Circuit Interrupter Protection (Commercial)

18

Article 210.8 GFCI

△ **210.8(B) Other Than Dwelling Units.**

All 125-volt through 250-volt receptacles supplied by single-phase branch circuits rated 150 volts or less to ground, 50 amperes or less, and all receptacles supplied by three-phase branch circuits rated 150 volts or less to ground, 100 amperes or less, installed in the following locations shall be provided with GFCI protection:

1) Bathrooms
2) Kitchens (All receptacles – must have a sink with permanent provisions for cooking)
3) Areas with sinks and permanent provisions fc food preparation, beverage preparation, or cooking

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Article 210.8 GFCI

210.8(B) GFCI Other Than Dwelling Units (Con't).

4) Buffet serving areas with permanent provisions for food serving, beverage serving, or cooking
5) Rooftops
6) Outdoors
7) Sinks where receptacles or cord-and-plug-connected fixed or stationary appliances are installed within 1.8 m (6 ft) from the top inside edge of the bowl of the sink

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Article 210.8 GFCI

210.8(B) GFCI Other Than Dwelling Units (Con't).

8) Indoor damp or wet locations
9) Locker rooms with associated showering facilities
10) Garages, accessory buildings, service bays, and similar areas other than vehicle exhibition halls and showrooms

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Article 210.8 GFCI

210.8(B) GFCI Other Than Dwelling Units (Con't).

11) Crawl spaces at or below grade level
12) Unfinished areas of basements
13) Aquariums, bait wells, and similar open aquatic vessels or containers, such as tanks or bowls, where receptacles are installed within 1.8 m (6 ft.) from the top inside edge or rim or from the conductive support framing of the vessel or container
14) Laundry areas
15) Bathtubs and shower stalls where receptacles are installed within 1.8 m (6 ft) of the outside edge of the bathtub or shower stall

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Article 210.8 GFCI

210.8(B) GFCI Commercial GFCI Exceptions:

#1 Dedicated to Snow melting systems

#2 GFCI Receptacles on rooftops can be readily accessible from the rooftop

#3 Receptacles within 6' of a sink in an industrial environment which could create an additional hazard. Must have a grounding conductor program (Laboratories)

#4 Industrial Laboratory stationary appliances

#5 Patient Care Areas

#6 Ceiling receptacles utilizing weight supporting attachment means for a ceiling fan

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Article 230 Services

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Article 230 Services

230.71 Maximum Number of Disconnects.

Each service shall have only one disconnecting means unless the requirements of 230.71(B) are met.

(A) General. For the purpose of this section, disconnecting means installed as part of listed equipment and used solely for the following shall not be considered a service disconnecting means:

(1) Power monitoring equipment
(2) Surge-protective device(s)
(3) Control circuit of the ground-fault protection system
(4) Power-operable service disconnecting means

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How many disconnects are permitted for each electrical service?

1. 2
2. 4
3. 6
4. 8

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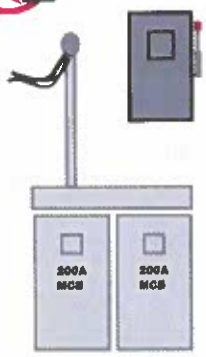
Article 230 Services

230.71(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:

193

Article 230 Services



(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 with barriers provided between each vertical section to maintain the inadvertent contact protection required in 230.62 based on access from the adjacent section(s)

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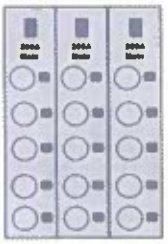
Article 230 Services



(4) Service disconnects in switchgear, transfer switches, or metering centers where each disconnect is located in a separate compartment

(5) Metering centers with a main service disconnecting means in each metering center

(6) Motor control center(s) where there is only one service disconnect in a motor control center unit and a maximum of two service disconnects provided in a single motor control center with barriers provided between each motor control center unit or compartment containing a service disconnect to maintain the inadvertent contact protection required in 230.62 based on access from adjacent motor control center unit(s) or compartment(s)

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Article 230 Services

230.72 Grouping of Disconnects.

230.72(A) General.

The two to six disconnects, if permitted in 230.71, shall be grouped. Each disconnect shall be marked to indicate the load served.

Exception: One of the two to six service disconnecting means permitted in 230.71, where used only for a water pump also intended to provide fire protection, shall be permitted to be located remote from the other disconnecting means. If remotely installed in accordance with this exception, a plaque shall be posted at the location of the remaining grouped disconnects denoting its location.

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Article 230 Services

230.72 Grouping of Disconnects.

230.72(B) Additional Service Disconnecting Means.

The one or more additional service disconnecting means for fire pumps, emergency systems, legally required standby, or optional standby services permitted by 230.2 shall be installed remote from the one to six service disconnecting means for normal service to minimize the possibility of simultaneous interruption of supply.

197

Article 240 and 450 Transformers

198

Article 240 Overcurrent Protection

240.4 Protection of Conductors.

Read table 450.3(B) correctly!

(F) Transformer Secondary Conductors. Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors shall not be considered to be protected by the primary overcurrent protective device. Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary, or a three-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary, shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

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ARTICLE 450
Transformers and Transformer Vaults

450.3 Overcurrent Protection

(B) Transformers 600 Volts, Nominal, or Less. Overcurrent protection shall be provided in accordance with Table 450.3(B).

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ARTICLE 450
Transformers and Transformer Vaults

Table 450.3(B) Maximum Rating or Setting of Overcurrent Protection for Transformers 1000 Volts and Less (as a Percentage of Transformer-Rated Current)

Protection Method	Primary Protection: Currents of 9 Amperes or More	Primary Protection: Currents Less Than 9 Amperes	Primary Protection: Currents Less Than 2 Amperes	Secondary Protection (See Note 2.): Currents of 9 Amperes or More	Secondary Protection (See Note 2.): Currents Less Than 9 Amperes
Primary only protection	125% (See Note 1.)	167%	300%	Not required	Not required
Primary and secondary protection	250% (See Note 3.)	250% (See Note 3.)	250% (See Note 3.)	125% (See Note 1.)	167%

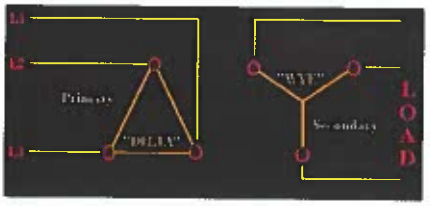
Notes:
1. Where 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, a higher rating that does not exceed the next higher standard rating shall be permitted.
2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped at one location. Where multiple overcurrent devices are installed, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device.
3. A transformer equipped with coordinated thermal overload protection by the manufacturer and arranged to interrupt the primary current shall be permitted to have primary overcurrent protection rated or set at a current value that is not more than six times the rated current of the transformer for transformers having not more than 6 percent impedance and not more than four times the rated current of the transformer for transformers having more than 6 percent but not more than 10 percent impedance.

201

Article 240 Overcurrent Protection

240.4 Protection of Conductors.

If the secondary conductors are not protected by the primary OCP device then they become a tap and you must use Article 240.21



202

Article 240 Overcurrent Protection

240.21(C) Transformer Secondary Conductors. A set of conductors feeding a single load, or each set of conductors feeding separate loads, shall be permitted to be connected to a transformer secondary, without overcurrent protection at the secondary, as specified in 240.21(C)(1) through (C)(6). Section 240.4(B) shall not be permitted for transformer secondary conductors.

No round up rule!

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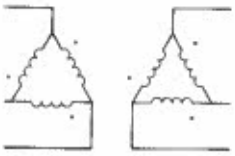
Article 240 Overcurrent Protection



240.12(C) Transformer Secondary Conductors.

(1) Protection by Primary Overcurrent Device. Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary, or a three-phase, delta-delta connected transformer having a 3-wire (single voltage) secondary, shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

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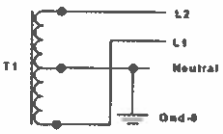
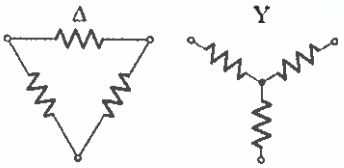
Article 240 Overcurrent Protection

240.12(C) Transformer Secondary Conductors.

Single-phase (other than 2 wire) and multi-phase (other than delta-delta, 3 wire) transformer secondary conductors are not considered to be protected by the primary overcurrent protective device.





205

Article 240 Overcurrent Protection

240.12(C) Transformer Secondary Conductors.

(2) Transformer Secondary Conductors Not over 3 m (10 ft) Long. If the length of secondary conductor does not exceed 3 m (10 ft) and complies with all of the following:

1a. Secondary Conductor size is not less than load

1b. Not less than the rating of the equipment containing an overcurrent device(s)

2. Do not extend beyond the equipment they supply.

3. Enclosed in a raceway

4. Rating of primary OCP device multiplied by the primary to secondary voltage ratio does not exceed 10x the secondary wire ampacity

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Article 240 Overcurrent Protection

240.21(C) Transformer Secondary Conductors.

(3) Industrial Installation Secondary Conductors Not over 7.5 m (25 ft) Long. For the supply of switchgear or switchboards in industrial installations only, where the length of the secondary conductors does not exceed 7.5 m (25 ft) and complies with all of the following:

(1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.

(2) The ampacity of the secondary conductors is not less than the secondary current rating of the transformer, and the sum of the ratings of the overcurrent devices does not exceed the ampacity of the secondary conductors.

(3) All overcurrent devices are grouped.

(4) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

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ARTICLE 450
Transformers and Transformer Vaults

Primary 400A fuse

400A Wire – round up permitted

Transformer conductors are not listed in the exceptions in table 240.4(G).

Rule #1: Transformer primary conductors are sized based on the selected primary overcurrent device rating.

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ARTICLE 450
Transformers and Transformer Vaults

Transformer Secondary conductors are sized as taps per Article 240.21(C).

Transformer permitted to be protected with Primary only protection:

Primary protection must be less than secondary conductor ampacity times the secondary to primary voltage ratio: Example 150-amp secondary conductor x 208/480 = 65 amps max primary overcurrent device.

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ARTICLE 450
Transformers and Transformer Vaults

Transformer Secondary conductors are sized as taps per Article 240.21(C).

Primary and Secondary Protection Length not over 10':

Primary protection multiplied by the primary to secondary transformer voltage ratio shall not exceed 10 times the ampacity of the secondary conductors:

Example: 400-amp primary OCD x 480/208 = 923.07 amps. Minimum 10' long secondary wire size is 92.3 amps.

210

ARTICLE 450
Transformers and Transformer Vaults

Transformer Secondary conductors are sized as taps per Article 240.21(C).

Primary and Secondary Protection Length not over 25' (Industrial only):

The ampacity of the secondary conductors is not less than the secondary current rating of the transformer and the sum of the OCD does not exceed the ampacity of conductors:

Example: 45 KVA transformer = 45000 / 208 / 1.732 = 124 amps secondary current rating.

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Transformer Example

125 AMP

PER 450.3(B)
PRI FLA X 250% = 127.75 A MAX

3#1 AWG AND 1#6 AWG GND – 1 1/2" C

TRANSFORMER
45 KVA, 480-120/208V
DELTA - WYE
PRIMARY AMPS = 54.1
SECONDARY AMPS = 124.9

4#2/0 AWG AND 1#4 AWG SSBJ – 2" C
(MAX 10' NO ROUND UP)

175 AMP

PER 450.3(B)
SEC FLA X 125% = 156.1 A PLUS NEXT SIDE HIGHER

Double-check that the rating of primary OCP device (125) multiplied by the primary to secondary voltage ratio (480/208 = 2.30) does not exceed 10x the secondary wire ampacity:
125 x 2.30 = 287.5
10 times = 28.7 amp min wire size

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ARTICLE 430
Motors, Motor Circuits, and Controllers

213

ARTICLE 430
Motors, Motor Circuits, and Controllers

Most electrical equipment is rated in volt-amperes (VA) or watt input.

Circuits supplying motors are sized according to the input to the motor. The input includes the motor losses and the power factor of the motor. The losses are not the type of information found on the nameplate of a motor.

Tables 430.249 and 430.250 contain accurate industry wide input ampere ratings for motors.

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ARTICLE 430
Motors, Motor Circuits, and Controllers

One horsepower equals approximately 746 watts without power factor considered.

It is important to understand that circuits that supply motors not rated in horsepower still must be sized according to the input of the motor, rated in amperes. Sizing circuits based solely on kilowatt output results in seriously undersized conductors (because the current requirements of the losses and the power facto are neglected) and the improper application of overcurrent devices.

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ARTICLE 430
Motors, Motor Circuits, and Controllers

430.6 Ampacity and Motor Rating Determination.

(1) Table Values. Other than for motors built for low speeds (less than 1200 RPM) or high torques, and for multispeed motors, the values given in **Table 430.247, Table 430.248, Table 430.249, and Table 430.250 shall be used to determine the ampacity** of conductors or ampere ratings of switches, branch-circuit short-circuit and ground-fault protection, instead of the actual current rating marked on the motor nameplate.

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ARTICLE 430
Motors, Motor Circuits, and Controller

430.6 Ampacity and Motor Rating Determination.

(1) Table Values. Where a motor is marked in amperes, but not horsepower, the horsepower rating shall be assumed to be that corresponding to the value given in Table 430.247, Table 430.248, Table 430.249, and Table 430.250, interpolated if necessary. Motors built for low speeds (less than 1200 RPM) or high torques may have higher full-load currents, and multispeed motors will have full-load current varying with speed, in which case the nameplate current ratings shall be used.

ARTICLE 430 — 217
Motors, Motor Circuits, and Controllers

Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors The following values of full-load currents are typical for motors running at speeds usual for belted motors and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

	Induction-Type Squirrel Cage and Wound Rotor (Amperes)							Synchronous-Type Unity Power Factor* (Amperes)			
Horsepower	115 Volts	200 Volts	208 Volts	230 Volts	460 Volts	575 Volts	2300 V	230 Volts	460 Volts	575 Volts	2300 Volts
½	4.4	2.5	2.4	2.2	1.1	0.9	—	—	—	—	—
¾	6.4	3.7	3.5	3.2	1.6	1.3	—	—	—	—	—
1	8.4	4.8	4.6	4.2	2.1	1.7	—	—	—	—	—
1½	12.0	6.9	6.6	6.0	3.0	2.4	—	—	—	—	—
2	13.6	7.8	7.5	6.8	3.4	2.7	—	—	—	—	—
3	—	11.0	10.6	9.6	4.8	3.9	—	—	—	—	—
5	—	17.5	16.7	15.2	7.6	6.1	—	—	—	—	—
7½	—	25.3	24.2	22	11	9	—	—	—	—	—
10	—	32.2	30.8	28	14	11	—	—	—	—	—

ARTICLE 430 — 218
Motors, Motor Circuits, and Controllers

	Induction-Type Squirrel Cage and Wound Rotor (Amperes)							Synchronous-Type Unity Power Factor* (Amperes)			
Horsepower	115 Volts	200 Volts	208 Volts	230 Volts	460 Volts	575 Volts	2300 V	230 Volts	460 Volts	575 Volts	2300 Volts
10	—	32.2	30.8	28	14	11	—	—	—	—	—
15	—	48.3	46.2	42	21	17	—	—	—	—	—
20	—	62.1	59.4	54	27	22	—	—	—	—	—
25	—	78.2	74.8	68	34	27	—	53	26	21	—
30	—	92	88	80	40	32	—	63	32	26	—
40	—	120	114	104	52	41	—	83	41	33	—
50	—	150	143	130	65	52	—	104	52	42	—
60	—	177	169	154	77	62	16	123	61	49	12
75	—	221	211	192	96	77	20	155	78	62	15
100	—	285	273	248	124	99	26	202	101	81	20
125	—	359	343	312	156	125	31	253	126	101	25
150	—	414	396	360	180	144	37	302	151	121	30
200	—	552	528	480	240	192	49	400	201	161	40
250	—	—	—	—	302	242	60	—	—	—	—
300	—	—	—	—	361	289	72	—	—	—	—

ARTICLE 430 — 219
Motors, Motor Circuits, and Controllers

430.6 Ampacity and Motor Rating Determination.

(2) Nameplate Values. Separate motor overload protection shall be based on the motor nameplate current rating.

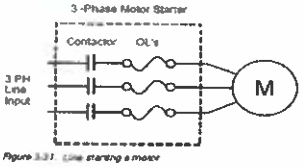
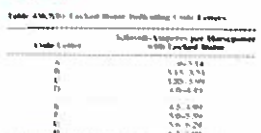


Figure 3.31 Line starting a motor

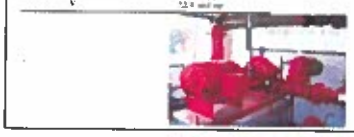
ARTICLE 430 — 220
Motors, Motor Circuits, and Controllers



430.7 Marking on Motors and Multimotor Equipment.

(B) Locked-Rotor Indicating Code Letters. Code letters marked on motor nameplates to show motor input with locked rotor shall be in accordance with Table 430.7(B).

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



20 HP type G Motor

Locked-rotor kVA = motor hp × maximum code letter value
= 20 × 6.29 = 125.8

Locked-rotor current = locked-rotor kVa / (√3 × KV)

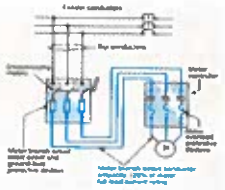
For 460 volts = 125.8 / (1.73 × 0.46) = 158 amperes

ARTICLE 430 — 221
Motors, Motor Circuits, and Controllers

430.9 Terminals.

(B) Wire-Bending Space in Enclosures. Minimum wire bending space within the enclosures for motor controllers shall be in accordance with Table 430.10(B) where measured in a straight line from the end of the lug or wire connector (in the direction the wire leaves the terminal) to the wall or barrier. Where alternate wire termination means are substituted for that supplied by the manufacturer of the controller, they shall be of a type identified by the manufacturer for use with the controller and shall not reduce the minimum wire-bending space.

ARTICLE 430 — 222
Motors, Motor Circuits, and Controllers



430.22 Single Motor. Conductors that supply a single motor used in a continuous duty application shall have an ampacity of not less than 125 percent of the motor full-load current rating, as determined by 430.6(A)(1), or not less than specified in 430.22(A) through (G).

(A) Direct-Current Motor-Rectifier Supplied.

(B) Multispeed Motor.

(C) Wye-Start, Delta-Run Motor.

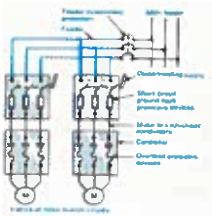
(D) Part-Winding Motor.

(E) Other Than Continuous Duty. 430.22(E)

(F) Separate Terminal Enclosure

(G) Conductors for Small Motors.

ARTICLE 430 — 223
Motors, Motor Circuits, and Controllers



430.24 Several Motors or a Motor(s) and Other Load(s). Conductors supplying several motors, or a motor(s) and other load(s), shall have an ampacity not less than the sum of each of the following:

(1) 125 percent of the full-load current rating of the highest rated motor, as determined by 430.6(A)

(2) Sum of the full-load current ratings of all the other motors in the group, as determined by 430.6(A)

(3) 100 percent of the non continuous non-motor load

(4) 125 percent of the continuous non motor load.

ARTICLE 430 — 224
Motors, Motor Circuits, and Controllers

IV. Motor Branch-Circuit Short-Circuit and Ground-Fault Protection

430.52 Rating or Setting for Individual Motor Circuit.

(C) Rating or Setting.

(1) In Accordance with Table 430.52. A protective device that has a rating or setting not exceeding the value calculated according to the values given in Table 430.52 shall be used.

Exception No. 1: ...the next higher standard ampere rating shall be permitted.

ARTICLE 430

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Motors, Motor Circuits, and Controllers

Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices

	Percentage of Full-Load Current			
Type of Motor	Nontime Delay Fuse[1]	Dual Element (Time-Delay) Fuse[1]	Instantaneous Trip Breaker	Inverse Time Breaker[2]
Single-phase motors	300	175	800	250
AC polyphase motors other than wound rotor	300	175	800	250
Squirrel cage — other than Design B energy-efficient	300	175	800	250
Design B energy-efficient	300	175	1100	250
Synchronous[3]	300	175	800	250
Wound-rotor	150	150	800	150
DC (constant voltage)	150	150	250	150

Note: For certain exceptions to the values specified, see 430.54.
[1] The values in the Nontime Delay Fuse column apply to time-delay Class CC fuses.
[2] The values given in the last column also cover the ratings of nonadjustable inverse time types of circuit breakers that may be modified as in 430.52(C)(1), Exceptions No. 1 and No. 2.

ARTICLE 430

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Motors, Motor Circuits, and Controllers

Table 240.4(G) Specific Conductor Applications

Conductor	Article	Section
Air-conditioning and refrigeration equipment circuit conductors	440, Parts III, VI	
Capacitor circuit conductors	460	460.8(B) and 460.25
Control and instrumentation circuit conductors (Type ITC)	727	727.9
Electric welder circuit conductors	630	630.12 and 630.32
Fire alarm system circuit conductors	760	760.43, 760.45, 760.121, and Chapter 9, Tables 12(A) and 12(B)
Motor-operated appliance circuit conductors	422, Part II	
Motor and motor-control circuit conductors	430, Parts II, III, IV, V, VI, VII	
Phase converter supply conductors	455	455.7
Remote-control, signaling, and power-limited circuit conductors	725	725.43, 725.45, 725.121, and Chapter 9, Tables 11(A) and 11(B)
Secondary tie conductors	450	450.6

240.4(G) Overcurrent Protection for Specific Conductor Applications.

Overcurrent protection for the specific conductors shall be permitted to be provided as referenced in Table 240.4(G).

227

Is a disconnect required at both the motor and controller?

1. Yes
2. No

ARTICLE 430

228

Motors, Motor Circuits, and Controllers

430.75 Disconnection.

(A) General. Motor control circuits shall be arranged so that they will be disconnected from all sources of supply when the disconnecting means is in the open position. The disconnecting means shall be permitted to consist of two or more separate devices, one of which disconnects the motor and the controller from the source(s) of power supply for the motor, and the other(s), the motor control circuit(s) from its power supply. Where separate devices are used, they shall be located immediately adjacent to each other.

ARTICLE 430

229

Motors, Motor Circuits, and Controllers

IX. Disconnecting Means 430.102 Location.

430.102(A) Motor Controller.

An individual disconnecting means shall be provided for each motor controller and shall disconnect the motor controller. The disconnecting means shall be located in sight from the motor controller location.

Exception 1 *– Motors over 1000 volts*

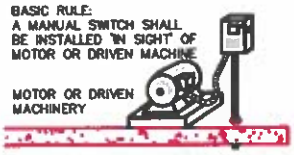
Exception 2 *– Group of coordinated motor controllers on a single machine*

Exception 3 *– Valve Actuator Assemblies*

ARTICLE 430

230

Motors, Motor Circuits, and Controllers



IX. Disconnecting Means 430.102 Location.

430.102(B) Motor.

A disconnecting means shall be provided for a motor in accordance with 430.102 (B)(1) or (B)(2).

430.102(B)(1) Separate Motor Disconnect

A disconnecting means for the motor shall be located in sight from the motor location and the driven machinery location.

ARTICLE 430

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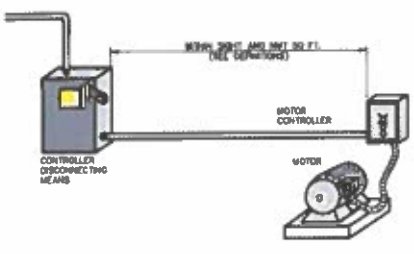
Motors, Motor Circuits, and Controllers



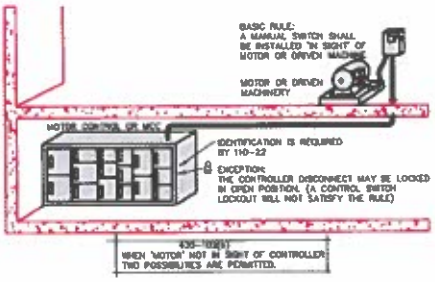
430.102(B)(2) Controller Disconnect.

The controller disconnecting means required in accordance with 430.102 (A) shall be permitted to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.

ARTICLE 430

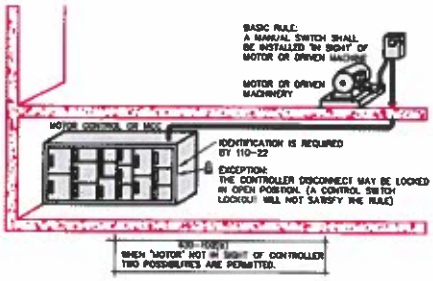
23

Motors, Motor Circuits, and Controller



Exception to (1) and (2): Th disconnecting means for th motor shall not be required under either of the following conditions if the motor controller disconnecting means required in 430.102(A) is lockable in accordance with 110.25:

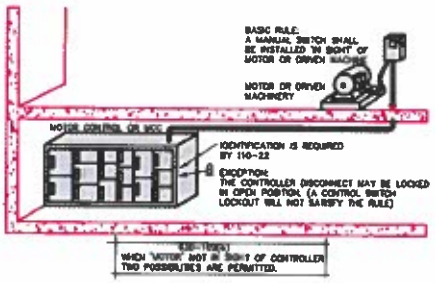
ARTICLE 430 — 233
Motors, Motor Circuits, and Controllers



(1) Where such a location of the disconnecting means for the motor is impracticable or introduces additional or increased hazards to persons or property

Informational Note: *Some examples of increased or additional hazards include, but are not limited to, motors rated in excess of 100 hp, multimotor equipment, submersible motors, motors associated with adjustable speed drives, and motors located in hazardous (classified) locations.*

ARTICLE 430 — 234
Motors, Motor Circuits, and Controllers



(2) In industrial installations, with written safety procedures, where conditions of maintenance and supervision ensure that only qualified persons service the equipment

Informational Note: For information on lockout/tagout procedures, see ***NFPA 70E-2021***, *Standard for Electrical Safety in the Workplace.*

ARTICLE 430 — 235
Motors, Motor Circuits, and Controllers

430.107 Readily Accessible. At least one of the disconnecting means shall be readily accessible.

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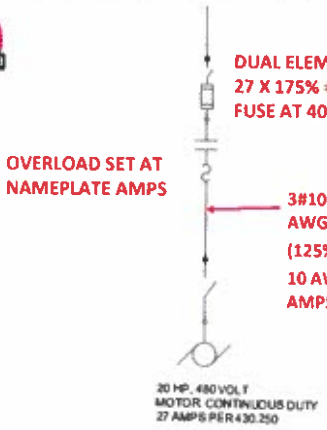
Motor Example



Use the wire rating on the ampacity of the conductor to the motor.

Remember, one of the disconnects (motor or controller) must be readily accessible.

237
Article 700
Emergency Systems

ARTICLE 700 — 238

700.2 Reconditioned Equipment.

Reconditioned transfer switches shall not be permitted.

700.3 Tests and Maintenance.

700.3(A) Commissioning Witness Test.

The authority having jurisdiction shall conduct or witness the commissioning of the complete system upon installation and periodically afterward.

Informational Note: See NECA 90, Standard for Commissioning Building Electrical Systems.

ARTICLE 700 — 239

700.3(B) Tested Periodically.

Systems shall be tested periodically on a schedule approved by the authority having jurisdiction to ensure the systems are maintained in proper operating condition.

700.3(C) Maintenance.

Emergency system equipment shall be maintained in accordance with manufacturer instructions and industry standards.

700.3(D) Written Record.

A written record shall be kept of such tests and maintenance.

ARTICLE 700 — 240

700.3(E) Testing Under Load.

Means for testing all emergency lighting and power systems during maximum anticipated load conditions shall be provided.

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ARTICLE 700

700.3(F) Temporary Source of Power for Maintenance or Repair of the Alternate Source of Power.

If the emergency system relies on a single alternate source of power, which will be disabled for maintenance or repair, the emergency system shall include permanent switching means to connect a portable or temporary alternate source of power that shall be available for the duration of the maintenance or repair. The permanent switching means to connect a portable or temporary alternate source of power shall comply with the following:

2

ARTICLE 700

(1) Connection to the portable or temporary alternate source of power shall not require modification of the permanent system wiring.

(2) Transfer of power between the normal power source and the emergency power source shall be accordance with 700.12. (Automatic transfer within 10 seconds)

(3) The connection point for the portable or temporary alternate source shall be marked with the phase rotation and system bonding requirements.

243

ARTICLE 700

(4) The switching means, including the interlocks, shall be listed and provided with mechanical or mechanical and electrical interlocking to prevent inadvertent interconnection of power sources.

(5) The switching means shall include a contact point that shall annunciate at a location remote from the generator or at another facility monitoring system to indicate that the permanent emergency source is disconnected from the emergency system.

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ARTICLE 700

(6) The permanent connection point for the temporary generator shall be located outdoors an shall not have cables from the connection point to the temporary generator routed through exterior windows, doors, or similar openings.

(7) A permanent label shall be field applied at the permanent connection point to identify the system voltage, maximum amperage, short-circuit current rating of the load side of equipment supplied, and ungrounded conductor identification in accordance with 210.5.

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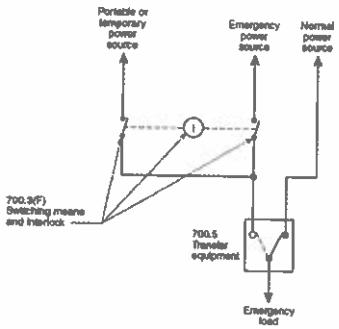
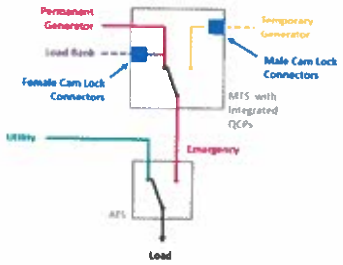
ARTICLE 700



Informational Note Figure 700.3(F)

24

ARTICLE 700



It shall be permissible to use manual switching to switch from the permanent source of power to the portable or temporary alternate source of power and to use the switching means for connection of a load bank.

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End of NEC Class

Thank-you

Tim Pool

File Attachments for Item:

ER-7 Voltage Drop (2023 NEC) (Independent Electrical Contractors of Greater Cincinnati)

All certifications (4 hours)

Staff Notes: Number of slides is small for a four-hour course because of the math.

ESIAC Recommendation:

Committee Recommendation:

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Kevin Collins

Organization: IEC of Greater Cincinnati

Address: 586 Kings Run Drive Cincinnati, OH 45232

E-mail: KCollins@iec-cincy.com Telephone: 513-542-0400

Website: iec-cincy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ *(i.e. BBS2018-429)*

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Voltage Drop

Course instructor: Sean Clark

Course description: We will calculate the voltages at a load based on conductor size, conductor material, distance from panel, ampacity of the load and the voltage system that it is fed from.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: TBD - IEC of Greater Cincinnati

Special Content:

Code Administration: [X]
Existing Buildings: [ ]
Electrical Instruction: [X]
Plumbing Instruction: [ ]

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? [ ] **On Demand** [ ] **Webinar** [ ]

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: [ ]
Administrative Course, All Certifications: [ ]

Commercial Certifications: [X]

Application materials included:

[ ] Course Outline or Course Learning Objectives
[X] Presentation Materials/Slides (not required for roundtable courses)
[ ] Assessment Materials (for online courses)
[ ] Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Voltage Drop

- Write down the formula

$$Vd = \frac{2\,K\,I\,L}{CMA}$$

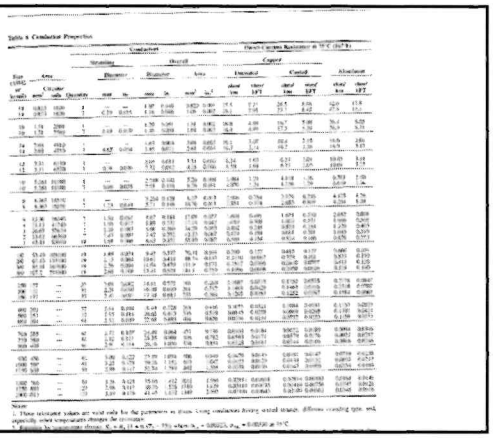
K= 12 for Cu*, 19 for Al*,
I = amperage,
L = length (one way)

Voltage Drop

$$L = \frac{CMA\,x\,Vd}{2\,K\,I}$$

$$CMA = \frac{2\,K\,I\,L}{Vd}$$

If 3 phase, replace "2" with "1.73" (square root of 3)



Voltage Drop

I have a 120 V circuit that pulls 4 amps. The conductors are #6 copper and the load is 300 feet away. What is my voltage drop?

Voltage Drop

I have a 120 V circuit that pulls 4 amps. The conductors are #6 copper and the load is 300 feet away. What is my voltage drop?

2 x 12 x 4 x 300 / 26,240 (Table 8)
= 28,800 / 26,240
= **1.09**
This circuit will lose 1.1 volts

Voltage Drop

I have a 120 V circuit that pulls 9 amps. The conductors are #8 Al and the load is 450 feet away. What is my voltage drop?

Voltage Drop

I have a 120 V circuit that pulls 9 amps. The conductors are #8 Al and the load is 450 feet away. What is my voltage drop?

2 x 19 x 9 x 450 / 16,510 =
= 153,900 / 16,510
= **9.32 volts**

Voltage Drop

- Feeders and branch circuits should be sized to maintain a maximum total voltage drop not to exceed 5% to the farthest outlet see **(215.2(A)(1)Informational note 2)**
  - 5% service to furthest point
  - 3% branch circuit panel to furthest point
- .03 x 120 = ***3.6*** is the max volts you can legally drop on a 120 V circuit
- .03 x 480 = 14.4 is the max volts you can legally drop on a 480 V circuit

Voltage Drop

I have a 120 V circuit that pulls 4 amps. The conductors are #6 copper and the load is 300 feet away. What is my voltage drop?

2 x 12 x 4 x 300 / 26,240 (Table 8)
= 28,800 / 26,240
= 1.09
This circuit will lose 1.1 volts
This would be a legal installation

Voltage Drop

I have a 120 V circuit that pulls 9 amps. The conductors are #8 Al and the load is 450 feet away. What is my voltage drop?

2 x 19 x 9 x 450 / 16,510 =
= 153,000 / 16,510
= 9.32 volts
Not allowed by code

Voltage Drop

- Question can be phrased differently:
- What is the maximum distance I can run #2 Cu on 120 V circuit that pulls 11 amps?

Voltage Drop

- What is the maximum distance I can run #2 Cu on 120 V circuit that pulls 11 amps?
- 120 x .03 = 3.6. This is the maximum volts that I can lose and still be legal.

$$L = \frac{66{,}360 \times 3.6}{2 \times 12 \times 11}$$

$$L = \frac{238{,}896}{264}$$

L = 904.9 feet

Voltage Drop

- What is the maximum distance I can run #10 Cu on 120 V circuit that pulls 8 amps?

Voltage Drop

- What is the maximum distance I can run #10 Cu on 120 V circuit that pulls 8 amps?

$$L = \frac{10{,}380 \times 3.6}{2 \times 12 \times 8}$$

$$L = \frac{37{,}368}{192}$$

$$L = 194.6$$

Voltage Drop

- What size copper conductors do you need for a 120 volt, 53 amp load that is 250 feet away? **K= 14**

Voltage Drop

- What size copper conductors do you need for a 120 volt, 53 amp load that is 250 feet away? K= 14

$$CMA = \frac{2 \times 14 \times 53 \times 250}{3.6}$$

$$CMA = \frac{371{,}000}{3.6}$$

$$CMA = 103{,}555 \ (1/0)$$

Voltage Drop

This course will go over the calculations to ensure that you do not exceed the 3% or 5% voltage drop per NEC 210.19 A for both single phase and three phase circuits.

Conductor type, length, voltage, conductor size and ampacity all are factors when deciding how to properly run circuits.

Sean Clark

901 Beechmeadow Ln. Cincinnati, Ohio 45238
(H)513/347-9054 (C)513/800-4450
sclark@ohiovalleyelectric.com

••••••••••••••••••••••••••••

A licensed electrician with over twenty years of experience in installing, maintaining, and repairing electrical wiring, equipment, and fixtures, ensuring that work is in accordance with relevant codes, fire alarm installations, electrical control systems, and high voltage terminations. A licensed electrician with three years teaching experience in first and second year electrical.

Summary of Qualifications

- More than twenty years experience.
- Three years experience in teaching first and second year electrical.
- Thorough knowledge of electrical systems including planning additions and modifications on secondary circuits. Controls and low voltage wiring
- Able to read commercial electrical blueprints and apply NEC through the full range of commercial and industrial maintenance and construction work.
- Can use appropriate tools and diagnostic equipment to repair, install, replace, and test electrical circuits, equipment and appliances.
- Excellent ability to diagnose and repair electrical controls, industrial motor control centers, and programmable logic controllers.
- Strong desire to study and comprehend new technology.
- In-depth ability to make mathematical computations.
- Considerable ability to explain instructions and guidelines to others effectively.
- Able to assign work to employees., prioritize the work of others and organize and coordinate the work of the unit. For subs and Primes.

Professional Experience

Ohio Valley Electrical Services 2011-Present

ABC Electrical Teacher 2010-2013

Beacon Electrical Contractors 2007-2011

Ohio Valley Electrical Services 1993-2007

Electrical Superintendant/Foreman/Instructor

- First and Second year electrical instructor
- Supervision of all electrical installations of as many as 50 electricians to assure that work was done safely, efficiently, properly and within time allowed.
- Trained multiple employees in all aspects of electrical work to be able to identify an employee's strengths and weaknesses to better utilize their skills. Traced out short circuits in wiring, using test meter.
- Coordinated and implemented electrical projects within a variety of environments including plants, hospitals, schools, retail stores, public facilities, waste water treatment plants industrial buildings;

projects include both new construction and underground electrical wiring as well as renovation within existing buildings. Parking Garages and Fed Ex Ground Facilities.

- Assemble, install, test, and maintain electrical or electronic wiring, equipment, appliances, apparatus, and fixtures, using hand tools and power tools.
- Connect wires to circuit breakers, transformers, or other components.
- Construct and fabricate parts, using hand tools and specifications.
- Diagnose malfunctioning systems, apparatus, and components, using test equipment and hand tools, to locate the cause of a breakdown and correct the problem.
- Inspect electrical systems, equipment, and components to identify hazards, defects, and the need for adjustment or repair, and to ensure compliance with codes.
- Plan layout and installation of electrical wiring, equipment and fixtures, based on job specifications and local codes.
- Test electrical systems and continuity of circuits in electrical wiring, equipment, and fixtures, using testing devices such as ohmmeters, voltmeters, and oscilloscopes, to ensure compatibility and safety of system.
- Perform business management duties such as maintaining records and files, preparing reports and ordering supplies and equipment.

Education & Certifications

Master Electrician License-State of Kentucky

Journeyman Electrician's License-Hamilton, Ohio

Fire Alarm License-State of Ohio

Certified in high voltage terminations and splices

Lift, Lull, Bobcat, and Boom/scissors lift licenses

OSHA-30 card

Certified in first aid and CPR training

Certified NCCER Core Curricula Instructor

Certified NCCER Electrical Instructor

Completed 4 year apprenticeship program

1 Year Pre-apprentice school (ABC)

High School Diploma (1991)

ARCH FLASH SAFETY TRAINING

PROJECTS-SUPERVISED

$4.5mil.-MASON HIGH SCHOOL ADDITION

$250.000-3CDC-5TH RACE PARKING GARAGE

$250.000-AVONEDALE APT. COMPLEX

$100.000-MAHOGANYS AT THE BANK-

1.2mil. -PATHEON CHEMICALS

$450.000- FED EX GROUND ADDITION

$250.000-LIBERTY WAY PROJECT

$500.000-GE AT THE BANKS

$100.000 - SYCAMORE SCHOOLS/POWER/CONTROL-

$50.000 - NKU RETROFIT

$250.000- UC POWER PLANT ADDITION

$75.000 - 580BLD/ CHEMED, RETROFIT

$4.0mil - DHL- CONVEYERS/SHELL

$90.000- DOUBLE TREE AIRPORT

$2.5mil- TWIN LAKES OF MONTGOMERY

$45.000- STEINMART ANDERSON

And many small T&M jobs.

All on time and under budget