Board of Building Standards

ELECTRICAL SAFETY INSPECTOR ADVISORY COMMITTEE
REQUEST FOR RECOMMENDATIONS

DATE: AUGUST 19, 2022
TIME: 10:00 AM
LOCATION: NO MEETING THIS MONTH

Personnel Certification Applications

P-1 Furry, Mark ESI
Certification ID# 8882
Current certifications- none, holds Electrical Contractor License

P-2 Hare, Bruce ESI
Certification ID# 8891
Current certification- none, holds Electrical Contractor license.

P-3 Heard, Michael BI, ESI
Certification ID# 8901
Current certifications- none, OCILB Electrical Contractor.
Staff notes-Recommend approval for ESI, have requested additional information on BI to separate commercial structural projects 8/11/22
Committee recommendations-

P-4 McClary, Jerry ESI
Certification ID# 8888
Current certifications- None

P-5 Sanders, Cecil ESI
Certification ID# 8880
Current certifications- none

P-6 Scott, Jeremy BI, ESI
Certification ID# 8900
Current certifications- none

P-7 Wakefield, Alex ESI
Certifications ID# 8905
Current certifications- None, Journeyman IBEW 25 years

P-8 Wilson, Aaron ESI, RBI
Certification ID# 8904
Current certifications- none

P-9 Young, Trenden - ESI
Cert ID: 8879
Current Certifications: None
Staff Notes: Received in June after ESIAC meeting: please review electrical experience.
ESIAC Recommendations:
Committee Recommendation:

Continuing Education Applications for Review

ER-1 2020 NEC Calculations Webinar Part 1 (Matthews Electrical Services)
BO, MPE, EPE, MechPE, ESI, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)
Staff Notes: Recommend addition of NRIUI, recommend approval.
ESIAC Recommendation:
Committee Recommendation:

ER-2 2020 NEC Calculations Webinar Part 2 (Matthews Electrical Services)
BO, MPE, EPE, MechPE, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)
Staff Notes: Add NRIUI, recommend approval.
ESIAC Recommendation:
Committee Recommendation:

ER-3 2020 NEC Hazardous Locations Webinar (Matthews Electrical Services)
BI, MPE, EPE, MechPE, ESI, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)
Staff Notes: Add NRIUI, recommend approval.
ESIAC Recommendation:
Committee Recommendation:

ER-4 2020 NEC Overview Webinar (Matthews Electrical Services)
BO, MPE, EPE, MechPE, ESI, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)
Staff Notes: Add NRIUI, recommend approval.
ESIAC Recommendation:
Committee Recommendation:

ER-5 2020 NEC Review (International Association of Electrical Inspectors)
All certifications except plumbing and IU (30 hours in four 7.5-hour sessions)
Staff Notes: Add NRIUI, RIUI, recommend approval.
ESIAC Recommendation:
Committee Recommendation:

ER-6 Electrical Safety Webinar Based on 2020 NEC and NFPA 70E (Matthews Electrical Services)
BO, MPE, EPE, MechPE, ESI, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)
Staff Notes: Add NRIUI, recommend approval.
ESIAC Recommendation:
Committee Recommendation:

File Attachments for Item:

P-1 Furry, Mark ESI

Certification ID# 8882

Current certifications- none, holds Electrical Contractor License

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

FURRY	MARK	
Last Name	*First Name*	*BBS Certification ID*

SECTION 1: CHECK INTERIM CERTIFICATION(S) BEING REQUESTED

☐ Building Official	☐ 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

* OHIO ELECTRICAL CONTRACTORS LICENSE EL # 46333 3/15/11

FURRY	MARK	
Last Name	*First Name*	*BBS Certification ID*

SECTION 3: EMPLOYMENT/EDUCATION

Formal Education	Date Graduated
BUCYRUS HIGH SCHOOL	5/1982
900 PERRY STREET, BUCYRUS, OH 44820	
Related Vocational or Technical Training	Years' Experience
PIONEER CAREER + TECH CENTER	1½ YR.
27 RYAN RD., SHELBY, OHIO 44875	
U.S. Military construction experience (MOS or other designation):	Years' Experience
N/A	
Place of Employment:	Years' Employed
ONE-WAY ELECTRIC LLC. (MY BUSINESS)	6/17 - PRESENT
466 SHERWOOD DR EAST, NEWARK OH 43055	

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)

FORRY	MARK	
Last Name	*First Name*	*BBS Certification ID*

SECTION 6: ELECTRICAL SAFETY INSPECTOR (ESI) - SPECIFIC EXPERIENCE QUALIFICATIONS
Applicants for Electrical Safety Inspector <u>Only</u> 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)*
78 NAUTICAL WAY, BUCKEYE LAKE, OHIO (NEW BUILD SINGLE FAMILY DWELLING) DESIGNED ELECTRICAL LAYOUT INSTALLED OUTSIDE RISER, PULLED ALL CIRCUITS REQUIRED PER LAYOUT, METER BOX AND ELECTRICAL BOX. INSTALLED GFCI AND ARC FAULT BREAKERS PER CODE REQUIREMENTS PERFORMED CALCULATIONS ON LOADS FOR PROPER BALANCE. PERFORMED CALCULATIONS ON BOX FILL CODE REQ. INSTALLED TAMPER-PROOF REQUIRED RECEPTICLES AND GFCI THROUGHOUT HOME PER CODE. LIGHTING INSTALLED (DID ENTIRE PROJECT FROM ROUGH TO FINISH BY MYSELF)	ONE-WAY ELECTRIC LLC (SELF EMPLOYED) 466 SHERWOOD DRIVE E NEWARK, OH 43055 CUSTOMER CONTACT: LISA + KEVIN BOHAN (614) 203-8799	MARCH 2022 - JULY 2022 (4 MONTHS)
Total Experience on This Page (In Months):		

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

FURRY	MARK	
Last Name	*First Name*	*BBS Certification ID*

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
72, 72½, 74, 74½ N. OHIO AVE COLUMBUS, OH (SINGLE-FAMILY DWELLINGS) LAID OUT ELECTRIC DESIGN FOR ALL 4 TOWNHOUSES, BUILT 4 GANG SERVICE, PANEL INSTALLATION FOR ALL 4 UNITS, PERFORMED ALL CALCULATIONS FOR LOADS, DID REQUIRED BONDING & GROUNDING PER NEC CODE. INSTALLED ALL REQ. BOXES FOR THE PROPER TERMINATION OF WIRING. POWERED AND LANDED WIRING FOR HVAC UNITS. COMPLETED PROJECT FROM ROUGH TO FINISH.	THE PHOENIX GROUP 3387 SNOUFFER RD, COLUMBUS CONTACT: FRED VERYSER PHONE: (614) 588-5241	5/17 - DECEMBER 2020 (43 MONTH)
FED-EX DISTRIBUTION CENTER 4600 POTH RD, COLUMBUS, OH PULLED WIRE, RAN AND BENT CONDUIT, USED SNORKEL LIFT SET JUNCTION BOXES FOR WIRE TERMINATION, INSTALLED LARGE INDUSTRIAL FANS, INSTALLED AND WIRED VARIABLE FREQUENCY DRIVES (VFD)	CUSTOM AIR HEATING & COOLING 935 CLAYCRAFT RD, COLUMBUS PHONE	JULY 2015 - SEPT 2015 (3 MONTHS)
BOB EVANS RESTAURANTS STATES: OHIO, INDIANA, VIRGINIA, DELAWARE, MARYLAND, NEW YORK, PENNSYLVANIA, MISSOURI MICHIGAN INSTALLED ELECTRIC FOR NEW HVAC ROOFTOP UNITS, SET NEW DISCONNECTS FOR EACH UNIT, TERMINATED WIRING TO RUN EACH UNIT, INSTALLED CONTACTORS, RE-WORKED CONDUIT.	GRIGGS ELECTRIC, 7535 PICKERINGTON RD. CANAL WINCH. G&F ELECTRIC (OWNED COMPANY) 6567 BROCK ST., DUBLIN, OH.	JUNE 2004 - SEPT. 2016 (144 MONTHS)
LUXURY POOLS AND LIVING SWIMMING POOL AND SPA INSTALL VARIOUS LOCATIONS IN OHIO INSTALLED DEDICATED ELECTRIC POOL PANELS, LAID PVC CONDUIT, PULLED THHN WIRE, RAN PANELS OFF OF MAIN HOUSE PANELS, RAN CALCULATIONS TO SUPPORT POOL PANEL, GROUNDING AND EQUIPO BONDING.	LUXURY POOLS AND LIVING 1605 SHAWNEE AVE., COLUMBUS	SEPT ~~2014~~ 2012 - MAY 2014 (20 MONTHS)
	Total Experience on This Page (In Months):	

* I DO HOLD AN OHIO ELECTRICAL LICENSE (EL#46333) SINCE 2011 (SEE ATTACHED COPY)
* I HAVE BEEN DOING ELECTRIC IN THE FIELD SINCE 2003. I STARTED AS AN APPRENTICE AND NOW I AM AN ELECTRICAL CONTRACTOR. I HAVE SPENT 19 YEARS (228 MONTHS) DOING ELECTRIC IN ALL RESIDENTAL AND COMMERCIAL SETTINGS. I HAVE DONE TO MANY CONSTRUCTION JOBS TO LIST.

FURRY	MARK	
Last Name	*First Name*	*BBS Certification ID*

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:

N/A

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: Mark A. Furry

Subscribed and duly sworn before me according to law, by the above named applicant this day 27 of June in the year 2022 at Licking, County of Ohio and State of Ohio.

Notary Public:

NOTARY PUBLIC STATE OF OHIO

DANIELLE GRAVES
Notary Public
State of Ohio
My Comm. Expires
May 20, 2025

Department of Commerce

Division of Industrial Compliance
Ohio Constructions Industry
Licensing Board O.C.I.L.B.

Mike DeWine
Sheryl Maxfield

MARK A FURRY
[redacted]

Mike DeWine
Governor

Sheryl Maxfield
Director

Electrical
CONTRACTOR'S LICENSE

Ohio License # 46333 Expiration Date: 03/15/2023

MARK A FURRY
ONE WAY ELECTRIC LLC
OWNER

Carol A. Ross
Board Secretary

William Koester
Administrative Chairperson

This is YOUR license. Plan Approvals obtained with YOUR license and posting of YOUR license indicates that YOU and YOUR liability insurance are assuming all responsibility for any projects performed under this license.

Mike DeWine
Governor

Sheryl Maxfield
Director

LICENSE MUST BE POSTED ON JOB SITE

OHIO CONSTRUCTION INDUSTRY LICENSING BOARD

Electrical

CONTRACTOR'S LICENSE

MARK A FURRY

ONE WAY ELECTRIC LLC

OWNER

Ohio License# **46333**

Expiration Date: **March 15, 2023**

STATE OF OHIO

LICENSE MUST BE POSTED ON JOB SITE

Carol A. Ross
Board Secretary

William Koester
Administrative Chairperson

DIC 3530 Rev 3/2020

File Attachments for Item:

P-2 Hare, Bruce ESI

Certification ID# 8891

Current certification- none, holds Electrical Contractor license.

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

Hare	Bruce	
Last Name	*First Name*	*BBS Certification ID*

SECTION 1: CHECK INTERIM CERTIFICATION(S) BEING REQUESTED

☐ Res. Building Official	☐ Res. Plans Examiner	☐ Res. Building Inspector
X Res ESI	☐ Res. Industrial Unit Inspector	☐ Res. Mechanical 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

Section 3: Employment/Education

a. Formal Education	Date Graduated
Muskingum Univesity	1978
Ohio University- MFA	1980
b. Related Vocational or Technical Training	**Years' Experience**
c. U.S. Military construction experience (MOS or other designation):	**Years' Experience**
d. Place of Employment:	**Years' Employed**
Hare Electric, Inc.	30

Hare	Bruce	
Last Name	*First Name*	*BBS Certification ID*

SECTION 5 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)
State of Ohio Electrician License #19775 Worked as an electrician, owner and supervisor of employees from Jan 1, 1996 until present.	Hare Electric, Inc-4180 Wooster Road, Rocky River, Ohio 44116- P# 440-570-0950	312 Months
	Total Experience on This Page (In Months):	312

Hare	Bruce	
Last Name	*First Name*	*BBS Certification ID*

SECTION 5 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)
	Total Experience on This Page (In Months):	

Hare	Bruce	
Last Name	*First Name*	*BBS Certification ID*

SECTION 6: PERSONAL HISTORY

1. Have you ever been convicted of any felony, or any crime involving moral turpitude? ☐ Yes ☒ No
2. If you answered "Yes" please explain below:
3. Have you served in the U.S. armed services? (If No, skip question 3) ☐ Yes ☒ No
4. If YES, were you discharged under honorable conditions? ☐ Yes ☐ No
   If you answered "No" please explain below:

SECTION 7: 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: B Hare

Subscribed and duly sworn before me according to law, by the above named applicant this day 22 of July in the year 2022 at Rocky River, County of Cuyahoga and State of Ohio.

Notary Public: Annabel M. Lopez

NOTARY PUBLIC STATE OF OHIO

ANNABEL M LOPEZ
Notary Public, State of Ohio
My Comm. Expires 02/01/2025

Department of Commerce

Division of Industrial Compliance
Ohio Constructions Industry
Licensing Board O.C.I.L.B

Mike DeWine
Sheryl Maxfield

HARE, BRUCE
[redacted]

Mike DeWine
Governor

Sheryl Maxfield
Director

Electrical
CONTRACTOR'S LICENSE

Ohio License # 19775 Expiration Date: 03/31/2025

BRUCE HARE
HARE ELECTRIC INC
OWNER

Carol A. Ross
Board Secretary

William Koester
Administrative Chairperson

This is YOUR license. Plan Approvals obtained with YOUR license and posting of YOUR license indicates that YOU and YOUR liability insurance are assuming all responsibility for any projects performed under this license.

Mike DeWine
Governor

Sheryl Maxfield
Director

LICENSE MUST BE POSTED ON JOB SITE

Electrical

CONTRACTOR'S LICENSE

BRUCE HARE

HARE ELECTRIC INC

OWNER

Ohio License# **19775**

Expiration Date: **March 31, 2025**

LICENSE MUST BE POSTED ON JOB SITE

Carol A. Ross
Board Secretary

William Koester
Administrative Chairperson

DIC 3530 Rev 3/2020

File Attachments for Item:

P-3 Heard, Michael BI, ESI

Certification ID# 8901

Current certifications- none, OCILB Electrical Contractor.

Staff notes-Recommend approval for ESI, have requested additional information on BI to separate commercial structural projects 8/11/22

Committee recommendations-

Heard	Michael	
Last Name	First Name	BBS Certification ID

Section 1: Check Interim Certification(s) Being Requested

☐ Building Official	☐ 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

Heard	Michael	
Last Name	First Name	BBS Certification ID

Section 3: Employment/Education

Formal Education	Date Graduated
Code classes 2022 Certificate Enclosed Once a year	01/2022
Related Vocational or Technical Training	**Years' Experience**
Wenonha High Vocational Tech	3yrs
U.S. Military construction experience (MOS or other designation):	**Years' Experience**
US Army	3yrs
Place of Employment:	**Years' Employed**
Heard Electric LLC	26yrs

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)

Heard	Michael	
Last Name	First Name	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: 22700
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)*
Total Experience on This Page (In Months):		

Heard — Last Name

Michael — First Name

BBS Certification ID

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
Family Dollar Stores	Mr. Jack Zakue	1999-2005
Canton Negro Oldtimers	Canton Negro Oldtimers Board	2002-2003
Stark Metropolitan Housing Authority. Various Housing Projects	Gwendolyn Torrence Retired	1999-Now
City of Canton, OH Housing & Urban Development Projects Residential Commercial Industrial	Canton City Building Dept.	2000- Now/ Present Time
Total Experience on This Page (In Months):		

Heard	Michael	
Last Name	*First Name*	*BBS Certification ID*

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: Michael Heard

Subscribed and duly sworn before me according to law, by the above named applicant this day 7th of July in the year 2022 at CSE FCU, County of Stark and State of Ohio.

Notary Public: Sadie D L.

SADIE D. LEWIS - NOTARY PUBLIC STATE OF OHIO - EXPIRES FEBRUARY 7, 2027

Licensing Board O.C.I.L.B.

HEARD, MICHAEL W

[redacted]

Mike DeWine
Governor

Sheryl Maxfield
Director

Electrical
CONTRACTOR'S LICENSE

Ohio License # 22700 Expiration Date: 03/31/2025

MICHAEL W HEARD
HEARD ELECTRIC LLC
OWNER

Carol A. Ross
Board Secretary

William Koester
Administrative Chairperson

This is YOUR license. Plan Approvals obtained with YOUR license and posting of YOUR license indicates that YOU and YOUR liability insurance are assuming all responsibility for any projects performed under this license.

Mike DeWine
Governor

Sheryl Maxfield
Director

LICENSE MUST BE POSTED ON JOB SITE

OHIO CONSTRUCTION INDUSTRY LICENSING BOARD

Electrical

CONTRACTOR'S LICENSE

MICHAEL W HEARD

HEARD ELECTRIC LLC

OWNER

Ohio License# **22700**

Expiration Date: **March 31, 2025**

STATE OF OHIO

LICENSE MUST BE POSTED ON JOB SITE

Carol A. Ross
Board Secretary

William Koester
Administrative Chairperson

DIC 3530 Rev 3/2020

Ohio | Bureau of Workers' Compensation

30 W. Spring St.
Columbus, OH 43215

Certificate of Ohio Workers' Compensation

This certifies that the employer listed below participates in the Ohio State Insurance Fund as required by law. Therefore, the employer is entitled to the rights and benefits of the fund for the period specified. This certificate is only valid if premiums and assessments, including installments, are paid by the applicable due date. To verify coverage, visit www.bwc.ohio.gov, or call 1-800-644-6292.

This certificate must be conspicuously posted.

Policy number and employer
01297719

HEARD ELECTRIC LLC
[redacted]

Period Specified Below
07/01/2022 to 07/01/2023

www.bwc.ohio.gov
Issued by: BWC

Stephanie McCloud

Administrator/CEO

You can reproduce this certificate as needed.

Ohio Bureau of Workers' Compensation

Required Posting

Section 4123.54 of the Ohio Revised Code requires notice of rebuttable presumption. Rebuttable presumption means an employee may dispute or prove untrue the presumption (or belief) that alcohol, marihuana or a controlled substance not prescribed by the employee's physician is the proximate cause (main reason) of the work-related injury.

The burden of proof is on the employee to prove the presence of alcohol, marihuana or a controlled substance was not the proximate cause of the work-related injury. An employee who tests positive or refuses to submit to chemical testing may be disqualified for compensation and benefits under the Workers' Compensation Act.

Ohio | Bureau of Workers' Compensation

You must post this language with the Certificate of Ohio Workers' Compensation.

ACORD®

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY): 06/01/2022

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER 330-492-2300 Stark Insurance Agency 4125 Martindale Rd NE Canton, OH 44705	CONTACT NAME: PHONE (A/C, No, Ext): 330-492-2300 FAX (A/C, No): E-MAIL ADDRESS:
	INSURER(S) AFFORDING COVERAGE / NAIC # INSURER A: Wayne Mutual INSURER B: INSURER C: INSURER D: INSURER E: INSURER F:
INSURED Heard Electric LLC [redacted]	

COVERAGES CERTIFICATE NUMBER: REVISION NUMBER:

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSR	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
	GENERAL LIABILITY ✔ COMMERCIAL GENERAL LIABILITY ☐ CLAIMS-MADE ☐ OCCUR GEN'L AGGREGATE LIMIT APPLIES PER: ☐ POLICY ☐ PRO-JECT ☐ LOC			ACP0304004	11/30/2021	11/30/2022	EACH OCCURRENCE	$1,000,000
							DAMAGE TO RENTED PREMISES (Ea occurrence)	$
							MED EXP (Any one person)	$5,000
							PERSONAL & ADV INJURY	$1,000,000
							GENERAL AGGREGATE	$2,000,000
							PRODUCTS - COMP/OP AGG	$2,000,000
								$
	AUTOMOBILE LIABILITY ☐ ANY AUTO ☐ ALL OWNED AUTOS ☐ SCHEDULED AUTOS ☐ HIRED AUTOS ☐ NON-OWNED AUTOS						COMBINED SINGLE LIMIT (Ea accident)	$
							BODILY INJURY (Per person)	$
							BODILY INJURY (Per accident)	$
							PROPERTY DAMAGE (Per accident)	$
								$
	☐ UMBRELLA LIAB ☐ OCCUR ☐ EXCESS LIAB ☐ CLAIMS-MADE ☐ DED ☐ RETENTION $						EACH OCCURRENCE	$
							AGGREGATE	$
								$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y/N ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? ☐ (Mandatory in NH) If yes, describe under DESCRIPTION OF OPERATIONS below	N/A					WC STATU-TORY LIMITS / OTH-ER	
							E.L. EACH ACCIDENT	$
							E.L. DISEASE - EA EMPLOYEE	$
							E.L. DISEASE - POLICY LIMIT	$

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (Attach ACORD 101, Additional Remarks Schedule, if more space is required)

CERTIFICATE HOLDER	CANCELLATION
City of Canton	SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS. AUTHORIZED REPRESENTATIVE Keith A. Miller

STARK COUNTY BUILDING DEPARTMENT
7235 Whipple Ave NW Suite A
NORTH CANTON, OH 44720

Ohio Board of Building Standards
6606 Tussing Rd
Reynoldsburg, Ohio 43068

RE: Michael Heard
Building and Electrical inspector application

Dear Sirs and Madams;

It is my pleasure to recommend Michael Heard applicate for Building and Electrical inspector certification process. As a registered electrical contractor (in Stark County) and building contractor our inspectors and myself have great confidence in his abilities. You may contact me at any time for any questions or concerns.

Respectfully submitted,

Angela Cavanaugh

Angela Cavanaugh, RA, Master Plans Examiner;
Chief Building Official Stark County

Phone # 330-451-1793 ajcavanaugh@starkcountyohio.gov www.ta191.com

June 06, 2022

Ohio Board of Building Standards
6606 Tussing Road
Reynoldsburg, Ohio 43068-9009

Re: Michael W. Heard
[redacted]

To: Electrical Safety Inspector Advisory Committee

Michael Heard has been a State of Ohio, Licensed Electrical Contractor; (OCILB) for over twenty years. I have inspected his electrical installations for numerous years and found them to in compliance with the National Electrical Code. He has a good working knowledge and understanding of the NEC requirements. I believe he would be an asset to the industry as an Electrical Safety Inspector. I recommend he should be approved to sit for the Electrical Safety Inspector exam, in Ohio.

Sincerely,

John M Labriola

John M. Labriola, Principal
Training Agency #191
BBS Personnel ID# 815

6/24/2022

To whom it may concern,

I've known Michael Heard for 15 plus years from our respective professions. He has been a consummate professional in all my dealings with him. He brings an amiable personality and great knowledge to his peers and customers alike. I would strongly recommend him to anyone that may need his services done.

Rick Hoffman (234) 207-6598

www.ta191.com

Certificate of Completion
O.C.I.L.B. Approved Course

awarded to:

Michael W. Heard

Ohio License # EL.22700

2020 “Proposed” National Electrical Code Changes & Updates

Date: Saturday; February 26, 2022
Course #1910054
8 Hours

John M. Labriola
John M. Labriola (Instructor)
Training Agency #191

File Attachments for Item:

P-4 McClary, Jerry ESI

Certification ID# 8888

Current certifications- None

McClary — *Last Name*

Jerry — *First Name*

BBS Certification ID

SECTION 1: CHECK INTERIM CERTIFICATION(S) BEING REQUESTED

☐ Building Official	☐ 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

McClary	Jerry	
Last Name	First Name	BBS Certification ID

SECTION 3: EMPLOYMENT/EDUCATION

Formal Education	Date Graduated
JONATHAN ALDER HIGH SCHOOL	JUNE 1 - 1986
MADISON COUNTY OHIO	
Related Vocational or Technical Training	Years' Experience
U.S. Military construction experience (MOS or other designation):	Years' Experience
Place of Employment:	Years' Employed
CASTLE ROCK CUSTOM ELECTRIC	20 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)

McClary	Jerry	
Last Name	*First Name*	*BBS Certification ID*

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

Applicants for Electrical Safety Inspector <u>Only</u> 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 <u>AND</u> 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)*
Total Experience on This Page (In Months):		

McClary | Jerry |
Last Name | First Name | BBS Certification ID

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
STARTED APPRENTICESHIP, WIRED NEW HOMES FOR DUFFY, AND PRIVATE OWNERS. SERVICE CHANGES AND REMODELS	HAWKINS ELECTRIC LILLY CHAPEL OHIO JIM HAWKINS - OWNER COMPANY DESOLVED	SEPTEMBER 16 1986 MAY 17 1988
WIRED NEW HOMES FOR ROCKFORD AND M I HOMES ALONG WITH VARIOUS OTHER BUILDERS. GOT INTO CUSTOM HOMES WIRING. WIRED AND SET SERVICES ON NUMEROUS APPARTMENT PROJECTS. WAS PART IN WIRING OF TWO CROSS COUNTRY INN MOTELS - AIRPORT AND OLENTANGY RIVER ROAD. ALSO REMODEL OF CONCOURSE HOTEL AT THE AIRPORT.	CENTRAL OHIO ELECTRIC HILLIARD OHIO 4620 WEAVER COURT NORTH BUFORD (BUMP) STOUT JAMES RUOFF MIKE ETLING COMPANY DESOLVED	MAY 18 1988 APRIL 19, 1999
SUPERVISOR FOR CREWS PLAN TAKEOFFS QUOTING OF JOBS OCCASIONAL WIRING OF HOUSES OR VARIOUS PROJECTS	MARTIN CUSTOM ELECTRIC MIKE MARTIN COMPANY DESOLVED	APRIL 20, 1999 MAY 2 - 2022
OWNER OF COMPANY. WIRING OF TRACK AND CUSTOM HOMES FOR VARIOUS BUILDERS. SCHUMACHER, JUSTUS CREATIONS MCKORMICK, MABRY CONST. SMUCKER CONST. LARRY JOHNSON BUILDERS WING BUILDERS, UNIBUILT, T.K. CONSTRUCTORS, ECT... SERVICE CHANGES, GENERATORS, AG POLE BARNS, CONDUCTED DAY TO DAY OPERATIONS OF BUSINESS, BIDS BILLING, SCHEDULING OF PROJECTS	CASTLE ROCK CUSTOM ELECTRIC JERRY MCCLARY 25096 STORMS ROAD WEST MANSFIELD OHIO 43358 937-302-0732	MAY 22 - 2002 PRESENT
	Total Experience on This Page (In Months):	427 MONTHS

35 YEARS 8 MONTHS

33

McClary — Last Name
Jerry — First Name
BBS Certification ID

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 30 of June in the year 2022 at Union County Building Department, County of Union and State of Ohio.

Notary Public: [signature]

NOTARIAL SEAL STATE OF OHIO

Lisa Damron
Notary Public, State of Ohio
My commission expires 12/28/2025

File Attachments for Item:

P-5 Sanders, Cecil ESI

Certification ID# 8880

Current certifications- none

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

Sanders	Cecil	
Last Name	*First Name*	*BBS Certification ID*

Section 1: Check Interim Certification(s) Being Requested

☐ Building Official	☐ 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

Sanders | Cecil |
Last Name | First Name | BBS Certification ID

SECTION 3: EMPLOYMENT/EDUCATION

Formal Education	Date Graduated
Valleyview HS + Miami Valley JVS	1987
Related Vocational or Technical Training	**Years' Experience**
Associated Builders + Construction Assoc.	6 yrs
4 yr apprenticeship / Misc. Code classes + cont. education	
U.S. Military construction experience (MOS or other designation):	**Years' Experience**
Place of Employment:	**Years' Employed**
Universal Electric	1998 - Present (24 yrs)
Evans Electric	1997-1998 1.5 yrs

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)

Sanders	Cecil	
Last Name	First Name	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)*
-Scene 75, Dayton -Remodel and Storm Repair of facility electrical Systems and game attractions, -Project Manager and install	Universal Electric 107 N. Main St Union, OH 45322 (937) 836-7252	June 2019- Jan. 2021 20 months
Total Experience on This Page (In Months):		20

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Sanders | Cecil |
Last Name | First Name | BBS Certification ID

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
Thaler Machine Co., Springboro, OH - wiring of new building including 2000 Amp electrical service, machine wiring, Buss Plug, lighting, + etc. - Design, Project Manager + install	Universal Electric 107 N. Main St. Union, OH 45322 937.836 7252	July 2020 - Feb 2021 (7 months)
Miami Valley Packaging 150 Janney Rd Dayton, OH - Remodel of existing bldg. Install new electrical service, wiring of office space and machine wiring - Project Manager + install	Universal Electric	Sept 2014 - Feb 2015 (6 mo)
Dark Star Marble + Granite Dayton, OH - Remodel of existing bldg. install new electrical service, wiring of office space + machine wiring - Project Manager + install	Universal Electric	Jan. 2019 - May 2019 (5 mo)
Little York Medical Dayton, OH - New electrical service, wire for patient rooms + offices - Project Manager and Install	Universal Electric	July 2005 - Jan 2006 (7 mo)
*	**Total Experience on This Page (In Months):**	25 mo

*Many more projects from 1989 - Present not listed available upon request.

Sanders	Cecil	
Last Name	First Name	BBS Certification ID

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: Cecil R. Sanders

Subscribed and duly sworn before me according to law, by the above named applicant this day 22nd of June in the year 2022 at Mont Englewood County of Mont and State of Ohio

Notary Public: Barbara Boyle

NOTARY PUBLIC STATE OF OHIO

BARBARA BOYLE
Notary Public
State of Ohio
Commission Exp. 09/29/2025

File Attachments for Item:

P-6 Scott, Jeremy BI, ESI

Certification ID# 8900

Current certifications- none

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

Scott	Jeremy	
Last Name	*First Name*	*BBS Certification ID*

SECTION 1: CHECK INTERIM CERTIFICATION(S) BEING REQUESTED

☐ Building Official	☐ 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

Scott	Jeremy	
Last Name	*First Name*	*BBS Certification ID*

SECTION 3: EMPLOYMENT/EDUCATION

Formal Education	Date Graduated
BA-American Military University	April 2022
Related Vocational or Technical Training	**Years' Experience**
U.S. Military construction experience (MOS or other designation):	**Years' Experience**
Camp Commandant/Team Engineer (MOS 18C/assistant)	05/'06/'09/'12/'13/'21
Unit Construction Supervisor (MOS 13XX)	2016-2020
Place of Employment:	**Years' Employed**
United States Marine Corps	20
North Ridgeville Building Department	3 Months

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)

Scott	Jeremy	
Last Name	*First Name*	*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)*
U.S. Government Secure Office Space on U.S. Military Base in Kuwait Commercial Construction Building and Electrical as Construction Supervisor and Journeyman Electrician equivalent	Special Purpose MAGTF 21.1 PO Box 555320 Camp Pendleton, CA 92055 1stLt Michael Crookshanks 770-354-9391 (SEE ADDITIONAL PAGES)	1/21-11/21 10 Months
Total Experience on This Page (In Months):		10

Scott	Jeremy	
Last Name	*First Name*	*BBS Certification ID*

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
U.S. Government Office Space on U.S. Military Base in Bahrain Commercial Construction Building and Electrical as Construction Supervisor and Journeyman Electrician equivalent	5th MEB TF 51/5 PCS 851 Box 320 FPO, AE 09834 Chief Warrent Officer-3 Ryan Butler 315-246-3223	06/16-12/17 18 Months
U.S. Government Secure Office Space and Meeting Room on U.S. Military Base in Herat, Afghanistan Commercial Construction Building and Electrical as Construction Supervisor and Journeyman Electrician equivalent	Marine Spectial Operations Command, 2nd MSOB Camp Lejuene, NC 28543 Chief Warrent Officer-3 Ahern Putnam 910-440-7017	11/12-4/13 6 Months
U.S. Government Secure Office Space and Meeting Room on U.S. Military Base in Helmand, Afghanistan Commercial Construction Building and Electrical as Construction Supervisor and Journeyman Electrician equivalent	2nd Battalion/8th Marines Secand Marine Regiment PSC Box 20103 Camp Lejuene, NC 28543 First Sergeant Jose Hernandez 910-451-5254	4/09-11/09 7 Months
U.S. Government Moral, Welfare, and Recreation Center on U.S. Military Base in Al Taqqadum, Iraq Commercial Construction Building and Electrical as Construction Supervisor and Journeyman Electrician equivalent	VMU-2 PSC Box 8077 Cherry Point, NC 28533 Sergeant Major Michael Grey 252-466-7560	2/06-11/06 9 Months
	Total Experience on This Page (In Months):	18

Scott	Jeremy	
Last Name	*First Name*	*BBS Certification ID*

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
U.S. Government Aviation Operations Center on U.S. Military Base in Al Taqqadum, Iraq Commercial Construction Building and Electrical as Construction Supervisor and Journeyman Electrician equivalent	VMU-2 PSC Box 8077 Cherry Point, NC 28533 Sergeant Major Michael Grey 252-466-7560	2/06-11/06 9 Months
U.S. Government Office Space on U.S. Military Base in Al Taqqadum, Iraq Commercial Construction Building and Electrical as Construction Supervisor and Journeyman Electrician equivalent	VMU-2 PSC Box 8077 Cherry Point, NC 28533 Sergeant Major Michael Grey 252-466-7560	2/05-11/05 9 Months
U.S. Government Hanger to Office Space Converstion on U.S. Military Base in Al Taqqadum, Iraq Commercial Construction Building and Electrical as Construction Supervisor and Journeyman Electrician equivalent	VMU-2 PSC Box 8077 Cherry Point, NC 28533 Sergeant Major Michael Grey 252-466-7560	2/05-11/05 9 Months
Uqbah Mosque Foundation 2222 Stokes Blvd Cleveland, Ohio 44106 Commercial Eletrical Journeyman Electrician equivalent	Scott Electricl Service 13300 Madison Ave Lakewood, Ohio 44107 Dave Graham 440-552-7571	12/00-9/02 21 Months
	Total Experience on This Page (In Months):	39

Scott	Jeremy	
Last Name	*First Name*	*BBS Certification ID*

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
Painesville High School Wrestling Gym 585 Painesville, Ohio 44077 Commercial Eletrical Journeyman Electrician equivalent	Scott Electricl Service 13300 Madison Ave Lakewood, Ohio 44107 Dave Graham 440-552-7571	4/01-9/02 17 Months
Apartment Building 8005 Detroit Ave Cleveland, Ohio 44102 Commercial Eletrical Journeyman Electrician equivalent	Scott Electricl Service 13300 Madison Ave Lakewood, Ohio 44107 Dave Graham 440-552-7571	6/99-8/01 26 Months
Apartment Building 1389 W. 64th Street Cleveland, Ohio 44102 Commercial Eletrical Journeyman Electrician equivalent	Scott Electricl Service 13300 Madison Ave Lakewood, Ohio 44107 Dave Graham 440-552-7571	1/98-11/00 34 Months
	Total Experience on This Page (In Months):	51

Scott	Jeremy	
Last Name	*First Name*	*BBS Certification ID*

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:

I am currently working with the City of North Ridgeville Building Department as part of the U.S. Govenment sponsored program Onward to Opportunity-Hiring Our Hero's Corporate Fellowship as part of my retirment transition program from active duty. I intend on accepting a position as a Building and Zonning Inspector once I complete this fellowship and will work within the North Ridgeville Building Department. Attached is a Statement of Service highlighting my approved retirement date.

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 4 of August in the year 2022 at North Ridgeville, County of Lorain and State of Ohio.

Notary Public: [signature]

NOTARIAL SEAL STATE OF OHIO

PATRICIA A. SIMON
NOTARY PUBLIC, STATE OF OHIO
My Commission Expires June 19, 2027

48

UNITED STATES MARINE CORPS
1ST INTELLIGENCE BATTALION
I MARINE EXPEDITIONARY FORCE INFORMATION GROUP
I MARINE EXPEDITIONARY FORCE
BOX 555327
CAMP PENDLETON, CA 92055-5327

IN REPLY REFER TO
1000
XO
8 Feb 22

From: Executive Officer, Counterintelligence/Human Intelligence Company, First Intelligence Battalion
To: Whom It May Concern

Subj: STATEMENT OF SERVICE/NOTICE OF ACCEPTANCE OF RETIREMENT AND ESTIMATED RETIREMENT PENSION PAY IN THE CASE OF MASTER SERGEANT JEREMY M. SCOTT [redacted] USMC

1. This is to certify that Master Sergeant Scott is an Active Duty United States Marine assigned to this command on Camp Pendleton, California. Master Sergeant Scott has been accepted for retirement from active duty.

2. Master Sergeant Scott is retiring after 20 years, one month and 19 days. Master Sergeant Scott's retirement pay is estimated to be [redacted] beginning in January 2023. Master Sergeant Scott is pending determination of disability rating from the Veterans Affairs.

3. Certified below is additional service related information pertaining to Master Sergeant Scott:

a. Military Status: Active

b. Citizenship: US

c. Date of Initial Entry: 11 November 2002

d. Date of Current Enlistment: 12 December 2019

e. Date Current Tour Began: 1 April 2020

f. Expiration of Active Service/Retirement: 31 December 2022

4. The point of contact is First Lieutenant Michael Crookshanks at Michael.crookshanks@usmc.mil or Comm: (760) 725-7226.

M. P. CROOKSHANKS

File Attachments for Item:

P-7 Wakefield, Alex ESI

Certifications ID# 8905

Current certifications- None, Journeyman IBEW 25 years

Wakefield	Alex	
Last Name	*First Name*	*BBS Certification ID*

SECTION 1: CHECK INTERIM CERTIFICATION(S) BEING REQUESTED

☐ Building Official	☐ 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

Wakefield	Alex	
Last Name	*First Name*	*BBS Certification ID*

Section 3: Employment/Education

Formal Education	Date Graduated
Glen Este High School	1978
Related Vocational or Technical Training	Years' Experience
IBEW Electrical 4 year Apprenticeship	25 Years
Warren County Career Center HVAC	11 Years
U.S. Military construction experience (MOS or other designation):	Years' Experience
US Navy Electricians Mate	4
Place of Employment:	Years' Employed
Kings Local School District	11 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)

Wakefield	Alex	
Last Name	*First Name*	*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* SEE ATTACHED	*Homer Steel and Trade* *125 Anytown Street* *My City, OH, 45454* *(419)555-1212* A member of IBEW local 212	*July 2013-May 2014* *(10 months)*
Total Experience on This Page (In Months):		300 months

Wakefield	Alex	
Last Name	*First Name*	*BBS Certification ID*

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
	Total Experience on This Page (In Months):	

Wakefield	Alex	
Last Name	*First Name*	*BBS Certification ID*

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: Alex Wakefield

Subscribed and duly sworn before me according to law, by the above named applicant this day 29 of July in the year 2022 at Kings Mills, OH, County of Warren and State of Ohio.

Notary Public: Lori Kesner

NOTARIAL SEAL STATE OF OHIO

LORI KESNER
NOTARY PUBLIC
STATE OF OHIO
Comm. Expires
04-11-2026

Work History Report for:

WAKEFIELD, ALEX J [redacted]

A MEMBER OF IBEW LOCAL 212

FOR WORK IN THE JURISDICTION OF IBEW LOCAL #212

START DATE	TERM. DATE	EMPLOYER	TERM. REASON	DISPATCH CLASS
07/31/1985	02/28/1986	ARCHIABLE ELECTRIC	REDUCTION IN	
05/21/1986		SCHERRER ELECTRIC	REDUCTION IN	
04/13/1989	05/23/1989	RIVERSIDE ELECTRIC	REDUCTION IN	
05/25/1989	12/07/1990	L.K. COMSTOCK	REDUCTION IN	
05/28/1991	06/13/1991	GLENWOOD ELECTRIC	REDUCTION IN	
06/24/1991	07/02/1991	DIAZ	REDUCTION IN	
07/08/1991	07/26/1991	E.S.I. INC.	REDUCTION IN	
08/05/1991	08/22/1991	KATHMAN ELECTRIC	REDUCTION IN	
08/26/1991	09/13/1991	A& Z ELECTRIC	REDUCTION IN	
10/07/1991	10/10/1991	LEGGE	REDUCTION IN	
10/10/1991	10/31/1991	NITRO	REDUCTION IN	
11/04/1991	11/04/1991	ELEX INC.	REQUEST	
11/13/1991	12/04/1991	BANTA ELECTRIC	REDUCTION IN	
12/16/1991		KATHMAN ELECTRIC	TURNED AROUND	
12/17/1991	01/03/1992	SNEED	REDUCTION IN	
01/20/1992		EMI (MIRG GROUP)	ILLNESS	
01/22/1992	02/06/1992	W.W. CLARK	REDUCTION IN	
02/07/1992	02/07/1992	LUCE ELECTRIC	REDUCTION IN	
02/10/1992	02/27/1992	EMI (MIRG GROUP)	REDUCTION IN	
03/02/1992	03/20/1992	QUALITY ELECTRIC	REDUCTION IN	
03/24/1992	03/26/1992	W.W. CLARK	REDUCTION IN	
03/30/1992	04/17/1992	DEARBORN	REDUCTION IN	
04/27/1992	05/08/1992	MAYERS ELECTRIC	REDUCTION IN	
04/27/1992		ARCHIABLE ELECTRIC	REFUSED CALL	
05/13/1992		GLENWOOD ELECTRIC	REDUCTION IN	

Work History Report for:

WAKEFIELD, ALEX J ([redacted]

A MEMBER OF IBEW LOCAL 212

FOR WORK IN THE JURISDICTION OF IBEW LOCAL #212

START DATE	TERM. DATE	EMPLOYER	TERM. REASON	DISPATCH CLASS
06/08/1992		MAYERS ELECTRIC	ILLNESS	
06/08/1992		W.W. CLARK	REFUSED CALL	
06/10/1992	06/23/1992	RIVERSIDE ELECTRIC	REDUCTION IN	
06/24/1992		W.W. CLARK	REFUSED CALL	
06/30/1992		HIGH VOLTAGE MAINT.	ILLNESS	
07/13/1992	11/12/1992	ARROW	REDUCTION IN	
03/29/1993	04/16/1993	SNEED	LAYOFF SHORT CALL	
04/29/1993	09/14/1993	L.K. COMSTOCK	REDUCTION IN	
03/21/1994	04/08/1994	SNEED	LAYOFF SHORT CALL	
06/06/1994	10/14/1994	D'LAURIN ELECTRIC CO.	REDUCTION IN	
10/18/1994	03/24/1995	CACHE VALLEY ELECTRIC	REDUCTION IN	
05/15/1995	06/02/1995	MAYERS ELECTRIC	LAYOFF SHORT CALL	
08/14/1995	01/11/1996	SUPERIOR	REDUCTION IN	
09/24/1996	10/11/1996	GLENWOOD ELECTRIC	LAYOFF SHORT CALL	
11/25/1996	12/10/1996	GLENWOOD ELECTRIC	LAYOFF SHORT CALL	
12/21/1996	12/24/1996	ELEX INC.	LAYOFF SHORT CALL	
04/15/1997	06/26/1997	MAYERS ELECTRIC	REDUCTION IN	
06/26/1997	07/24/1997	R. KELLY	REDUCTION IN	
07/28/1997	08/07/1997	BANTA ELECTRIC	REDUCTION IN	
08/11/1997	11/21/1997	OWENSVILLE ELECTRIC	REDUCTION IN	
05/04/1998	09/04/1998	EMI (MIRG GROUP)	REDUCTION IN	
11/23/1998	04/02/1999	HYRE	REDUCTION IN	
04/12/1999	04/27/1999	BANTA ELECTRIC	REDUCTION IN	
04/27/1999	05/18/1999	GLENWOOD ELECTRIC	REDUCTION IN	
05/21/1999	09/03/1999	HALL ENGINEERING	REDUCTION IN	
09/16/1999	09/22/1999	LUCE ELECTRIC	REDUCTION IN	

Work History Report for:

WAKEFIELD, ALEX J ([redacted]

A MEMBER OF IBEW LOCAL 212

FOR WORK IN THE JURISDICTION OF IBEW LOCAL #212

START DATE	TERM. DATE	EMPLOYER	TERM. REASON	DISPATCH CLASS
10/05/1999	12/07/1999	UNITED ELECTRIC CO.	REDUCTION IN	
12/08/1999	03/10/2000	E.S.I. INC.	REDUCTION IN	
03/14/2000	03/24/2000	L.K. COMSTOCK	REDUCTION IN	
03/27/2000	07/13/2000	MNI ELECTRIC	REDUCTION IN	
07/17/2000	09/19/2000	ED SIMON & CO.	REDUCTION IN	
09/20/2000	09/22/2000	AYER ELECTRIC	LAYOFF SHORT CALL	
02/19/2001	04/13/2001	GLENWOOD ELECTRIC	REDUCTION IN	
09/17/2001	06/07/2002	BANTA ELECTRIC	REDUCTION IN	
09/17/2001		AYER ELECTRIC	QUIT/VOLUNTARY	
07/24/2002	08/23/2002	FLUOR CONSTRUCTORS	REDUCTION IN	
08/30/2002	05/27/2004	BANTA ELECTRIC	REDUCTION IN	
08/30/2004	01/28/2005	BANTA ELECTRIC	REDUCTION IN	INSIDE J.W.
02/22/2005	02/25/2005	BANTA ELECTRIC	REDUCTION IN	INSIDE J.W.
08/01/2005	03/03/2006	BANTA ELECTRIC	REDUCTION IN	INSIDE J.W.
04/17/2006	06/09/2006	BANTA ELECTRIC	REDUCTION IN	INSIDE J.W.
07/24/2006	08/25/2006	BANTA ELECTRIC	REDUCTION IN	INSIDE J.W.
11/06/2006	01/08/2007	WAGNER INDUSTRIAL ELECTRIC	QUIT/VOLUNTARY	INSIDE J.W.
01/08/2007	08/14/2009	BANTA ELECTRIC	REDUCTION IN	INSIDE J.W.
09/08/2009	12/31/2009	BANTA ELECTRIC	REDUCTION IN	INSIDE J.W.
05/24/2010	05/28/2010	BANTA ELECTRIC	LAYOFF LESS THAN	INSIDE J.W.

File Attachments for Item:

P-8 Wilson, Aaron ESI, RBI

Certification ID# 8904

Current certifications- none

Wilson	Aaron	
Last Name	*First Name*	*BBS Certification ID*

Section 1: Check Interim Certification(s) Being Requested

☐ Res. Building Official	☐ Res. Plans Examiner	☒ Res. Building Inspector
	☐ Res. Industrial Unit Inspector	☐ Res. Mechanical 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

Section 3: Employment/Education

a. Formal Education	Date Graduated
Associated Builders and Contractors, Sinclair Community College	8-31-2007
b. Related Vocational or Technical Training	Years' Experience
Associated Builders and Contractors, Sinclair Community College	4+
c. U.S. Military construction experience (MOS or other designation):	Years' Experience
d. Place of Employment:	Years' Employed
Applied Research Solutions, Cohen Brothers, Dayton Public Schools,	21

Fuyao Glass, Ohio Valley Elec, Beacon Elec, LVS

Wilson	Aaron	
Last Name	*First Name*	*BBS Certification ID*

SECTION 4: OBC/RCO 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)

SECTION 5: 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.

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)*
Various projects, Ohio/Kentucky area Installed lighting, receptacles, distribution systems, troubleshoot, conduit, new construction and remodel.	Beacon Electric 7815 Redsky Dr. Cincinnati, OH 45249 513-851-0711	April 2007-November 2008 (19 months)
Ohio district schools, Ohio Installed automated building systems, HVAC controls, troubleshoot, electrical distribution.	Low voltage specialists 291 West Bergey St. Wadsworth, OH 44281 330-336-5097	April 2009-November 2011 (31 months)
Various projects, Ohio Installed lighting, receptacles, distribution systems, troubleshoot, conduit, new construction, remodel, fire alarm systems.	Ohio valley electrical 4582 Cornell Rd. Blue Ash, OH 45241 513-771-2410	December 2011-June 2015 (56 months)
Total Experience on This Page (In Months):		106

Board of Building Standards

Application for Interim Certification, Building Department Personnel

Wilson	Aaron	
Last Name	*First Name*	*BBS Certification ID*

SECTION 5 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)
Glass manufacture, Ohio Preventative maintenance for all equipment, work orders, maintain proper assembly line function, and repairs. Electrical technician	Fuyao glass america 2801 W Stroop Rd. Moraine, OH 45439 937-496-5777	June 2015-August 2017 (26 months)
Various Schools, Ohio Installs, repairs, upgrade electrical systems, lighting, electrical panels, review and determine methods of installations. Journey Electrician	Dayton public schools 136 S. Ludlow St. Dayton, Ohio 45402 937-542-3000	August 2017-Febuary 2018 (6 months)
Recycling yards, Various states Quality routine and preventative electrical maintenance on recycling equipment. Install new equipment and systems. Journeyman Electrician	Cohen 1520 14th Ave. Middletown, OH 45044 513-422-3696	April 2018 -March 2019 (11 months)
WPAFB, Ohio Assessing existing power circuitry within a 650,000 sq ft national defense facility. Hook electric up to new furniture and reconfigured workstations, data racks, and UPS panels. Journeyman electrician	Applied Research Solutions 51 Plus St, Suite 240 Beavercreek, OH 45440 937-912-6100	March 2019 -Present (40 months plus)
Previous electrical companies that are out of business that I've worked for.	D'Laurin Electric Dayton, OH	August 2001- December 2006 (54 months)
Started apprenticeship and completed at D'Laurin Electric. New construction, residential, service calls, panel upgrades, troubleshoot, and ran projects.	Evans Electric Dayton, OH	January 2007 -April 2007 (3 months)
	Total Experience on This Page (In Months):	140

Wilson	Aaron	
Last Name	*First Name*	*BBS Certification ID*

SECTION 6: PERSONAL HISTORY

1. Have you ever been convicted of any felony, or any crime involving moral turpitude? ☐ Yes ☒ No
2. If you answered "Yes" please explain below:
3. Have you served in the U.S. armed services? (If No, skip question 3) ☐ Yes ☐ No
4. If YES, were you discharged under honorable conditions? ☐ Yes ☐ No
   If you answered "No" please explain below:

SECTION 7: 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: ____________________

Subscribed and duly sworn before me according to law, by the above named applicant this day 5th of August in the year 2022 at Fairborn, County of Greene and State of Ohio.

Notary Public: ____________________

SEAL

NOTARY PUBLIC
STATE OF OHIO

TERESA L HORVATH, Notary Public
In and for the State of Ohio
My Commission Expires May 28, 2024


ARS
Applied Research Solutions
Rockstar of the Quarter
June 2022
Aaron Wilson
NASIC LG

ARS
Applied Research Solutions

Mr. Aaron Wilson

is awarded the

ARS Quarterly Award

for his exemplary work and dedication to the NASIC and LGX missions. Mr. Wilson is an integral part of the LGX Execution Team where he serves as an electrical technician assessing existing power circuitry within a 650,000 sq ft national defense mission oriented facility. He is also responsible for hooking up all electric to facility workstations that are either reconfigured or brand new. Mr. Wilson's role has been crucial to the overall success of the LGX team providing in house electrical support. These efforts are directly responsible for projects remaining on or ahead of schedule, ensuring critical NASIC missions continue uninterrupted. In addition to his technical successes, Mr. Wilson's professionalism and attitude exceeds customer expectations, bolstering team cohesion and effectiveness. He is always willing to go above and beyond his duties to assure that the mission is supported to fullest of his capabilities.

Robin De La Vega

Robin De La Vega
Program Manager

2020

COHEN

July 26th, 2022

To: Whom it may Concern

This letter is regarding the previous employment status for Aaron Wilson, who was an employee with Cohen Brothers beginning on 04/09/2018. Aaron was employed as a journeyman electrician until his resignation on 3/15/2019, when given the opportunity to further his skills outside of our company.

Aaron was a dedicated worker during his tenure with Cohen and we would not hesitate in saying that he would be a welcome addition to any company willing to consider him for employment.

Additional questions and information requests, including personal references and work history records can be sent to the human resources department at (513) 422-3696 ext.2396.

Sincerely,

Brad Schrand

Human Resources Manager
Cohen Brothers Recycling

December 28, 2017

Darryl A Holt
Associate Director
Dayton Public School
4280 James H McGee Blvd
Dayton, Ohio, 45417
daholt6905@gmail.com

Re: Aaron Wilson; The Letter of Reference

To Whom It May Concern:

Mr. Aaron Wilson has worked in a number of professional services from industrial maintenance to building/facilities maintenance for a time of 5 years. Mr. Wilson has also served as public servant with the Dayton Public Schools where he was able to demonstrate host technical knowledge in the area of electrical applications.

Throughout his employment, Mr. Wilson has conducted himself with highest professionalism, commitment and dependability. Mr. Wilson had begun his career by working in maintenance and manufacturing Industry where he worked in the position of an ELECTRICIAN. This was definitely an incredibly challenging and a highly skilled person, Mr. Wilson has exceeded the expectations and was given a glowing review by management and her co-workers.

I would strongly recommend Mr. Wilson for any role within the Dayton Public Schools, where he surely would be a valuable asset. His skills, his professionalism and his dedication are definitely outstanding.

Please feel free to contact me at any point of time if you have any further quires.

Sincerely,

Darryl A. Holt

Mr. Darryl A. Holt
937-760-1555

Governmental Verification

This verification is system-generated with data provided directly by the employer. If any information is missing, it is because the employer did not provide this information for inclusion in the CCC Verify verification.

The information displayed below is an official and authentic employment verification report generated from CCCVerify.com. This verification is system-generated with data provided by the employer directly. If any information is missing, it is because the employer did not provide this information for inclusion in the CCCVerify verification.

Report Requested: 7/22/2022 9:07 AM
Report Tracking Number: 9e62ca3d-80c0-4870-82fe-e56dc10dc985

Data Source

Name: FUYAO GLASS AMERICA, INC
Division:
Address: 800 FUYAO AVENUE MORAINE OH 45439

Employee

First Name:	AARON	Last Name:	WILSON
Employee Address:	[redacted]		
Employee SSN:	[redacted]		
Employee ID:	001070	Work Site:	DAYTON
Hire and Separation Date(s):			

Work Site	Most Recent Hire Date	Most Recent Separation Date
DAYTON	6/29/2015	8/17/2017

First Hire Date:	6/29/2015	First Term Date:	8/17/2017
Work Status:	INACTIVE	Employment Type:	Full-time
Job Title:	ELECTRICAL TECHNICIAN	Current Length of Service:	2 Year(s), 2 Month(s)

Medical Benefits

Enrollment Type:	N/A	Carrier:	N/A
Employee Eligible:	N/A	Employee Enrolled:	N/A

Dental Benefits

Enrollment Type:	N/A	Carrier:	N/A
Employee Eligible:	N/A	Employee Enrolled:	N/A

Payroll

Pay:	29.00	Rate Frequency:	Hourly
Unused Vacation Amount:	N/A		
Unused Personal Amount:	N/A		
Unused Sick Pay Amount:	N/A		

Year-to-Date Income Details

OhioValley
ELECTRICAL SERVICES
An Employee Owned Company

8/4/22

To whom this may concern,

Aaron Wilson was a journeyman electrician here at Ohio Valley Electrical from December 2011 to June 2015.

Thanks,
Annie Klayer
HR Director

"Your Project is Our Reputation"
4585 Cornell Road • Cincinnati • OH 45241
P: 513-771-2410
Ohio License #22430 • Kentucky License #CE-16111
www.ohiovalleyelectric.com

EMPLOYEE-OWNED EO CERTIFIED

Low Voltage Specialists, Inc.
"Exceeding your expectations is our goal"

July 25, 2022

Aaron Wilson
[redacted]

Mr. Aaron Wilson:

In response to your request to verify your employment with Low Voltage Specialists, Inc., I have the following information:

Hire Date: March 31, 2010
Release Date: November 19, 2011
Position: Low Voltage Electrician
Total Hours Worked: 3468

Please let me know if you need any additional information or have any questions.

Sincerely,

Ellen M. Tollett
President

291 West Bergey Street, Wadsworth, Ohio, 44281 .... (330) 336-5097 .... www.lvscompany.com

BEACON
electrical contractors

Committed to Quality, Service and Customer Satisfaction.

Date: July 21, 2022

To: To Whom This May Concern

From: Kathy Shock
Payroll Administrator

Re: Employment dates for Aaron Wilson

Please be advised that Aaron worked for Beacon Electric Company as a Journeyman electrician from 4/30/2007 to 11/14/2008.

If you need additional information, please feel free to call at 513-851-0711 ext.222.

Thanks,

Kathy Shock
Payroll Administrator
Beacon Electric Company

OSHA Occupational Safety and Health Administration

21-600613695

This card acknowledges that the recipient has successfully completed a 30-hour Occupational Safety and Health Training Course in **Construction Safety and Health**

Aaron Wilson

Scott McCormick

(Trainer name – print or type)

4-29-11

(Course end date)

SINCLAIR COMMUNITY COLLEGE

State of Ohio
Department of Commerce
Division of State Fire Marshal
FIRE PROTECTION LICENSE
AARON WILSON
54.57.2855
Expiration Date: 10/01/2022

Signature ____________________

This card shall be on your person while performing listed activities.

This license shall be carried on your person while performing the listed activities.

STATE OF OHIO

Certificate of Completion of Apprenticeship

ISSUED BY
THE OHIO STATE APPRENTICESHIP COUNCIL

This is to certify that: **Aaron K Wilson**

has fulfilled the terms of the apprenticeship agreement in accordance with the registered standards and requirements, with related instruction and is hereby recognized and qualified as a journeyperson

Electr:cian

together with all the rights, privileges and opportunities which everywhere pertain thereto.

In testimony Whereof, the Ohio State Apprenticeship Council of the Ohio Department of Job and Family Services in cooperation with the Bureau of Apprenticeship and Training, U.S. Department of Labor, do affix the Great Seal of the State of Ohio.

Witnessed Over Our Signatures and Seal:

Sponsored by:

ABC Ohio Valley SW

Springboro, Ohio

Given at Columbus in the State of Ohio,

this 31st *day of* August *A.D.* 2007

DIRECTOR, OHIO STATE APPRENTICESHIP COUNCIL

CHAIRMAN, OHIO STATE APPRENTICESHIP COUNCIL

TED STRICKLAND
GOVERNOR OF OHIO

July 10, 2006

Aaron Wilson
ABC Ohio Valley CEF
33 Greenwood Lane
Springboro, OH 45066

Dear Aaron,

On behalf of the National Center for Construction Education and Research, I congratulate you for successfully completing the NCCER's standardized craft training program.

As the NCCER's most recent graduate, you are a valuable member of today's skilled construction and maintenance workforce. The skills that you have acquired through the NCCER craft training programs will enable you to perform quality work on construction and maintenance projects, promote the image of these industries and enhance your long-term career opportunities.

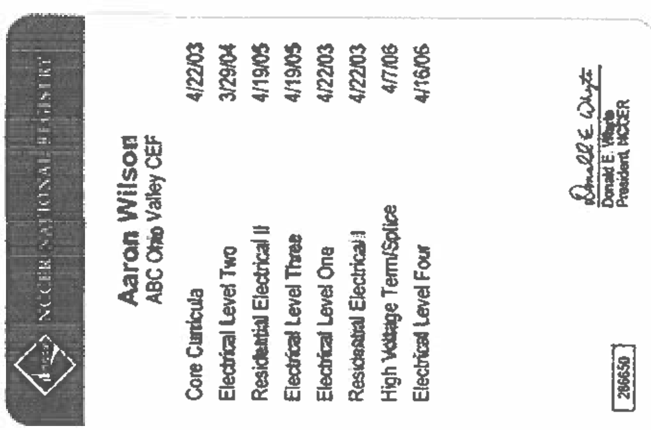
We encourage you to continue your education as you advance in your construction career. Please do not hesitate to contact us for information regarding our Management Education and Safety Programs or if we can be of any assistance to you.

Enclosed please find your certificate, transcript and wallet card. If you have any questions regarding your credentials, contact the Registry Department at 352-334-0911. Once again, congratulations on your accomplishments and best wishes for a successful career in the construction and maintenance industries.

Sincerely,

Donald E. Whyte

Donald E. Whyte
President, NCCER


NCCER NATIONAL REGISTRY

Aaron Wilson
ABC Ohio Valley CEF

Core Curricula	4/22/03
Electrical Level Two	3/29/04
Residential Electrical II	4/19/05
Electrical Level Three	4/19/05
Electrical Level One	4/22/03
Residential Electrical I	4/22/03
High Voltage Term/Splice	4/7/06
Electrical Level Four	4/16/06

Donald E. Whyte
President, NCCER

286650

Wilson	Aaron	
Last Name	*First Name*	*BBS Certification ID*

SECTION 1: CHECK INTERIM CERTIFICATION(S) BEING REQUESTED

☐ Building Official	☐ 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

Wilson	Aaron	
Last Name	*First Name*	*BBS Certification ID*

SECTION 3: EMPLOYMENT/EDUCATION

Formal Education	Date Graduated
Associated Builders and Contractors, Sinclair Community College	08/31/2007
Related Vocational or Technical Training	Years' Experience
Associated Builders and Contractors, Sinclair Community College	4+
U.S. Military construction experience (MOS or other designation):	Years' Experience
Place of Employment:	Years' Employed
Applied Research Solutions, Cohen Brothers, Dayton Public Schools, Fuyao Glass, Ohio Valley Elec, Beacon Elec, LVS	21

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)

Wilson	Aaron	
Last Name	*First Name*	*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)*
Various projects, Ohio/Kentucky area Installed lighting, receptacles, distribution systems, troubleshoot, conduit, new construction and remodel.	Beacon Electric 7815 Redsky Dr. Cincinnati, OH 45249 513-851-0711	April 2007-November 2008 (19 months)
Ohio district schools, Ohio Installed automated building systems, HVAC controls, troubleshoot, electrical distribution.	Low voltage specialists 291 West Bergey St. Wadsworth, OH 44281 330-336-5097	April 2009-November 2011 (31 months)
Various projects, Ohio Installed lighting, receptacles, distribution systems, troubleshoot, conduit, new construction, remodel, fire alarm systems.	Ohio valley electrical 4582 Cornell Rd. Blue Ash, OH 45241 513-771-2410	December 2011-June 2015 (56 months)
Total Experience on This Page (In Months):		106

Wilson	Aaron	
Last Name	*First Name*	*BBS Certification ID*

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
Glass manufacture, Ohio Preventative maintenance for all equipment, work orders, maintain proper assembly line function, and repairs. Electrical technician	Fuyao glass america 2801 W Stroop Rd. Moraine, OH 45439 937-496-5777	June 2015-August 2017 (26 months)
Various Schools, Ohio Installs, repairs, upgrade electrical systems, lighting, electrical panels, review and determine methods of installations. Journey Electrician	Dayton public schools 136 S. Ludlow St. Dayton, Ohio 45402 937-542-3000	August 2017-Febuary 2018 (6 months)
Recycling yards, Various states Quality routine and preventative electrical maintenance on recycling equipment. Install new equipment and systems. Journeyman Electrician	Cohen 1520 14th Ave. Middletown, OH 45044 513-422-3696	April 2018 -March 2019 (11 months)
WPAFB, Ohio Assessing existing power circuitry within a 650,000 sq ft national defense facility. Hook electric up to new furniture and reconfigured workstations, data racks, and UPS panels. Journeyman electrician	Applied Research Solutions 51 Plus St, Suite 240 Beavercreek, OH 45440 937-912-6100	March 2019 -Present (40 months plus)
Previous electrical companies that are out of business that I've worked for. Started apprenticeship and completed at D'Laurin Electric. New construction, residential, service calls, panel upgrades, troubleshoot, and ran projects.	D'Laurin electric Dayton, OH Evans Electric Dayton, OH	August 2001- December 2006 (54 months) January 2007 -April 2007 (3 months)
	Total Experience on This Page (In Months):	140

Wilson	Aaron	
Last Name	*First Name*	*BBS Certification ID*

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: Aaron Wilson

Subscribed and duly sworn before me according to law, by the above named applicant this day 5th of August in the year 2022 at Fairborn, County of Greene and State of Ohio.

Notary Public: Teresa L Horvath

SEAL

NOTARY PUBLIC
STATE OF OHIO

TERESA L HORVATH, Notary Public
In and for the State of Ohio
My Commission Expires May 28, 2024

80


ARS
Applied Research Solutions
Rockstar of the Quarter
June 2022
Aaron Wilson
NASIC LG

ARS
Applied Research Solutions

Mr. Aaron Wilson

is awarded the

ARS Quarterly Award

for his exemplary work and dedication to the NASIC and LGX missions. Mr. Wilson is an integral part of the LGX Execution Team where he serves as an electrical technician assessing existing power circuitry within a 650,000 sq ft national defense mission oriented facility. He is also responsible for hooking up all electric to facility workstations that are either reconfigured or brand new. Mr. Wilson's role has been crucial to the overall success of the LGX team providing in house electrical support. These efforts are directly responsible for projects remaining on or ahead of schedule, ensuring critical NASIC missions continue uninterrupted. In addition to his technical successes, Mr. Wilson's professionalism and attitude exceeds customer expectations, bolstering team cohesion and effectiveness. He is always willing to go above and beyond his duties to assure that the mission is supported to fullest of his capabilities.

Robin De La Vega

Robin De La Vega
Program Manager

2020

COHEN

July 26th, 2022

To: Whom it may Concern

This letter is regarding the previous employment status for Aaron Wilson, who was an employee with Cohen Brothers beginning on 04/09/2018. Aaron was employed as a journeyman electrician until his resignation on 3/15/2019, when given the opportunity to further his skills outside of our company.

Aaron was a dedicated worker during his tenure with Cohen and we would not hesitate in saying that he would be a welcome addition to any company willing to consider him for employment.

Additional questions and information requests, including personal references and work history records can be sent to the human resources department at (513) 422-3696 ext.2396.

Sincerely,

Brad Schrand

Human Resources Manager
Cohen Brothers Recycling

December 28, 2017

Darryl A Holt
Associate Director
Dayton Public School
4280 James H McGee Blvd
Dayton, Ohio, 45417
daholt6905@gmail.com

Re: Aaron Wilson; The Letter of Reference

To Whom It May Concern:

Mr. Aaron Wilson has worked in a number of professional services from industrial maintenance to building/facilities maintenance for a time of 5 years. Mr. Wilson has also served as public servant with the Dayton Public Schools where he was able to demonstrate host technical knowledge in the area of electrical applications.

Throughout his employment, Mr. Wilson has conducted himself with highest professionalism, commitment and dependability. Mr. Wilson had begun his career by working in maintenance and manufacturing Industry where he worked in the position of an ELECTRICIAN. This was definitely an incredibly challenging and a highly skilled person, Mr. Wilson has exceeded the expectations and was given a glowing review by management and her co-workers.

I would strongly recommend Mr. Wilson for any role within the Dayton Public Schools, where he surely would be a valuable asset. His skills, his professionalism and his dedication are definitely outstanding.

Please feel free to contact me at any point of time if you have any further quires.

Sincerely,

Darryl A. Holt

Mr. Darryl A. Holt
937-760-1555

Governmental Verification

This verification is system-generated with data provided directly by the employer. If any information is missing, it is because the employer did not provide this information for inclusion in the CCC Verify verification.

The information displayed below is an official and authentic employment verification report generated from CCCVerify.com. This verification is system-generated with data provided by the employer directly. If any information is missing, it is because the employer did not provide this information for inclusion in the CCCVerify verification.

Report Requested: 7/22/2022 9:07 AM
Report Tracking Number: 9e62ca3d-80c0-4870-82fe-e56dc10dc985

Data Source

Name:	FUYAO GLASS AMERICA, INC
Division:	
Address:	800 FUYAO AVENUE MORAINE OH 45439

Employee

First Name:	AARON	Last Name:	WILSON
Employee Address:	[redacted]		
Employee SSN:	[redacted]		
Employee ID:	001070	Work Site:	DAYTON
Hire and Separation Date(s):			

Work Site	Most Recent Hire Date	Most Recent Separation Date
DAYTON	6/29/2015	8/17/2017

First Hire Date:	6/29/2015	First Term Date:	8/17/2017
Work Status:	INACTIVE	Employment Type:	Full-time
Job Title:	ELECTRICAL TECHNICIAN	Current Length of Service:	2 Year(s), 2 Month(s)

Medical Benefits

Enrollment Type:	N/A	Carrier:	N/A
Employee Eligible:	N/A	Employee Enrolled:	N/A

Dental Benefits

Enrollment Type:	N/A	Carrier:	N/A
Employee Eligible:	N/A	Employee Enrolled:	N/A

Payroll

Pay:	29.00	Rate Frequency:	Hourly
Unused Vacation Amount:	N/A		
Unused Personal Amount:	N/A		
Unused Sick Pay Amount:	N/A		

Year-to-Date Income Details

OhioValley
ELECTRICAL SERVICES
An Employee Owned Company

8/4/22

To whom this may concern,

Aaron Wilson was a journeyman electrician here at Ohio Valley Electrical from December 2011 to June 2015.

Thanks,
Annie Klayer
HR Director

"Your Project is Our Reputation"
4585 Cornell Road • Cincinnati • OH 45241
P: 513-771-2410
Ohio License #22430 • Kentucky License #CE-16111
www.ohiovalleyelectric.com

EMPLOYEE OWNED EO CERTIFIED

Low Voltage Specialists, Inc.
"Exceeding your expectations is our goal"

July 25, 2022

Aaron Wilson
[redacted]

Mr. Aaron Wilson:

In response to your request to verify your employment with Low Voltage Specialists, Inc., I have the following information:

Hire Date: March 31, 2010
Release Date: November 19, 2011
Position: Low Voltage Electrician
Total Hours Worked: 3468

Please let me know if you need any additional information or have any questions.

Sincerely,

Ellen M. Tollett
President

291 West Bergey Street, Wadsworth, Ohio, 44281 .... (330) 336-5097 .... www.lvscompany.com

BEACON
electrical contractors

Committed to Quality, Service and Customer Satisfaction.

Date: July 21, 2022

To: To Whom This May Concern

From: Kathy Shock
Payroll Administrator

Re: Employment dates for Aaron Wilson

Please be advised that Aaron worked for Beacon Electric Company as a Journeyman electrician from 4/30/2007 to 11/14/2008.

If you need additional information, please feel free to call at 513-851-0711 ext.222.

Thanks,

Kathy Shock
Payroll Administrator
Beacon Electric Company

OSHA Occupational Safety and Health Administration

21-600613695

This card acknowledges that the recipient has successfully completed a 30-hour Occupational Safety and Health Training Course in

Construction Safety and Health

Aaron Wilson

Scott McCormick

(Trainer name – print or type)

4-29-11

(Course end date)

SINCLAIR COMMUNITY COLLEGE

Sinclair Community College upon the recommendation of the Engineering Division

This license shall be carried on your person while performing the listed activities.

State of Ohio
Department of Commerce
Division of State Fire Marshal

FIRE PROTECTION LICENSE
AARON WILSON
54.57.2855
Expiration Date: 10/01/2022

Signature____________________

This card shall be on your person while performing listed activities.

Community
College

STATE OF OHIO

Certificate of Completion of Apprenticeship

ISSUED BY
THE OHIO STATE APPRENTICESHIP COUNCIL

This is to certify that: **Aaron K Wilson**

has fulfilled the terms of the apprenticeship agreement in accordance with the registered standards and requirements, with related instruction and is hereby recognized and qualified as a journeyperson

Electrician

together with all the rights, privileges and opportunities which everywhere pertain thereto.

In testimony Whereof, *the Ohio State Apprenticeship Council of the Ohio Department of Job and Family Services in cooperation with the Bureau of Apprenticeship and Training, U.S. Department of Labor, do affix the Great Seal of the State of Ohio.*

Witnessed Over Our Signatures and Seal:

Sponsored by:

ABC Ohio Valley SW

Springboro, Ohio

Given at Columbus in the State of Ohio,

this **31st** *day of* **August** *A.D.* **2007**

DIRECTOR, OHIO STATE APPRENTICESHIP COUNCIL

CHAIRMAN, OHIO STATE APPRENTICESHIP COUNCIL

TED STRICKLAND
GOVERNOR OF OHIO

July 10, 2006

Aaron Wilson
ABC Ohio Valley CEF
33 Greenwood Lane
Springboro, OH 45066

Dear Aaron,

On behalf of the National Center for Construction Education and Research, I congratulate you for successfully completing the NCCER's standardized craft training program.

As the NCCER's most recent graduate, you are a valuable member of today's skilled construction and maintenance workforce. The skills that you have acquired through the NCCER craft training programs will enable you to perform quality work on construction and maintenance projects, promote the image of these industries and enhance your long-term career opportunities.

We encourage you to continue your education as you advance in your construction career. Please do not hesitate to contact us for information regarding our Management Education and Safety Programs or if we can be of any assistance to you.

Enclosed please find your certificate, transcript and wallet card. If you have any questions regarding your credentials, contact the Registry Department at 352-334-0911. Once again, congratulations on your accomplishments and best wishes for a successful career in the construction and maintenance industries.

Sincerely,

Donald E. Whyte

Donald E. Whyte
President, NCCER

NCCER NATIONAL REGISTRY

Aaron Wilson
ABC Ohio Valley CEF

Core Curricula	4/22/03
Electrical Level Two	3/29/04
Residential Electrical II	4/19/05
Electrical Level Three	4/19/05
Electrical Level One	4/22/03
Residential Electrical I	4/22/03
High Voltage Term/Splice	4/7/06
Electrical Level Four	4/16/06

Donald E. Whyte
Donald E. Whyte
President, NCCER

286550

File Attachments for Item:

P-9 Young, Trenden - ESI

Cert ID: 8879

Current Certifications: None

Staff Notes: Received in June after ESIAC meeting: please review electrical experience.

ESIAC Recommendations:

Committee Recommendation:

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

Young	Trenden	
Last Name	*First Name*	*BBS Certification ID*

SECTION 1: CHECK INTERIM CERTIFICATION(S) BEING REQUESTED

☐ Building Official	☐ 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		
☐	☐	Plans Examiner Certification		
☐	☐	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				
Fire Protection System Designer Certification				
Medical Gas Piping Inspector Certification				

Young	Trenden	
Last Name	*First Name*	*BBS Certification ID*

SECTION 3: EMPLOYMENT/EDUCATION

Formal Education	Date Graduated
Related Vocational or Technical Training	Years' Experience
Independent Electrical Contractors of Cincinnati (IEC)	2
U.S. Military construction experience (MOS or other designation):	Years' Experience
Place of Employment:	Years' Employed

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)

Young	Trenden	
Last Name	*First Name*	*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)*
Total Experience on This Page (In Months):		

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

Young	Trenden	
Last Name	*First Name*	*BBS Certification ID*

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
Radius at the Banks - Electrical layout and prep	Valley Interiors 2203 Fowler Street Cincinnati, OH 45206 513.961.0400	From 11/14 To 09/15
Huhtamaki, Ohio - Installed, landed and tested fiber optics. - Installed power distribution units, IDF cabinets. - Installed, landed and tested CAT VI. - Installed conduit, motors and disconnects in for paper balers.	Bizcom 682 Tuxedo Place Cincinnati, OH 45206 513.961.7200	From 12/18 To 11/19 From 10/20 To 01/21 From 04/21 To 08/21
Festo - Installed electrical conduit, placed fire alarm wiring including smoke and siren wiring, and terminated fire electrical systems.	Bizcom 682 Tuxedo Place Cincinnati, OH 45206 513.961.7200	From 11/19 To 05/20
TQL - Installed electrical conduit, panels, switches, outlets, and lighting. - Installed and tested generator. - Managed electrical instalation crew.	Bizcom 682 Tuxedo Place Cincinnati, OH 45206 513.961.7200	From 05/20 To 10/20
Amazon - Installed security systems and IDF cabinets.	Bizcom 682 Tuxedo Place Cincinnati, OH 45206 513.961.7200	From 01/21 To 02/21
Hutamaki, Alabama - Installed, landed, terminated and tested fiber optics	Bizcom 682 Tuxedo Place Cincinnati, OH 45206 513.961.7200	From 03/21 To 04/21
	Total Experience on This Page (In Months):	49

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

Young	Trenden	
Last Name	*First Name*	*BBS Certification ID*

List Each Construction Project AND Specific Type of Work Performed	Name of Employer, Contact, Address, Telephone Number	Project Time: From_ To _ (MM/YY)
Uptown Rental Apartments - Installed electrical wiring from main transformer into the weather head then down into the meter and into the panel.	Superior Electric 14840 Decoursey Pike Morning View, KY 41063 859.472.3335	From 08/21 To 10/21
Uptown Rental Properties - Replacement of recepticles, lighting, electrical switches, breakers, and service panels.	Superior Electric 14840 Decoursey Pike Morning View, KY 41063 859.472.3335	From 11/21 To 01/22
Campbell County Schools - Retrofitting and replacing lighting, installing receptacles and switches.	Superior Electric 14840 Decoursey Pike Morning View, KY 41063 859.472.3335	From 02/22 To 06/22
	Total Experience on This Page (In Months):	11

Young	Trenden	
Last Name	*First Name*	*BBS Certification ID*

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: Trenden Young

Subscribed and duly sworn before me according to law, by the above named applicant this day 21 of June in the year 2022 at Clermont County Public Health, County of Clermont and State of Ohio.

Notary Public: [illegible]

NOTARIAL SEAL
STATE OF OHIO

Apprentice Transcript

IEC PRIDE

Student ID: 109004
Name: Trenden Young
Address: [redacted]
Sponsor: CEATC
Note:

Gender: [redacted]
Birth Date:
Registration Date (DOI): 2/27/2019
Graduation Date: N/A
Status: Dropped
Status Date: 8/5/2021

Apprentice Class Year	Apprentice Class Session	Instructor	Result Date	Related Instruction (RI) possible	Related Instruction (RI) required	Related Instruction (RI) attended	GPA (70 passing)	Result
1st Year	1 - Apprenticeship	Nixon, Randy	05/13/2020	164.00	152.00	156.00	72.64	P

On-Job-Training (OJT) Hours (Minimum 8000 OJT Required)			
Prior Hours Credit Granted	0.00		
On-Job-Training Hours	3528.00		
Total OJT Hours	3528.00	Hours Through Date	7/31/2021

Certifications & Awards Received

	Issue Date	Expiration Date	Cert Status
CPR	08/15/2019	08/15/2021	
Globally Harmonized System Training	08/15/2019		Complete
OSHA 10 HR	08/20/2019		Complete
First Aid	08/22/2019	08/22/2021	
Aerial Work Platform Safety Training	09/10/2019	09/10/2022	

Issued By: Gina Young
Gina Young, Apprenticeship Coordinator

Date Issued: 6/20/2022
(Unofficial without raised seal)

Sponsor: Cincinnati Electrical Apprenticeship & Training Committee (CEATC)
c/o Independent Electrical Contractors
586 Kings Run Drive - Cincinnati, Ohio 45232
(513) 542-0400
www.iec-cincy.com

File Attachments for Item:

ER-1 2020 NEC Calculations Webinar Part 1 (Matthews Electrical Services)

BO, MPE, EPE, MechPE, ESI, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)

Staff Notes: Recommend addition of NRIUI, recommend approval.

ESIAC Recommendation:

Committee Recommendation:

[redacted]

APPLICATION
FOR
Continuing Education Course Approval

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

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.

COURSE SUBMITTER: Henry Peter Matthews

Course Submitter: Henry Peter Matthews
(Contact Name)

Organization: Matthews Electrical Services
(Organization/Company)

Address: 1203 McKinley Place
(Include Room Number, Suite, etc.)

City: Fostoria State: Ohio Zip: 44830

E-Mail: hpmatthews@matthewselectrical.net

Telephone: 419-575-3488 Fax:

Course Sponsor:

COURSE INFORMATION:

Course Title: NEC Calculations Part 1 Webinar

New Course Submittal: ☒ Update Course: ☐ Prior Approval Number:

Purpose and Objective: The objective of this course is to cover the basics of electricity and to review electrical calculations that are required for NEC-compliant installations. This course will cover some of the basic principles of electricity including Ohm's Law, Kirchoff's Law, the power equation, the metric system, single phase vs. three phase power and more. It will also cover critical calculations such as conductor sizing, raceway sizing and raceway fill.

Number of Instructional Contact Hours that can be obtained upon completion: 4

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

Program Applicable for the Following Participants:

Building Official ☒ Master Plans Examiner ☒ Building Inspector ☒ Fire Protection Inspector ☐ Mechanical Inspector ☒
Plumbing Plans Exam. ☐ Plumbing Inspector ☐
Electrical Plans Exam. ☒ Non-Res IU Inspector ☐
Mechanical Plans Exam. ☒

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

Electrical Safety Inspectors ☐
Location of ESI Course: www.matthewselectricalservices.net Date(s) of ESI Course(s): September 17, 2022

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
Course Sponsor:	Organization sponsoring or requesting the program (if any)	
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:	Copy of quizzes or tests to be given	x
Completed Application:		x

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

RECEIVED
JUN 27 2022
BOARD OF BUILDING STANDARDS

ELECTRICAL CALCULATIONS Part I
Outline

1. Welcome
2. Webinar Rules and Expectations
3. Roll Call: Attendance and Introductions
4. Electricity Basics
5. Alternating Current and Direct Current
6. The metric system
7. Temperature conversions (Fahrenheit and Celsius)
8. Ohms Law, Kirchoff's Law
9. Series and Parallel connections
10. The Power Equation
11. The Power Triangle (VA, Watts, VARs, Power Factor)
12. Battery Math: Amps, Watts, Amp-hours, Watt-Hours
13. Sizing Generators: Kilowatts, Kilowatt-hours
14. Wire Sizes
15. Wire Ampacity Calculations and Derating Factors
16. Definition of Current Carrying Conductors
17. Wire conduit fill
18. Preview of Part II
    a. Box Fill calculations
        i. Outlet boxes
        ii. Tap boxes, junction boxes, pull boxes
    b. Service, load and demand Calculations
    c. Motor calculations
    d. Transformer calculations
    e. Misc. calculations
19. Wrap Up
20. Dismissal

Henry Peter Matthews, PE, CPE, CESCP, PVA

<u>Home Address</u>
1203 McKinley Place
Fostoria, Ohio 44830
Email: hpmatthews@matthewselectrical.net
Home Phone: 419-701-7707
Cell Phone: 419-575-3488

<u>Work Address</u>
Marathon Petroleum Company
539 South Main Street
Findlay, Ohio 45840
Email: hpmatthews@marathonpetroleum.com
Office phone: 419-421-3423
Cell phone: 419-957-2110

Work Experience

Marathon Petroleum Company, LP; Findlay, Ohio — June 2006 – Present
- Advanced Senior Engineer/Electrical Specialist
- Electrical Engineering Supervisor – Terminal Engineering
- Project Engineer – Major Projects
- Electrical Designer – Retail Division

Cooper Standard Automotive, Bowling Green, Ohio — July 1993 – June 2006
- Plant Engineering Manager
- Plant Electrical Engineer

Toledo Engineering Company (consultant); Toledo, Ohio — June 1989 – July 1993
- Electrical Drafter

Education

Bowling Green State University; Bowling Green, Ohio — Aug 2003
Masters of Business Administration

Pennsylvania State University; University Park, PA — Dec 1989
BS Electrical Engineering

Solar Energy International, Paonia, Colorado — Sept 2021
Solar PV Training

Owens Community College; Findlay, Ohio — April 2017
Certificate: Introductory Welding

Penn Foster Career School — July 2010
Certificate: Plumbing

Penn Foster Career School — October 2004
Certificate: Electrician

Certifications

Professional Engineer (PE): OH, MI, IN, KY, IL, WI
Photovoltaic Associate (PVA) by NABCEP
Certified Electrical Safety Compliance Professional (CESCP), NFPA
Certified Plant Engineer (CPE): Association for Facility Engineers
Building Operator Certification (BOC): Northwest Energy Efficiency Council

Licenses	**Ohio Electrical Contractor**, Ohio Department of Commerce, License # 46972 **Ohio Training Agency**, Ohio Construction Industry Licensing Board, Agency #48714 **Ohio Training Agency,** Ohio Board of Building Standards
Special Training	**Solar Energy International (SEI),** Paonia, Colorado

- Solar Electric and Design and Installation Course, April 2021, 60 hours
- PV Systems Fundamentals (Battery-Based), June 2021, 40 hours
- Advanced PV System Design and the NEC, June-July 2021, 60 hours
- Comparing Battery Technologies, July 2021, 10 hours
- Tools and Techniques for Operations and Maintenance of PV Systems, 9/21, 40 HR

Affiliations

Institute of Electrical and Electronics Engineers (IEEE) – Senior Member
International Association of Electrical Inspectors (IAEI)
NFPA Section Member for Architects, Engineers and Building Officials
Illumination Engineering Society of North America (IESNA)
API RP 545 former Co-Chair, American Petroleum Institute, Lightning Protection for Above Ground Storage Tanks (2017- 2018)

Business Ownership	**Matthews Electrical Services, Owner** **Designer Cuts Hair Salon, LLC; Co-owner**

Biography

Henry has worked in the electrical, power, electronics, instrumentation, controls and communication fields for over 30 years. He earned his Bachelor of Science degree in Electrical Engineering from Penn State University in 1989. Henry worked as a consultant for Toledo Engineering Company in Toledo, Ohio as a drafter and field technician.

In 1993 he started working for Cooper Standard Automotive Company in Bowling Green, Ohio in 1993 as a Plant Electrical Engineer. He was then promoted to Plant Engineering Manager in 2000. During this time, he earned his Professional Engineering License in Ohio.

In 2003, Henry earned his MBA at Bowling Green State University.

In 2006, Henry joined Marathon Petroleum Company in Findlay, Ohio. He then went on to obtain his Professional Engineers license in Electrical Engineering for Michigan, Indiana, Illinois, West Virginia, Kentucky, Minnesota and Wisconsin. During his tenure at Marathon, Henry has had several roles including Electrical Design Engineer, Project Engineer and Electrical Supervisor. He is currently an Advanced Senior Engineer where he writes electrical standards for the company and conducts a community of practice for all the company's electrical engineers and safety professionals.

During his time at Cooper Standard Automotive and Marathon Petroleum, Henry developed a passion for teaching, learning and applying Electrical Construction Codes. At Cooper, he trained the entire non-electrical maintenance staff to perform basic electrical tasks.

At Marathon, Henry works with the Learning and Development Department to conduct multiple training sessions for new hires and seasoned engineers on various topics including Electrical Safety, Grounding and Bonding, Hazardous Area Location, Electrical Inspection, Motors, Lightning protection Static Electricity Mitigation, Reading and Understanding Electrical Diagrams, Programmable Logic Controllers and more.

Henry also works very closely with the Talent Acquisition Teams and visits numerous college campuses to deliver presentations on Engineering, Career Development, Networking and other topics.

Henry recently served as the Co-chair of the API Recommended Practice 545 Task Group for Lightning Mitigation for Above Ground Storage Tanks. In this role, he works with engineers, scientists and manufacturers from all over the world to evaluate the impacts of lightning and static electricity on metal above ground storage tanks.

His passion for teaching and Electrical Safety has motivated him to earn the Certified Electrical Safety Compliance Professional Certification (CESCP) from NFPA. He also regularly attends numerous electrical and safety conferences and training sessions conducted by NFPA, IEEE, API.

Previously, Henry was the President of the Fostoria, Ohio area Toastmasters team.

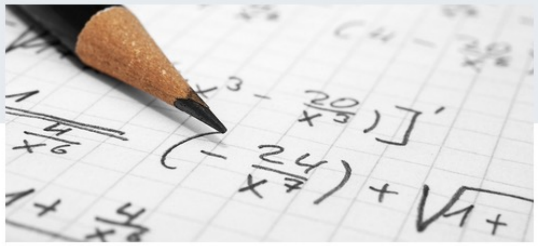
Henry is also a member of the International Association of Electrical Inspectors.

Henry also owns two small businesses:

> **Matthews Electrical Services** - that performs mainly limited residential and small commercial electrical services and conducts training for licensed electricians in the state of Ohio.
>
> **Designer Cuts Hair Salon, LLC** – Henry co-owns the beauty salon with his wife.

NEC Electrical Calculations Pt. 1

Matthews Electrical Services
Ohio Training Agency #48714
Henry Matthews, PE, CPE, CESCP



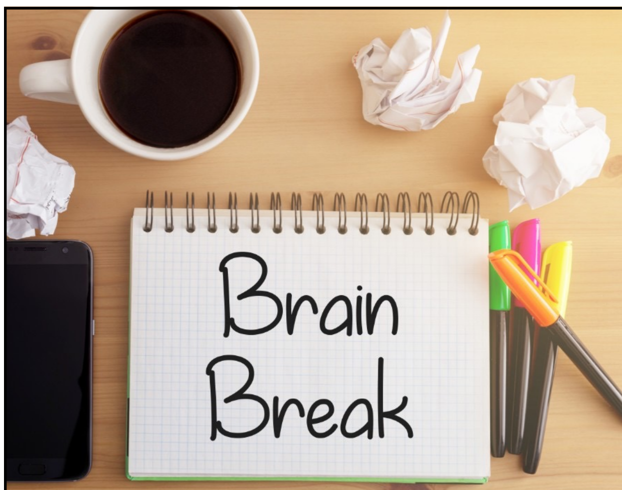
MATTHEWS ELECTRICAL SERVICES

1

Webinar Rules

- Attendee must be present the entire time (except breaks)
- Turn webcam on after breaks and at end of class
  - Instructor will periodically check for presence of all attendees
- Mute microphone at all times
  - Prevents distraction during webinar
  - Instructor may activate participant microphone if verbal response is needed

2



Breaks (New!)

- 5-minute break every 45 minutes
- Schedule
  - 7:00 AM Start
  - 7:45 Break 1
  - 8:30 Break 2
  - 9:15 Break 3
  - 10:00 Break 4
  - 10:45 Break 5

3

WELCOME!

- Goals
  - Review electrical theory
  - Review important NEC Calculations
  - Make session engaging
    - Discussion
    - Videos
    - Polls
  - Make 4 hours as productive as possible!

4

Disclaimer

- I don’t know everything!
- It will be IMPOSSIBLE to learn all the important calculations in 4 hours!
- But we’ll try to cover as much as possible

5

5

Disclaimer #2

- The views and opinions presented in this class are those of Matthews Electrical Services and not necessarily those of the various entities the presenter represents or has previously or currently works for.
- The material used in this class is based on documented publicly-available information (NFPA, OSHA, IEEE etc.)
- The interpretation of this material is based on the presenters experience and training of the subject matter.

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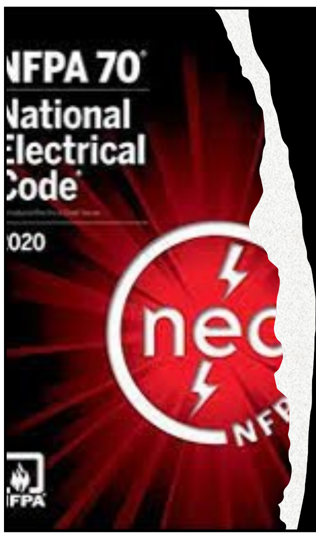
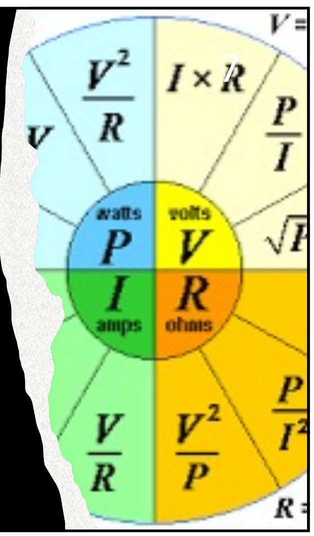
6



NEC Electrical Calculations



7

Resources Used

- 2017 and 2020 NEC
- Ugly’s Electrical References
- www.NFPA.org (Link)
- Mike Holt’s Illustrated Guide to Electrical Exam Preparation 2017

8

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9

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Mike Holt Videos

- Are All Terminals Rated 75 degree C [110.14(C)(1)(a)]
  - https://www.youtube.com/embed/SUjDUvQMTss
- Branch Circuit Conductor Sizing [210.20]
  - https://www.youtube.com/embed/tS4vjbW55Cc
- Conductor sizing based on terminal rating [110.14(C)]
  - https://www.youtube.com/embed/k7d03Tic6LE
- Feeder Conductor sizing [215.2]
  - https://www.youtube.com/embed/ItJ0YNOZ4wA
- How Do I Size an LB [110.3(B)]
  - https://www.youtube.com/embed/2Go0uGb2Kdg

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Mike Holt Videos

- Motor Branch Conductor Sizing [430.22(A)]
  - https://www.youtube.com/embed/buK7LT0yvwE
- Motor Full Load Current (FLC): 430.6(A)(1)
  - https://www.youtube.com/embed/Sic1uoua3og
- Motor Full Load Amps – Nameplate (FLA): 430.6(A)(2)
  - https://www.youtube.com/embed/2cprO8ZdT1U
- Outlet Box Sizing [314.16(A)]
  - https://www.youtube.com/embed/bVQO7B_EWHg
- Overhead Conductor Clearances [225.18]
  - https://www.youtube.com/embed/R9DHjGObyKw

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Mike Holt Videos

- Pull and Junction Boxes, 4 AWG and Larger [314.28]
  - https://www.youtube.com/embed/olwTdmOC1FA
- Feeder Taps [240.21(B)(1)]
  - https://www.youtube.com/embed/uJRSrB4E7dY
- Raceway sizing [300.17 and Annex C]
  - https://www.youtube.com/embed/ruceLol9gJw
- Receptacle Outlets, Number on a dwelling circuit [220.14(I)]
  - https://www.youtube.com/embed/s4Euin0EsRY

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Other information

- OCILB (Ohio Construction Industry Licensing Board)
- IAEI (International Association of Electrical Inspectors)

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Agenda

- Basic math review
- Electrical Theory review
- Basic electrical components (resistors, capacitors, inductors)
- Basic electrical circuits
- Voltage drop
- Single phase/3 phase power
- Conduit fill
- Outlet box fill

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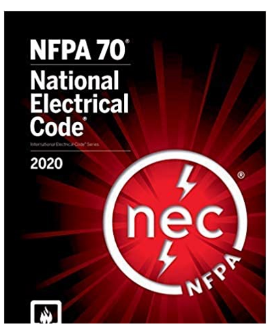
Recommendations for This Course

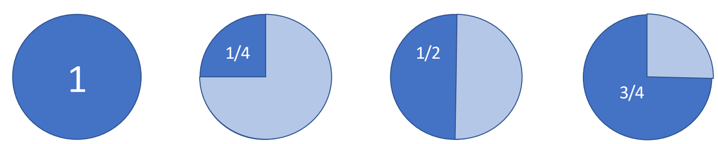


- Have copy of NEC for reference
- Grab a basic calculator perform simple calculations
- Advise me to slow down if something is not clear
- Don't be afraid to question something if you don't agree

15

15

Fractions



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Fractions to Decimal

- Examples
- ½ = 1 ÷ 2 = 0.50
- 3/8 = 3 ÷ 8 = 0.375
- 11/16 = 11 ÷ 16 = 0.6875

17

Quiz:

- Convert the following fraction to a decimal: 3/16
  A. 0.1875
  B. 0.237
  C. 1.875
  D. 0.321

- Answer: A
  - 3 ÷ 16 = 0.1875

18

Decimals

- 1,111.1
  10ths
- 1,111.11
  100ths
- 1,111.111
  1000ths
- 1,111.1111
  10,000ths
- 1,111.11111
  100,000ths

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Rounding

- Usually applies to decimals to get at a number that's easier to work with
- Can round up or round down
- Example: 10.123
- How do we round to the nearest one-hundredth?
- 10.123 2 is in the hundredth space
- Look at the number in the thousandths place: 3
  - If it is 5 or higher, round UP
  - If it is 4 or less, round DOWN
- Since 3 is less than 5, round DOWN
  - Means drop the 3
  - 2 stays the same
- Result is 10.12

20

Rounding

- Usually applies to decimals to get at a number that's easier to work with
- Can round up or round down
- Example: 10.125
- How do we round to the nearest one-hundredth?
- 10.123 2 is in the hundredth space
- Look at the number in the thousandths place: 5
  - If it is 5 or higher, round UP
  - If it is 4 or less, round DOWN (leave it alone)
- Since 5 is equal to 5, round UP
  - Raise the hundredths spot (2) to 3
  - Drop the 3 in the thousandths spot
- Result is 10.13

21

Percentages

- Percentage to Decimal:
- Divide percent by 100:
  - 50% = 50/100 = 0.5
  - 23.4% = 23.4/100 = 0.234
  - 167% = 167/100 = 1.67
- Or move decimal point two places to the left:
  - 50%: 50.0 ➡ .50 = .5
  - 23.4%: 23.4 ➡ 0.234
  - 167%: 167.0 ➡ 1.67

22

Quiz

- Convert the following percent to a decimal: 215%
  - A. 21.5
  - B. 2.15
  - C. 0.215
  - D. 215.0
- Answer : B
  - 215 ÷ 100 = 2.15

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Using Percentages

- Example:
  - We have a wire with an ampacity (current-carrying capacity) of 20 amps. We need to increase it by 150%. What ampacity wire should we be using?
  - 20 x 150% = 20 x 1.50 = 30
- Answer: new wire should have ampacity of 30 amps

24

Using Multipliers

- Convert % to decimal. Result will be multiple
- Example: 125% → 1.25
- 1.25 is the multiplier

- Example: An overcurrent protection device (circuit breaker or fuse) must be sized no less than 125% of the continuous load. If the load is 80A, the overcurrent protection device will have to be sized no smaller than what size?
- Answer: 80A x 1.25 = 100A

25

Reciprocals

- To obtain a reciprocal of a number, divide the number by 1
- For example:
- What is the reciprocal of 80%?
  - First convert percent to a decimal: 0.80 = 0.8
  - Divide 0.8 by 1 = 1/0.8 = 1.25
  - If you want to change this back to a %, then multiply by 100
    - 1.25 x 100 = 125%

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Squaring a Number

- Squaring a number means multiplying it by itself.
- This comes in handy when calculation area (wire for example)
- Example: What is the square of 9?
- Answer: 9 x 9 = 81

- What is the square of 4.25?
- Answer: 4.25 x 4.25 = 18.06

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Where Would We Do This?

- Calculating area of a room
- Comparing pizza sizes
- And many more

- Example: What is the area of a room that is 10 feet wide by 10 feet long?
- Answer: 10 x 10 = 10^2 = 100

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Where Would We Do This?

- Example: What's the area of a 6-inch diameter pizza vs a 12-inch pizza
- Answer:
- Diameter refers to a circle
- Area of a circle = $\pi \times r^2$, $\pi = 3.14159$
- The radius is ½ of the diameter:
  - Radius = 6/2 = 3 inches for 6" pizza
  - Radius = 12/2 = 6 inches for 12" pizza
- Area of 6" pizza: $3.14 \times 3^2 = 3.14 \times 9 = 28.26$ in^2 (square inches)
- Area of 12" pizza: $3.14 \times 6^2 = 3.14 \times 36 = 113.04$ in^2 (square inches)
- 113.04/28.26 = 4
- The 12 inch pizza is 4 times larger!

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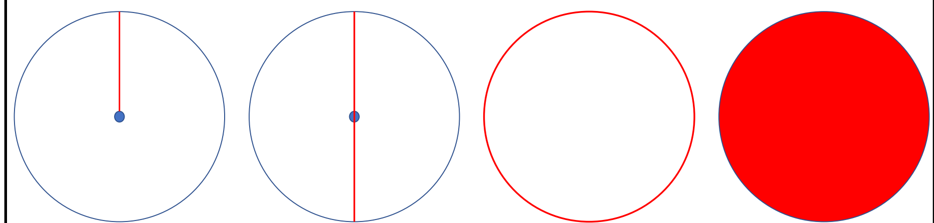
Circular Math

$\pi = 3.14159...$

Area = 3.14159 x radius x radius
Area = πr^2



Radius (R or r)

Diameter (D)
Diameter = 2 x Radius

Radius usually written a "r"

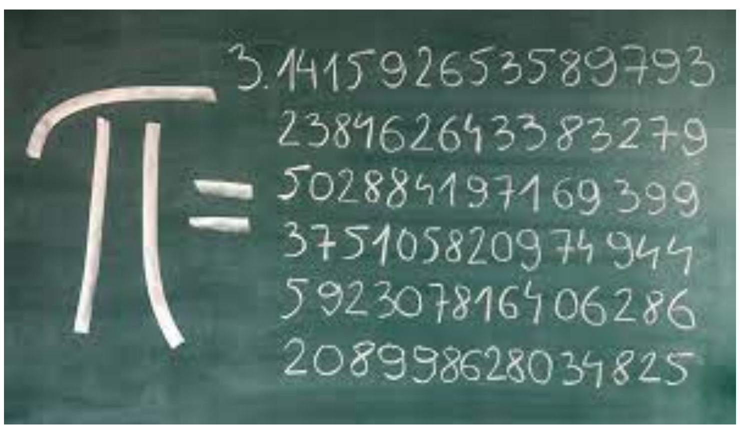
Circumference =
Distance around circle

$= 2 \times \pi \times r = 2\pi r$

Area (A) = space inside
Of circle

30

30



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Ohms Law

- Voltage = Current x Resistance
- V = I x R
- Can also be written as…
- E = I x R (E stands for electromotive force)

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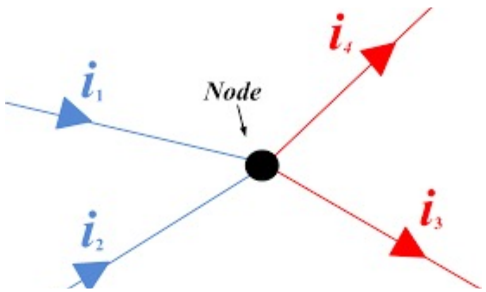


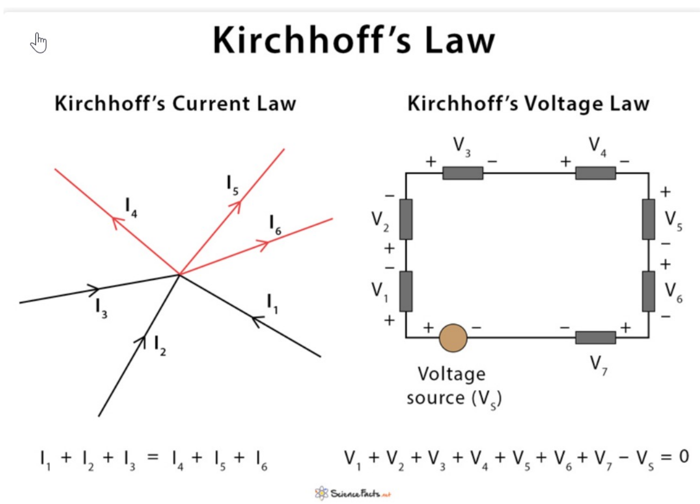
- First Law (Current)
- The sum of the currents arriving at any point must equal the sum of the currents leaving that point

33

Kirchoff's Laws

- Second Low (Voltage)
- The total voltage applied to any closed circuit path is always equal to the sum of the voltage drops in that path
- Or
- The algebraic cum fo all the voltages encounterd in any loop equals zero

34



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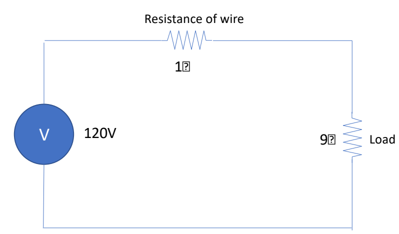

Ohms Law: V = I x R
I = V/R

Total Resistance (R) = 1 + 9 = 10 ohms

I = 120V/10Ω = 12A

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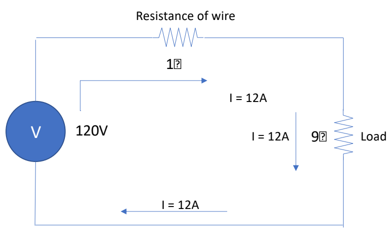

Ohms Law: V = I x R
I = V/R

Total Resistance (R) = 1 + 9 = 10 ohms

I = 120V/10⍰ = 12A

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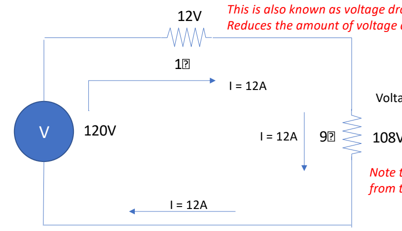
Voltage across wire = I x R = 12A x 1⍰ = 12V

This is also known as voltage drop across the wire
Reduces the amount of voltage available to the load



Voltage across load = I x R = 12A x 9⍰ = 108V

Note that the load does not get the full 120V due to voltage drop from the wire

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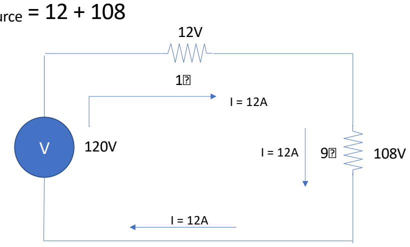
Sum of the Loads Equals the Sum of the Voltage Source

$120V_{source}$ = voltage drop across wire (12V) and voltage drop across the load (108V)
$120V_{source}$ = 12 + 108



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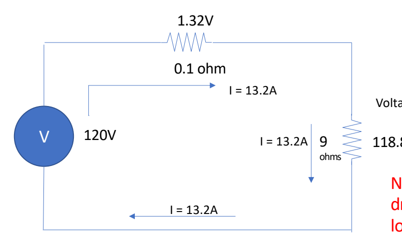
Using Larger Wire (Lower Resistance)

Total circuit resistance = 0.1 + 9 = 9.1 ohms

Ohms Law: V = I x R

I = V/R = 120/9.1 = 13.18 = 13.2A

Voltage across wire = I x R = 13.2A x 0.1 ohms = 1.32V



Voltage across load = I x R = 13.2A x 9 ohms = 118.8 V

Notice that smaller wire results in less voltage drop across the wire and more voltage to the load

Check:

Source: 120V
Wire + Load: 1.32V + 118.8V = 120.12V slight variation due to rounding

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Voltage Drop "Recommendations"

- Not an NEC requirement

210.19 Conductors — Minimum Ampacity and Size.

(A) Branch Circuits Not More Than 600 Volts.

Informational Note No. 1: See **310.14** for ampacity and temperature limitations of conductors.

Informational Note No. 2: See Part II of Article **430** for minimum rating of motor branch-circuit conductors.

Informational Note No. 3: Conductors for branch circuits as defined in Article **100**, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, provide reasonable efficiency of operation. See Informational Note No. 2 of **215.2(A)(1)** for voltage drop on feeder conductors.

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Voltage Drop Quiz

- If the resistance of #12 stranded coated copper wire is 2.05 ohms/1000 ft, what is the resistance of 50 ft. of the wire
- Answer:
  - 2.05 ohms/1000 ft x 50 ft = (2.05 x 50)/1000 = 102.5/1000 = 0.1025 ohms

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Voltage Drop Quiz

- Using the answer from the previous quiz…
- What is the voltage drop across the wire if the current in the circuit is 20 amps
- Resistance of wire from previous quiz = 0.1025 ohms
- Voltage drop across the wire is $I_{circuit}$ x R_{wire} = 20 A x 0.1025 ohms = 2.05 volts

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Voltage Drop Quiz

- Using the answer from the previous quiz…
- Is this voltage drop acceptable for a 120 volt circuit?
- Find percent voltage drop:
  - Voltage drop wire/Voltage drop of source =
  - 2.05/120 = 0.01708
  - To change to a percentage, multiply by 100
  - 0.01708 x 100 = 1.70%
- This is less than 3% (branch circuit), therefore it is acceptable i.e., #12 wire is ok

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215.2 Minimum Rating and Size.

(A) Feeders Not More Than 1000 Volts.

Informational Note No. 1: See Examples D1 through D11 in Informative Annex D.

Informational Note No. 2: Conductors for feeders, as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation.

Informational Note No. 3: See 210.19(A), Informational Note No. 4, for voltage drop for branch circuits.

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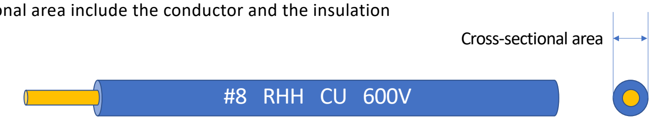
Cross Sectional Area of Wire

Required for calculating conduit fill, box fill etc.

Cross sectional area include the conductor and the insulation



See NEC Chapter 9, Table 5

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Pin Header

Table 5 Dimensions of Insulated Conductors and Fixture Wires

Type	Size (AWG or kcmil)	Approximate Area mm²	Approximate Area in.²	Approximate Diameter mm	Approximate Diameter in.
Type: FFH-2, RFH-1, RFH-2, RFHH-2, RHH*, RHW*, RHW-2*, RHH, RHW, RHW-2, SF-1, SF-2, SFF-1, SFF-2, TF, TFF, THHW, THW, THW-2, TW, XF, XFF					
RFH-2, FFH-2, RFHH-2	18	9.355	0.0145	3.454	0.136
	16	11.10	0.0172	3.759	0.148
RHH, RHW, RHW-2	14	18.90	0.0293	4.902	0.193
	12	22.77	0.0353	5.385	0.212
	10	28.19	0.0437	5.994	0.236
	8	53.87	0.0835	8.280	0.326
	6	67.16	0.1041	9.246	0.364
	4	86.00	0.1333	10.46	0.412
	3	98.13	0.1521	11.18	0.440
	2	112.9	0.1750	11.99	0.472
	1	171.6	0.2660	14.78	0.582
	1/0	196.1	0.3039	15.80	0.622
	2/0	226.1	0.3505	16.97	0.668
	3/0	262.7	0.4072	18.29	0.720
	4/0	306.7	0.4754	19.76	0.778

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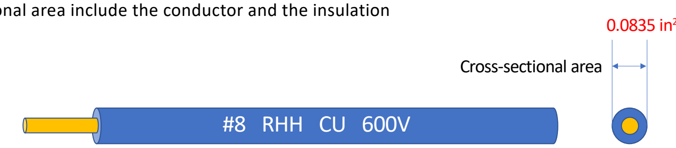
Cross Sectional Area of Wire

Cross sectional area include the conductor and the insulation



See NEC Chapter 9, Table 5

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DC Math

- V = I x R
- Volts = Amps x Resistance
- P = V X I
- Power = Volts x Amps
- Watts = Volts x Amps

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DC Math

Example:

12V solar module

Rated 100 watts

P = V x I

I = P/V

I = 100 watts/12 volts

I = 8.33 Amps

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Power vs Energy

Power is measured in Watts: instantaneous measurements	Energy is measured in Watt-hours: power over time (consumption)
• Example: lamps, appliances, generators etc.	• Batteries, utility meters

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Definitions

Watts: instantaneous measure of Power

Watt-Hour (Watt-Hr): measure of Energy. Power measured over a period of time

- Batteries, UPS systems, Solar Generators etc.

Example: LED lamp, rated 5 watts, 120 VAC

- Power rating: 5 Watts, reading with power meter
- Energy usage:
  - 5 watts for 1 hour = 5 watt-hrs
  - 5 watts for 24 hours = 120 watt-hrs

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Metric System Prefixes

Prefix	Symbol	Multiplier (Scientific Notation)	Multiplier
Exa	E	10^{18}	1,000,000,000,000,000,000
Peta	P	10^{15}	1,000,000,000,000,000
Tera	T	10^{12}	1,000,000,000,000
Giga	G	10^{9}	1,000,000,000
Mega	M	10^{6}	1,000,000
Kilo	k	10^{3}	1,000
Hecto	h	10^{2}	100
Deka	da	10^{1}	10
Deci	d	10^{-1}	0.1
Centi	c	10^{-2}	0.01
Milli	m	10^{-3}	0.001
Micro	µ	10^{-6}	0.000,001
Nano	n	10^{-9}	0.000,000,001
Pico	p	10^{-12}	0.000,000,000,001
Femto	f	10^{-15}	0.000,000,000,000,001
Atto	A	10^{-18}	0.000,000,000,000,000,001

Meter = m = 1

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Unit Conversions

- 1 kW (kilowatt) = 1000 watts
- Watts/1000 = kW
- Example: 2000 watts/1000 = 2 kW
- Example: 10 kW = 10 x 1000 = 10,000 watts

- 1MW (megawatt) = 1,000,000 watts = 1 million watts
- Watts/1,000,000 = MW
- Example: 6,000,000/1,000,000 = 1 MW
- Example: 9 MW = 9 x 1,000,000 = 9,000,000 watts

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Unit Conversions

- 1 GW (gigawatt) = 1,000,000,000 watts = 1 Billion Watts
- Watts/1,000,000,000 = GW
- Example: 2,000,000,000 watts/1,000,000,000= 2 GW

- 1MW (megawatt) = 1,000,000 watts
- Watts/1,000,000 = MW
- Example: 6,000,000/1,000,000 = 6 MW
- Example: 9 MW = 9 x 1,000,000 = 9,000,000 watts

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Key Conversions

- 1 inch = 2.54 centimeters
- Example: How many centimeters is 4 inches?
- Answer: 4 x 2.54 = 10.16 centimeters(cm)

- 1 cm = 0.3937 inches
- Example: How many inches is 9 centimeters (cm)?
- Answer: 9 x 0.3937 = 3.5433 inches

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Key Conversions

- 1 inch = 25.4 centimeters
- Example: How many millimeters (mm) is 4 inches?
- Answer: 4 x 25.4 = 101.6 centimeters (cm)

- 1 mm = 0.03937 inches
- Example: How many inches is 9 millimeters (mm)?
- Answer: 9 x 0.03937= 0.35433 inches

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Electrical 101

- V = I x R (volts = current x resistance)
- I = V/R
- R = V/I

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Current vs Impact on the Human Body

Current in miliamps (ma)	Probable Effect on the Human Body
1 ma (.001 amp)	Perception level. Slight tingling sensation. Still dangerous under certain conditions.
5 ma (.005 amp)	Slight shock felt; not painful but disturbing. Avergage individual can let go. However, strong involuntary reactions to shocks in this range may lead to injuries.
6 ma – 16 ma (.006 - .016) amps	Painful shock, begin to lose muscular control. Commonly referred to as the freezing current or "let-go" range.
17 ma – 99 ma (0.017 -.099) amps	Extreme Pain, respiratory arrest, severe muscular contractions. Individual cannot let go. Death is possible.
100 ma – 2000 ma (.1 - 2 amps)	Ventricular fibrillation (uneven, uncoordinated pumping of the heart.) Muscular contraction and nerve damage begins to occur. Death is likely.
greater than 2000 ma (2 amps)	Cardiac arrest, internal organ damage, and severe burns. Death is probable

Note: GFCIs are set just below the "let-go" range (6ma)

Iron Man 3 : https://www.youtube.com/watch?v=RRt3VROjXP0

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Math Basics

Ohms Law: V = I x R

Power: P = V x I

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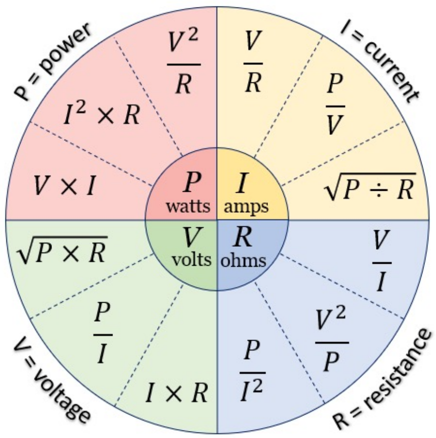
Math Basics



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Temperature Conversions

- Celsius (C) and Fahrenheit (F)
- C to F = C x 9/5 + 32
  - Example: 40ºC =
    - 40 x 9 = 360
    - 360/5 = 72
    - 72 + 32 = 104ºF
- F to C = (F -32) x 5/9
  - Example: 104ºF =
  - 104 -32 = 72
  - 72 x 5 = 360
  - 360/9 = 40ºC

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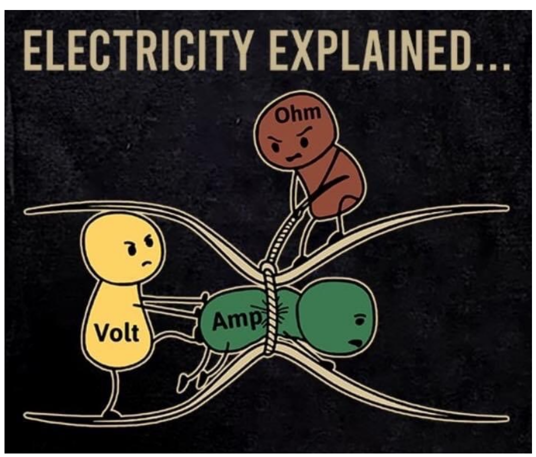
Voltage, Current and Resistance



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Motor, Generator & Transformer Ratings

- Motors rated in Horsepower or HP
- Generators rated in Watts (W) or KW
- Transformers rated in VA or KVA

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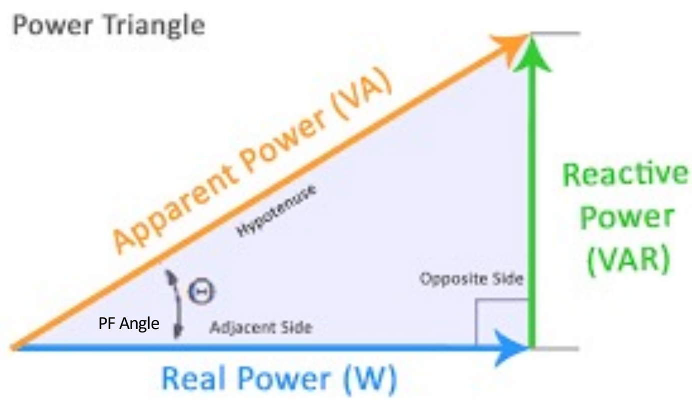

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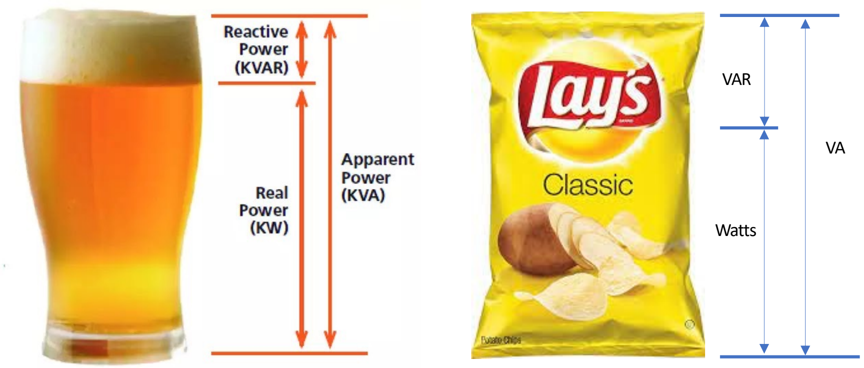

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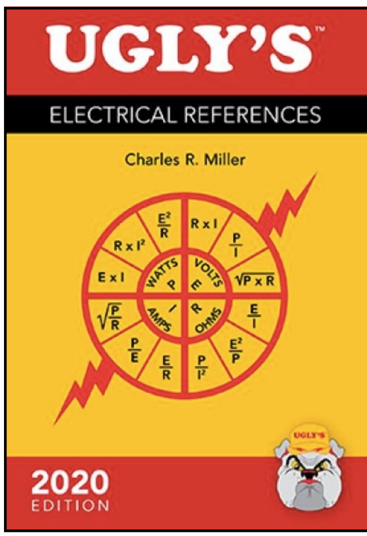

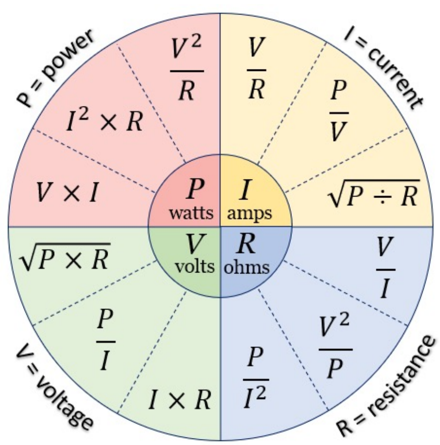

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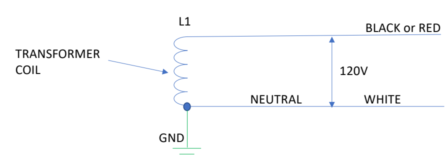
Single Phase, 120V Circuit

Two Wire (L1, Neutral)



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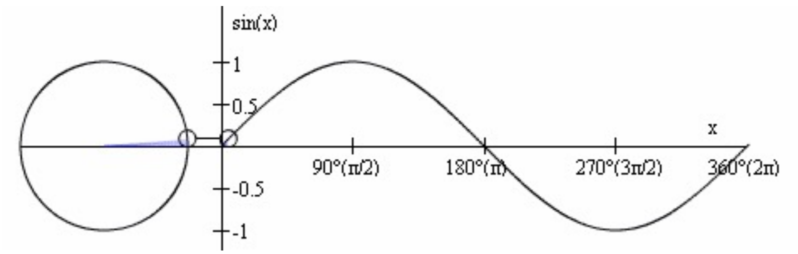
Single Phase Generator Visualizationon



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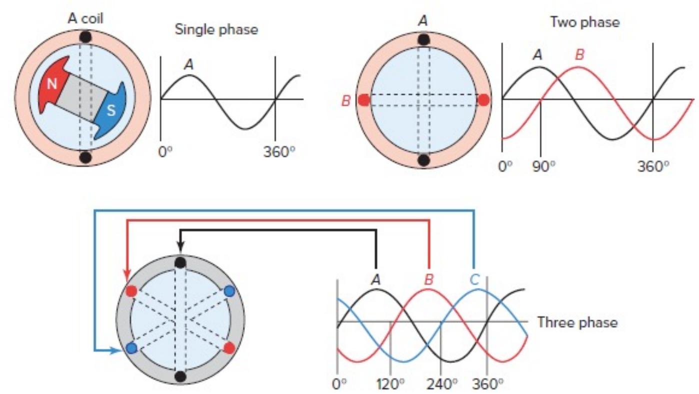

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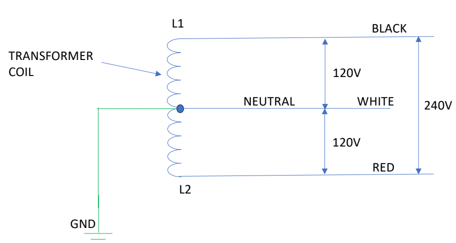
Single Phase (Split Phase) 120V/240V Circuit

Three Wire (L1, L2, Neutral)



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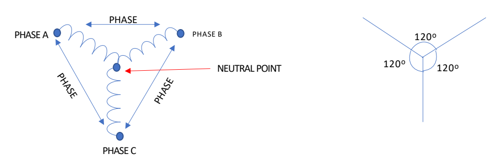
Three Phase WYE (Y) CIRCUIT



PHASES OF TRANSFORMER OR GENERATOR ARE 120 DEGREES APART

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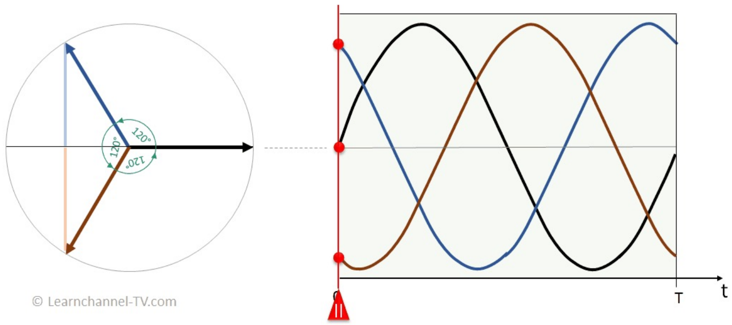
Rotating Power Visualized



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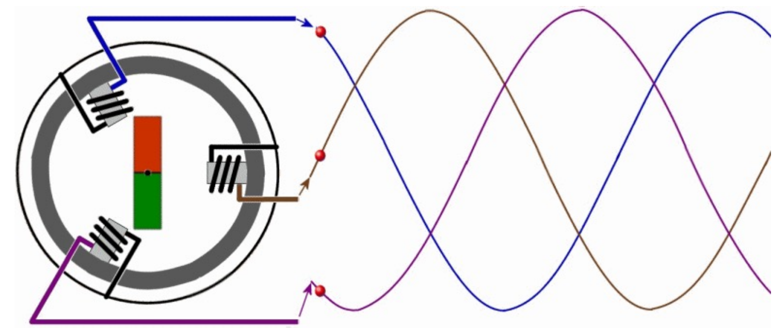

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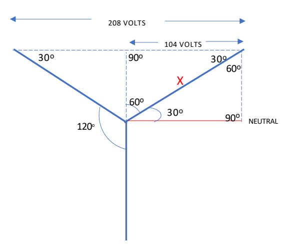
Why Does the Phase to Phase and Phase to Line Voltage Differ by a Factor of 1.73?

ANSWER: TRIGONOMETRY (Triangles) AND PYTHAGOREAN THEOREM ☹



TRIANGLE HAS 180 DEGREES

Cosine of Angle = Adjacent/Hypotenuse
Cosine (30) = 104/X
X = 104/Cosine (30)
X = 104/0.866 = 120.09

208/120 = 1.733

Also !
480/277 = 1.73
4160/2400 = 1.73
And so on and so on

Also! $\sqrt{3} = 1.73$

HINT! To convert from 3-phase to single phase, divide voltage by 1.73

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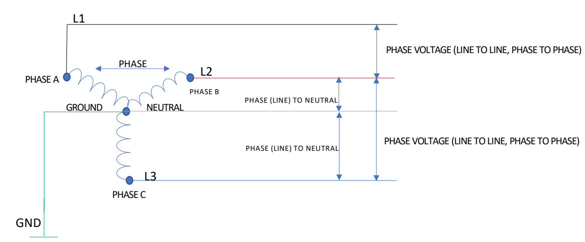
Three Phase WYE (Y) CIRCUIT



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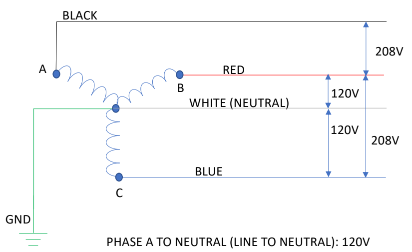
Three Phase WYE (Y) CIRCUIT
120V/208V, 4-WIRE



PHASE A TO NEUTRAL (LINE TO NEUTRAL): 120V
PHASE B TO NEUTRAL (LINE TO NEUTRAL): 120V
PHASE C TO NEUTRAL (LINE TO NEUTRAL): 120V

PHASE A TO PHASE B (LINE TO LINE): 208V
PHASE B TO PHASE C (LINE TO LINE): 208V
PHASE C TO PHASE A (LINE TO LINE): 208V

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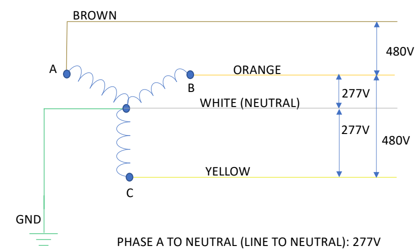
Three Phase WYE (Y) CIRCUIT
277V/480V, 4-WIRE



PHASE A TO NEUTRAL (LINE TO NEUTRAL): 277V
PHASE B TO NEUTRAL (LINE TO NEUTRAL): 277V
PHASE C TO NEUTRAL (LINE TO NEUTRAL): 277V

PHASE A TO PHASE B (LINE TO LINE): 480V
PHASE B TO PHASE C (LINE TO LINE): 480V
PHASE C TO PHASE A (LINE TO LINE): 480V

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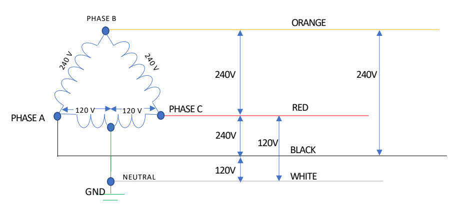
Three Phase Delta Circuit, 120/240V
4-Wire (Line 1, Line 2, Line 3, Neutral)



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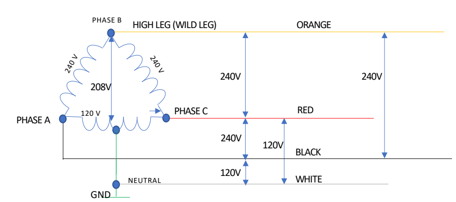
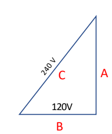
Three Phase Delta Circuit, 120/240V
4-Wire (Line 1, Line 2, Line 3, Neutral)





$C^2 = A^2 + B^2$

$A^2 = C^2 - B^2$

$A = \sqrt{C^2 - B^2}$

$A = \sqrt{240^2 - 120^2}$

$A = \sqrt{57600 - 14{,}400}$

$A = \sqrt{43{,}200}$

$A = 207.84 = 208$

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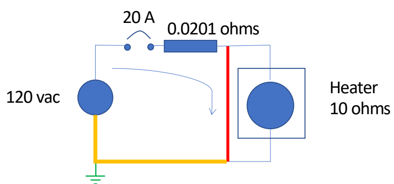
Ground Fault



Calculation of current:

V=I x R

I = V/R = 120/(resistance of wire)

I = 120/(0.0402) = **2985 amps!!**

20 A circuit breaker trips: stops flow of current

- Effective Ground Fault Path Established!
  - People protected
  - Wire protected
  - Equipment protected

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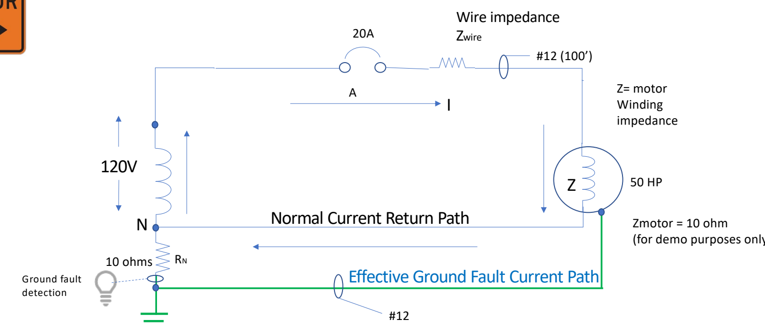
Resistance Grounding

NEC Table 8, Chapter 9
Z of #12 copper wire = 2.05 ohms/1000 ft.
Z of 100' = 0.205 ohms
Z of 200 ' = 0.410 ohms



V= I x R

I = V/R

I = 120V/(Zwire +tot Zmotor)

I = 120/(.410 + 10) = 120/10.41

I = 11.53 A

The Earth: Abnormal Ground Fault Current Path

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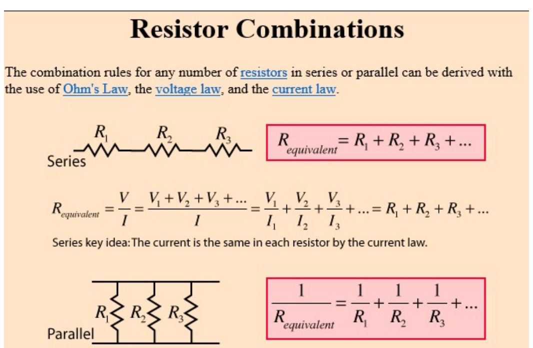
Why Do We Put Ground Rods in Parallel?



Resistor Combinations

The combination rules for any number of resistors in series or parallel can be derived with the use of Ohm's Law, the voltage law, and the current law.

Series

$$R_{equivalent} = R_1 + R_2 + R_3 + \dots$$

$$R_{equivalent} = \frac{V}{I} = \frac{V_1 + V_2 + V_3 + \dots}{I} = \frac{V_1}{I_1} + \frac{V_2}{I_2} + \frac{V_3}{I_3} + \dots = R_1 + R_2 + R_3 + \dots$$

Series key idea: The current is the same in each resistor by the current law.

Parallel

$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

To lower resistance, add ground rods (electrodes) in parallel

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Volume

- The volume of an enclosure equals the length x width x height of the enclosure
- The result is in cubic inches, cubic centimeters, cubic feet, cubic yards etc.
- It is written as in^3, cm^3, ft^3, yds^3, m^3 etc.

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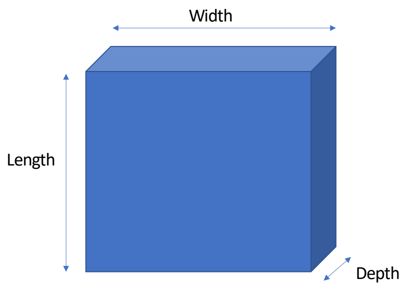
Volume



VOLUME = Width x Length x Depth
VOLUME = W x L x D

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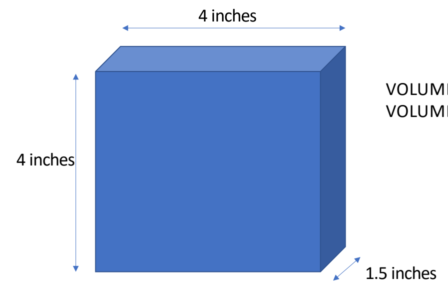
Volume



VOLUME = Width x Length x Depth
VOLUME = 4 x 4 x 1.5 = 24 cubic inches (in^3)

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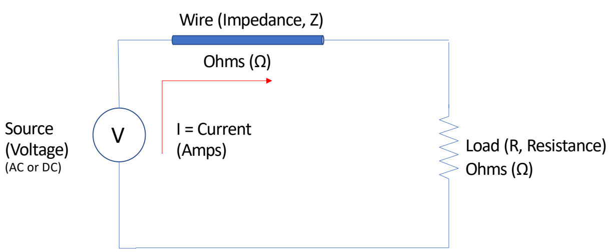
Circuits



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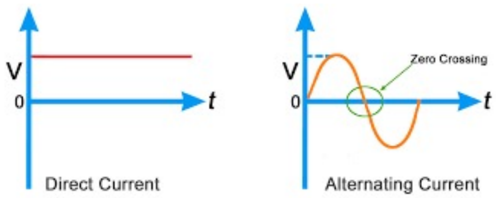
Voltage

- Can be written as V or E
- V stands for Voltage after Alessandro Volta
- E stands for Electromotive Force or EMF
- Both are the same
- “Electrical Pressure”
- Can be AC or DC



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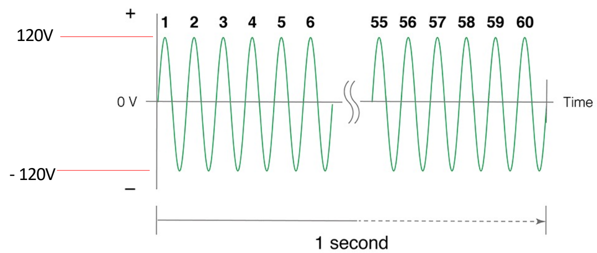
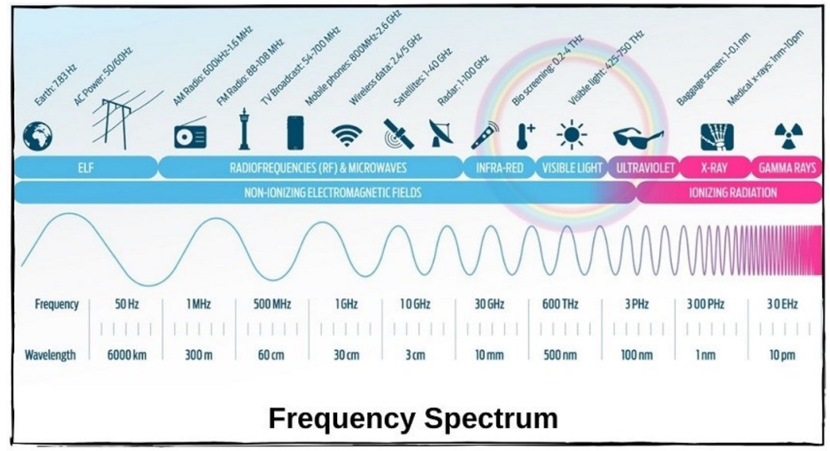
Frequency

- AC Voltage and Current has a frequency
- In the United States, it is 60 Hz or 60 cycles per second
- Sinusoidal waveform crosses 0, 120 times a second





Frequency

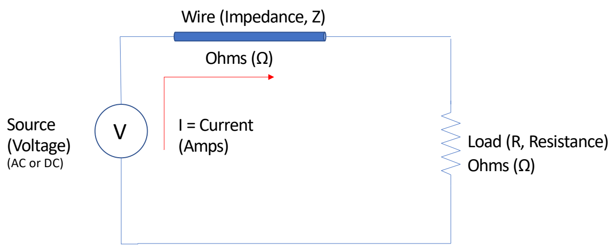
Frequency	Number of cycles/sec	1/cycles =	milliseconds	Harmonic (frequency/60)
60	60	0.0167	16.67	1
120	120	0.0083	8.33	2
180	180	0.055	5.55	3
240	240	0.00416	4.16	4
300	300	0.0033	3.33	5

60 Hz Frequency

Cycles	seconds	milliseconds
1	0.0167	16.67
1/2	0.0083	8.33
1/4	0.00416	4.16

Speed of Current-Limiting Fuses!

Circuits



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Current

- Expressed as "I"
- I originally referred to Intensity
- Measured in Amps or Amperes after Andre-Marie Ampere
- Can be AC or DC
- Flow of charges in a circuit
- "Pushed or Pulled" by voltage
- Higher voltages result in higher current flows
- Must have a closed circuit to flow
- If a break in circuit occurs, flow of current will stop or find leakage paths
- Current will return to its source, not the earth (except lightning)

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Current

- Current will take any and all available paths to return to its source
- Most of the current will take the path of least resistance
- This can best be explained by Kirchoff's Law

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Resistance

- Resistance (R) is measured in ohms
- Named after Georg Ohm
- Ω (Omega) is the symbol for resistance
- Can be thought of providing resistance to the flow of current
- Low resistance promotes higher current flow
- High resistance restricts current flow
  - Require higher amps to energize load
- Ex: larger diameter wire has lower resistance than smaller diameter wire
- High resistance can be a source of heating
- Most loads have significant resistive component

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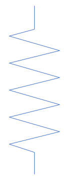
Resistors

- Resistors have resistance
- Resistors can be arranged in series, parallel or both



R (ohms)

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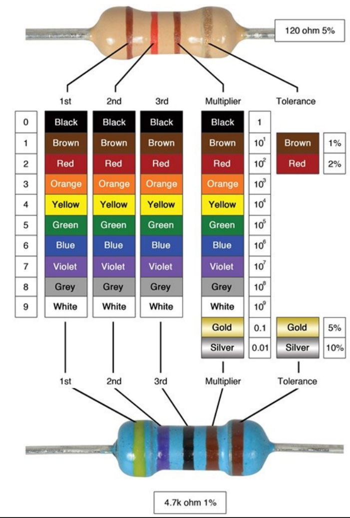

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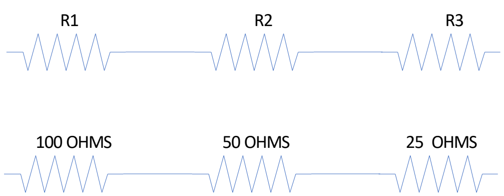
Series Resistance



TOTAL RESISTANCE R = R1 + R2 + R3

TOTAL RESISTANCE R = 100 + 50 + 25 = 175 OHMS

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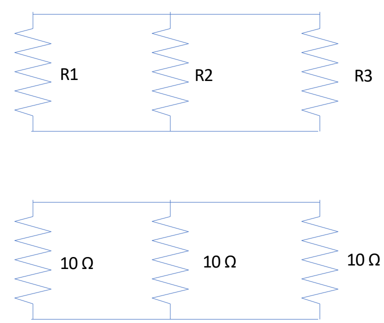
Parallel Resistance



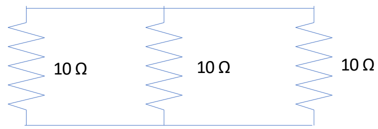
$$\frac{1}{R_{Tot}} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

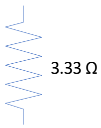
$$\frac{1}{R_{Tot}} = \frac{1}{10} + \frac{1}{10} + \frac{1}{10}$$

100

100

Parallel Resistance





$$\frac{1}{R_{Tot}} = \frac{1}{10} + \frac{1}{10} + \frac{1}{10}$$

$$\frac{1}{R_{Tot}} = 0.1 + 0.1 + 0.1 = 0.3$$

$$\frac{1}{R_{Tot}} = 0.3$$

$$R_{Tot} = \frac{1}{0.3} = 3.33\ \Omega$$

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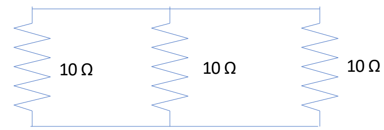
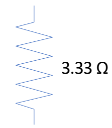
Parallel Resistance Shortcut
For Equal Resistances Only





$$R_{Tot} = \frac{R}{\text{Number of Resistors}}$$

$$R_{Tot} = \frac{10}{3} = 3.33\ \Omega$$

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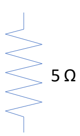
Parallel Resistance Shortcut
For Equal Resistances Only

$$R_{Tot} = \frac{R}{\text{Number of Resistors}}$$

$$R_{Tot} = \frac{10}{2} = 5\ \Omega$$



Hint: If 2 same-value resistors are in parallel, the total resistance is exactly half the value of one of the resistors

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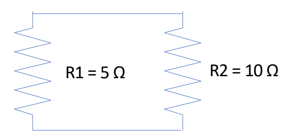
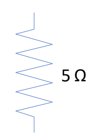
Parallel Resistance Shortcut
For 2 Resistors Only



$$R_{Tot} = \frac{R1 \text{ X } R2}{R1 + R2}$$

$$R_{Tot} = \frac{5 \text{ X } 10}{5 + 10} = \frac{50}{15}\ 3.33 = 5\ \Omega$$



Hint: If 2 same-value resistors are in parallel, the total resistance is exactly half the value of one of the resistors

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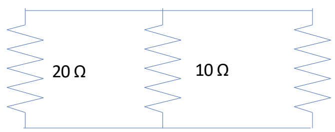
Hints for Resistors in Parallel

- The total resistance will always be lower than any one of the individual resistors
- The total resistance will always be lower than the value of the lowest resistor
- Resistance should always be positive. It may be a decimal, but it should be positive
- Guess the possible value of the total resistance below



$1/R_{tot} = 0.05 + 0.1 + 0.5 = 0.65$

$R_{tot} = 1/0.65 = 1.538\ \Omega$

$$\frac{1}{R_{Tot}} = \frac{1}{20} + \frac{1}{10} + \frac{1}{5} = 1.538\ \Omega$$

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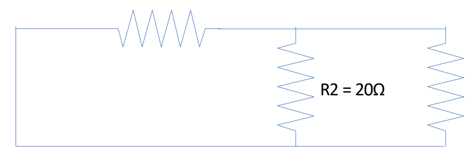
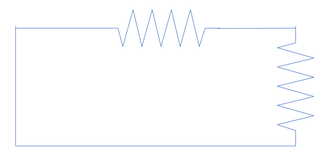
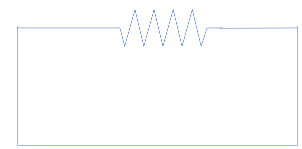
Series and Parallel Resistance





$R_{TOT} = R1 + R2||R3 = 10\Omega + 10\Omega = 20\Omega$



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Resistance (R) and Impedance (Z)

- Both are measured in ohms
- DC circuits only have resistance
- AC circuits have resistance (R), inductance (L) and capacitance (C)
- Both are used interchangeably in 60 Hz circuits because L and C are nearly 0 at this low frequency
- Impedance expressed as Z

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Impedance and Resistance

Z = Impedance
R = Resistance
X_L = Inductive Reactance
X_C = Capacitive Reactance

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

- AC circuits have impedance (Z) consisting of resistance, inductance and capacitance
- In purely DC circuits, Z = R, in other words
- In most situations where the frequency is 60 Hz and amps are less than 40 amps, the loads are mostly resistive,
  the inductive and capacitive reactances are small.

- In these cases, the impedance and resistance are nearly equal

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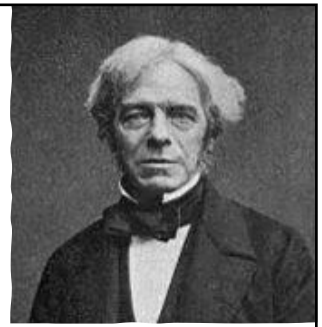
Capacitance

- Capacitance is measured in Farads after Michael Faraday
- Capacitors are noted by the character "C"
- Defined as the ability to store electric charge
- Units of capacitance are F (Farads), mF (milli Farads), μF (micro Farads), nF (nano Farads), pF (pico Farads) etc.



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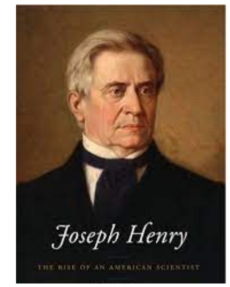
Inductors and Inductance

- Inductance discovered by Michael Faraday
- Inductors are basically a coil of wired
- Inductance is denoted by the symbol "L" after Henrich Lenz
- It is measure in Henrys or "H" after Joseph Henry
- It is another energy storage device
- Inductance is the tendency of an electrical conductor to oppose a change in the electric current flowing through it

Heinrich Lenz



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Inductance

- Basically anything that has a coil has inductance
- Examples: solenoids, motors, transformers etc.
- Helps create magnetic fields

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Impedance and Resistance

- Wire has resistance, inductance and capacitance
- Therefore it has impedance (Z)

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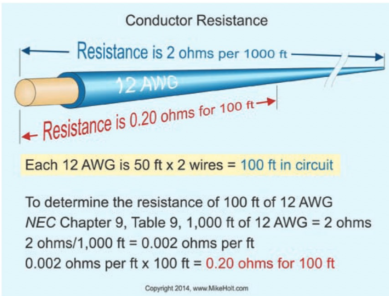

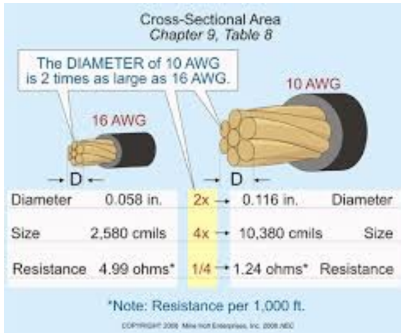

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Pin Header

Table 9 Alternating-Current Resistance and Reactance for 600-Volt Cables, 3-Phase, 60 Hz, 75°C (167°F) — Three Single Conductors in Conduit

Ohms to Neutral per Kilometer / Ohms to Neutral per 1000 Feet

Size (AWG or kcmil)	X_L (Reactance) for All Wires: PVC, Aluminum Conduits	X_L (Reactance) for All Wires: Steel Conduit	AC Resistance for Uncoated Copper Wires: PVC Conduit	AC Resistance for Uncoated Copper Wires: Aluminum Conduit	AC Resistance for Uncoated Copper Wires: Steel Conduit	AC Resistance for Aluminum Wires: PVC Conduit	AC Resistance for Aluminum Wires: Aluminum Conduit	AC Resistance for Aluminum Wires: Steel Conduit	Effective Z at 0.85 PF for Uncoated Copper Wires: PVC Conduit	Effective Z at 0.85 PF for Uncoated Copper Wires: Aluminum Conduit	Effective Z at 0.85 PF for Uncoated Copper Wires: Steel Conduit	Effective Z at 0.85 PF for Aluminum Wires: PVC Conduit	Effective Z at 0.85 PF for Aluminum Wires: Aluminum Conduit	Effective Z at 0.85 PF for Aluminum Wires: Steel Conduit	Size (AWG or kcmil)
14	0.190	0.240	10.2	10.2	10.2	—	—	—	8.9	8.9	8.9	—	—	—	14
	0.058	0.073	3.1	3.1	3.1	—	—	—	2.7	2.7	2.7	—	—	—	
12	0.177	0.223	6.6	6.6	6.6	10.5	10.5	10.5	5.6	5.6	5.6	9.2	9.2	9.2	12
	0.054	0.068	2.0	2.0	2.0	3.2	3.2	3.2	1.7	1.7	1.7	2.8	2.8	2.8	
10	0.164	0.207	3.9	3.9	3.9	6.6	6.6	6.6	3.6	3.6	3.6	5.9	5.9	5.9	10
	0.050	0.063	1.2	1.2	1.2	2.0	2.0	2.0	1.1	1.1	1.1	1.8	1.8	1.8	
8	0.171	0.213	2.56	2.56	2.56	4.3	4.3	4.3	2.26	2.26	2.30	3.6	3.6	3.6	8
	0.052	0.065	0.78	0.78	0.78	1.3	1.3	1.3	0.69	0.69	0.70	1.1	1.1	1.1	
6	0.167	0.210	1.61	1.61	1.61	2.66	2.66	2.66	1.44	1.48	1.48	2.33	2.36	2.36	6
	0.051	0.064	0.49	0.49	0.49	0.81	0.81	0.81	0.44	0.45	0.45	0.71	0.72	0.72	
4	0.157	0.197	1.02	1.02	1.02	1.67	1.67	1.67	0.95	0.95	0.98	1.51	1.51	1.51	4
	0.048	0.060	0.31	0.31	0.31	0.51	0.51	0.51	0.29	0.29	0.30	0.46	0.46	0.46	

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Pin Header

Table 8 Conductor Properties

Size (AWG or kcmil)	Area: mm^2	Area: Circular mils	Conductors, Stranding: Quantity	Stranding Diameter: mm	Stranding Diameter: in.	Overall Diameter: mm	Overall Diameter: in.	Overall Area: mm^2	Overall Area: $in.^2$	DC Resistance at 75°C (167°F), Copper, Uncoated: ohm/km	Copper, Uncoated: ohm/kFT	Copper, Coated: ohm/km	Copper, Coated: ohm/kFT	Aluminum: ohm/km	Aluminum: ohm/kFT
18	0.823	1620	1	—	—	1.02	0.040	0.823	0.001	25.5	7.77	26.5	8.08	42.0	12.8
18	0.823	1620	7	0.39	0.015	1.16	0.046	1.06	0.002	26.1	7.95	27.7	8.45	42.8	13.1
16	1.31	2580	1	—	—	1.29	0.051	1.31	0.002	16.0	4.89	16.7	5.08	26.4	8.05
16	1.31	2580	7	0.49	0.019	1.46	0.058	1.68	0.003	16.4	4.99	17.3	5.29	26.9	8.21
14	2.08	4110	1	—	—	1.63	0.064	2.08	0.003	10.1	3.07	10.4	3.19	16.6	5.06
14	2.08	4110	7	0.62	0.024	1.85	0.073	2.68	0.004	10.3	3.14	10.7	3.26	16.9	5.17
12	3.31	6530	1	—	—	2.05	0.081	3.31	0.005	6.34	1.93	6.57	2.01	10.45	3.18
12	3.31	6530	7	0.78	0.030	2.32	0.092	4.25	0.006	6.50	1.98	6.73	2.05	10.69	3.25
10	5.261	10380	1	—	—	2.588	0.102	5.26	0.008	3.984	1.21	4.148	1.26	6.561	2.00
10	5.261	10380	7	0.98	0.038	2.95	0.116	6.76	0.011	4.070	1.24	4.226	1.29	6.679	2.04
8	8.367	16510	1	—	—	3.264	0.128	8.37	0.013	2.506	0.764	2.579	0.786	4.125	1.26
8	8.367	16510	7	1.23	0.049	3.71	0.146	10.76	0.017	2.551	0.778	2.653	0.809	4.204	1.28
6	13.30	26240	7	1.56	0.061	4.67	0.184	17.09	0.027	1.608	0.491	1.671	0.510	2.652	0.808
4	21.15	41740	7	1.96	0.077	5.89	0.232	27.19	0.042	1.010	0.308	1.053	0.321	1.666	0.508

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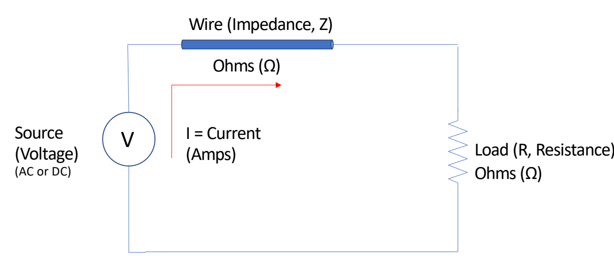
Circuits



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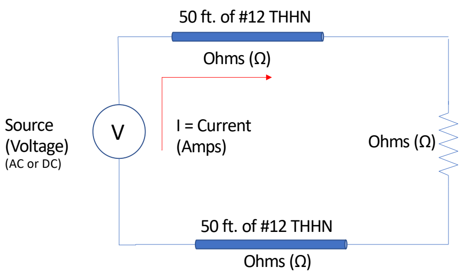
Resistance of Wire



Conductor Resistance

Each 12 AWG is 50 ft x 2 wires = 100 ft in circuit

To determine the resistance of 100 ft of 12 AWG
NEC Chapter 9, Table 9, 1,000 ft of 12 AWG = 2 ohms
2 ohms/1,000 ft = 0.002 ohms per ft
0.002 ohms per ft x 100 ft = 0.20 ohms for 100 ft

100 ft. total wire length

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Pin Header

Table 8 Conductor Properties

Size (AWG or kcmil)	Area mm²	Area Circular mils	Conductors Stranding Quantity	Stranding Diameter mm	Stranding Diameter in.	Overall Diameter mm	Overall Diameter in.	Overall Area mm²	Overall Area in.²	Copper Uncoated ohm/km	Copper Uncoated ohm/kFT	Copper Coated ohm/km	Copper Coated ohm/kFT	Aluminum ohm/km	Aluminum ohm/kFT
18	0.823	1620	1	—	—	1.02	0.040	0.823	0.001	25.5	7.77	26.5	8.08	42.0	12.8
18	0.823	1620	7	0.39	0.015	1.16	0.046	1.06	0.002	26.1	7.95	27.7	8.45	42.8	13.1
16	1.31	2580	1	—	—	1.29	0.051	1.31	0.002	16.0	4.89	16.7	5.08	26.4	8.05
16	1.31	2580	7	0.49	0.019	1.46	0.058	1.68	0.003	16.4	4.99	17.3	5.29	26.9	8.21
14	2.08	4110	1	—	—	1.63	0.064	2.08	0.003	10.1	3.07	10.4	3.19	16.6	5.06
14	2.08	4110	7	0.62	0.024	1.85	0.073	2.68	0.004	10.3	3.14	10.7	3.26	16.9	5.17
12	3.31	6530	1	—	—	2.05	0.081	3.31	0.005	6.34	1.93	6.57	2.01	10.45	3.18
12	3.31	6530	7	0.78	0.030	2.32	0.092	4.25	0.006	6.50	1.98	6.73	2.05	10.69	3.25
10	5.261	10380	1	—	—	2.588	0.102	5.26	0.008	3.984	1.21	4.148	1.26	6.561	2.00
10	5.261	10380	7	0.98	0.038	2.95	0.116	6.76	0.011	4.070	1.24	4.226	1.29	6.679	2.04
8	8.367	16510	1	—	—	3.264	0.128	8.37	0.013	2.506	0.764	2.579	0.786	4.125	1.26
8	8.367	16510	7	1.23	0.049	3.71	0.146	10.76	0.017	2.551	0.778	2.653	0.809	4.204	1.28
6	13.30	26240	7	1.56	0.061	4.67	0.184	17.09	0.027	1.608	0.491	1.671	0.510	2.652	0.808
4	21.15	41740	7	1.96	0.077	5.89	0.232	27.19	0.042	1.010	0.308	1.053	0.321	1.666	0.508

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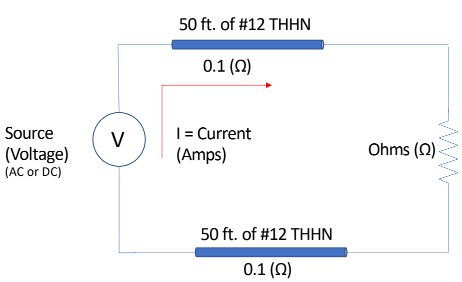
Resistance of Wire



Conductor Resistance

Each 12 AWG is 50 ft x 2 wires = 100 ft in circuit

To determine the resistance of 100 ft of 12 AWG
NEC Chapter 9, Table 9, 1,000 ft of 12 AWG = 2 ohms
2 ohms/1,000 ft = 0.002 ohms per ft
0.002 ohms per ft x 100 ft = 0.20 ohms for 100 ft

100 ft. total wire length
0.1 ohms + 0.1 ohms = 0.2 ohms

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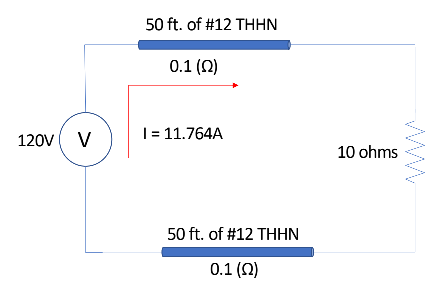
Voltage Drop of Wire



$I = V/R$
$I = 120/(R_{wire} + R_{load})$
$I = 120/(0.2 + 10) = 120/10.2 = 11.764$ Amps

Voltage drop across wire = $I \times R_{wire}$
$V_{drop} = 11.764 \times 0.2 = 2.35V$

100 ft. total wire length
0.1 ohms + 0.1 ohms = 0.2 ohms

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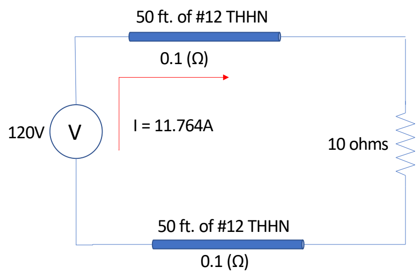
120

%Voltage Drop of Wire



100 ft. total wire length
0.1 ohms + 0.1 ohms = 0.2 ohms

I = V/R
$I = 120/(R_{wire} + R_{load})$
I = 120/(0.2 +10) = 120/10.2 = 11.764 Amps

Voltage drop across wire = I x R_{wire}
V_{drop} = 11.764 x 0.2 = 2.35V

% Voltage Drop of Wire = 2.35V/120V =0.0195

Convert to a percentage: 0.0195 x 100 = 1.95%

Compare:
1.95% less than recommended 3% from branch
Circuit breaker to load.

Therefore Voltage Drop is acceptable

121

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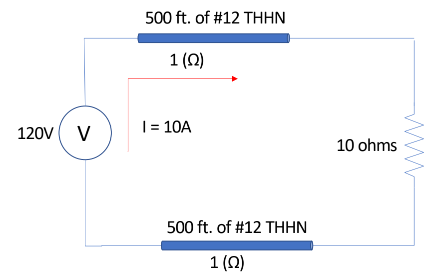
%Voltage Drop of Wire – Longer Wire



Chapter 9, Table 8:
- 2 ohms/1000 ft
- 1000 ft x 2 ohms/1000 ft = 2 ohms

I = V/R
$I = 120/(R_{wire} + R_{load})$
I = 120/(2 +10) = 120/12 = 10 Amps

Voltage drop across wire = I x R_{wire}
V_{drop} = 10 x 2 = 20V

% Voltage Drop of Wire = 20V/120V =0.167

Convert to a percentage: 0.167 x 100 = 16.67%

Compare:
16.67% more than recommended 3% from branch
Circuit breaker to load.

Therefore Voltage Drop is **not acceptable**

Try larger wire and/or shorter runs

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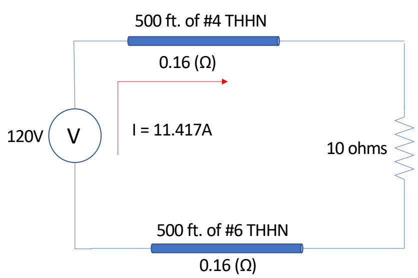
%Voltage Drop of Wire – Larger Wire



Chapter 9, Table 8:
- 0.321 ohms/1000 ft (note lower resistance!)
- 1000 ft x 0.321 ohms/1000 ft = 0.321 ohms
- For each wire segment: 0.321/2 = 0.16

I = V/R
$I = 120/(R_{wire} + R_{load})$
I = 120/(0.321 +10) = 120/10.321 = 11.626 Amps

Voltage drop across wire = I x R_{wire}
V_{drop} = 11.626 x 0.321 = 3.73 V

% Voltage Drop of Wire = 3.73V/120V =0.031

Convert to a percentage: 0.031 x 100 = 3.1%

Compare:
3.1 % is slightly more than 3% from branch
Circuit breaker to load recommendation

Therefore Voltage Drop may be acceptable.

Judgement call

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Table 8 Conductor Properties

Size (AWG or kcmil)	Conductors: Area mm²	Conductors: Area Circular mils	Stranding: Quantity	Stranding: Diameter mm	Stranding: Diameter in.	Overall: Diameter mm	Overall: Diameter in.	Overall: Area mm²	Overall: Area in.²	DC Resistance at 75°C (167°F), Copper Uncoated ohm/km	Copper Uncoated ohm/kFT	Copper Coated ohm/km	Copper Coated ohm/kFT	Aluminum ohm/km	Aluminum ohm/kFT
18	0.823	1620	1	—	—	1.02	0.040	0.823	0.001	25.5	7.77	26.5	8.08	42.0	12.8
18	0.823	1620	7	0.39	0.015	1.16	0.046	1.06	0.002	26.1	7.95	27.7	8.45	42.8	13.1
16	1.31	2580	1	—	—	1.29	0.051	1.31	0.002	16.0	4.89	16.7	5.08	26.4	8.05
16	1.31	2580	7	0.49	0.019	1.46	0.058	1.68	0.003	16.4	4.99	17.3	5.29	26.9	8.21
14	2.08	4110	1	—	—	1.63	0.064	2.08	0.003	10.1	3.07	10.4	3.19	16.6	5.06
14	2.08	4110	7	0.62	0.024	1.85	0.073	2.68	0.004	10.3	3.14	10.7	3.26	16.9	5.17
12	3.31	6530	1	—	—	2.05	0.081	3.31	0.005	6.34	1.93	6.57	2.01	10.45	3.18
12	3.31	6530	7	0.78	0.030	2.32	0.092	4.25	0.006	6.50	1.98	6.73	2.05	10.69	3.25
10	5.261	10380	1	—	—	2.588	0.102	5.26	0.008	3.984	1.21	4.148	1.26	6.561	2.00
10	5.261	10380	7	0.98	0.038	2.95	0.116	6.76	0.011	4.070	1.24	4.226	1.29	6.679	2.04
8	8.367	16510	1	—	—	3.264	0.128	8.37	0.013	2.506	0.764	2.579	0.786	4.125	1.26
8	8.367	16510	7	1.23	0.049	3.71	0.146	10.76	0.017	2.551	0.778	2.653	0.809	4.204	1.28
6	13.30	26240	7	1.56	0.061	4.67	0.184	17.09	0.027	1.608	0.491	1.671	0.510	2.652	0.808
4	21.15	41740	7	1.96	0.077	5.89	0.232	27.19	0.042	1.010	0.308	1.053	0.321	1.666	0.508

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Conduit Fill

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Conduit Fill

- Table 1 of Chapter 9 in the NEC lists the maximum fill of conduit based on the size of the conductors it contains

Chapter 9, Table 1 Maximum Percent Conduit Fill	
Number of Conductors	Percent Fill Permitted
1 Conductors	53%
2 Conductors	31%
3 or more conductors	40%

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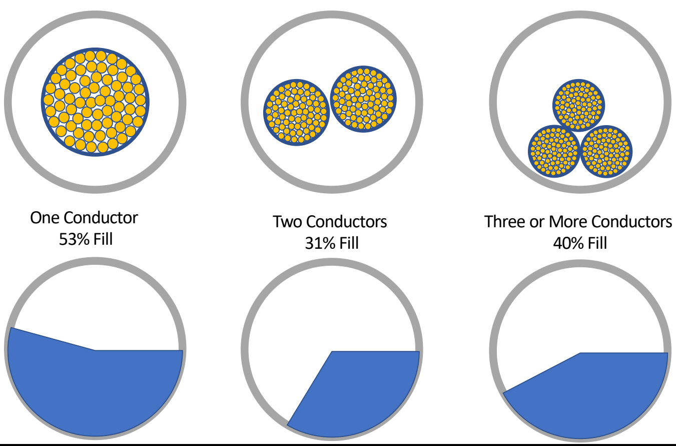
Conduit Fill



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Conduit Fill

- All conductors counted, including equipment grounding conductors, bonding conductors and neutrals (Table 9, note 3)
  - Different than when calculating "ampacity" where EGC and some neutrals not counted.
- Exception for conduit nipples 24 inches or less (Table 9, note 4).
  - 60% fill allowed

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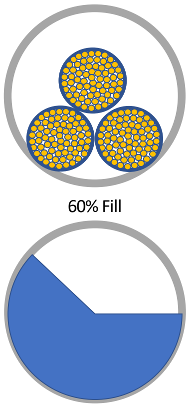
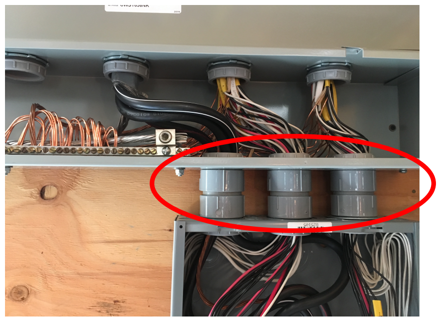
Conductor Fill for Nipples 24 inches or less





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Quiz

- What's the cross sectional area of permitted conductor fill for a trade size 1" EMT conduit that is 30 inches long containing four conductors?
- Answer:
  - We know that since it is not a nipple (24" or less) and it has more than 3 conductors, the 40% max fill limit is applicable
  - Check Chapter 9, Table 4 for EMT, 40% column
  - 0.346 sq. inches

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Table 4 Dimensions and Percent Area of Conduit and Tubing (Areas of Conduit or Tubing for the Combinations of Wires Permitted in Table 1, Chapter 9)

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%	
		mm^2	$in.^2$	mm^2	$in.^2$	mm^2	$in.^2$	mm^2	$in.^2$	mm	in.	mm^2	$in.^2$
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

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Quiz (Alternative Solution)

- What's the cross sectional area of permitted conductor fill for a trade size 1" EMT conduit that is 30 inches long containing four conductors?
- Answer:
  - We know that since it is not a nipple (24" or less) and it has more than 3 conductors, the 40% max fill limit is applicable
  - Check Chapter 9, Table 4 for EMT, Total Area column (last column)
  - 0.864" for total area of 1" EMT
  - 0.864 x 40% = 0.864 x 0.40 = 0.3456 = 0.346 sq. inches

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Table 4 Dimensions and Percent Area of Conduit and Tubing (Areas of Conduit or Tubing for the Combinations of Wires Permitted in Table 1, Chapter 9)

Article 358 — Electrical Metallic Tubing (EMT)

		Over 2 Wires 40%		60%		1 Wire 53%		2 Wires 31%		Nominal Internal Diameter		Total Area 100%	
Metric Designator	Trade Size	mm^2	$in.^2$	mm^2	$in.^2$	mm^2	$in.^2$	mm^2	$in.^2$	mm	in.	mm^2	$in.^2$
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

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Conduit Fill – Same Size Conductors

- If all of the conductors are the same size, use Annex C in the NEC to size conduit fill

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Informative Annex C — Conduit, Tubing, and Cable Tray Fill Tables for Conductors and Fixture Wires of the Same Size

Table

- C.1 — Electrical Metallic Tubing (EMT)
- C.1(A)* — Electrical Metallic Tubing (EMT)
- C.2 — Electrical Nonmetallic Tubing (ENT)
- C.2(A)* — Electrical Nonmetallic Tubing (ENT)
- C.3 — Flexible Metal Conduit (FMC)
- C.3(A)* — Flexible Metal Conduit (FMC)
- C.4 — Intermediate Metal Conduit (IMC)
- C.4(A)* — Intermediate Metal Conduit (IMC)
- C.5 — Liquidtight Flexible Nonmetallic Conduit (Type LFNC-A)
- C.5(A)* — Liquidtight Flexible Nonmetallic Conduit (Type LFNC-A)
- C.6 — Liquidtight Flexible Nonmetallic Conduit (Type LFNC-B)
- C.6(A)* — Liquidtight Flexible Nonmetallic Conduit (Type LFNC-B)
- C.7 — Liquidtight Flexible Nonmetallic Conduit (Type LFNC-C)
- C.7(A) — Liquidtight Flexible Nonmetallic Conduit (Type LFNC-C)
- C.8 — Liquidtight Flexible Metal Conduit (LFMC)
- C.8(A)* — Liquidtight Flexible Metal Conduit (LFMC)
- C.9 — Rigid Metal Conduit (RMC)

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Conduit Fill Example – Same Size Conductors

- What is the minimum size EMT conduit required for the following conductors?
- (5) #12 THHN conductors

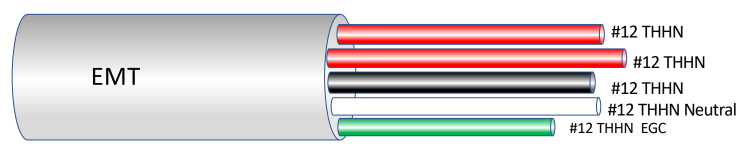

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Table C.1 Maximum Number of Conductors or Fixture Wires in Electrical Metallic Tubing (EMT) (Based on Chapter 9: Table 1, Table 4, and Table 5)

Type	Conductor Size (AWG/kcmil)	Trade Size (Metric Designator) 3/8 (12)	1/2 (16)	3/4 (21)	1 (27)	1 1/4 (35)	1 1/2 (41)	2 (53)	2 1/2 (63)	3 (78)	3 1/2 (91)	4 (103)	5 (129)	6 (155)
CONDUCTORS														
THHN, THWN, THWN-2	14	–	12	22	35	61	84	138	241	364	476	608	–	–
	12	–	9	16	26	45	61	101	176	266	347	443	–	–
	10	–	5	10	16	28	38	63	111	167	219	279	–	–
	8	–	3	6	9	16	22	36	64	96	126	161	–	–
	6	–	2	4	7	12	16	26	46	69	91	116	–	–
	4	–	1	2	4	7	10	16	28	43	56	71	–	–
	3	–	1	1	3	6	8	13	24	36	47	60	–	–
	2	–	1	1	3	5	7	11	20	30	40	51	–	–
	1	–	1	1	1	4	5	8	15	22	29	37	–	–
	1/0	–	1	1	1	3	4	7	12	19	25	32	–	–
	2/0	–	0	1	1	2	3	6	10	16	20	26	–	–
	3/0	–	0	1	1	1	3	5	8	13	17	22	–	–
	4/0	–	0	1	1	1	2	4	7	11	14	18	–	–
	250	–	0	0	1	1	1	3	6	9	11	15	–	–
	300	–	0	0	1	1	1	3	5	7	10	13	–	–
	350	–	0	0	1	1	1	2	4	6	9	11	–	–
	400	–	0	0	0	1	1	1	4	6	8	10	–	–
	500	–	0	0	0	1	1	1	3	5	6	8	–	–

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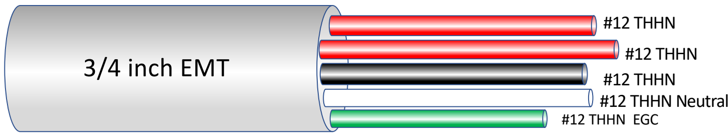
Conduit Fill Example – Same Size Conductors

- According to Chapter 9, table 4 table for THHN wire in EMT conduit, a maximum of 9 conductors can be installed in 1/2" conduit
- Since 5 is less than 9, 1/2" conduit is the minimum size conduit that can be used



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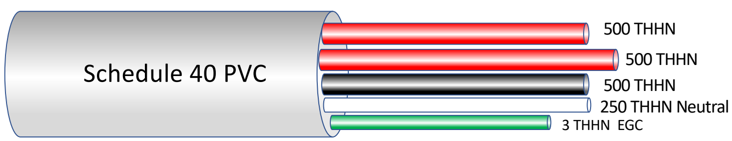
Conduit Fill Example –Different Size Conductors

- What is the minimum size Schedule 40 PVC conduit required for the following conductors?



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Conduit Fill Example –Different Size Conductors

- Refer to Chapter 9, Table 5 for THHN Wire

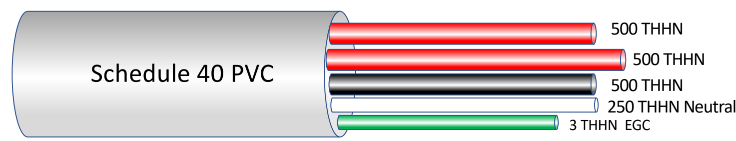

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Table 5 Dimensions of Insulated Conductors and Fixture Wires

Type	Size (AWG or kcmil)	Approximate Area mm²	Approximate Area in.²	Approximate Diameter mm	Approximate Diameter in.
THHN, THWN, THWN-2	14	6.258	0.0097	2.819	0.111
	12	8.581	0.0133	3.302	0.130
	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
	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	256.1	0.3970	18.06	0.711
	300	297.3	0.4608	19.46	0.766
Type: FEP, FEPB, PAF, PAFF, PF, PFA, PFAH, PFF, PGF, PGFF, PTF, PTFF, TFE, THHN, THWN, THWN-2, Z, ZF, ZFF, ZHF					
THHN, THWN, THWN-2	350	338.2	0.5242	20.75	0.817
	400	378.3	0.5863	21.95	0.864
	500	456.3	0.7073	24.10	0.949

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Conduit Fill Example –Different Size Conductors

- Refer to Chapter 9, Table 5 for THHN Wire
- (1) 500 THHN = 0.7073 in^2 x 3 conductors = 2.1219 in^2
- (1) 250 THHN = 0.3970 in^2 x 1 conductors = 0.3970 in^2
- (1) 3 THHN = 0.0973 in^2 x 1 conductors = 0.0973 in^2

Total Area of Conductors = 2.6162 in^2

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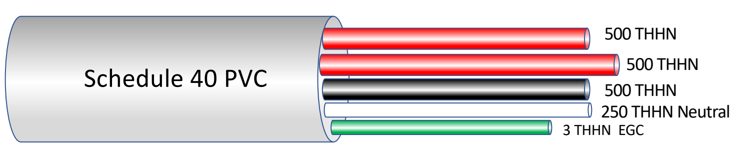
Conduit Fill Example –Different Size Conductors

- Refer to Chapter 9, Table 4 (PVC), 40% fill
- Total Area of Conductors = 2.6162 in^2
- Area of conduit used for wiring must be larger than 2.6162 in^2 in 40% column



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Articles 352 and 353 — Rigid PVC Conduit (PVC), Schedule 40, and HDPE Conduit (HDPE)

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	74	0.114	110	0.171	97	0.151	57	0.088	15.3	0.602	184	0.285
21	3/4	131	0.203	196	0.305	173	0.269	101	0.157	20.4	0.804	327	0.508
27	1	214	0.333	321	0.499	284	0.441	166	0.258	26.1	1.029	535	0.832
35	1 1/4	374	0.581	561	0.872	495	0.770	290	0.450	34.5	1.360	935	1.453
41	1 1/2	513	0.794	769	1.191	679	1.052	397	0.616	40.4	1.590	1282	1.986
53	2	849	1.316	1274	1.975	1126	1.744	658	1.020	52.0	2.047	2124	3.291
63	2 1/2	1212	1.878	1817	2.817	1605	2.488	939	1.455	62.1	2.445	3029	4.695
78	3	1877	2.907	2816	4.361	2487	3.852	1455	2.253	77.3	3.042	4693	7.268
91	3 1/2	2511	3.895	3766	5.842	3327	5.161	1946	3.018	89.4	3.521	6277	9.737
103	4	3237	5.022	4855	7.532	4288	6.654	2508	3.892	101.5	3.998	8091	12.554
129	5	5099	7.904	7649	11.856	6756	10.473	3952	6.126	127.4	5.016	12748	19.761
155	6	7373	11.427	11060	17.140	9770	15.141	5714	8.856	153.2	6.031	18433	28.567

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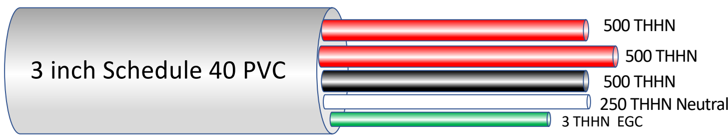
Conduit Fill Example –Different Size Conductors

- Refer to Chapter 9, Table 4 (PVC), 40% fill
- Total Area of Conductors = 2.6162 in^2
- Area of conduit used for wiring must be larger than 2.6162 in^2 in 40% column
- 2.907 in^2 is larger than 2.6162 in^2, so 3 in. conduit is the minimum size that can be used



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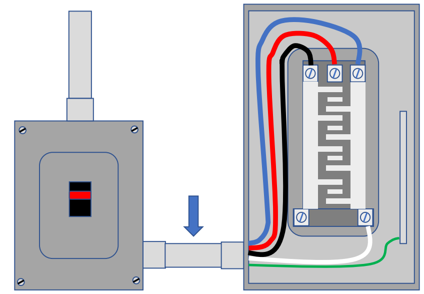
Conduit Nipple Conduit Fill



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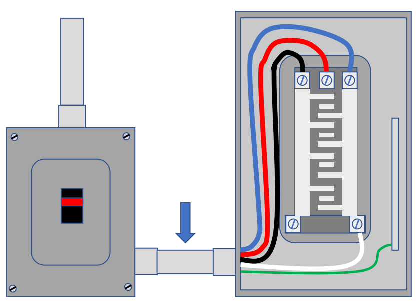
Conduit Nipple Conduit Fill Example

- What's the minimum trade size RMC nipple required for three, 3/0 THHN conductors, one 1 THHN conductor, and one 6 THHN conductor?



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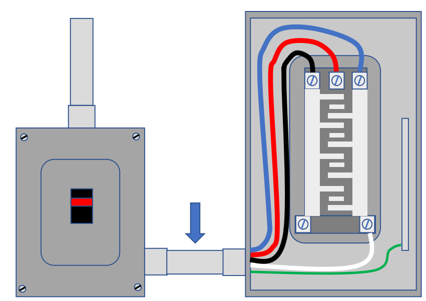
Conduit Nipple Conduit Fill Example

- Since the raceway is a nipple less than 24 inches in length, it can be filled up to 60%
- Use Table 5 in Chapter 9 to obtain area of THHN conductors



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Type	Size (AWG or kcmil)	Approximate Area mm²	Approximate Area in.²	Approximate Diameter mm	Approximate Diameter in.
THHN, THWN, THWN-2	14	6.258	0.0097	2.819	0.111
	12	8.581	0.0133	3.302	0.130
	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
	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	256.1	0.3970	18.06	0.711
	300	297.3	0.4608	19.46	0.766
Type: FEP, FEPB, PAF, PAFF, PF, PFA, PFAH, PFF, PGF, PGFF, PTF, PTFF, TFE, THHN, THWN, THWN-2, Z, ZF, ZFF, ZHF					
THHN, THWN, THWN-2	350	338.2	0.5242	20.75	0.817
	400	378.3	0.5863	21.95	0.864
	500	456.3	0.7073	24.10	0.949

Table 5 Dimensions of Insulated Conductors and Fixture Wires

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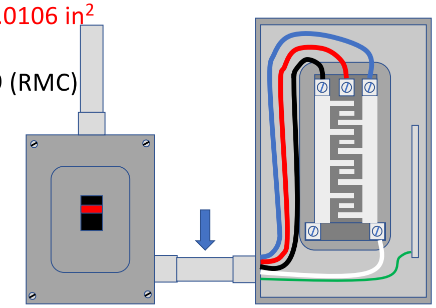
Conduit Nipple Conduit Fill Example

- 1 - 3/0 THHN = 0.2679 in^2 x 3 conductors = 0.8037 in^2
- 1 - #1 THHN = 0.1562 in^2 x 1 conductor = 0.1562 in^2
- 1 - #6 THHN = 0.0507 in^2 x 1 conductor = 0.0507 in^2
- Total area of conductors = 1.0106 in^2
- Refer to Table 4 in Chapter 9 (RMC)



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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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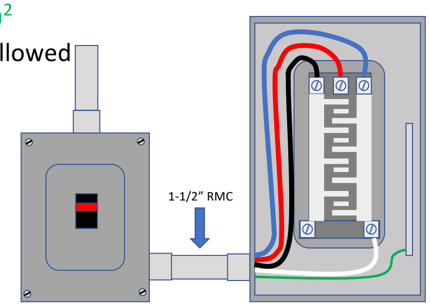
Conduit Nipple Conduit Fill Example

- Total area of conductors = 1.0106 in^2
- Refer to Table 4 in Chapter 9 (RMC)
- 60% fill of a 1-1/4" conduit = 0.916 in^2 ➡ Too small!
- 60% fill of a 1-1/2" conduit = 1.2453 in^2
- Therefore 1-1/2" conduit is min. size allowed



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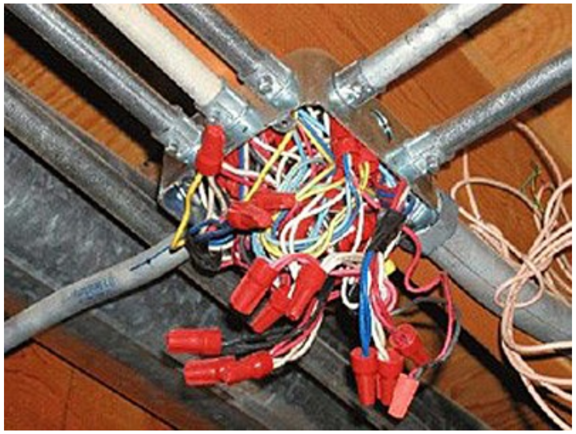

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Outlet Box Fill (NEC 314.16) All Conductors Same Size

- Insulation type does not matter
- Use Table 314.16(A) to:
  - Determine the number of conductors permitted in the outlet box
  - Determine outlet box size required for the given number of conductors
- Outlet Box Sizing [314.16(A)]
  - https://www.youtube.com/embed/bVQO7B_EWHg

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Pin Header

Table 314.16(A) Metal Boxes

Box Trade Size			Minimum Volume		Maximum Number of Conductors* (arranged by AWG size)						
mm	in.		cm³	in.³	18	16	14	12	10	8	6
100 × 32	$(4 \times 1\frac{1}{4})$	round/octagonal	205	12.5	8	7	6	5	5	5	2
100 × 38	$(4 \times 1\frac{1}{2})$	round/octagonal	254	15.5	10	8	7	6	6	5	3
100 × 54	$(4 \times 2\frac{1}{8})$	round/octagonal	353	21.5	14	12	10	9	8	7	4
100 × 32	$(4 \times 1\frac{1}{4})$	square	295	18.0	12	10	9	8	7	6	3
100 × 38	$(4 \times 1\frac{1}{2})$	square	344	21.0	14	12	10	9	8	7	4
100 × 54	$(4 \times 2\frac{1}{8})$	square	497	30.3	20	17	15	13	12	10	6
120 × 32	$(4\frac{11}{16} \times 1\frac{1}{4})$	square	418	25.5	17	14	12	11	10	8	5
120 × 38	$(4\frac{11}{16} \times 1\frac{1}{2})$	square	484	29.5	19	16	14	13	11	9	5
120 × 54	$(4\frac{11}{16} \times 2\frac{1}{8})$	square	689	42.0	28	24	21	18	16	14	8
75 × 50 × 38	$(3 \times 2 \times 1\frac{1}{2})$	device	123	7.5	5	4	3	3	3	2	1
75 × 50 × 50	$(3 \times 2 \times 2)$	device	164	10.0	6	5	5	4	4	3	2
75× 50 × 57	$(3 \times 2 \times 2\frac{1}{4})$	device	172	10.5	7	6	5	4	4	3	2
75 × 50 × 65	$(3 \times 2 \times 2\frac{1}{2})$	device	205	12.5	8	7	6	5	5	4	2
75 × 50 × 70	$(3 \times 2 \times 2\frac{3}{4})$	device	230	14.0	9	8	7	6	5	4	2

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Pin Header

Table 314.16(A) Metal Boxes

Box Trade Size			Minimum Volume		Maximum Number of Conductors* (arranged by AWG size)						
mm	in.		cm³	in.³	18	16	14	12	10	8	6
75 × 50 × 38	$(3 \times 2 \times 1\frac{1}{2})$	device	123	7.5	5	4	3	3	3	2	1
75 × 50 × 50	$(3 \times 2 \times 2)$	device	164	10.0	6	5	5	4	4	3	2
75× 50 × 57	$(3 \times 2 \times 2\frac{1}{4})$	device	172	10.5	7	6	5	4	4	3	2
75 × 50 × 65	$(3 \times 2 \times 2\frac{1}{2})$	device	205	12.5	8	7	6	5	5	4	2
75 × 50 × 70	$(3 \times 2 \times 2\frac{3}{4})$	device	230	14.0	9	8	7	6	5	4	2
75 × 50 × 90	$(3 \times 2 \times 3\frac{1}{2})$	device	295	18.0	12	10	9	8	7	6	3
100 × 54 × 38	$(4 \times 2\frac{1}{8} \times 1\frac{1}{2})$	device	169	10.3	6	5	5	4	4	3	2
100 × 54 × 48	$(4 \times 2\frac{1}{8} \times 1\frac{7}{8})$	device	213	13.0	8	7	6	5	5	4	2
100 × 54 × 54	$(4 \times 2\frac{1}{8} \times 2\frac{1}{8})$	device	238	14.5	9	8	7	6	5	4	2
95 × 50 × 65	$(3\frac{3}{4} \times 2 \times 2\frac{1}{2})$	masonry box/gang	230	14.0	9	8	7	6	5	4	2
95 × 50 × 90	$(3\frac{3}{4} \times 2 \times 3\frac{1}{2})$	masonry box/gang	344	21.0	14	12	10	9	8	7	4
min. 44.5 depth	FS — single cover/gang $(1\frac{3}{4})$		221	13.5	9	7	6	6	5	4	2
min. 60.3 depth	FD — single cover/gang $(2\frac{3}{8})$		295	18.0	12	10	9	8	7	6	3
min. 44.5 depth	FS — multiple cover/gang $(1\frac{3}{4})$		295	18.0	12	10	9	8	7	6	3
min. 60.3 depth	FD — multiple cover/gang $(2\frac{3}{8})$		395	24.0	16	13	12	10	9	8	4

*Where no volume allowances are required by 314.16(B)(2) through (B)(5).

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Box Volume

- Includes:
- Plaster rings
- Raised covers
- Extension rings

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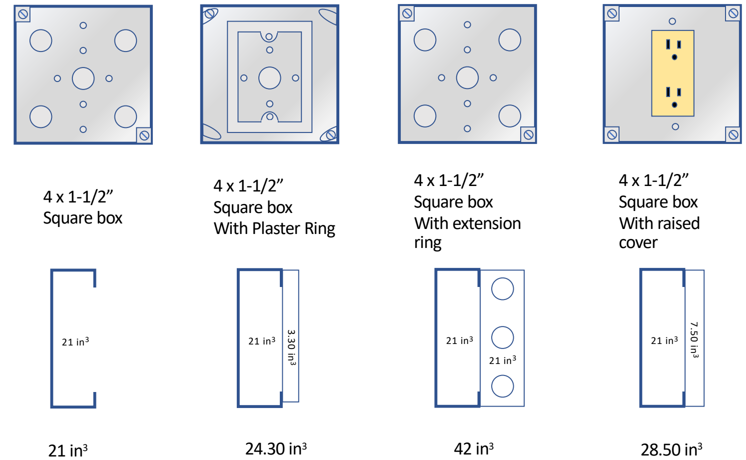

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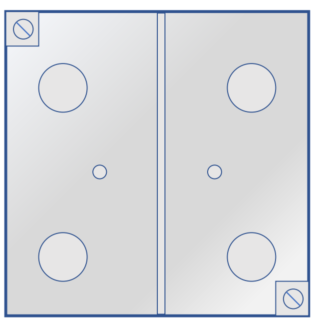
Box With Dividers - Marked [314.16(A)]

- Use volume on barriers to calculate volume if marked



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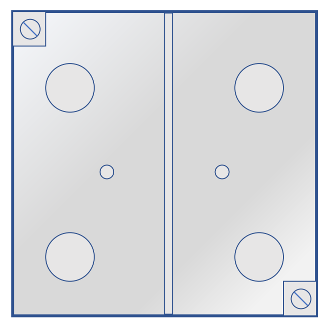
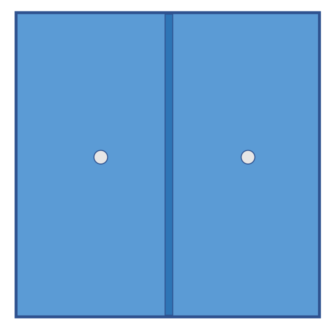
Box With Dividers – Not Marked

- Use ½ in^3 if metallic



- Use 1 in^3 if nonmetallic



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Box Fill Calculations: 314.16(B)

- Not included in calculations:
  - Locknuts
  - Bushings
- Each space within a box with a barrier shall be calculated separately

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Conductor Fill: 314.16(B)(1)

- Counted once:
  - Each conductor that originates outside the box and terminates or is spliced within the box
  - Each conductor that passes through the box without splice or termination
- Counted twice:
  - Each loop or coil of unbroken conductor
- Not counted:
  - No part of which leaves the box

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Conductor Fill: 314.16(B)

- Not counted:
  - Switches
  - Receptacles
  - Luminaire studs or hickeys
  - Cable clamps
  - Equipment grounding conductors

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Table 314.16(B) Volume Allowance Required per Conductor

Conductor AWG	Volume Cubic Inches
18	1.50
16	1.75
14	2.00
12	2.25
10	2.50
8	3.00
6	5.00

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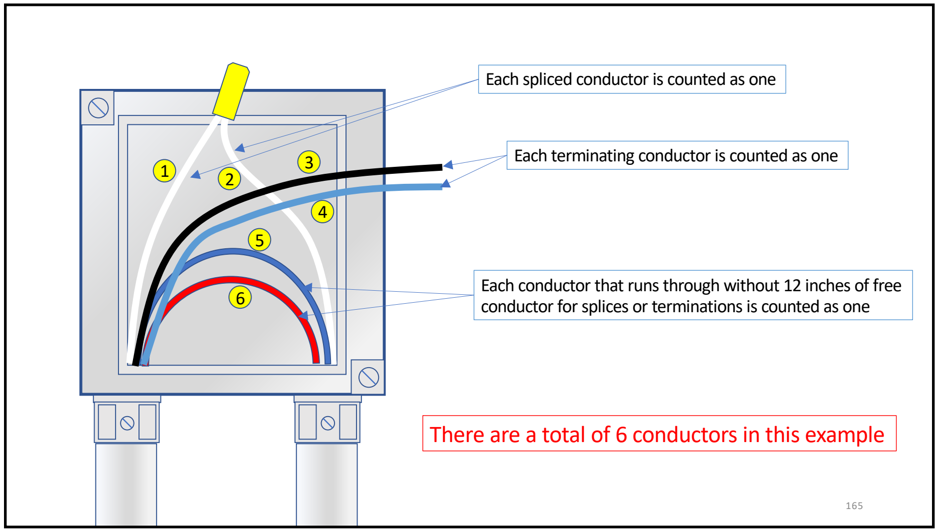

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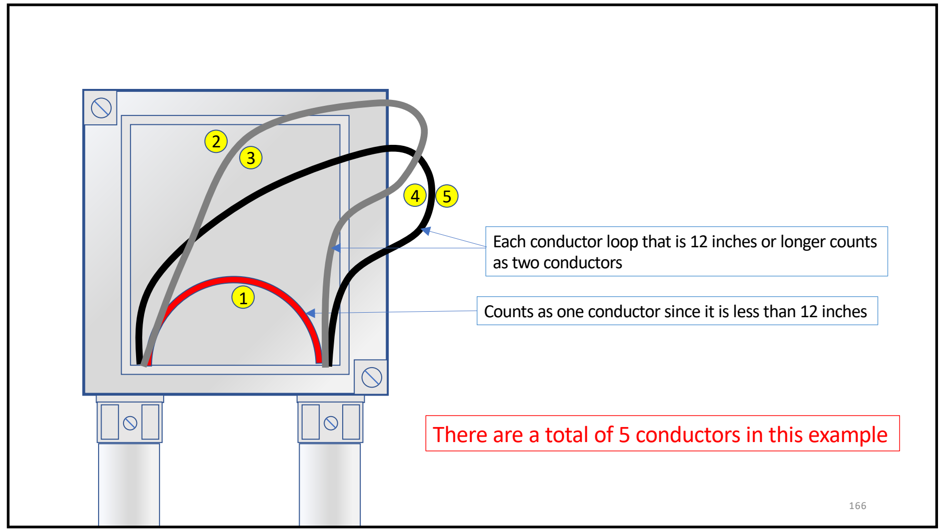

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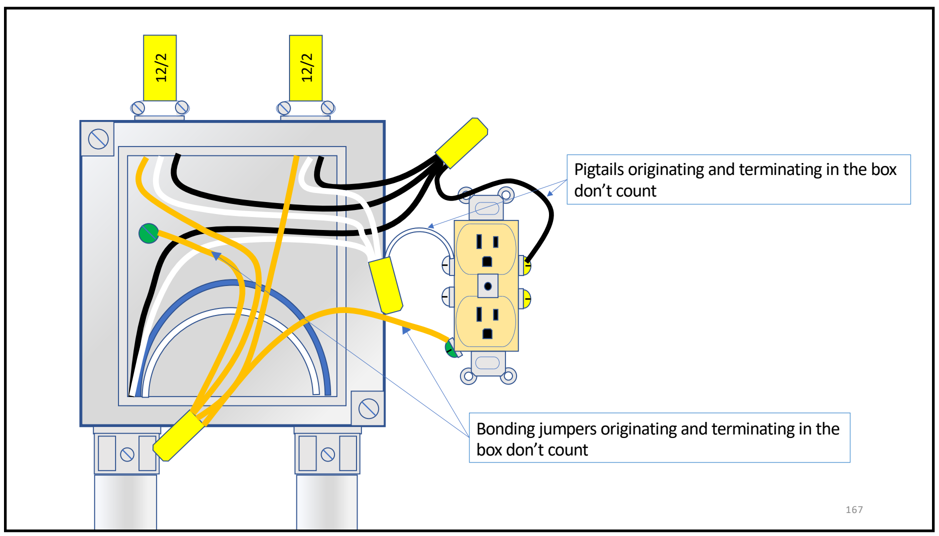

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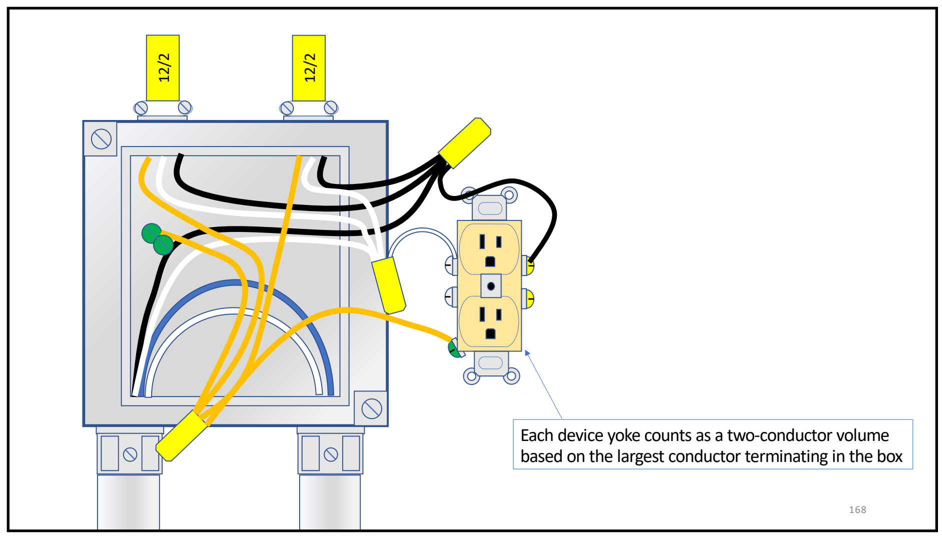

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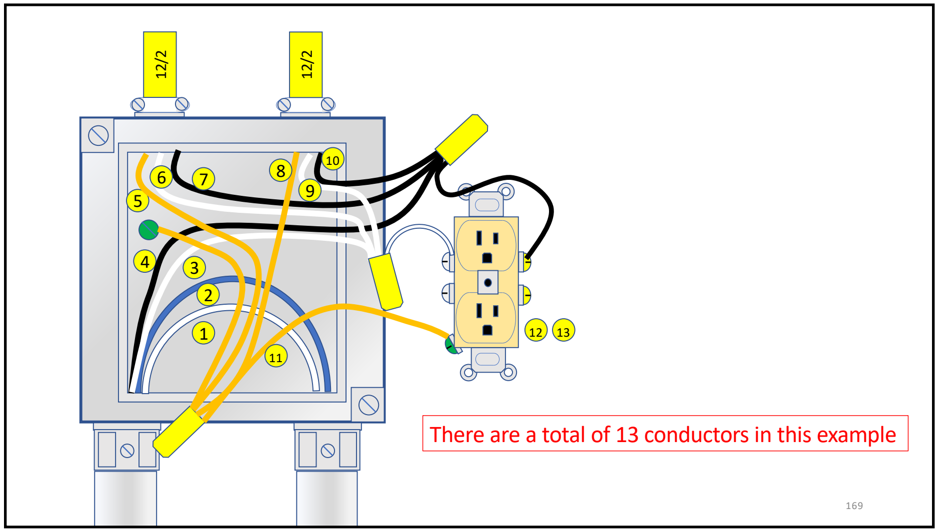

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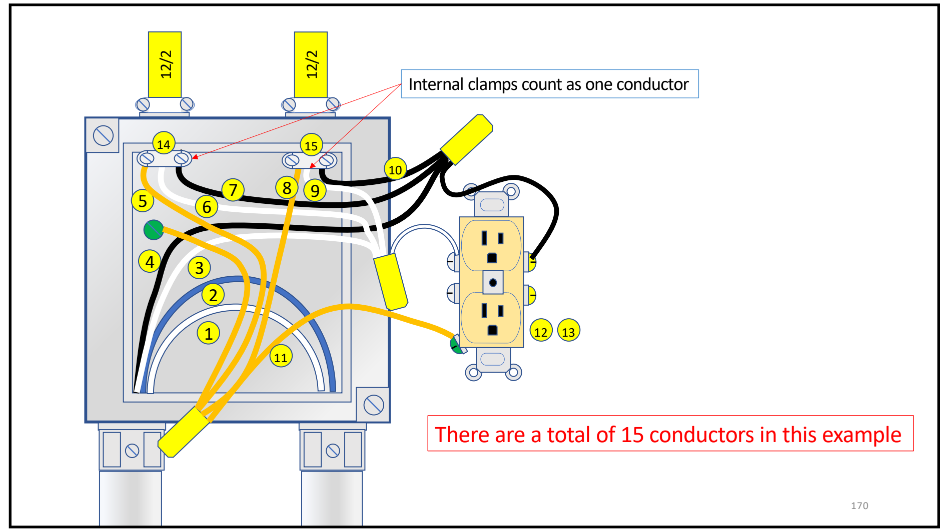

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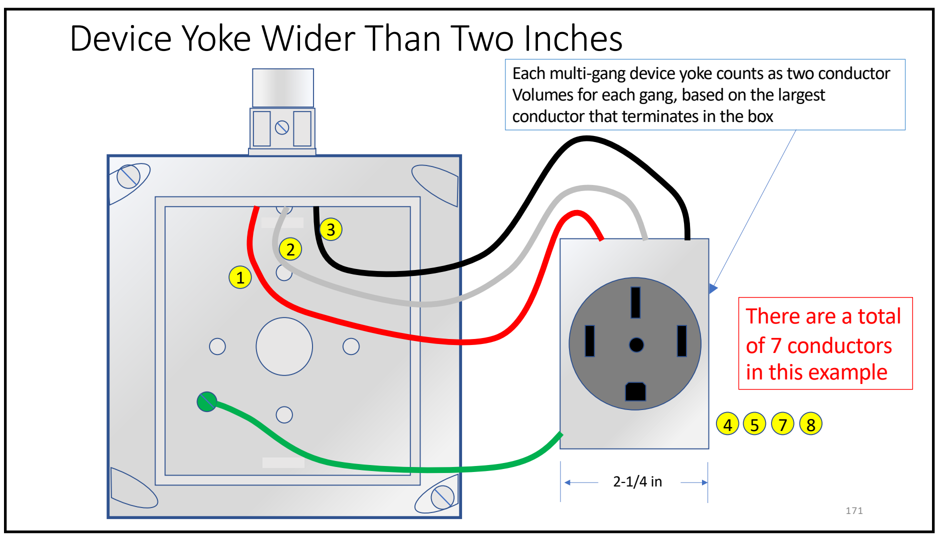

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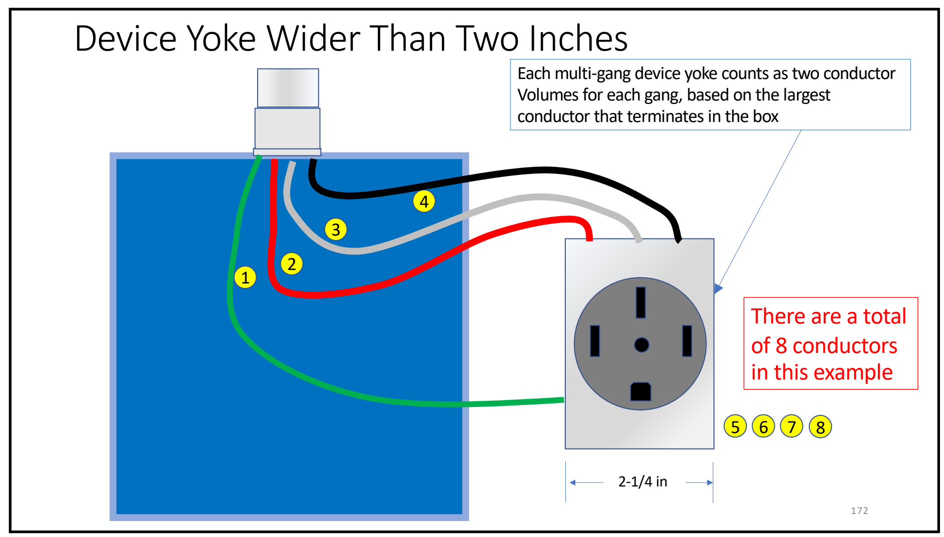

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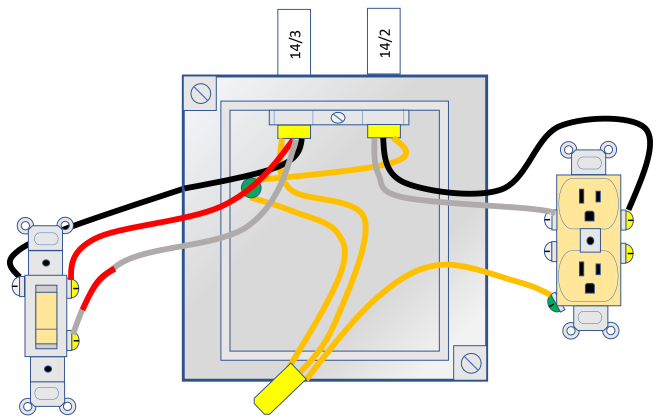
Box Fill Calculations: Same Wire Size



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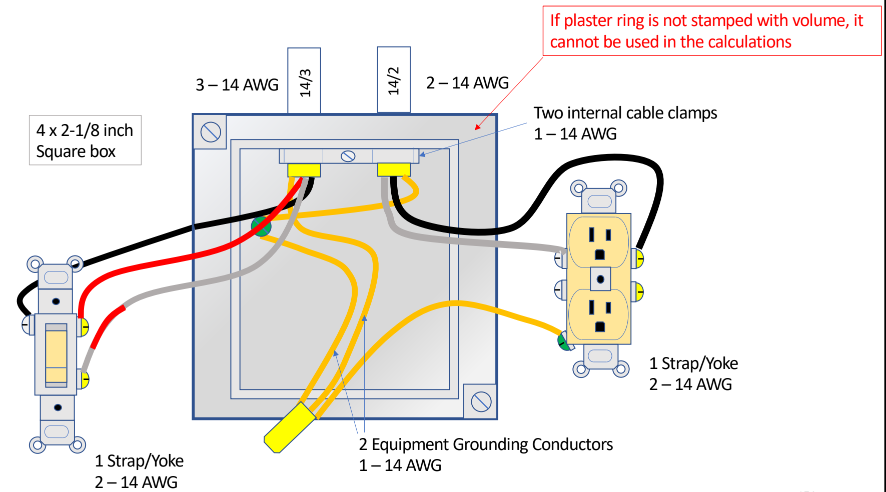

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Box Fill and Box Size Selection

- Determine number of #14 AWG conductors
  - 14/3 NM — 3- 14 AWG conductors
  - 14/2 NM — 2 – 14 AWG conductors
  - Switch — 2 – 14 AWG conductors
  - Cable clamp — 1 - 14 AWG conductors
  - Receptacle — 2 – 14 AWG conductors
  - Equipment Grounding Conductor — 1 - 14 AWG conductors
  - **Total** — **11 – 14 AWG conductors**

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Box Fill and Box Size Selection

- Determine the volume of the #14 AWG conductors
- Reference Table 314.16(B)
  - 14 AWG: 2 cubic inches each
  - 2 cubic inches x 11 conductors = 22.00 cubic inch
  - **Total Volume** **22.00 cubic inch**

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in Header

Table 314.16(B) Volume Allowance Required per Conductor

Size of Conductor (AWG)	Free Space Within Box for Each Conductor	
	cm^3	$in.^3$
18	24.6	1.50
16	28.7	1.75
14	32.8	2.00
12	36.9	2.25
10	41.0	2.50
8	49.2	3.00
6	81.9	5.00

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Box Fill and Box Size Selection

- Select the outlet box from table 314.16(A)
  - A 4-inch x 2-1/8 in. square box can accommodate a maximum of 15, #14 AWG conductors
  - A 4-inch x 1-1/2 inch square box can only accommodate 10 conductors. This is not enough to contain the calculated 11 conductors
  - Therefore, the 4 x 2-1/8 in. square box is the minimum that can be used

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Pin Header

Table 314.16(A) Metal Boxes

Box Trade Size			Minimum Volume		Maximum Number of Conductors* (arranged by AWG size)					
mm	in.		cm^3	$in.^3$	18	16	14	12	10	8
100 × 32	(4 × 1 1/4)	round/octagonal	205	12.5	8	7	6	5	5	5
100 × 38	(4 × 1 1/2)	round/octagonal	254	15.5	10	8	7	6	6	5
100 × 54	(4 × 2 1/8)	round/octagonal	353	21.5	14	12	10	9	8	7
100 × 32	(4× 1 1/4)	square	295	18.0	12	10	9	8	7	6
100 × 38	(4 × 1 1/2)	square	344	21.0	14	12	10	9	8	7
100 × 54	(4 × 2 1/8)	square	497	30.3	20	17	15	13	12	10
120 × 32	(4 11/16 × 1 1/4)	square	418	25.5	17	14	12	11	10	8
120 × 38	(4 11/16 × 1 1/2)	square	484	29.5	19	16	14	13	11	9
120 × 54	(4 11/16 × 2 1/8)	square	689	42.0	28	24	21	18	16	14
75 × 50 × 38	(3 × 2 × 1 1/2)	device	123	7.5	5	4	3	3	3	2
75 × 50 × 50	(3 × 2 × 2)	device	164	10.0	6	5	5	4	4	3
75× 50 × 57	(3× 2 × 2 1/4)	device	172	10.5	7	6	5	4	4	3
75 × 50 × 65	(3 × 2 × 2 1/2)	device	205	12.5	8	7	6	5	5	4
75 × 50 × 70	(3 × 2 × 2 3/4)	device	230	14.0	9	8	7	6	5	4

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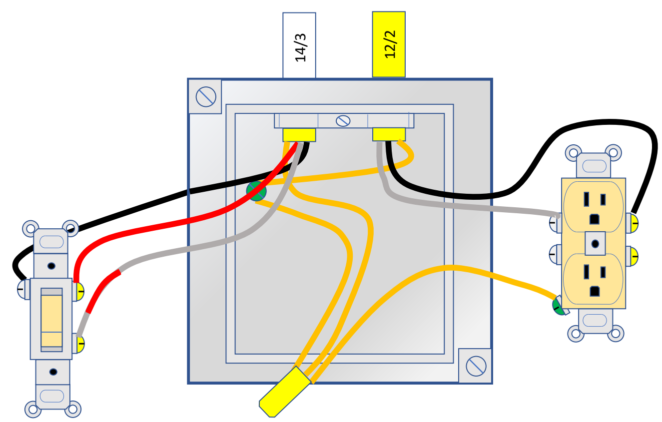
Box Fill Calculations: Different Wire Size



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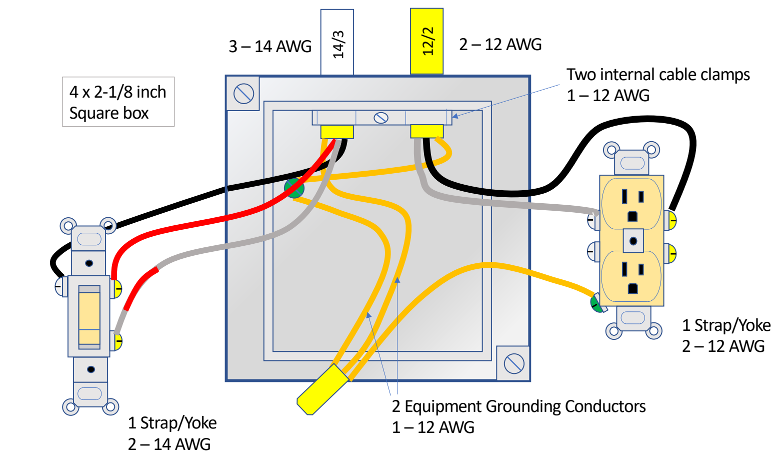

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Box Fill and Box Size Selection

- Determine number of #14 AWG conductors
  - 14/3 NM — 3- 14 AWG conductors
  - Switch — 2 – 14 AWG conductors
  - **Total** — **5 – 14 AWG conductors**
- Determine number of #12 AWG conductors
  - 12/2 NM — 2 – 12AWG conductors
  - Cable clamp — 1 - 12 AWG conductors
  - Receptacle — 2 – 12 AWG conductors
  - Equipment Grounding Conductor — 1 - 12 AWG conductors
  - **Total** — **6 – 12 AWG conductors**

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Box Fill and Box Size Selection

- Determine the volume of the #14 AWG conductors
- Reference Table 314.16(B)
  - 14 AWG: 2 cubic inches each
  - 2 cubic inches x 5 conductors = 10.00 cubic inch
  - 12 AWG: 2.25 cubic inches each
  - 2.25 cubic inches x 6 conductors = 13.50 cubic inch
  - **Total Volume** **23.50 cubic inch**

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in Header — Table 314.16(B) Volume Allowance Required per Conductor

Size of Conductor (AWG)	Free Space Within Box for Each Conductor	
	cm^3	$in.^3$
18	24.6	1.50
16	28.7	1.75
14	32.8	2.00
12	36.9	2.25
10	41.0	2.50
8	49.2	3.00
6	81.9	5.00

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Box Fill and Box Size Selection

- Select the outlet box from table 314.16(A)
  - A 4-inch x 2-1/8 square box: 30.30 cubic inches
  - Is large enough to contain the 23.50 cubic inches calculated above.

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Pin Header

Table 314.16(A) Metal Boxes

Box Trade Size			Minimum Volume		Maximum Number of Conductors* (arranged by AWG size)					
mm	in.		cm^3	$in.^3$	18	16	14	12	10	8
100 × 32	(4 × 1 1/4)	round/octagonal	205	12.5	8	7	6	5	5	5
100 × 38	(4 × 1 1/2)	round/octagonal	254	15.5	10	8	7	6	6	5
100 × 54	(4 × 2 1/8)	round/octagonal	353	21.5	14	12	10	9	8	7
100 × 32	(4× 1 1/4)	square	295	18.0	12	10	9	8	7	6
100 × 38	(4 × 1 1/2)	square	344	21.0	14	12	10	9	8	7
100 × 54	(4 × 2 1/8)	square	497	30.3	20	17	15	13	12	10
120 × 32	(4 11/16 × 1 1/4)	square	418	25.5	17	14	12	11	10	8
120 × 38	(4 11/16 × 1 1/2)	square	484	29.5	19	16	14	13	11	9
120 × 54	(4 11/16 × 2 1/8)	square	689	42.0	28	24	21	18	16	14
75 × 50 × 38	(3 × 2 × 1 1/2)	device	123	7.5	5	4	3	3	3	2
75 × 50 × 50	(3 × 2 × 2)	device	164	10.0	6	5	5	4	4	3
75× 50 × 57	(3× 2 × 2 1/4)	device	172	10.5	7	6	5	4	4	3
75 × 50 × 65	(3 × 2 × 2 1/2)	device	205	12.5	8	7	6	5	5	4
75 × 50 × 70	(3 × 2 × 2 3/4)	device	230	14.0	9	8	7	6	5	4

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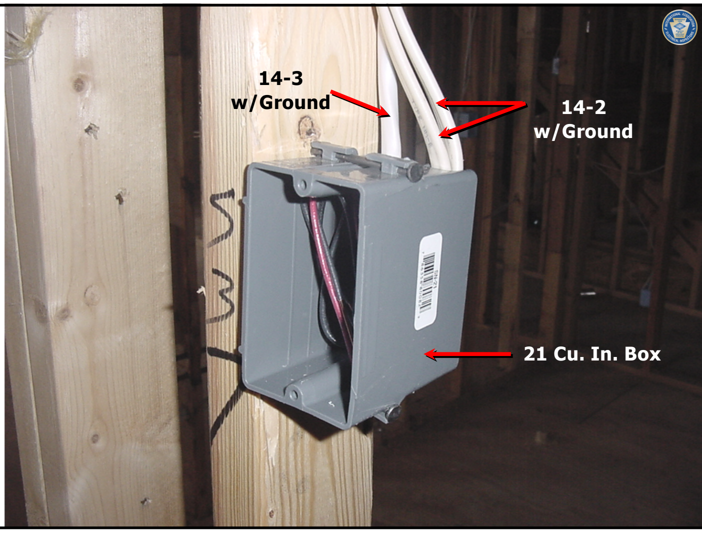

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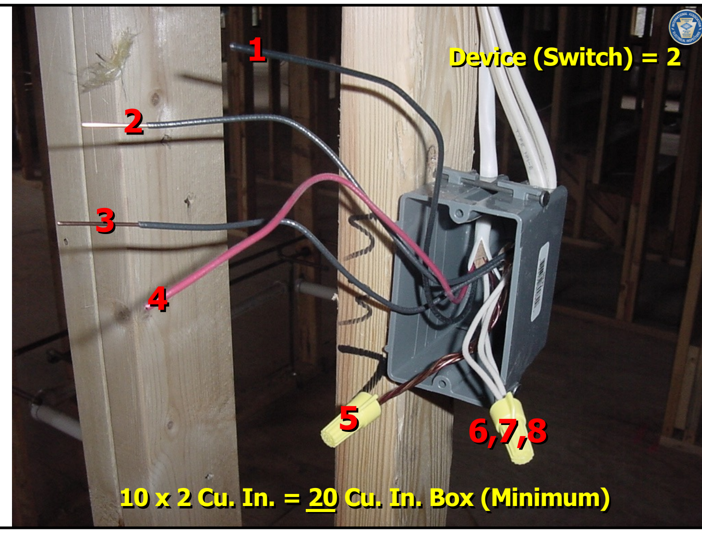

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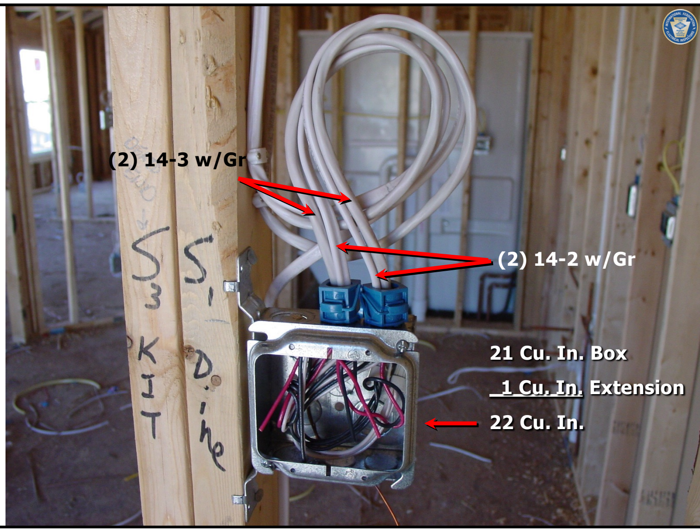

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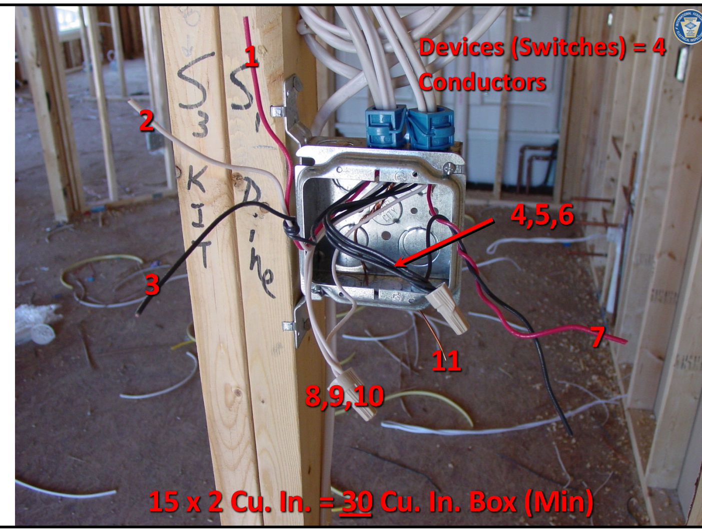

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CONGRATULATIONS!

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Next Steps

- A Certificate of Completion will be emailed to those who successfully completed course
- 4 hours of Code Class Hours will be reported to the OCILB for Code Continuing Education Credits
- Contact instructor at hpmatthews@matthewselectrical.net for any questions or comments
- Make sure you completely sign out of webinar after the next slide!

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File Attachments for Item:

ER-2 2020 NEC Calculations Webinar Part 2 (Matthews Electrical Services)

BO, MPE, EPE, MechPE, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)

Staff Notes: Add NRIUI, recommend approval.

ESIAC Recommendation:

Committee Recommendation:

[redacted]

APPLICATION
FOR
Continuing Education Course Approval

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

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.

COURSE SUBMITTER: Henry Peter Matthews

Course Submitter: Henry Peter Matthews
(Contact Name)

Organization: Matthews Electrical Services
(Organization/Company)

Address: 1203 McKinley Place
(Include Room Number, Suite, etc.)

City: Fostoria State: Ohio Zip: 44830

E-Mail: hpmatthews@matthewselectrical.net

Telephone: 419-575-3488 Fax:

Course Sponsor:

COURSE INFORMATION:

Course Title: NEC Calculations Part 2 Webinar

New Course Submittal: [x] Update Course: [ ] Prior Approval Number:

Purpose and Objective: The objective of this course is to cover the basics of electricity and to review electrical calculations that are required for NEC-compliant installations. This course will follow up on some of the calculations from NEC Electrical Calculations Part 1. This course will review calculations for pull boxes, conductor sizing and protection, voltage drop, residential load and service calculations, tap rules, and motor calculations.

Number of Instructional Contact Hours that can be obtained upon completion: 4

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

Program Applicable for the Following Participants:

- Building Official [x]
- Master Plans Examiner [x]
- Plumbing Plans Exam. [ ]
- Electrical Plans Exam. [x]
- Mechanical Plans Exam. [x]
- Building Inspector [x]
- Fire Protection Inspector [ ]
- Mechanical Inspector [x]
- Plumbing Inspector [ ]
- Non-Res IU Inspector [ ]

- Res Building Official [x]
- Res Plans Examiner [x]
- Res Building Inspector [x]
- Res Mechanical Inspector [x]
- Res IU Inspector [x]

Electrical Safety Inspectors [ ]
Location of ESI Course: www.matthewselectricalservices.net Date(s) of ESI Course(s): September 24, 2022

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
Course Sponsor:	Organization sponsoring or requesting the program (if any)	
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:	Copy of quizzes or tests to be given	x
Completed Application:		x

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

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JUN 27 2022
BOARD OF BUILDING STANDARDS

ELECTRICAL CALCULATIONS Part 2
Outline

1. Welcome
2. Webinar Rules and Expectations
3. Roll Call: Attendance and Introductions
4. Review of Part 1
5. Box Fill calculations
    a. Outlet boxes
    b. Tap boxes, junction boxes, pull boxes
6. Tap rules
7. Service, load and demand Calculations
8. Motor calculations
9. Transformer calculations
10. Misc. calculations
11. Wrap Up
12. Dismissal

Henry Peter Matthews, PE, CPE, CESCP, PVA

Home Address
1203 McKinley Place
Fostoria, Ohio 44830
Email: hpmatthews@matthewselectrical.net
Home Phone: 419-701-7707
Cell Phone: 419-575-3488

Work Address
Marathon Petroleum Company
539 South Main Street
Findlay, Ohio 45840
Email: hpmatthews@marathonpetroleum.com
Office phone: 419-421-3423
Cell phone: 419-957-2110

Work Experience

Marathon Petroleum Company, LP; Findlay, Ohio — June 2006 – Present

- Advanced Senior Engineer/Electrical Specialist
- Electrical Engineering Supervisor – Terminal Engineering
- Project Engineer – Major Projects
- Electrical Designer – Retail Division

Cooper Standard Automotive, Bowling Green, Ohio — July 1993 – June 2006

- Plant Engineering Manager
- Plant Electrical Engineer

Toledo Engineering Company (consultant); Toledo, Ohio — June 1989 – July 1993

- Electrical Drafter

Education

Bowling Green State University; Bowling Green, Ohio — Aug 2003
Masters of Business Administration

Pennsylvania State University; University Park, PA — Dec 1989
BS Electrical Engineering

Solar Energy International, Paonia, Colorado — Sept 2021
Solar PV Training

Owens Community College; Findlay, Ohio — April 2017
Certificate: Introductory Welding

Penn Foster Career School — July 2010
Certificate: Plumbing

Penn Foster Career School — October 2004
Certificate: Electrician

Certifications

Professional Engineer (PE): OH, MI, IN, KY, IL, WI
Photovoltaic Associate (PVA) by NABCEP
Certified Electrical Safety Compliance Professional (CESCP), NFPA
Certified Plant Engineer (CPE): Association for Facility Engineers
Building Operator Certification (BOC): Northwest Energy Efficiency Council

Licenses

Ohio Electrical Contractor, Ohio Department of Commerce, License # 46972
Ohio Training Agency, Ohio Construction Industry Licensing Board, Agency #48714
Ohio Training Agency, Ohio Board of Building Standards

Special Training

Solar Energy International (SEI), Paonia, Colorado

- Solar Electric and Design and Installation Course, April 2021, 60 hours
- PV Systems Fundamentals (Battery-Based), June 2021, 40 hours
- Advanced PV System Design and the NEC, June-July 2021, 60 hours
- Comparing Battery Technologies, July 2021, 10 hours
- Tools and Techniques for Operations and Maintenance of PV Systems, 9/21, 40 HR

Affiliations

Institute of Electrical and Electronics Engineers (IEEE) – Senior Member
International Association of Electrical Inspectors (IAEI)
NFPA Section Member for Architects, Engineers and Building Officials
Illumination Engineering Society of North America (IESNA)
API RP 545 former Co-Chair, American Petroleum Institute, Lightning Protection for Above Ground Storage Tanks (2017- 2018)

Business Ownership

Matthews Electrical Services, Owner
Designer Cuts Hair Salon, LLC; Co-owner

Biography

Henry has worked in the electrical, power, electronics, instrumentation, controls and communication fields for over 30 years. He earned his Bachelor of Science degree in Electrical Engineering from Penn State University in 1989. Henry worked as a consultant for Toledo Engineering Company in Toledo, Ohio as a drafter and field technician.

In 1993 he started working for Cooper Standard Automotive Company in Bowling Green, Ohio in 1993 as a Plant Electrical Engineer. He was then promoted to Plant Engineering Manager in 2000. During this time, he earned his Professional Engineering License in Ohio.

In 2003, Henry earned his MBA at Bowling Green State University.

In 2006, Henry joined Marathon Petroleum Company in Findlay, Ohio. He then went on to obtain his Professional Engineers license in Electrical Engineering for Michigan, Indiana, Illinois, West Virginia, Kentucky, Minnesota and Wisconsin. During his tenure at Marathon, Henry has had several roles including Electrical Design Engineer, Project Engineer and Electrical Supervisor. He is currently an Advanced Senior Engineer where he writes electrical standards for the company and conducts a community of practice for all the company's electrical engineers and safety professionals.

During his time at Cooper Standard Automotive and Marathon Petroleum, Henry developed a passion for teaching, learning and applying Electrical Construction Codes. At Cooper, he trained the entire non-electrical maintenance staff to perform basic electrical tasks.

At Marathon, Henry works with the Learning and Development Department to conduct multiple training sessions for new hires and seasoned engineers on various topics including Electrical Safety, Grounding and Bonding, Hazardous Area Location, Electrical Inspection, Motors, Lightning protection Static Electricity Mitigation, Reading and Understanding Electrical Diagrams, Programmable Logic Controllers and more.

Henry also works very closely with the Talent Acquisition Teams and visits numerous college campuses to deliver presentations on Engineering, Career Development, Networking and other topics.

Henry recently served as the Co-chair of the API Recommended Practice 545 Task Group for Lightning Mitigation for Above Ground Storage Tanks. In this role, he works with engineers, scientists and manufacturers from all over the world to evaluate the impacts of lightning and static electricity on metal above ground storage tanks.

His passion for teaching and Electrical Safety has motivated him to earn the Certified Electrical Safety Compliance Professional Certification (CESCP) from NFPA. He also regularly attends numerous electrical and safety conferences and training sessions conducted by NFPA, IEEE, API.

Previously, Henry was the President of the Fostoria, Ohio area Toastmasters team.

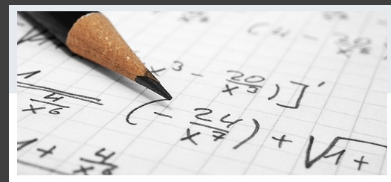
Henry is also a member of the International Association of Electrical Inspectors.

Henry also owns two small businesses:

> **Matthews Electrical Services** - that performs mainly limited residential and small commercial electrical services and conducts training for licensed electricians in the state of Ohio.
>
> **Designer Cuts Hair Salon, LLC –** Henry co-owns the beauty salon with his wife.

NEC Electrical Calculations Pt. 2

Matthews Electrical Services
Ohio Training Agency #48714
Henry Matthews, PE, CPE, CESCP



MATTHEWS ELECTRICAL SERVICES

1

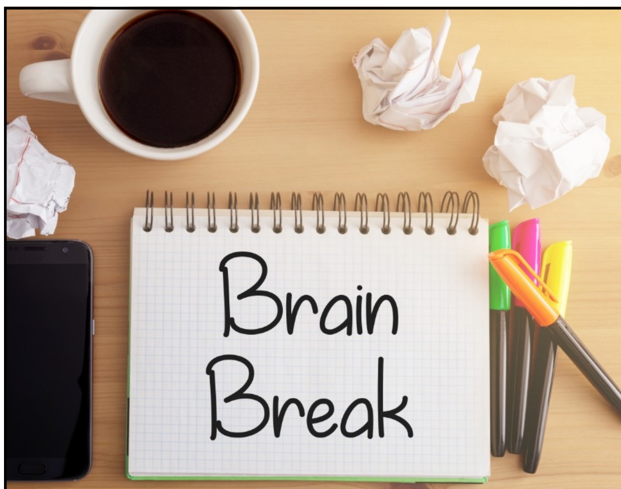
1

Webinar Rules

- Attendee must be present the entire time (except breaks)
- Turn webcam on after breaks and at end of class
  - Instructor will periodically check for presence of all attendees
- Mute microphone at all times
  - Prevents distraction during webinar
  - Instructor may activate participant microphone if verbal response is needed

2

2



Breaks (New!)

- 5-minute break every 45 minutes
- Schedule
  - 7:00 AM Start
  - 7:45 Break 1
  - 8:30 Break 2
  - 9:15 Break 3
  - 10:00 Break 4
  - 10:45 Break 5

3

WELCOME!

- Goals
  - Review electrical theory
  - Review important NEC Calculations
  - Make session engaging
    - Discussion
    - Videos
    - Polls
  - Make 4 hours as productive as possible!

4

4

Disclaimer

- I don't know everything!
- It will be IMPOSSIBLE to learn all the important calculations in 4 hours!
- But we'll try to cover as much as possible

5

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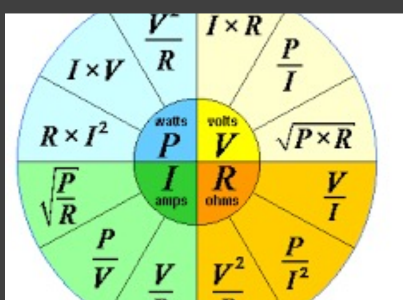
Disclaimer #2

- The views and opinions presented in this class are those of Matthews Electrical Services and not necessarily those of the various entities the presenter represents or has previously or currently works for.
- The material used in this class is based on documented publicly-available information (NFPA, OSHA, IEEE etc.)
- The interpretation of this material is based on the presenters experience and training of the subject matter.

6

6

NEC Electrical Calculations



7

7

Resources Used

- 2017 and 2020 NEC
- Ugly's Electrical References
- www.NFPA.org (Link)
- Mike Holt's Illustrated Guide to Electrical Exam Preparation 2017
- Ecmweb.com online magazine
- Ecmag.com online magazine

8

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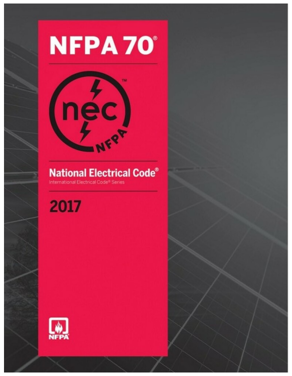

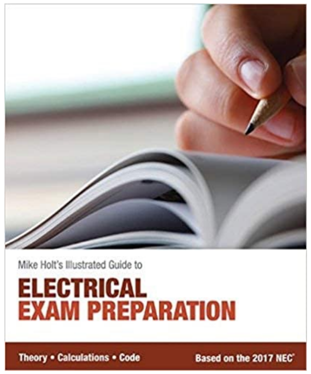

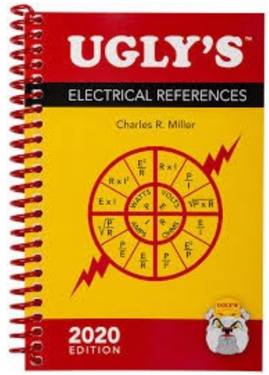

9

9

Mike Holt Videos

- Are All Terminals Rated 75 degree C [110.14(C)(1)(a)]
  - https://www.youtube.com/embed/SUjDUvQMTss
- Branch Circuit Conductor Sizing [210.20]
  - https://www.youtube.com/embed/tS4vjbW55Cc
- Conductor sizing based on terminal rating [110.14(C)]
  - https://www.youtube.com/embed/k7d03Tic6LE
- Feeder Conductor sizing [215.2]
  - https://www.youtube.com/embed/ItJ0YNOZ4wA
- How Do I Size an LB [110.3(B)]
  - https://www.youtube.com/embed/2Go0uGb2Kdg

10

10

Mike Holt Videos

- Motor Branch Conductor Sizing [430.22(A)]
  - https://www.youtube.com/embed/buK7LT0yvwE
- Motor Full Load Current (FLC): 430.6(A)(1)
  - https://www.youtube.com/embed/Sic1uoua3og
- Motor Full Load Amps – Nameplate (FLA): 430.6(A)(2)
  - https://www.youtube.com/embed/2cprO8ZdT1U
- Outlet Box Sizing [314.16(A)]
  - https://www.youtube.com/embed/bVQO7B_EWHg
- Overhead Conductor Clearances [225.18]
  - https://www.youtube.com/embed/R9DHjGObyKw

11

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Mike Holt Videos

- Pull and Junction Boxes, 4 AWG and Larger [314.28]
  - https://www.youtube.com/embed/olwTdmOC1FA
- Feeder Taps [240.21(B)(1)]
  - https://www.youtube.com/embed/uJRSrB4E7dY
- Raceway sizing [300.17 and Annex C]
  - https://www.youtube.com/embed/ruceLol9gJw
- Receptacle Outlets, Number on a dwelling circuit [220.14(I)]
  - https://www.youtube.com/embed/s4Euin0EsRY

12

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Other information

- [OCILB (Ohio Construction Industry Licensing Board)]
- [IAEI (International Association of Electrical Inspectors)]

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Agenda

- Box pulls
- Conductor sizing and protection
- Overcurrent protection
- Conductor Ampacity
- Feeder Tap Rules
- Dwelling Unit Load Calculations (Method 1)
- Motor Calculations
- Transformer Calculations

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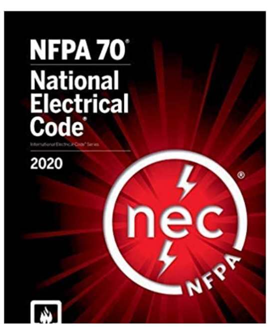
Recommendations for This Course



- Have copy of NEC for reference
- Grab a basic calculator perform simple calculations
- Advise me to slow down if something is not clear
- Don't be afraid to question something if you don't agree

15

15

Note:

- All references and calculations are based on the **2017 NEC** which is the current version adopted by the state of Ohio

16

Part I Review

- Basic math review
- Electrical Theory review
- Basic electrical components (resistors, capacitors, inductors)
- Basic electrical circuits
- Voltage drop
- Single phase/3 phase power
- Conduit fill
- Outlet box fill

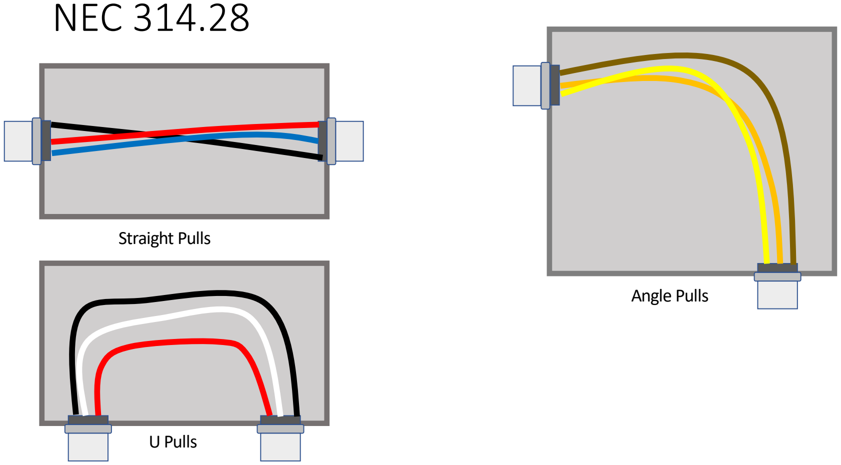
17

Pull Boxes, Junction Boxes, and Conduit Bodies

- For conductors #4 AWG and larger, pull boxes, junction boxes and conduit bodies must be sized in accordance with 314.28 of the NEC

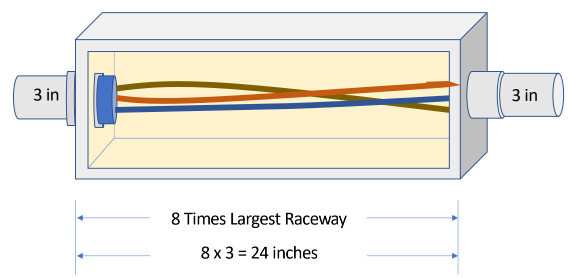
18

NEC 314.28



20

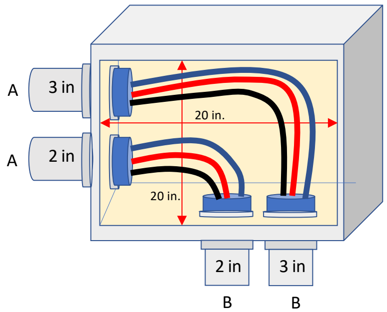
314.28(A)(1) Straight Pulls



The length of the box must be at least 8 times the trade size of the largest raceway

21

314.28(A)(2) Angle Pulls



A = (6 x 3) + 2, A = 20 in.

B = (6 x 3) + 2, B = 20 in.

The distance (measured from the conductor wall entry
To the opposite wall) must be at least 6 times the trade size of the
Largest raceway, plus the sum of the diameters of the remaining
Raceways on the same wall and row.

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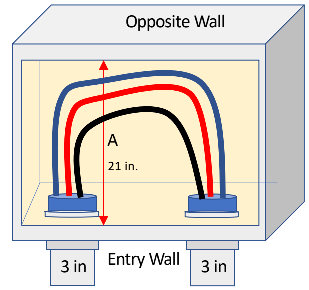
314.28(A)(2) U-Pulls

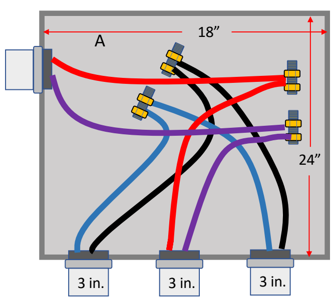


A = (6 x 3) + 3, A = 21 in.

The distance must be at least 6 times the largest raceway, plus
the sum of the other raceways on the same wall and row.

23

314.28(A)(2) Splices



A = 6 x 3 = 18 in.

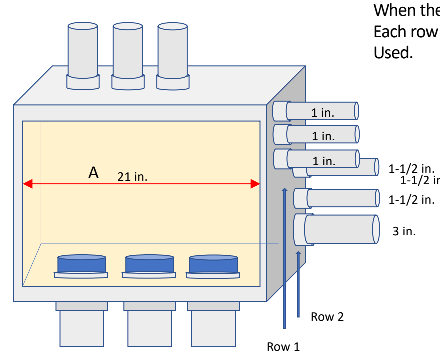
B = (6 x 3) +3 + 3 = 24 in.

When conductors are spliced, the distance from where the raceways
enter to the opposite wall must be at least 6 times the trade size of
the largest raceway plus the sum of all other raceways on the same
wall and row.

24

314.28(A)(2) Multiple Rows of Conduit

When there’s more than on row of conduit on the same wall,
Each row must be calculated separately and the larger answer
Used.



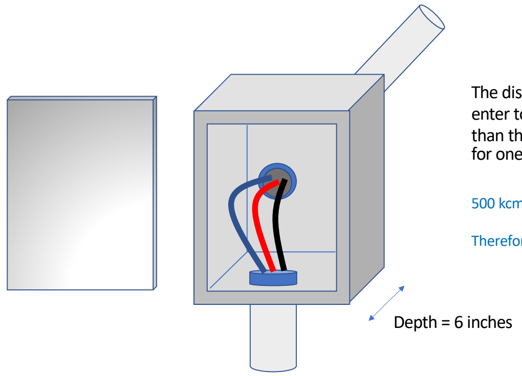
Row 1 = (6 x 1) + 1 +1 = 8
Row 2 = (6 x 3) + 1-1/2 + 1-1/2 = 21 in.

Use largest dimension (21 in.) to
determine box size

Therefore 21 inches is used for the A
dimension

25

Pull and Junction Boxes, Depth Conductors 314.28(A)(2)



The distance from where the conductors enter to the removable cover can't be less than the bending distance listed in Table 312.6(A) for one wire per terminal

500 kcmil = 6 inches per Table 312.6(A)

Therefore depth of panel can be no less than 6"

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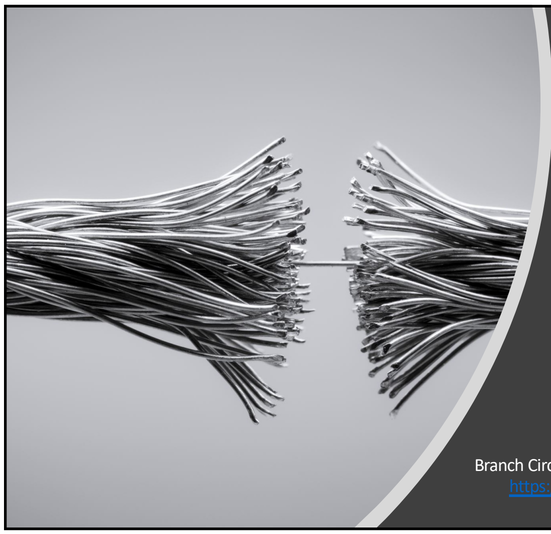
Pin Header

Table 312.6(A) Minimum Wire-Bending Space at Terminals and Minimum Width of Wiring Gutters

Wire Size (AWG or kcmil)		Wires per Terminal								
		1		2		3		4		5
All Other Conductors	Compact Stranded AA-8000 Aluminum Alloy Conductors (see Note 2)	mm	in.	mm	in.	mm	in.	mm	in.	mm
14–10	12–8	Not specified		–	–	–	–	–	–	–
8–6	6–4	38.1	$1\frac{1}{2}$	–	–	–	–	–	–	–
4–3	2–1	50.8	2	–	–	–	–	–	–	–
2	1/0	63.5	$2\frac{1}{2}$	–	–	–	–	–	–	–
1	2/0	76.2	3	–	–	–	–	–	–	–
1/0–2/0	3/0–4/0	88.9	$3\frac{1}{2}$	127	5	178	7	–	–	–
3/0–4/0	250–300	102	4	152	6	203	8	–	–	–
250	350	114	$4\frac{1}{2}$	152	6	203	8	254	10	–
300–350	400–500	127	5	203	8	254	10	305	12	–
$\boxed{400–500}$	600–750	152	$\boxed{6}$	203	8	254	10	305	12	356
600–700	800–1000	203	8	254	10	305	12	356	14	406
750–900	–	203	8	305	12	356	14	406	16	457
1000–1250	–	254	10	–	–	–	–	–	–	–
1500–2000	–	305	12	–	–	–	–	–	–	–

27



Conductor Sizing and Protection

Branch Circuit Conductor Sizing [210.20]
https://www.youtube.com/embed/tS4vjbW55Cc

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Conductor Properties

- All conductors have a certain amount of resistance
- When current flows through wire, this resistance creates heat
- The heat can damage the wire insulation
- If the insulation is damaged, short circuits and other negative events can occur
- If the wire is too small to handle the available current, the wire could overheat and cause fires
  - Short circuits
  - Open circuits
  - Toxic fumes
  - Equipment malfunction
  - And much more…

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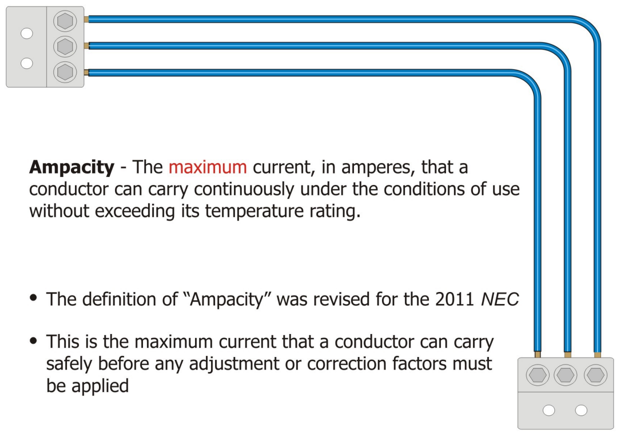
Article 100 Definitions: Ampacity



Ampacity - The maximum current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

- The definition of "Ampacity" was revised for the 2011 *NEC*
- This is the maximum current that a conductor can carry safely before any adjustment or correction factors must be applied

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Conductor Insulation Identification

Letter	Description
No H	60 degree C insulation rating
H	75 degree C insulation rating
HH	90 degree C insulation rating permitted in dry locations
-2	90 degree C insulation rating permitted in wet locations
N	Nylon outer cover
T	Thermoplastic Insulation
R	Rubber Insulation
X	Cross-linked polyethylene insulation
U	Underground
W	Permitted in Wet or Damp locations

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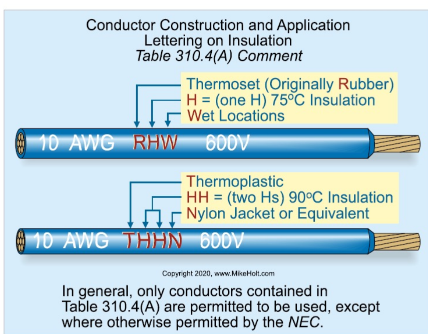

Figure 6–1

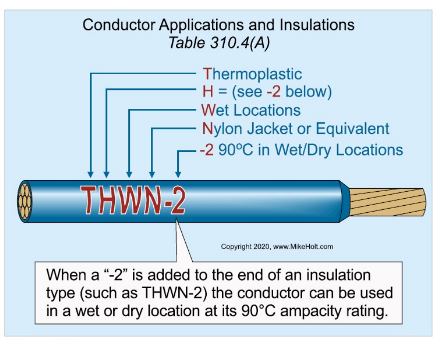

Figure 6–3

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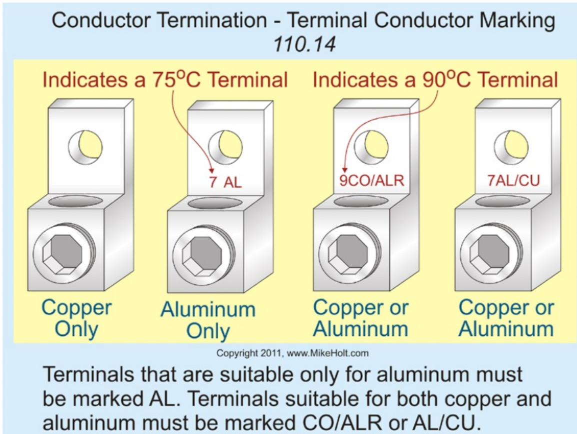
Equipment Terminal Rating -110.14(C)

- Conductors must be sized using their ampacity from the insulation temperature rating column of Table 310.15(B)(16) 2017 NEC that corresponds to the lowest temperature rating of any terminal, device, or conductor of the circuit.

Conductor sizing based on terminal rating [110.14(C)]
https://www.youtube.com/embed/k7d03Tic6LE

33



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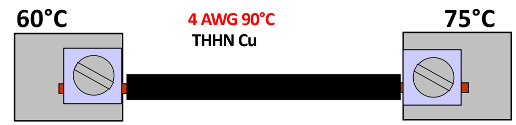
Both Ends Must Be Considered



	60 deg C	75 deg C	90 deg C
Ampacity(Amps)	70	85	95

The final ampacity is 70 amps even though the wire is rated for 90 amps due to the 60 deg C terminal

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Pin Header

Table 310.15(B)(16) (formerly Table 310.16) Allowable Ampacities of Insulated Conductors Rated Up to and Including 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)*

	Temperature Rating of Conductor [See Table 310.104(A).]						
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	
Size AWG or kcmil		COPPER		ALUMINUM OR COPPER-CLAD ALUMINUM			Size AWG or kcmil
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

36

Equipment 100A and Less [110.14(C)(1)(a)(1)]

- Unless otherwise listed and/or marked…
- Conductors terminating on equipment terminals must be sized using the 60 deg C temperature column of Table 310.15(B)(16)

37

Equipment 100A and Less, Conductor Sized to 60°C [110.14(C)(1)(a)(1)]

Equipment terminals rated 100A or less and pressure connector terminals for 14 AWG through 1 AWG conductors, must have the conductor sized to the 60°C temperature rating listed in Table 310.15(B)(16). Figure 6–3

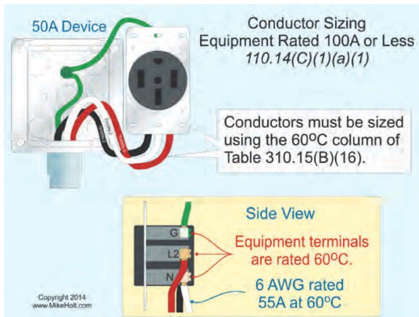


Figure 6–3

38

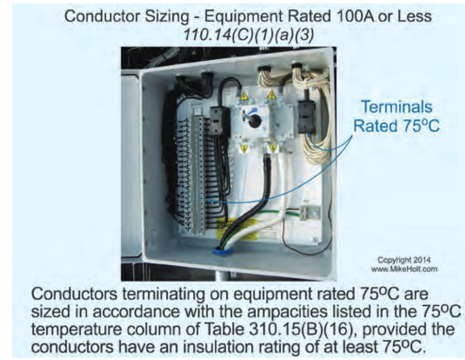


Figure 6–4

39

Equipment Over 100A, Conductor Sized to 75°C [110.14(C)(1)(b)(1)]

Terminals for equipment rated over 100A and pressure connector terminals for conductors larger than 1 AWG must have the conductor sized according to the 75°C temperature rating listed in Table 310.15(B)(16). Figure 6–5

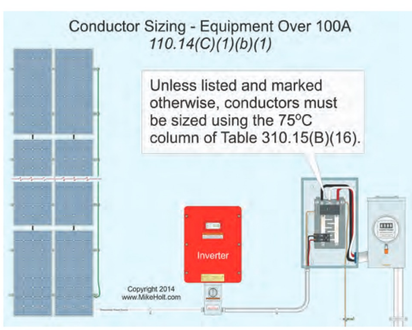


Figure 6–5

40

Terminals Rated 90°C, Conductor Sized to 90°C [110.14(C)(2)]

The 90°C ampacity column of Table 310.15(B)(16) can be used for separately installed connectors if the conductor and terminals are rated at least 90°C. Figure 6–6

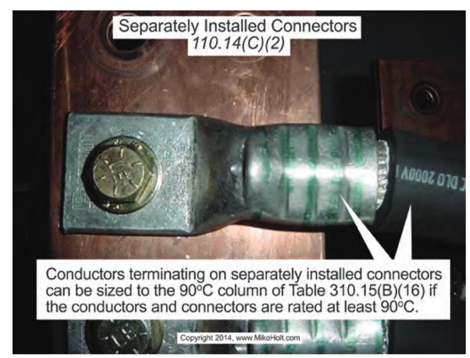
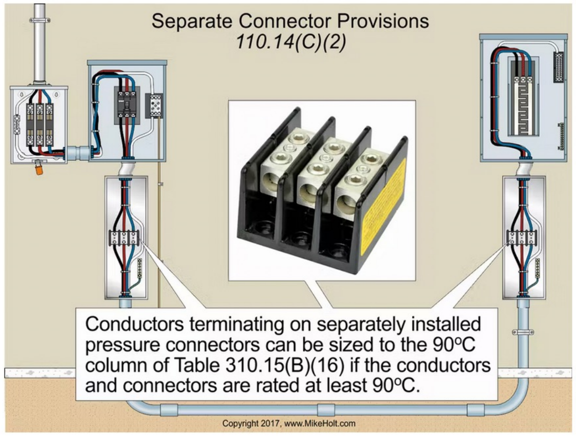


Figure 6–6

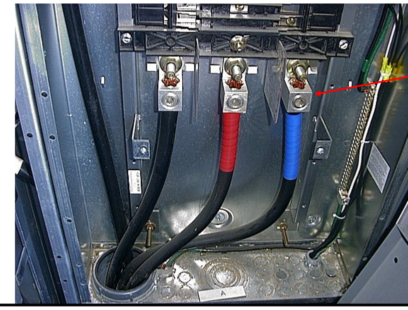
41



42

Example 1

- According to Table 310.15(B)(16), what size THHN conductor is required to supply a 150A feeder?



43

Example 1 Continued

- Equipment rated 100A
- Conductor size limited by equipment terminal rating and conductor insulation rating
- THHN is rated for 90 deg C, BUT, terminals are only rated for 75 deg C
- Therefore must use 75 deg C column in table

44

Pin Header

Table 310.15(B)(16) (formerly Table 310.16)
Allowable Ampacities of Insulated Conductors Rated Up to and Including 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)*

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.104(A).]						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)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	
		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

45

Example Continued

- 1/0 THHN is good for 170A at 90 deg C, BUT
- Terminals are only rated for 75 deg C
- Therefore 75 deg C column must be used
- 1/0 THHN at 75 deg C = 150A
- 1/0 will work!

46

Example 2

- What size XHHW copper conductor can be used to interconnect 90 deg C rated power distribution blocks that are protected by a 400A overcurrent protection device serving a 300A continuous load?

47

Example 2 Continued

- 300A is a continuous load, therefore multiply 300 x 1.25 (125%) = 375A
- 400 kcmil wire at 90 deg. C is rated at 380A
- Since terminals are rated for 90 deg. C, we can use this column
- Can a 400A circuit breaker or fuse protect wire rated for 380A?
- Normally no, but the next size up rule per NEC 240.4(B) applies here

48

(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) The conductors being protected are not part of a branch circuit supplying more than one receptacle for cord-and-plug-connected portable loads.

(2) The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments).

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

49

Pin Header

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

Standard Ampere Ratings				
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	—	—	—

50

Pin Header

Table 310.15(B)(16) (formerly Table 310.16) Allowable Ampacities of Insulated Conductors Rated Up to and Including 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)*

	Temperature Rating of Conductor [See Table 310.104(A).]						
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	
Size AWG or kcmil	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			Size AWG or kcmil
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
700	385	460	520	315	375	425	700

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Example 2 Continued

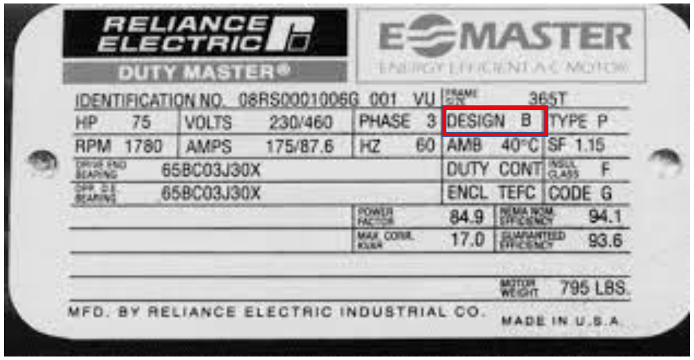
- Answer: 400 kcmil, rated 380 amps at 90 deg C is acceptable

52

Motor Terminals, Conductors Sized to 75 deg C 110.14(C)(1)(a)(4)

For motors marked with Design letters B, C, or D, conductors having an insulation rating of 75 deg C or higher can be used, provided the ampacity of such conductors doesn't exceed the 75 deg C ampacity.

53



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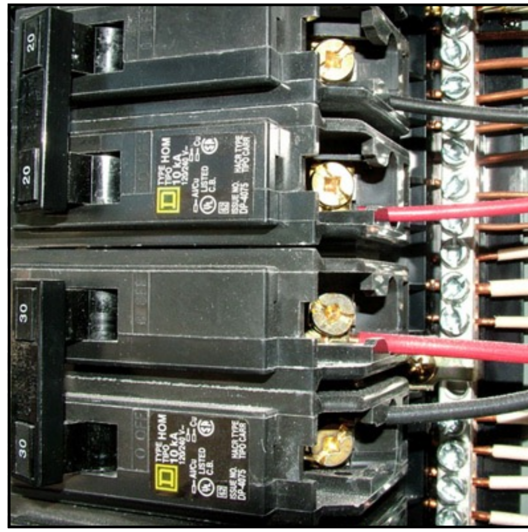


Overcurrent Protection
Article 240

General rule:

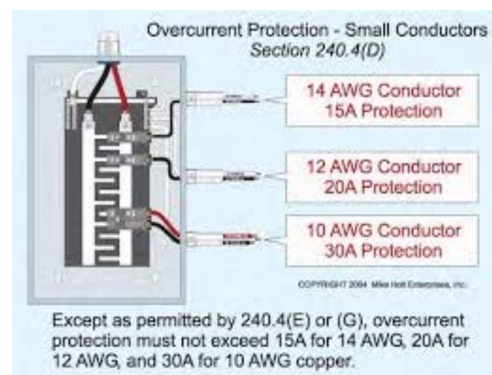
Conductors must be protected from overcurrent at the point where they receive their power supply in accordance with their ampacities

55

"Next Size Up" for Overcurrent Devices

- Overcurrent Devices rated 800A and less [240.4(B)]
  - Next size up ALLOWED (if all conditions met)
- Overcurrent Devices rated over 800A [240.(C)]
  - Next size up NOT ALLOWED!
  - Conductors must be protected by overcurrent device not exceeding the ampacity of the conductor
  - For example: a conductor rated for 1250 Amps cannot be protected by a 1600 amp CB. It must be protected by a 1200 amp or less CB or fuse.

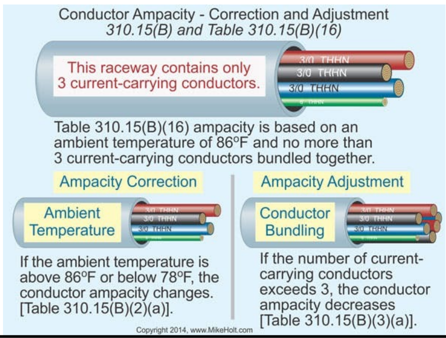
56



57

Conductor Ampacity , Correction and Adjustment

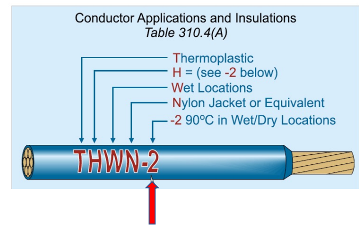
- Adjustments for temperatures outside of 78 – 86 deg F
- More than 3 current-carrying conductors

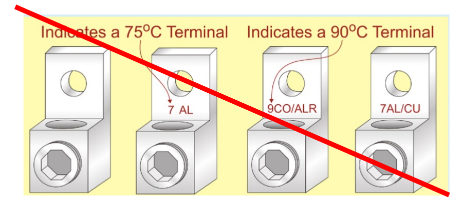


58

Important Tip!

When correcting or adjusting conductor ampacity, the ampacity is based on the temperature insulation rating of the conductor as listed on table 310.15(B)(16), NOT the temperature rating of the terminal





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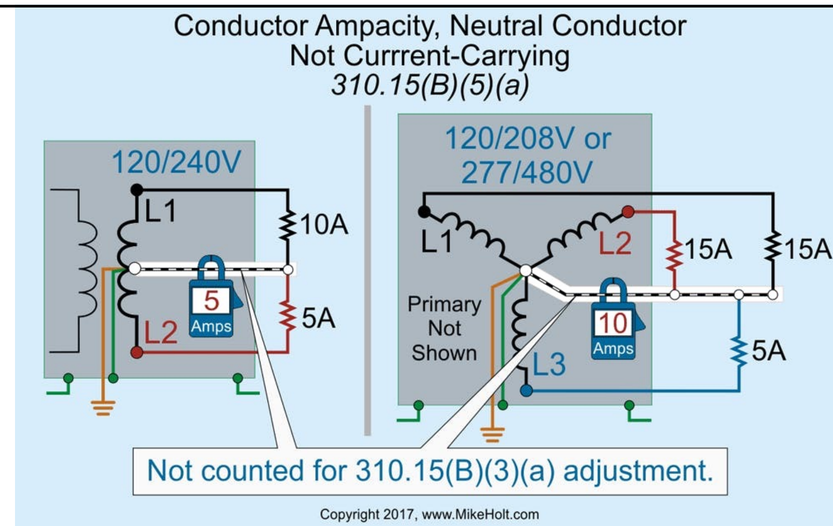
Current-Carrying Conductors (Exemptions)

- Grounding and Bonding conductors
- Neutral conductors under the following conditions are not counted per 310.15(B)(5)
  - Neutral conductors that only carry the unbalanced current from other conductors of the same circuit
  - In other words, if the circuit is balanced (single phase or three phase) and it contains a neutral, then the neutral is not counted.

60



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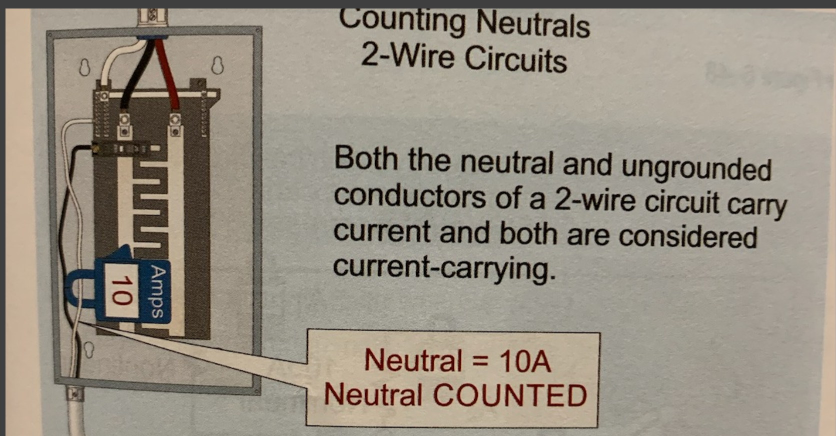

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Example when neutral is included as a current-carrying conductor

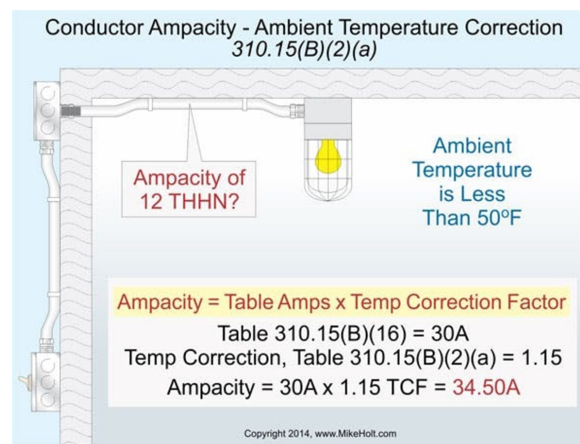
- Three phase, circuit containing, 3 hot conductors, a neutral and equipment grounding conductor
- One phase, for whatever reason, is not energized
- Then the neutral is not balanced and will be carrying more than the unbalanced current.
- In this case, the neutral will be counted as a current-carrying conductor

63

Table 310.15(B)(2)(a)

Ambient Temperature °F	Ambient Temperature °C	Correction Factor 75 °C Conductors	Correction Factor 90 °C Conductors
50 or less	10 or less	1.20	1.15
51 -59 deg F	11 -15 deg C	1.15	1.12
60 – 68 deg F	16 -20 deg C	1.11	1.08
69 -77 deg F	21 -25 deg C	1.05	1.04
78 – 86 deg F	26 – 30 deg C	1.00	1.00
87 – 95 deg F	31 – 35 deg C	0.94	0.96
96 – 104 deg F	36 – 40 deg C	0.88	0.91
105 – 113 deg F	41 – 45 deg C	0.82	0.87
114 – 122 deg F	46 – 50 deg C	0.75	0.82
123 – 131 deg F	51 – 55 deg C	0.67	0.76
132 – 140 deg F	56 – 60 deg C	0.58	0.71
141 – 149 deg F	61- 65 deg C	0.47	0.65
150 – 158 deg F	66 – 70 deg C	0.33	0.58
159 – 167 deg F	71 – 75 deg C	0.00	0.50
168 – 176 deg F	76 – 80 deg C	0.00	0.41
177 – 185 deg F	81 – 85 deg C	0.00	0.29

64



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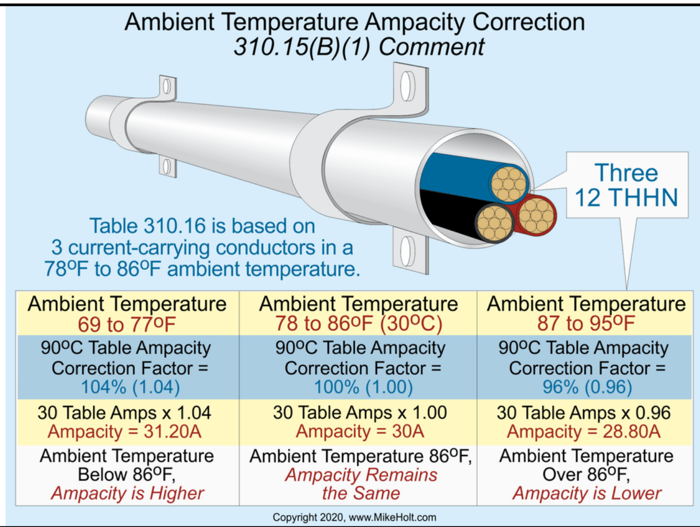


66

Rooftop Temperature Adder [310.15(B)(3)(c)]

- Raceways and Cables Exposed to Sunlight on Rooftops
- Where raceways or cables are exposed to direct sunlight and located less than 7/8 inches above the roof, a temperature adder of 60 deg F/33 deg C is to be added to the outdoor temperature to determine the ambient temperature for the application of the ampacity correction in accordance with Table 31015(B)(2)(a).

67

Example

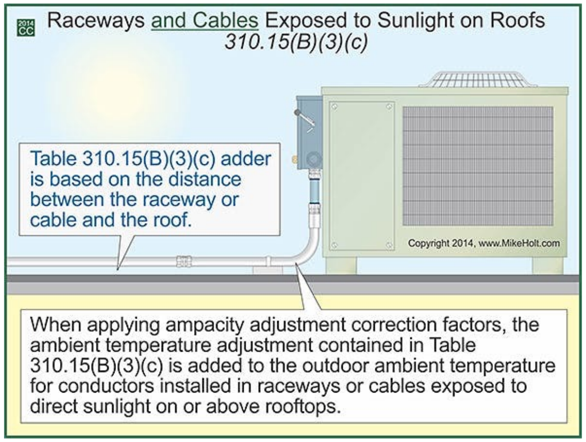
- What is the ampacity of #6 THWN-2 conductors when it is installed in conduit ½ from the roof surface when the outdoor temp is 96 deg F?
- THWN-2 conductors are rated 75A at 90 deg C per Table 310.15(B)(16)
- Correction factor for mounting on roof less than 7/8" is:
  - 96 deg F + 60 deg F = 156 deg F
- Per Table 310.15(B)(2)(a), 156 deg F has a correction factor of 0.58 for 90 deg F conductors
- 75A x 0.58 = 43.5A
- The #6 THWN-2 wire has new ampacity of 43.5A!

68

Table 310.15(B)(2)(a)

Ambient Temperature °F	Ambient Temperature °C	Correction Factor 75 °C Conductors	Correction Factor 90 °C Conductors
50 or less	10 or less	1.20	1.15
51 -59 deg F	11 -15 deg C	1.15	1.12
60 – 68 deg F	16 -20 deg C	1.11	1.08
69 -77 deg F	21 -25 deg C	1.05	1.04
78 – 86 deg F	26 – 30 deg C	1.00	1.00
87 – 95 deg F	31 – 35 deg C	0.94	0.96
96 – 104 deg F	36 – 40 deg C	0.88	0.91
105 – 113 deg F	41 – 45 deg C	0.82	0.87
114 – 122 deg F	46 – 50 deg C	0.75	0.82
123 – 131 deg F	51 – 55 deg C	0.67	0.76
132 – 140 deg F	56 – 60 deg C	0.58	0.71
141 – 149 deg F	61- 65 deg C	0.47	0.65
150 – 158 deg F	66 – 70 deg C	0.33	0.58
159 – 167 deg F	71 – 75 deg C	0.00	0.50
168 – 176 deg F	76 – 80 deg C	0.00	0.41
177 – 185 deg F	81 – 85 deg C	0.00	0.29

69



70

Four or More Current-Carrying Conductors 310.15(B)(3)(a)

- Applies where four or more current-carrying conductors are installed in a raceway or 24 inches long
- Requires ampacity adjustment per Table 310.15(B)(3)(a)

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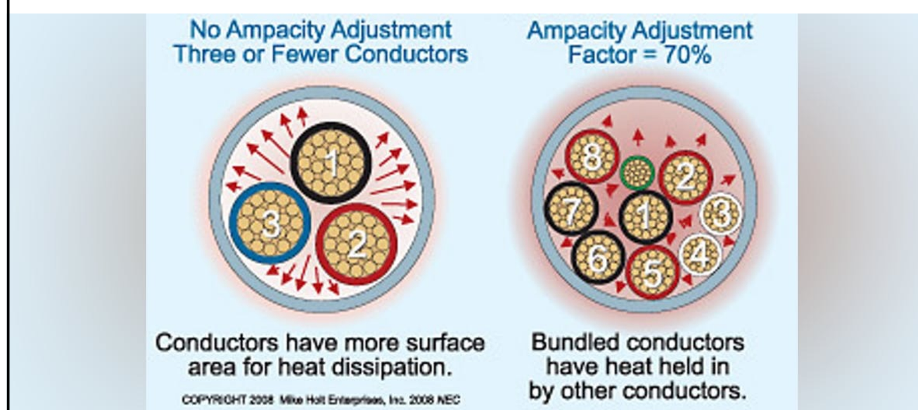
Table 310.15(B)(3)(a) Conductor Ampacity Adjustment for More Than Three Current-Carrying Conductors

Number of Conductors	Adjustment
4-6	0.80 or 80%
7-9	0.70 or 70%
10- 20	0.50 or 50%
21 – 30	0.45 or 45%
31- 40	0.40 or 40%
41 and above	0.35 or 35%
The number of conductors is the total number of conductors, including spare conductors, adjusted in accordance with 310.15(B)(5) and (B)(6). It doesn't include conductors that can't be energized at the same time.	

72



73

Example

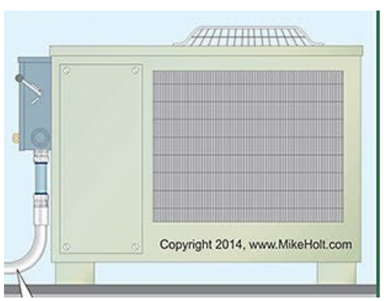
- Multiple conductor adjustment (more than 3 conductors in raceway)
- Ambient Temperature correction
- Rooftop adjustment

74

75

Example

- What is the ampacity of four current-carrying 12 THWN-2 conductors installed in a raceway on the rooftop with an ambient temp of 94 deg F?



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Example

- Look for key words
- What is the ampacity of <u>four</u> current-carrying 12 <u>THWN-2</u> conductors installed in a <u>raceway</u> on the <u>rooftop</u> with an ambient temp of **94 deg F**?

- THWN-2 is rated for 90 deg C per Table 310.15(B)(16)
- #12 wire at 90 deg C is rated for 30A

- **<u>Adjustment 1</u>**: for 4 Conductors ➡ Table 310.15(B)(3)(a) for more than 3 conductors
  - Use **0.80** adjustment factor for 4 conductors

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Example

- **Adjustment 2**: Conductors on rooftop installed 7/8" or less from surface:
  - Add 60 deg F to ambient temp
  - Ambient temp is 94 deg F: 94 + 60 = 154 deg F
  - Use table 310.15(B)(2)(a) Ambient Temp Correction
  - For 154 deg F, adjustment is 0.58 for 90 deg C conductors
- Combining adjustments: 30 x 0.80 x 0.58 = 13.92 A
- May be necessary to run larger wire and conduit or simpler yet, install conduit at least 1 inch above the roof!

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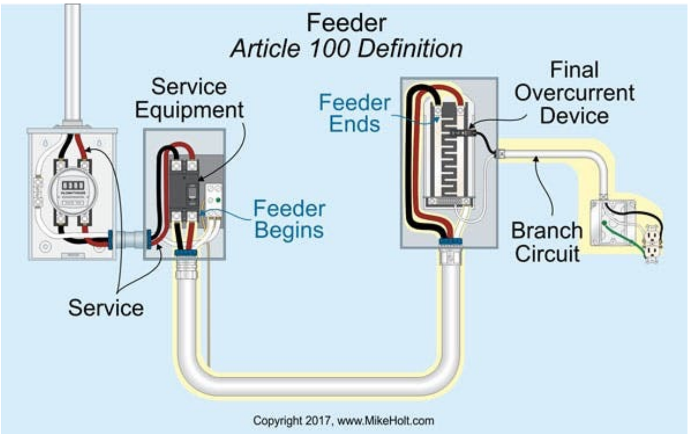
Overcurrent Protection and Conductor Sizing 210.20(A)

- Branch circuit overcurrent protection devices must have a rating of not less than **125** percent of the continuous loads plus **100** percent of the non-continuous loads
- Continuous Load: A load where the maximum current is expected to continue for **3 hours** or more.

79



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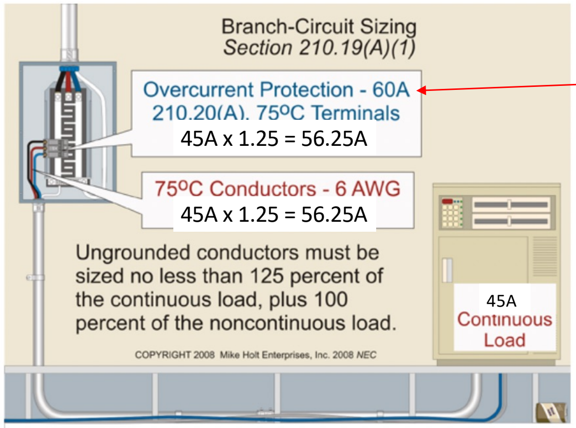


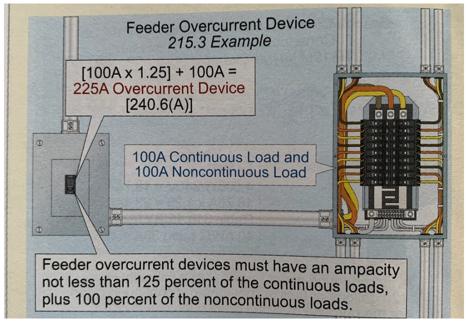
Next size up

#6 AWG wire on 75 deg C terminals rated for 65A per Table 310.15(B)(16)

81

Feeder Overcurrent Protection [215.2]

- Feeder overcurrent protection devices must have a rating of not less than 125% of the continuous loads, plus 100% of the non-continuous loads.



Feeder Conductor sizing [215.2]
https://www.youtube.com/embed/ItJ0YNOZ4wA

82

Example

- What size feeder conductor (THHN) is required for a 200A continuous load?
- Look for key words:
  - THHN: 90 deg C insulation
  - 200A continuous load: implies multiplying by 1.25 or 125%
  - 200 x 1.25 = 250A
- 250 kcmil THHN rated for 255A @ 70 deg C per Table 310.15(B)(16)

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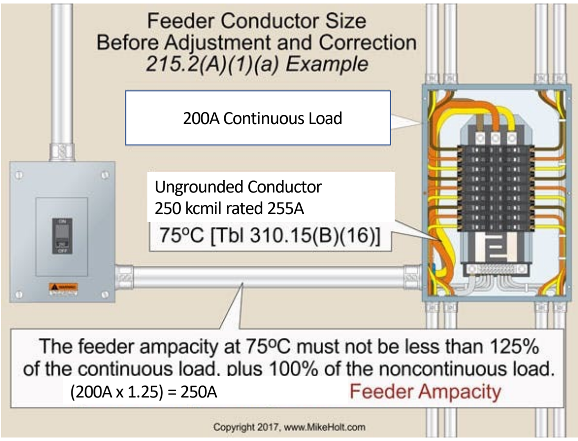


84

Feeder Tap Rules!

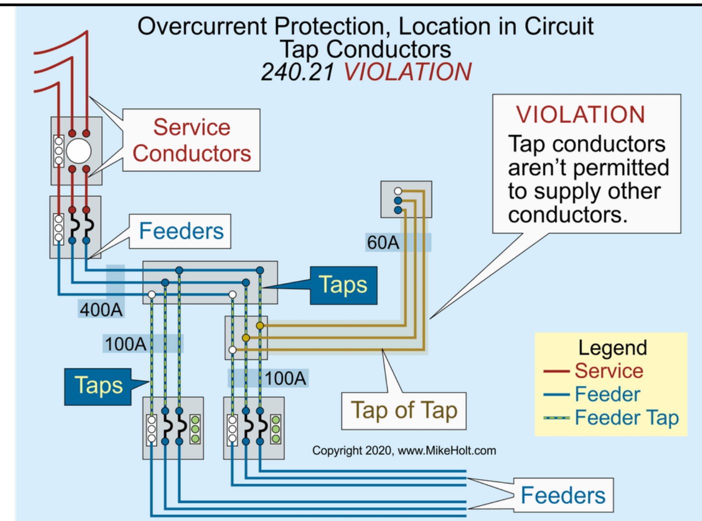
85

Feeder Tap Rules

- **Tap**: A conductor, other than a service conductor (feeder or branch circuit), that has overcurrent protection rated higher than normally allowed in 240.2

- General rule: Conductors shall be protected from overcurrent at the point where they receive power. This is not always possible for some conductors – like taps

86



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The tap is permitted at any point on the load side of the feeder OCPD. The "next size up" rule in Sec. 240.4(B) is not permitted for feeder tap conductors.

(1) Feeder Tap Not Over 10 Feet. Tap conductors up to 10 ft long are permitted when they comply with the following:

(1) Tap conductors have an ampacity equal to or greater than:

a. The calculated load per Art. 220, and

b. The rating of the OCPD or the equipment supplied by the tap conductors.

(2) The tap conductors are not permitted to extend beyond the equipment they supply.

(3) The tap conductors are installed within a raceway.

(4) Tap conductors that leave the enclosure where the tap is made must have an ampacity of at least 10% of the rating of the OCPD that protects the feeder.

Informational Note: If a tap supplies a panelboard, the tap conductors must terminate in an OCPD per Sec. 408.36.

88

10-ft tap rule

The length of your tap determines which rules to apply to it. When a tap is not over 10 ft, you determine the tap conductor size using the 10-ft tap rule. There are four rules for 10-ft taps, but it's the first of those four [Sec. 240.21(B)(1)(1)] you follow when sizing the tap conductors:

The ampacity of the tap conductors must be at least the:

1. Combined calculated loads on the circuits supplied by the tap conductors [Sec. 240.21(B)(1)(a)], and
2. Rating of the equipment containing an OCPD supplied by the tap conductors or (at least the) rating of the OCPD of the tap conductors.

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Example 1

Question: What size 10-ft tap conductor is needed from a 400A circuit breaker to supply a 200A panelboard if the terminals are rated 75°C, as shown in **Fig. 2**?

(a) 1/0 AWG

(b) 2/0 AWG

(c) 3/0 AWG

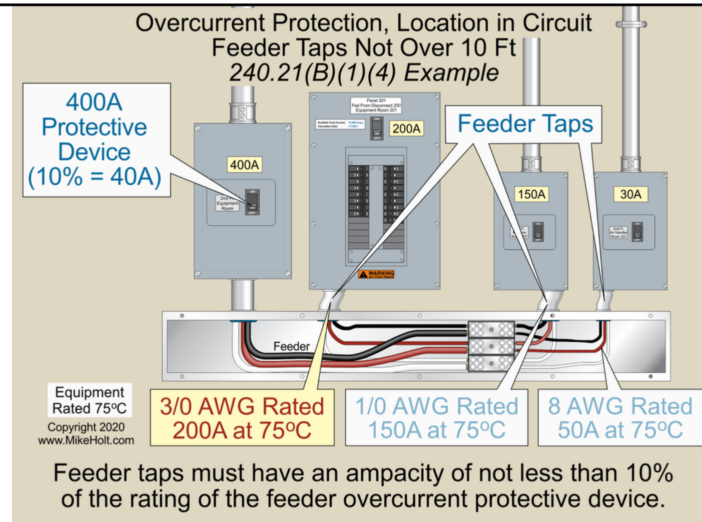
(d) 4/0 AWG

Solution: Ten Percent of 400A = 40A minimum conductor ampacity permitted

3/0 AWG is rated 200A at 75°C [Sec. 110.14(C)(1)(b)(2) and Table 310.16], which is greater than 10% of the rating of the 400A OCPD.

Answer: (c) 3/0 AWG

90



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Example 2

Question: What size 10-ft tap conductor is needed from a 400A circuit breaker to supply a 150A feeder disconnect if the terminals are rated 75°C?

(a) 1/0 AWG

(b) 2/0 AWG

(c) 3/0 AWG

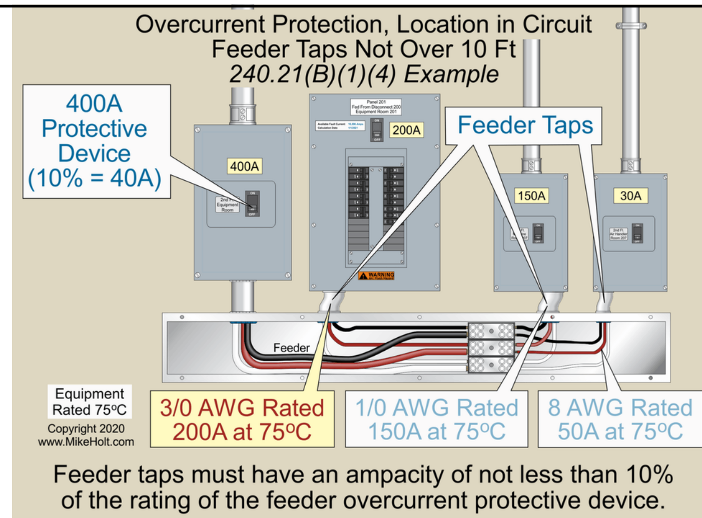
(d) 4/0 AWG

Solution: Ten Percent of 400A = 40A minimum conductor ampacity permitted

1/0 AWG is rated 150A at 75°C [Sec. 110.14(C)(1)(b)(2) and Table 310.16], which is greater than 10% of the rating of the 400A OCPD.

Answer: (a) 1/0 AWG

92



93

Example 3

Question: What size 10-ft tap conductor is needed from a 400A circuit breaker to supply a 30A feeder disconnect if the terminals are rated 75°C?

(a) 8 AWG

(b) 6 AWG

(c) 4 AWG

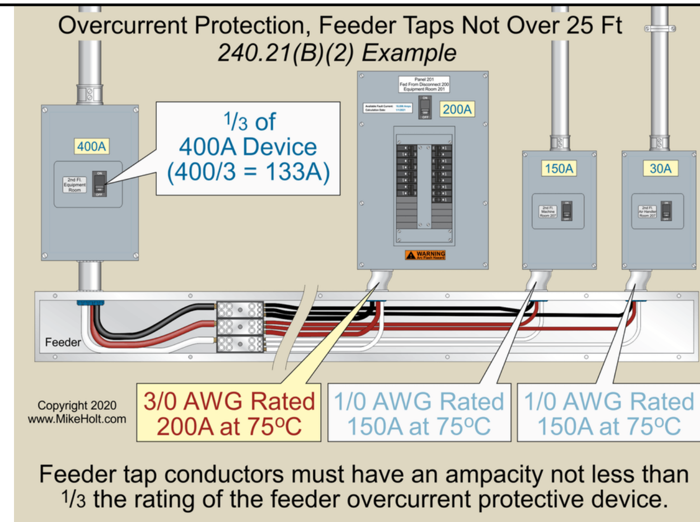
(d) 3 AWG

Solution: Ten Percent of 400A = 40A minimum conductor ampacity permitted

8 AWG is rated 50A at 75°C [Sec. 110.14(C)(1)(a)(3) and Table 310.16], which is greater than 10% of the rating of the 400A OCPD.

Answer: (a) 8 AWG

94



95

25-ft tap rule

Tap conductors up to 25 ft long are permitted when they comply with the following:

(1) The tap conductor has an ampacity of at least 1/3 the rating of the OCPD that protects the feeder.

(2) The tap conductors terminate in an OCPD and have an ampacity equal to or greater than the rating of the OCPD.

Notice how this differs from the 10-ft tap rule. It's shifted from being based on the load the tap feeds to being based on the rating of the feeder OCPD.

96

Example 1

Question: What size 25-ft tap conductor is needed from a 400A circuit breaker to supply a 200A panelboard if the terminals are rated 75°C, as shown in **Fig. 3**?

(a) 1/0 AWG

(b) 2/0 AWG

(c) 3/0 AWG

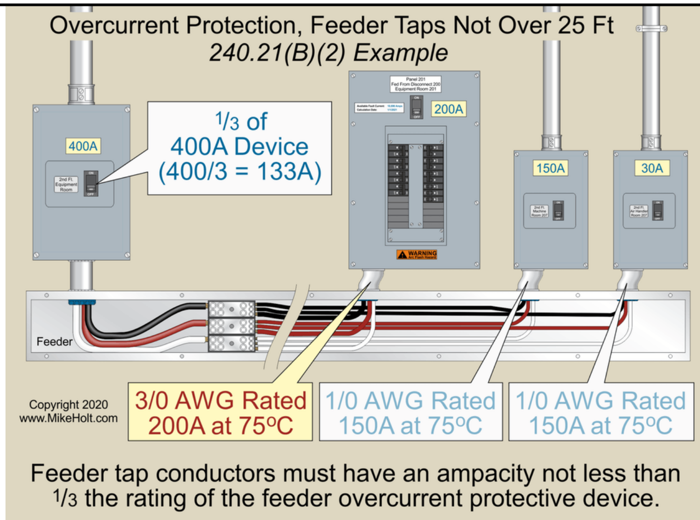
(d) 4/0 AWG

Solution: The tap conductor must have a minimum rating of at least 133A (1/3 the rating of the 400A OCPD).

3/0 AWG is rated 200A at 75°C [Sec. 110.14(C)(1)(b)(2) and Table 310.16], which is greater than 133A (1/3 the rating of the 400A OCPD) and equal to the 200A disconnect.

Answer: (c) 3/0 AWG

97



98

Example 2

Question: What size 25-ft tap conductor is needed from a 400A circuit breaker to supply a 150A feeder disconnect if the terminals are rated 75°C?

(a) 1/0 AWG

(b) 2/0 AWG

(c) 3/0 AWG

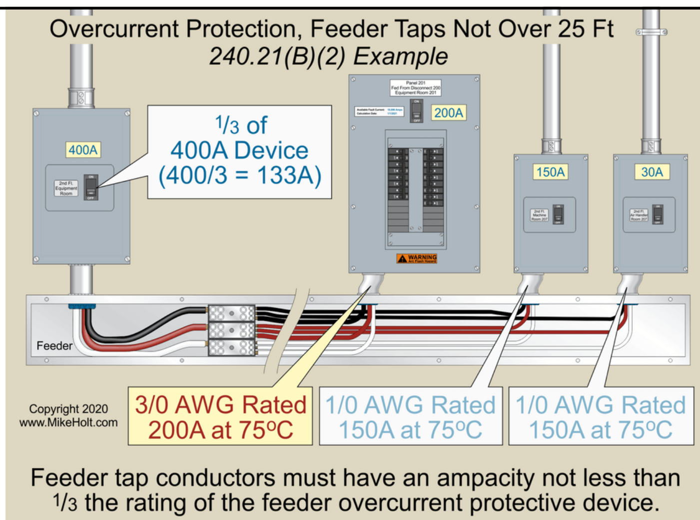
(d) 4/0 AWG

Solution: The tap conductor must have a minimum rating of at least 133A (1/3 the rating of the 400A OCPD).

1/0 AWG is rated 150A at 75°C [Sec. 110.14(C)(1)(b)(2) and Table 310.16], which is greater than 133A (1/3 the rating of the 400A OCPD) and equal to the 150A disconnect.

Answer: (a) 1/0 AWG

99



100

Example 3

Question: What size 25-ft tap conductor is needed from a 400A circuit breaker to supply a 30A feeder disconnect if the terminals are rated 75°C?

(a) 3 AWG

(b) 2 AWG

(c) 1 AWG

(d) 1/0 AWG

Solution: The tap conductor must have a minimum rating of at least 133A (1/3 the rating of the 400A OCPD).

1/0 AWG is rated 150A at 75°C [Sec. 110.14(C)(1)(b)(2) and Table 310.16], which is greater than 133A (1/3 the rating of the 400A OCPD) and greater than the 30A disconnect.

Answer: (d) 1/0 AWG

101

Outside feeder taps

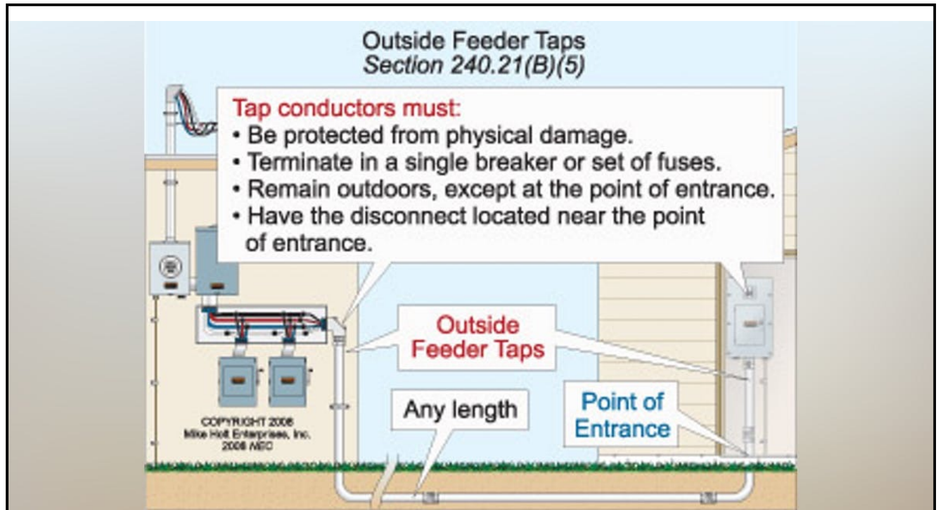
Outside tap conductors can be of unlimited length if they comply with all of the following [Sec. 240.21(B)(5)]:

(1) The outside tap conductors are protected from physical damage.

(2) The outside tap conductors terminate in a single circuit breaker or a single set of fuses that limits the load to the ampacity of the conductors.

(3) The tap's OCPD is part of the building feeder disconnect.

102



103

Article 430 Motors

- Motors present unique challenges
  - High starting (inrush current)
    - How to start motor without tripping circuit breaker
  - Motors are very expensive – protection motor is a priority in many cases
  - Adequately protecting motor feeder
  - Modes of protection
    - Short circuit
    - Overload
  - Multiple motors on a circuit

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Modes of Motor Protection

- Short Circuit
  - Very high levels of current from
    - Ground faults
    - Phase-to- phase faults
- Overload
  - Lower levels of current from
    - Gradual overheating due to
      - High loads
      - Unbalance
      - Extreme temperatures
      - Equipment malfunction or damage
      - Multiple other causes

105

Modes of Motor Protection

- Short Circuit
  - Circuit Breakers and fuses
- Overload
  - Overload devices
    - "Heaters"
    - Overload relays

106

Article 430 Motors

- Challenges (continued)
  - Safety: stopping, torque, speed control, guarding moving parts
  - Lots of energy: inductive
  - Produce heat
  - Vibration: impacts connections and cabling
  - Impacts power factor
  - What is a motor running backwards?

107

Chapter 4: Equipment for General Use

- Article 430: Motors, Motor Circuits, and Controllers
  - Part XIV. Tables

108

Table 430.248 Full-Load Currents in Amperes, Single-Phase Alternating-Current Motors

The following values of full-load currents are for motors running at usual speeds and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120 and 220 to 240 volts.

Horsepower	115 Volts	200 Volts	208 Volts	230 Volts
1/6	4.4	2.5	2.4	2.2
1/4	5.8	3.3	3.2	2.9
1/3	7.2	4.1	4.0	3.6
1/2	9.8	5.6	5.4	4.9
3/4	13.8	7.9	7.6	6.9
1	16	9.2	8.8	8.0
1 1/2	20	11.5	11.0	10
2	24	13.8	13.2	12
3	34	19.6	18.7	17
5	56	32.2	30.8	28
7 1/2	80	46.0	44.0	40
10	100	57.5	55.0	50

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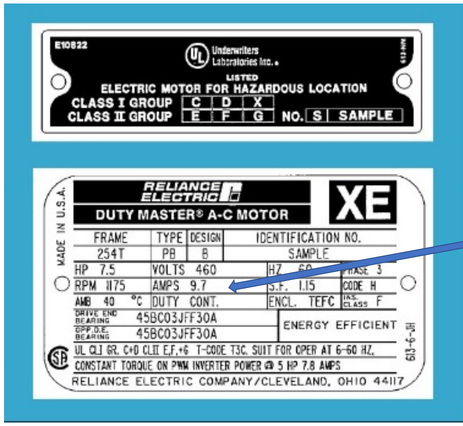
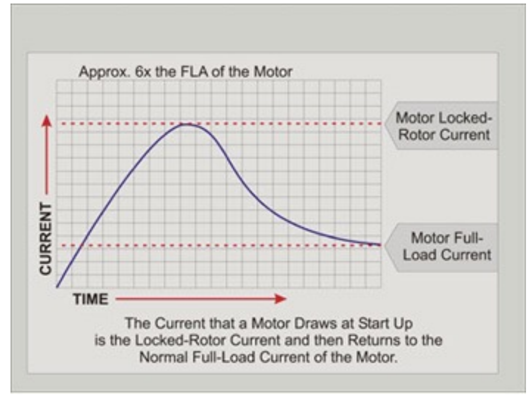
Motor Nameplate



FLA
Full Load Amps

110

Typical Motor Starting Curve



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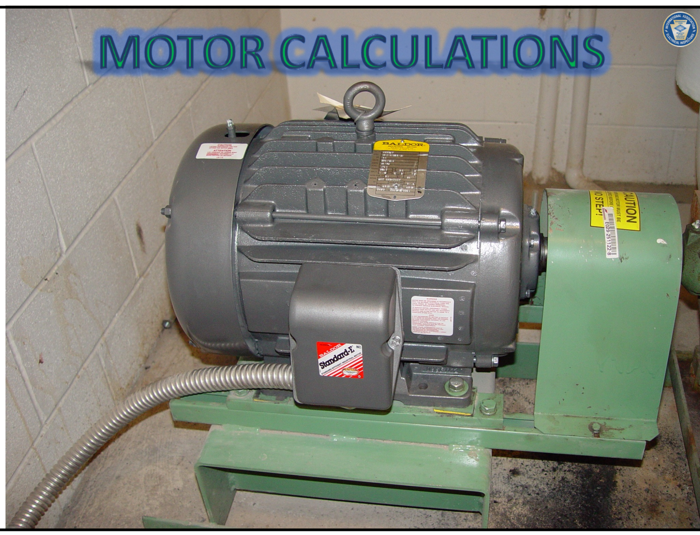


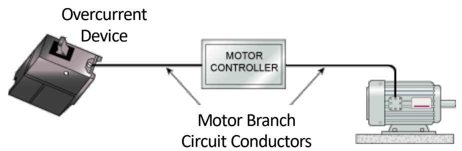
112

Hint

- Full Load Amps (FLA) refers to the motor nameplate amps
- Full Load Current (FLC) refers to the tables in article 430

- FLA: "A" can stand for Actual motor amps
- FLC: "C" can stand for Code book (NEC tables)

113



Motor Branch Circuit:

- A motor branch circuit includes all conductors between the branch-circuit protective device and the motor as shown above

114

For general application:

- According to 430.6(A), the ampacity values given in the motor full-load current tables must be used to calculate the ampacity of motor branch-circuit conductors *(for other than specific motors)*
- Tables 430.248 and 430.250 are the full load currents (FLC) for most motors of normal torque values and common speeds

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Dwelling Unit Calculations

116

Standard Method Load Calculations

Article 220, Part III

- Article 220 allow two different methods of calculating residential loads
  1. The standard method in Part III
  2. The optional method in Part IV
- Methods are different and give different results
- Must use one or the other
- Rules from either can't be mixed together
- On exam, they will usually tell you which method to use

117

Procedure to Determine Feeder or Service Size for a Dwelling Unit Using Standard Method

1. General Lighting and General Use Receptacles, Small-Appliances and Laundry Circuits [Table 220.42]
   - These loads will most likely not be operating all at the same time at full load
   - Therefore the NEC permits a demand factor to be applied to the **total connected load** [220.52)

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⌕ Pin Header **Table 220.42 Lighting Load Demand Factors** ×

Type of Occupancy	Portion of Lighting Load to Which Demand Factor Applies (Volt-Amperes)	Demand Factor (%)
Dwelling units	First 3000 at	100
	From 3001 to 120,000 at	35
	Remainder over 120,000 at	25
Hospitals*	First 50,000 or less at	40
	Remainder over 50,000 at	20
Hotels and motels, including apartment houses without provision for cooking by tenants*	First 20,000 or less at	50
	From 20,001 to 100,000 at	40
	Remainder over 100,000 at	30
Warehouses (storage)	First 12,500 or less at	100
	Remainder over 12,500 at	50
All others	Total volt-amperes	100

*The demand factors of this table shall not apply to the calculated load of feeders or services supplying areas in hospitals, hotels, and motels where the entire lighting is likely to be used at one time, as in operating rooms, ballrooms, or dining rooms.

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1. Determine Feeder Demand Load

A. Determine the total connected load for:
   1) General lighting and receptacles at 3 VA per sq. ft [220.12]
   2) Two small-appliance circuits at 1,500 VA [220.52(A)] and
   3) One laundry circuit at 1,500 VA

B. Apply the Table 220.42 demand factors to the total connected load

C. Calculate the first 3000 VA at 100% demand. Calculate the remaining VA at 35% demand

120

2. Appliances [220.53]

A. A 75% demand factor can be applied when 4 or more appliances are fastened in place and are on the same feeder
   - Examples: waste disposer, dishwasher, trash compactor, water heater…

B. This does not apply to space heating equipment [220.51], clothes dryers [220.54], cooking appliances [220.55] or air-conditioning equipment

Note: This demand factor is applied to the nameplate rating of the appliances

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3. Clothes Dryer [220.54]

A. The feeder or service load for clothes dryers must not be less than 5000 Watts or the nameplate rating
B. The demand factors from Table 220.54 can be applied if there are more than 4 dryers in the dwelling unit
C. A feeder or service dryer load isn't required if the dwelling unit doesn't contain an electric dryer

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4. Cooking Equipment

Household cooking appliances rated over 1-3/4 kW can have the feeder and service calculated according to the demand factors of Table 220.55, including notes, 1, 2, and 3

123

Pin Header

Table 220.55 Demand Factors and Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over $1^3/_4$ kW Rating (Column C to be used in all cases except as otherwise permitted in Note 3.)

Number of Appliances	Demand Factor (%) (See Notes) Column A (Less than $3^1/_2$ kW Rating)	Demand Factor (%) (See Notes) Column B ($3^1/_2$ kW through $8^3/_4$ kW Rating)	Column C 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

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Notes:
1. Over 12 kW through 27 kW ranges all of same rating. For ranges individually rated more than 12 kW but not more than 27 kW, the maximum demand in Column C shall be increased 5 percent for each additional kilowat rating or major fraction thereof by which the rating of individual ranges exceeds 12 kW.
2. Over $8^3/_4$ kW through 27 kW ranges of unequal ratings. For ranges individually rated more than $8^3/_4$ kW and of different ratings, but none exceeding 27 kW, an average value of rating shall be calculated by adding toget ratings of all ranges to obtain the total connected load (using 12 kW for any range rated less than 12 kW) and dividing by the total number of ranges. Then the maximum demand in Column C shall be increased 5 percent kilowatt or major fraction thereof by which this average value exceeds 12 kW.
3. Over $1^3/_4$ kW through $8^3/_4$ kW. In lieu of the method provided in Column C, it shall be permissible to add the nameplate ratings of all household cooking appliances rated more than $1^3/_4$ kW but not more than $8^3/_4$ kW a multiply the sum by the demand factors specified in Column A or Column B for the given number of appliances. Where the rating of cooking appliances falls under both Column A and Column B, the demand factors for e column shall be applied to the appliances for that column, and the results added together.
4. Branch-Circuit Load. It shall be permissible to calculate the branch-circuit load for one range in accordance with Table 220.55. The branch-circuit load for one wall-mounted oven or one counter-mounted cooking unit s the nameplate rating of the appliance. The branch-circuit load for a counter-mounted cooking unit and not more than two wall-mounted ovens, all supplied from a single branch circuit and located in the same room, shall calculated by adding the nameplate rating of the individual appliances and treating this total as equivalent to one range.
5. This table shall also apply to household cooking appliances rated over $1^3/_4$ kW and used in instructional programs.

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5. Air-Conditioning Versus Heat

- Since air-conditioning and heating equipment aren't usually on at the same time, the smaller of the two loads can be omitted [220.60]
- The air-conditioning load is calculated at 100% [220.50]
- The fixed electric heating and load is calculated at 100% [220.51]

126

Standard Method Load Calculations Example

- What size service is required for a 1,500 sq. ft. dwelling unit containing the following loads?

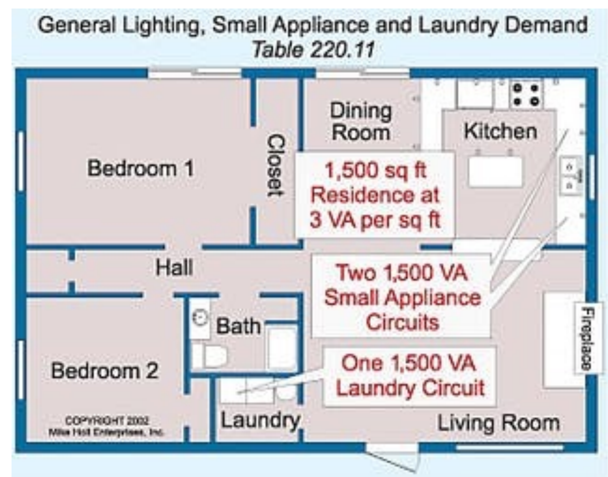
Equipment	Wattage (VA)
Dishwasher	1,500 VA
Waste Disposer	1,000 VA
Water Heater	4,5000 W
Dryer	4,000 W
Range	14,000 W
Air-Conditioning	17A, 240V
Electric Heating (one control unit)	8,000 W

127

Step 1. General Lighting and Receptacles

• 1500 sq. ft x 3VA =	4500 VA
• Small appliance circuits: 1500 VA x 2 =	3000 VA
• Laundry circuit: 1500 VA x 1 =	1500 VA
• Total Connected Load	9000 VA
• Take first 3000 VA at 100%: 3000 x 1 =	3000
• Take remainder at 35%: 6000 x 0.35 =	2100
• Demand Load	5,100

128



129

Step 2: Appliance Demand Load

- Dishwasher: 1500VA
- Waste Disposer: 1000VA
- Water Heater: <u>4500 W</u>
- Demand Load 7000 VA

130

Step 3: Dryer Demand Load

- The dryer load must not be less than 5000W 5000W

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Step 4: Cooking Equipment Load

A. Determine the Column C value for 14,000 W range:
   - 14 kW exceeds 12 kW by 2kW
   - Must be increased 5% for each kW over 12kW per note 1
   - 2 x 5% = 10%
   - 10% increase = 110% = 1.1 multiplier

B. Determine the demand load:
   - Refer to Table 220.55 Column C value x multiplier from above
   - Demand load = 8kW x 1.1 = 8000 x 1.1 = 8800W

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Pin Header ×

Table 220.55 Demand Factors and Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over $1^{3}/_{4}$ kW Rating (Column C to be used in all cases except as otherwise permitted in Note 3.)

Number of Appliances	Demand Factor (%) (See Notes) Column A (Less than $3^{1}/_{2}$ kW Rating)	Demand Factor (%) (See Notes) Column B ($3^{1}/_{2}$ kW through $8^{3}/_{4}$ kW Rating)	Column C 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

133

Notes:
1. Over 12 kW through 27 kW ranges all of same rating. For ranges individually rated more than 12 kW but not more than 27 kW, the maximum demand in Column C shall be increased 5 percent for each additional kilowat rating or major fraction thereof by which the rating of individual ranges exceeds 12 kW.
2. Over $8\tfrac{3}{4}$ kW through 27 kW ranges of unequal ratings. For ranges individually rated more than $8\tfrac{3}{4}$ kW and of different ratings, but none exceeding 27 kW, an average value of rating shall be calculated by adding toget ratings of all ranges to obtain the total connected load (using 12 kW for any range rated less than 12 kW) and dividing by the total number of ranges. Then the maximum demand in Column C shall be increased 5 percent kilowatt or major fraction thereof by which this average value exceeds 12 kW.
3. Over $1\tfrac{3}{4}$ kW through $8\tfrac{3}{4}$ kW. In lieu of the method provided in Column C, it shall be permissible to add the nameplate ratings of all household cooking appliances rated more than $1\tfrac{3}{4}$ kW but not more than $8\tfrac{3}{4}$ kW a multiply the sum by the demand factors specified in Column A or Column B for the given number of appliances. Where the rating of cooking appliances falls under both Column A and Column B, the demand factors for e column shall be applied to the appliances for that column, and the results added together.
4. Branch-Circuit Load. It shall be permissible to calculate the branch-circuit load for one range in accordance with Table 220.55. The branch-circuit load for one wall-mounted oven or one counter-mounted cooking unit s the nameplate rating of the appliance. The branch-circuit load for a counter-mounted cooking unit and not more than two wall-mounted ovens, all supplied from a single branch circuit and located in the same room, shall calculated by adding the nameplate rating of the individual appliances and treating this total as equivalent to one range.
5. This table shall also apply to household cooking appliances rated over $1\tfrac{3}{4}$ kW and used in instructional programs.

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Step 5: Air-Conditioning vs. Heat Demand Load

1. Power = Volts x Amps
2. AC Load = 240V x 17A = 4080 VA
3. 4080VA/1000 = 4.08 kVA
4. Compare Heat load and AC Load
    1. Heat load = 8kW (8000W)
    2. AC load = 4.08kVA (4080 VA)
    3. The heating load is larger, so omit the AC load
5. Go with 8000W heating load

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Step 6: Combine loads from steps 1-5

Step 1. General Lighting Demand Load:	5100 VA
Step 2. Appliance Demand Load:	7000 VA
Step 3. Dryer Demand Load:	5000 W
Step 4. Cooking Equipment Demand Load:	8800 W
Step 5. Heating Demand Load:	8000 W
Total Demand Load	33,900 VA

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6. Feeder and Service Conductor Size

- For one-family dwellings and individual dwelling units of two-family and multifamily dwellings…
- Service and feeder conductors supplied by a single-phase, 120/240V system can be sized using 310.15(B)(7)
    - The conductors can be sized to 83% of the service overcurrent protection device rating (not the calculated load)

NOTE: The 83% deduction cannot be used for two-family or multi-family dwellings

137

(7) 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).

For one-family dwellings and the individual dwelling units of two-family and multifamily dwellings, single-phase feeder conductors consisting of 2 ungrounded conductors and the neutral conductor from a 208Y/120 volt system shall be permitted to be sized in accordance with **310.15(B)(7)**(1) through (3).

(1) For a service rated 100 through 400 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.

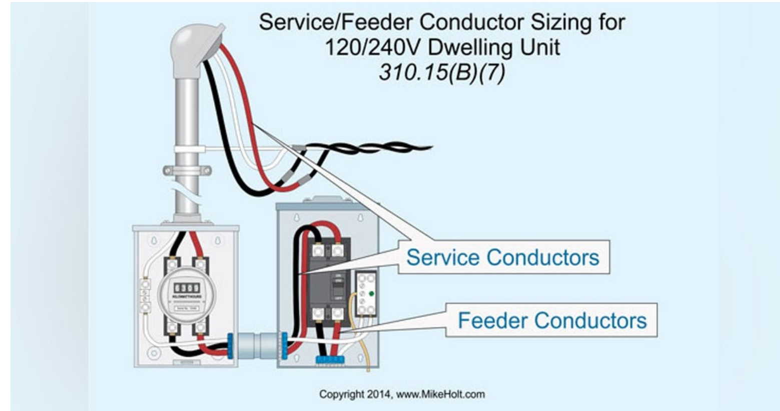
(2) For a feeder rated 100 through 400 amperes, the feeder conductors supplying the entire load associated with a one-family dwelling, or the feeder conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an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

(3) In no case shall a feeder for an individual dwelling unit be required to have an ampacity greater than that specified in **310.15(B)(7)**(1) or (2).

(4) Grounded conductors shall be permitted to be sized smaller than the ungrounded conductors, if the requirements of **220.61** and **230.42** for service conductors or the requirements of **215.2** and **220.61** for feeder conductors are met.

310.15(B)(7)

138



Service conductors supplying the entire load for a one-family dwelling can be sized not less than 83%
Of the service rating

139

Service Size Conductor Example

- What size conductors are required if the calculated load for a dwelling unit equals 33,900 VA from previous example
- Find Amps: 33,900 VA/240V = 141A
- Use 150A service for 141A
- Service conductor = 83% of service rating per 310.15(B)(7)
  - 150 x 0.83 = 125A
- Use 1 AWG rated for 130A at 75 deg C

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Pin Header

Table 310.15(B)(16) (formerly Table 310.16) Allowable Ampacities of Insulated Conductors Rated Up to and Including 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)*

	Temperature Rating of Conductor [See Table 310.104(A).]						
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	
Size AWG or kcmil		COPPER		ALUMINUM OR COPPER-CLAD ALUMINUM			Size AWG or kcmil
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

141

Neutral Demand Calculations

- Uses only loads that use the neutral conductor:
  - General lighting and receptacles
  - Small appliances
  - Cooking equipment
  - Clothes dryer

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Neutral Service and Feeder Calculation [220.61(B)]

- Use 100% of calculated general lighting and receptacle demand: 5100VA
- Use 100% of calculated appliance demand load: 2500 VA
- Cooking Equipment Neutral Load [220.61(B)(1)]
  - Calculated as 70% of demand load
  - From previous example, demand load = 8800 VA
  - 8800 VA x 0.70 = 6160 VA
- Dryer neutral load [220.61(B)(1)]
  - Based on 70% of the demand load
  - From previous example, dryer demand load = 5000W
  - 5000W x 0.70 = 3500 W

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Total Neutral Load

• General Lighting and Receptacle demand:	5100 VA
• Appliance Demand Load:	2500 VA
• Dryer Demand Load:	3500 W
• Cooking Equipment Demand Load:	<u>6160 W</u>
• Total Neutral Demand	17260 VA

- Neutral amps = neutral demand/system voltage: 17,260/240 =72A
- #4 AWG at 75 deg C is rated for 85A per Table 310.15(B)(16)
- Therefore minimum neutral size required is #4 AWG

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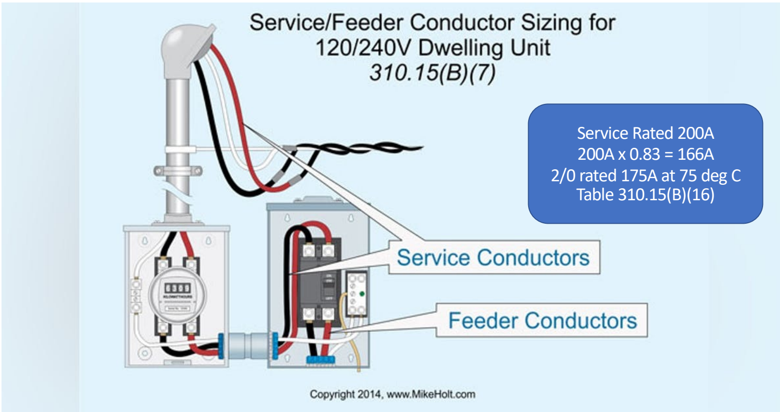
Service Size Conductor Example 2

- What size conductors are required if the calculated load for a dwelling unit equals 195A, and the service disconnect is rated 200A?

145



Service conductors supplying the entire load for a one-family dwelling can be sized not less than 83%
Of the service rating

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Pin Header

Table 310.15(B)(16) (formerly Table 310.16)
Allowable Ampacities of Insulated Conductors Rated Up to and Including 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)*

	Temperature Rating of Conductor [See Table 310.104(A).]						
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	
Size AWG or kcmil	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			Size AWG or kcmil
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
700	385	460	520	315	375	425	700

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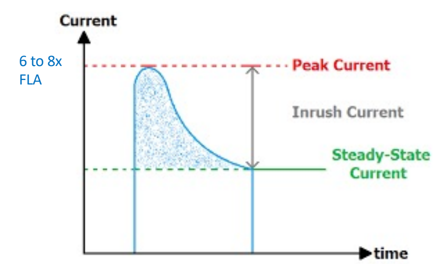
Optional Method Load Calculations
[Article 220, Part IV]

- Section 220.82
- Used for dwelling units served by 120/240V or 120/208V, 3-wire service or feeder
- Service or feeder having ampacity of 100A or larger

148

Motors

- Motor present unique challenges
- Expensive, large, heavy, moving parts
- Impact on power system
- High inrush current
  - Need to allow motor to start without tripping
- Needs protection against
  - Short circuits
  - Ground faults
  - Overcurrent



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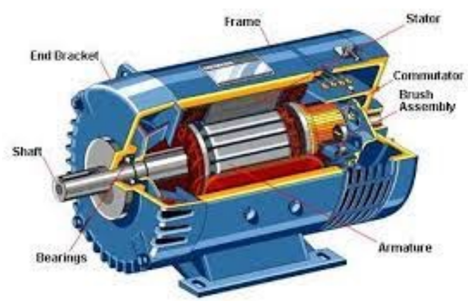
Motors

- Motor Branch Conductor Sizing [430.22(A)]
  - https://www.youtube.com/embed/buK7LT0yvwE
- Motor Full Load Current (FLC): 430.6(A)(1)
  - https://www.youtube.com/embed/Sic1uoua3og
- Motor Full Load Amps – Nameplate (FLA): 430.6(A)(2)
  - https://www.youtube.com/embed/2cprO8ZdT1U



150

Motor Branch-Circuit Conductors

- Section 430.22(A) requires the ampacity of motor branch-circuit conductors supplying a single motor used in a continuous duty application to be 125% of the motor full-load current (FLC)
- Branch-circuit conductors must be selected from the allowable ampacity tables *[primarily Table 310.15(B)(16)]*

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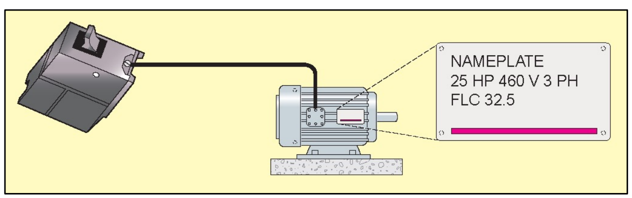
Motor Branch-Circuit Conductors



- What is the minimum ampacity of the branch-circuit conductors for a 25 hp, 460 volt, 3-phase squirrel-cage motor with a nameplate full-load current rating of 32.5 amperes?

152

Branch-Circuit Conductors

- Section 430.6(A)(1)
  - Nameplate FLA is not to be used
  - Use Table value for FLC
  - Table 430.250, 25 hp at 460 volts
  - Table value FLC = 34 amperes
- Section 430.22
  - Ampacity = FLC × 125%
  - Ampacity = 34 A × 1.25 = 42.5 amperes
- Answer: **42.5 amperes**

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Pin Header

Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors

Horsepower	Induction-Type Squirrel Cage and Wound Rotor (Amperes)							Synchronous-Type Unity Power Factor* (Amperes)		
	115 Volts	200 Volts	208 Volts	230 Volts	460 Volts	575 Volts	2300 Volts	230 Volts	460 Volts	575 Volts
he following values of ull-load currents are ypical for motors unning at speeds usual or belted motors and notors with normal orque characteristics. he voltages listed are ated motor voltages. he currents listed shall e permitted for ystem voltage ranges f 110 to 120, 220 to 40, 440 to 480, and 50 to 600 volts.										
1/2	4.4	2.5	2.4	2.2	1.1	0.9	—	—	—	—
3/4	6.4	3.7	3.5	3.2	1.6	1.3	—	—	—	—
1	8.4	4.8	4.6	4.2	2.1	1.7	—	—	—	—
1 1/2	12.0	6.9	6.6	6.0	3.0	2.4	—	—	—	—
2	13.6	7.8	7.5	6.8	3.4	2.7	—	—	—	—
3	—	11.0	10.6	9.6	4.8	3.9	—	—	—	—
5	—	17.5	16.7	15.2	7.6	6.1	—	—	—	—

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Pin Header

Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors

Horsepower	Induction-Type Squirrel Cage and Wound Rotor (Amperes)							Synchronous-Type Unity Power Factor* (Amperes)		
	115 Volts	200 Volts	208 Volts	230 Volts	460 Volts	575 Volts	2300 Volts	230 Volts	460 Volts	575 Volts
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
75	—	221	211	192	96	77	20	155	78	62
100	—	285	273	248	124	99	26	202	101	81
125	—	359	343	312	156	125	31	253	126	101
150	—	414	396	360	180	144	37	302	151	121
200		552	528	480	240	192	49	400	201	161
250	—	—	—	—	302	242	60	—	—	—
300	—	—	—	—	361	289	72	—	—	—
350	—	—	—	—	414	336	83	—	—	—
400	—	—	—	—	477	382	95	—	—	—

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Motor Branch-Circuit Conductors

- Motors that are permitted to use the nameplate value *(instead of Table values)* for sizing the branch-circuit conductors are as follows:
  - Low speed and multispeed motors
  - Listed appliances and specific equipment
  - Torque motors
  - AC adjustable voltage motors
  - Adjustable-speed drive systems

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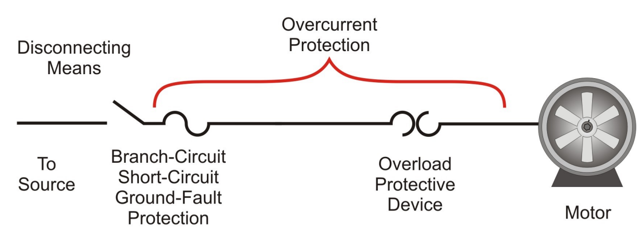
Overcurrent Protection

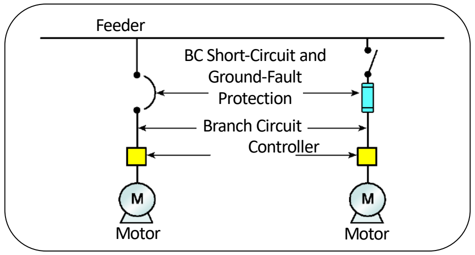


Branch-Circuit Short-Circuit Ground-Fault Protection: Intended to protect the motor branch-circuit conductors, the motor control apparatus, and the motors against overcurrent due to short circuits or ground faults [430.51]

Overload Protective Device: Intended to protect motors, motor-control apparatus, and motor branch-circuit conductors against excessive heating due to motor overloads and failure to start [430.31]

157

Short-Circuit and Ground-Fault Protection



Purpose:

- To protect circuit conductors, motors and motor controller equipment from overcurrent due to short-circuits and ground-faults

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Short-Circuit and Ground-Fault Protection

The fundamental rule of 430.52(C)(1) requires:

- The maximum rating or setting of the protective device must not exceed the values calculated according to Table 430.52
- And, from a practical point of view, Exception No. 1 permits the next higher standard size overcurrent device to be used
- This is often referred to as "round up rule"

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Short-Circuit and Ground-Fault Protection

- The "motor branch-circuit short-circuit and ground-fault protective" device actually refers to a typical fuse or circuit breaker that…
  - is set to trip at a higher rating than a branch-circuit fuse or circuit breaker for a common circuit
  - protects the motor branch circuit against short circuits and ground faults only
  - does not protect the motor circuit against overloads

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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	Dual Element (Time-Delay) Fuse	Instantaneous Trip Breaker	Inverse Time Breaker
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	300	175	800	250
Wound rotor	150	150	800	150
Direct current (constant voltage)	150	150	250	150

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Pin Header

Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices

Type of Motor	Percentage of Full-Load Current: Nontime Delay 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.

[3]Synchronous motors of the low-torque, low-speed type (usually 450 rpm or lower), such as are used to drive reciprocating compressors, pumps, and so forth, that start unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 percent of full-load current.

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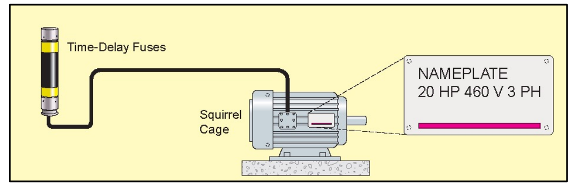
Short-Circuit and Ground-Fault Protection



- Determine the maximum overcurrent protection permitted according to Table 430.52 for a typical 20 HP, 3 phase, 460 volt, Design B, squirrel cage or synchronous motor
- The overcurrent protective devices selected for this example include time-delay fuses but for training, we will consider an inverse time breaker as well

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Pin Header

Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors

	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 Volts	230 Volts	460 Volts	575 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
75	—	221	211	192	96	77	20	155	78	62
100	—	285	273	248	124	99	26	202	101	81
125	—	359	343	312	156	125	31	253	126	101
150	—	414	396	360	180	144	37	302	151	121
200		552	528	480	240	192	49	400	201	161
250	—	—	—	—	302	242	60	—	—	—
300	—	—	—	—	361	289	72	—	—	—
350	—	—	—	—	414	336	83	—	—	—
400	—	—	—	—	477	382	95	—	—	—

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Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices

Type of Motor	Percentage of Full-Load Current: Nontime Delay Fuse	Dual Element (Time-Delay) Fuse	Instantaneous Trip Breaker	Inverse Time Breaker
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	300	175	800	250
Wound rotor	150	150	800	150
Direct current (constant voltage)	150	150	250	150

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Trip on high levels of fault current very fast.
Won't trip on low levels of overcurrent

Inverse Time (Thermal Magnetic) Breaker

Has as magnetic portion for tripping fast on
High fault levels.

And has a thermal portion which allows for
tripping on low overcurrent levels – longer trip

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Short-Circuit and Ground-Fault Protection

- Solution: Using Time-Delay Fuses
- Table 430.250: 20 HP at 460 volts
- FLC = 27 amperes
- Table 430.52: Time-delay fuse 175%
- OCPD rating = 27 A × 1.75 = 47.25 amperes
- 430.52(C)(1), Ex. No. 1 permits next larger standard size
- 240.6(A) next larger size, 50 ampere
- 50 amperes is the maximum rating of the time-delay fuse for the 20 HP motor
- Answer: **50 ampere time-delay fuses**

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- Solution: Using an Inverse Time Circuit Breaker
- Table 430.250: 20 HP = 27 amperes
- Table 430.52: inverse time circuit breaker, 250%
- OCPD = FLC × 250%
- OCPD = 27 A × 2.50 = 67.5 amperes
- 430.52(C)(1), Ex. No. 1 permits next larger standard size
- 240.6(A), next larger, 70 amperes
- 70 amperes is the maximum rating of the inverse time CB for the 20 HP motor
- Answer: **70 ampere inverse time circuit breakers**

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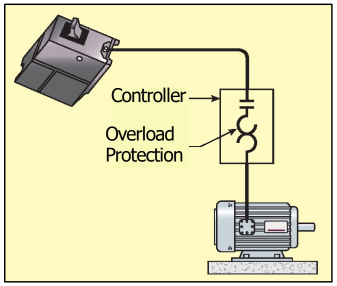
Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices

	Percentage of Full-Load Current			
Type of Motor	Nontime Delay Fuse	Dual Element (Time-Delay) Fuse	Instantaneous Trip Breaker	Inverse Time Breaker
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	300	175	800	250
Wound rotor	150	150	800	150
Direct current (constant voltage)	150	150	250	150

169

Motor Overload Protection

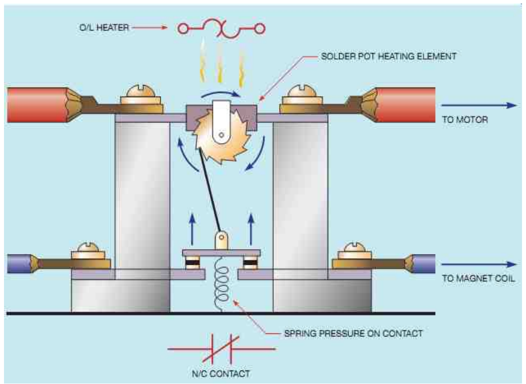


Overload Protection

- The purpose of motor overload (OL) protection is to protect the motor, motor control apparatus, and motor branch-circuit conductors against excessive heating due to overloads

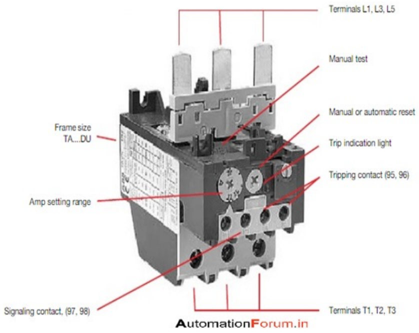
170

Bi-Metallic (Mechanical) Overload



171

Electronic Overload Device



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Motor Overload Protection

- The overload current is a current that, when it persists for a sufficient length of time, can damage the equipment and/or the conductors
- Overloads are caused by the following:
  - Failure to start,
  - Excessive load on motor,
  - Worn motor bearings, or
  - Other mechanical problems

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Motor Overload Protection

- Section 430.32(A)(1) requires that overload protective devices for continuous duty motors, rated more than one horsepower, be sized according to the motor nameplate FLA and the following motor nameplate information
  - Service factor not less than 1.15 = 125%
  - Temperature rise not over 40°C = 125%
  - All other motors = 115%
- These percentages are generally considered the maximum OL protection unless…
- *[See 430.32(C) not sufficient to start motor]*

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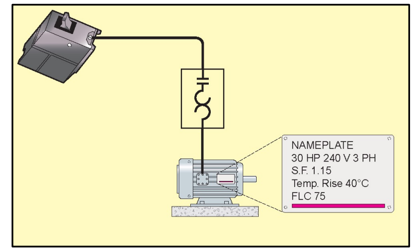
Motor Overload Protection



- Determine the maximum overload protection *(OL protection)* for a 30 HP, 240 volt, 3-phase, squirrel-cage induction motor with a nameplate full-load current of 75 amperes, service factor of 1.15, and a temperature rise of 40°C

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Motor Overload Protection

- 430.32(A)(1), *(Max. OL protection)* :
- Use nameplate FLA
- Service factor 1.15, temperature rise 40°C, 125%
- OL protection = FLC × 125%
- OL protection = 75 A × 1.25 = 93.75 amperes
- Answer: **90 amperes**

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Motor Overload Protection

- One of the goals of overload protection is to protect a piece of electrical equipment as close to its rated full-load current as possible, while not having nuisance tripping during the starting current period
- There are other permissions within the *Code* to adjust the previous requirements
- Those adjustments are permitted by the *Code* to allow for hard motor starting, different levels of protection, and different types of overload protection devices

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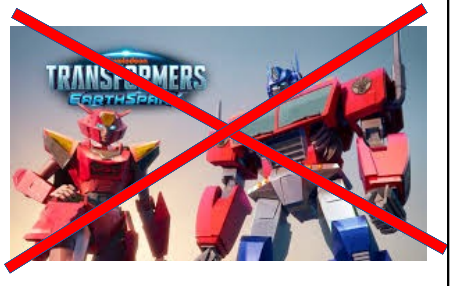
Transformer Calculations



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Transformer Basics

- Works on the principle of mutual induction
- Power measured in VA (Volts-Amps)
- Can be single phase or three phase
- Typically have a primary and secondary winding
- Current in one winding induces a current in another winding
- Voltage and current determined by the number of turns of wire in the windings
- Can step or step down voltage
- Windings require protection from damage

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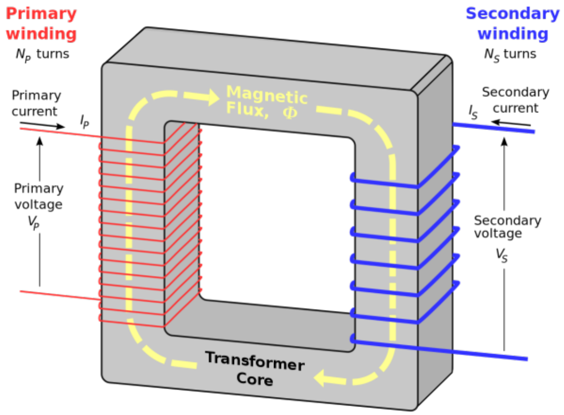
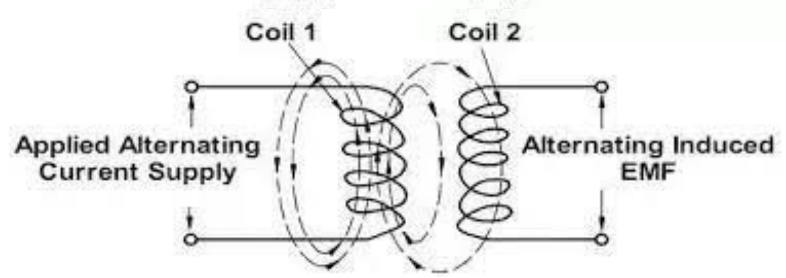


180



181

Transformer Basics

- It is difficult to apply overcurrent protection directly to output of transformer windings to protect output conductors
- Therefore tap rules apply

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Transformer Overcurrent Protection

- Objective: To protect the windings, not the conductors
- Reference section 450.3(B)

Table 450.3(B) Primary Protection Only	
Primary Current Rating	Maximum Protection
9A or more	125%, note 1
Less than 9A	167%
Less than 2A	300%
Note 1: Where 125% of the primary current doesn't correspond to a standard rating of a fuse or nonadjustable circuit breaker, the next higher rating is permitted[240.6(A)]	

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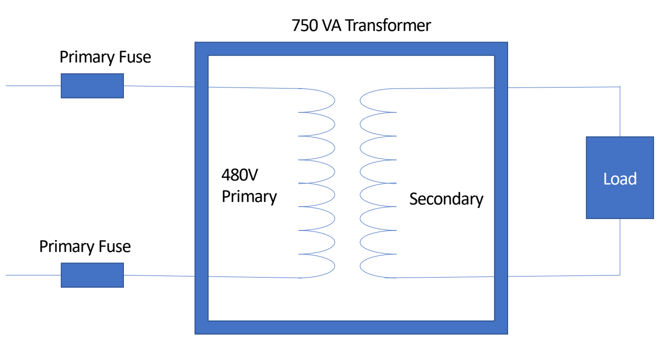
Primary Overcurrent Protection – Less Than 2A Example



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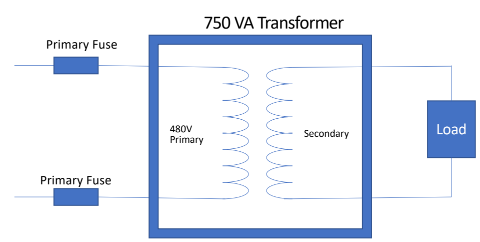
Primary Overcurrent Protection – Less Than 2A Example

- What's the maximum primary overcurrent protection device rating for a 750VA continuously loaded, single-phase, 480V transformer?



Primary

P = VxA
A = P/V = 750VA/480V = 1.56A

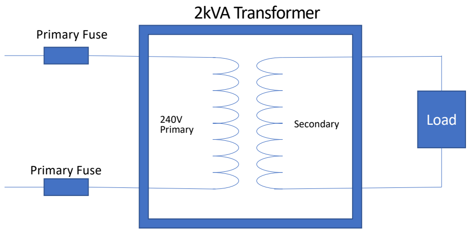
Protection

Per Table 450.3(B), for primary current less than 2A, the Maximum overcurrent protection is 300% or 3.00
I_{pri} = 1.56A x 3 = 4.68A
Round down to 4 amps since next size up only applies to Primary current greater than 9A per note on Table 450.3(B)

185

Primary Overcurrent Protection – Less Than 9A Example

- What's the maximum primary overcurrent protection device rating for a 2kVA continuously loaded, single-phase, 240V transformer?



Primary

P = V x A
A = P/V = 2000VA/240V = 8.33A

Protection

Per Table 450.3(B), for primary current less than 9A, the Maximum overcurrent protection is 167% or 1.67
I_{pri} = 8.33A x 1.67 = 13.92A
Round down to 13 amps since next size up only applies to Primary current greater than 9A per note on Table 450.3(B)

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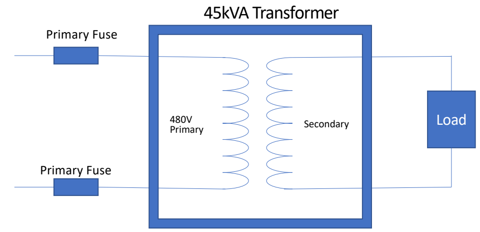
Primary Overcurrent Protection – Greater Than 9A Example

- What's the maximum primary overcurrent protection device rating for a 2kVA continuously loaded, three-phase, 480V transformer?



Primary

P = V x A x 1.73
A= P/(V x1.73) = 45,000VA/(480 x 1.73) = 51.19A

Protection

Per Table 450.3(B), for primary current greater than 9A, the Maximum overcurrent protection is 125% or 1.25
I_{pri} = 54.19A x 1.25 = 67.74A
Round up to 70 amps since next size up applies to Primary current greater than 9A per note on Table 450.3(B)

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Pin Header

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

Standard Ampere Ratings				
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	—	—	—

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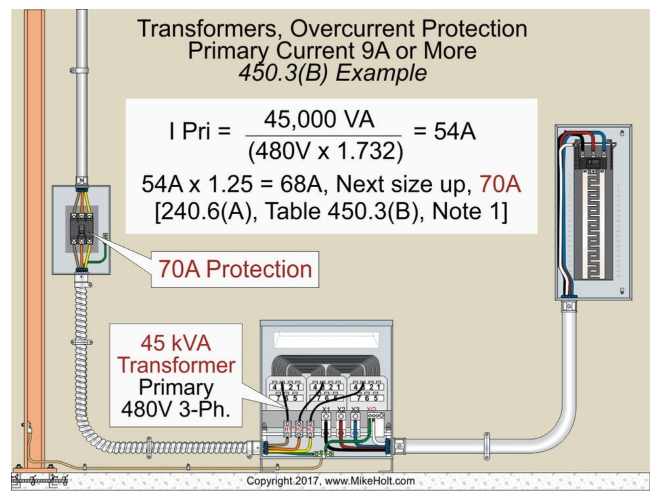

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Transformer Primary Conductor Sizing

- Conductors must be sized no less than 125% of the continuous loads, plus 100 percent of the noncontinous loads, based on the terminal temperature rating ampacities as listed in Table 310.15(B)(16) before and ampacity adjustment [210.19(A)(1)]

190

Transformer Primary Conductor Sizing

- Conductors must be protected against overcurrent in accordance with their ampacity after ampacity adjustment
  - Adjustments:
    - More than 3 conductors
    - Temperature
    - Above roof if it applies

191

Primary Conductor Sizing Example 1

- What size primary conductors can be used for a 45 kVA continuously loaded transformer, 3-phase, 480V transformer, where the primary overcurrent protection device is sized at 70A

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Primary Conductor Sizing Example

- Look for key words

- What size primary conductors can be used for a 45 kVA continuously loaded transformer, 3-phase, 480V transformer, where the primary overcurrent protection device is sized at 70A

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Primary Conductor Sizing Example 1

1. Size the primary conductor at 125% of the primary current rating
   - I = 45,000 VA/(480V x 1.732) = 54A
   - 54 x 1.25 = 68A
   - Per table 310.15(B)(16), #4 wire at 60 deg C terminals is rated for 70A
2. Verify that the conductors are protected in accordance with their ampacities [240.4]
   - 4 AWG rated 70A at 60 deg C is permitted to be protected by a 70A primary overcurrent protection device

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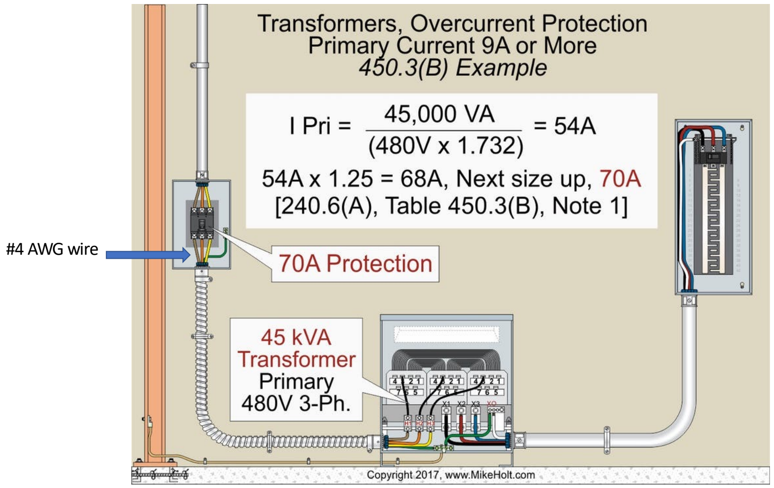
Pin Header

Table 310.15(B)(16) (formerly Table 310.16) Allowable Ampacities of Insulated Conductors Rated Up to and Including 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)*

	Temperature Rating of Conductor [See Table 310.104(A).]						
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	
Size AWG or kcmil		COPPER		ALUMINUM OR COPPER-CLAD ALUMINUM			Size AWG or kcmil
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

195



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Primary Conductor Sizing Example 2

- What size primary conductors can be used for a 75 kVA continuously loaded transformer, 3-phase, 480V transformer, where the primary overcurrent protection device is sized at 125A

197

Primary Conductor Sizing Example 2

1. Size the primary conductor at 125% of the primary current rating
   - I = 75,000 VA/(480V x 1.732) = 90A
   - 90 x 1.25 = 113A
   - Per table 310.15(B)(16), #2 wire at 75 deg C terminals is rated for 115A

2. Verify that the conductors are protected in accordance with their ampacities [240.4]
   - 2 AWG rated 115A at 75 deg C is permitted to be protected by a 125A primary overcurrent protection device.
   - However, the maximum continuous load is limited to 92 A (115A x 80%) in accordance with 215.2(A)

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CONGRATULATIONS!

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Next Steps

- A Certificate of Completion will be emailed to those who successfully completed course
- 4 hours of Code Class Hours will be reported to the OCILB for Code Continuing Education Credits
- Contact instructor at hpmatthews@matthewselectrical.net for any questions or comments
- Make sure you completely sign out of webinar after the next slide!

200

200

201

File Attachments for Item:

ER-3 2020 NEC Hazardous Locations Webinar (Matthews Electrical Services)

BI, MPE, EPE, MechPE, ESI, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)

Staff Notes: Add NRIUI, recommend approval.

ESIAC Recommendation:

Committee Recommendation:

[redacted]

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: Henry Peter Matthews

Course Submitter: Henry Peter Matthews
(Contact Name)
Organization: Matthews Electrical Services
(Organization/Company)
Address: 1203 McKinley Place
(Include Room Number, Suite, etc.)
City: Fostoria State: Ohio Zip: 44830
E-Mail: hpmatthews@matthewselectrical.net
Telephone: 419-575-3488 Fax:
Course Sponsor:

COURSE INFORMATION:

Course Title: NEC Hazardous Locations

New Course Submittal: [x] Update Course: [ ] Prior Approval Number:

Purpose and Objective: The purpose of this webinar is to introduce attendees to the various requirements for Hazardous Locations in chapter 5 with special focus on Articles 500, 501, 502, and 503. This class will cover Class I, Class II and Class III conditions and will describe the differences between Division 1 and Division 2 locations. This class will also cover the special wiring and equipment requirements for hazardous (classified) locations.

Number of Instructional Contact Hours that can be obtained upon completion: 4

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

Program Applicable for the Following Participants:

- Building Official [x]
- Master Plans Examiner [x]
- Plumbing Plans Exam. [ ]
- Electrical Plans Exam. [x]
- Mechanical Plans Exam. [x]
- Building Inspector [x]
- Fire Protection Inspector [ ]
- Mechanical Inspector [x]
- Plumbing Inspector [ ]
- Non-Res IU Inspector [ ]

- Res Building Official [x]
- Res Plans Examiner [x]
- Res Building Inspector [x]
- Res Mechanical Inspector [x]
- Res IU Inspector [x]

Electrical Safety Inspectors [ ]
Location of ESI Course: www.matthewselectricalservices.net Date(s) of ESI Course(s): November 19, 2022

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
Course Sponsor:	Organization sponsoring or requesting the program (if any)	
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:	Copy of quizzes or tests to be given	x
Completed Application:		x

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

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BOARD OF BUILDING STANDARDS

Form: 1526 BBS 31023210

Hazardous Locations

- Review Chapter 5 of the NEC that covers hazardous locations
- Learn the definitions of the various hazardous locations: Class I, Class II, Class III
- Learn the definitions of the various divisions associated with the classes: Division 1 and Division 2
- Learn the difference between the Division method and Zone method of classification
- Review the wiring methods required for hazardous locations
    - Sealing requirements
    - Enclosure requirements
    - Equipment selection
    - Grounding and bonding requirements
- Understand what types of equipment are required in hazardous locations
- Understand how to read hazardous area classification drawings
- Learn the various alternative methods for installations in hazardous locations
    - Enclosure pressurization
    - Intrinsic safety equipment
    - Hermetically sealed equipment
    - Sealed contacts
- Learn how Temperature codes (T-codes) impact equipment selection
- Learn how to conduct electrical installations in the following areas:
    - Gas fueling stations
    - Petrochemical processing locations
    - Automobile service stations and garage
    - Aircraft refueling locations
    - Hazardous chemical storage locations
    - Dust handling locations
    - Locations with air-suspended fibers (textiles for example)
    - Tank farms and pipeline facilities
    - Many others
- Learn how to understand the various European methods and how they may or may not apply in the United States.

Henry Peter Matthews, PE, CPE, CESCP, PVA

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Work Experience

Marathon Petroleum Company, LP; Findlay, Ohio — June 2006 – Present

- Advanced Senior Engineer/Electrical Specialist
- Electrical Engineering Supervisor – Terminal Engineering
- Project Engineer – Major Projects
- Electrical Designer – Retail Division

Cooper Standard Automotive, Bowling Green, Ohio — July 1993 – June 2006

- Plant Engineering Manager
- Plant Electrical Engineer

Toledo Engineering Company (consultant); Toledo, Ohio — June 1989 – July 1993

- Electrical Drafter

Education

Bowling Green State University; Bowling Green, Ohio — Aug 2003
Masters of Business Administration

Pennsylvania State University; University Park, PA — Dec 1989
BS Electrical Engineering

Solar Energy International, Paonia, Colorado — Sept 2021
Solar PV Training

Owens Community College; Findlay, Ohio — April 2017
Certificate: Introductory Welding

Penn Foster Career School — July 2010
Certificate: Plumbing

Penn Foster Career School — October 2004
Certificate: Electrician

Certifications

Professional Engineer (PE): OH, MI, IN, KY, IL, WI
Photovoltaic Associate (PVA) by NABCEP
Certified Electrical Safety Compliance Professional (CESCP), NFPA
Certified Plant Engineer (CPE): Association for Facility Engineers
Building Operator Certification (BOC): Northwest Energy Efficiency Council

Licenses **Ohio Electrical Contractor**, Ohio Department of Commerce, License # 46972
Ohio Training Agency, Ohio Construction Industry Licensing Board, Agency #48714
Ohio Training Agency, Ohio Board of Building Standards

Special Training **Solar Energy International (SEI),** Paonia, Colorado

- Solar Electric and Design and Installation Course, April 2021, 60 hours
- PV Systems Fundamentals (Battery-Based), June 2021, 40 hours
- Advanced PV System Design and the NEC, June-July 2021, 60 hours
- Comparing Battery Technologies, July 2021, 10 hours
- Tools and Techniques for Operations and Maintenance of PV Systems, 9/21, 40 HR

Affiliations

Institute of Electrical and Electronics Engineers (IEEE) – Senior Member
International Association of Electrical Inspectors (IAEI)
NFPA Section Member for Architects, Engineers and Building Officials
Illumination Engineering Society of North America (IESNA)
API RP 545 former Co-Chair, American Petroleum Institute, Lightning Protection for Above Ground Storage Tanks (2017- 2018)

Business Ownership **Matthews Electrical Services, Owner**
Designer Cuts Hair Salon, LLC; Co-owner

Biography

Henry has worked in the electrical, power, electronics, instrumentation, controls and communication fields for over 30 years. He earned his Bachelor of Science degree in Electrical Engineering from Penn State University in 1989. Henry worked as a consultant for Toledo Engineering Company in Toledo, Ohio as a drafter and field technician.

In 1993 he started working for Cooper Standard Automotive Company in Bowling Green, Ohio in 1993 as a Plant Electrical Engineer. He was then promoted to Plant Engineering Manager in 2000. During this time, he earned his Professional Engineering License in Ohio.

In 2003, Henry earned his MBA at Bowling Green State University.

In 2006, Henry joined Marathon Petroleum Company in Findlay, Ohio. He then went on to obtain his Professional Engineers license in Electrical Engineering for Michigan, Indiana, Illinois, West Virginia, Kentucky, Minnesota and Wisconsin. During his tenure at Marathon, Henry has had several roles including Electrical Design Engineer, Project Engineer and Electrical Supervisor. He is currently an Advanced Senior Engineer where he writes electrical standards for the company and conducts a community of practice for all the company's electrical engineers and safety professionals.

During his time at Cooper Standard Automotive and Marathon Petroleum, Henry developed a passion for teaching, learning and applying Electrical Construction Codes. At Cooper, he trained the entire non-electrical maintenance staff to perform basic electrical tasks.

At Marathon, Henry works with the Learning and Development Department to conduct multiple training sessions for new hires and seasoned engineers on various topics including Electrical Safety, Grounding and Bonding, Hazardous Area Location, Electrical Inspection, Motors, Lightning protection Static Electricity Mitigation, Reading and Understanding Electrical Diagrams, Programmable Logic Controllers and more.

Henry also works very closely with the Talent Acquisition Teams and visits numerous college campuses to deliver presentations on Engineering, Career Development, Networking and other topics.

Henry recently served as the Co-chair of the API Recommended Practice 545 Task Group for Lightning Mitigation for Above Ground Storage Tanks. In this role, he works with engineers, scientists and manufacturers from all over the world to evaluate the impacts of lightning and static electricity on metal above ground storage tanks.

His passion for teaching and Electrical Safety has motivated him to earn the Certified Electrical Safety Compliance Professional Certification (CESCP) from NFPA. He also regularly attends numerous electrical and safety conferences and training sessions conducted by NFPA, IEEE, API.

Previously, Henry was the President of the Fostoria, Ohio area Toastmasters team.

Henry is also a member of the International Association of Electrical Inspectors.

Henry also owns two small businesses:

> **Matthews Electrical Services** - that performs mainly limited residential and small commercial electrical services and conducts training for licensed electricians in the state of Ohio.
>
> **Designer Cuts Hair Salon, LLC** – Henry co-owns the beauty salon with his wife.

NEC Hazardous Locations Webinar

OCILB COURSE NO. 4871421

Matthews Electrical Services

Ohio Training Agency #48714

Henry Matthews, PE, CPE, CESCP

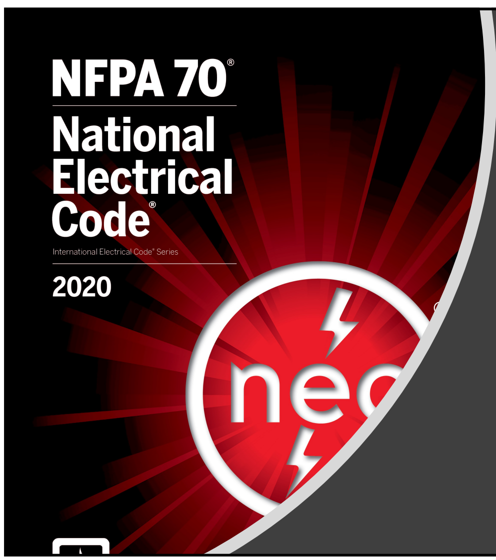
1

1

Webinar Rules

- Attendee must be present the entire time (except breaks)
- Webinar may be recorded
  - Proof of attendance and participant identity
  - Potential OCILB audits
- Turn on webcam:
  - After breaks
  - Before end of class
  - At instructor discretion to check attendance
- Mute microphone at all times
  - Prevents distraction during webinar
  - Instructor may activate participant microphone if verbal response is needed

2



Chapter 5 Special Occupancies (Hazardous Locations)

3

Disclaimer

- The views and opinions presented in this course are those of Matthews Electrical Services and not necessarily those of the various entities the presenter references
- The views also does not necessarily reflect the views of his previous or current employers
- The material used in this class is based on documented publicly-available information (NFPA, OSHA, ESFI etc.)
- The interpretation of this material is based on the presenter's experience and training of the subject matter.

4

4

Disclaimer

- This presentation references equipment and websites from various manufacturers, agencies and other resources. This is not intended to endorse particular products, vendors, websites or manufacturers.
- The content is shown for educational purposes only.

5

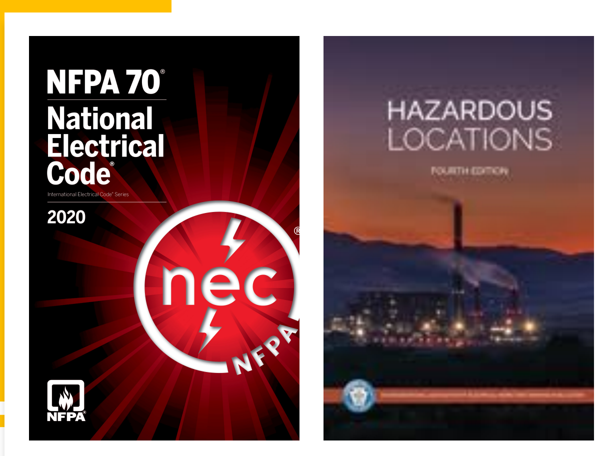
5

WELCOME!

- Goals
  - Promote learning
  - Make session engaging
    - Discussion
    - Videos
  - Make time as productive as possible!

6

6



Hazardous (Classified) Locations

References

7

Agenda

- The Basics
- Hazardous Area Classification (aka Hazardous Location) example
- Movie Time!
- Wrap Up

8

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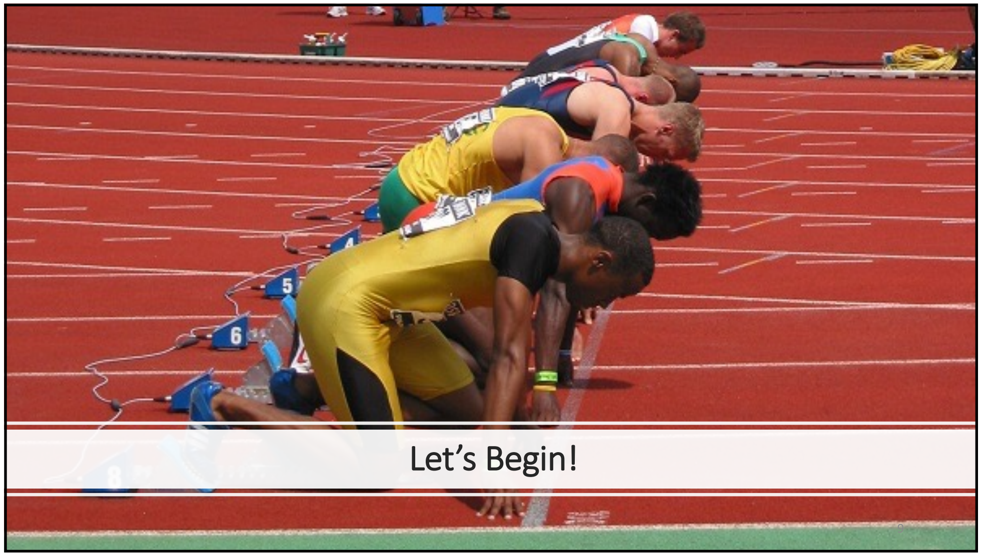

Let's Begin!

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But First…

Let's take a poll

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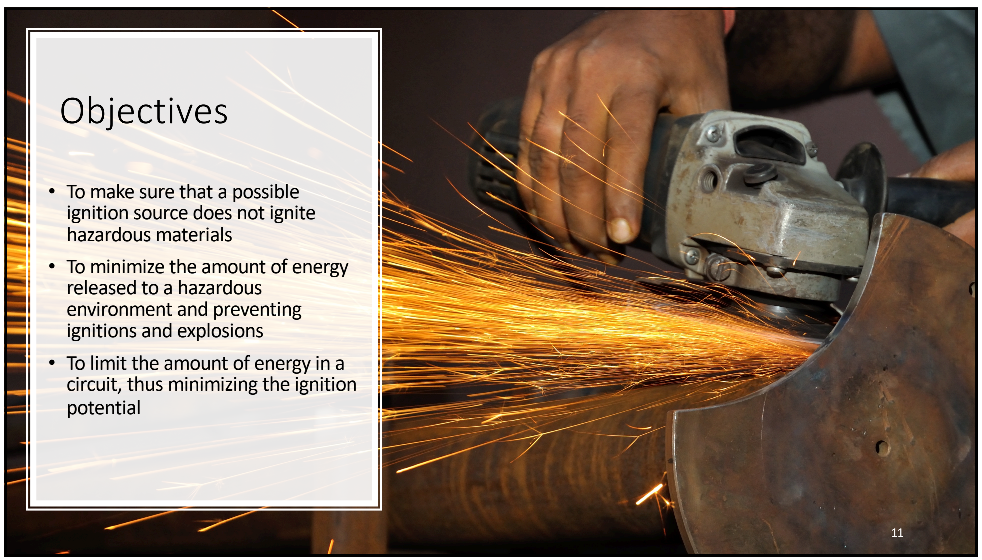

Objectives

- To make sure that a possible ignition source does not ignite hazardous materials
- To minimize the amount of energy released to a hazardous environment and preventing ignitions and explosions
- To limit the amount of energy in a circuit, thus minimizing the ignition potential

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Where Does This Apply?

- Gas stations
- Service garages
- Bulk storage facilities (oil, gas, grain etc.)
- Painting facilities
- Textile factories
- Refineries
- Chemical processing facilities
- Oil and gas processing facilties
- Aircraft hangers
- Manufacturing facilities where dust can collect

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Why Do We Care?

- Special wiring
- Special equipment
- Special procedures

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Scope of Training

- Will focus on Class and Division system
- Will mention Zone System but not focus on it
- Cover basics of Hazardous Locations
- Answer questions

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Introduction to Hazardous Locations

- https://www.youtube.com/watch?v=DZRL1-ugfAQ

HUBBELL KILLARK®

15

15

The Fire Triangle

16

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Fuel

17

Ignition Sources

18

Definitions: Flash Point

Flash Point: The lowest temperature at which sufficient vapor or liquid is generated to form an ignitable mixture with air near the surface of the liquid

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Definitions: Flammable Liquids

Flammable Liquids: have a flash point below 100 degrees F and a vapor pressure not exceeding 40 psia

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Definitions: Combustible Liquids

Combustible liquids: have a flash point at or above 100 degrees F and will form an ignitable mixture only when heated above their flash point.

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Combustible Dusts

Combustible dust is finely divided solid material 500 microns or smaller and present a fire or explosion hazard when dispersed and ignited in air

- *(i.e., material that passes through a U.S. No. 35 sieve as defined in ASTM E 11-09, Standard Specification for Wire Cloth and Sieves for Testing Purposes)*

Informational Note: See ASTM E 1226–12a, Standard Test Method for Explosibility of Dust Clouds, or ISO 6184-1, Explosion protection systems - Part 1: Determination of explosion indices of combustible dusts in air, for procedures for determining the explosibility of dusts

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https://www.youtube.com/watch?v=s_erxHvs_Ac&feature=emb_title

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Ignitible Fibers/Flyings

These materials are currently not defined in any NFPA document or any other industry document

Note: Section 506.6 Group IIIA materials are defined as solid particles, including fibers, greater than 500 μm (micrometer) in nominal size, which may be suspended in air and could settle out of the atmosphere under their own

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Definitions: Vapor Density

- Some materials are lighter than air. Others are heavier than air
- Lighter than air gases have a vapor density less than 1.0
- Tend dissipate rapidly
- Rarely accumulate to form an ignitable atmosphere

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Definitions: Vapor Density

- Heavier than air gases have a vapor density greater than 1.0
- Poses high risk due to tendency to collect
- Tend to fall to grade level or below grade
- May remain for a significant amount of time until dispersed naturally or mechanically

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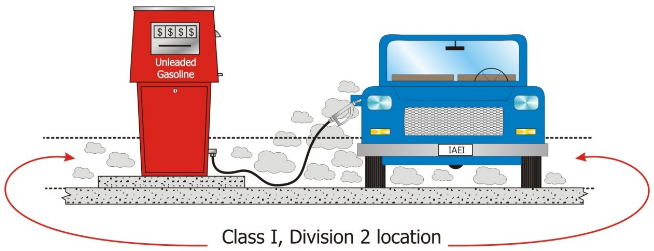
Gasoline Vapors Heavier Than Air

Gasoline vapors are heavier than air and fall to the lowest points



Class I, Division 2 location
NEC Table 514.3(B)(1)

Hazardous (classified) location at motor fuel dispensers is Class I, Division 2 up to a level of 450 mm (18 in.) above grade within 6.0 m (20 ft) of the dispensers owing to the fact that gasoline vapors are heavier than air and fall to lowest points.

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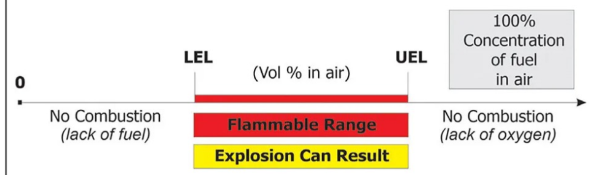
Flammable Range

Between the Lower Explosive Limit *(LEL)* and the Upper Explosive Limit *(UEL)*, EXPLOSIONS can result



Methane has LEL of 5 and a UEL of 15
Hydrogen has a LEL of 4 and a UEL of 75

Figure 8. The flammability scale showing the range of flammability for certain items.

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Where to Find Chemical Information

- Material Safety Data Sheets (MSDS) now called Safety Data Sheets (SDS)
- NFPA 497

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Page 1 of 4
Procter & Gamble
Fabric & Home Care Division
Ivorydale Technical Center
5299 Spring Grove Avenue
Cincinnati, OH 45217-1087

MATERIAL SAFETY DATA SHEET

MSDS: FH/C/2003/BCWT-5RYR49 — Issue Date: October 24, 2008
Supersedes: N/A — Issue Date: February 12, 2006

SECTION I - CHEMICAL PRODUCT

Identity: **Liquid Cleaner**
Brands: **COMET Cleaner with Bleach (Professional Line)**
Hazard Rating: Health: 1; Flammability: 0; Reactivity: 0 — 4=EXTREME, 3=HIGH, 2= MODERATE, 1=SLIGHT, 0=NOT SIGNIFICANT
Emergency Telephone Number: 1-800-332-7787 or call Local Poison Control Center

SECTION II - COMPOSITION AND INGREDIENTS

Ingredients/Chemical Name: Water (7732-18-5), sodium hydroxide (1310-73-2), sodium hypochorite (7681-52-9), sodium salt (142-31-4 & 151-21-3), surface safety agent and perfume.

This mixture, when tested as a whole, is considered an eye irritant within the meaning of the OSHA Communication Standard

Hazardous Ingredients as defined by OSHA, 29 CFR 1910.1200 and/or WHMIS under the HPA:

Chemical Name	Common Name	CAS No.	Recommended Limits	Composition Range	LD50/LC50
Sodium hypochlorite	Bleach	7681- 52-9	ACGIH STEL: $2mg/m^3$	0. 5-1.5%	
Sodium hydroxide	Caustic soda	1310-73-2	ACGIH STEL: 2 mg/m^3 OSHA PEL: 2 mg/m^3	0.1-1%	

SECTION III - HAZARDS IDENTIFICATION

Health Hazards (Acute and Chronic):
Ingestion: May cause mild , transient gastrointestinal irritation with nausea, vomiting or diarrhea.
Eye Contact: May cause mild, transient irritation with stinging and tearing similar to that caused by other detergents.
Skin: May be irritating to skin. May further irritate already irritated or extremely dry skin.
Inhalation: Mild mucous membrane irritant.

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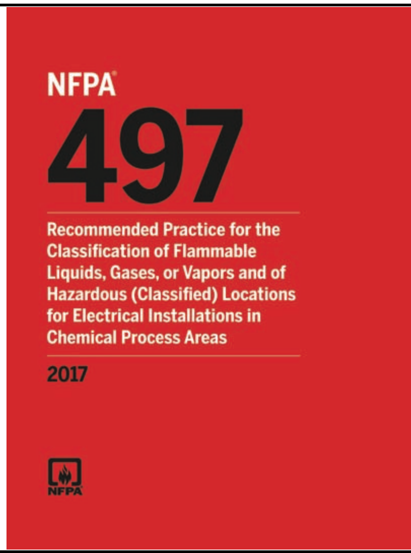

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ties, is provided in Table 4.4.2.

Table 4.4.2 Selected Chemicals

Chemical	CAS No.	Class I Division Group	Type[a]	Flash Point (°C)	AIT (°C)	%LFL	%UFL	Vapor Density (Air = 1)	Vapor Pressure[b] (mm Hg)	Class I Zone Group[c]	MIE (mJ)	MIC Ratio	MESG (mm)
Acetaldehyde	75–07–0	C^{d}	I	−38	175	4.0	60.0	1.5	874.9	IIA	0.37	0.98	0.92
Acetic Acid	64–19–7	D^{d}	II	39	426		19.9	2.1	15.6	IIA		2.67	1.76
Acetic Acid-tert-Butyl Ester	540–88–5	D	II			1.7	9.8	4.0	40.6				
Acetic Anhydride	108–24–7	D	II	49	316	2.7	10.3	3.5	4.9	IIA			1.23
Acetone	67–64–1	D^{d}	I	−20	465	2.5	12.8	2.0	230.7	IIA	1.15	1.00	1.02
Acetone Cyanohydrin	75–86–5	D	IIIA	74	688	2.2	12.0	2.9	0.3				
Acetonitrile	75–05–8	D	I	6	524	3.0	16.0	1.4	91.1	IIA			1.50
Acetylene	74–86–2	A^{d}	GAS		305	2.5	100	0.9	36600	IIC	0.017	0.28	0.25
Acrolein (Inhibited)	107–02–8	$B(C)^{d}$	I		235	2.8	31.0	1.9	274.1	IIB	0.13		
Acrylic Acid	79–10–7	D	II	54	438	2.4	8.0	2.5	4.3	IIB			0.86
Acrylonitrile	107–13–1	D^{d}	I	0	481	3	17	1.8	108.5	IIB	0.16	0.78	0.87
Adiponitrile	111–69–3	D	IIIA	93	550			1.0	0.002				
Allyl Alcohol	107–18–6	C^{d}	I	22	378	2.5	18.0	2.0	25.4	IIB			0.84
Allyl Chloride	107–05–1	D	I	−32	485	2.9	11.1	2.6	366	IIA		1.33	1.17
Allyl Glycidyl Ether	106–92–3	$B(C)^{e}$	II		57			3.9					
Alpha-Methyl Styrene	98–83–9	D	II		574	0.8	11.0	4.1	2.7				
n-Amyl Acetate	628–63–7	D	I	25	360	1.1	7.5	4.5	4.2	IIA			1.02
sec-Amyl Acetate	626–38–0	D	I	23		1.1	7.5	4.5		IIA			
Ammonia	7664–41–7	$D^{d,f}$	GAS		651	15	28	0.6	7498.0	IIA	680	6.85	3.17
Aniline	62–53–3	D	IIIA	70	615	1.2	8.3	3.2	0.7	IIA			
Benzene	71–43–2	D^{d}	I	−11	498	1.2	7.8	2.8	94.8	IIA	0.20	1.00	0.99
Benzyl Chloride	98–87–3	D	IIIA		585	1.1		4.4	0.5				
Bromopropyne	106–96–7	D	I	10	324	3.0							
n-Butane	106–97–8	$D^{d,g}$	GAS		288	1.9	8.5	2.0		IIA	0.25	0.94	1.07
1,3-Butadiene	106–99–0	$B(D)^{d,e}$	GAS		420	2.0	11.5	1.9		IIB	0.13	0.76	0.79
1-Butanol	71–36–3	D^{d}	I	36	343	1.4	11.2	2.6	7.0	IIA			0.91
Butyl alcohol(s) (butanol-2)	78–92–2	D^{d}	I	23.8	405	1.7	9.8	2.6		IIA			

(continues)

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Chemical	CAS No.	Class I Division Group	Type[a]	Flash Point (°C)	AIT (°C)	%LFL	%UFL	Vapor Density (Air = 1)	Vapor Pressure[b] (mm Hg)	Class I Zone Group[c]	MIE (mJ)	MIC Ratio	MESG (mm)
Ethyl Chloride	75–00–3	D	GAS	−50	519	3.8	15.4	2.2					
Ethyl Formate	109–94–4	D	GAS	−20	455	2.8	16.0	2.6		IIA			0.94
Ethyl Mercaptan	75–08–1	C^{d}	I	−18	300	2.8	18.0	2.1	527.4	IIB		0.90	0.90
n-Ethyl Morpholine	100–74–3	C	I	32				4.0					
2-Ethyl-3-Propyl Acrolein	645–62–5	C	IIIA	68				4.4					
Ethyl Silicate	78–10–4	D	II					7.2					
Formaldehyde (Gas)	50–00–0	B	GAS		430	7	73	1.0		IIB			0.57
Formic Acid	64–18–6	D	II	50	434	18.0	57.0	1.6	42.7	IIA			1.86
Fuel Oil 1	8008–20–6	D	II or $IIIA^{k}$	$38–72^{k}$	210	0.7	5.0						
Fuel Oil 2			II or $IIIA^{k}$	$52–96^{k}$	257								
Fuel Oil 6			IIIA or $IIIB^{k}$	$66–132^{k}$									
Furfural	98–01–1	C	IIIA	60	316	2.1	19.3	3.3	2.3				0.94
Furfuryl Alcohol	98–00–0	C	IIIA	75	490	1.8	16.3	3.4	0.6				
Gasoline	8006–61–9	D^{d}	I	−46	280	1.4	7.6	3.0					
n-Heptane	142–82–5	D^{d}	I	−4	204	1.0	6.7	3.5	45.5	IIA	0.24	0.88	0.91
n-Heptene	81624–04–6	D^{g}	I	−1	204			3.4					0.97
n-Hexane	110–54–3	$D^{d,g}$	I	−23	225	1.1	7.5	3.0	152	IIA	0.24	0.88	0.93
Hexanol	111–27–3	D	IIIA	63				3.5	0.8	IIA			0.98
2-Hexanone	591–78–6	D	I	35	424	1.2	8.0	3.5	10.6				
Hexene	592–41–6	D	I	−26	245	1.2	6.9		186				
sec-Hexyl Acetate	108–84–9	D	II	45				5.0					
Hydrazine	302–01–2	C	II	38	23		98.0	1.1	14.4				
Hydrogen	1333–74–0	B^{d}	GAS		500	4	75	0.1		IIC	0.019	0.25	0.28

Flash point: - 46 deg C = -50.8 deg F
AIT: 280 deg C = 536 deg F

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Classifications

Class I	Flammable and combustible gases and vapors
Class II	Combustible dust
Class III	Ignitible fibers and combustible flyings

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Two Systems of Classification

- The *Division System* and the *Zone System*
- The divisions or zones provide the degree of hazard in classified locations
  - Class I, II, or III Locations
    - Divisions 1 and 2
  - Class I or II Locations
    - Zones 0, 1, and 2

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Hazardous (Classified) Locations

- Article 500 – Hazardous (Classified) Locations, Classes I, II and III, Divisions 1 and 2
- Article 501 – Class I Locations
- Article 502 – Class II Locations
- Article 503 – Class III Locations
- Article 504 – Intrinsically Safe Systems
- Article 505 – Zone 0, 1 and 2 Locations
- Article 506 – Zone 20, 21 and 22 Locations for Combustible Dusts or Ignitible Fibers/Flyings

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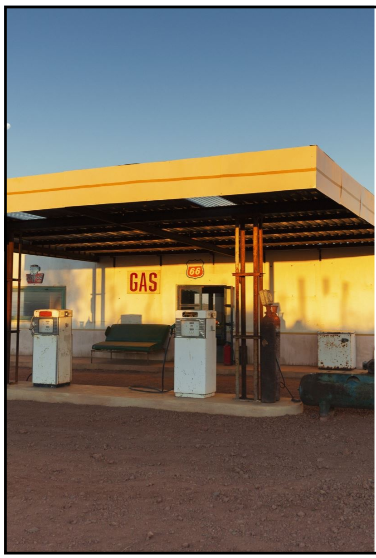

Hazardous (Classified) Locations

- Article 511 – Commercial Garages, Repair and Storage
- Article 513 – Airport Hangers
- Article 514 – Motor Fuel Dispensing Facilities
- Article 515 – Bulk Storage Plants
- Article 516 – Spray Application, Dipping, Coating and Printing Processes Using Flammable or Combustible Materials

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Divisions Simplified

Division 1: hazardous materials present during normal operations

Division 2: hazardous materials present during abnormal operations

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Division 1 Areas

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Division 2 Areas

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Equipment Selection in Hazardous Locations

Evaluate area. Is it hazardous?

YES

Can Equipment be installed outside of hazardous locations?

YES

Install equipment per Chapters 1 - 4 in the NEC

NO

Install equipment per Chapters 1 - 4 in the NEC

NO

Install equipment per Chapters 5 in the NEC

Determine classification

Select equipment that matches classification(s)

Use special wiring methods prescribed in Chapter 5

Check and test installations for integrity

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Hazardous Location Decision Tree

Assess the area
Are Hazardous Materials Present?

Assess the equipment
Can it be an ignition source?

Assess the environment
Can something external be an ignition source?
Open flame, exposed to lightning, overhead power lines, exposed to extreme heat (sunlight, reflection etc.)

Assess your tools
Can they be an ignition source?
Drills, grinders, welders, heat guns, screwdrivers, hammers etc.

Develop Mitigation Plans:
Emergency Procedures, PPE requirements, tool selection, notifications, communication, ventilation, barriers etc.

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Why Do We Do This?

https://www.youtube.com/watch?v=a96kriSo6EQ&t=61s

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Class I Location – Definition 500.5(B)

- Class I locations are those in which flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.
- Class I locations shall include those specified in 500.5(B)(1) and (B)(2)

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Class I, Division 1

- A location in which ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors can exist under normal operating conditions, or
- A location in which ignitable concentrations of such flammable gases, flammable liquid-produced vapors, or combustible liquids above their flash points, may exist frequently because of repair or maintenance operations or because of leakage, or
- A location in which breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases, flammable liquid-produced vapors and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition

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Class I, Division 2

- A location in which volatile flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are handled, processed, or used, but in which the liquids, vapors or gases
  - Will normally be confined within closed container or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems or in case of abnormal operation of equipment, or
  - Are normally prevented by positive mechanical ventilation and which might become hazardous through failure or abnormal operation of the ventilating equipment

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Groups

Group	Material(s)
A	Acetylene
B	Hydrogen
C	Ethylene
D	Gasoline-Propane-Methane

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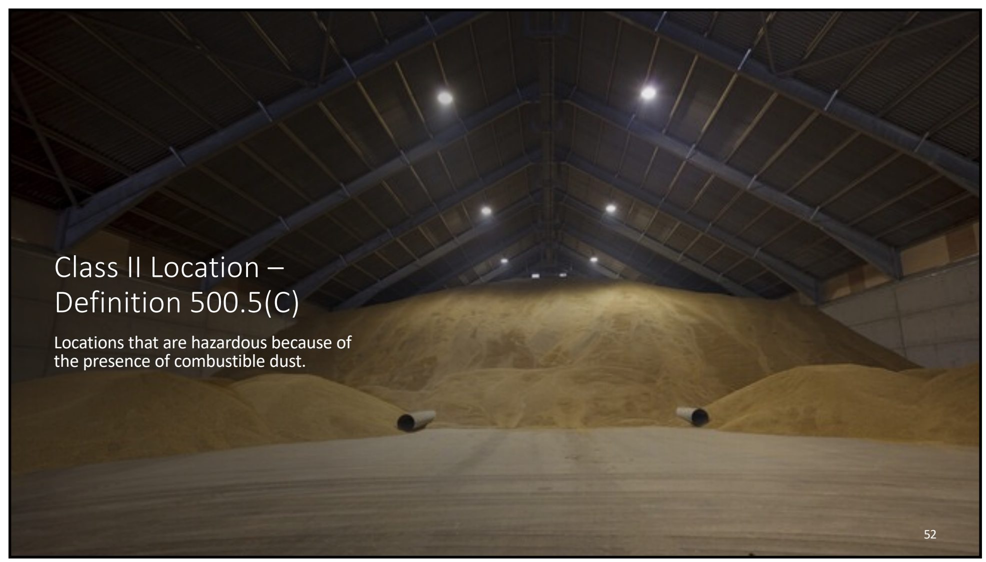

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Class II, Division 1

- A location

1. In which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitable mixtures, or
2. Where mechanical failure or abnormal operation or machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electrical equipment, through operation of protection devices, or from other causes, or
3. In which Group E combustible dusts may be present in quantities sufficient to be hazardous in normal or abnormal operation conditions

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Class II, Division 2

- A location in which:

1. Combustible dust due to abnormal operations may be present in the air in quantities sufficient to produce explosive or ignitable mixtures, or
2. Where combustible dust accumulations are present but are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but could as a result of infrequent malfunctioning of handling or processing equipment become suspended in the air; or

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Class II, Division 2

3. A location In which combustible dust accumulations on, in, or in the vicinity of the electrical equipment could be sufficient to interfere with the safe dissipation of heat from electrical equipment, or could be ignitable by abnormal operation or failure of electrical equipment.

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Class III Location -Definition 500.5(D)

- Locations that are hazardous because of the presence of easily ignitable fibers or where materials producing combustible flyings are handled, manufactured, or used, but in which such fibers/flyings ae not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures.

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Class III, Division 1

- A location in which easily ignitable fibers/flyings are handled, manufactured or used

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Class III, Division 2

- A location in which easily ignitable fibers/flyings are stored or handled other than in the process of manufacture.

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Protection Techniques (500.7)

- Explosionproof equipment
- Dust Ignitionproof
- Dusttight
- Purged and Pressurized
- Intrinsic Safety
- Nonincendive Circuit
- Nonincedive Component
- Oil immersion
- Hermetically sealed
- Combustible gas detection
- Optical radiation methods (new for 2020 NEC)

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Explosion Proof Enclosures

- https://www.youtube.com/watch?v=nccrAqNUPbs

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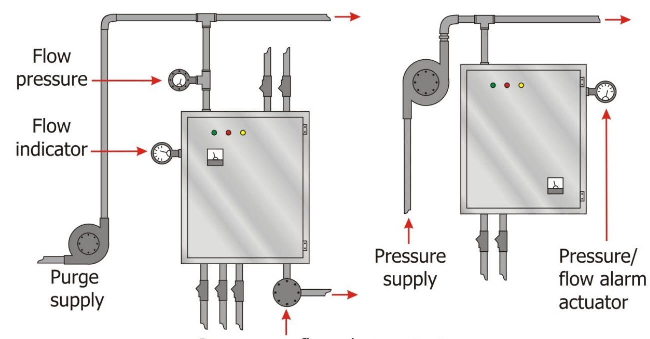
Purged and Pressurized Technique



Enclosure purged using a protective gas to remove flammable gas or vapor

Enclosure pressurized with a protective gas to keep flammable gas, vapor, combustible dust, or ignitible fiber out

Note: Types X, Y, and Z purging are addressed in NFPA 496

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Hazardous (Classified) Locations, Protection Techniques
Purged and Pressurized Systems
500.7(D)

Purged and pressurized systems are permitted for equipment in any hazardous (classified) locations for which they are identified.

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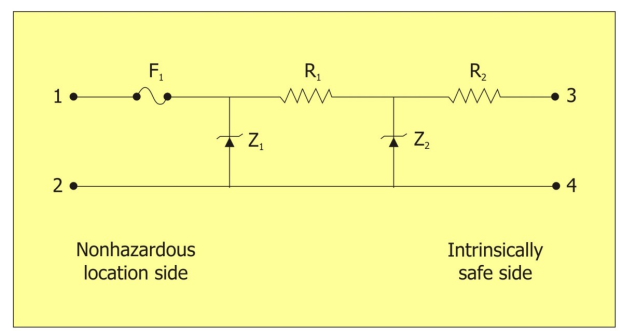
Basic Diagram of Fused Zener Diode Barrier

Intrinsically-Safe Circuit



Reproduction of NEC Handbook Exhibit 504.2

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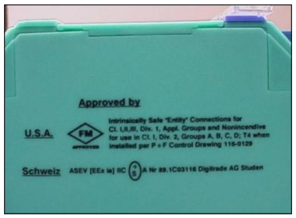

- Typical Zener diode barriers in an assembly that is part of a large system
- A close up view of the information on the barrier that refers to a specific control drawing

Photos from IAEI Archives

65

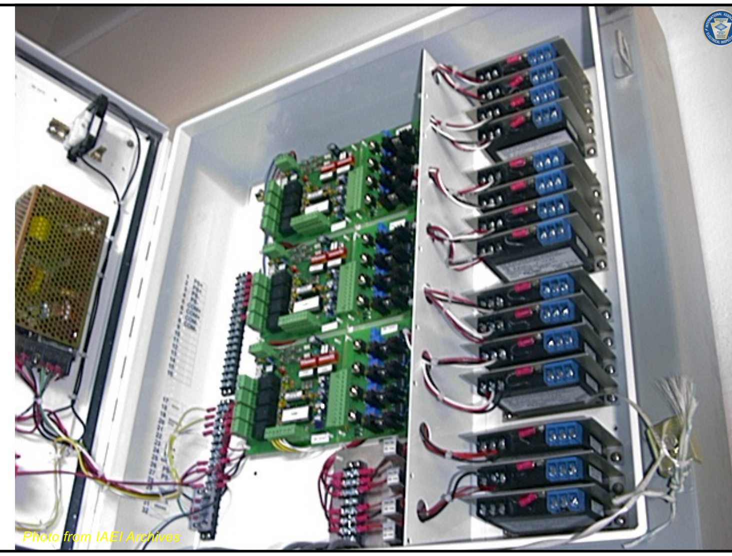

Photo from IAEI Archives

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Nonincendive Protection Techniques

- Nonincendive systems are made up of various components, field wiring, equipment, and apparatus
- The nonincendive protection technique includes circuitry in which any arc or thermal effect produced under normal operating conditions of the equipment is not capable, under specified test conditions, of igniting a flammable gas-air, vapor-air, or dust-air mixture
- *See NEC 500.2 Definitions*
- This protection technique is permitted to be used in Class I and II, Division 2, and Class III, Divisions 1 and 2 locations *[500.7(F)]*

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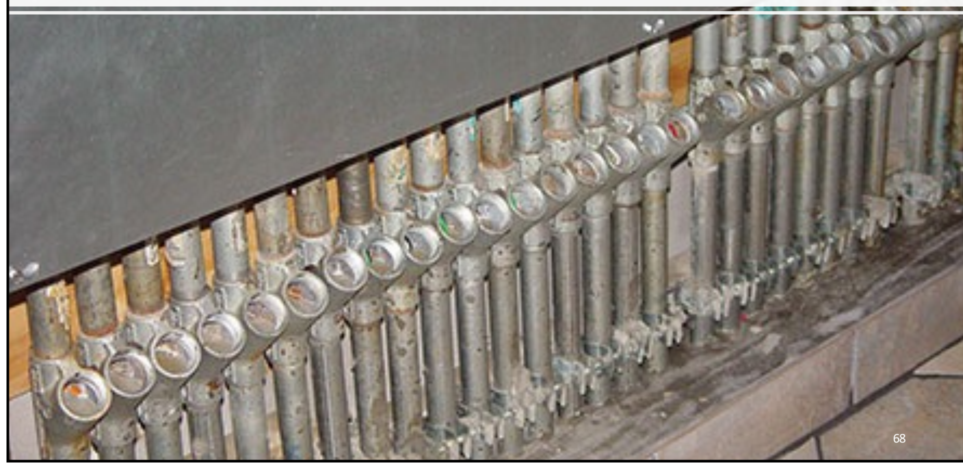
Conduit Seals



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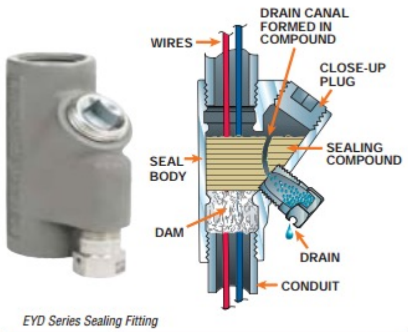
Conduit seals

- To prevent the passage of hot gases in conduit from one area to another that could create an ignition source

Prevent Hazardous Gas



EYD Series Sealing Fitting

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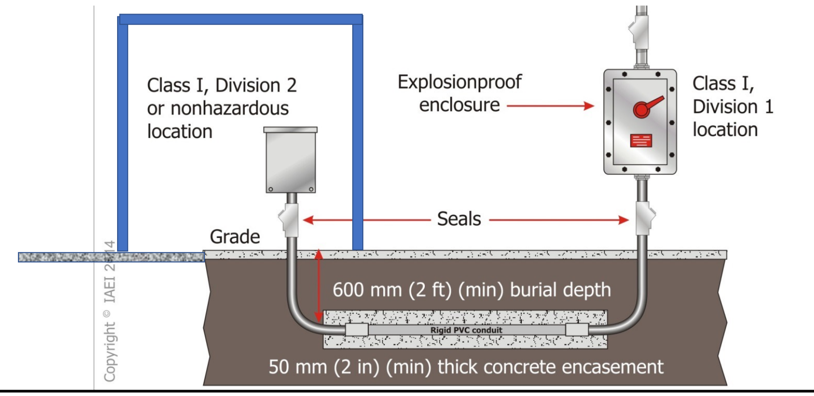
Prevent Hazardous Vapors From Accumulating in Non-Hazardous Areas
And to Prevent Vapors from Accumulating in Equipment with Ignition Sources



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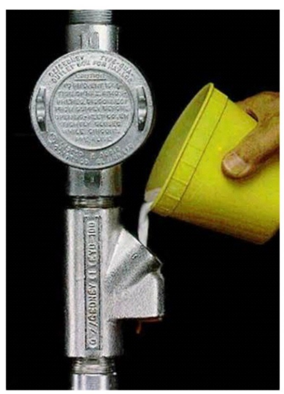
Sealing Compound and Technique



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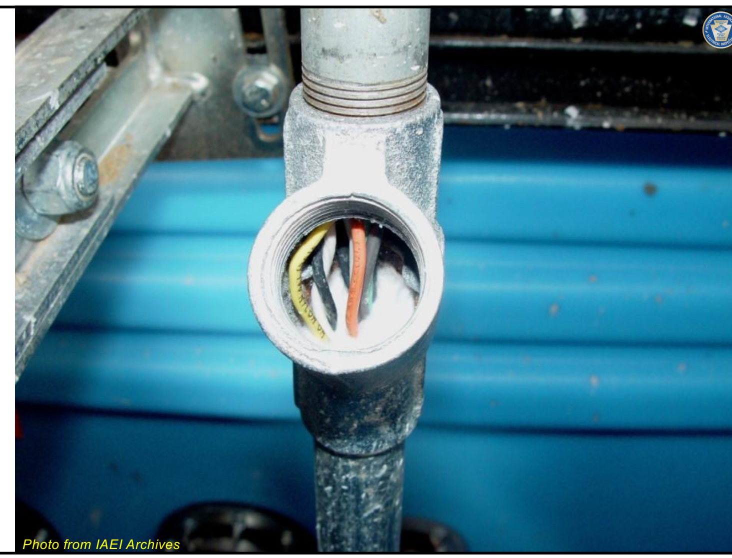

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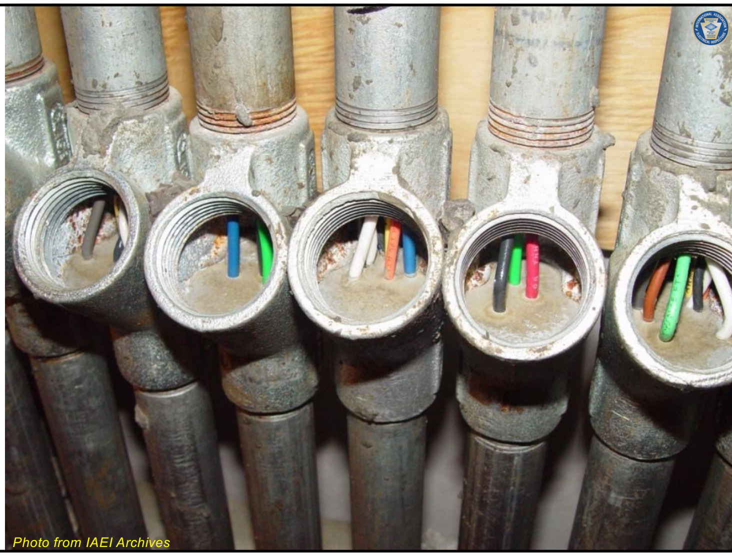

73

General Sealing Requirements *(cont.)*

- Thickness of the compound in a sealing fitting cannot be less than 16 mm (5/8 in.) in any case
- Must generally not be less than the trade size of the raceway
- See 501.15(C)(3)

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General Sealing Requirements *(cont.)*

- Cross-sectional area of conductors or optical fiber tubes *(metallic or nonmetallic)* in a sealing fitting is not permitted to exceed 25% of the cross-sectional area of the conduit of the same trade size *(unless it is specifically identified for a higher percentage of conductor fill) [See 501.15(C)(6)]*
- No splices or taps are permitted in sealing fittings *[See 501.15(C)(4)]*

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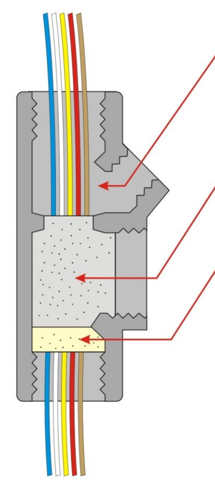
Conduit Fill in Sealing Fittings



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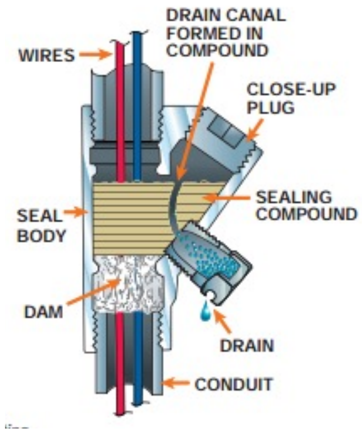
Important!

- Because of filling compound, achieving maximum conduit fill of 40% for 3 or more wires may not be possible
- May have to order oversized conduit seals rated for 40% fill



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EYSX Expanded Fill Explosionproof Conduit Sealing Fittings

EYSX expanded fill sealing fittings from Eaton's Crouse-Hinds Division provide 40% wire fill capacity to allow uninterrupted runs in a conduit system. They are designed to restrict the passage of gases, vapors or flames from one portion of the electrical installation to another, limit explosions to the sealed off enclosure, and limit pre-compression or "pressure piling" in conduit systems. EYSX expanded fill sealing fittings are available for installation in both horizontal or vertical positions.

Photo is representative

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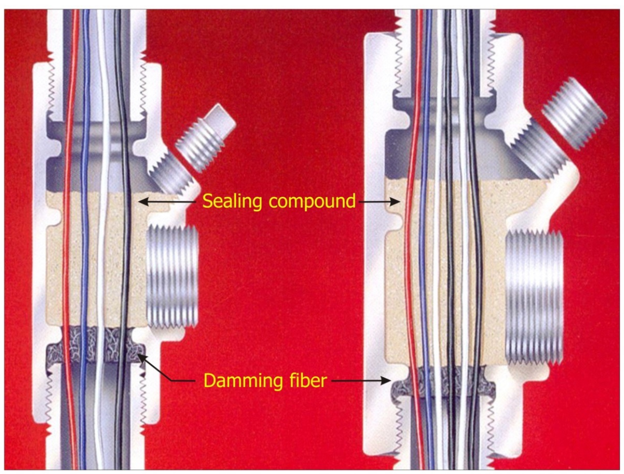
Conduit Fill in Sealing Fittings



Courtesy of Appleton EGS Electrical Group

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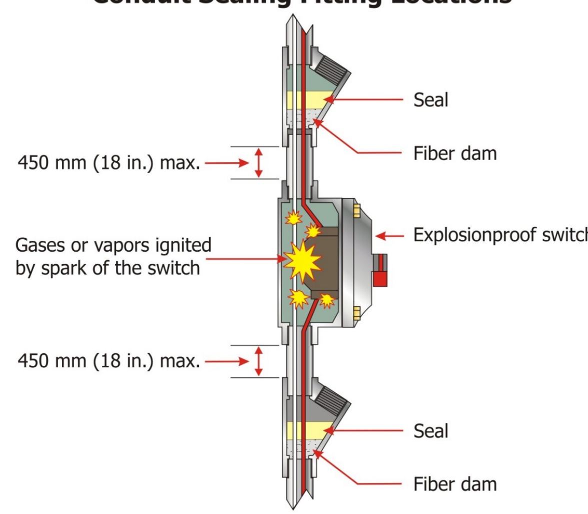
Conduit Sealing Fitting Locations



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Conductor Interstices

- Gas and vapor passage or flame propagation may occur through the interstices *(spaces or gaps)* between strands in conductor sizes larger than 2 AWG that include standard stranding
- Compact stranding can help minimize these possibilities

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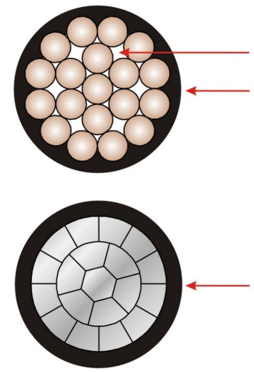
Conductor Strands



Gas or vapor and propagation of flames may occur through interstices *(spaces or gaps)* between strands of standard stranded conductors in sizes larger than 2 AWG

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Bonding

Ground faults returning to its source can create heat and be a possible ignition source if the current has to travel across loose connections:

- Knockout connections
- Loose conduit connections
- loose fittings

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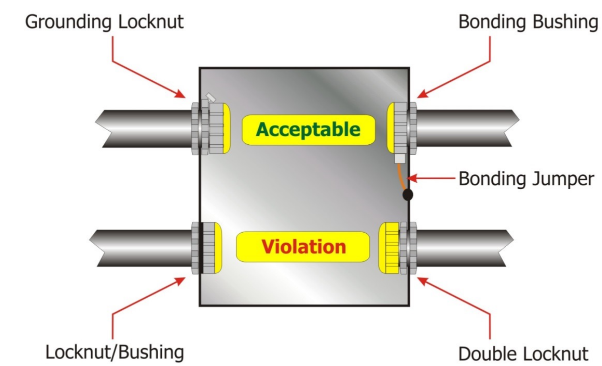
Bonding Requirements in Hazardous Locations



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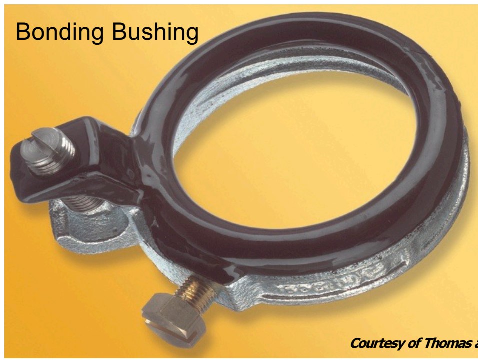
Grounding (bonding) bushing suitable for service bonding



Courtesy of Thomas and Betts

Photo from IAEI Archives

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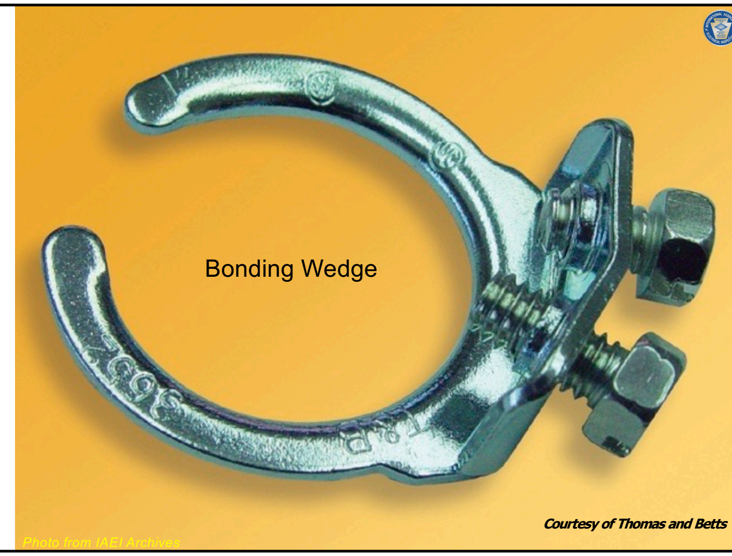

Courtesy of Thomas and Betts

Photo from IAEI Archives

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Five Threads Fully Engaged

- Equipment provided with threaded entries for threaded conduit or fittings, listed conduit, listed conduit fittings, or listed cable fittings shall be used
- Conduit and fittings for this use shall be threaded with a National (American) Standard Pipe Taper (NPT) thread
- NPT-threaded entries made into explosionproof equipment shall be made up with at least five threads fully engaged
- Listed explosionproof equipment, which have joints with factory-threaded NPT entries shall be made up with at least four and one-half threads that are fully engaged and wrenchtight.

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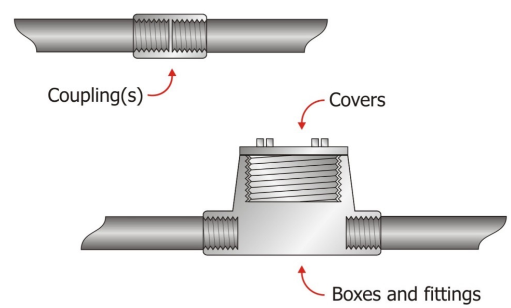
Five Full Threads Fully Engaged

Five full threads engaged ensures integrity of explosionproof equipment

Maintains effective ground-fault current path



It is extremely imperative that all threaded fittings and joints be made up wrenchtight to prevent arcing from these threaded joints

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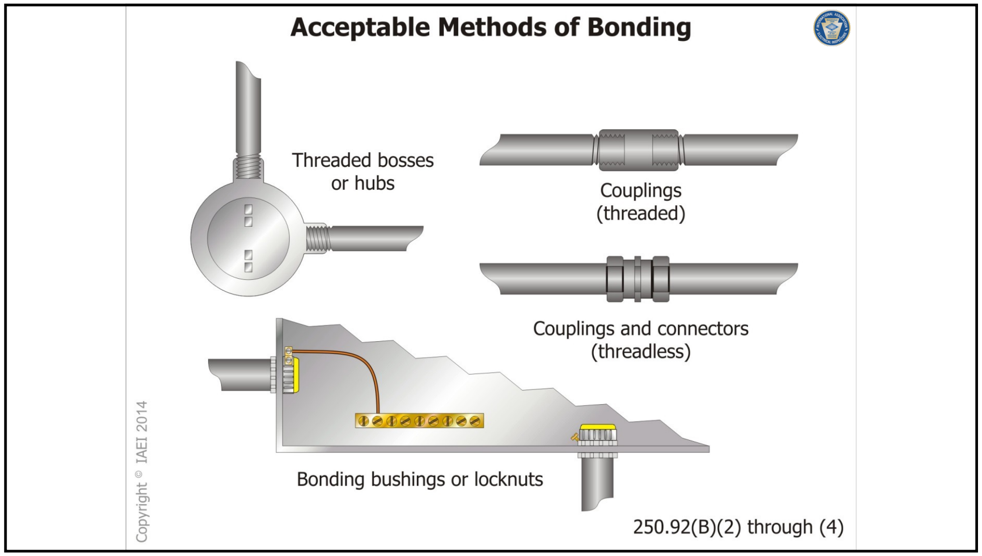
Acceptable Methods of Bonding
Threaded bosses or hubs
Couplings (threaded)
Couplings and connectors (threadless)
Bonding bushings or locknuts
250.92(B)(2) through (4)
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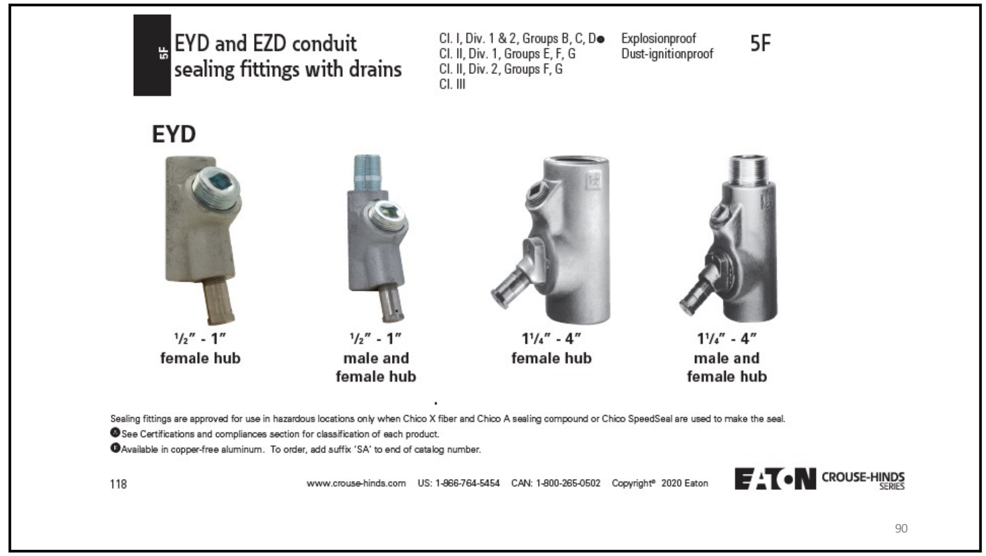
5F
EYD and EZD conduit sealing fittings with drains
Cl. I, Div. 1 & 2, Groups B, C, D
Cl. II, Div. 1, Groups E, F, G
Cl. II, Div. 2, Groups F, G
Cl. III
Explosionproof
Dust-ignitionproof
5F
EYD
½" - 1" female hub
½" - 1" male and female hub
1¼" - 4" female hub
1¼" - 4" male and female hub
Sealing fittings are approved for use in hazardous locations only when Chico X fiber and Chico A sealing compound or Chico SpeedSeal are used to make the seal.
See Certifications and compliances section for classification of each product.
Available in copper-free aluminum. To order, add suffix 'SA' to end of catalog number.
118
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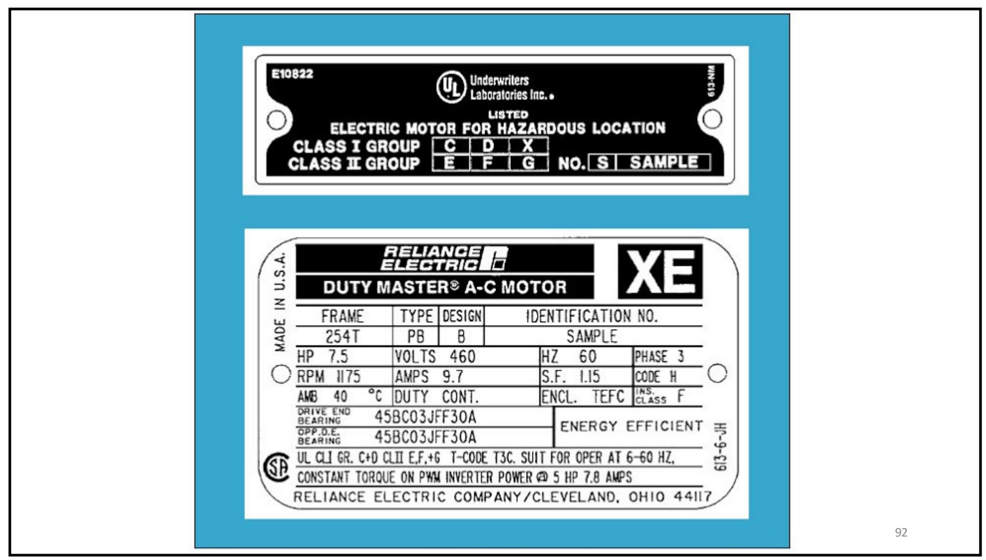
EATON CROUSE-HINDS SERIES
90

90


Explosion Proof Motors
91

91


E10822
Underwriters Laboratories Inc.
LISTED
ELECTRIC MOTOR FOR HAZARDOUS LOCATION
CLASS I GROUP C D X
CLASS II GROUP E F G
NO. S SAMPLE
RELIANCE ELECTRIC
XE
DUTY MASTER® A-C MOTOR
MADE IN U.S.A.
FRAME 254T
TYPE PB
DESIGN B
IDENTIFICATION NO. SAMPLE
HP 7.5
VOLTS 460
HZ 60
PHASE 3
RPM 1175
AMPS 9.7
S.F. 1.15
CODE H
AMB 40 °C
DUTY CONT.
ENCL. TEFC
INS. CLASS F
DRIVE END BEARING 45BC03JFF30A
OPP. D.E. BEARING 45BC03JFF30A
ENERGY EFFICIENT
UL CL I GR. C+D CL II E,F,+G T-CODE T3C. SUIT FOR OPER AT 6-60 HZ.
CONSTANT TORQUE ON PWM INVERTER POWER @ 5 HP 7.8 AMPS
RELIANCE ELECTRIC COMPANY/CLEVELAND, OHIO 44117
92

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Temperature (T-Codes)

Maximum Temperature		Temperature Class (T-Code)
Degrees C	Degrees F	
450	842	T1
300	572	T2
280	536	T2A
260	500	T2B
230	446	T2C
215	419	T2D
200	392	T3
180	356	T3A
165	329	T3B
160	320	T3C
135	275	T4
120	248	T4A
100	212	T5
85	185	T6

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Table 4.4.2 Selected Chemicals

Chemical	CAS No.	Class I Division Group	Type[a]	Flash Point (°C)	AIT (°C)	%LFL	%UFL	Vapor Density (Air = 1)	Vapor Pressure[b] (mm Hg)	Class I Zone Group[c]	MIE (mJ)	MIC Ratio	MESG (mm)
Acetaldehyde	75–07–0	C[d]	I	−38	175	4.0	60.0	1.5	874.9	IIA	0.37	0.98	0.92
Acetic Acid	64–19–7	D[d]	II	39	426		19.9	2.1	15.6	IIA		2.67	1.76
Acetic Acid-tert-Butyl Ester	540–88–5	D	II			1.7	9.8	4.0	40.6				
Acetic Anhydride	108–24–7	D	II	49	316	2.7	10.3	3.5	4.9	IIA			1.23
Acetone	67–64–1	D[d]	I	−20	465	2.5	12.8	2.0	230.7	IIA	1.15	1.00	1.02
Acetone Cyanohydrin	75–86–5	D	IIIA	74	688	2.2	12.0	2.9	0.3				
Acetonitrile	75–05–8	D	I	6	524	3.0	16.0	1.4	91.1	IIA			1.50
Acetylene	74–86–2	A[d]	GAS		305	2.5	100	0.9	36600	IIC	0.017	0.28	0.25
Acrolein (Inhibited)	107–02–8	B(C)[d]	I		235	2.8	31.0	1.9	274.1	IIB	0.13		
Acrylic Acid	79–10–7	D	II	54	438	2.4	8.0	2.5	4.3	IIB			0.86
Acrylonitrile	107–13–1	D[d]	I	0	481	3	17	1.8	108.5	IIB	0.16	0.78	0.87
Adiponitrile	111–69–3	D	IIIA	93	550			1.0	0.002				
Allyl Alcohol	107–18–6	C[d]	I	22	378	2.5	18.0	2.0	25.4	IIB			0.84
Allyl Chloride	107–05–1	D	I	−32	485	2.9	11.1	2.6	366	IIA		1.33	1.17
Allyl Glycidyl Ether	106–92–3	B(C)[e]	II		57			3.9					
Alpha-Methyl Styrene	98–83–9	D	II		574	0.8	11.0	4.1	2.7				
n-Amyl Acetate	628–63–7	D	I	25	360	1.1	7.5	4.5	4.2	IIA			1.02
sec-Amyl Acetate	626–38–0	D	I	23		1.1	7.5	4.5		IIA			
Ammonia	7664–41–7	D[d,f]	GAS		651	15	28	0.6	7498.0	IIA	680	6.85	3.17
Aniline	62–53–3	D	IIIA	70	615	1.2	8.3	3.2	0.7	IIA			
Benzene	71–43–2	D[d]	I	−11	498	1.2	7.8	2.8	94.8	IIA	0.20	1.00	0.99
Benzyl Chloride	98–87–3	D	IIIA		585	1.1		4.4	0.5				
Bromopropyne	106–96–7	D	I	10	324	3.0							
n-Butane	106–97–8	D[d,g]	GAS		288	1.9	8.5	2.0		IIA	0.25	0.94	1.07
1,3-Butadiene	106–99–0	B(D)[d,e]	GAS		420	2.0	11.5	1.9		IIB	0.13	0.76	0.79
1-Butanol	71–36–3	D[d]	I	36	343	1.4	11.2	2.6	7.0	IIA			0.91
Butyl alcohol(s) (butanol-2)	78–92–2	D[d]	I	23.8	405	1.7	9.8	2.6		IIA			

57 deg C = 134.6 deg F

(continues)

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Wiring Methods in Hazardous Locations

- Rigid Metallic conduit (5 threads engaged)
- Enclosures and fittings rated for hazardous area
- Grounded hubs and bushings
- Conduit seals and drainage
- Special cable and connectors (mineral-insulated cable e.g.)
- Flexible conduit and coupling rated for the hazardous area

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Goals

- Locate equipment outside of hazardous location if possible
  - Avoid expensive equipment
  - Avoid special wiring requirements
  - Avoid future hazards

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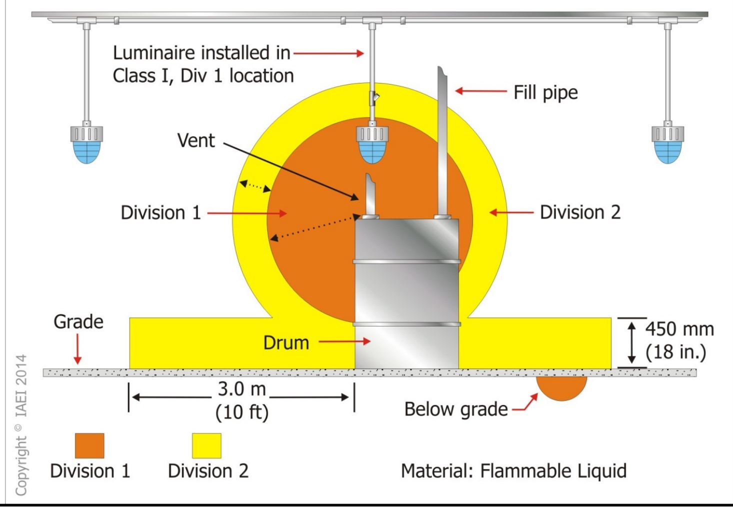
Equipment Shall Be Suitable for the Location



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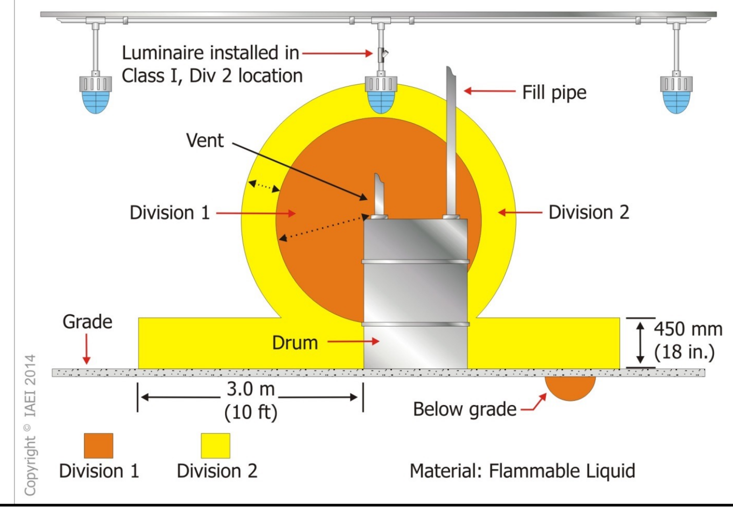
Equipment Shall Be Suitable for the Location



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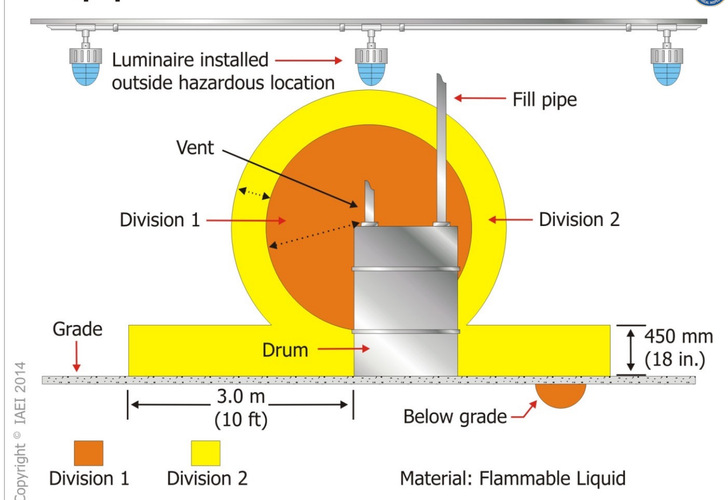
Equipment Installed Outside Hazardous Location



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The *Zone System* of Classification

- The *Zone System* of classifying a hazardous *(classified)* locations is fairly new to the *NEC* and is part of a larger effort to harmonize the rules in the *NEC* with other international standards *[International Electrotechnical Commission (IEC)]*
- The *Zone System* offers another method of hazardous area classification in addition to the *Division System*
- The *Zone System* of classifying hazardous locations requires the supervision of a qualified person as indicated in 505.7(A), which is not a requirement in the *Division System*

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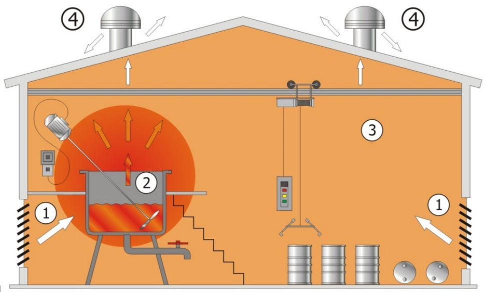
Typical Zone System Hazardous Location

CONDITIONS:

① All manual ventilation
② Zone 0 area
③ Zone 1 area
④ Non-hazardous area



- Open air mixing tanks
- No mechanical ventilation
- Products stored in work area

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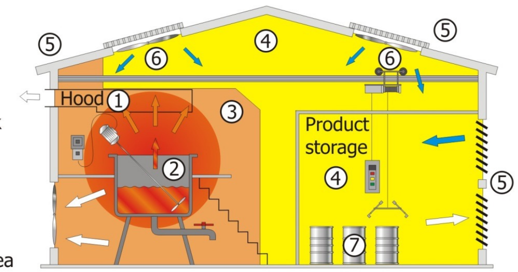
Typical Zone System Hazardous Location

CONDITIONS:

① Hood over tank
② Zone 0 area
③ Zone 1 area
④ Zone 2 area
⑤ Unclassified area
⑥ Mechanical ventilation
⑦ Stored products separated from work area

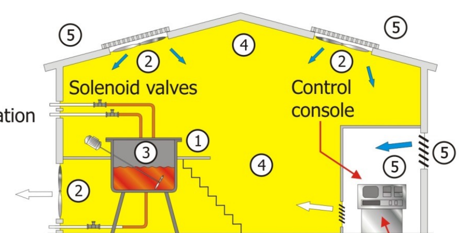


102

Typical Zone System Hazardous Location

CONDITIONS:

① Tank closed
② Mechanical ventilation
③ Zone 0
④ Zone 2
⑤ Unclassified area



Operations control outside zones in an unclassified location

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Class 1 - Zone Groups

Group IIC	Group IIB	Group IIA
Acetylene	Ethylene	Propane
Hydrogen	Diethyl Ether	Benzene
Carbon Disulfide	1, 3 Butadiene	Styrene
	Ethylene Oxide	Hexane
	Cyclopropane	Ethanol
	Methyl Acetate	Methane
		Kerosene
		Ethyl Acrylate

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Basic Articles 500 and 505 Group Comparisons

Article 500 Groups	Typical Materials	Article 505 Groups
A	Acetylene	IIC
B	Hydrogen	IIC
C	Ethylene	IIB
D	Gasoline-Propane-Methane	IIA

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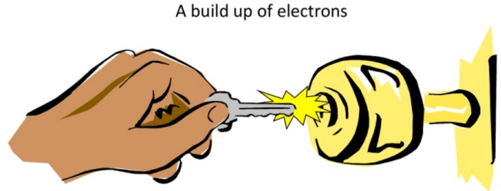
Grounding

Static Electricity

A build up of electrons



The **shock** you get from rubbing our shoes on the carpet and then touching something metal like a door knob

A **transfer of electrons** to equalize (stabilize) negative electrons and positive protons.

Help minimize Static Electricity generation

https://www.youtube.com/watch?v=T6VKxmUPb3g

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Reasons Why RMC and IMC are Preferred in Hazardous Locations

- PVC and Fiberglass conduit can contribute to the buildup of static electricity
- Metallic conduit can help relax static charges since most are grounded
- Metallic conduit can be a primary or secondary path for ground fault current
- Provides shielding against noise
- Metallic conduit can actually reduce the magnitude of ground fault currents since the magnetic fields created during a fault can reduce (choke) the fields created by the faulted wires

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Cables, Conduit, Magnetism and Inductive Heating

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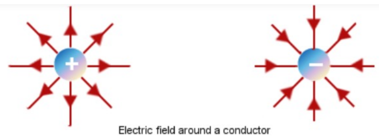
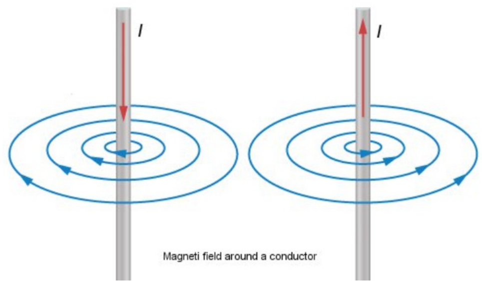


Electric field around a conductor

The magnetic field around a conductor consists of concentric circles of magnetic lines of force around the same conductor, whose direction corresponds to the instantaneous direction of current flow through the conductor:



Magneti field around a conductor

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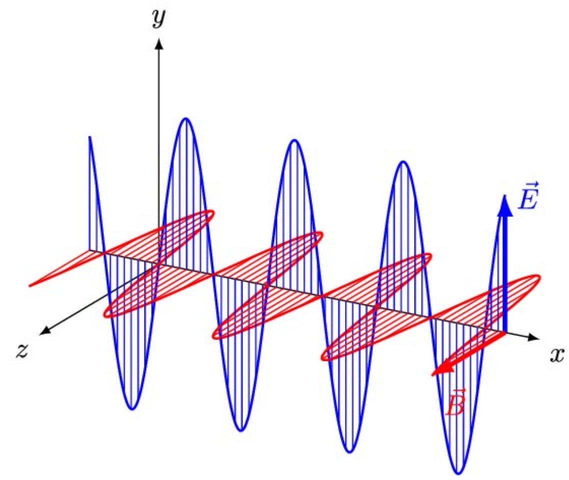

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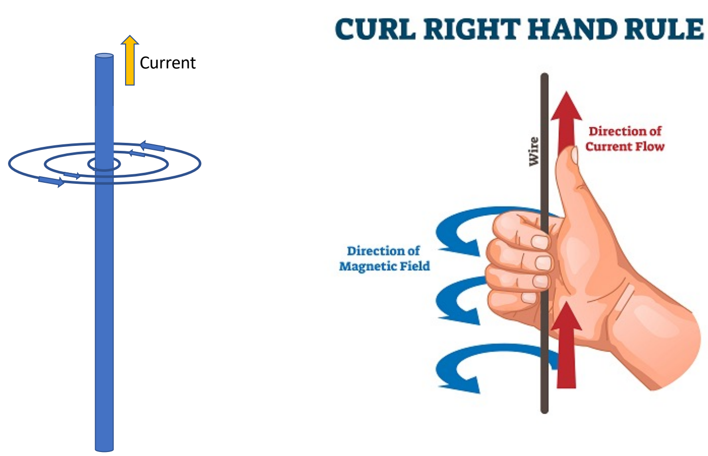

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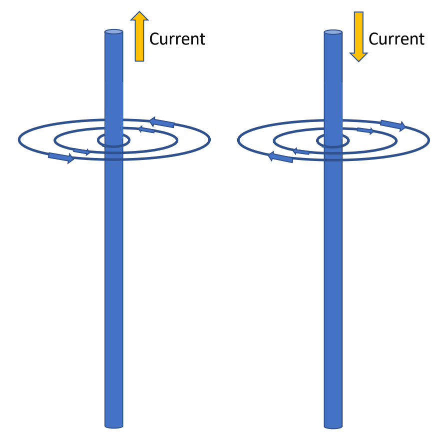

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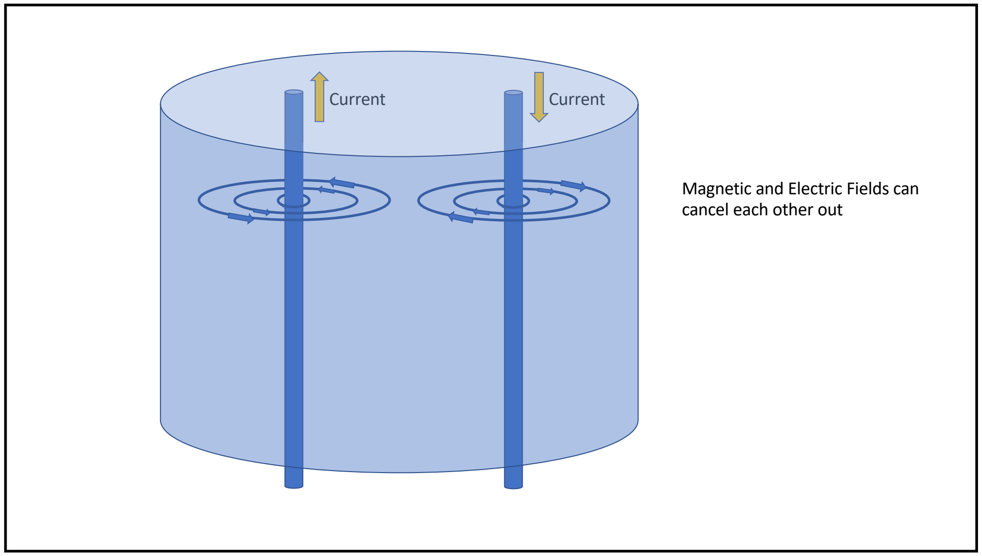

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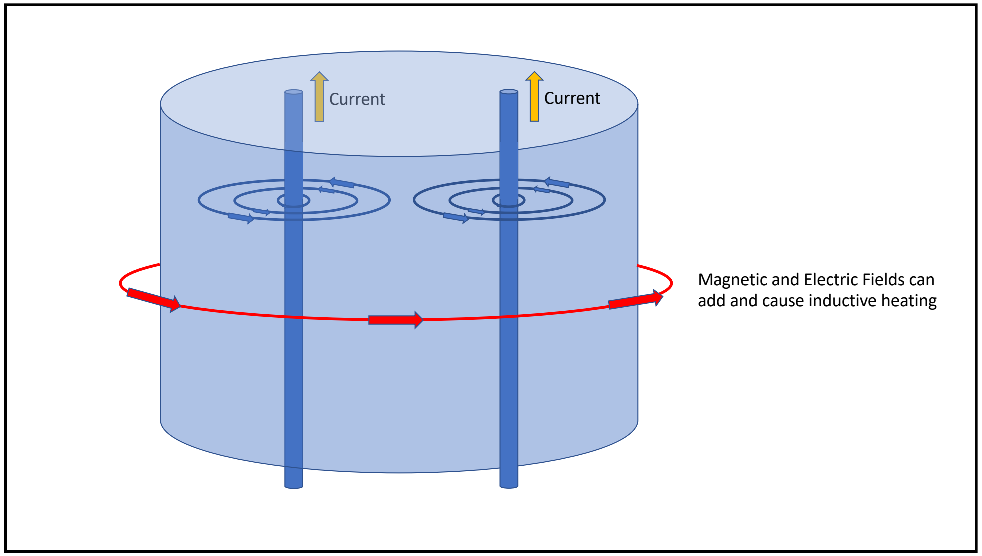

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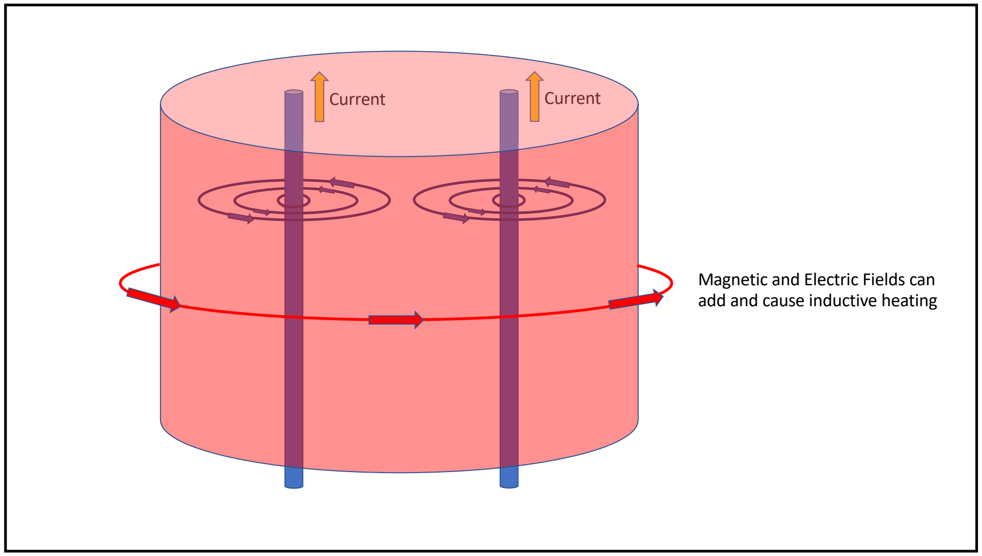

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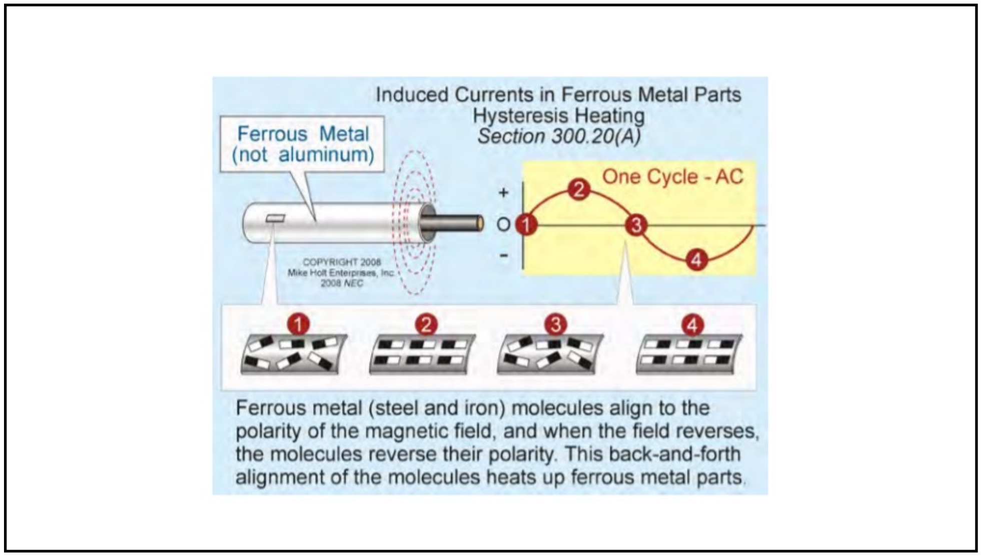

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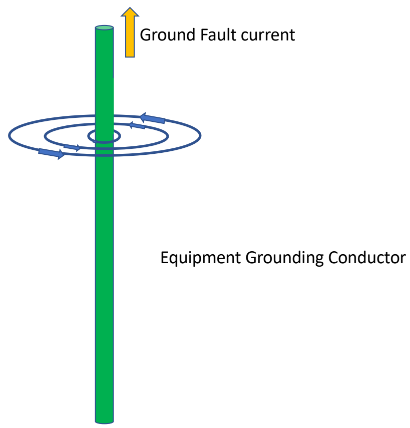

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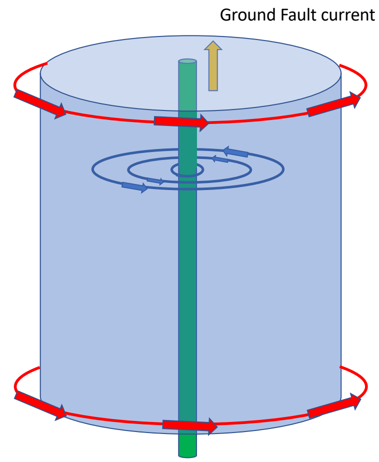

- High ground fault current induces current onto metallic (ferrous) conduit.
- Creates a magnetic field in the conduit.
- This expanding and collapsing magnetic field interacts with magnetic field in the EGC.
- Tends to choke and possibly reduce intensity of ground fault current
- Can also heat up conduit.

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Introduction to Hazardous Locations

- https://www.youtube.com/watch?v=DZRL1-ugfAQ

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Hazardous Location Example

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Lighting Upgrade in a Service Garage

- What you need
  - Layout of garage
  - Materials used in the garage
  - Information about ventilation of the garage
  - Perform a Hazardous Area Classification assessment

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Impacts

- What type of lighting and equipment to install
- What wiring and raceway methods to employ
- What options are available to mitigate?
- Risks to employees, public
- Liability

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Details

- Building
  - One level garage
  - Three overhead doors
  - No forced ventilation
  - Vents located on east and west walls
  - Conduits come into building from above ground storage tanks outside
    - Monitoring tank levels and temperatures

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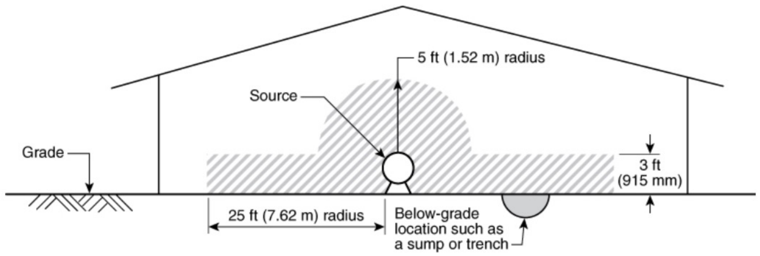
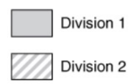


Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	



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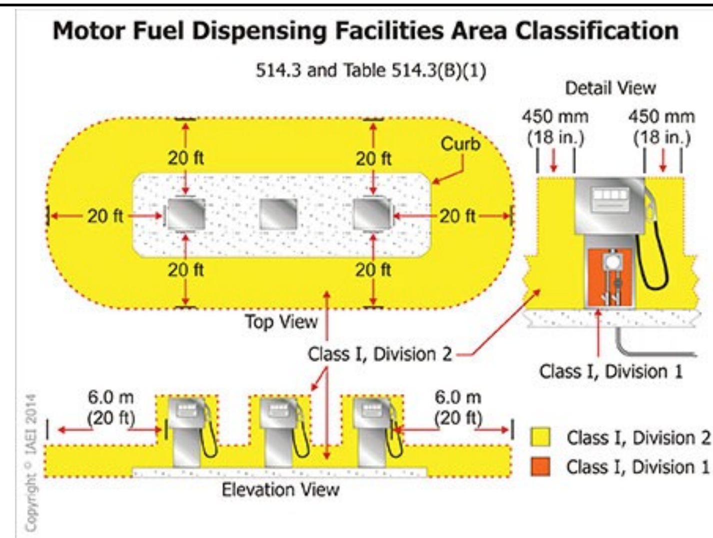

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5.10.15 Compressed Gas Cylinders (Material: Lighter than or Equal to Air, including hydrogen).

(See ***Figure 5.10.15****.)*

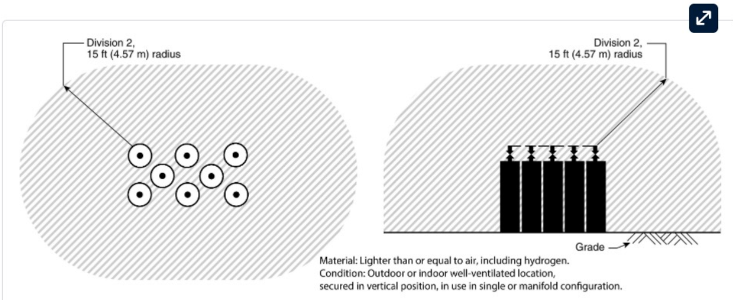

Figure 5.10.15 Compressed Gas Cylinders (material: lighter than or equal to air, including hydrogen).

127

5.10.16 Compressed Gas Cylinders (Material: Heavier Than Air).

(See ***Figure 5.10.16****.)*

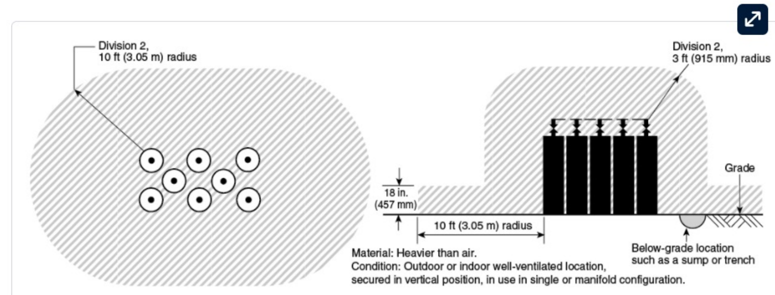

Figure 5.10.16 Compressed Gas Cylinders (material: heavier than air).

128

(See *Figure 5.10.6*.)

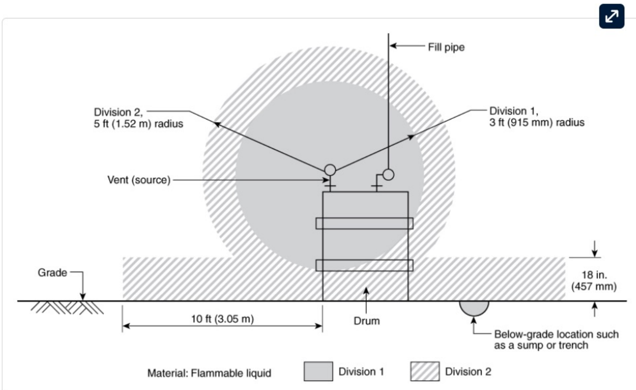

Figure 5.10.6 Drum Filling Station Located Either Outdoors or Indoors in an Adequately Ventilated Building. The material being handled is a flammable liquid.

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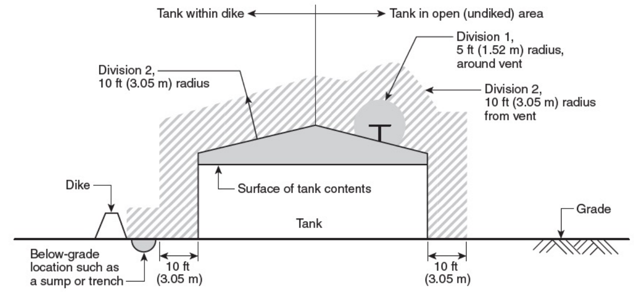

Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size		X	X
Pressure			X
Flow rate		X	X

Division 1

Division 2

FIGURE 5.10.4(a) Product Storage Tank Located Outdoors, at Grade. The material that is being stored is a flammable liquid.

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Materials

- Motor Oil
- Gasoline
- Windshield Washer Fluid
- Antifreeze
- Batteries
- Transmission Fluid
- Brake fluid
- Compressed Air
- Water
- Waste water
- Cleaning chemicals

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Material Properties

- Group
- Class
- Flash Point
- Vapor Density
- Autoignition Temperature (AIT)
- LFL% and UFL%
- Vapor Density
- Minimum Ignition Energy (MIE)
- Minimum Emission Safety Gap (MESG)

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Tools

- Impact Wrench
- Hand Tools
- Drills
- Grinder
- Welder

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Equipment

- Light fixtures
- Battery chargers
- Computer equipment
- air compressors
- Electrical panels
- Propane Heater
- Grinder
- Welder
- Lube pumps
- Motor

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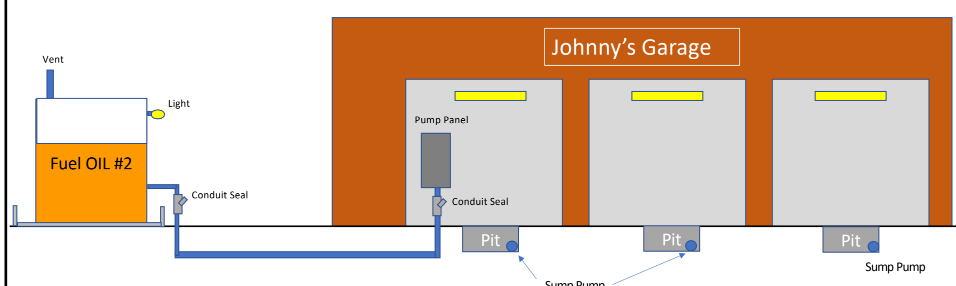
Elevation (Side) View



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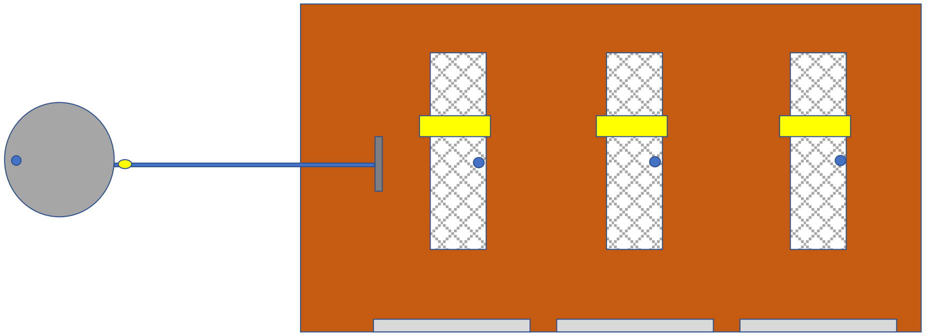
Plan (Top) View



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Perform Hazardous Area Classification

- Obtain Hazardous Area Classification diagram if one exists
- If not, create one
  - Identify possible material handling points
  - Where will material be under normal conditions?
  - Where will material be under abnormal conditions (leaks, spills, testing etc.)?
  - Do not include areas such as inside pipes, tanks, equipment etc.
  - Look at areas such as flanges, nozzles, sumps, filters, strainers, pits etc.

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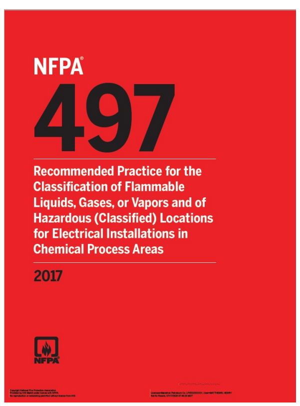
Per NFPA 497: Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas



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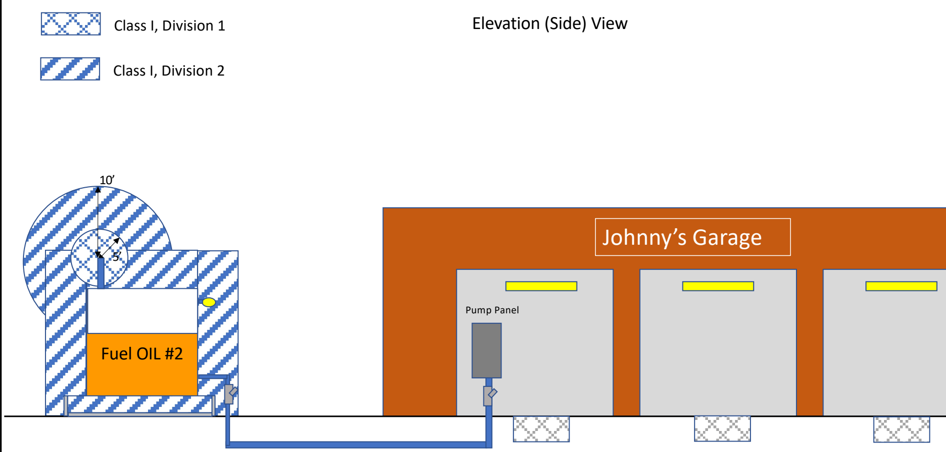

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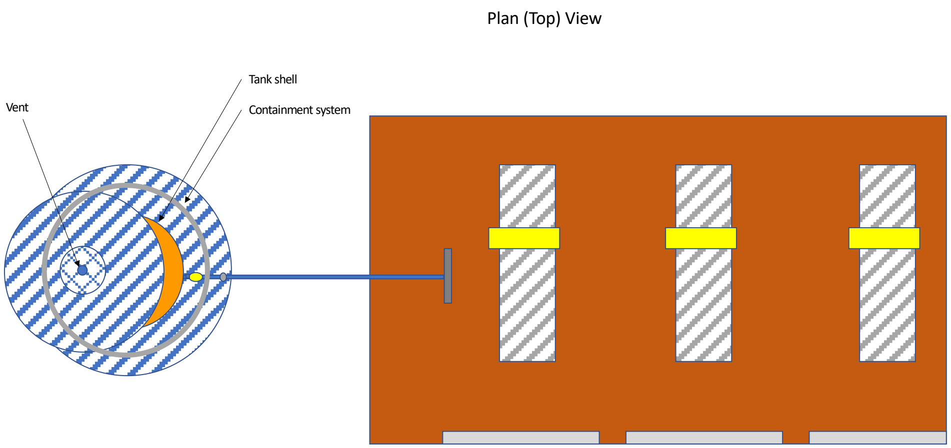

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Specifications

- Fuel Oil #2
  - Auto-ignition temperature: 257 deg. C (494.6 deg. F)
  - Per NFPA 497 Table 4.4.2
- Desired Lamp fixture??
  - General or Hazardous Location?

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How to Choose Right Lamp Fixture

- Hazardous Location: Class I, Division 2 
- Material Present: Fuel Oil #2, AIT = 494.6 deg F
- Lamp is located in a hazardous location and the surface temp cannot exceed 494.6 deg. F or it can ignite the fuel oil vapors

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NEC Table 500.8(C) Classification of Maximum Surface Temperature

Maximum Temperature

degrees C	degrees F	T-Code
450	842	T1
300	572	T2
280	536	T2A
260	500	T2B
230	446	T2C
215	419	T2D
200	392	T3
180	356	T3A
165	329	T3B
160	320	T3C
135	275	T4
120	248	T4A
100	212	T5
85	185	T6

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Surface temp of fixture cannot exceed 494.6 deg. F

Select T-code: T2C or better

Maximum Temperature		
degrees C	degrees F	T-Code
450	842	T1
300	572	T2
280	536	T2A
260	500	T2B
230	446	T2C
215	419	T2D
200	392	T3
180	356	T3A
165	329	T3B
160	320	T3C
135	275	T4
120	248	T4A
100	212	T5
85	185	T6

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Review the Group Codes

Class I (Gases or Vapors)

Class I hazardous locations are subdivided into the following four groups, depending on the type of flammable gases or vapors present:

Group A	Atmospheres containing acetylene.
Group B	Atmospheres containing hydrogen, fuel and combustible process gases containing more than 30 percent hydrogen by volume, or gases or vapors of equivalent hazard such as butadiene, ethylene oxide, propylene oxide and acrolein.
Group C	Atmospheres such as ethyl ether, ethylene, or gases or vapors of equivalent hazard.
Group D	Atmospheres such as acetone, ammonia, benzene, butane, cyclopropane, ethanol, gasoline, hexane, methanol, methane, natural gas, naphtha, propane, or gases or vapors of equivalent hazard.

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This fixture is ~~not~~ ok for Class I, Division 1 locations!

Champ VMV LED luminaires

Cl. I, Div. 2, Groups A, B, C, D
Cl. I, Zone 2, nA
Cl. II, Groups E, F, G
Cl. III & Simultaneous Presence

UL/cUL Listed
IECEx/ATEX/CE
Wet Locations
NEMA 4X; IP66

2L

The Champ VMV LED family

Champ® VMV LED luminaires are designed to provide full-spectrum, crisp, white light with custom IES Type I, III and V distribution. Nine versions of the VMV LED are available, providing ideal solutions for a wide range of applications.

Model	Typical lumens (Type V) A	Watts	Lumens per watt	Equivalent HID luminaire	Typical energy savings / lifetime
VMV3L	3,531	29	122	70W-100W	Up to 77%
VMV5L	5,256	41	129	100W-150W	Up to 67%
VMV7L	7,120	54	131	150W-175W	Up to 67%
VMV9L	9,134	74	124	250W-320W	Up to 74%
VMV11L	11,034	89	123	320W-400W	Up to 74%
VMV13L	13,226	130	102	400W	Up to 68%
VMV17L	18,793	168	112	400W-600W	Up to 72%
VMV21L	22,110	196	113	600W-750W	Up to 74%
VMV25L	26,531	232	114	750W-1000W	Up to 77%

Applications:

- For areas with mounting heights of up to 60 feet
- Oil and gas refineries, drilling rigs, petrochemical facilities, food and beverage facilities, platforms, loading docks, tunnels, indoor/outdoor spotlighting, outdoor wall and stanchion mounted general area lighting, and where flammable vapors, gases, ignitable dusts, fibers or flyings are present
- Locations requiring continuous and consistent light levels in extreme ambient temperatures
- Where extremely corrosive, wet, dusty, hot and/or cold conditions exist
- Classified and hazardous locations

Features:

- Instant illumination and restrike
- Cold temperature operation/no warm-up required
- Option for redundancy in drivers with multiple series circuits connected to

Certifications and compliances:

- DesignLights Consortium® Qualified (some models are not DLC qualified) B

NEC/CEC:

- Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, nA; Class II, Groups E, F, G; Class III
- Zone 21 tb
- Simultaneous Presence
- Wet locations, NEMA 4X, IP66

UL standards:

- UL844; UL1598 – Luminaires; UL1598A – Marine; UL8750; UL50; UL50E

CSA standard:

- cUL Listed to CSA standard CSA C22.2 No. 137

IEC: C

- IEC 60079-0:2011; IEC 60079-15:2010; IEC 60079-31:2013; IEC 60598-2-1:1979; IEC 60529:2001
- Ex nA IIC T* Gc -40 to +40
- Ex nA IIC T* Gc -40 to +55

Certifications and compliances (continued):

ATEX/CE: C

- EN 60079-0:2012 +A11:2013; EN 60079-15:2010; EN 60079-31:2014; EN 60598-2-1:1989; EN 60929:1991 +A1:2001
- Ex II 3 G Ex nA IIC T* Gc -40 to +40
- Ex II 3 G Ex nA IIC T* Gc -40 to +55
- Ex II 3 G Ex nA IIC T* Gc -40 to +65
- Ex II 2 D Ex tb IIIC T*°C Db IP66 -40 to +40
- Ex II 2 D Ex tb IIIC T*°C Db IP66 -40 to +55
- Ex II 2 D Ex tb IIIC T*°C Db IP66 -40 to +65

VMV3L-VMV11L only

- DEMKO 13 ATEX 1475031X; DEMKO 13 ATEX 1305741X

VMV13L-VMV25L only

- DEMKO 14 ATEX 1324722X; DEMKO 14 ATEX 2274231X

Standard materials:

- Lamp housing and adapter – die cast

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Electrical ratings:

	VMV3L	VMV5L	VMV7L	VMV9L	VMV11L	VMV13L	VMV17L	VMV21L	VMV25L
Voltage range, UNV1 (VAC 50/60 Hz)	120-277	120-277	120-277	120-277	120-277	120-277	120-277	120-277	120-277
Voltage range, UNV1 (VDC 50/60 Hz)	108-250	108-250	108-250	108-250	108-250	108-250	108-250	108-250	108-250
Input power (watts)	29	41	54	74	89	131	168	196	232
Input amps at 120-277 VAC	0.24 - 0.11	0.34 - 0.16	0.45 - 0.23	0.61 - 0.31	0.74 - 0.41	1.08 - 0.48	1.40 - 0.62	1.64 - 0.73	1.94 - 0.87
Voltage range, UNV34 (VAC 50/60 Hz)	347-480	347-480	347-480	347-480	347-480	347-480	347-480	347-480	347-480
Input power (watts)	27	44	58	73	91	127	175	208	263
Input amps at 347-480 VAC	0.06 - 0.08	0.09 - 0.12	0.12 - 0.16	0.15 - 0.21	0.19 - 0.26	0.21 - 0.26	0.49 - 0.37	0.58 - 0.43	0.73 - 0.55
Power factor	>0.90	>0.90	>0.90	>0.90	>0.90	>0.90	>0.90	>0.90	>0.90
Total harmonic distortion (THD)	<20%	<20%	<20%	<20%	<20%	<20%	<20%	<20%	<20%

Temperature performance data:

					Simultaneous rating	Class I, Zone 2	Class III, Div. 1 / Class II, Div. 1, Groups E, F, G
Lamp / lumen output	Driver type	Ambient temp. °C	Class I, Div. 2	Class II, Div. 1	Class I, Div. 2; Div. 1	AEx nA; Ex nA	Zone 21, AEx tb IIIC
3L, 5L, 7L, 9L, 11L	/UNV1	40	T5	T5	T3C	T5	T72°C
3L, 5L, 7L, 9L, 11L	/UNV1	55	T5	T4A	T3A	T5	T87°C
3L, 5L, 7L, 9L, 11L	/UNV1	65	T4A	T4A	T3A	T4	T92°C
3L, 5L, 7L, 9L, 11L	/UNV34	40	T3C	T5	T3C	T4	T70°C
3L, 5L, 7L, 9L, 11L	/UNV34	55	T3A	T4A	T3A	T4	T85°C
3L, 5L, 7L, 9L, 11L	/UNV34	65	T3A	T4A	T3A	T4	T92°C
13L, 17L	/UNV1; /UNV34	40	T4A	T5	T4A	T6	T66°C
13L, 17L	/UNV1; /UNV34	55	T4	T4A	T4	T5	T81°C
21L, 25L	/UNV1; /UNV34	40	T4A	T5	T4A	T6	T71°C
21L, 25L	/UNV1; /UNV34	55	T4	T4A	T4	T5	T86°C

D Custom optics not available with colored LEDs.

82 www.crouse-hinds.com US: 1-866-764-5454 CAN: 1-800-265-0502 Copyright® 2019 Eaton

EATON CROUSE-HINDS SERIES

All models will work

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Checklist

- Determine Hazardous Classification: Class I, Division 2 ✓
- Identify material(s) used in area: Fuel Oil #2 ✓
- Check NFPA 497 for properties including AIT: 494.6 deg F ✓
- Identify Group Classification (A,B,C,D): D ✓
- Check transmission path of vapors. Install conduit seals as necessary
- Select light fixture:
  - Verify proper hazardous classification: Class I, Division 2 ✓
  - Verify material group codes: D ✓
  - Verify maximum surface temperature (T-Code) ✓
  - Verify that fixture is properly listed, identified, marked and/or labeled: ✓

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Installation requirements

- Boundary Seals
- Conduit Selection
- Wire selection
- Enclosure selection
- Fixture installation

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Installation requirements

- Boundary Seals
  - Location: before leaving Class I, Div 2 and after re-emerging
    - Within 18" of grade
  - No unions, couplings, boxes etc. after seal
  - Threaded connections
- Conduit Selection and installation
  - RMC, IMC with listed fittings
  - Exceptions: see NEC
- Wire selection: seal so that no gases can get between wire strands
- Enclosure selection
- Fixture installation

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In Hazardous Locations, **when completely and properly installed and maintained**, Type 7 and 10 enclosures are designed to contain an internal explosion without causing an external hazard. Type 8 enclosures are designed to prevent combustion through the use of oil-immersed equipment. Type 9 enclosures are designed to prevent the ignition of combustible dust.

Type 7 Enclosures constructed for indoor use in hazardous (classified) locations classified as Class I, Division 1, Groups A, B, C, or D as defined in NFPA 70.

Type 8 Enclosures constructed for either indoor or outdoor use in hazardous (classified) locations classified as Class I, Division 1, Groups A, B, C, and D as defined in NFPA 70.

Type 9 Enclosures constructed for indoor use in hazardous (classified) locations classified as Class II, Division 1, Groups E, F, or G as defined in NFPA 70.

Type 10 Enclosures constructed to meet the requirements of the Mine Safety and Health Administration, 30 CFR, Part 18.

National Electrical Manufacturers Association
1300 N. 17th Street, Suite 1752
Rosslyn, VA 22209

Approved by NEMA Enclosures Section
November 2005

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Table B-1
[From NEMA 250-2003]
Comparison of Specific Applications of Enclosures
for Indoor Hazardous Locations
(If the installation is outdoors and/or additional protection is required by
Table 1 and Table 2, a combination-type enclosure is required.)

Provides a Degree of Protection Against Atmospheres Typically Containing (See NFPA 497M for Complete Listing)	Class	Enclosure Types 7 and 8, Class I Groups ** A	B	C	D	Enclosure Type 9, Class II Groups E	F	G	10
Acetylene	I	X	...	...	...	...	...	...	...
Hydrogen, manufactured gas	I	...	X	...	...	...	...	...	...
Diethyl ether, ethylene, cyclopropane	I	...	...	X	...	...	...	...	...
Gasoline, hexane, butane, naphtha, propane, acetone, toluene, isoprene	I	...	...	...	X	...	...	...	...
Metal dust	II	...	...	...	...	X	...	...	...
Carbon black, coal dust, coke dust	II	...	...	...	...	...	X	...	...
Flour, starch, grain dust	II	...	...	...	...	...	...	X	...
Fibers, flyings *	III	...	...	...	...	...	...	X	...
Methane with or without coal dust	MSHA	...	...	...	...	...	...	...	X

* For Class III type ignitable fibers or combustible flyings see the National Electrical Code, Article 500.
** Due to the characteristics of the gas, vapor, or dust, a product suitable for one Class or Group may not be suitable for another Class or Group unless marked on the product.

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Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2

API RECOMMENDED PRACTICE 500
THIRD EDITION, DECEMBER 2012

ERRATA, JANUARY 2014

REAFFIRMED, JULY 2021

154

Warning: not actually layout of DWH rig
Educational purposes only!

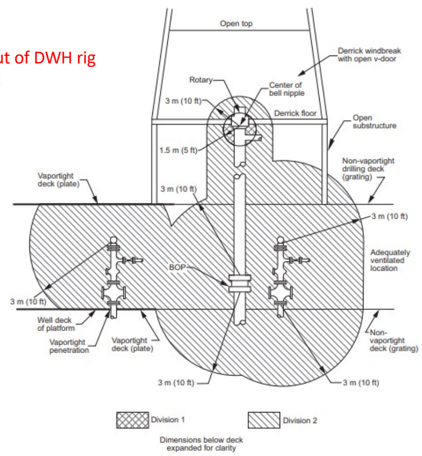

Figure 31—Platform Drilling Rig, Adequately Ventilated in Substructure and Inside Derrick, Several Producing Wells Beneath in an Adequately Ventilated Area (See 10.4.1.3)

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Warning: not actually layout of DWH rig
Educational purposes only!

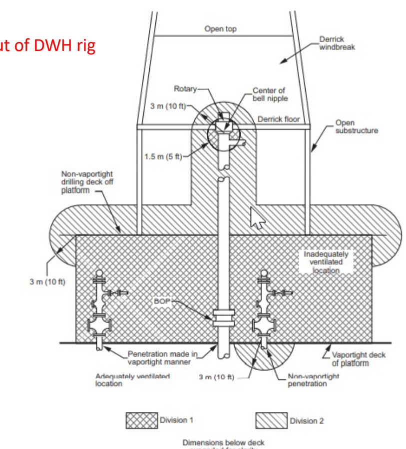

Figure 32—Platform Drilling Rig, Adequate Ventilation in Substructure and Inside Derrick, Several Producing Wells Beneath in an Inadequately Ventilated Location (See 10.4.1.4 and 10.5.1.4)

156

Warning: not actually layout of DWH rig
Educational purposes only!

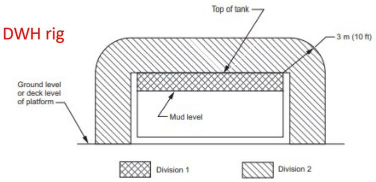

Figure 33—Mud Tank in a Nonenclosed Adequately Ventilated Area (See 10.4.2.1, 10.4.2.2, 10.4.3.1, and 10.4.3.2)

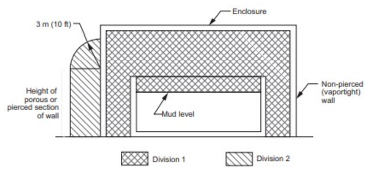

Figure 34—Mud Tank in an Inadequately Ventilated Area (See 10.4.2.3, 10.4.3.3, and 10.12.3)

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Summary

Identify	Identify	Choose	Use	AVOID
Identify classification of area before doing work	Identify ignition sources, flammable and combustible materials	Choose appropriate equipment	Use proper wiring and installation methods	AVOID HAZARDOUS LOCATIONS IF POSSIBLE!

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CONGRATULATIONS!

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Next Steps

- A Certificate of Completion will be emailed to those who successfully completed course
- 4 hours of Code Class Hours will be reported to the OCILB for Code Continuing Education Credits
- Contact instructor at hpmatthews@matthewselectrical.net for any questions or comments
- Make sure you completely sign out of webinar after the next slide!

160

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File Attachments for Item:

ER-4 2020 NEC Overview Webinar (Matthews Electrical Services)

BO, MPE, EPE, MechPE, ESI, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)

Staff Notes: Add NRIUI, recommend approval.

ESIAC Recommendation:

Committee Recommendation:

[redacted]

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: Henry Peter Matthews

Course Submitter: Henry Peter Matthews (Contact Name)

Organization: Matthews Electrical Services (Organization/Company)

Address: 1203 McKinley Place (Include Room Number, Suite, etc.)

City: Fostoria State: Ohio Zip: 44830

E-Mail: hpmatthews@matthewselectrical.net

Telephone: 419-575-3488 Fax:

Course Sponsor:

COURSE INFORMATION:

Course Title: NEC Overview

New Course Submittal: [x] Update Course: [ ] Prior Approval Number:

Purpose and Objective: The objective of this course is to take a high level overview of the NEC from cover to cover. This webinar will provide the attendee with tips on how to find information more efficiently. It will also cover how to get involved in the code-making process and review the history of the NEC. This course will cover the many popular articles and sections from all 8 chapters, Chapter 9 tables and various appendices.

Number of Instructional Contact Hours that can be obtained upon completion: 4

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

Program Applicable for the Following Participants:

- Building Official [x]
- Master Plans Examiner [x]
- Plumbing Plans Exam. [ ]
- Electrical Plans Exam. [x]
- Mechanical Plans Exam. [x]
- Building Inspector [x]
- Fire Protection Inspector [ ]
- Mechanical Inspector [x]
- Plumbing Inspector [ ]
- Non-Res IU Inspector [ ]

- Res Building Official [x]
- Res Plans Examiner [x]
- Res Building Inspector [x]
- Res Mechanical Inspector [x]
- Res IU Inspector [x]

Electrical Safety Inspectors [ ]
Location of ESI Course: www.matthewselectricalservices.net Date(s) of ESI Course(s): September 3, 2022

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
Course Sponsor:	Organization sponsoring or requesting the program (if any)	
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:	Copy of quizzes or tests to be given	x
Completed Application:		x

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

RECEIVED
JUN 27 2022
BOARD OF BUILDING STANDARDS

National Electrical Code Webinar Overview

Course Outline

(4 Code Credit Hours)

1. Objectives:
    a. Learning how to navigate through the NEC
    b. How to find information
    c. Where to get help on the code if needed
2. How to Use Webinar: instructions
3. Introductions: Instructor and attendees
4. Poll:
    a. What do you want to get out of this class?
    b. What topics are you most interested in?
5. History of the NEC
6. The Code Cycle
7. The NEC Style Guide
8. NFPA website
    a. Viewing standards
    b. Public inputs
    c. Temporary Interim Amendments (TIAs)
9. Table of Contents
10. Committees and Code-Making Panels
11. How to read the NEC
    a. Chapters and Articles
    b. Changes, deletions
    c. Informational notes
    d. References to standards
12. Article 90: Scope
13. Chapter 1: General
    a. Article 100: Definitions
    b. Article 110 Requirements for Electrical Installations
14. Chapter 2: Wiring and Protection
    a. Article 210: Branch Circuits
    b. Article 215: Feeders
    c. Article 230: Services
    d. Article 240: Overcurrent Protection
    e. Article 242: Overvoltage Protection
    f. Article 250: Grounding and Bonding

Henry Peter Matthews, PE, CPE, CESCP, PVA

Home Address
1203 McKinley Place
Fostoria, Ohio 44830
Email: hpmatthews@matthewselectrical.net
Home Phone: 419-701-7707
Cell Phone: 419-575-3488

Work Address
Marathon Petroleum Company
539 South Main Street
Findlay, Ohio 45840
Email: hpmatthews@marathonpetroleum.com
Office phone: 419-421-3423
Cell phone: 419-957-2110

Work Experience

Marathon Petroleum Company, LP; Findlay, Ohio — June 2006 – Present

- Advanced Senior Engineer/Electrical Specialist
- Electrical Engineering Supervisor – Terminal Engineering
- Project Engineer – Major Projects
- Electrical Designer – Retail Division

Cooper Standard Automotive, Bowling Green, Ohio — July 1993 – June 2006

- Plant Engineering Manager
- Plant Electrical Engineer

Toledo Engineering Company (consultant); Toledo, Ohio — June 1989 – July 1993

- Electrical Drafter

Education

Bowling Green State University; Bowling Green, Ohio — Aug 2003
Masters of Business Administration

Pennsylvania State University; University Park, PA — Dec 1989
BS Electrical Engineering

Solar Energy International, Paonia, Colorado — Sept 2021
Solar PV Training

Owens Community College; Findlay, Ohio — April 2017
Certificate: Introductory Welding

Penn Foster Career School — July 2010
Certificate: Plumbing

Penn Foster Career School — October 2004
Certificate: Electrician

Certifications

Professional Engineer (PE): OH, MI, IN, KY, IL, WI
Photovoltaic Associate (PVA) by NABCEP
Certified Electrical Safety Compliance Professional (CESCP), NFPA
Certified Plant Engineer (CPE): Association for Facility Engineers
Building Operator Certification (BOC): Northwest Energy Efficiency Council

Licenses **Ohio Electrical Contractor**, Ohio Department of Commerce, License # 46972
Ohio Training Agency, Ohio Construction Industry Licensing Board, Agency #48714
Ohio Training Agency, Ohio Board of Building Standards

Special Training **Solar Energy International (SEI),** Paonia, Colorado

- Solar Electric and Design and Installation Course, April 2021, 60 hours
- PV Systems Fundamentals (Battery-Based), June 2021, 40 hours
- Advanced PV System Design and the NEC, June-July 2021, 60 hours
- Comparing Battery Technologies, July 2021, 10 hours
- Tools and Techniques for Operations and Maintenance of PV Systems, 9/21, 40 HR

Affiliations

Institute of Electrical and Electronics Engineers (IEEE) – Senior Member
International Association of Electrical Inspectors (IAEI)
NFPA Section Member for Architects, Engineers and Building Officials
Illumination Engineering Society of North America (IESNA)
API RP 545 former Co-Chair, American Petroleum Institute, Lightning Protection for Above Ground Storage Tanks (2017- 2018)

Business Ownership **Matthews Electrical Services, Owner**
Designer Cuts Hair Salon, LLC; Co-owner

Biography

Henry has worked in the electrical, power, electronics, instrumentation, controls and communication fields for over 30 years. He earned his Bachelor of Science degree in Electrical Engineering from Penn State University in 1989. Henry worked as a consultant for Toledo Engineering Company in Toledo, Ohio as a drafter and field technician.

In 1993 he started working for Cooper Standard Automotive Company in Bowling Green, Ohio in 1993 as a Plant Electrical Engineer. He was then promoted to Plant Engineering Manager in 2000. During this time, he earned his Professional Engineering License in Ohio.

In 2003, Henry earned his MBA at Bowling Green State University.

In 2006, Henry joined Marathon Petroleum Company in Findlay, Ohio. He then went on to obtain his Professional Engineers license in Electrical Engineering for Michigan, Indiana, Illinois, West Virginia, Kentucky, Minnesota and Wisconsin. During his tenure at Marathon, Henry has had several roles including Electrical Design Engineer, Project Engineer and Electrical Supervisor. He is currently an Advanced Senior Engineer where he writes electrical standards for the company and conducts a community of practice for all the company's electrical engineers and safety professionals.

During his time at Cooper Standard Automotive and Marathon Petroleum, Henry developed a passion for teaching, learning and applying Electrical Construction Codes. At Cooper, he trained the entire non-electrical maintenance staff to perform basic electrical tasks.

At Marathon, Henry works with the Learning and Development Department to conduct multiple training sessions for new hires and seasoned engineers on various topics including Electrical Safety, Grounding and Bonding, Hazardous Area Location, Electrical Inspection, Motors, Lightning protection Static Electricity Mitigation, Reading and Understanding Electrical Diagrams, Programmable Logic Controllers and more.

Henry also works very closely with the Talent Acquisition Teams and visits numerous college campuses to deliver presentations on Engineering, Career Development, Networking and other topics.

Henry recently served as the Co-chair of the API Recommended Practice 545 Task Group for Lightning Mitigation for Above Ground Storage Tanks. In this role, he works with engineers, scientists and manufacturers from all over the world to evaluate the impacts of lightning and static electricity on metal above ground storage tanks.

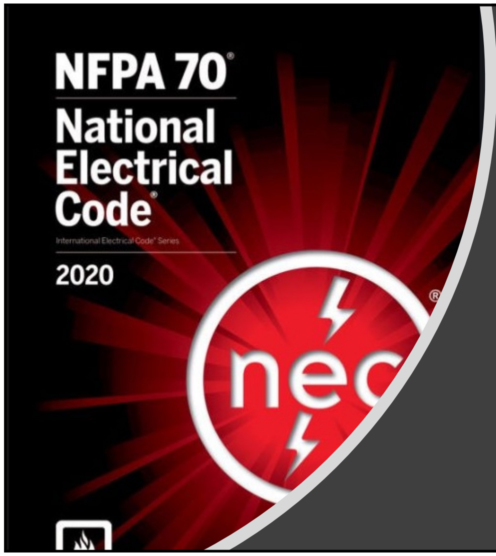
His passion for teaching and Electrical Safety has motivated him to earn the Certified Electrical Safety Compliance Professional Certification (CESCP) from NFPA. He also regularly attends numerous electrical and safety conferences and training sessions conducted by NFPA, IEEE, API.

Previously, Henry was the President of the Fostoria, Ohio area Toastmasters team.

Henry is also a member of the International Association of Electrical Inspectors.

Henry also owns two small businesses:

> **Matthews Electrical Services** - that performs mainly limited residential and small commercial electrical services and conducts training for licensed electricians in the state of Ohio.
>
> **Designer Cuts Hair Salon, LLC** – Henry co-owns the beauty salon with his wife.



Overview of the National Electrical Code

(NFPA 70 aka the NEC)

1

MATTHEWS ELECTRICAL SERVICES

Overview of the NEC Webinar

Matthews Electrical Services

Ohio Training Agency #48714

Henry Matthews, PE, CPE, CESCP

2

Webinar Rules

- Attendee must be present the entire time (except breaks)
- Webinar may be recorded
  - Proof of attendance and participant identity
  - Potential OCILB audits
- Turn webcam on after breaks and at end of class
  - Instructor will periodically check for presence of all attendees
- Mute microphone at all times
  - Prevents distraction during webinar
  - Instructor may activate participant microphone if verbal response is needed

3

WELCOME!

- Goals
  - Promote learning
  - Make session engaging
    - Discussion
    - Videos
    - Case Studies
    - Polls
  - Make 4 hours as productive as possible!

4

CERTIFICATE OF COMPLETION

THIS CERTIFIES THAT

JOE STUDENT

OCILB License no: 12345 (Electrical)

HAS SUCCESSFULLY COMPLETED THE TRAINING REQUIREMENTS FOR

NEC Overview

OCILB COURSE NUMBER: 4871422

February 5, 2022	MATTHEWS ELECTRICAL SERVICES Agency #48714	HENRY P. MATTHEWS PE, CESCP
DATE		INSTRUCTOR

5

5

Disclaimer #1

- I don’t know everything!
- It will be IMPOSSIBLE to learn everything about the NEC in 4 hours!
- But we’ll try to cover the main points

6

Disclaimer #2

- The views and opinions presented in this class are those of Matthews Electrical Services and not necessarily those of the various entities the presenter represents or has previously or currently works for.
- The material used in this class is based on documented publicly-available information (NFPA, OSHA, IEEE etc.)
- The interpretation of this material is based on the presenters experience and training of the subject matter.

7

Disclaimer #3

- This presentation uses video and props from various electrical equipment manufacturers. This is not intended to endorse any particular products, vendors or manufacturers.

- The content is shown for educational purposes only.

8

9

Other Resources

- NFPA: www.nfpa.org
- OSHA: www.osha.gov
- IEEE (Electrical Safety Workshop): http://www.ewh.ieee.org/cmte/ias-esw/
- IAEI: www.iaei.org
- Mike Holt Enterpises: www.MikeHolt.com
- Electrical Construction and Maintenance (EC&M) website: www.ecmweb.com
- NEMA: www.nema.org
- UL: www.ul.com
- NECA: www.necanet.org
- Brainfiller.com: www.brainfiller.com
- E-Hazard: https://www.e-hazard.com/
- Electrical Safety Foundation International (ESFi): https://www.esfi.org/
- Electrical Engineering Portal: www.electrical-engineering-portal.com
- www.Westex.com
- www.fluke.com

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My Favorites!

www.nfpa.org	www.iaei.org	www.mikeholt.com	www.esfi.org
www.brainfiller.com	www.tyndaleusa.com	https://www.ecmag.com/	https://www.ecmweb.com/

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Let's Begin!

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Objectives

- Learn tools on how to navigate the NEC
- Take a high level look at the NEC structure
- Be able to find most common subject matter
- How to contribute to improvement of the NEC

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The Great Chicago Fire of 1871

14

Early Origins of the NFPA and the NEC
World Columbian Exposition, Chicago, 1893

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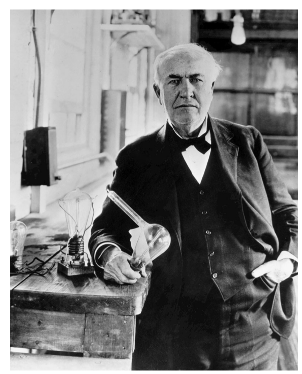
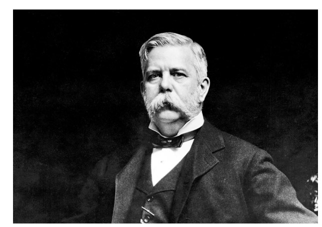
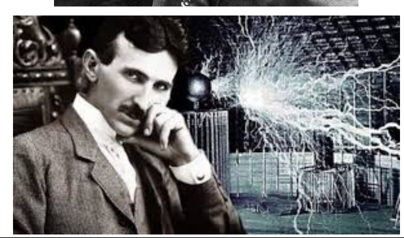
https://www.youtube.com/watch?v=ONMHUGVZmeg







William Henry Merrill
Boston Electrician

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National Fire Protection Agency (NFPA)

- Electric current creates heat
- Excessive heat can cause fire
- The NEC is born!

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History of the NEC

- Sponsored by the National Fire Protection Agency (NFPA) since 1911
- Original version developed in 1897
- 2020 Version represents the 55th edition
- Started 3-year cycle in 1975
- Prior to that it varied from 1 to 3 years

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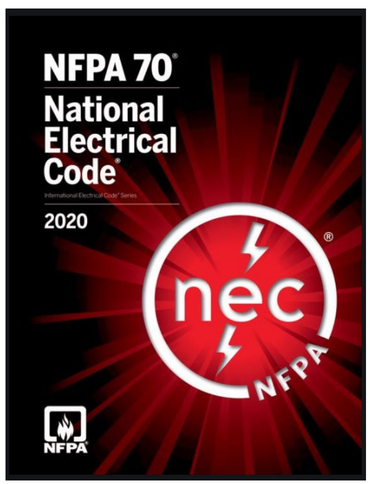
Trivia: What Does the Cover Remind You Of?



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Videos

- Square D 2020 NEC: What Changed and Who Changed it?
  - https://www.youtube.com/watch?v=2Yn8RJiehEA&list=PLGo9TRGblRRuYIiZFdol5B5QIbBVNSwNg&index=1
- Tour of the NEC
  - https://www.nfpa.org/NEC/About-the-NEC

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Recommendations for this Webinar

- Grab your NEC book if you have one
- Don't memorize sections
- Try to focus on NEC structure
- General Requirements (Chapters 1-4)
- Special Situations (Chapters 5-8)
- Additional Guidance (Ch 9 and Annexes)

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How to Get Code Information

- NFPA: www.nfpa.org
- International Association of Electrical Inspectors (IAEI): www.iaei.org
- Electrical Safety Foundation International (ESFI): www.esfi.org
- Mike Holt Enterprises: www.mikeholt.com
- Ohio Board of Building Standards: https://codes.iccsafe.org/
- OSHA: www.OSHA.gov 1910.303 Subpart S

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Other Information

- National Electrical Manufacturers Association: www.NEMA.org
- Institute of Electrical and Electronic Engineers: www.IEEE.org
- Underwriters Laboratories: www.ul.com
- National Electrical Contractors Association: www.necanet.org
- Manufacturer Websites:
  - Eaton, Schneider Electric (Square D), Siemens, Hubbell, Leviton, Appleton, Littelfuse etc.

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Math Basics

Ohms Law: V = I x R

Power: P = V x I

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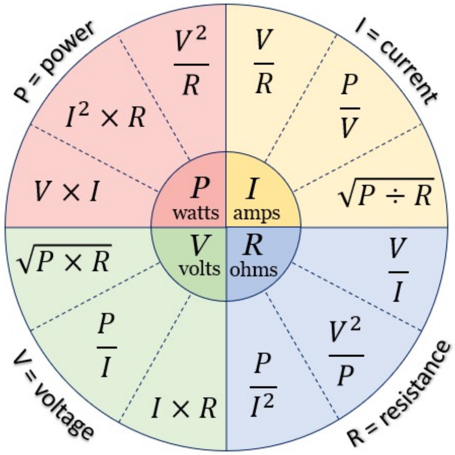
Math Basics



25

Temperature Conversions

- Celsius (C) and Fahrenheit (F)
- C to F = C x 9/5 + 32
  - Example: 40°C =
    - 40 x 9 = 360
    - 360/5 = 72
    - 72 + 32 = 104°F
- F to C = (F -32) x 5/9
  - Example: 104°F =
  - 104 -32 = 72
  - 72 x 5 = 360
  - 360/9 = 40°C

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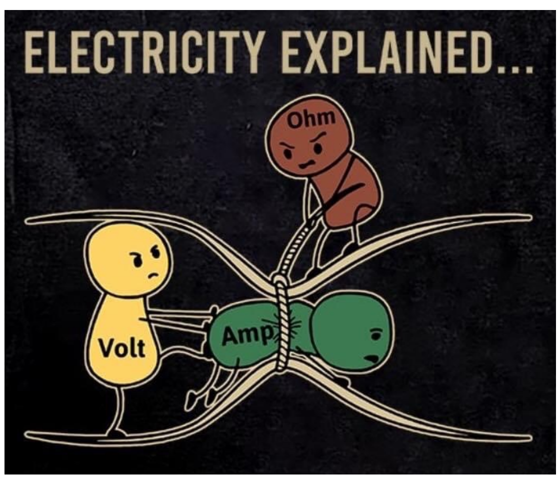
Voltage, Current and Resistance



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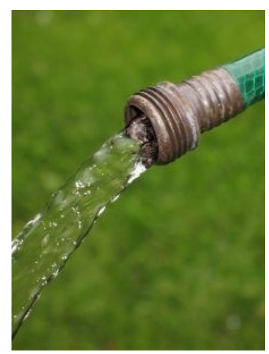
Voltage and Current Analogy



Fire Bucket Brigade by Monroe Historical Society

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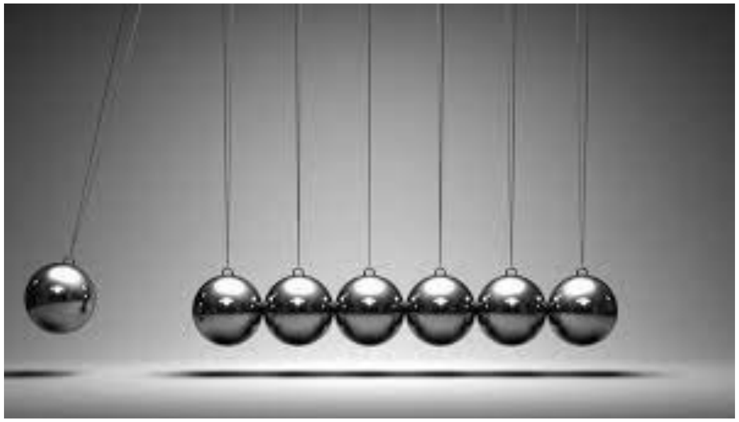

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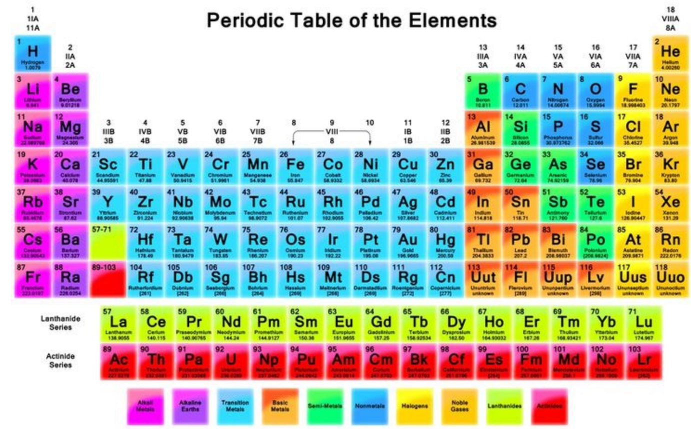
OH No! Not Chemistry!



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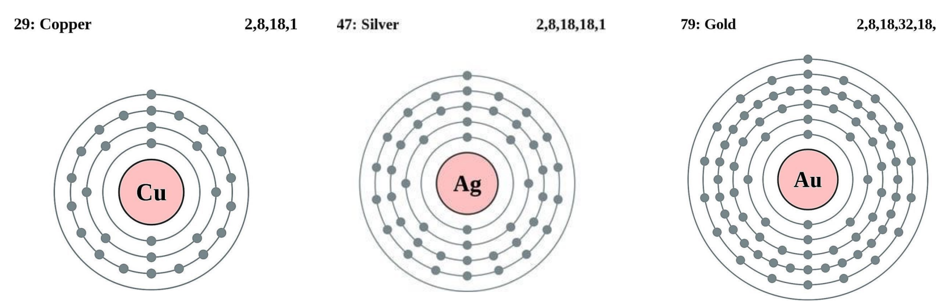
How Does Current Flow?



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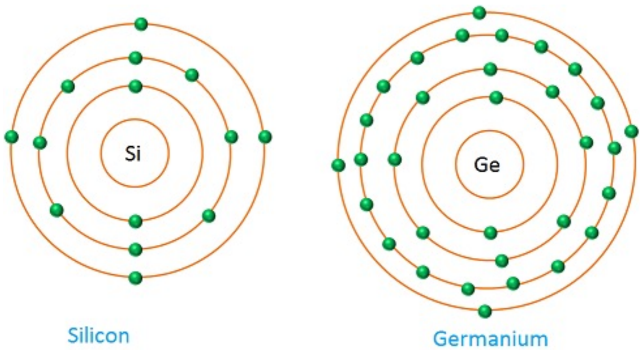
Insulators



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Get Involved in the Code

- https://www.youtube.com/watch?v=2Yn8RJiehEA&list=PLGo9TRGblRRuYIiZFdol5B5QIbBVNSwNg&index=1

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Public Input No. 2079-NFPA 70-2020 [New Section after 501.15(A)]

TITLE OF NEW CONTENT
501.15(A)(5) Underground Raceways

Statement of Problem and Substantiation for Public Input

Currently there exists requirements for underground wiring and raceways in several sections (ex. Aircraft hangars, fuel dispensing facilities, bulk storage). However there is no general section in 501 and the requirements listed in the sections mentioned above seem inconsistent.

Also guidance is required for sealing of conduits that start in a classified area, go underground and re-emerge in the same classified area.

Recommendation to add wording that provides guidance that conduit seals are not required for conduit installed under the following conditions:
--The conduit goes underground and re-emerges from ground in the same classification. For example, it originates in a Class I, Div 1 area, goes underground and re-emerges in the same Class I, Div 1 area. The conduit does not go under any other classified or unclassified areas.

--The equipment where the conduit will installed will be listed and marked for the hazardous location

--RMC or IMC is used for the entire length of the conduit installation except as exempted by other other sections (Fuel dispensing locations for example)

-- threaded connections are utilized for all connections.

Justification: Additional guidance for underground wiring within a classification is needed.

Submitter Information Verification

Submitter Full Name: Henry Matthews
Organization: [redacted]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jul 29 08:38:23 EDT 2020
Committee: NEC-P14

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NEC Structure

- Chapters
- Articles
- Parts
- Sections

<u>Example:</u>
Chapter 2: Wiring and Protection
Article 250: Grounding and Bonding
Part II: System Grounding
Section 250.20: AC Systems to Be Grounded

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How to use the Code

- https://www.youtube.com/watch?v=OVTS2yDIFM4&t=1s

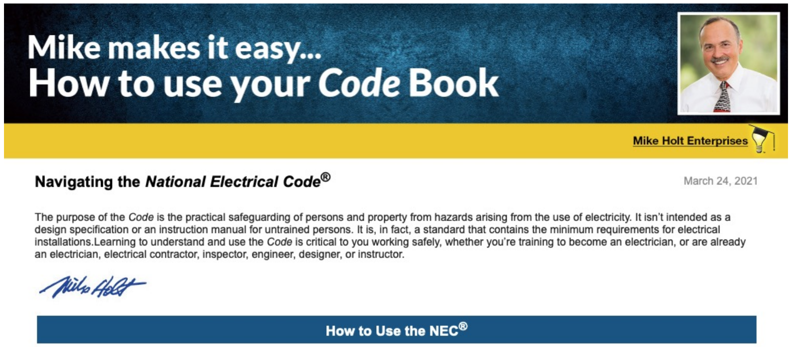

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Table of Contents

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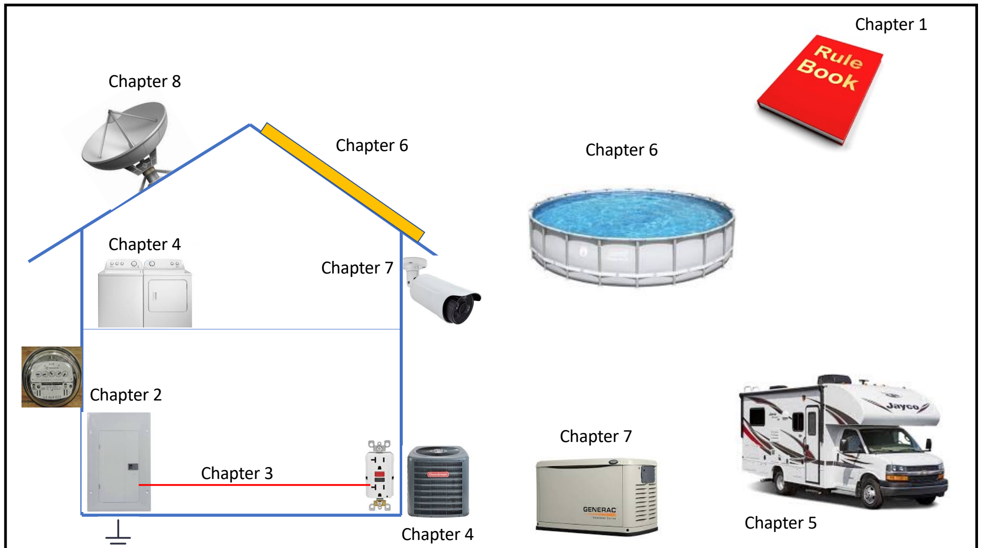

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Code-Making Panels (CMPs)

- 18 total
- Made up of:
  - Manufacturer reps
  - Power Company reps
  - Laboratory reps
  - Contractor
  - Inspectors
  - Union reps
  - Training reps
  - Organizations (IAEI, IEEE eg.)
  - Requires consensus for change

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Code-Making Panel No. 2

Articles 210, 220, Annex D, Examples D1 through D6

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Rep. International Association of Electrical Inspectors

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Charles L. Boynton, The DuPont Company, Inc., TX [U]
Rep. American Chemistry Council
Daniel Buuck, National Association of Home Builders (NAHB), DC [U]
Rep. National Association of Home Builders
Steve Campolo, Leviton Manufacturing Company, Inc., NY [M]
Thomas A. Domitrovich, Eaton Corporation, MO [M]
Rep. National Electrical Manufacturers Association
Nehad El-Sherif, Saskatoon, SKCanada [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.
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Alan Manche, Schneider Electric, KY [M]
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Michael Weaver, M&W Electric, OR [IM]
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Rep. U.S. Consumer Product Safety Commission

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Code-Making Panel No. 5

Articles 200, 250

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Rep. Steel Tube Institute of North America
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Trevor N. Bowmer, Telcordia (Ericsson), NJ [U]
Rep. Alliance for Telecommunications Industry Solutions
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Rep. Copper Development Association Inc.
Paul Dobrowsky, Innovative Technology Services, NY [U]
Rep. American Chemistry Council
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Joseph Harding, Power Tool Institute, OH [M]
Daleep C. Mohla, DCM Electrical Consulting Services, Inc., TX [U]
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(Alt. to G. Scott Harding)
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(Alt. to David Brender)

Nonvoting

Robert A. Nelson, Canadian Standards Association, Canada [RT]

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COMMITTEE PERSONNEL

Code-Making Panel No. 6

Articles 310, 311, 320, 322, 324, 326, 328, 330, 332, 334, 336, 337, 338, 340, 382, 394, 396, 398, 399, 400, 402, Chapter 9, Tables 5 through 9, Annex B and Example D7

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Rep. American Chemistry Council
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Herman J. Hall, Austin, TX [M]
(Alt. to Timothy Earl)
Samuel R. La Dart, City of Memphis, TN [L]
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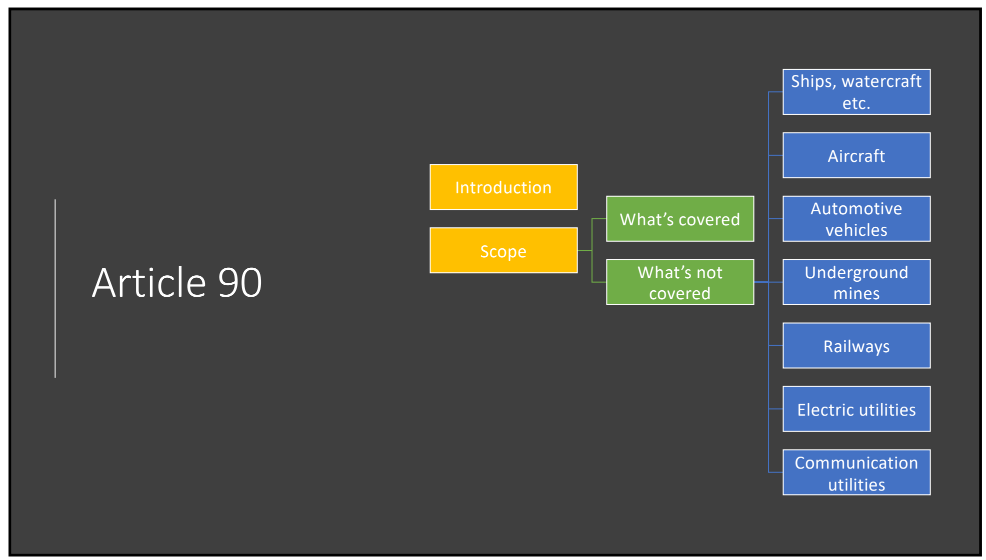

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Scope Change 90.2(A)(5)

- The NEC now covers the installation and supply of power from shore to ships and watercraft
- Installations used to export electric power from vehicles to premises wiring or for bi-directional current flow

https://www.youtube.com/watch?v=kSAxNZ5dI8E&t=17s

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Chapter 1: General

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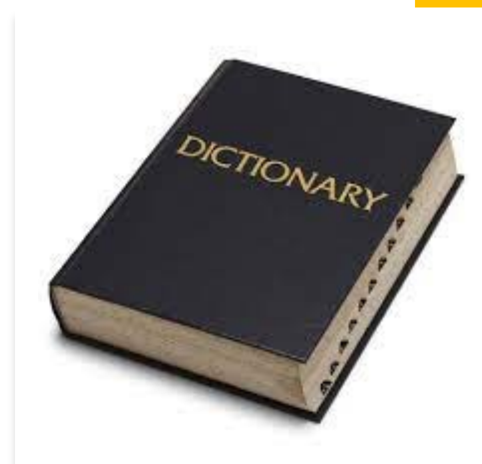
Definitions

- Part I: General
- Part II: Over 1000 Volts, Nominal
- Part III (New): Hazardous (Classified) Locations



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Chapter 1: General

- Article 100: Definitions
  - **Receptacle:** A contact device installed at the outlet for the connection of electrical utilization equipment designed to mate with corresponding contact device with not other contact device on the same yoke or strap. A multiple receptacle is two or more contact devices on the same yoke or strap.

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Chapter 1: General

- Article 100: Definitions
  - **Outlet**: A point on the wiring system at which current is taken to supply utilization equipment

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Chapter 1: General

- Article 100: Definitions
  - **Receptacle outlet**: An outlet device where one or more receptacles are installed

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Service

- The conductors and equipment connecting the servicing utility to the wiring system of the premises served.

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Service Equipment

- The necessary equipment, consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the serving utility and intended to constitute the main control and disconnect of the serving utility.

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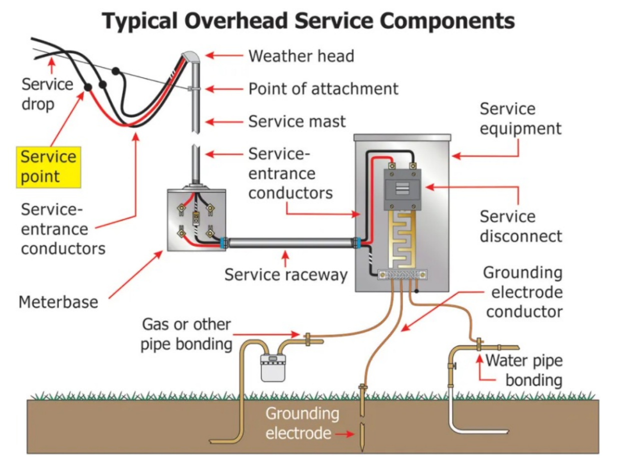

www.iaei.org

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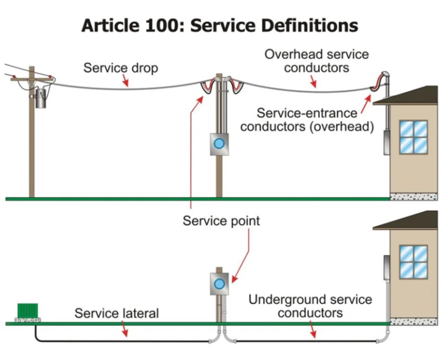
Service Point

- The point of connection between the facilities of the serving utility and the premises wiring



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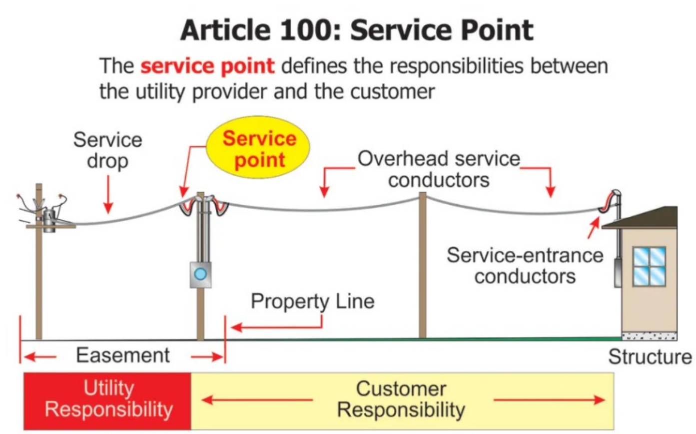

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Service Conductors

- The conductors from the service point to the service disconnecting means

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Why is This Important?

- Determine whether equipment is a fed from utility or separately derived system
- Demarcation between service conductors and feeders
- Ownership of equipment
- Labeling and marking
- Rating of equipment: Short Circuit Current Rating (SCCR)

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Article 110: Requirements for Electrical Installations

- Examination, Identification, Installation, Use and Listing of Equipment
- Arc Flash Hazard Warning
- Equipment marking
- Working spaces
- Enclosure selection: Table 110.28

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Article 110: Requirements for Electrical Installations

- 110.3(B) Equipment that is listed, labeled, or both shall be installed and used in accordance with any instructions included in the listing or labeling.

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Article 110: Requirements for Electrical Installations

- 110.12 Mechanical Execution of Work
  - Electrical Equipment shall be installed in a neat and workmanlike manner.

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Chapter 2

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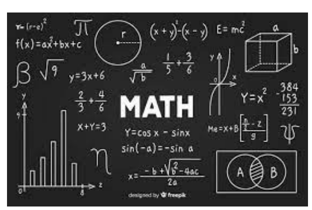
Chapter 2: Wiring and Protection



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Chapter 2: Wiring and Protection

- What's in this chapter?
  - Article 200: Use and ID of Grounded Conductors (Neutrals)
  - Article 210: Branch Circuits
    - 210.8 GFCIs
    - 210.12 AFCIs
    - 210.13 GFPEs
    - 210.50 Receptacle Outlets
  - Article 215: Feeders
  - Article 220: Branch-Circuit Feeder, and Service Load Calculations
  - Article 225: Outside Branch Circuits and Feeders
  - Article 230: Services
  - Article 240: Overcurrent Protection
  - Article 242: Overvoltage Protection
  - Article 250: Grounding and Bonding

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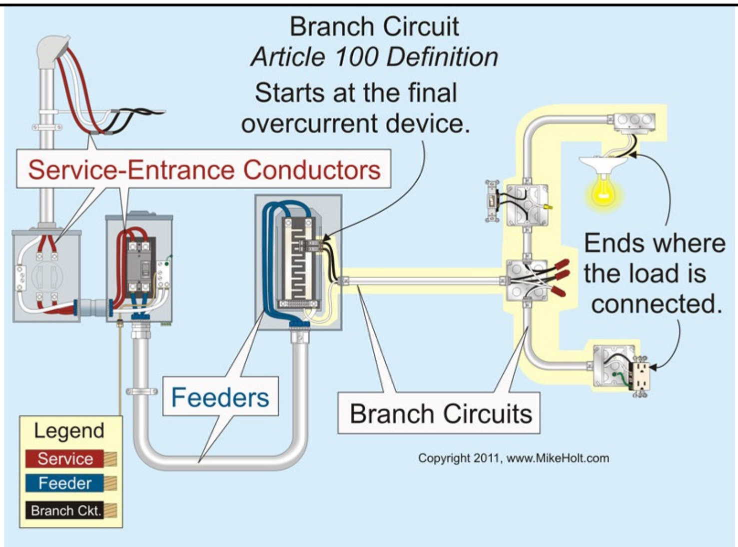

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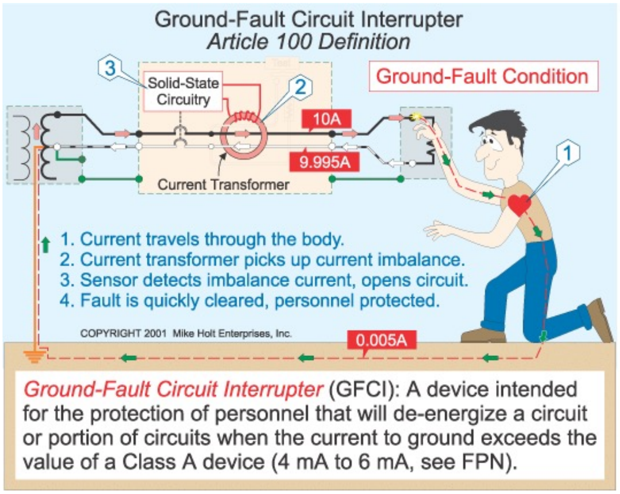

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Dwelling Unit GFCI requirements	Article 210.8(A)
Bathrooms	210.8(A)(1)
Garages and Accessory Buildings	210.8(A)(2)
Outdoors	210.8(A)(3)
Crawl Spaces	210.8(A)(4)
Basements (finished and unfinished)	210.8(A)(5)
Kitchens	210.8(A)(6)
Sinks	210.8(A)(7)
Boathouses	210.8(A)(8)
Bathtubs and shower stalls	210.8(A)(9)
Laundry Areas	210.8(A)(10)
Indoor Damp and Wet Locations (new)	210.8(A)(11)
Boast Hoist	555.9

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GFCI Requirements for Other Than Dwelling Units	Article 210.8(B)
Bathrooms	210.8(B)(1)
Kitchens or areas with sink and permanent provisions for food preparation or cooking	210.8(B)(2)
Rooftops	210.8(B)(3)
Outdoors	210.8(B)(4)
Sinks	210.8(B)(5)
Indoor damp and wet locations	210.8(B)(6)
Locker rooms with shower facilities	210.8(B)(7)
Garages and accessory buildings	210.8(B)(8)
Crawl Spaces – at or below grade	210.8(B)(9)
Unfinished areas of basements	210.8(B)(10)
Laundry areas	210.8(B)(11)
Bathtubs and Shower Stalls	210.8(B)(12)

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UNITED STATES
DEPARTMENT OF LABOR

Occupational Safety and Health Administration

CONTACT US FAQ A TO Z INDEX ENGLISH ESPAÑOL

1	200376515	09/06/2013	0454510	X	7623	Employee Electrocuted While Rewiring Air Conditioner
2	202553525	10/14/2011	0950631		8062	Worker Amputates Fingertip While Servicing Air Conditioner
3	200103711	08/06/2010	0522300	X	8744	Employee Is Electrocuted While Working On Air Conditioner
4	202080560	07/26/2010	0453730	X	7623	Employee Is Killed While Servicing Air Conditioner
5	200002954	11/05/2009	0728500	X	1711	Employee Is Electrocuted While Servicing Air Conditioner
6	200713584	02/12/2009	0636900	X	3585	Employee Is Killed While Replacing Filter In Air Conditioner
7	200374023	08/08/2006	0454510	X	7011	Employee Is Electrocuted While Servicing Air Conditioner
8	202004776	08/03/2006	0317000	X	3699	Employee Is Electrocuted While Servicing Air Conditioner
9	201923893	07/06/2006	0626700	X	1711	Employee Electrocuted While Installing Air Conditioner
10	200373736	11/07/2005	0454510	X	4961	Employee Killed By Falling Air Conditioner
11	200211746	05/13/2005	0626000	X	7623	Employee Is Killed While Installing Air Conditioner In Attic
12	200993301	06/01/2004	0551800	X	1711	Employee Electrocuted While Repairing Air Conditioner
13	201158219	09/23/2003	0950633		3716	Employee Struck By Falling Air Conditioner

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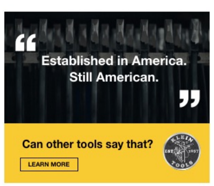
EC&M

LOG IN REGISTER SEARCH

LATEST FROM NATIONAL ELECTRICAL CODE

Moving Violations Video No. 248: NEC Receptacle Violation
Oct. 7, 2021
content

Stumped by the Code? Rules for Multiple Type MC Cables...
Oct. 7, 2021
content



NATIONAL ELECTRICAL CODE

Two TIAs Issued for the 2020 NEC Regarding GFCI Protection

June 14, 2021

https://www.ecmweb.com/national-electrical-code/article/21166916/two-tias-issued-for-the-2020-nec-regarding-gfci-protection

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GFCI Requirements Common to Both Dwelling and Non-Dwelling Units	Articles
Crawl Space lighting outlets	210.8(C)
Specific Appliances	210.8(D)
Equipment Requiring Servicing	210.8(E) and 210.63
Outdoor Outlets	210.8(F)
Sumps Pumps	422.5(A)(6)
Dishwashers	422.5(A)(7)
Docks, marinas, boatyards etc.	Article 555
Swimming Pools, Spas, hot tubs, baptismal pools, splash ponds, etc.	Article 680

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AFCI Requirements

https://www.facebook.com/nationalelectricalcode/videos/389481495412648/

Area	AFCI Code reference
Kitchen	210.12(A)
Dining Room	210.12(A)
Bedroom	210.12(A)
Closets	210.12(A)
Living Room	210.12(A)
Family Room	210.12(A)
Parlor	210.12(A)
Libraries	210.12(A)
Hallway	210.12(A)
Laundry Room	210.12(A)
Den	210.12(A)
Sunroom	210.12(A)
Recreation Room	210.12(A)
Dormitory units	210.12(B)
Dormitory bathrooms	210.12(B)
Patient Sleeping Rooms in Nursing Homes and Limited-Care Facilities	210.12(C)
Hotel Guest rooms and suites	210.12(D)

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Article 220: Calculations

- Lighting Loads: Non-Dwelling and Dwelling Units
- Demand factors
- Feeder and Service Load Calculations: 2 types permitted
  - Part III:
  - Part IV: Alternative Method
- Square D: 2020 Load Calculations 220.12:
  - https://www.youtube.com/watch?v=mmxEdxZsNd0&list=PLGo9TRGblRRuYIiZFdol5B5QIbBVNSwNg&index=5

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Article 225: Outside Branch Circuits and Feeders

- Clearances
- Protection
- Number of supplies
  - Alert! Section 225.30(B) Common Supply Equipment
- Disconnects

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230.85 Emergency Disconnects

- https://www.youtube.com/watch?v=J6xfGKSLSf4 Square D
- https://www.youtube.com/watch?v=3EU9aOjWW4c NFPA

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Article 240 Overcurrent Protection

- Overcurrent Devices Rated 800A or less
  - Overcurrent maximum limit for small conductors -240.3(D)
    - 14 AWG Copper: 15 amps
    - 12 AWG Copper: 20 amps
    - 10 AWG Copper: 30 amps
- Feeder Tap rule: 240.21(B)
  - Tap Conductor (240.2): A conductor, other than a service conductor, that have overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors that are protected as described elsewhere in 240.4

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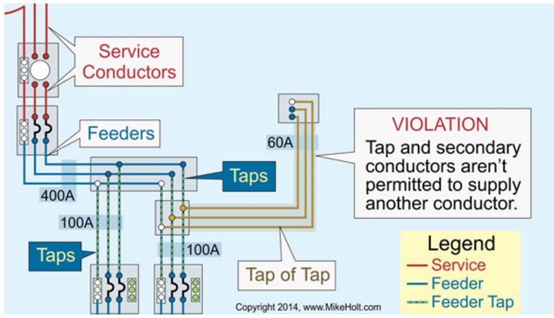
Tap Rules

- Objectives: all wires shall be protected from overcurrent at their source
- However, taps are not or can't be protected at their source. Examples
  - Wires originating from power blocks
  - Wires originating from transformer secondaries



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Tap Rules

- Taps not over 10 ft long
  - Conductor ampacity cannot be less than 1/10 of the feeder O/C device rating
- Taps not over 25 ft long
  - Conductor ampacity cannot be less than 1/3 of the feeder O/C device rating
- Taps supplying a transformer not over 25 feet long
  - Primary conductors have a minimum ampacity of 1/3 the O/C rating protecting the feeders
  - Secondary conductors have an ampacity not less than transformer turns ratio multiplied by 1/3 the rating of the O/C device protecting the feeders.

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Article 242 Overvoltage Protection (New)

- Covers
  - overcurrent protection devices
  - Surge Protective Devices (SPDs) , less than or equal to 1000V
  - Surge Arrestors, greater than 1000V

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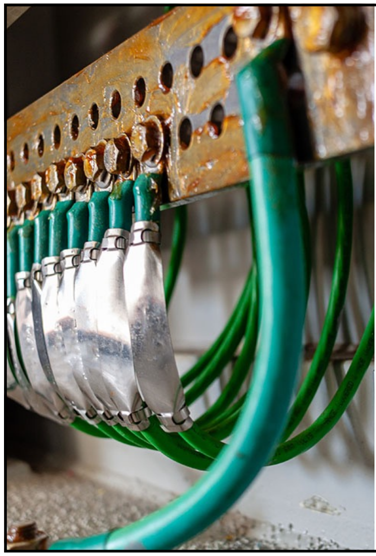

Article 250 Grounding and Bonding

Story Time

- General (Part I)
- System Grounding (Part II)
- Grounding Electrode System and Grounding Electrode Conductor (Part III)
  - Table 250.66 for sizing the GEC
- Enclosure, Raceway, and Service Cable Connections (Part IV)
- Bonding (Part V)
  - Table 250.102(C)(1) for sizing Grounded Conductor (Neutral), MBJ and SBJ, SSBJ
- Equipment Grounding and Equipment Grounding Conductors (Part VI)
  - Table 250.122 for sizing EGC
- Methods of Equipment Grounding Conductor Connections (Part VII)
- Direct Current Systems (Part VIII)
- Instruments, Meters and Relays (Part IX)
- Grounding of Systems and Circuits of Over 1000V (Part X)

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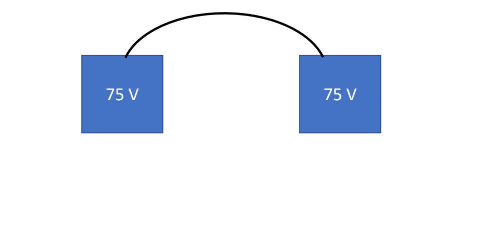
Bonding Example (Before)

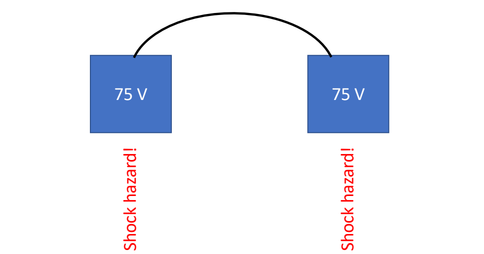
84

Bonding Example (After)



85

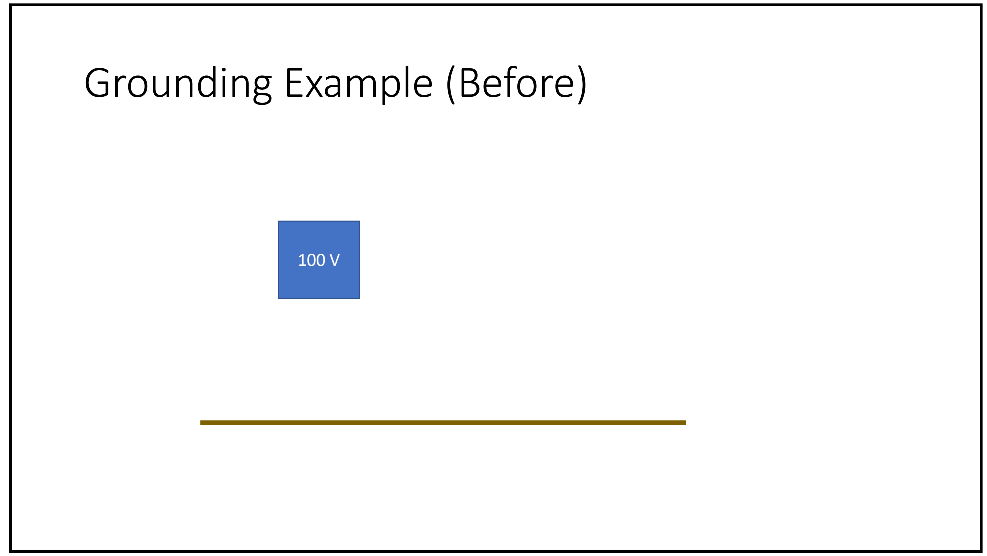
Bonding Example (After)



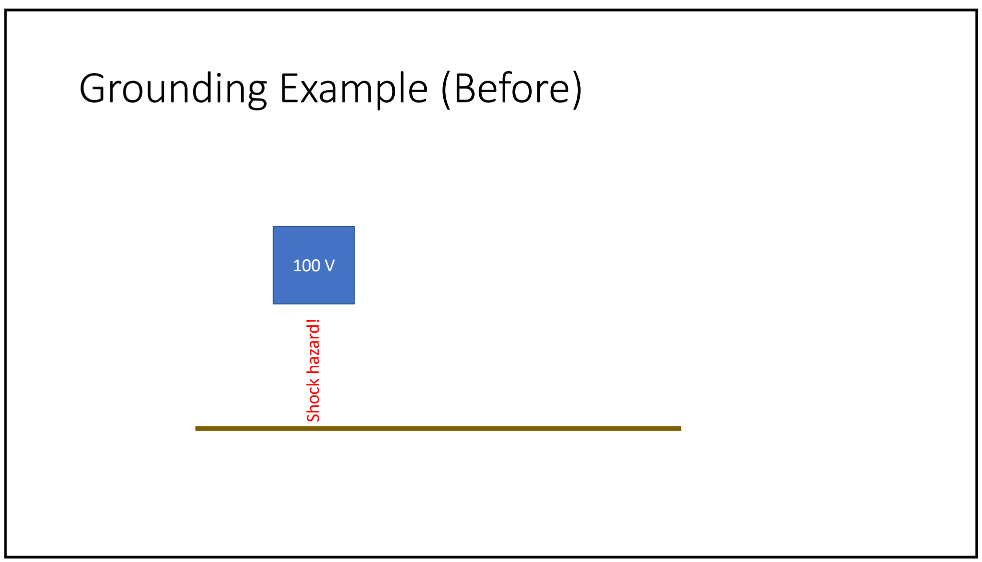
86


Bonding

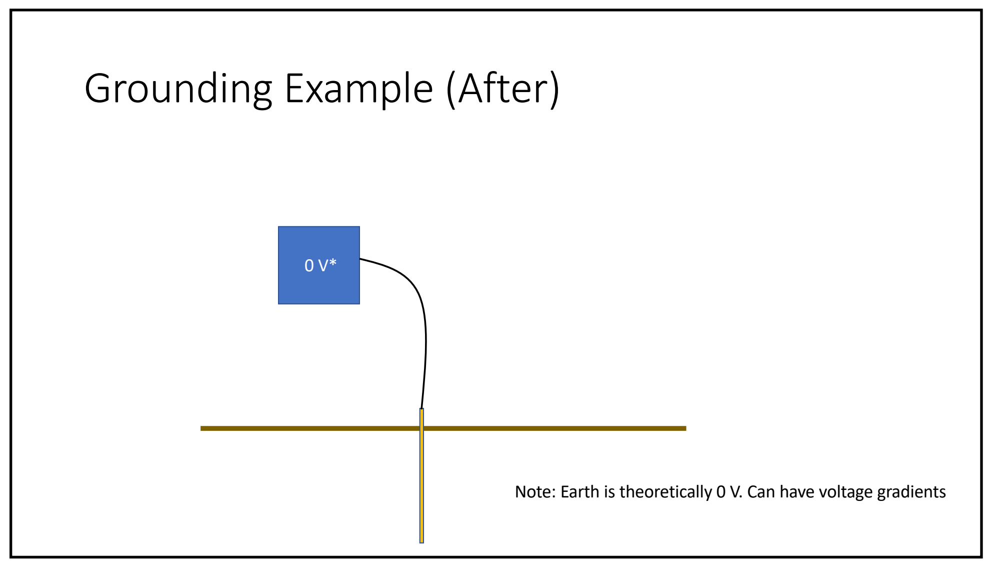
87


Grounding Example (Before)
100 V

88


Grounding Example (Before)
100 V
Shock hazard!

89


Grounding Example (After)
0 V*
Note: Earth is theoretically 0 V. Can have voltage gradients

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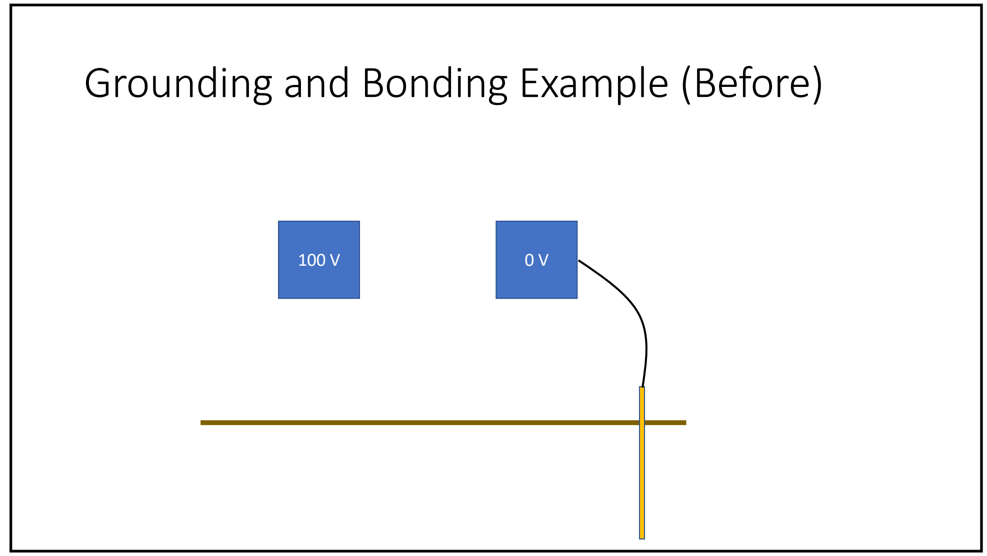
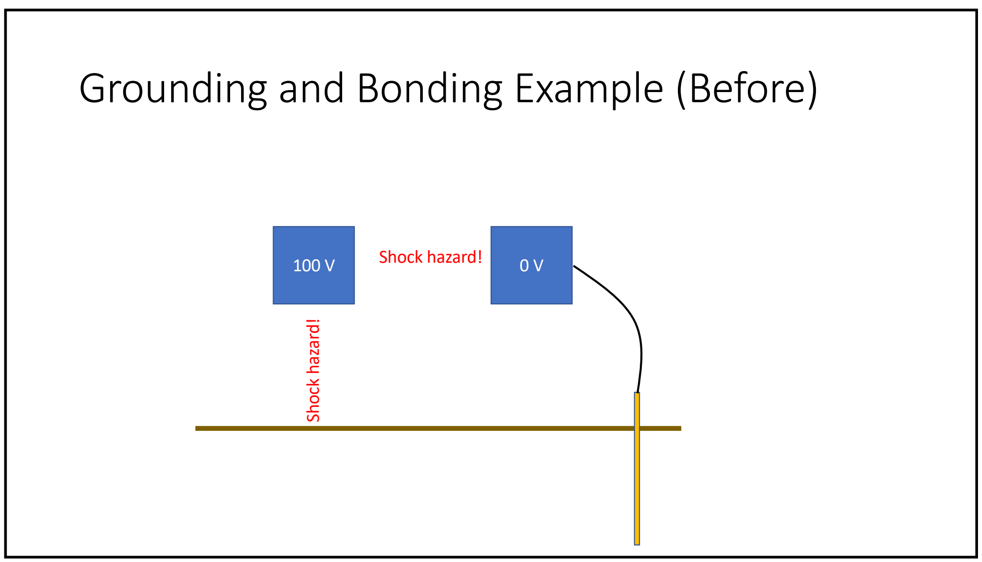
Grounding
(Grounded)

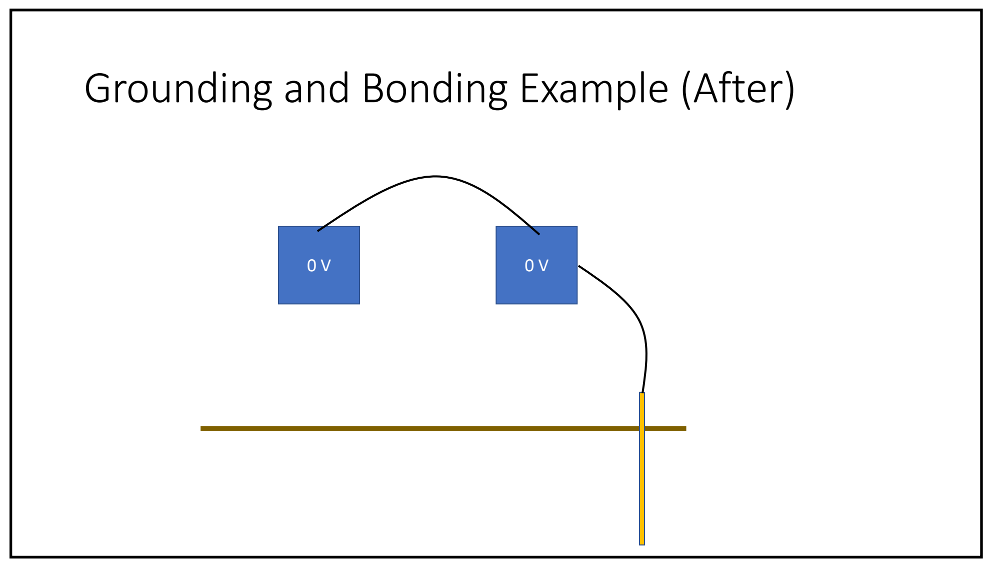
91


Grounding and Bonding Example (Before)
100 V
0 V

92


Grounding and Bonding Example (Before)
100 V
Shock hazard!
0 V
Shock hazard!

93


Grounding and Bonding Example (After)
0 V
0 V

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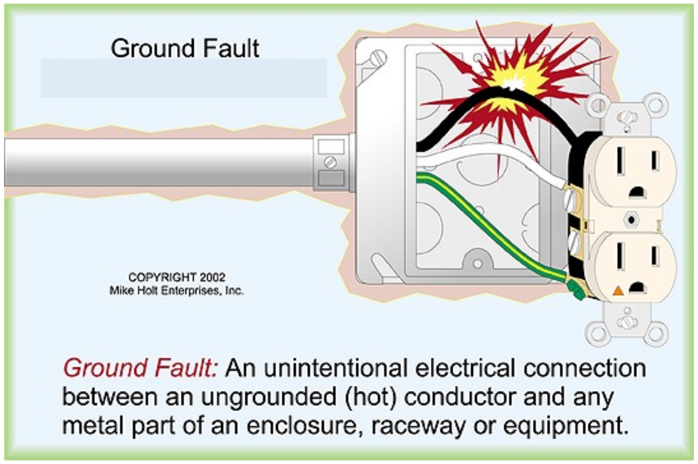

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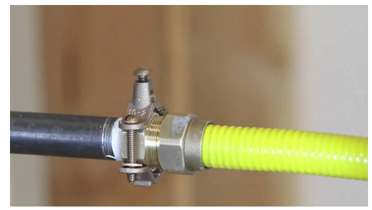
CSST Gas Line - 250.104B

- Shall be bonded to the grounding system
- NOTE: CHECK WITH LOCAL AHJ, GAS COMPANY AND ELECTRIC UTILITY
- Who will do the bonding? Gas company, plumber, electrician?
- https://www.youtube.com/watch?v=7QiNMnDdXQ8



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FACT SHEET

ELECTRICAL BONDING OF GAS PIPING SYSTEMS rev.9-06-17

American Gas Association

This fact sheet provides an overview of the requirements for the electrical bonding of fuel gas piping systems to the electrical grounding system based on ANSI Z223.1/NFPA 54, National Fuel Gas Code - 2018 (NFGC). The bonding requirements in previous code editions, in local jurisdictions, or in specific situations, may differ.

The fact sheet is not intended to replace knowledge of applicable local and national codes or address specific situations. The user should consult a competent professional and be thoroughly familiar with all applicable local codes, specific manufacturer's installation instructions and the National Electrical Code (NEC®)[1] before attempting to bond any fuel-gas installation.

WHAT IS AN ELECTRICAL BOND?

An electrical bond is an electrically conductive and continuous path from the gas piping to the grounding electrode system.

WHY BOND GAS PIPING?

Bonding is required to prevent a possible electric shock hazard for persons that may be in contact with the gas piping and other grounded metallic building components. A stock

7.12.2 * CSST. CSST gas piping systems and gas piping systems containing one or more segments of CSST, shall be electrically continuous and bonded to the electrical service grounding electrode system or where provided, lightning protection grounding electrode system.

7.12.2.1 The bonding jumper shall connect to a metallic pipe, pipe fitting, or CSST fitting.

7.12.2.2 The bonding jumper shall not be smaller than 6 AWG copper wire or equivalent.

7.12.2.3 The length of the jumper between the connection to the gas piping system and the grounding electrode system shall not exceed 75 ft (22 m). Any additional grounding electrodes installed to meet this requirement shall be bonded to the electrical service grounding electrode system or where provided, lightning protection grounding electrode system.

7.12.2.4 Bonding connections shall be in accordance with NFPA 70, *National Electrical Code®*.

7.12.2.5 Devices used for the bonding connection shall be listed for the application in accordance with UL 467, *Grounding and Bonding Equipment*.

7.12.3 Arc Resistant Jacketed CSST. CSST listed with an arc resistant jacket or coating system in accordance with ANSI LC 1/CSA 6.26, *Fuel Gas Piping Systems Using Corrugated Stainless*

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Another One of My Favorites!

- Eaton
  - https://www.youtube.com/watch?v=JGf-bhHEt9Y&list=PL8XobqCtN9Z9zmxXF91EJpX2k8FjdRIEb&index=11
- Equipment Bonding: https://www.mikeholt.com/tv-nec.php
- What is the sphere of influence?
  - What is the Sphere of Influence? – YouTube
- What is a grounding electrode?
  - What is a Grounding Electrode? – YouTube
- What is a fault current path?
  - https://www.youtube.com/watch?v=V9Gf55DxSao&t=22s

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Chapter 3: Wiring Methods and Material

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THE REORGANIZATION OF NEC ARTICLE 310

CODES AND STANDARDS JULY/AUGUST 2021 KEITH LOFLAND

Article 310 Conductors for General Wiring

Article 310 was extensively reorganized for the 2020 *NEC* for clarity and to increase the usability of this article

From www.IAEI.org

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Chapter 3 Wiring Methods and Material

- Common structure for most raceway articles
- 109 pages long (12% of entire NEC!)
- General requirements
- Cover requirements Table 300.5 (less than 1000V), Table 300.50
- 310.4 Conductor Insulation
    - https://www.youtube.com/watch?v=0jlXmj-LdNQ

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Conductor Insulation Identification

Letter	Description
No H	60 degree C insulation rating
H	75 degree C insulation rating
HH	90 degree C insulation rating permitted in dry locations
-2	90 degree C insulation rating permitted in wet locations
N	Nylon outer cover
T	Thermoplastic Insulation
R	Rubber Insulation
X	Cross-linked polyethylene insulation
U	Underground
W	Permitted in Wet or Damp locations

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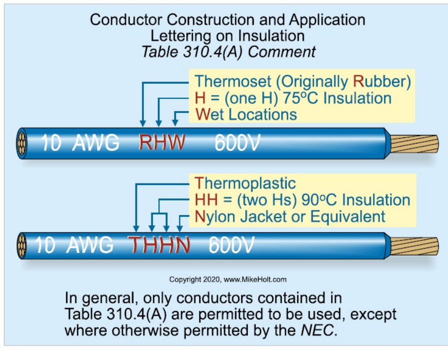

Figure 6–1

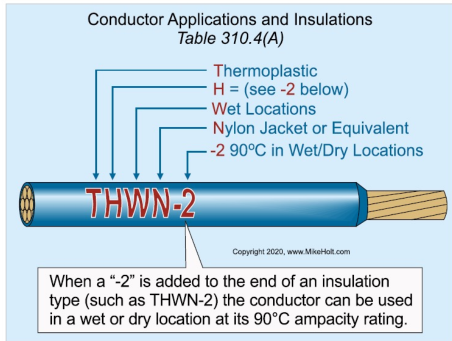

Figure 6–3

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Article 310: Conductors for General Wiring

- 12 tables (not all are listed below)
  - Table 310.4(A) Conductor Applications and Insulation Rated 600 Volts
  - Table 310.12 Single-Phase Dwelling Services and Feeders
  - Table 310.15(B)(1) & (B)(2) Ambient Temperature Correction Factors
  - Table 310.15(C)(1) Adjustment Factors for More than 3 Current-Carrying Conductors
  - Table 310.16 Ampacity of Insulated Conductors with not More Than Three Current-Carrying Conductors in Raceway, Cable or Earth (Directly Buried)
  - Table 310.17 Ampacities of Single-Insulated Conductors in Free Air

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Article 311: Medium Voltage Conductors and Cable

- New section
- Scope: Medium Voltage Cables (MV): 2001 V up to 35,000V nominal
- Multiple tables

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Chapter 3 Wiring Methods and Material

- Article 300: General Requirements for Wiring Methods and Materials
- Article 310: Conductors for General Wiring
- Article 311: Medium Voltage Conductors and Cable
- Article 312: Cabinets, Cutout Boxes and Meter Socket Enclosures
- Article 314: Outlet, Device, Pull and Junction Boxes; Conduit Bodies; Fittings; and Handhole Enclosures

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Chapter 3 Wiring Methods and Material

- Article 320: Armored Cable: Type AC
- Article 322: Flat Cable Assemblies: Type FC
- Article 324: Flat Conductor Cable: Type FCC
- Article 326: Integrated Gas Spacer Cable: Type ICS
- Article 330: Metal-Clad: Type MC
- Article 332: Mineral-Insulated, Metal-Sheathed Cable: Type MI
- Article 334: Nonmetallic-Sheathed Cable: Types NM and NMC
- Article 336: Power and Control Tray Cable: Type TC

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Chapter 3 Wiring Methods and Material

- Article 337: Type P Cable
- Article 338: Service-Entrance Cable: Types SE and USE
- Article 340: Underground Feeder and Branch-Circuit Cable: Type UF
- Article 342: Intermediate Metal Conduit: Type IMC
- Article 344: Rigid Metal Conduit: Type RMC
- Article 348: Flexible Metal Conduit: Type FMC
- Article 350: Liquidtight Flexible Metal Conduit: Type LFMC
- Article 352: Rigid Polyvinyl Chloride Conduit: Type PVC

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Chapter 3 Wiring Methods and Material

- Article 353: High Density Polyethylene Conduit: Type HDPE Conduit
- Article 354: Nonmetallic Underground Conduit with Conductors: Type NUCC
- Article 355: Reinforced Thermosetting Resin Conduit: Type RTRC aka Fiberglass
- Article 356: Liquidtight Flexible Nonmetallic Conduit: Type LFNC
- Article 358: Electrical Metallic Tubing: Type EMT
- Article 360: Flexible Metallic Tubing: Type FMT

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Chapter 3 Wiring Methods and Material

- Article 362: Electrical Nonmetallic Tubing: Type ENT
- Article 366: Auxiliary Gutters
- Article 368: Busways
- Article 370: Cablebus
- Article 372: Cellular Concrete Floor Raceways
- Article 374: Cellular Metal Floor Raceways
- Article 376: Metal Wireways
- Article 378: Nonmetallic Wireways

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Chapter 3 Wiring Methods and Material

- Article 380: Multioutlet Assembly
- Article 382: Nonmetallic Extensions
- Article 384: Strut-Type Channel Raceway
- Article 386: Surface Metal Raceways
- Article 388: Surface Nonmetallic Raceways
- Article 390: Underfloor Raceways
- Article 392: Cable Trays
- Article 393: Low-Voltage Suspended Ceiling Power Distribution Systems

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Chapter 3 Wiring Methods and Material

- Article 394: Concealed Knob-and-Tube Wiring
- Article 396: Messenger-Supported Wiring
- Article 398: Open Wiring on Insulator
- Article 399: Outdoor Overhead Conductors Over 1000 volts

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Chapter 4: Equipment for General Use

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Chapter 4: Equipment for General Use

- 110 pages (12% of NEC)
- Full Load Amps (FLA) vs Full Load Current (FLC)
  - Full Load Amps – Motor Nameplate
  - Full Load Current – Tables in this chapter
- Motors draw up to 6 to 8 times FLA when starting
- Presents challenges for overcurrent protective devices
  - Allow motor to start but not nuisance trip
- Basic 3-phase, AC, induction motor operating principle
  - https://www.youtube.com/watch?v=LtJoJBUSe28

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Chapter 4: Equipment for General Use

- Article 400: Flexible Cords and Flexible Cables
  - Table 400.4 Flexible Cords and Flexible Cables
- Article 402: Fixture Wires
  - Table 402.3 Fixture wires
- Article 404: Switches
- Article 406: Receptacles, Cord Connectors, and Attachment Plugs (Caps)
  - 406.12 Tamper Resistant Receptacles
  - https://www.mikeholt.com/tv-nec.php

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Tamper Resistant Receptacles	Reference
Dwelling units including	406.12(1)
Attached and detached garages and accessory buildings to dwelling units	406.12(1)
Common areas of multifamily dwellings	406.12(1)
Guest rooms and guest suites of hotels, motels, and their common area	406.12(2)
Child care facilities	406.12(3)
Preschools and Education facilities	406.12(4)
Business office, corridors, waiting rooms and the like in clinics, medical and dental offices, and outpatient facilities	406.12(5)
Subset of assemblies occupancies described in 518.2 to include places of awaiting transportation, gyms, skating rinks and auditoriums	406.12(6)
Dormitory Units	406.12(7)
Assisted Living Facilities	406.12(8)

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Chapter 4: Equipment for General Use

- Article 408: Switchboards, Switchgear and Panelboards
- Article 409: Industrial Control Panels
- Article 410: Luminaires, Lampholders and Lamps
- Article 411: Low Voltage Lighting
- Article 422: Appliances
  - 422.5 GFCI requirements

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Article 410, part XVI – Horticultural Lighting Equipment

- Type of Change: New
- 2020 NEC: new section added to for Horticultural Lighting Equipment
- Reason: due to the advent of special plant growth (legal marijuana for example) LED sources and discharge lamps, and the increase of indoor plant growing facilities, horticultural lighting equipment is a rapidly expanding technology.

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Horticultural Lighting
NFPA Journal, (May-June 2018)

Another issue the 2020 NEC may address is horticultural lighting. As marijuana legalization sweeps the country, marijuana grow facilities are becoming an electrical safety concern for many enforcers. (NFPA Journal covered the fire hazards of the cannabis industry in its September/October 2016 cover story, "Growing Pains.") There's nothing especially unique happening electrically, but it's an intense load. A 2016 article in The Guardian shed light on how energy intensive grow operations can be. In Boulder County, Colorado, for example, one 5,000-square-foot grow facility was found to be consuming about 29,000 kilowatt hours of electricity each month—by comparison, a nearby household in the county used less than 1,000 kilowatt hours, according to the article.

NFPA Marijuana growing:
https://www.youtube.com/watch?time_continue=2&v=yJFtXGJkw5s&feature=emb_logo

https://www.youtube.com/watch?v=aPN5I5kFqh4

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Chapter 4: Equipment for General Use

- Article 424: Fixed Electric Space-Heating Equipment
- Article 425: Fixed Resistance and Electrode Industrial Process Heating Equipment
- Article 426: Fixed Outdoor Electric Deicing and Snow Melting Equipment
- Article 427: Fixed Electric Heating Equipment for Pipelines and Vessels

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Chapter 4: Equipment for General Use

- Article 430: Motors, Motor Circuits, and Controllers
  - Table 430.7(B) Locked-Rotor Indicating Code Letters
  - Table 430.10(B) Minimum Wire-Bending Space at the Terminals of Enclosed Motor Controllers
  - Part II. Motor Circuit Conductors
  - Part III. Motor and Branch Circuit Overload Protection
  - Part IV. Motor Branch-Circuit Short-Circuit and Ground-Fault Protection
  - Part V. Motor Feeder Short-Circuit and Ground-Fault Protection
  - Part VI. Motor Control Circuits
  - Part VII. Motor Controllers
  - Part VIII. Motor Control Centers

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Chapter 4: Equipment for General Use

- Article 430: Motors, Motor Circuits, and Controllers
  - Part IX. Disconnecting Means
  - Part X. Adjustable-Speed Drives
  - Part XI. Over 1000 Volts, Nominal
  - Part XII. Protection of Live Parts – All Voltages
  - Part XIII. Grounding – All Voltages

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Article 430 Motors

- Motors present unique challenges
  - High starting (inrush current)
    - How to start motor without tripping circuit breaker
  - Motors are very expensive – protection motor is a priority in many cases
  - Adequately protecting motor feeder
  - Modes of protection
    - Short circuit
    - Overload
  - Multiple motors on a circuit

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Article 430 Motors

- Challenges (continued)
  - Safety: stopping, torque, speed control, guarding moving parts
  - Lots of energy: inductive
  - Produce heat
  - Vibration: impacts connections and cabling
  - Impacts power factor
  - What is a motor running backwards?

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Chapter 4: Equipment for General Use

- Article 430: Motors, Motor Circuits, and Controllers
  - Part XIV. Tables

Table 430.248 Full-Load Currents in Amperes, Single-Phase Alternating-Current Motors
The following values of full-load currents are for motors running at usual speeds and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120 and 220 to 240 volts.

Horsepower	115 Volts	200 Volts	208 Volts	230 Volts
1/6	4.4	2.5	2.4	2.2
1/4	5.8	3.3	3.2	2.9
1/3	7.2	4.1	4.0	3.6
1/2	9.8	5.6	5.4	4.9
3/4	13.8	7.9	7.6	6.9
1	16	9.2	8.8	8.0
1 1/2	20	11.5	11.0	10
2	24	13.8	13.2	12
3	34	19.6	18.7	17
5	56	32.2	30.8	28
7 1/2	80	46.0	44.0	40
10	100	57.5	55.0	50

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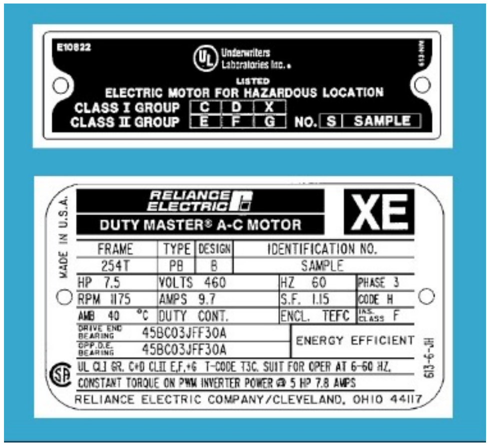
Motor Nameplate



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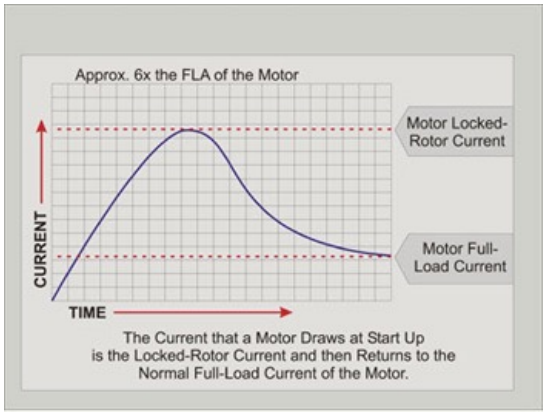
Typical Motor Starting Curve



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Adjustable Speed Drives (ASDs)

- NEC does not use Variable Frequency Drive (VFD)
- A VFD is a type of ASD
- Several types of ASDs
  - VFDs
  - Servo motors
  - Stepper motors
  - Electric Actuators etc.

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Article 440 Air-Conditioning and Refrigeration Equipment

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Article 445 Generators

- Generators present specific challenges
  - Source of energy
    - Can be a separately derived source
    - Grounding and bonding
- Safety:
  - Backfeed protection
  - Overload protection

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Transformers

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Article 450 Transformers and Transformer Vaults

- Transformers present unique challenges
  - Highly inductive
- Source of energy
- High inrush, similar to a motor
  - how to energize transformer without tripping
- Protecting the transformer
  - Primary-side protection
  - Secondary-side protection
  - Primary and secondary side protection
- Protecting the secondary conductors
- Produces Heat

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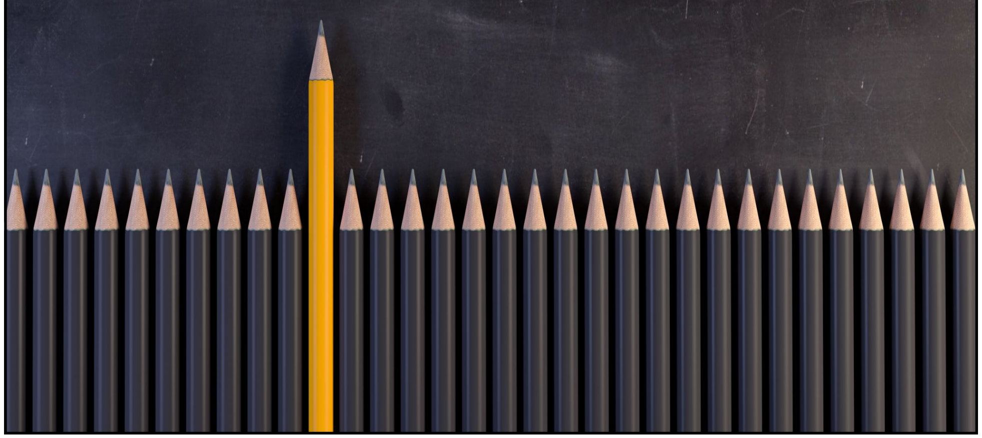
Chapter 5: Special Occupancies



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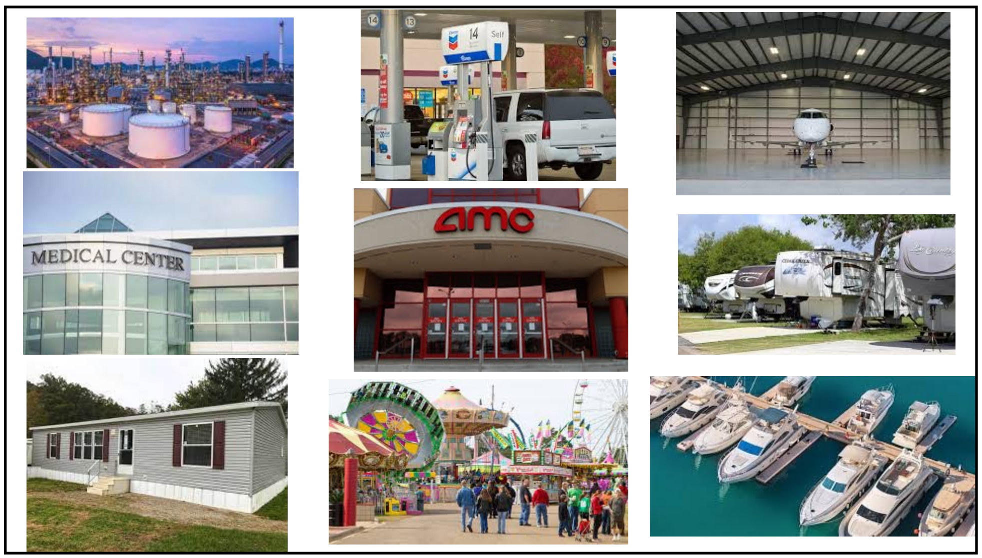

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Chapter 5: Special Occupancies

- Article 500: Hazardous (Classified) Locations, Classes I, II and III, Divisions 1 and 2
- Article 501: Class I Locations
- Article 502: Class II Locations
- Article 503: Class III Locations
- Article 504: Intrinsically Safe Systems
- Article 505: Zone 0, 1 and 2 Locations
- Article 506: Zone 20, 21, and 22 Locations for Combustible Dusts or Ignitible Fibers/Flyings

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Chapter 5: Special Occupancies

- Article 510: Hazardous (Classified) Locations – Specific
- Article 511: Commercial Garages, Repair and Storage
- Article 513: Aircraft Hangers
- Article 514: Motor Fuel Dispensing Facilities
- Article 515: Bulk Storage Plants
- Article 516: Spray Application, Dipping, Coating and Printing Processes Using Flammable or Combustible Materials

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Chapter 5 GFCI Requirements

Requirement	Article
Commercial Garages	511.12
Agricultural Buildings △	547.5(G)
Mobile Homes, Manufactured Homes, Mobile Homes △	550.13(B)

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Chapter 5: Special Occupancies

- Article 517: Health Care Facilities
- Article 518: Assembly Occupancies
- Article 520: Theaters, Audience Areas of Motion Picture and Television Studios, Performance Areas, and Similar Locations
- Article 522: Control Systems for Permanent Amusement Attractions
- Article 525: Carnivals, Circuses, Fairs and Similar Events
- Article 540: Motion Picture Projection Rooms

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Chapter 5: Special Occupancies

- Article 545 Manufactured Buildings and Relocatable Structures
- Article 547: Agricultural Buildings
- Article 550: Mobile Homes, Manufactured Homes and Mobile Home Parks
- Article 551: Recreational Vehicles and Recreational Vehicle Parks
- Article 552: Park Trailers
- Article 555: Marinas, Boatyards, Floating Buildings, and Commercial and Noncommercial Docking Facilities
- Article 590: Temporary Installations

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555.35 GFCI and GFPE Requirements for Marinas, Boatyards, Docking FacilitiesLo			
Location	Type	Protection (trip) Level	Reference
Shore power receptacles	GFPE	30 ma	555.35(A)
15A, 20A receptacles other than shore power	GFCI (Type A)	4 - 6 ma	555.35(B)
Main, feeder, and branch circuits installed on docking facilities*	GFPE	100 ma	555.35(C)

https://www.youtube.com/watch?v=bNNTlhKRe-g

* Exception: transformer secondaries of separately derived systems where secondary conductors exceed 10 ft installed in raceway

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Introduction to Hazardous Locations

- https://www.youtube.com/watch?v=DZRL1-ugfAQ

HUBBELL KILLARK®

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Chapter 6: Special Equipment

- Article 600: Electric Signs and Outline Lighting
- Article 604: Manufactured Wiring Systems
- Article 605: Office Furnishings
- Article 610: Cranes and Hoists
- Article 620: Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts

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Chapter 6: Special Equipment

- Article 625: Electric Vehicle Power Transfer System
- Article 626: Electrified Truck Parking Spaces
- Article 630: Electric Welders

- https://www.youtube.com/watch?v=lgbGs_B8Puc&feature=emb_logo

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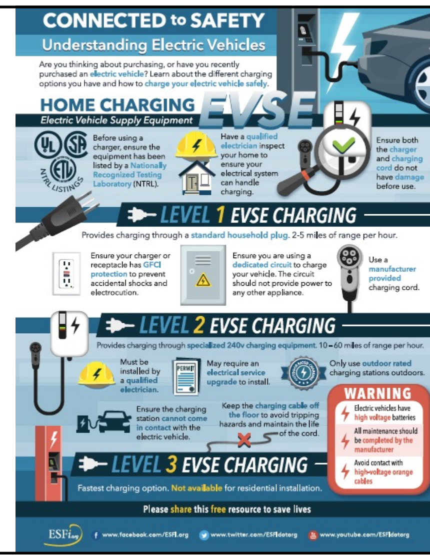

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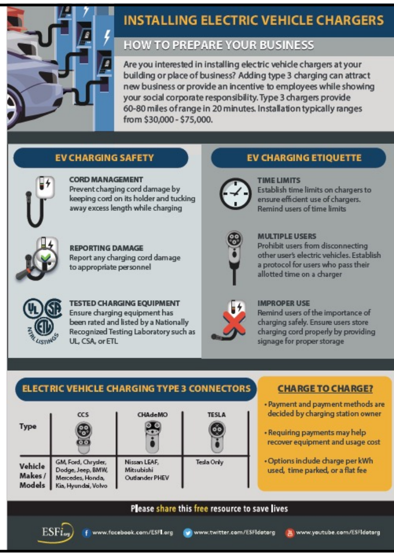

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Chapter 6: Special Equipment

- Article 640: Audio Signal Processing, Amplification, and Reproduction Equipment
- Article 645: Information Technology Equipment
- Article 646: Modular Data Centers
- Article 647: Sensitive Electronic Equipment

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Chapter 6: Special Equipment

- Article 650: Pipe Organs
- Article 660: X-Ray Equipment
- Article 665: Induction and Dielectric Heating Equipment
- Article 668: Electrolytic Cells
- Article 669: Electroplating
- Article 670: Industrial Machinery

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Chapter 6 GFCI Requirements

Requirement	Reference
Elevator Pits, Hoistways, Dumbwaiters etc. ⚠	620.6
Electric Vehicle Charging Equipment ⚠	625.54
Storable and Portable Immersion Pools	680.35
Permanently Installed Immersion Pools	680.45
Fountains including Splash Pads ⚠	680.50
Pool motors ⚠	680.21(C)
Pool pump motor replacements	680.21(D)
Pool equipment room	680.22(A)(5)
Permanently Installed Non-submersible pumps	680.59
Natural and Artificially Made Bodies of Water ⚠	682.15

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Chapter 6: Special Equipment

- Article 675: Electrically Driven or Controlled Irrigation Machines
- Article 680: Swimming Pools, Fountains, and Similar Installations
- Article 682: Natural and Artificially Made Bodies of Water
- Article 685: Integrated Electrical Systems
- Article 690: Solar Photovoltaic (PV) Systems
- Article 691: Large Scale Photovoltaic (PV) Electric Supply Stations

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Chapter 6: Special Equipment

- Article 685: Integrated Electrical Systems
- Article 690: Solar Photovoltaic (PV) Systems
- Article 691: Large Scale Photovoltaic (PV) Electric Supply Stations
- Article 692: Fuel Cell Systems
- Article 694: Wind Electric Systems
- Article 695: Fire Pumps

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Chapter 6

- 625.1 Electric Vehicle Power Transfer System
- Solar Photovoltaic Systems, Scope:
  - https://www.youtube.com/watch?v=gZT9y0Ougao

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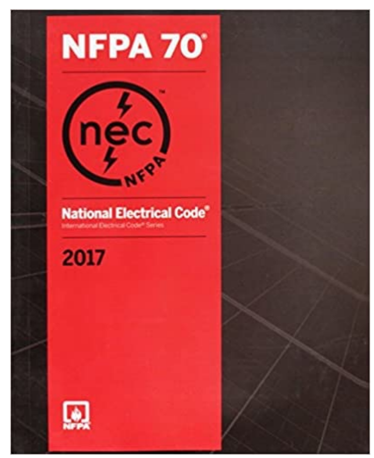
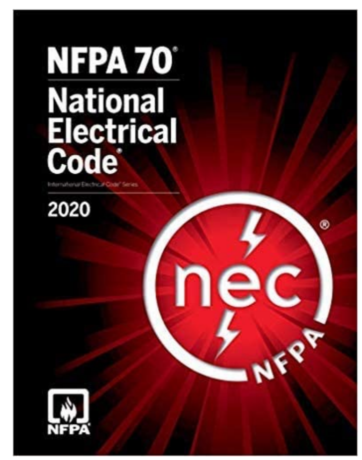
Future of the NEC?





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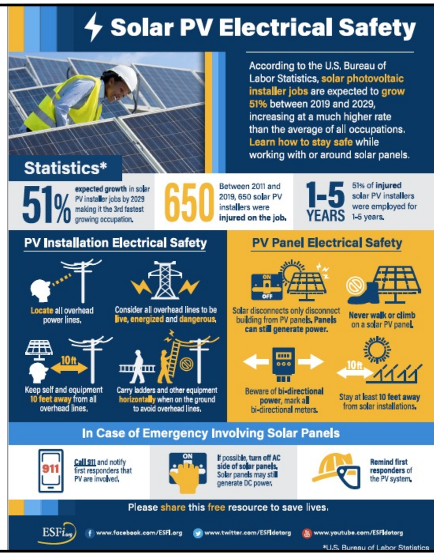

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Article 690: Solar Photovoltaic (PV) Systems

- Part I: General (definitions)
- Part II: Circuit Requirements
  - Maximum voltage: no greater than 1000V (690.7)
    - One and two-family dwelling units limited to 600V.
    - Limited to 1500VDC when not located on or in buildings
- Good reference:
  - Photovoltaic Array Performance Model (SAND 2004-3535)
  - Sandia National Laboratories

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Safety

- Can generate high levels of DC current
- Solar panels can generate power with low levels of light.
- AFCIs required for DC circuits over 80V (690.11) – note exception
- Rapid shutdown requirements for systems on buildings (690.12)
  - Goal – protect firefighters, note exception
- External disconnect requirements

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Chapter 7: Special Conditions

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Chapter 7

- 700.2 Emergency Systems Definition
  - [Emergency System, Classification [700.2] - YouTube]
- 725.1 Class 1, Class 2, Class 3 Remote-Control, Signaling and Power-Limited Circuits
  - https://www.youtube.com/watch?v=0jlXmj-LdNQ
- 706.1 Energy Storage Systems
  - https://www.youtube.com/watch?v=Wp5qkrV7tAY&feature=emb_logo&app=desktop

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Energy Storage Systems (ESS)

- The rapid development and deployment of energy storage systems present unique hazards to electricians and first responders.

https://www.nfpa.org/ess

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Chapter 7: Special Conditions

- Article 700: Emergency Systems
- Article 701: Legally Required Standby Systems
- Article 702: Optional Standby Systems
- Article 705: Interconnected Electric Power Production Sources
  - Works closely with Article 690: PV Systems
  - Lots of new stuff in this article for 2020!
  - Part II. Microgrids
- Article 706: Energy Storage Systems
  - Also works closely with PV systems

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Chapter 7: Special Conditions

- Article 708: Critical Operations Power Systems (COPS)
  - Determined by municipal, state, federal or other governmental agencies
  - Examples: power systems, HVAC, fire alarm, security, communications etc.
- Article 710: Stand Alone Systems
- Article 712: Direct Current Microgrids
- Article 720: Circuits and Equipment Operating at Less Than 50 Volts
- Article 725: Class 1, Class 2 and Class 3 Remote-Control, Signaling and Power-Limited Circuits
  - Different from minimum wire sizes, ampacity and adjustment and correction factors, overcurrent protection, insulation requirements and others from chapters 1 – 4.

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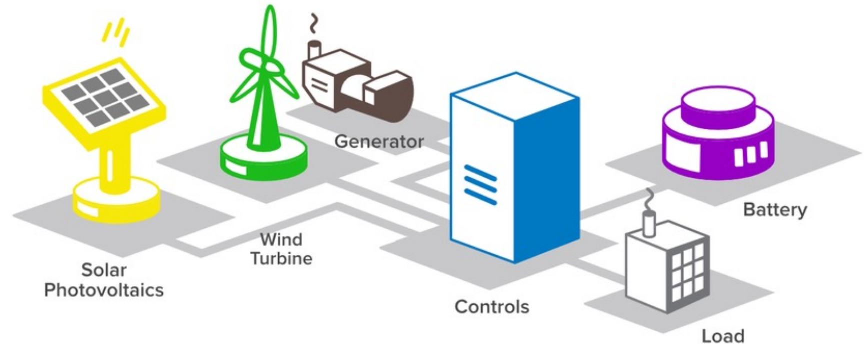

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Chapter 7: Special Conditions

- Article 727: Instrumentation Tray Cable: Type ITC
- Article 728: Fire-Resistive Cable Systems
- Article 750: Energy Management Systems
- Article 760: Fire Alarm Systems
- Article 770: Optical Fiber Cables

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Chapter 8: Communications Systems

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Chapter 8: Communications Systems

- Article 800: General Requirements for Communication Systems (NEW)
- Article 805: Communication Circuits
- Article 810: Radio and Television Equipment
- Article 820: Community Antenna Television and Radio Distribution Equipment
- Article 830: Network-Powered Broadband Communications Systems
- Article 840: Premises-Powered Broadband Communications System

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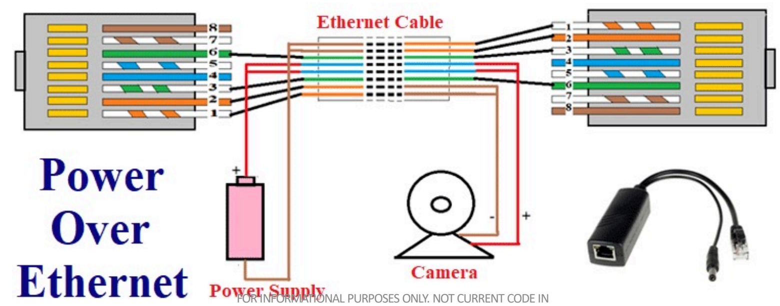
Power of Ethernet (PoE)

- https://www.youtube.com/watch?v=G7w0MSBV54Y



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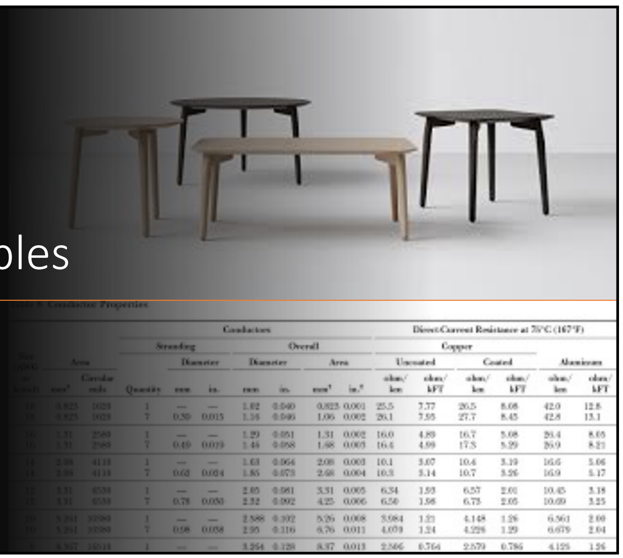
Chapter 9: Tables



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Chapter 9: Tables

- Table 1: Percent of Cross Section of Conduit and Tubing for Conductors and Cables
- Table 2: Radius of Conduit and Tubing Bends
- Table 4: Dimensions and Percent Area of Conduit and Tubing
- Table 5: Dimensions of Insulated Conductors and Fixture Wires
- Table 5A: Compact Copper and Aluminum Building Wire Nominal Dimensions and Areas
- Table 8: Conductor Properties
- Table 9: AC Resistance and Reactance for 600 Volt Cables, 3-PH, 60 Hz, 75 deg C – Three Single Conductors in Conduit

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Chapter 9: Tables

- Table 10: Conductor Stranding
- Table 11(A): Class 2 and Class 3 AC Power Source Limitations
- Table 11(B): Class 2 and Class 3 DC Power Source Limitations
- Table 12(A): PLFA AC Power Source Limitations
- Table 12(B): PLFA DC Power Source Limitations

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Informative Annexes

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Informative Annexes

- Annex D: Examples — Load calculations
- Annex E: Types of Construction
- Annex F: Availability and Reliability for Critical Operations Power of Functional Performance Tests (FPTs) for Critical Power Systems
- Annex G: Supervisory Control and Data Acquisitions (SCADA)
- Annex H: Administration and Enforcement
- Annex I: Recommended Tightening Torque Tables from UL Standard 486A-486B

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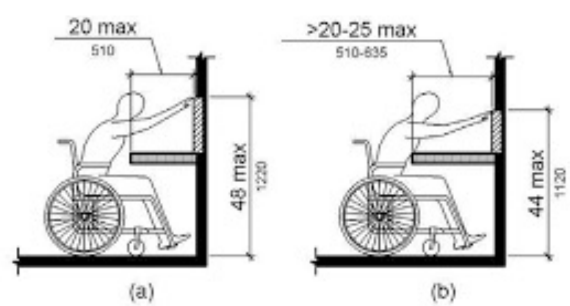
Annex J: ADA Standards for Accessible Design



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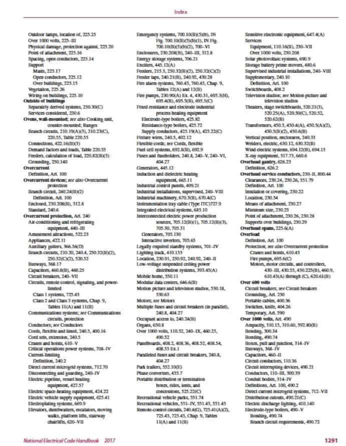

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CONGRATULATIONS!

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Next Steps

- A Certificate of Completion will be emailed to those who successfully completed course
- 4 hours of Code Class Hours will be reported to the OCILB for Code Continuing Education Credits
- Contact instructor at hpmatthews@matthewselectrical.net for any questions or comments
- Make sure you completely sign out of webinar after the next slide!

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File Attachments for Item:

ER-5 2020 NEC Review (International Association of Electrical Inspectors)

All certifications except plumbing and IU (30 hours in four 7.5-hour sessions)

Staff Notes: Add NRIUI, RIUI, recommend approval.

ESIAC Recommendation:

Committee Recommendation:

APPLICATION
FOR
Continuing Education Course Approval

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

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.

COURSE SUBMITTER:

Course Submitter: Lorenzo Adam
(Contact Name)
Organization: SW Division IAEI
(Organization/Company)
Address: 27 Penbrooke Ct
(Include Room Number, Suite, etc.)
City: Monroe State: Oh Zip: 45050
E-Mail: ladam@masonoh.org
Telephone: 513-435-2622 Fax:
Course Sponsor: SW Division IAEI

COURSE INFORMATION:

Course Title: 2020 NEC REVIEW ~~- Ch. 1 & 2~~

New Course Submittal: ☒ Update Course: ☐ Prior Approval Number:

Purpose and Objective: To provide Attendees with an overview and explanation of the subjects presented and to provide a level of uniformity among inspectors, contractors, professional designers and jurisdictions

Instructors: Various ESI's and IAEI Members

Number of Instructional Contact Hours that can be obtained upon completion: 30 ~~7.5 Hours~~

If Multi-Session, Number of Instructional Contact Hours Per Session: 4 sessions, 7.5 hours ea.

Program Applicable for the Following Participants:

Building Official ☒ Master Plans Examiner ☒ Building Inspector ☒ Fire Protection Inspector ☒ Mechanical Inspector ☒
Plumbing Plans Exam. ☐ Plumbing Inspector ☐
Electrical Plans Exam. ☒ Non-Res IU Inspector ☐
Mechanical Plans Exam. ☒

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

Electrical Safety Inspectors ☒
Location of ESI Course: Mason, Ohio Date(s) of ESI Course(s): September 10, 2022

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	
Course Sponsor:	Organization sponsoring or requesting the program (if any)	
Course Title:	Name of course (related to content)	
Purpose/Objective:	Describe purpose and how course will improve competency of certification(s) listed	
Contact Hours:	Indicate instructional time and credit requested in hours (e.g.: 0.5 hr, 1 hr, 3.5 hrs)	
Participants:	Check off each certification for which credit is requested (for which course relates to certification)	
Content of Program:	Include collated agenda, time schedule, course outline; list specific sections of code, references, and topics covered	
Course Materials:	Collated workbooks, handouts, hard copy or electronic versions of program is available	
Instructor(s) Info.:	Resume of professional/educational qualifications & teaching/training experience/BBS certifications	
Test Materials:	Copy of quizzes or tests to be given	
Completed Application:		

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

2022 30-Hour Course
Sponsored by Southwest Division Ohio IAEI

Facility

The facility is conveniently located in Mason, about 1mile from I-71 and 3 miles from I-75. Classes are held at the **City of Mason, Community Room, 6000 Mason-Montgomery Rd., Mason, Ohio.** The room occupancy is good for 100 students comfortably with tables and chairs. There are provisions for audio-visual equipment (screen, microphone, and speakers). Restrooms are located nearby the room for females and males. Refreshments are served during the morning. Duration of the instruction is 7.5 hours. 7:30am – 4:00pm.

Course Materials

Every attendee is responsible for bringing an edition of the 2017 and 2020 NEC. The instructors will also have on hand the necessary references to answer questions about other codes or standards. Most of the presentations are on a slide-format (Power Point).

2020 NEC REVIEW

Agenda for September 10th, 2022

Instructors: Dewayne Jenkins, Gaylord Poe, Caty Robinson, Lorenzo Adam, Pete Baldauf.

7:00 – 7:30 am	Registration
7:30 – 9:30 am	NEC Review Chapters 1
9:30 – 9:40 am	Break
9:40 – 12:00 m	NEC Review Chapters 1
12:00 – 1:00 pm	Lunch Break
1:00 – 2:35 pm	NEC Review Chapters 2
2:35 – 2:45 pm	Break
2:45 – 4:00 pm	NEC Review Chapters 2

2020 NEC REVIEW

Course outline for September 10th, 2022

This first Saturday will cover **Changes in Chapters 1 and 2** of the 2020 NEC. The instruction will include the proper use and limitations for material and equipment used for electrical installations and the requirements for compliance with the NEC.

The instructor will also emphasize the importance of the changes and it affects future code proposals.

- Chapter 1. General
    - Articles 100 and 110
- Chapter 2. Wiring and Protection.
    - Articles 210 – 220 – 225 - 230

The presentation will be in Power Point format. Contractors and ESIs will benefit as well as Plans Examiners and Professional Designers by getting first-hand information on these changes. Both, the Ohio Building Code, and the Residential Code of Ohio, in chapters 27 and 33 respectively refers to **2017 NFPA 70** as the standard to comply with electrical installations.
Even though the State of Ohio has not adopted the 2020 NFPA 70 version, the purpose of this class is to update the attendees on the code changes and not on the enforcement.

2020 NEC REVIEW

Agenda for October 8th, 2022

Instructors: Dewayne Jenkins, Gaylord Poe, Caty Robinson, Lorenzo Adam, Pete Baldauf.

7:00 – 7:30 am	Registration
7:30 – 9:30 am	NEC Review Chapters 3
9:30 – 9:40 am	Break
9:40 – 12:00 m	NEC Review Chapters 3
12:00 – 1:00 pm	Lunch Break
1:00 – 2:35 pm	NEC Review Chapters 4
2:35 – 2:45 pm	Break
2:45 – 4:00 pm	NEC Review Chapters 4

2020 NEC REVIEW

Course outline for October 8th, 2022

This second Saturday will cover **Changes in Chapter 3 through 4** of the 2020 NEC. The instruction will include the proper use and limitations for material and equipment used for electrical installations and the requirements for compliance with the NEC.

The instructor will also emphasize the importance of the changes.

- Chapter 3. Wiring Methods and Materials.
  - Article 300
- Chapter 4. Equipment.
  - Articles 400 – 404 – 406 – 410 – 422 – 440 – 445 - 450

The presentation will be in Power Point format. Contractors and ESIs will benefit as well as Plans Examiners and Professional Designers by getting first-hand information on these changes. Both, the Ohio Building Code, and the Residential Code of Ohio, in chapters 27 and 33 respectively refers to **2017 NFPA 70** as the standard to comply with electrical installations.
Even though the State of Ohio has not adopted the 2020 NFPA 70 version, the purpose of this class is to update the attendees on the code changes and not on the enforcement.

2020 NEC REVIEW

Agenda for November 12th, 2022

Instructors: **Dewayne Jenkins, Gaylord Poe, Caty Robinson, Lorenzo Adam, Pete Baldauf.**

7:00 – 7:30 am	Registration
7:30 – 9:30 am	NEC Review Chapters 5
9:30 – 9:40 am	Break
9:40 – 12:00 m	NEC Review Chapters 5
12:00 – 1:00 pm	Lunch Break
1:00 – 2:35 pm	NEC Review Chapters 6
2:35 – 2:45 pm	Break
2:45 – 4:00 pm	NEC Review Chapters 6

2020 NEC REVIEW

Course outline for November 12th, 2022

This third Saturday will cover **Changes in Chapter 5 and 6** of the 2020 NEC. The instruction will include the proper use and limitations for material and equipment used for electrical installations and the requirements for compliance with the NEC.

The instructor will also emphasize the importance of the changes.

- Chapter 5. Special Occupancies.
  - Articles 500 – 511 – 514 – 517 – 525 - 590
- Chapter 6. Special Equipment.
  - Article 600 - 625

The presentation will be in Power Point format. Contractors and ESIs will benefit as well as Plans Examiners and Professional Designers by getting first-hand information on these changes. Both, the Ohio Building Code, and the Residential Code of Ohio, in chapters 27 and 33 respectively refers to **2017 NFPA 70** as the standard to comply with electrical installations.

Even though the State of Ohio has not adopted the 2020 NFPA 70 version, the purpose of this class is to update the attendees on the code changes and not on the enforcement.

2020 NEC REVIEW

Agenda for December 10th, 2022

Instructors: Dewayne Jenkins, Gaylord Poe, Caty Robinson, Lorenzo Adam, Pete Baldauf.

7:00 – 7:30 am	Registration
7:30 – 9:30 am	NEC Review Chapters 7
9:30 – 9:40 am	Break
9:40 – 12:00 m	NEC Review Chapters 7
12:00 – 1:00 pm	Lunch Break
1:00 – 2:35 pm	NEC Review Chapters 8
2:35 – 2:45 pm	Break
2:45 – 4:00 pm	NEC Review Chapters 8

2020 NEC REVIEW

Course outline for December 10th, 2022

This second session will cover **Changes in Chapter 7 through 8** of the 2020 NEC. The instruction will include the proper use and limitations for material and equipment used for electrical installations and the requirements for compliance with the NEC.

The instructor will also emphasize the importance of the changes.

- Chapter 7. Special Conditions.
  - Articles 700 – 701 – 702 – 725 – 760
- Chapter 8. Communications Systems.
  - Article 800

The presentation will be in Power Point format. Contractors and ESIs will benefit as well as Plans Examiners and Professional Designers by getting first-hand information on these changes. Both, the Ohio Building Code, and the Residential Code of Ohio, in chapters 27 and 33 respectively refers to **2017 NFPA 70** as the standard to comply with electrical installations.
Even though the State of Ohio has not adopted the 2020 NFPA 70 version, the purpose of this class is to update the attendees on the code changes and not on the enforcement.

INSTRUCTOR QUALIFICATIONS

Lorenzo M. Adam

Lorenzo started his electrical training in 1983. In 1988, he started his own electrical company. In 1996, he obtained the State Electrical Inspector certification. In 1997, he joined the City of Troy as a Building/Electrical Inspector. Currently, he works for the City of Mason. Lorenzo has an Electrical Plans Examiner, Residential Building Official, Building Inspector, Building Official interim certification from the State of Ohio. Lorenzo is currently the secretary/treasurer for the SW Division of IAEI, Ohio Chapter, secretary/treasurer for the Ohio Chapter IAEI and Treasurer and Past President of the Southwestern Ohio Building Officials Association (SWOBOA).

Address: 27 Penbrooke Ct., Monroe, Ohio 45050

Gaylord K. Poe

Gaylord Poe started his longstanding career in the electrical industry in 1969. He earned his Electrical Safety Inspector Certificate (#592) in 1978. He continued to work as an electrician until 1983 when he joined the IBI team as a commercial/industrial field inspector. He was promoted to Commercial Coordinator in 1986, to Assistant Chief Electrical Inspector in 1994, and to Chief Electrical Inspector and President in 2000. He earned his Ohio Electrical Plan Examiner and IAEI Electrical Inspector-Plan Review certificates in 2005. He is the only Ohio ESI certified by the IAEI as a Master Electrical Inspector (2009).
Gaylord is a member of the UL Electrical Council, the NFPA, the Cincinnati Business Development and Permit Center Advisory Committee, the Board of Trustees for the GCEA, the Electrical Trades Advisory Committee for Scarlet Oaks JVS, and is actively involved in course development and training classes for the continuing education programs of the IAEI, IEC, GCEA, and NECA. Gaylord has been involved with the IAEI since the early 1980's. He currently has become the Past-President of the IAEI SW Division, in which he served for 17 years combine.

Address: Suite 125-W, 250 West Court Street, Cincinnati, OH 45202

Caty Robinson

Caty Robinson began her electrical career working as an apprentice in the Dayton, Ohio area. As a member of IBEW Local 82 Caty served a full apprenticeship and worked in the field as a journeyman wireman for Kastle Electric. Caty's Ohio certification #2647 is for ESI (2004) and EPE (2013). Caty joined Inspection Bureau, Inc. (IBI) in 2008 as a commercial Electrical Safety Inspector. Caty currently serves as IBI's Commercial Coordinator and inspects in IBI's commercial territories and Kentucky. Caty is also a member of the IAEI Ohio Chapter SW Division

Address: Suite 125-W, 250 West Court Street, Cincinnati, OH 45202

Peter M. Baldauf

Peter has been in the electrical industry for over 15 years. He began his electrical career working through a trade school in Dayton, Ohio. After graduation, he enrolled in the Associated Builders and Contractors State certified electrical apprenticeship program. Peter attended the program for the full four years and upon completion of the program, he relocated to Tacoma, Washington. In Tacoma, he sat for a State administered test and received State of Washington certification as a journeyman electrician, which is required by the Division of Labor and Industry in that State to perform work as an electrician. Upon his return to the State of Ohio, Peter sat for and was issued a license by the State of Ohio to perform duties associated with the installation and servicing of fire alarm systems. He also applied and sat for the test to become a State Certified Electrical Safety Inspector. He was awarded this Certification in September of 1998. Peter began his career in public service with Montgomery County Building Regulations as an Electrical Inspector in August of 1999. He is currently employed with the City of Vandalia as an Electrical Inspector. Peter also instructs classes for the Master Electrical Contractors Association, Adequate Wiring Committee, and International Association of Electrical Inspectors. He also has certification through the City of Dayton Board of Education as an Adult Education Instructor.

Address: 3600 Shroyer Road, Kettering, OH 45429

Daniel Dewayne Jenkins

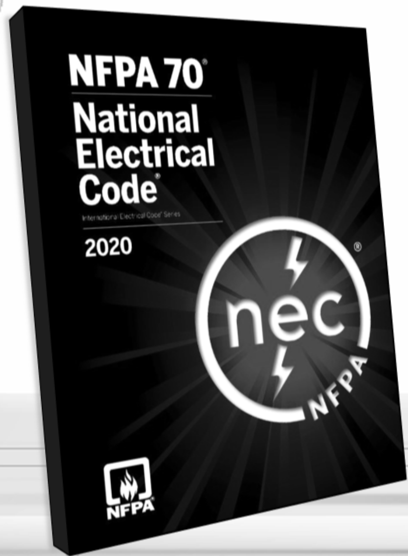
Dewayne started his career in the electrical field in 1982 in Dayton, Ohio and several years of experience in the electrical industry both as a contractor and inspector. He served 4 years in an electrical apprenticeship program and has over 8 years in the field as a journeyman electrician and he has 4 years, to his credit, as an electrical estimator and project manager.

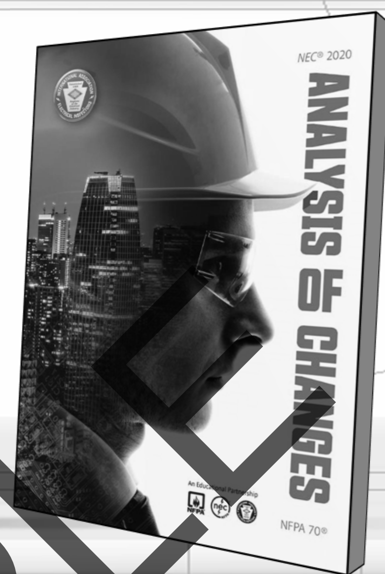
Dewayne has been a licensed electrical contractor and a certified electrical safety inspector since 1996. He also holds Ohio certifications as building inspector (1998), electrical plans examiner (2006) and residential building official (2007) and chief building official (2008). He is currently employed by the City of Kettering in the position as an electrical plans examiner, electrical safety inspector and building inspector.

Dewayne is an adjunct lecturer II for Sinclair Community College in the electrical trades for several years. A technical presenter for the Ohio Board of Building Standards (OBBS), International Association of Electrical Inspectors (IAEI), Master Electrical Contractors Association (MECA), Adequate Wiring Committee (AWC) & Greater Cincinnati Electrical Association (GCEA). He has served as President for the Ohio Chapter IAEI (2010). Dewayne has also served as President of the Miami Valley Building Officials Council (2002 & 2003). He currently is the President of the Southwest Division, IAEI and serves on the Electrical Safety Inspector Advisory Committee for the Ohio Board of Building Standards.

Address: 3600 Shroyer Road, Kettering, OH 45429

Analysis of Changes – 2020 *NEC*





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New Articles for the 2020 *NEC*

Article 242 Overvoltage Protection (CMP-10) This article provides the general requirements, installation requirements, and connection requirements for overvoltage protection and overvoltage protective devices. Part II covers surge-protective devices (SPDs) permanently installed on premises wiring systems of not more than 1000 volts, nominal, while Part III covers surge arresters permanently installed on premises wiring systems over 1000 volts, nominal.	**Article 311 Medium Voltage Conductors and Cable (CMP-6)** This article covers the use, installation, construction specifications, and ampacities for Type MV medium voltage conductors and cable. Type MV conductor and cable requirements that were previously found in Articles 310 (Conductors or General Use) and 328 (Medium Voltage Cable) were consolidated into one article.
Article 337 Type P Cable (CMP-6) This article covers the use, installation, and construction specifications for up through 2000 volt Type P cable (armored and unarmored). Type P cable is a factory assembly of one or more insulated flexible tinned copper conductors, with associated equipment grounding conductor(s), with or without a braided metallic armor and with an overall nonmetallic jacket.	**Article 800 General Requirements for Communications Systems (CMP-16)** This article covers general requirements for communications systems. These general requirements apply to communications circuits, community antenna television and radio distribution systems, network-powered broadband communications systems, and premises-powered broadband communications systems, unless modified by Articles 805, 820, 830, and or 840. *[Previous Article 800 (Communication Circuits) is now Article 805]*

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Article 100 Part III Hazardous (Classified) Locations (CMP-14)

The hazardous (classified) location definitions will be moved to new Part III of Article 100 for added clarity and usability

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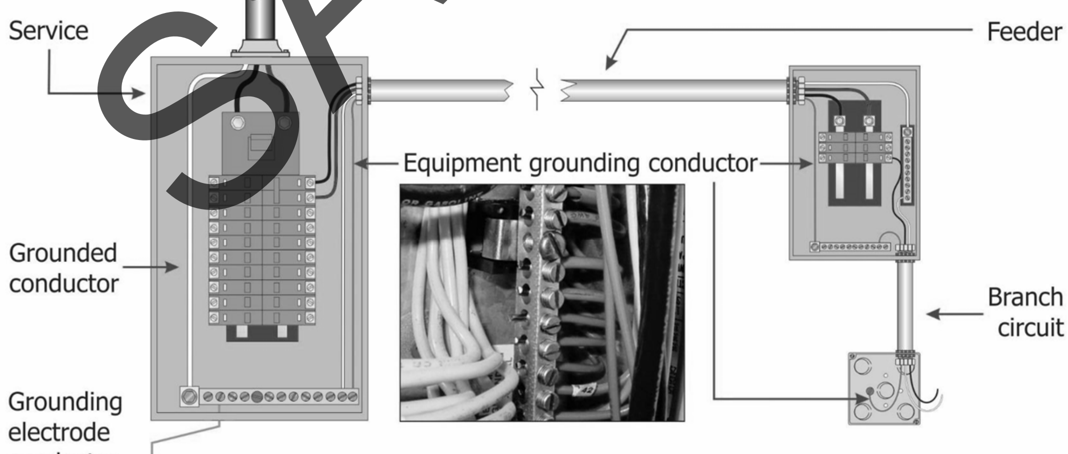
Article 100 Definitions: Grounded Conductor (I-Note)

Grounded Conductor. A system or circuit conductor that is intentionally grounded. (CMP-5)



Informational Note: Although an equipment grounding conductor is grounded, it is not considered a grounded conductor.

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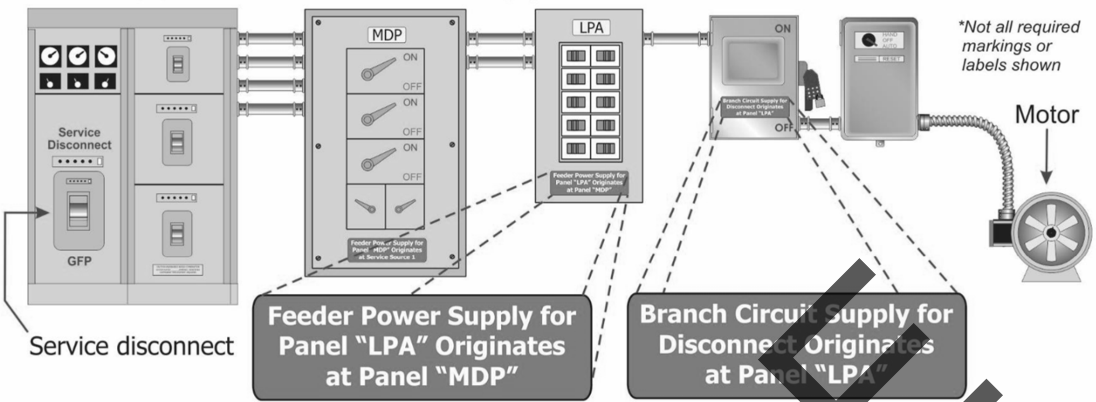
110.22(A) Identification of Disconnecting Means



Each disconnecting means shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident

In other than one- or two-family dwellings, the marking shall include the identification of the circuit source that supplies the disconnecting means

The marking shall be of sufficient durability to withstand the environment involved

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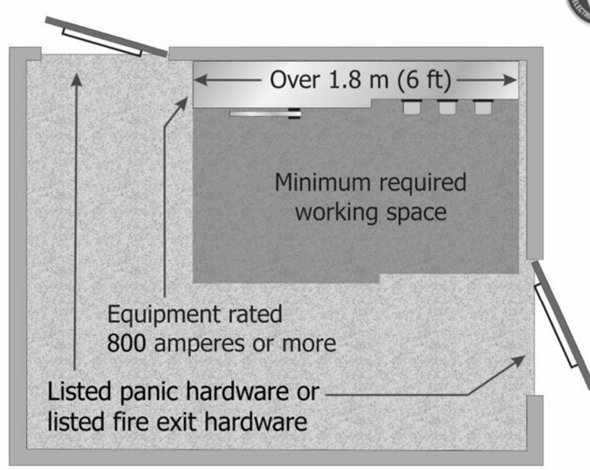
110.26(C)(3) Personnel Doors



Where equipment rated **800 amperes** or more that contains overcurrent devices, switching devices, or control devices is installed and there is a personnel door(s) intended for entrance to and egress from the working space less than 7.6 m (25 ft) from the nearest edge of the working space, the door(s) shall open in the direction of egress and be equipped with **listed panic hardware** or listed fire exit hardware.

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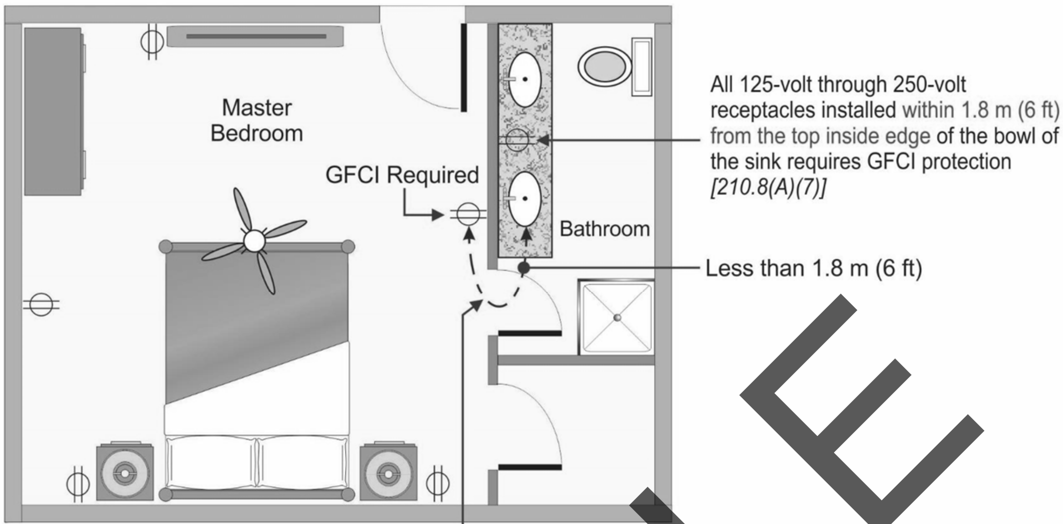
210.8 Measurements for GFCI Protection



When determining if GFCI protection for personnel is required and a measurement is involved, the distance from a receptacle is required to be measured as the shortest path the supply cord of an appliance connected to the receptacle would follow without piercing a floor, wall, ceiling, or fixed barrier, or the shortest path without passing through a ~~door, doorway,~~ ~~or~~ window *[210.8]*

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Table 220.12 General Lighting Loads by Non-Dwelling Occupancy *(Part 1)*

Type of Occupancy	Unit Load Volt-amperes/m²	Unit Load Volt-amperes/ft²
Automotive facility	16	1.5
Convention Center	15	1.4
Courthouse *(was Courtrooms)*	15 ~~22~~	1.4 ~~2.0~~
Dormitory	16	1.5
Exercise center	15	1.4
Fire station	14	1.3
Gymnasium[a] *(was Armories and auditoriums)*	18 ~~11~~	1.7 ~~1.0~~
Health care clinic *(was Hospitals)*	17 ~~22~~	1.6 ~~2.0~~
Hospital	17	1.6
Hotels and motels, including apartment houses without provisions for cooking by tenants[b]	18 ~~22~~	1.7 ~~2.0~~
Library	16	1.5
Manufacturing facility[c] *(was Industrial commercial (loft) bldg)*	24 ~~22~~	2.2 ~~2.0~~
Motion picture theater	17	1.6
Museum	17	1.6
Office[d] *(was Office buildings)*	14 ~~39~~	1.3 ~~3.5~~

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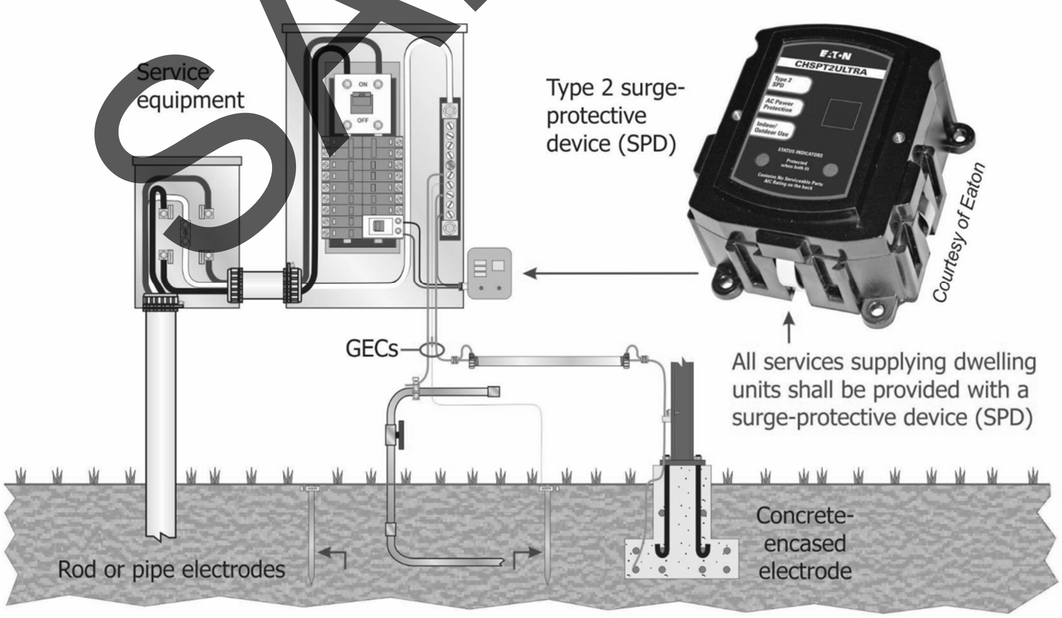
Table 220.12 General Lighting Loads by Non-Dwelling Occupancy *(Part 2)*

Type of Occupancy	Unit Load	
	Volt-amperes/m²	**Volt-amperes/ft²**
Parking garage[e] *[was Garages-commercial (storage)]*	3 ~~6~~	0.3 ~~0.5~~
Penitentiary	13	1.2
Performing arts theater	16	1.5
Police station	14	1.3
Post office	17	1.6
Religious facility *(was Churches)*	24 ~~11~~	2.2 ~~1.0~~
Restaurant[f] *(was Restaurants and Clubs)*	16 ~~22~~	1.5 ~~2.0~~
Retail[g, h] *(was Barber shops and beauty parlors and Stores)*	20 ~~33~~	1.9 ~~3.0~~
School/university *(was Schools)*	33	3.0
Sports arena	33	3.0
Town hall	15	1.4
Transportation	13	1.2
Warehouse	13 ~~3~~	1.2 ~~0.25~~
Workshop	18	1.7

114

230.67 Surge Protection for Dwelling Units

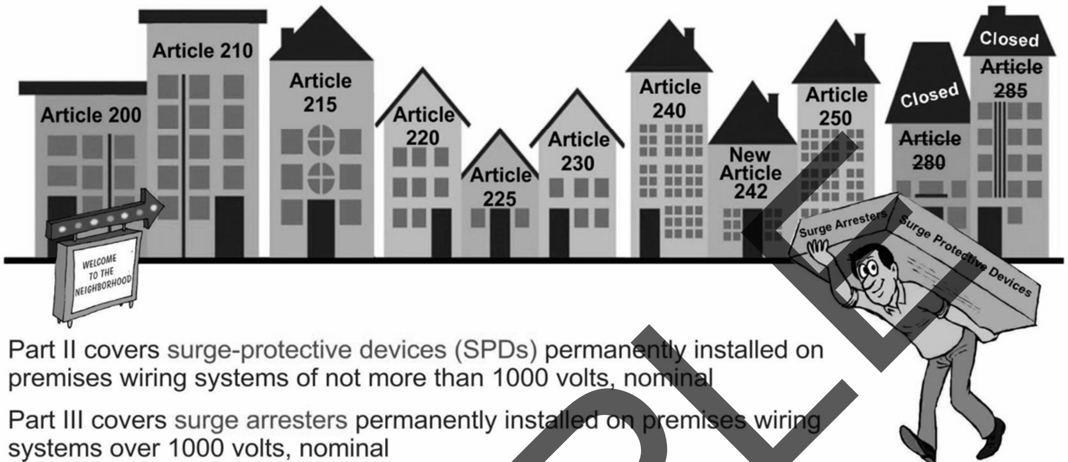


131

Article 242 Overvoltage Protection

New Article 242 added to provide the general, installation, and connection requirements for overvoltage protection and overvoltage protective devices

Relocates previous Articles 280 and 285 into a new Article 242

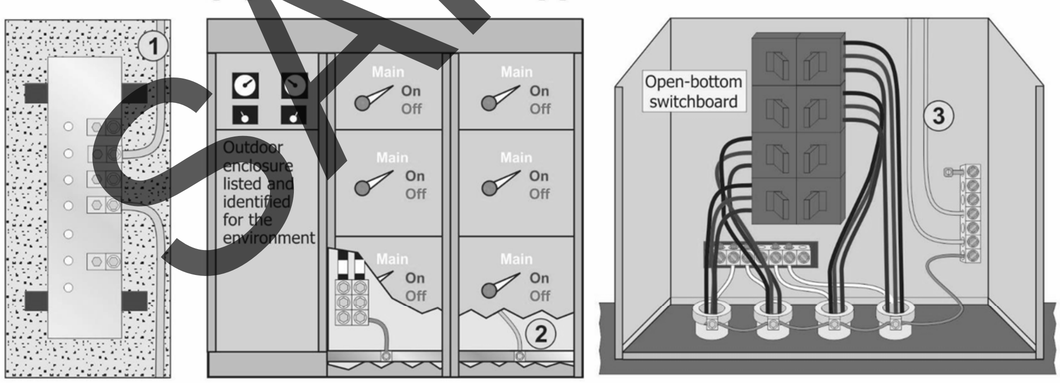


Part II covers surge-protective devices (SPDs) permanently installed on premises wiring systems of not more than 1000 volts, nominal

Part III covers surge arresters permanently installed on premises wiring systems over 1000 volts, nominal

147

250.64(A) Aluminum or Copper-Clad Aluminum GECs



Grounding electrode conductors (GEC) of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

1. Bare or covered GECs ***not permitted*** to be installed where subject to corrosive conditions or be installed in direct contact with concrete *(without an extruded polymeric covering)*
2. Terminations made within outdoor enclosures that are listed and identified for the environment are ***permitted*** within 450 mm (18 in.) of bottom of the enclosure
3. Aluminum or copper-clad aluminum GECs installed external to buildings or equipment enclosures ***not permitted*** to be terminated within 450 mm (18 in.) of the earth

152

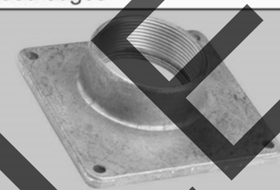
300.4(G) Protection Against Physical Damage - ~~Insulated~~ Fittings

Where raceways contain 4 AWG or larger insulated circuit conductors, and conductors enter a cabinet, a box, an enclosure, or a raceway, conductors shall be protected by any of the following:

(1) Identified fitting providing a smoothly rounded insulating surface

(2) A listed metal fitting that has smoothly rounded edges

(3) Separation from the fitting or raceway by using an identified insulating material that is securely fastened in place



(4) Threaded hubs or bosses (integral part of cabinet, box, enclosure, or raceway) with smoothly rounded or flared entry

178

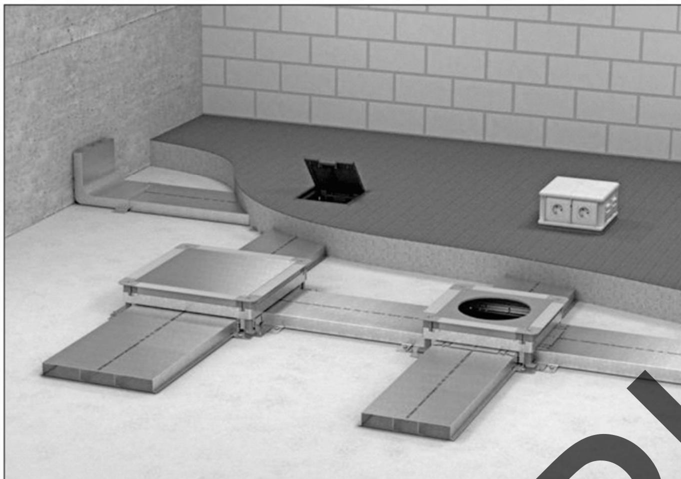
334.2 Nonmetallic-Sheathed Cable - Type NMS Deleted

All references to Type NMS cable has been deleted from Article 334 as this cable construction is no longer manufactured

228

374.6 Listing Requirements for Cellular Metal Floor Raceways

A new 374.6 was added to Article 374 requiring all cellular metal floor raceways to be listed



Cellular Metal Floor Raceway

248

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

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

Metal faceplates are required to be bonded to an equipment grounding conductor (EGC)

Listed kits or listed assemblies are not required to be connected to an EGC if (4) conditions are met, including if the device is provided with a nonmetallic faceplate and the device is designed such that no metallic faceplate replaces the one provided

Snap Switches

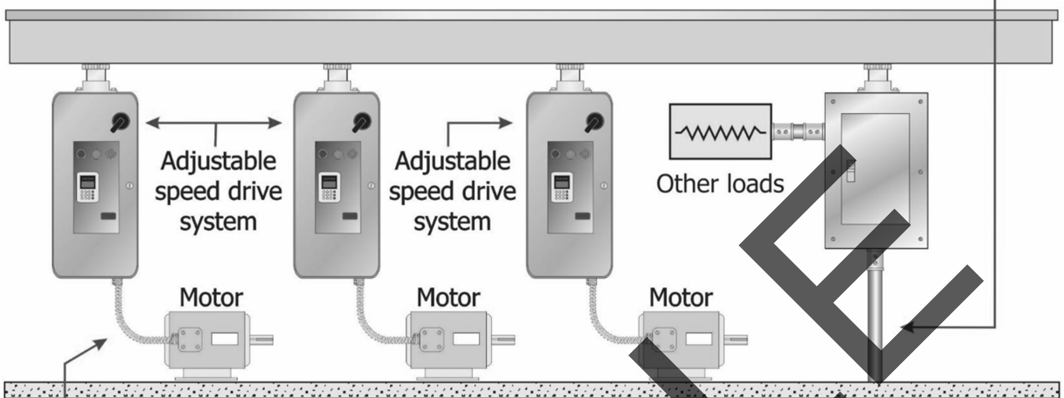
Dimmers

Control Switches

274

430.122(D) Several Motors or Motor(s) and Other Load(s)- Adjustable-Speed Drive Systems With Power Conversion Equipment

Conductors supplying several motors or motor(s) and other load(s), including power conversion equipment, required to have calculated ampacity in accordance with 430.24, using the rated input current of the power conversion equipment



Output conductors between power conversion equipment and the motor must have an ampacity equal to or larger than 125 percent of the motor full-load current (w/ exception) [430.122(B)]

355

445.18(D) Emergency Shutdown Device at Dwelling Units

Can be *(but not required to be)* this

An outdoor emergency generator shutdown device is required for generators installed at one- and two-family dwelling units *(other than cord-and-plug-connected generators)*

366

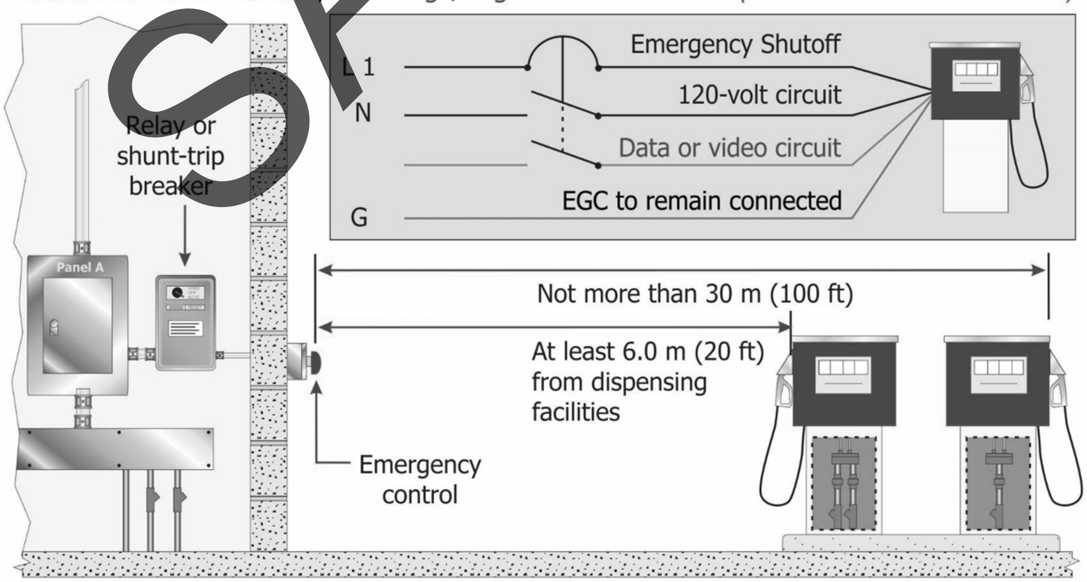
500.7(K) Combustible Gas Detection System

These requirements surrounding a combustible gas detection system as a protection technique were appropriately revised and expanded to provide more sufficient detail to install and operate a gas detection system

8

514.11(A) Emergency Controls for Fuel Dispensers

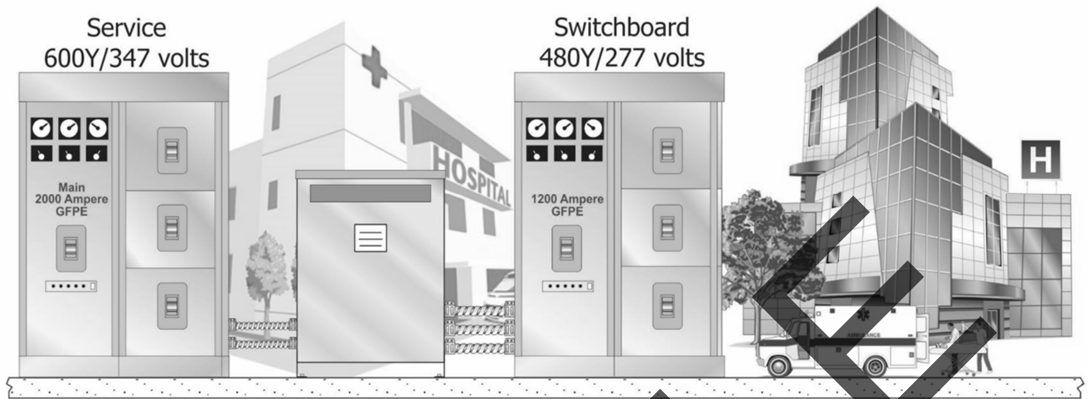
Emergency shutoff device shall disconnect simultaneously from the source of supply, all conductors of the circuits, including the grounded conductor *(EGCs to remain connected)*



26

517.17(D) Performance Testing of GFP Systems at Health Care Facilities

When ground-fault protection of equipment is first installed, each level required to be performance tested to ensure compliance with 517.17(C) *(selectively coordinated)*



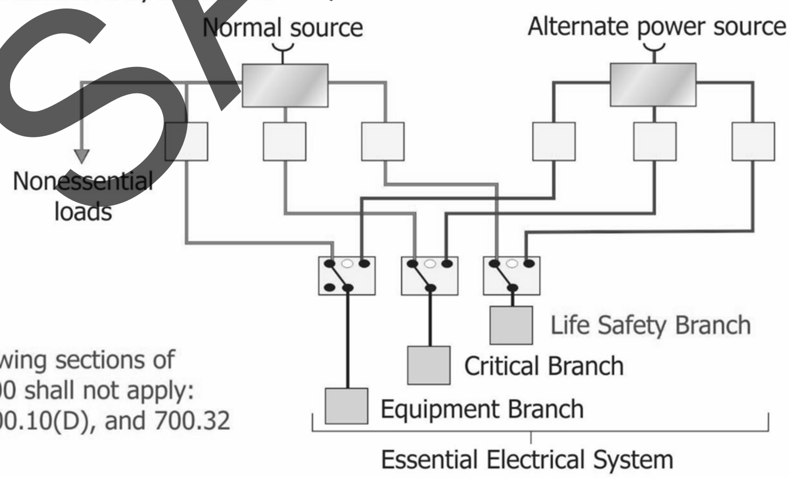
Testing to be conducted by a qualified person(s) using a test process in accordance with the instruction provided with the equipment

Written record of this testing to be kept and made available to the authority having jurisdiction

32

517.26 Application of Other Articles (Health Care Facilities)

Life safety branch of the essential electrical system shall meet the requirements of Article 700, except as amended by Article 517



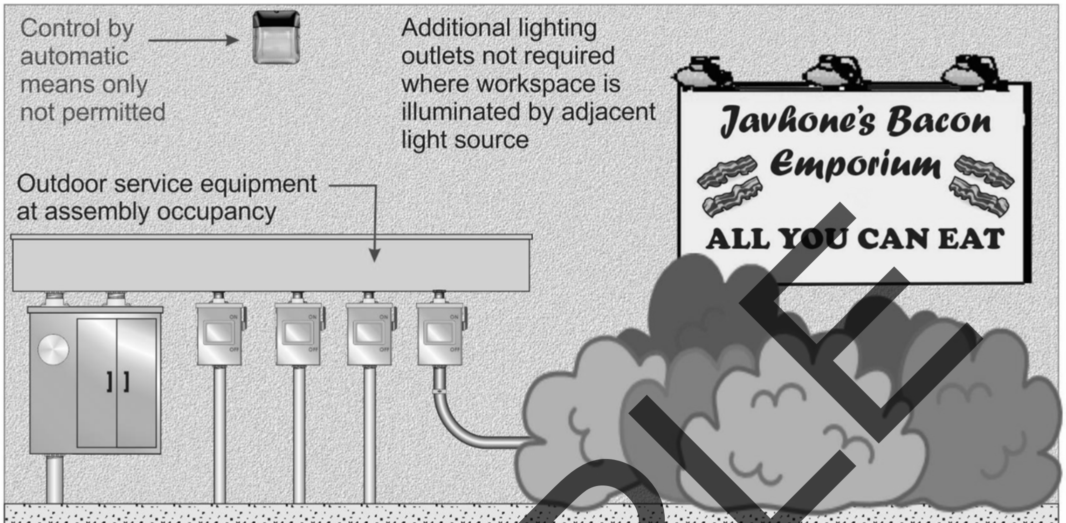
The following sections of Article 700 shall not apply: 700.4, 700.10(D), and 700.32

Branch circuits that supply emergency lighting shall be installed to provide service from a source complying with 700.12 when normal supply for lighting is interrupted or where single circuits supply luminaires containing secondary batteries (amended from 700.17)

35

518.6 Outdoor Illumination - Assembly Occupancies

Illumination required for working spaces about fixed service equipment, switchboards, switchgear, panelboards, or motor control centers installed outdoors that serve assembly occupancies



41

525.20(G) Protection of Flexible Cords or Cables

Flexible cords or cables accessible to the public shall be arranged to minimize tripping hazards

Flexible cords or cables permitted to be covered with nonconductive matting secured to the walkway surface *or* protected with another approved cable protection method

The matting or other protection method cannot constitute a greater tripping hazard than the uncovered cables

48

550.32(E) Supply Receptacles for Mobile or Manufactured Homes

Receptacles located outside mobile or manufactured homes required to be provided with GFCI protection as specified by 210.8(A)

Receptacles providing power to mobile or manufactured homes in accordance with 550.10, are not required to be provided with GFCI protection

62

555.35(B) Leakage Current Measurement Device at Marinas, Etc.

Where more than three receptacles supply shore power to boats, a leakage current measurement device shall be available and be used to determine leakage current from each boat that will utilize shore power

Photo courtesy of
Marina Electrical Equipment (MEE)

Leakage current measurement will provide the capability to determine when an individual boat has defective wiring or other problems contributing to hazardous voltage and current

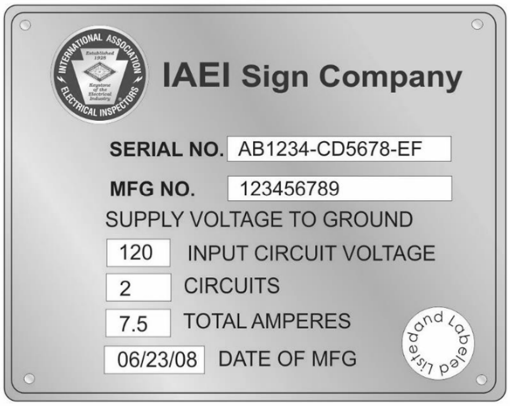
The use of a test device will allow the facility operator to identify a boat that is creating problems

The use of a test device will also help the facility operator prevent a particular boat from contributing to hazardous voltage and current in the marina area

77

600.4(D) Visibility of Markings - Electric Signs and Outline Lighting

Signs and outline lighting systems required to be marked with such things as manufacturer's name, trademark, input voltage and current rating, maximum allowable lamp wattage per lampholder, and other means of identification [600.4(A) and (C)]



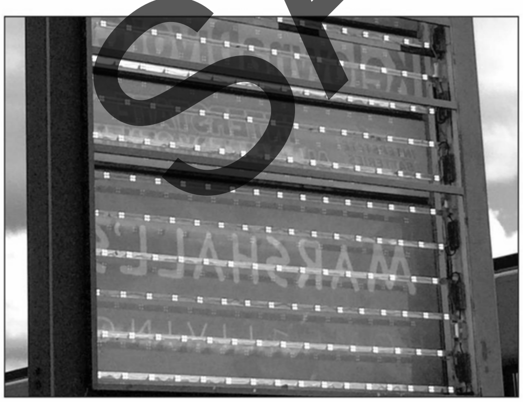
Markings and listing labels are required to be visible after installation and must be permanently applied in a location visible prior to servicing

Marking permitted to be installed in a location not viewed by the public

91

600.35 Retrofit Kits

New 600.35 gives specific installation instructions for retrofit kits for signs and outline lighting systems



General-use or sign-specific retrofit kits for sign or outline lighting systems to include installation instructions and requirements for field conversion of a host sign

Retrofit kits shall be listed and labeled

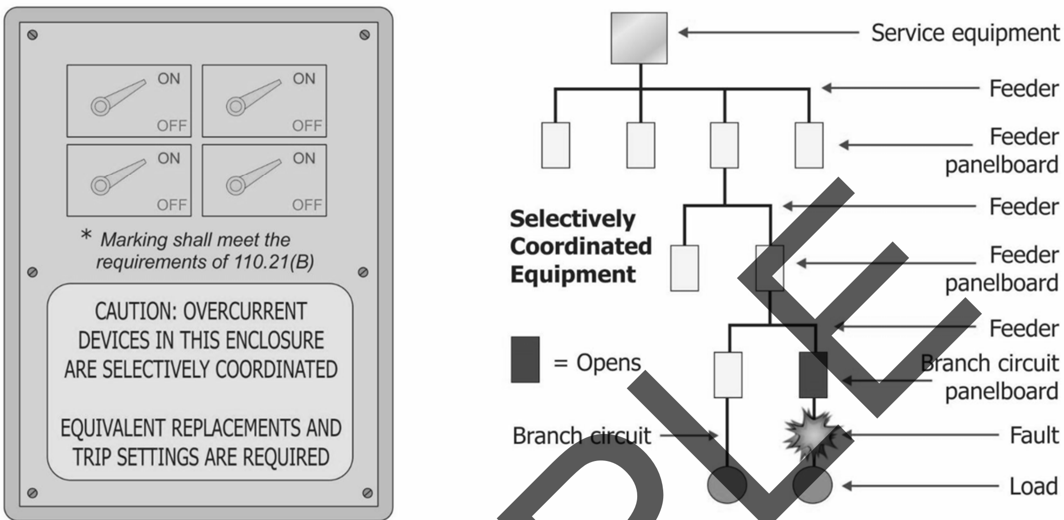
All parts that are not replaced by a retrofit kit shall be inspected for damage

99

620.65 Signage for Selective Coordination

(Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts)

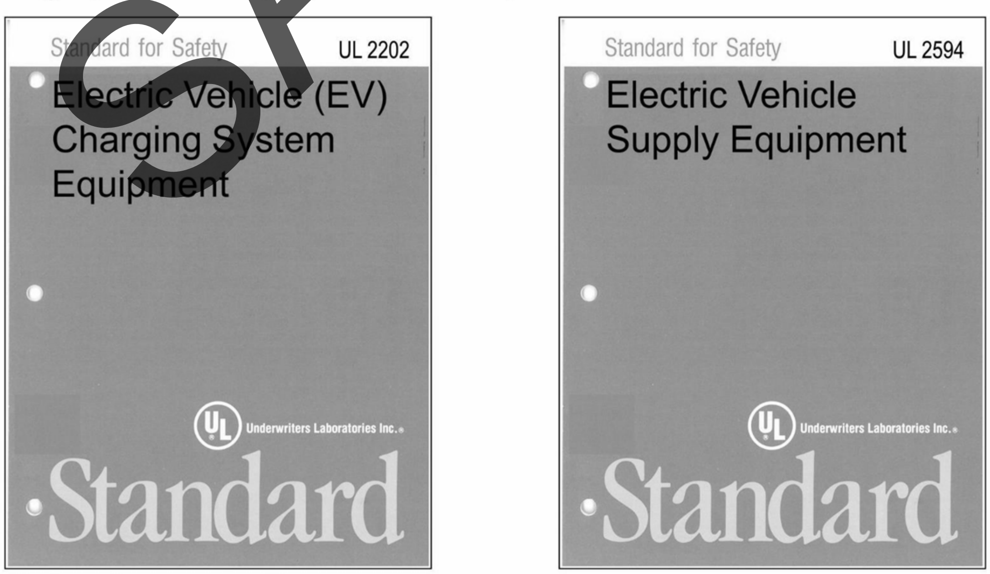
Equipment enclosures containing selectively coordinated overcurrent devices required to be legibly marked in the field to indicate that the overcurrent devices are selectively coordinated



106

Article 625 - Part II EV Equipment Construction

All product construction requirements in Part II of Article 625 addressing product features that are an integral part of the listing requirements for EV product were removed from Article 625



113

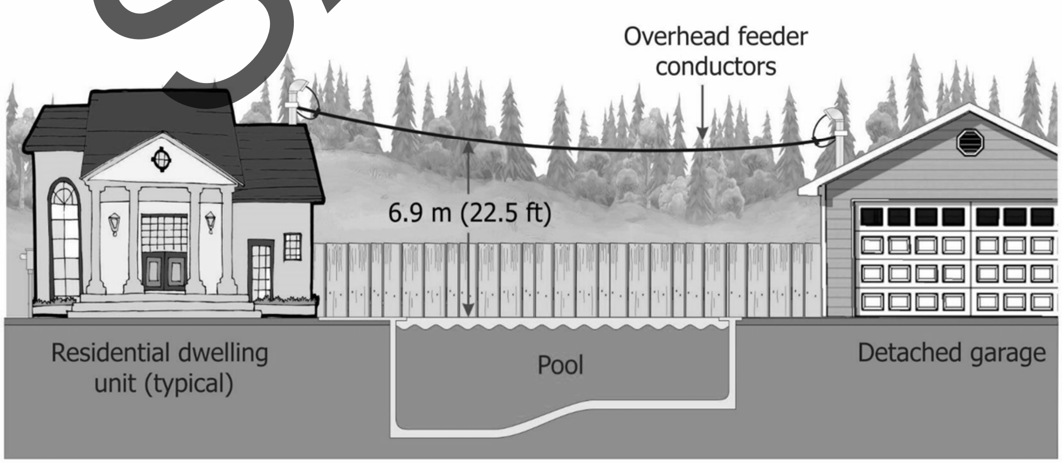
680.2 and 680.14 Corrosive Environments

Corrosive Environment. Areas where pool sanitation chemicals are stored, handled, or dispensed, and confined areas under decks adjacent to such areas, as well as areas with circulation pumps, automatic chlorinators, filters, open areas under decks adjacent to or abutting the pool structure, and similar locations.

131

680.9(A) Overhead Power Conductor Clearances

The minimum clearances for overhead power conductors *(not just service conductors)* from pools, fountains, etc. shall comply with the provisions in Table 680.9(A) for conductors operating at 0 to 750 volts to ground [6.9 m (22.5 ft)] *(typical)*

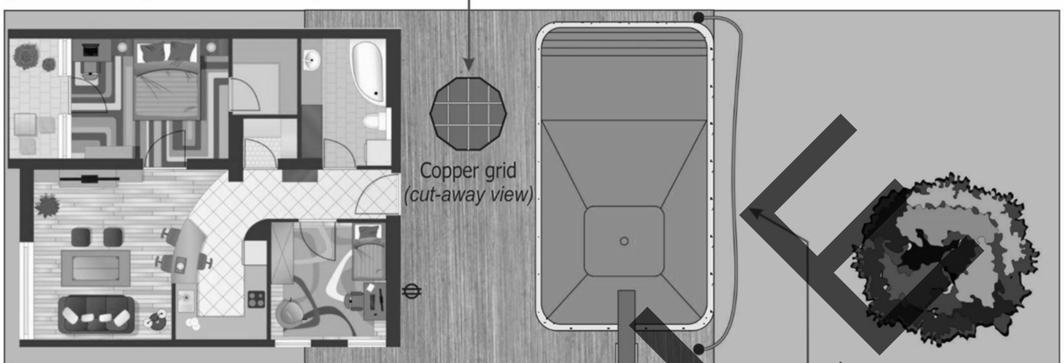


143

680.26(B)(2)(c) Copper Grid for Perimeter Surfaces

Where structural reinforcing steel is not available or encapsulated, an 8 AWG copper grid system is permitted to be utilized arranged in a 300-mm (12-in.) by 300-mm (12-in.) network of conductors in a uniformly spaced perpendicular grid pattern with a tolerance of 100 mm (4 in.)

Required to be secured within or under the deck or unpaved surfaces between 100 mm to 150 mm (4 in. to 6 in.) below the subgrade



A single 8 AWG solid copper conductor or structural reinforcing steel *(rebar or wire mesh)* in the concrete is also permitted as the bonding grid for the perimeter surface

160

690.4(B) PV Equipment Listing and Evaluation

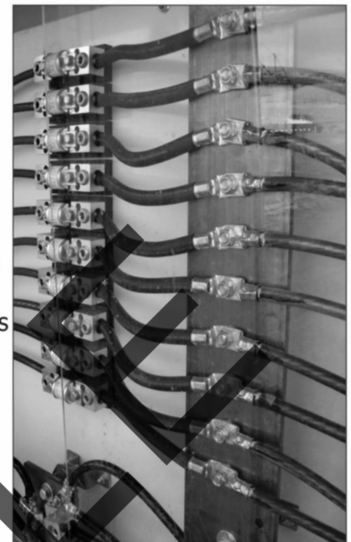
Equipment intended for use in PV systems required to be listed or be evaluated for the application and have a field label applied

178

690.31 Wiring Methods for Solar Photovoltaic (PV) Systems

690.31 was revised and re-organized for clarity and to bring PV wiring methods for PV source and output circuits to one location

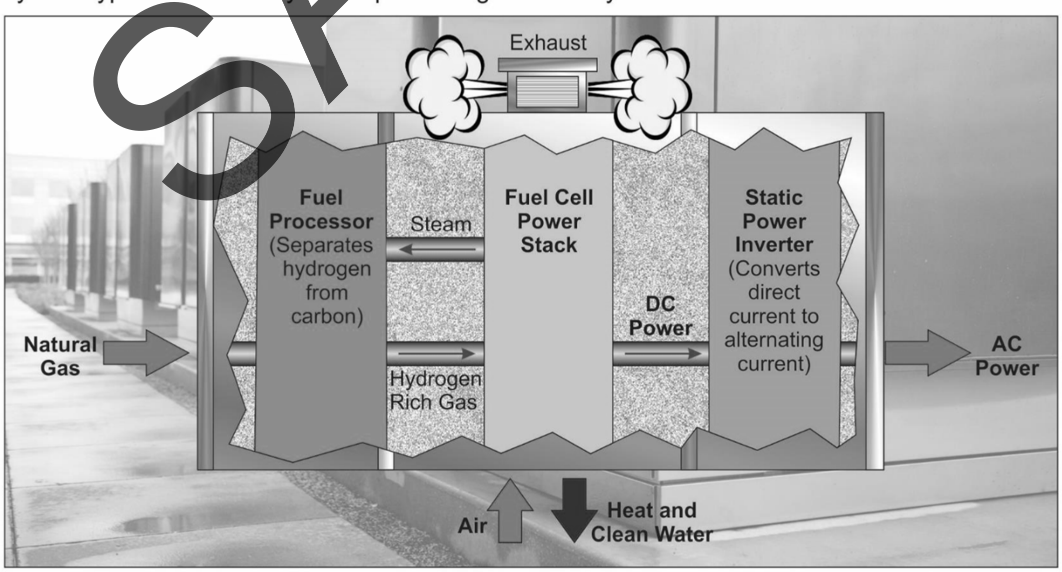
- (A) Wiring Systems
- (B) Identification and Grouping
  - (1) Identification
  - (2) Grouping
- (C) Cables
  - (1) Single-Conductor Cables
  - (2) Cable Tray
  - (3) Multiconductor Jacketed Cables
  - (4) Flexible Cords and Cables Connected to Tracking PV Arrays
  - (5) Flexible, Fine Stranded Cables
  - (6) Small-Conductor Cables
- (D) Direct-Cirrent on or in Buildings
  - (1) Flexible Wiring Methods
  - (2) Marking and labeling Required
- (E) Bipolar Photovoltaic Systems



203

692.4(B) Identification of Power Sources (Fuel Cell Systems)

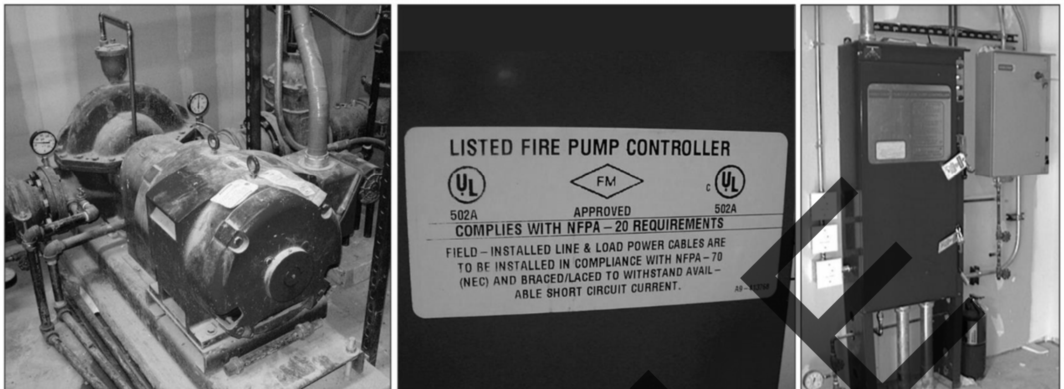
Three separate List Items where created to clearly identify the requirements for different fuel cell system types to add clarity to the placarding of these systems



223

695.3(C)(3) Selective Coordination (Fire Pumps)

Fire pumps in multibuilding campus-style complexes require all overcurrent protective device(s) to be selectively coordinated with all supply-side overcurrent protective device(s)

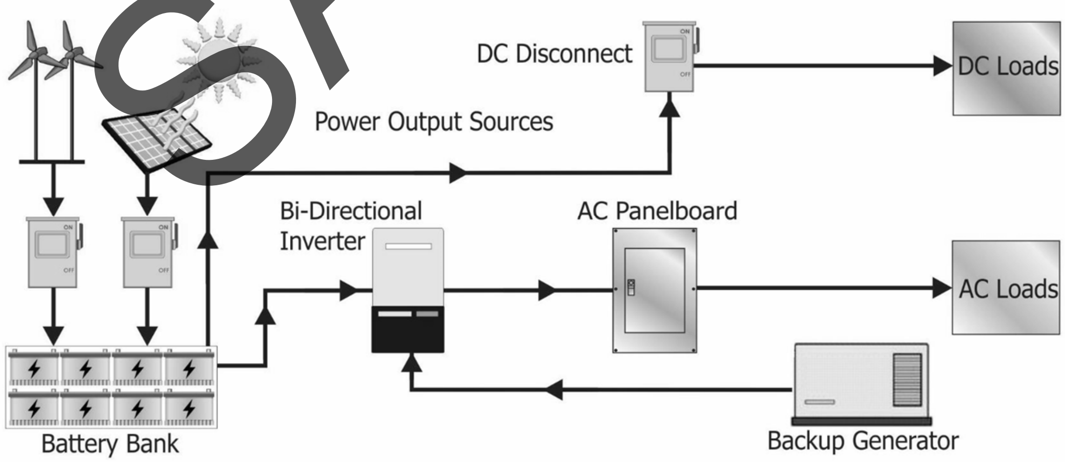


Selective coordination required to be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems

226

710.15 General Requirements for Stand-Alone Systems

New provisions added to 710.15 to recognize that stand-alone systems can deliver power to three-phase applications as well as single-phase systems

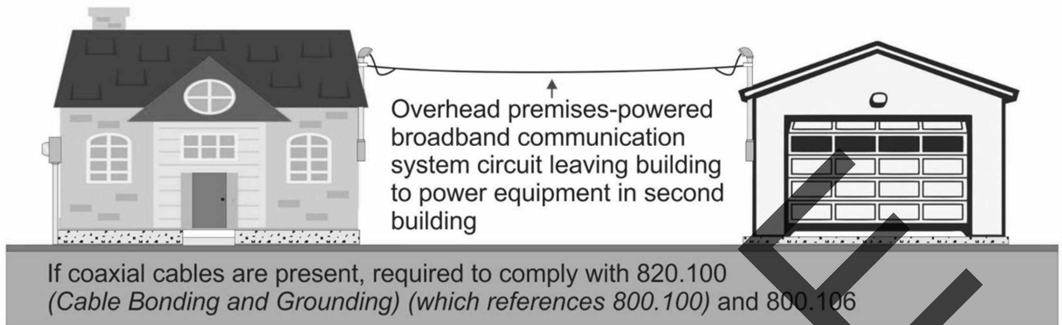


710.15(D): Three-phase Supply. Stand-alone and microgrid systems are permitted to supply three-phase, 3-wire or 4-wire systems

267

840.94 and 840.102 Premises Circuits Leaving the Building

840.94: Requires circuits leaving a building to power equipment remote to that building or outside the exterior zone of protection defined by a 46 m (150 ft) radius rolling sphere, to comply with 805.90 *(Protective Devices)* and 805.93 *(Grounding, Bonding, or Interruption of Non-Current-Carrying Metallic Sheath Members of Communications Cables)*



840.102: Requires communications wires and cables circuits leaving the building to power equipment remote to the building or outside the exterior zone of protection defined by a 46 m (150 ft) radius rolling sphere to comply with 800.100 *(Cable and Primary Protector Bonding and Grounding)* and 800.106 *(Primary Protector Grounding and Bonding at Mobile Homes)*

313

File Attachments for Item:

ER-6 Electrical Safety Webinar Based on 2020 NEC and NFPA 70E (Matthews Electrical Services)

BO, MPE, EPE, MechPE, ESI, BI, MI, RBO, RPE, RBI, RMI, RIUI (4 hours)

Staff Notes: Add NRIUI, recommend approval.

ESIAC Recommendation:

Committee Recommendation:

[redacted]

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: Henry Peter Matthews

Course Submitter: Henry Peter Matthews
(Contact Name)

Organization: Matthews Electrical Services
(Organization/Company)

Address: 1203 McKinley Place
(Include Room Number, Suite, etc.)

City: Fostoria State: Ohio Zip: 44830

E-Mail: hpmatthews@matthewselectrical.net

Telephone: 419-575-3488 Fax:

Course Sponsor:

COURSE INFORMATION:

Course Title: Electrical Safety Based on the NEC and NFPA 70E

New Course Submittal: ☒ Update Course: ☐ Prior Approval Number:

Purpose and Objective: The objective of this course is to cover some of the major electrical safety sections in the NEC including working space, clearances, labeling, listing, marking, GFCI requirements and others. This course will also cover the main points of NFPA 70E, its connection to the NEC, NFPA 70B and OSHA. It will also cover important concepts including establishing an electrically safe work condition, performing risk assessments and hazard analysis, interpreting arc flash warning labels, covering the roles of the qualified and unqualified persons, wearing the appropriate PPE and many other topics. This course will also discuss the main electrical hazards of shock and arc flash.

Number of Instructional Contact Hours that can be obtained upon completion: 4

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

Program Applicable for the Following Participants:

Building Official ☒
Master Plans Examiner ☒
Plumbing Plans Exam. ☐
Electrical Plans Exam. ☒
Mechanical 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: www.matthewselectricalservices.net Date(s) of ESI Course(s): September 10, 2022

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
Course Sponsor:	Organization sponsoring or requesting the program (if any)	
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:	Copy of quizzes or tests to be given	x
Completed Application:		x

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

RECEIVED
JUN 27 2022
BOARD OF BUILDING STANDARDS

NFPA 70E and the NEC

The National Electric Code aka NEC (NFPA 70) is intended to instruct us how to install electrical systems and equipment safely. It is a minimum standard and the goal is to protect people and equipment.

NFPA 70E Electrical Safety Standard in the Workplace works with the NEC and the main focus is to protect the people who install the electrical systems and equipment.

These very important standards work hand-in-hand, but there are some important distinctions that you must be aware of. There are also some concepts that may be confusing to some.

In this session, we will focus on NFPA 70E but highlight and discuss the areas where it interacts with the NEC. Select references from OSHA 1910 Subpart S (Industry Electrical), OSHA 1926 Subpart K (Construction Electrical) and 1926 Subpart V (Electric Power, Transmission and Distribution) will also be covered.

The scope of the NEC will be compared with the scope of the National Electric Safety Code (NESC - IEEE C2) to make the distinction between residential/commercial/industrial installations and utility company requirements.

Some of the topics that will be covered will be:

NEC

- Arc Flash Warning Label
- Marking Requirements
- Identification of Disconnecting Means
- Spaces about electrical equipment
    - working space
    - clear space
    - dedicated equipment space
- Guarding of live parts
- Guarding of equipment and working space
- Assured Equipment Grounding Conductor (OSHA requirement)

NFPA 70E

- Electrical Safety definitions
- Qualified vs. Unqualified: What does it mean? Who's qualified? Who's unqualified?
- The Arc Flash Label: The difference between the NEC version and the NFPA 70E version
    - Shock Boundaries: Restricted, Limited

    - Arc Flash Boundaries
    - Working distance
    - How incident energy is calculated.
    - The definition of cal/cm^2
    - How PPE (Personal Protective Equipment) levels are determined
    - How the arc flash and shock protection boundaries are established
- NFPA 70E tables vs calculations: Which one should I use? When?
- Normal Operations: What is this and how is it used?
- Establishing and Electrically Safe Working Condition
- How to mitigate arc flash severity
- Risk and Hazard assessment
- The role of communication
- When is an Electrical Energized Work Permit required? What are the exceptions?
- First Aid and Emergency response. Who is required to be trained? What level of training is required
- Record Keeping and documentation
- GFCIs and other protective devices
- Extension cord
- What is the Assured Equipment Grounding Conductor Program?
- When are two-people required to do work?
- How do I implement and Electrical Safety Program?
- PPE selection, use, testing and care requirements

At the end of this training, the attendee will have a better understanding of all electrical safety requirements in the NEC and NFPA 70E. The attendee will also understand the differences and similarities of related codes and standards.

Henry Peter Matthews, PE, CPE, CESCP, PVA

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539 South Main Street
Findlay, Ohio 45840
Email: hpmatthews@marathonpetroleum.com
Office phone: 419-421-3423
Cell phone: 419-957-2110

Work Experience

Marathon Petroleum Company, LP; Findlay, Ohio — June 2006 – Present
- Advanced Senior Engineer/Electrical Specialist
- Electrical Engineering Supervisor – Terminal Engineering
- Project Engineer – Major Projects
- Electrical Designer – Retail Division

Cooper Standard Automotive, Bowling Green, Ohio — July 1993 – June 2006
- Plant Engineering Manager
- Plant Electrical Engineer

Toledo Engineering Company (consultant); Toledo, Ohio — June 1989 – July 1993
- Electrical Drafter

Education

Bowling Green State University; Bowling Green, Ohio — Aug 2003
Masters of Business Administration

Pennsylvania State University; University Park, PA — Dec 1989
BS Electrical Engineering

Solar Energy International, Paonia, Colorado — Sept 2021
Solar PV Training

Owens Community College; Findlay, Ohio — April 2017
Certificate: Introductory Welding

Penn Foster Career School — July 2010
Certificate: Plumbing

Penn Foster Career School — October 2004
Certificate: Electrician

Certifications

Professional Engineer (PE): OH, MI, IN, KY, IL, WI
Photovoltaic Associate (PVA) by NABCEP
Certified Electrical Safety Compliance Professional (CESCP), NFPA
Certified Plant Engineer (CPE): Association for Facility Engineers
Building Operator Certification (BOC): Northwest Energy Efficiency Council

Licenses	**Ohio Electrical Contractor**, Ohio Department of Commerce, License # 46972 **Ohio Training Agency**, Ohio Construction Industry Licensing Board, Agency #48714 **Ohio Training Agency,** Ohio Board of Building Standards
Special Training	**Solar Energy International (SEI),** Paonia, Colorado • Solar Electric and Design and Installation Course, April 2021, 60 hours • PV Systems Fundamentals (Battery-Based), June 2021, 40 hours • Advanced PV System Design and the NEC, June-July 2021, 60 hours • Comparing Battery Technologies, July 2021, 10 hours • Tools and Techniques for Operations and Maintenance of PV Systems, 9/21, 40 HR
Affiliations	**Institute of Electrical and Electronics Engineers (IEEE) – Senior Member** **International Association of Electrical Inspectors (IAEI)** **NFPA Section Member** for Architects, Engineers and Building Officials **Illumination Engineering Society of North America (IESNA)** **API RP 545 former Co-Chair**, American Petroleum Institute, Lightning Protection for Above Ground Storage Tanks (2017- 2018)
Business Ownership	**Matthews Electrical Services, Owner** **Designer Cuts Hair Salon, LLC; Co-owner**

Biography

Henry has worked in the electrical, power, electronics, instrumentation, controls and communication fields for over 30 years. He earned his Bachelor of Science degree in Electrical Engineering from Penn State University in 1989. Henry worked as a consultant for Toledo Engineering Company in Toledo, Ohio as a drafter and field technician.

In 1993 he started working for Cooper Standard Automotive Company in Bowling Green, Ohio in 1993 as a Plant Electrical Engineer. He was then promoted to Plant Engineering Manager in 2000. During this time, he earned his Professional Engineering License in Ohio.

In 2003, Henry earned his MBA at Bowling Green State University.

In 2006, Henry joined Marathon Petroleum Company in Findlay, Ohio. He then went on to obtain his Professional Engineers license in Electrical Engineering for Michigan, Indiana, Illinois, West Virginia, Kentucky, Minnesota and Wisconsin. During his tenure at Marathon, Henry has had several roles including Electrical Design Engineer, Project Engineer and Electrical Supervisor. He is currently an Advanced Senior Engineer where he writes electrical standards for the company and conducts a community of practice for all the company's electrical engineers and safety professionals.

During his time at Cooper Standard Automotive and Marathon Petroleum, Henry developed a passion for teaching, learning and applying Electrical Construction Codes. At Cooper, he trained the entire non-electrical maintenance staff to perform basic electrical tasks.

At Marathon, Henry works with the Learning and Development Department to conduct multiple training sessions for new hires and seasoned engineers on various topics including Electrical Safety, Grounding and Bonding, Hazardous Area Location, Electrical Inspection, Motors, Lightning protection Static Electricity Mitigation, Reading and Understanding Electrical Diagrams, Programmable Logic Controllers and more.

Henry also works very closely with the Talent Acquisition Teams and visits numerous college campuses to deliver presentations on Engineering, Career Development, Networking and other topics.

Henry recently served as the Co-chair of the API Recommended Practice 545 Task Group for Lightning Mitigation for Above Ground Storage Tanks. In this role, he works with engineers, scientists and manufacturers from all over the world to evaluate the impacts of lightning and static electricity on metal above ground storage tanks.

His passion for teaching and Electrical Safety has motivated him to earn the Certified Electrical Safety Compliance Professional Certification (CESCP) from NFPA. He also regularly attends numerous electrical and safety conferences and training sessions conducted by NFPA, IEEE, API.

Previously, Henry was the President of the Fostoria, Ohio area Toastmasters team.

Henry is also a member of the International Association of Electrical Inspectors.

Henry also owns two small businesses:

Matthews Electrical Services - that performs mainly limited residential and small commercial electrical services and conducts training for licensed electricians in the state of Ohio.

Designer Cuts Hair Salon, LLC – Henry co-owns the beauty salon with his wife.

Electrical Safety
Based on the NEC and NFPA 70E

MATTHEWS ELECTRICAL SERVICES

Ohio Training Agency #48714

Henry Matthews, PE, CPE, CESCP
hpmatthews66@att.net
hpmatthews@matthewselectrical.net

1

Webinar Rules

Be	Attendee must be present the entire time (except breaks)
Be	Webinar may be recorded • Proof of attendance and participant identity • Potential OCILB audits
Keep	Keep webcam active* • Instructor will periodically check for presence of all attendees • During presentation, participant view will be blocked
Mute	Mute microphone at all times • Prevents distraction during webinar • Instructor may activate participant microphone if verbal response is needed

6

2

Webinar Completion

- Certificate of completion will be sent via email to all attendees
- 4 hours of Ohio OCILB Code and/or OBBS credits will be submitted to the state board within 48 hours of class
- Feedback is encouraged to improve future webinars!
- Send other inquires, feedback and questions to: hpmatthews@matthewselectrical.net
- 419-701-7707
- 419-575-3488 (cell)

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3

WELCOME!

- Goals
  - Promote learning
  - Make session engaging
    - Discussion
    - Videos
    - Case Studies
    - Polls
  - Make 4 hours as productive as possible!

4

Objectives

- To provide basic information on electrical safety for all persons working on or around electrical equipment.
- This information is to protect the worker and bystanders near the location(s) where work is being performed.
- Provide information in simple terms to facilitate understanding and comprehension.

5

Disclaimer #1

I don't know everything!

I'm just very passionate about electrical safety!

6

Disclaimer #2

This safety training is not intended to replace other forms of training that may be required for your company or customer's safety requirements.

- OSHA 10, NFPA hour for example

However… it may satisfy NFPA 70E 110.2(A)(4)

- Type of training…shall be classroom, on-the-job, or a combination of the two. Type shall be determined by the owner.
- Check with your owner or person-in-charge

7

Disclaimer #3

The views and opinions presented in this class are those of Matthews Electrical Services and not necessarily those of the various entities the presenter represents or has previously or currently works for.

The material used in this class is based on documented publicly-available information (NFPA, OSHA, IEEE etc.)

The interpretation of this material is based on the presenters experience and training of the subject matter.

8

Disclaimer #4

This presentation uses video from various electrical equipment manufacturers. This is not intended to endorse any particular products, vendors or manufacturers.

The content is shown for educational purposes only.

9

Other Resources

- NFPA: www.nfpa.org
- OSHA: www.osha.gov
- IEEE (Electrical Safety Workshop): http://www.ewh.ieee.org/cmte/ias-esw/
- IAEI: www.iaei.org
- Mike Holt Enterprises: www.MikeHolt.com
- NEMA: www.nema.org
- UL: www.ul.com
- NECA: www.necanet.org
- Brainfiller.com: www.brainfiller.com
- E-Hazard: https://www.e-hazard.com/
- Electrical Safety Foundation International (ESFi): https://www.esfi.org/
- Fluke Corporation: www.Fluke.com
- Westex: www.westex.com
- Schneider Electric: www.schneiderelectric.com
- Eaton Corporation: www.eaton.com
- Red Vector Training: www.redvector.com
- Schweitzer Engineering Labs: www.selinc.com

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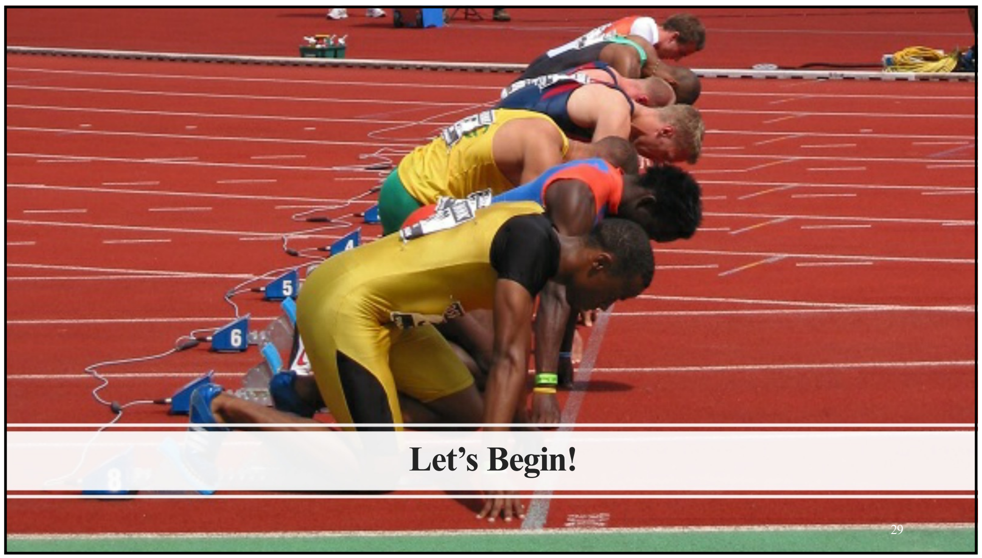
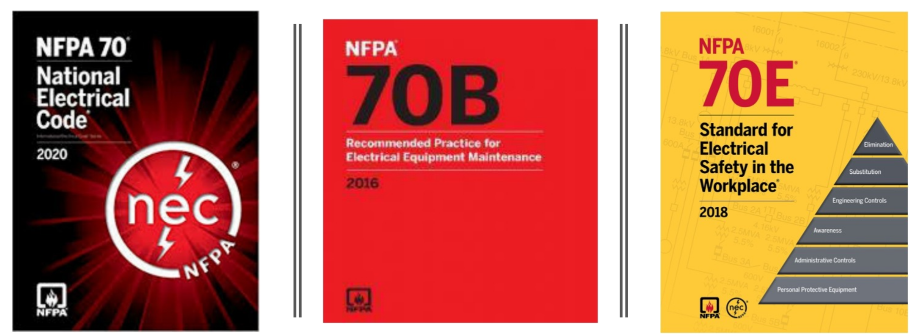


Let's Begin!

11



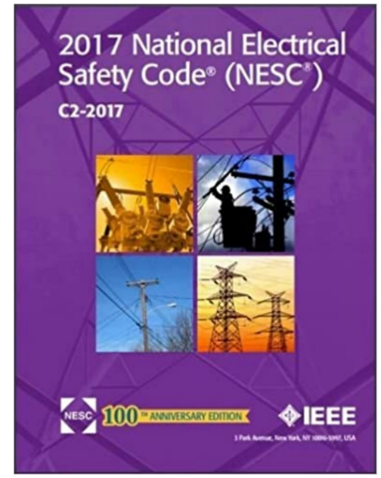
The NEC "Suite"

12

A New Safety Code is in Town!

13

Not in Scope
but
Important!



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Notice!

- Some of the NEC material is based on the 2020 NEC edition which is not currently in effect in Ohio

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Survey: Electrical Safety is a Broad Topic

What type of training do you want today?

What topics do you want to cover?

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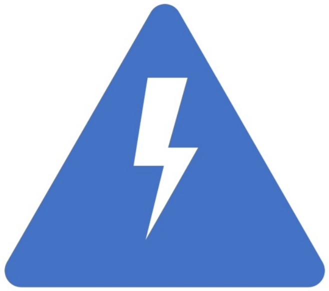
Why Do We Need Electrical Safety Training?



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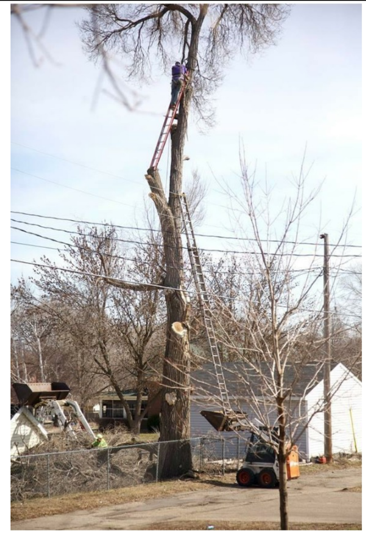

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Courtesy American Society
Of Safety Professionals(ASS)

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Why?!

ESFI Warns Against Participating in Outlet Challenge

Posted 01-22-2020 12:00 AM in Announcements

Dangerous TikTok Challenge Sparks Warning

ESFI is warning parents and children against the dangers of participating in the "outlet challenge." The challenge involves partially plugging in a cellphone charger into an outlet and then sliding a penny down the wall onto the exposed prongs. This challenge can have disastrous consequences including fires, injuries, and electrocution. The students involved in the prank conducted in Plymouth, Massachusetts could be facing criminal charges.

https://www.necn.com/news/local/fire-officials-warn-parents-about-outlet-challenge/2221457/

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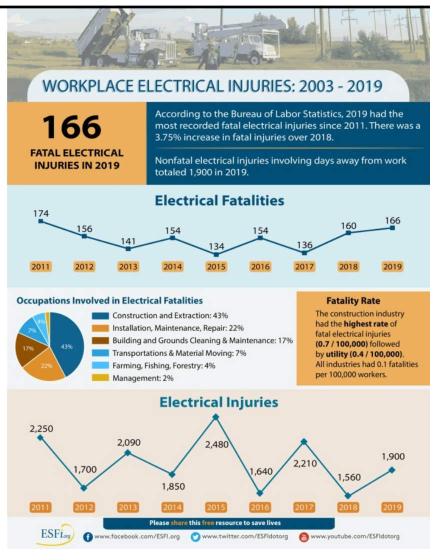

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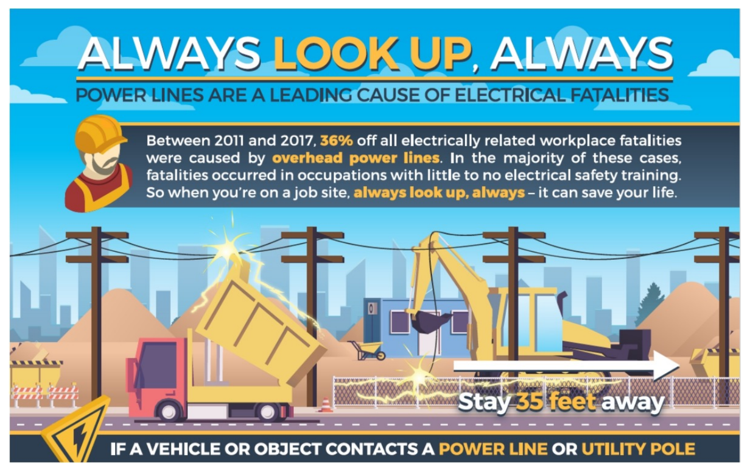

https://www.esfi.org/resource/residential-construction-workplace-safety-751

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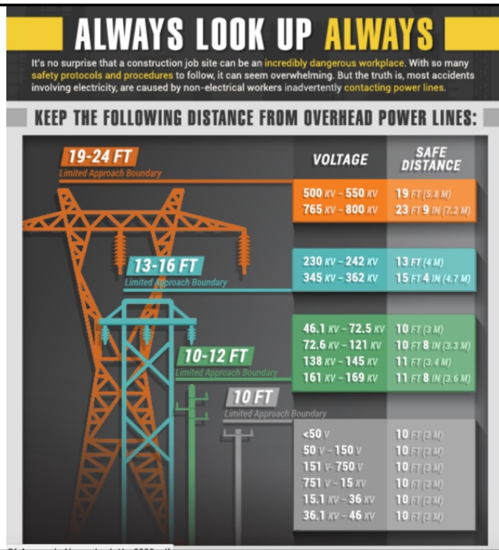

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Introduction to Electrical Safety

https://www.fluke.com/en-us/learn/blog/safety/electrical-safety-videos

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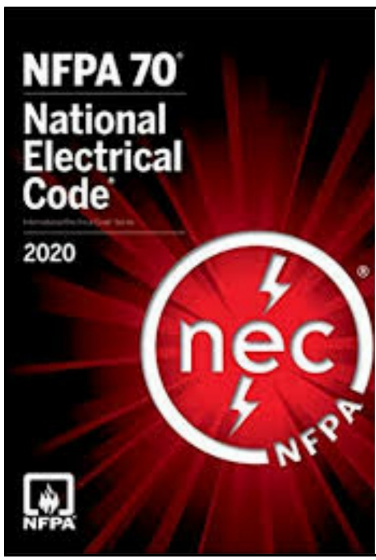

Electrical Safety References

- National Electric Code (NEC, NFPA 70)
  - Mainly concerned with safe installations for occupants and users
- NFPA 70E focuses on worker safety
- NFPA 70B focuses on electrical equipment maintenance
- OSHA 1910 focuses on contractors
- OSHA 1926 focuses on industry
- NESC (National Electrical Safety Code, IEEE-C2)
  - focuses on utility installations
- IEEE 1584 Short Circuit calculations
  - Recently revised in 2018

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NEC Safety Highlights

Definitions

Labeling requirements

Safe Working Spaces, Clearances

GFCI requirements

Grounding and Bonding

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NEC 110.3 Examination, Identification, Installation, Use and Listing (Product Certification) of Equipment

- Opinion: Similar to OSHA's General Duty Clause
- NEC 110.3(B) Installation and Use
  - Equipment that is listed, labeled, or both shall be installed and used in accordance with any instructions included in the listing or labeling.

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OSHA® Occupational Safety and Health Administration

OSHA General Duty Clause 5(a)(1):

(a) Each employer --

(1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;

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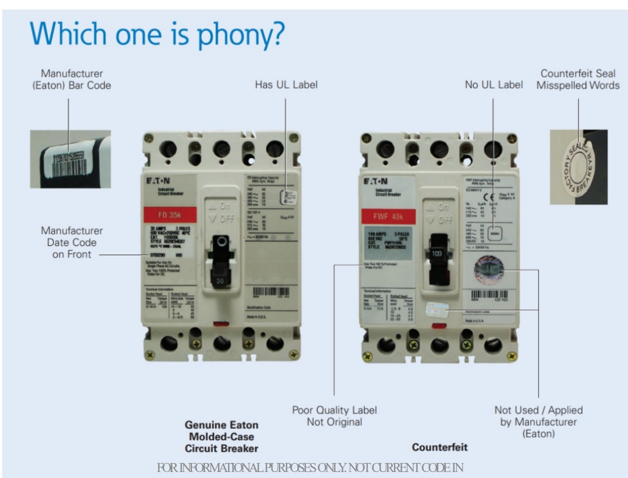
Source: www.eaton.com



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LISTING: Nationally Recognized Testing Laboratories (NRTL)

(List Maintained by OSHA)

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Working Space

- Adequate working space shall be allocated around electrical equipment to provide for maintenance and safe operation

	Minimum Clear Distance		
Nominal Voltage	Condition 1	Condition 2	Condition 3
0-150	3 ft	3 ft	3 ft
151-600	3 ft	3 ft – 6 in.	4 ft
601-1000	3 ft	4 ft	5 ft

Note: not related to Shock tables in NFPA 70E

https://www.youtube.com/watch?v=gEYuLld_USA

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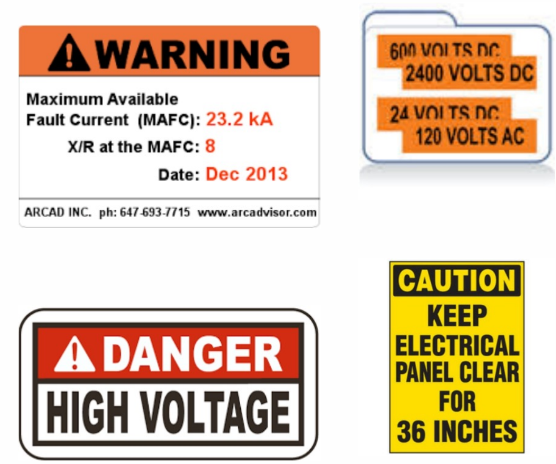
Labeling (hazard communication)

- Frequent target of inspectors!
- 2nd leading OSHA citations
- New:
  - Upstream source identifier
  - SCCR (field labeling)
  - Disconnect location (signs)



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Contrast

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OSHA 2019 Most Cited Violations (Source www.nsc.org)

1. Fall Protection – General Requirements (1926.501)	6,010
2. Hazard Communication (1910.1200)	3,671
3. Scaffolding (1926.451)	2,813
4. Lockout/Tagout (1910.147)	2,606
5. Respiratory Protection (1910.134)	2,450
6. Ladders (1926.1053)	2,345
7. Powered Industrial Trucks (1910.178)	2,093
8. Fall Protection – Training Requirements (1926.503)	1,773
9. Machine Guarding (1910.212)	1,743
10. Eye and Face Protection (1926.102)	1,411

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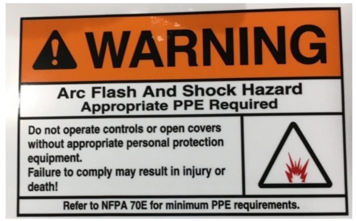
Arc Flash Labels!

- Two Types
  - NEC version [110.16]: "generic label" (mandatory)
  - NFPA 70E version [130.5(H)]
- NEC version Required for:
  - Switchgear, switchboards,
  - Panelboards, meter sockets,
  - MCCs that require servicing,
  - Maintenance, adjustments, examination etc.
  - Exception: dwelling units
- NEC version Required for:
  - Service equipment, rated 1200 amps or more
  - Contain nominal system voltage
  - Available fault current
  - Clearing time of overcurrent device
  - Date that label was affixed
  - NFPA arc Flash label can be substituted for this
  - Ties this to NFPA 70E tables for PPE selection



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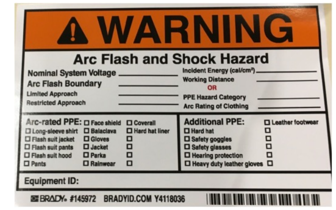
Arc Flash Labels (more on this later)

- NFPA 70E version
  - Required if 70E adopted by facility
- Required for:
  - Switchgear, switchboards,
  - Panelboards, meter sockets,
  - MCCs that require servicing,
  - Maintenance, adjustments, examination etc.
  - Exception: dwelling units
- Must contain:
  - Nominal system voltage
  - Arc flash boundary
  - And at least one of the following:
    - Available incident energy and working distance or arc flash PPE category (not both)
    - Minimum arc rating of clothing
    - Site specific level of PPE



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Electrical Hazards

SHOCK

ARC FLASH

More than 90% of electrical fatalities among US workers are due to electrical shock. - IAEI

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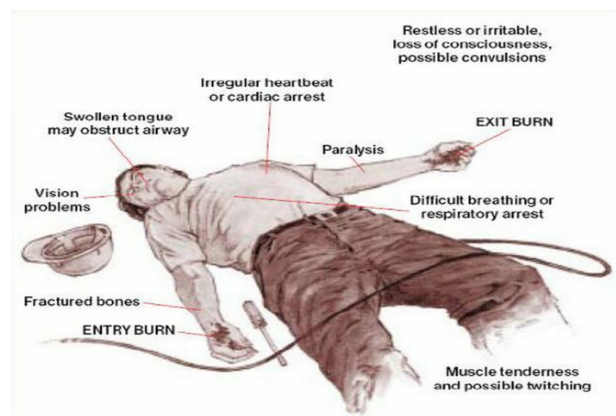
Electrical Injuries and Impacts



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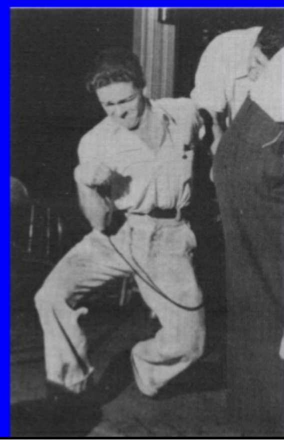
EFFECTS OF ELECTRIC SHOCK ON MAN

Charles F. Dalziel
University of California
Berkeley, California



1904–1986

Invented GFCI 1961

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Current vs Impact on the Human Body

Current in miliamps (ma)	Probable Effect on the Human Body
1 ma (.001 amp)	Perception level. Slight tingling sensation. Still dangerous under certain conditions.
5 ma (.005 amp)	Slight shock felt; not painful but disturbing. Avergage individual can let go. However, strong involuntary reactions to shocks in this range may lead to injuries.
6 ma – 16 ma (.006 - .016) amps	Painful shock, begin to lose muscular control. Commonly referred to as the freezing current or "let-go" range.
17 ma – 99 ma (0.017 -.099) amps	Extreme Pain, respiratory arrest, severe muscular contractions. Individual cannot let go. Death is possible.
100 ma – 2000 ma (.1 - 2 amps)	Ventricular fibrillation (uneven, uncoordinated pumping of the heart.) Muscular contraction and nerve damage begins to occur. Death is likely.
greater than 2000 ma (2 amps)	Cardiac arrest, internal organ damage, and severe burns. Death is probable

Note: GFCIs are set just below the "let-go" range (6ma)

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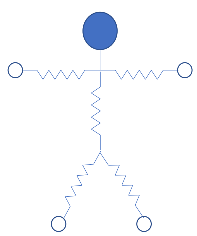
Body Resistance Chart

Paths Electricity Can Take Through Body

The lower the resistance, the more current flows

V=I x R
I=V/R

Body Part	Resistance (ohms)
Dry, intact skin (no cuts or scabs)	100,000 – 600,000
Wet skin	1000
Within the body	400
Ear to ear	100



- Differences in men and women
- Salty and sweaty skin lowers resistance

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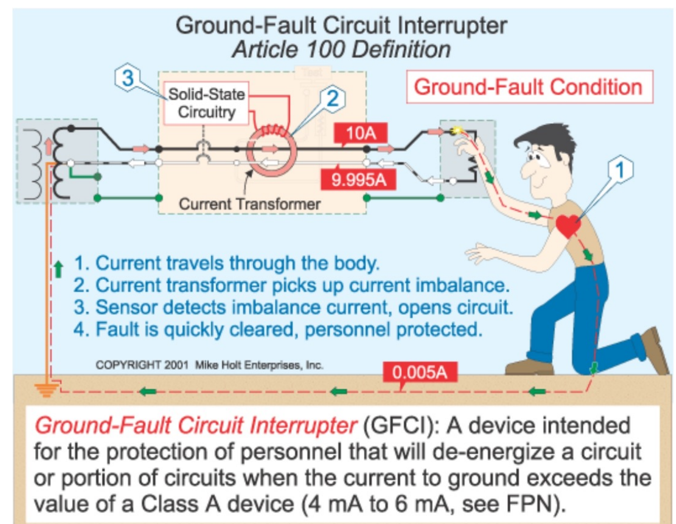

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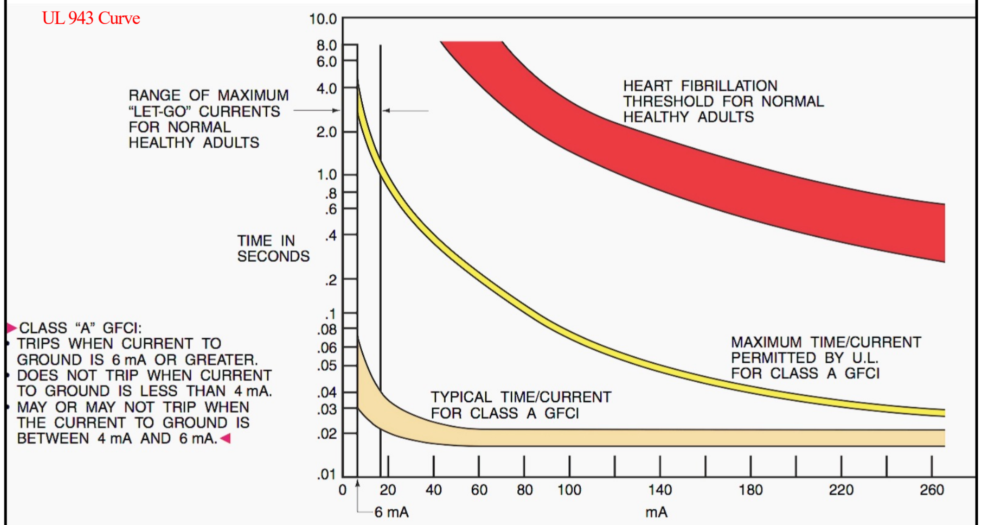
UL 943 Curve



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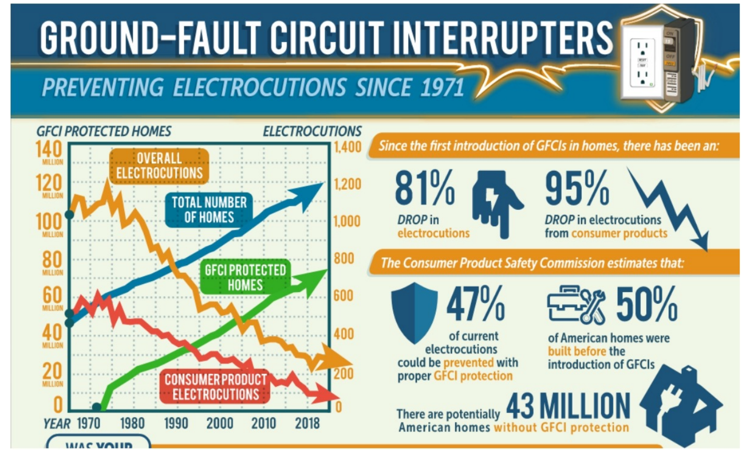

www.efsi.org

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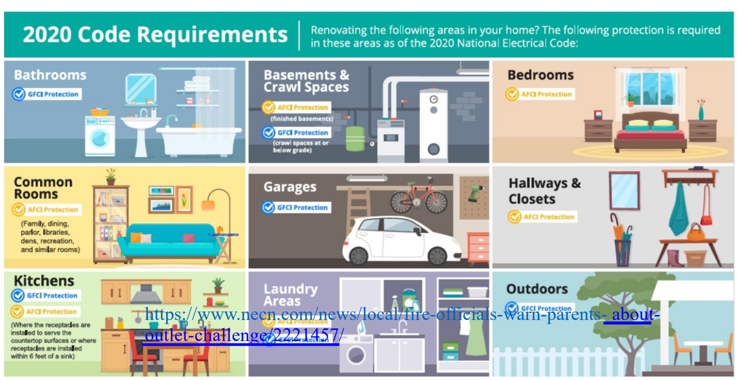
GFCI Requirements

https://www.esfi.org/resource/gfci-virtual-demonstration-481



https://www.necn.com/news/local/fire-officials-warn-parents-about-outlet-challenge/2221457/

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Dwelling Unit GFCI requirements	Article 210.8(A)
Bathrooms	210.8(A)(1)
Garages and Accessory Buildings	210.8(A)(2)
Outdoors	210.8(A)(3)
Crawl Spaces	210.8(A)(4)
Basements (finished and unfinished)	210.8(A)(5)
Kitchens	210.8(A)(6)
Sinks	210.8(A)(7)
Boathouses	210.8(A)(8)
Bathtubs and shower stalls	210.8(A)(9)
Laundry Areas	210.8(A)(10)
Indoor Damp and Wet Locations (new)	210.8(A)(11)
Boast Hoist	555.9

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Appliances


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Cases That Drove Change

52-year old plumber killed while installing dishwasher, came in contact with energized range

10-year old girl killed behind energized appliance

Oklahoma child retrieving pet behind clothes dryer

10-year old boy playing hide and seek

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GFCI Requirements for Other Than Dwelling Units	Article 210.8(B)
Bathrooms	210.8(B)(1)
Kitchens or areas with sink and permanent provisions for food preparation or cooking	210.8(B)(2)
Rooftops	210.8(B)(3)
Outdoors	210.8(B)(4)
Sinks	210.8(B)(5)
Indoor damp and wet locations	210.8(B)(6)
Locker rooms with shower facilities	210.8(B)(7)
Garages and accessory buildings	210.8(B)(8)
Crawl Spaces – at or below grade	210.8(B)(9)
Unfinished areas of basements	210.8(B)(10)
Laundry areas	210.8(B)(11)
Bathtubs and Shower Stalls	210.8(B)(12)

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GFCI Requirements Common to Both Dwelling and Non-Dwelling Units		Articles
Crawl Space lighting outlets		210.8(C)
Specific Appliances		210.8(D)
Equipment Requiring Servicing		210.8(E) and 210.63
Outdoor Outlets	⚠	210.8(F)
Sumps Pumps	⚠	422.5(A)(6)
Dishwashers		422.5(A)(7)
Docks, marinas, boatyards etc.	⚠	Article 555
Swimming Pools, Spas, hot tubs, baptismal pools, splash ponds, etc.	⚠	Article 680

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What About Electric Water Heaters?

- For right now…
- Even though it may be located in a basement, restroom or laundry room and
- It is 240 V
- It is not required is it is **<u>hard-wired</u>**
- GFCI required if plug and cord connected
- NEC is looking into this for possible 2023 changes or guidance since people are reporting shocks from water heaters
- Check with your AHJ or inspector

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Chapter 5 GFCI Requirements

Requirement	Article
Commercial Garages	511.12
Agricultural Buildings ⚠	547.5(G)
Mobile Homes, Manufactured Homes, Mobile Homes ⚠	550.13(B)

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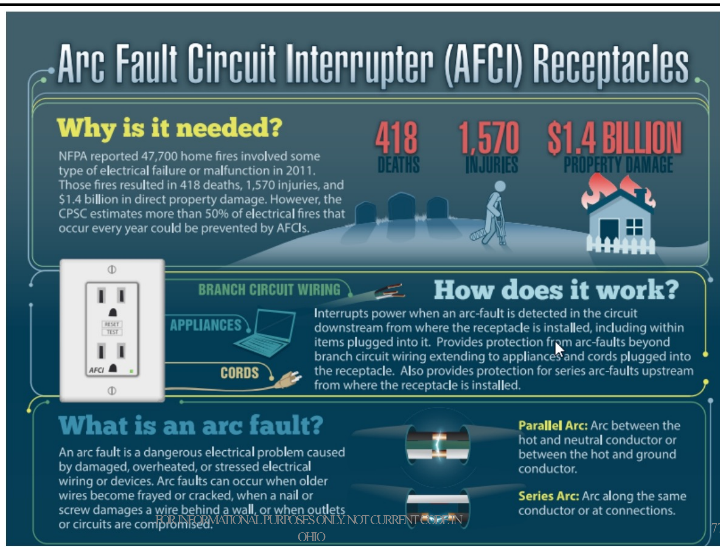
www.ESFi.org



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AFCI Requirements

Area	AFCI	AFCI Code reference
Kitchen	X	210.12(A)
Dining Room	X	210.12(A)
Bedroom	X	210.12(A)
Closets	X	210.12(A)
Living Room	X	210.12(A)
Family Room	X	210.12(A)
Parlor	X	210.12(A)
Libraries	X	210.12(A)
Hallway	X	210.12(A)
Laundry Room	X	210.12(A)
Den	X	210.12(A)
Sunroom	X	210.12(A)
Recreation Room	X	210.12(A)
Dormitory units	X	210.12(B)
Dormitory bathrooms	X	210.12(B)
Patient Sleeping Rooms in Nursing Homes and Limited-Care Facilities	X	210.12(C)
Hotel Guest rooms and suites	X	210.12(D)

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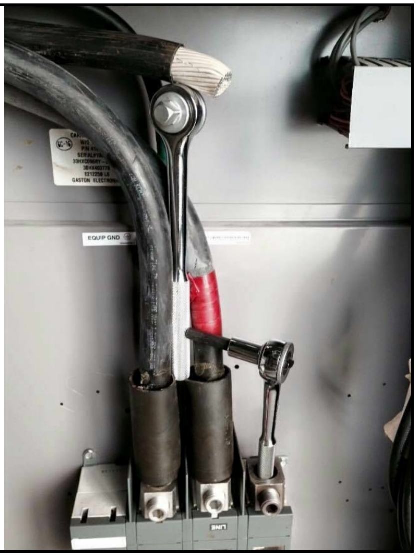
More Safety Hazards



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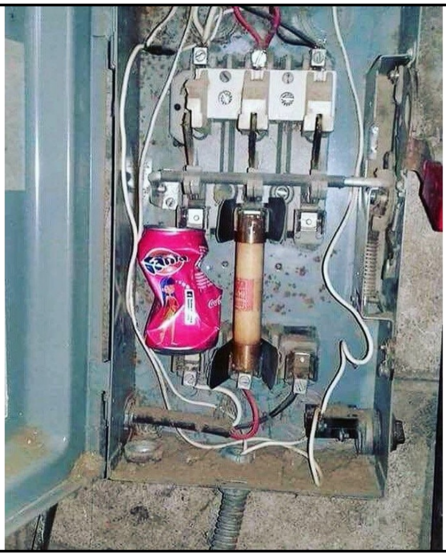

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And the Winner Is…

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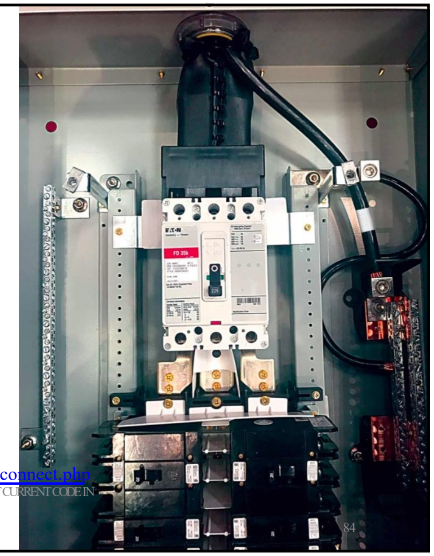
230.62(C) Barriers

Prelude to 230.71

Barriers shall be placed in service equipment such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons of maintenance equipment while servicing load terminations

Sidebar: How reliable are equipment doors?

https://www.e-hazard.com/learn/arc-flash-videos/arc-flash- 100a-disconnect.php



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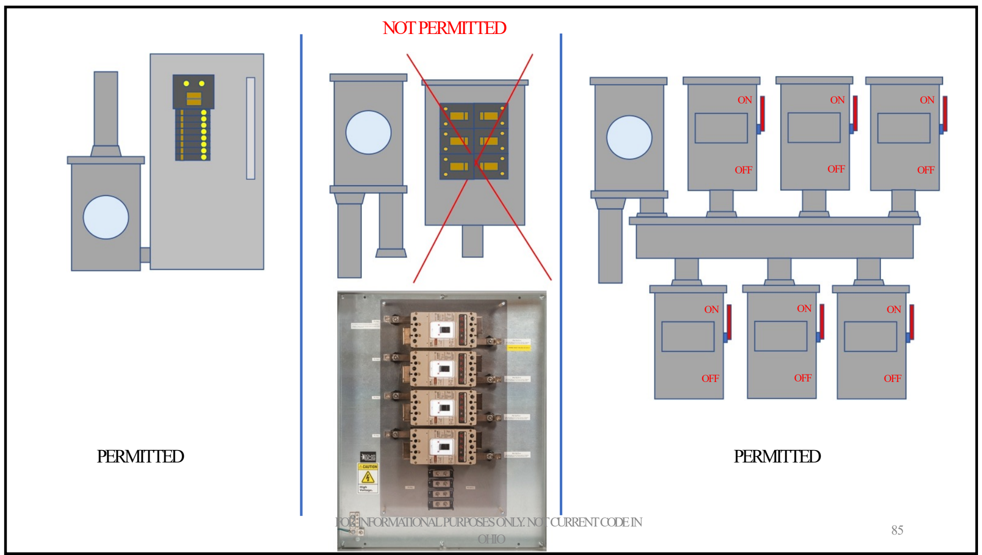

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230.85 Exterior Emergency Disconnects for Dwelling Units

- Type of change: New
- 2020 NEC:
  - An emergency disconnect is now required at an exterior readily accessible location for dwelling units.
  - Note: it can include the service disconnecting means.
  - Special Marking required: EMERGENCY DISCONNECT, SERVICE DISCONNECT e.g.
- Reason: Safety
  - Enhances the safety for first responders
  - With alternative sources of power available (PV, generators, batteries, UPS, wind turbines etc.), first responders often find it difficult to find reliable way to kill power in emergencies
- Three Options…

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406.12 Tamper-Resistant Receptacle

- Type of change: New/Revision
- 2020 NEC: Requirements for tamper-resistant (TR) receptacles were expanded to attached and detached garages and accessory buildings of dwelling units.
- Common areas of multifamily dwelling units and hotels and motels are included as well.
- Assisted living facilities was also added.

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Tamper Resistant Receptacles	Reference
Dwelling units including	406.12(1)
Attached and detached garages and accessory buildings to dwelling units	406.12(1)
Common areas of multifamily dwellings	406.12(1)
Guest rooms and guest suites of hotels, motels, and their common area	406.12(2)
Child care facilities	406.12(3)
Preschools and Education facilities	406.12(4)
Business office, corridors, waiting rooms and the like in clinics, medical and dental offices, and outpatient facilities	406.12(5)
Subset of assemblies occupancies described in 518.2 to include places of awaiting transportation, gyms, skating rinks and auditoriums	406.12(6)
Dormitory Units	406.12(7)
Assisted Living Facilities	406.12(8)

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More Useless Trivia!

POWER!

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Kilowatts vs KVA

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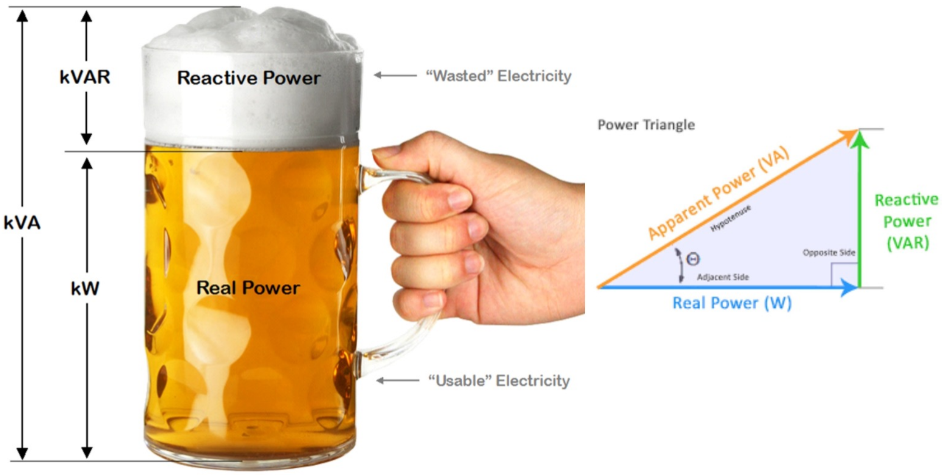

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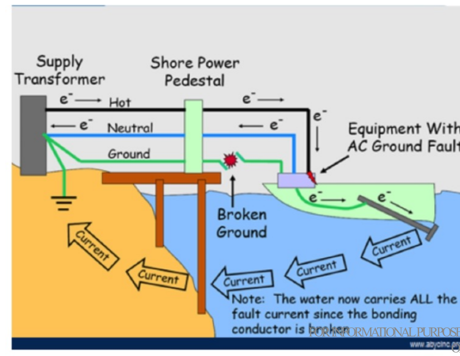
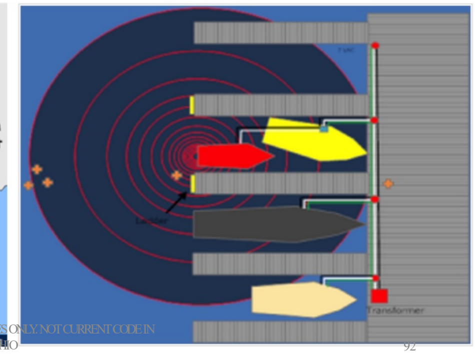
Electric Shock Drowning

https://www.youtube.com/watch?time_continue=1&v=Cwj4lSMfH68&feature=emb_logo

https://www.boatus.com/seaworthy/esd.asp





74

555.35 GFPE and GFCI Protection at Marinas, Boatyards, Etc.

Shore power receptacles shall have individual GFPE not exceeding 30 milliamperes [555.35(A)(1)]

All 125-volt, single-phase, 15- and 20-ampere receptacles *(other than shore power)* shall be provided with Class A GFCI protection [555.35(A)(2)]

Feeder and branch-circuit conductors installed on docking facilities shall be provided with GFPE set to open at currents not exceeding 100 milliamperes with downstream GFPE coordination permitted at the feeder overcurrent protective device [555.35(A)(3)]

75

Chapter 6 GFCI Requirements

Requirement		Reference
Elevator Pits, Hoistways, Dumbwaiters etc.	⚠	620.6
Electric Vehicle Charging Equipment	⚠	625.54
Storable and Portable Immersion Pools		680.35
Permanently Installed Immersion Pools		680.45
Fountains including Splash Pads	⚠	680.50
Pool motors	⚠	680.21(C)
Pool pump motor replacements		680.21(D)
Pool equipment room		680.22(A)(5)
Permanently Installed Non-submersible pumps		680.59
Natural and Artificially Made Bodies of Water	⚠	682.15

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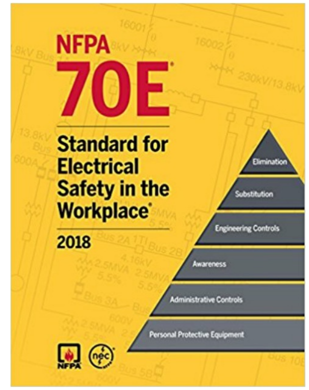
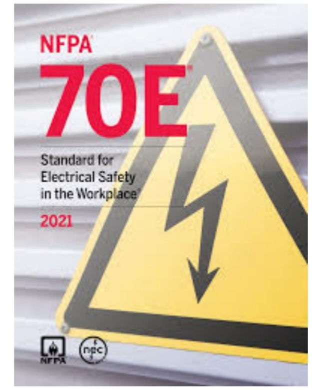
Arc Fault Circuit Interrupter

https://www.youtube.com/watch?v=C-SBly_2bPQ

77

NFPA 70E Electrical Safety in the Workplace





78

NFPA Faces of Fire: https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Top-fire-causes/Electrical/Faces-of-Fire

http://www.e-hazard.com/arc-flash-resources/videos/

79

NFPA 70E Highlights

- Definitions
- Hierarchy of Risk Controls
- Safe Work Practices
- Qualified vs Unqualified Persons
- Establishing an Electrically Safe Work Condition
- PPE selection (Table vs Incident Energy Method)
- Lockout Tagout and Energy Isolation
- Shock and Arc Flash Protection Boundaries
- "Normal Operating Conditions" (controversial)
- Energized Work and Energized Work Permit
- Communication
- Emergency Procedures
- Training and documentation to prove it

80

Key Concepts

- Don't work on equipment live!
- Turn off equipment 50V and before working on it
- Electrical Hazards:
  - Shock
  - Arc Flash
- Conduct Hazard Assessment
- The role of the Qualified Person
- Energy Isolation/Lockout Tagout
- Wear proper PPE
- Understand the arc flash label
- Concept of incident energy
- Communication

81

50 Volts

TRIVIA: WHY 50 VOLTS?

82

Electricity Safety Basics

- Electrical current wants to go back to its source!
  - Not necessarily ground
  - It may use the ground to get back to the source
- It will take any and all available paths to get back to the source – including people
  - Most of the current will travel on the "path of least resistance (impedance)
  - Provides safe shortcut for current to return to source

83

Key Factors in Electrical Safety

- Speed (of circuit breaker, fuse, relay, overload etc.)
- Distance (from hazardous energy)
- Amount of energy (from faults – short circuit, ground fault)

https://selinc.com/solutions/arc-flash-solutions/

84

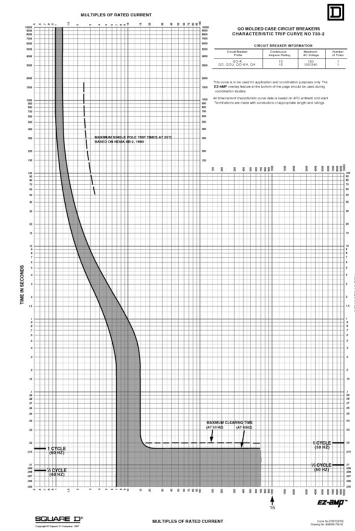
Incident Energy (Calories/cm^2)

- Measure of energy
- 1.2 cal/cm^2 = equals onset of just curable 2nd degree burn (blister)

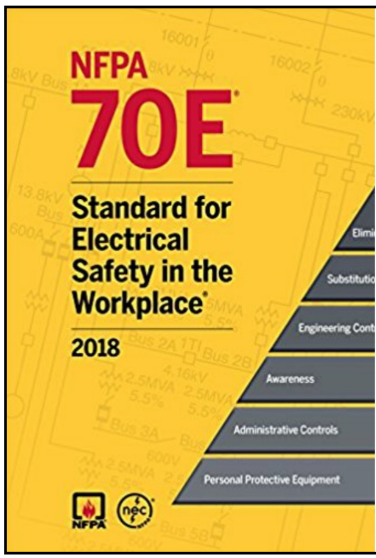
85

Circuit Breaker
Time Coordination Curve

- Fastest circuit breaker takes 3 or 4 cycles to react
- Fuses are typically faster
- Solid state relays are fastest
- Condition of circuit breaker a factor
- The higher the current, the faster a breaker will operate
- The faster a breaker operates, the lower the amount of dangerous energy that gets through



86



Notice the Cover

- Hierarchy of Risk Controls (ANSI Z10)
- In order of priority to promote electrical safety

Elimination
Substitution
Engineering Controls
Awareness
Administrative Controls
PPE

87

Examples

- **Elimination -** Turn it off!
- **Substitution** – 24 VDC for 120 VDC
- **Engineering Controls** – arc resistant gear, coordination
- **Awareness** – training, labels
- **Administrative Controls** – standards, policies, codes
- **PPE** – last line of defense

88

Purpose

- provide a practical safe working environment for workers and observers from the hazards of electricity

89

Scope

- Industrial, Commercial, Government etc.
- Practices recommended for residential, but not mentioned specifically in NFPA 70E
- Not covered: utilities outside of buildings, marine, communications industry

90

91

92

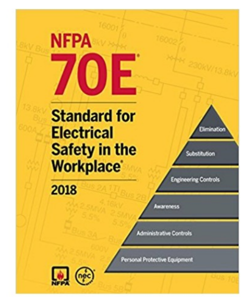
93

94

95

The OSHA Connection

- OSHA is the "Shall"
- NFPA 70E is the "How"



OSHA®
Occupational Safety and Health Administration

96

Definitions

Arc Flash Hazard

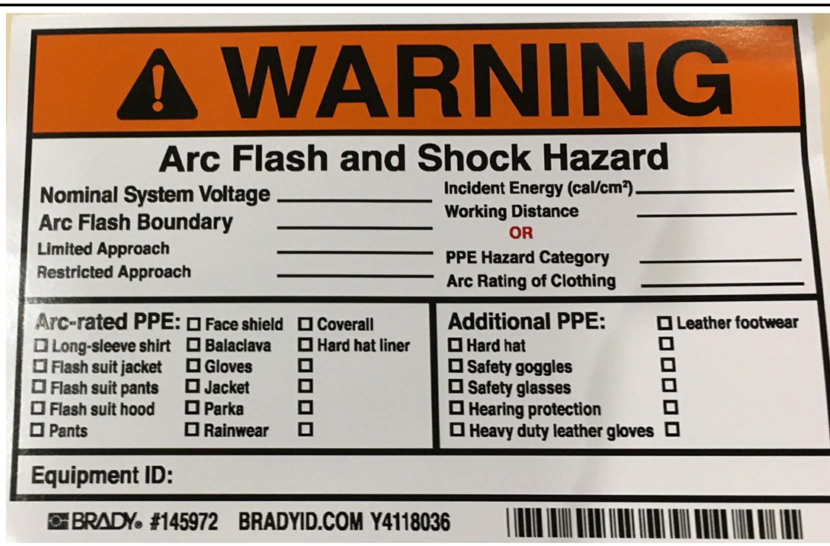
- A source of possible injury or damage to health associated with the release of energy caused by an electric arc

97

1.2 Calorie/cm_2

- Threshold for just-curable second degree burn
  https://tyndaleusa.com/fr-safety-resources/arc-flash-video-recap-2019/

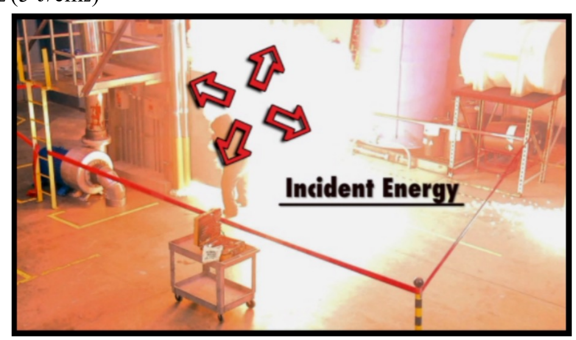
98



99

Definitions

- Arc Flash Boundary
  - an approach limit from an arc source at which the incident energy equals 1.2 cal/cm_2 (5 J/cm_2)



100

Definitions

Limited Approach Boundary

- approach limit at a distance from an exposed energized conductor or circuit within which a shock hazard exists.

101

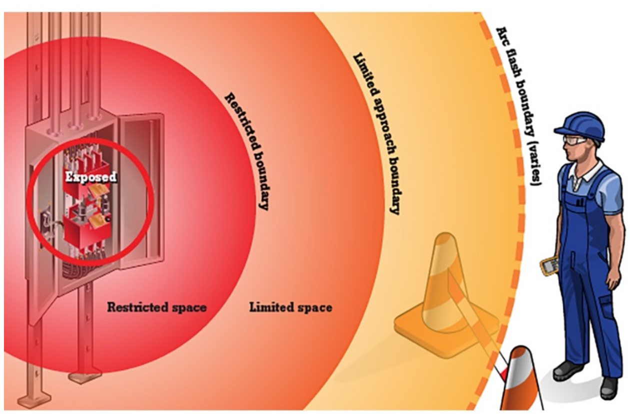
Definitions

Restricted Approach Boundary

- An approach limit at a distance from an exposed energized conductor where there is an increased likelihood of electric shock, due to electrical arc-over associated with inadvertent movement.

102

Shock and Arc Flash Protection Boundaries



103

Definitions

De-energized

Free from any electrical connection to a source of voltage and from electrical charge

104

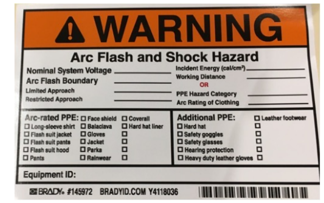
Definitions

Electrically Safe Work Condition

A state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection.

105

Arc Flash Labels!



- NFPA 70E version
- Required for:
  - Switchgear, switchboards,
  - Panelboards, meter sockets,
  - MCCs that require servicing,
  - Maintenance, adjustments etc.
  - Exception: dwelling units
- Must contain:
  - Nominal system voltage
  - Arc flash boundary
  - And at least one of the following:
    - Available incident energy and working distance or arc flash PPE category (not both)
    - Minimum arc rating of clothing
    - Site specific level of PPE

106

Definitions

Energized

Electrically connected to, or is, a source a voltage.

107

Definitions

Exposed

- Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated.

108

Definitions

Guarded
- Covered, shielded, fenced, enclosed, by covers, barriers, screens, mats etc. to remove the likelihood of someone coming into contact with energized conductors

109

Definitions

Incident Energy
- The amount of thermal energy delivered a surface, a certain distance from the source, generated during an electrical arc event.
  - expressed in calories per square centimeter (cal/cm^2).

110

Definitions

Qualified Person

- One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installation and has received safety training to identify the hazards and reduce the associated risk.

111

The Qualified Person

- Important!
  - A person may be considered Qualified with regard to certain equipment or tasks, but be Unqualified as to other equipment or tasks due to lack of training or experience

https://www.esfi.org/resource/workplace-safety-the-importance-of-qualified-electrical-workers-670

112

RESPONSIBILITIES

- Job safety planning
- Lockout/tagout program audit
- Knows construction and operation of equipment
- Identify electrical hazards
- Familiar with PPE
- Familiar with precautionary techniques
- Familiar with electrical safety policies and procedures
- Knowledgeable of insulating and shielding materials
- Knowledgeable of insulated tools and test equipment
- Allowed in the limited and restricted approach boundaries with proper PPE

113

RESPONSIBILITIES

- Has skills to:
  - Identify exposed energized part
  - Determine nominal voltage of energized electrical conductors
  - Know the approach distances
  - Assess risks
  - Select the appropriate risk control method (pyramid)
  - Testing, troubleshooting,voltage measuring
  - And many more…

114

Verification of Absence of Voltage (0 volts)

- The Qualified Person:
  - Verify proper equipment that will be isolated – especially for look-a-like equipment
  - Open disconnect(s) to affected equipment
  - Tests to verify that no voltage exists before work begins
    - Tests voltage detector on known voltage source prior to test
    - Puts on PPE per arc flash label to conduct tests
    - Conducts test
    - Checks meter on known voltage source again

  (VERIFY – TEST- VERIFY)
  - Locks Out/Tags Out equipment*
  - Gives okay to perform work

  - *Note: during this process, a start command shall be given to make sure equipment **DOES NOT START**

115

Definitions

Risk Assessment

- A process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required.

116

Definitions

Switchgear, Arc-resistant

- Equipment designed to withstand an arc flash by deflecting fault released energy away from the employee.

117

Definitions

Working Distance

- The distance between a person's face and chest area and a prospective arc source.

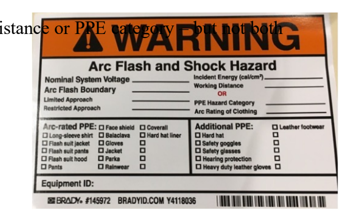
118

Typically 18", 24" or 36"

119

Equipment Labeling

- Equipment requiring examination, servicing, adjustment or maintenance <u>while energized</u> shall be marked with a label
- Label shall have:
  1. Nominal system voltage
  2. Arc flash boundary
  3. At least one of the following:
     - Incident energy and corresponding working distance or PPE category but not both
     - Minimum arc rating of clothing
     - Site-specific PPE



120

The Unqualified Person

- One who is not a Qualified person
- May perform tasks considered part of the normal or routine job duties

121

Not Understanding the Hazards!

- How many times have you seen this scenario?

https://www.youtube.com/watch?v=ObevFZMohuA

- What Can Go Wrong?
  - Shock
  - Burns
  - Temporary blindness
  - Temporary hearing loss
  - Smoke inhalation
  - Knocked back from blast into another hazard
  - Knocked off of ladder
  - Loss of lighting – stumble into another hazard
  - Loss of power to potential critical ops
  - Potential fire
  - Confusion
  - Disorientation
  - Death!

122

Communication: Job Briefing

- The employee in charge shall conduct a job briefing before starting each job that covers
  - Important issues from the risk assessment process

And, addresses issues and concerns from:

- Special precautions
- PPE requirements
- Existing conditions
- Job site analysis
- What if analysis
- Emergency response and communication

123

Emergency Response

- Contact release
- First Aid, Emergency Response and Resuscitation
  - Includes CPR and AED use
- Training
- Verification of Training
- Documentation
- OSHA 2- Person Rule

124

Training Requirements

- Lockout/Tagout Procedure Training
- Emergency Response Training
  - Contact release
  - First, aid, emergency response and resuscitation
    - CPR
    - AED availability
    - Training shall occur at a frequency that satisfies the requirements of the certifying body
- Training Verification
- Documentation

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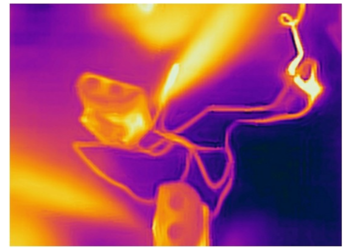
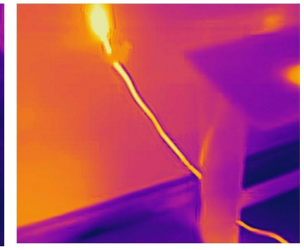




Extension Cords!

126

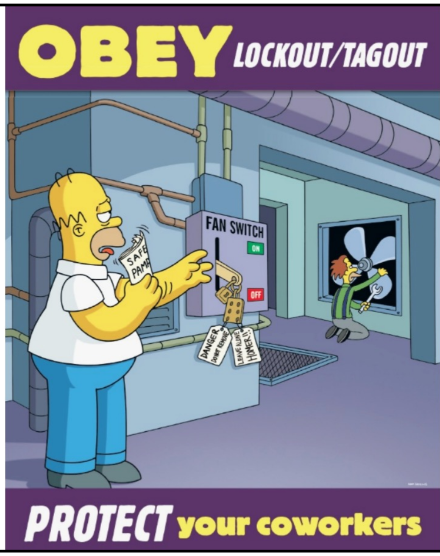
Establishing an Electrically Safe Work Condition

127

Electrically Safe Work Conditions

- Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exist:
  - The employee is within the limited approach boundary
  - The employee interacts with equipment where conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

128



129

Lockout/Tagout Program

- Responsiblities
- Devices: Locks/Tags
- Identification
- Beware of circuit interlocks
- Control devices cannot be used as primary LOTO devices
- Simple or Complex
- Cord and plug exception

https://www.osha.gov/video/shipyard_accidents/15_lockout_tagout_failure.html

130

Lockout/Tagout Program

- Beware of identical equipment
- chance of locking out wrong equipment

131

Process for Establishing and Verifying and Electrically Safe Work Condition

- Determine all possible source of energy
- Interrupt current, open disconnect device
- Verify blades of disconnecting device are open (if possible)
- Release stored electrical energy (capacitors for example)
- Release or block stored mechanical energy (springs e.g.)
- Apply LOTO devices
- Check for absence of voltage using contact meter
    - Test meter with known voltage first
    - Test meter with known voltage after testing for voltage
    - Exceptions: permanently mounted test devices allowed

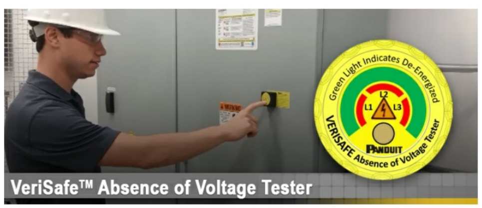
132

Arc Flash and Incident Energy Reduction Methods

- Arc-resistant switchgear: https://www.youtube.com/watch?v=yTQDgGEpNJQ
- Light Detection Relays: https://selinc.com/solutions/arc-flash-solutions/
- Maintenance Mode switches:
  - make circuit breakers operate faster (instantaneous trip)
- Remote racking devices: https://www.youtube.com/watch?v=IburZAlAnN4
- Remote switch activation (Chicken Switches): https://marteklimited.com/chicken-switch/
- Resistance grounding (high resistance grounding): http://videos.eaton.com/experience/detail/videos/power-quality/video/5854799660001/high-resistance-grounding-hrg?autoStart=true
- Zone selective interlocking (relaying schemes)

133

134



Exception 1

Exception 2: Can be used for applications > 1000 V

135

Caution! Not rated for use over 1000V

136

Beware of induced voltages or stored electrical energy!

Ensure proper rating and capacity

137

Energized Work

- Energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increased risks
  - Water treatment facilities, emergency life support systems, hazardous location ventilation e.g.
- Energized work allowed if it can be demonstrated that de-energization if infeasible due to equipment design or operational limitations
- Equipment operating at less than 50V shall not be required to be de-energized….
  - Use caution! Batteries for example
  - Perform risk assessment

138

Is it Safe to Operate This Switch?

- https://www.youtube.com/watch?v=rV3FBKMRawo

139

NORMAL OPERATING CONDITIONS (NORMAL CONDITIONS)

- Source of much confusion, misinterpretation
- Leads to misapplication and increased risk
- Lots of debate on this topic
- Undergone several changes over years

Question:

Can I operate a circuit breaker or switch without PPE?
Will the enclosure door offer me some protection?

Arc Flash Video With Door Blowing Open (2:32)
https://brainfiller.com/videos/page/2/

140

Normal Operating Conditions (continued)

- Normal operation of electric equipment shall be permitted where a normal operating condition exists. A normal operating condition exists when all of the following conditions are satisfied:

1. The equipment is properly installed
2. The equipment is properly maintained
3. The equipment if used in accordance with instructions included in the listing and labeling and in accordance with manufacturer's instructions *(new in 2018 version)*
4. The equipment doors are closed and secured
5. All equipment covers are in place and secured
6. There is no evidence of impending failure

141

Energized Electrical Work Permit

- Exemptions
  - Testing, troubleshooting, voltage measurements
  - Thermography, ultrasound and other diagnostics
  - General housekeeping

- PROPER PPE MUST STILL BE WORN!!

- https://www.e-hazard.com/blog/wp-content/uploads/2018/01/ENERGIZED-ELECTRICAL-WORK-PERMIT-2015.pdf

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143

Shock PPE

- Rubber Gloves with leather protectors (pg 43)
- Rubber sleeves
- Rubber mats
- Rubber blankets
- Dielectric footwear (pg 59)

144

Voltage Classification for Shock Protection Gloves

ASTM Labeling Chart
Natural Rubber Electrical Insulating Gloves

Class Color	Proof Test Voltage AC/DC	Max. Use Voltage AC/DC	Insulating Rubber Glove Label
00 Beige	2,500 / 10,000	500 / 750	10
0 Red	5,000 / 20,000	1,000 / 1,500	10
1 White	10,000 / 40,000	7,500 / 11,250	10
2 Yellow	20,000 / 50,000	17,000 / 25,500	10
3 Green	30,000 / 60,000	26,500 / 39,750	10
4 Orange	40,000 / 70,000	36,000 / 54,000	10

Rubber gloves must be worn with approved leather protectors!

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Arc Flash Risk Assessment

- Risk assessment: Likelihood vs Severity
- Arc Flash Boundary: incident energy = 1.2 cal/cm2
- Arc Flash Boundary determined by either:
  - Incident energy analysis: Table 130.5(G)
  - PPE category method: Table 130.7 (C)(15)

Important! Both methods cannot be used. Choose one

Important! PPE category table 130.7(C)(15)(c) cannot be used with incident energy method

146

Arc Flash PPE Selection

Use incident energy analysis → Use Table 130.5(G) To determine PPE

Use "Table" Method → Use Table 130.5(C) To determine if PPE is required → Use Table 130.7(C)(15)(a) To determine PPE Category → Use Table 130.7(C)(15)(c) To determine PPE

Pg 86

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Electrical PPE Categories

Note: PPE category 0 no longer used

Hazard/Risk Category	
0	Untreated natural fiber Shirt (long sleeve) Pants (long) Safety glasses Hearing protection Heavy duty leather gloves (as needed)
1 (4 cal/cm²)	Arc-rated long-sleeve shirt Arc-rated pants or overall Arc-rated face shield with hard hat Safety glasses Hearing protection Leather & voltage rated gloves (as needed) Leather work shoes
2 (8 cal/cm²)	Arc-rated long-sleeve shirt Arc-rated pants or overall Arc-rated face shield & balaclava or Arc flash suit with hard hat Safety glasses, Hearing protection Leather & voltage rated gloves (as needed) Leather work shoes
3 (25 cal/cm²)	Arc-rated long-sleeve jacket Arc-rated pants Arc-rated flash hood with hard hat Safety glasses, Hearing protection Leather & voltage rated gloves (as needed) Leather work shoes
4 (40 cal/cm²)	Arc-rated long-sleeve jacket Arc-rated pants Arc-rated flash hood with hard hat Safety glasses, Hearing protection Leather & voltage rated gloves (as needed) Leather work shoes

APTV: Arc Thermal Protective Value
(Maximum arc flash protection value)

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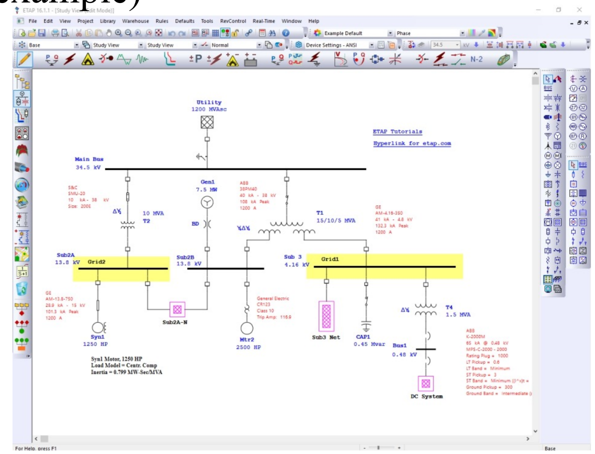
Incident Energy Method

- Calculated by:
  - Software: ETAP, SKM, Easy Power
  - Hand calculations: based on IEEE 1584
    - See Annex D
- Impacted by:
  - Circuit breaker or fuse clearing time
  - Amount of short-circuit current available
  - Condition of equipment
  - User input (accuracy of one-line diagram) – Henry's input
- Shall be reviewed every 5 years

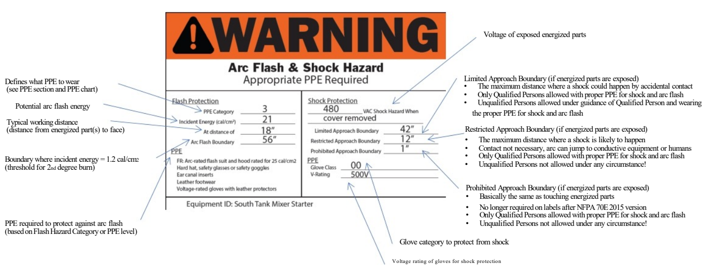
149

Engineering Analysis (ETAP example)



150

How to interpret the Information on the label



Note: Arc Flash labels come in many different configurations

151

Circuit Breaker Resetting

- A circuit breaker should no longer be reset without investigation
  - Repetitive opening and closing of breakers prohibited
  - Qualified person should determine if ok to re-engergize
- Exception if the cause is an overload condition vs. a fault
- Note: repetitive closing into a fault will damage a breaker

COULD BE DANGEROUS!

152

Overhead Lines

- Refer to "movable conductors" in Shock distance tables
- Guidance also found in NEC, NESC
- Generally 10 ft. up to 50,000 volts
- OSHA table

https://www.youtube.com/watch?v=4QcctfnUeOM
(ladders)

https://www.youtube.com/watch?v=Y2MwX738e1Y
(cranes)

29 CFR 1926.1408
Table A

Voltage	Minimum Clearance Distance
Up to 50 kV	10 feet
Above 50-200 kV	15 feet
Above 200-350 kV	20 feet
Above 350-500 kV	25 feet
Above 500-750 kV	35 feet
Above 750-1000 kV	45 feet
Above 1000 kV	(As established by the utility owner/operator or registered professional engineer who is a qualified person with respect to electrical power transmission and distribution)

Figure 1. OSHA's minimum clearance distances.

https://www.esfi.org/resource/workplace-safety-always-look-up-673

153

Underground Lines

- Beware of buried cable, conduit

154

Diagnostics, Troubleshooting and Testing

- Exception* is permitted to allow diagnostics and testing on energized circuits
  - Qualified person(s) must be involved
    - Establish Limited Approach and Arc Flash boundaries
  - **Must wear proper PPE per the arc flash label OR Tables**
  - Barriers must be erected
  - Select appropriately rated tools
    - Proper voltage rating
    - Good condition

*Energized work permit is not required

155

Second Person Requirements
(OSHA 1910.169)

- Some electrical work requires a second qualified person:
  - To summon medical help in an emergency
  - Knows how to safely release victims if shocked
  - Knows CPR, First Aid and AED use
- May be required when:
  - Working on or near power lines
  - Working on transformers, regulators, capacitors
  - Using mechanical lifts
  - Other work that exposes employee to electrical hazards greater than normal operations
- DISCUSS THIS IN RISK ASSESSMENT AND PRE-JOB!!!

156

Multi-meter Safety

- Proper ratings and certifications (UL and other NRTL)
  - Beware of the CE mark!
- Most meters are not intrinsically safe!
  - Hot work permit needed for use in hazardous areas
- Test leads condition
- Meter condition
- Check Battery level
- Check against a known voltage source
- Proper connection of leads
- Safety – use proper PPE (gloves, glasses)
  - Obey arc flash label for other PPE requirements
- Use good quality meters !

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Overvoltage category	In brief	Examples
CAT IV	Three-phase at utility connection, any outdoor conductors	• Refers to the "origin of installation," i.e., where low-voltage connection is made to utility power • Electricity meters, primary overcurrent protection equipment • Outside and service entrance, service drop from pole to building, run between meter and panel • Overhead line to detached building, underground line to well pump
CAT III	Three-phase distribution, including single-phase commercial lighting	• Equipment in fixed installations, such as switchgear and polyphase motors • Bus and feeder in industrial plants • Feeders and short branch circuits, distribution panel devices • Lighting systems in larger buildings • Appliance outlets with short connections to service entrance
CAT II	Single-phase receptacle connected loads	• Appliance, portable tools, and other household and similar loads • Outlet and long branch circuits • Outlets at more than 10 meters (30 feet) from CAT III source • Outlets at more that 20 meters (60 feet) from CAT IV source
CAT I	Electronic	• Protected electronic equipment • Equipment connected to (source) circuits in which measures are taken to limit transient overvoltages to an appropriately low level • Any high-voltage, low-energy source derived from a high-winding resistance transformer, such as the high-voltage section of a copier

Table 1. Overvoltage installation categories. IEC 1010 applies to *low-voltage* (< 1000 V) test equipment.

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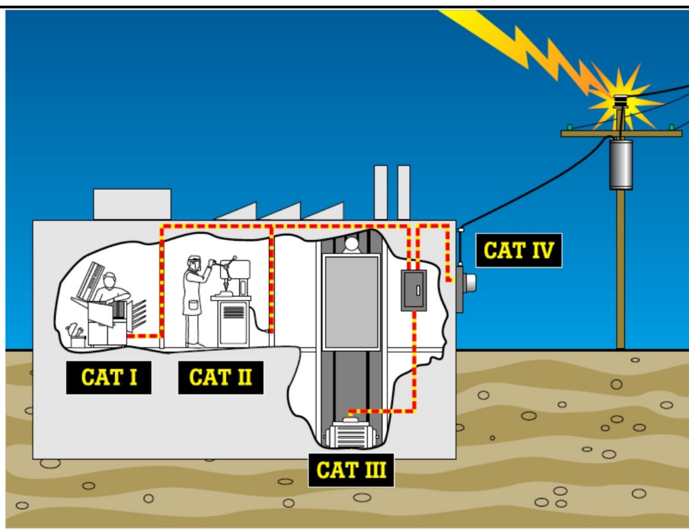

Figure 1. Location, location, location.

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NFPA 70E Tables

Note: outdated label- for demonstration purposes only

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130.5 ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS

N Table 130.4(D)(a) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems

(1)	(2)	(3)	(4)
	Limited Approach Boundary[b]		Restricted Approach Boundary[b]; Includes Inadvertent Movement Adder
Nominal System Voltage Range, Phase to Phase[a]	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–150 V[d]	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
151 V–750 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)
751 V–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)
15.1 kV–36 kV	3.0 m (10 ft 0 in.)	1.8 m (6 ft 0 in.)	0.8 m (2 ft 9 in.)
36.1 kV–46 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)
46.1 kV–72.5 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
72.6 kV–121 kV	3.3 m (10 ft 8 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
138 kV–145 kV	3.4 m (11 ft 0 in.)	3.0 m (10 ft 0 in.)	1.2 m (3 ft 10 in.)
161 kV–169 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.3 m (4 ft 3 in.)
230 kV–242 kV	4.0 m (13 ft 0 in.)	4.0 m (13 ft 0 in.)	1.7 m (5 ft 8 in.)
345 kV–362 kV	4.7 m (15 ft 4 in.)	4.7 m (15 ft 4 in.)	2.8 m (9 ft 2 in.)
500 kV–550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.6 m (11 ft 8 in.)
765 kV–800 kV	7.2 m (23 ft 9 in.)	7.2 m (23 ft 9 in.)	4.9 m (15 ft 11 in.)

Notes:
(1) For arc flash boundary, see 130.5(A).
(2) All dimensions are distance from exposed energized electrical conductors or circuit part to employee.
[a]For single-phase systems above 250 volts, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732.
[b]See definition in Article 100 and text in 130.4(D)(2) and Informative Annex C for elaboration.
[c]*Exposed movable conductors* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.
[d]This includes circuits where the exposure does not exceed 120 volts nominal.

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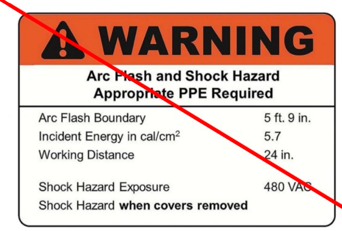
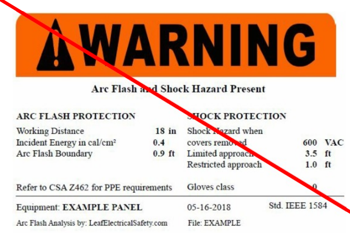
Using the Table Method

- Use when
  - No or limited information exists regarding facility electrical hazards
  - An incident energy analysis has not been done





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What is the Likelihood of an Arc Flash Event?

- What type of task(s) will you be working on?

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130.6 ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS

Table 130.5(C) Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems

Task	Equipment Condition	Likelihood of Occurrence*
Reading a panel meter while operating a meter switch. Performing infrared thermography and other non-contact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers. Working on control circuits with exposed energized electrical conductors and circuit parts, nominal 125 volts ac or dc, or below without any other exposed energized equipment over nominal 125 volts ac or dc, including opening of hinged covers to gain access. Examination of insulated cable with no manipulation of cable. For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an open rack. For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.	Any	No
For ac systems, work on energized electrical conductors and circuit parts, including voltage testing. For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including voltage testing. Removal or installation of CBs or switches. Opening hinged door(s) or cover(s) or removal of bolted covers (to expose bare, energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers. Application of temporary protective grounding equipment, after voltage test. Working on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 volts. Insertion or removal of individual starter buckets from motor control center (MCC). Insertion or removal (racking) of circuit breakers (CBs) or starters from cubicles, doors open or closed. Insertion or removal of plug-in devices into or from busways. Examination of insulated cable with manipulation of cable. Working on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control center. Insertion or removal of revenue meters (kW-hour, at primary voltage and current). Removal of battery conductive intercell connector covers. For dc systems, working on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source. Opening voltage transformer or control power transformer compartments. Operation of outdoor disconnect switch (hookstick operated) at 1 kV through 15 kV. Operation of outdoor disconnect switch (gang-operated, from grade) at 1 kV through 15 kV.	Any	Yes

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Determining PPE Category

- What is the available fault current in kA?
- How fast is the fuse or circuit breaker (clearing time)?

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Table 130.7(C)(15)(a) Arc-Flash PPE Categories for Alternating Current (ac) Systems

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	1	485 mm (19 in.)
Panelboards or other equipment rated greater than 240 volts and up to 600 volts Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 42 kA available fault current; maximum of 0.33 sec (20 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	6 m (20 ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Metal-clad switchgear, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Arc-resistant switchgear 1 kV through 15 kV [for clearing times of less than 0.5 sec (30 cycles) with an available fault current not to exceed the arc-resistant rating of the equipment], and metal-enclosed interrupter switchgear, fused or unfused of arc-resistant-type construction, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	N/A (doors closed) 4 (doors open)	N/A (doors closed) 12 m (40 ft)
Other equipment 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)

Note: For equipment rated 600 volts and below and protected by upstream current-limiting fuses or current-limiting circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below arc flash PPE category 1.

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Select PPE

- Look up PPE Category on chart
- Select voltage rated gloves
- Hard hat
- Face shield
- Balaclava
- Foot wear
- Hearing protection
- Eye protection

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Table 130.7(C)(15)(c) Personal Protective Equipment (PPE)

Arc-Flash PPE Category	PPE
1	**Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm^2 (16.75 J/cm^2)[a]** Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield[b] or arc flash suit hood Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Heavy-duty leather gloves[d] Leather footwear (AN)
2	**Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm^2 (33.5 J/cm^2)[a]** Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield[b] and arc-rated balaclava Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Heavy-duty leather gloves[d] Leather footwear
3	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm^2 (104.7 J/cm^2)[a]** Arc-rated long-sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc flash suit jacket (AR) Arc-rated arc flash suit pants (AR) Arc-rated arc flash suit hood Arc-rated gloves[d] Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Leather footwear
4	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm^2 (167.5 J/cm^2)[a]** Arc-rated long-sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc flash suit jacket (AR) Arc-rated arc flash suit pants (AR) Arc-rated arc flash suit hood Arc-rated gloves[d] Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Leather footwear

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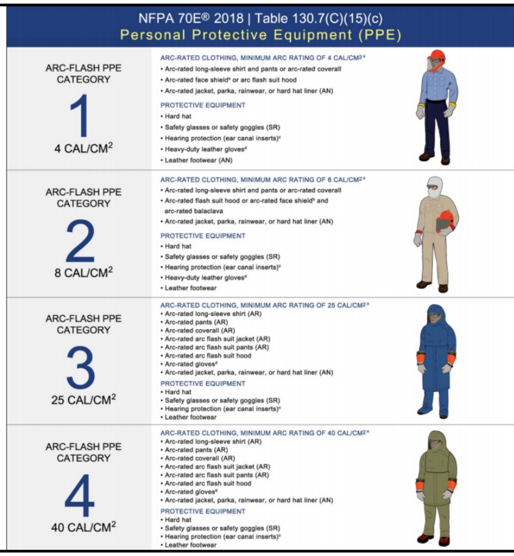

NFPA 70E® 2018 | Table 130.7(C)(15)(c)
Personal Protective Equipment (PPE)

ARC-FLASH PPE CATEGORY 1 — 4 CAL/CM²

ARC-RATED CLOTHING, MINIMUM ARC RATING OF 4 CAL/CM²[a]
- Arc-rated long-sleeve shirt and pants or arc-rated coverall
- Arc-rated face shield[b] or arc flash suit hood
- Arc-rated jacket, parka, rainwear, or hard hat liner (AN)

PROTECTIVE EQUIPMENT
- Hard hat
- Safety glasses or safety goggles (SR)
- Hearing protection (ear canal inserts)[c]
- Heavy-duty leather gloves[d]
- Leather footwear (AN)

ARC-FLASH PPE CATEGORY 2 — 8 CAL/CM²

ARC-RATED CLOTHING, MINIMUM ARC RATING OF 8 CAL/CM²[a]
- Arc-rated long-sleeve shirt and pants or arc-rated coverall
- Arc-rated flash suit hood or arc-rated face shield[b] and arc-rated balaclava
- Arc-rated jacket, parka, rainwear, or hard hat liner (AN)

PROTECTIVE EQUIPMENT
- Hard hat
- Safety glasses or safety goggles (SR)
- Hearing protection (ear canal inserts)[c]
- Heavy-duty leather gloves[d]
- Leather footwear

ARC-FLASH PPE CATEGORY 3 — 25 CAL/CM²

ARC-RATED CLOTHING, MINIMUM ARC RATING OF 25 CAL/CM²[a]
- Arc-rated long-sleeve shirt (AR)
- Arc-rated pants (AR)
- Arc-rated coverall (AR)
- Arc-rated arc flash suit jacket (AR)
- Arc-rated arc flash suit pants (AR)
- Arc-rated arc flash suit hood
- Arc-rated gloves[d]
- Arc-rated jacket, parka, rainwear, or hard hat liner (AN)

PROTECTIVE EQUIPMENT
- Hard hat
- Safety glasses or safety goggles (SR)
- Hearing protection (ear canal inserts)[c]
- Leather footwear

ARC-FLASH PPE CATEGORY 4 — 40 CAL/CM²

ARC-RATED CLOTHING, MINIMUM ARC RATING OF 40 CAL/CM²[a]
- Arc-rated long-sleeve shirt (AR)
- Arc-rated pants (AR)
- Arc-rated coverall (AR)
- Arc-rated arc flash suit jacket (AR)
- Arc-rated arc flash suit pants (AR)
- Arc-rated arc flash suit hood
- Arc-rated gloves[d]
- Arc-rated jacket, parka, rainwear, or hard hat liner (AN)

PROTECTIVE EQUIPMENT
- Hard hat
- Safety glasses or safety goggles (SR)
- Hearing protection (ear canal inserts)[c]
- Leather footwear

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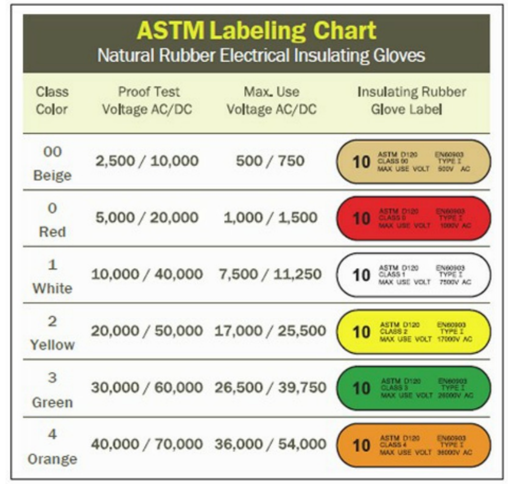

ASTM Labeling Chart
Natural Rubber Electrical Insulating Gloves

Class Color	Proof Test Voltage AC/DC	Max. Use Voltage AC/DC	Insulating Rubber Glove Label
00 Beige	2,500 / 10,000	500 / 750	10
0 Red	5,000 / 20,000	1,000 / 1,500	10
1 White	10,000 / 40,000	7,500 / 11,250	10
2 Yellow	20,000 / 50,000	17,000 / 25,500	10
3 Green	30,000 / 60,000	26,500 / 39,750	10
4 Orange	40,000 / 70,000	36,000 / 54,000	10

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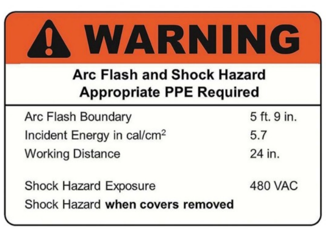
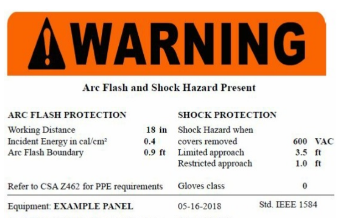
Using the Incident Energy Analysis

- Use when an incident energy analysis has been done





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130.6 ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS

N **Table 130.5(G) Selection of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method Is Used**

Incident energy exposures equal to 1.2 cal/cm² up to 12 cal/cm²
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Long-sleeve shirt and pants or coverall or arc flash suit (SR)
Arc-rated face shield and arc-rated balaclava or arc flash suit hood (SR)[b]
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)
Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear
Incident energy exposures greater than 12 cal/cm²
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Long-sleeve shirt and pants or coverall or arc flash suit (SR)
Arc-rated arc flash suit hood
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)
Arc-rated gloves or rubber insulating gloves with leather protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear

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ASTM Labeling Chart
Natural Rubber Electrical Insulating Gloves

Class Color	Proof Test Voltage AC/DC	Max. Use Voltage AC/DC	Insulating Rubber Glove Label
00 Beige	2,500 / 10,000	500 / 750	10 ASTM D120 CLASS 00
0 Red	5,000 / 20,000	1,000 / 1,500	10 ASTM D120 CLASS 0
1 White	10,000 / 40,000	7,500 / 11,250	10 ASTM D120 CLASS 1
2 Yellow	20,000 / 50,000	17,000 / 25,500	10 ASTM D120 CLASS 2
3 Green	30,000 / 60,000	26,500 / 39,750	10 ASTM D120 CLASS 3
4 Orange	40,000 / 70,000	36,000 / 54,000	10 ASTM D120 CLASS 4

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CONGRATULATIONS!

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Next Steps

- A Certificate of Completion will be emailed to those who successfully completed course
- 4 hours of Code Class Hours will be reported to the OCILB for Code Continuing Education Credits
- Contact instructor at hpmatthews@matthewselectrical.net for any questions or comments
- Make sure you completely sign out of webinar after the next slide!

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