ALTERNATIVE ENERGY SOLUTIONS®

State of Connecticut

Continuing Education for Electricians

Education Provider Application

2022 License Renewal Year

License Types: E-1, E-2, E-9 Unlimited License Holders

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DEPARTMENT OF ADMINISTRATIVE SERVICES

2018 Connecticut State Building Code

DIVISION OF CONSTRUCTION SERVICES
Office of the State Building Inspector

450 Columbus Boulevard
Hartford, CT 06103

MELODY A. CURREY
Commissioner

JOSEPH V. CASSIDY, P.E.
State Building Inspector

DRAFT
FOR PUBLIC COMMENT
JANUARY 2, 2018

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2018 CONNECTICUT STATE BUILDING CODE

INTRODUCTION

Adopted and Referenced Publications

Pursuant to Connecticut General Statute §29-252, as amended by Public Act 16-215, the following national model codes, as amended herein, are adopted and shall be known as the 2018 Connecticut State Building Code:

2015 International Building Code
2009 ICC/ANSI A117.1 Accessible and Usable Buildings and Facilities
2015 International Existing Building Code
2015 International Plumbing Code
2015 International Mechanical Code
2015 International Energy Conservation Code
2017 NFPA 70, National Electrical Code, of the National Fire Protection Association Inc.
2015 International Residential Code of the International Code Council, Inc.

Copies of the International Codes may be obtained from the International Code Council, Inc., 4051 West Flossmoor Road., Country Club Hills, IL 60478-5795 (website: www.iccsafe.org).

Copies of the 2017 NFPA 70, National Electrical Code, may be obtained from the National Fire Protection Association Inc., 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02169-7471 (website: www.nfpa.org).

Copies of the 2018 Connecticut State Building Code document may be downloaded from the website: www.portal.ct.gov/DAS.

The requirements of the 2018 State Building Code shall apply to all work for which a permit application was made on or after the date of adoption.

As used in this document, these annotations have the following meaning:

Add: A section or subsection preceded by (Add) indicates the addition of this section or subsection to the adopted referenced standard.

Amd: A section or subsection preceded by (Amd) indicates the substitution of this section or subsection in the adopted referenced standard.

Del: A section or subsection preceded by (Del) indicates the deletion of this section or subsection from the adopted referenced standard.

AMENDMENTS TO THE 2017 NFPA 70, NATIONAL ELECTRICAL CODE

ARTICLE 90 – INTRODUCTION

(Amd) **90.2 Scope.**

(A) Covered. This Code covers the installation of electrical conductors, equipment and raceways; signaling and communications conductors, equipment and raceways; and optical fiber cables and raceways for the following:

(1) Public and private premises, including:

a. buildings and structures;

b. installations in detached one- and two-family dwellings and multiple single-family dwellings (townhouses) not more than three stories in height with a separate means of egress and their accessory structures shall be in accordance with the requirements of this code or with the requirements of the 2015 International Residential Code portion of the State Building Code;

c. utility connections, additions and alterations to mobile homes;

d. utility connections to recreational vehicles; and

e. floating buildings.

(2) Yards, lots, parking lots, carnivals and industrial substations.

(3) Installations of conductors and equipment that connect to the supply of electricity.

(4) Installations used by the electric utility, such as office buildings, warehouses, garages, machine shops and recreational buildings that are not an integral part of a generating plant, substation or control center.

(B) Not covered. This code does not cover the following:

(1) Installations in ships, watercraft other than floating buildings, railway rolling stock, aircraft or automotive vehicles other than mobile homes and recreational vehicles

(2) Installations underground in mines and self-propelled mobile surface mining machinery and its attendant electrical trailing cable

(3) Installations of railways for generation, transformation, transmission or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communications purposes

(4) Installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations

(5) Installations under the exclusive control of an electric utility where such installations

a. Consist of service drops or service laterals, and associated metering; or

The State Building Inspector has the responsibility for administering the State Building Code, interpreting the State Building Code and for granting exceptions from specific rules of the State Building Code. See the definition of "Special Permission," and Article 90.4.

(Amd) **Special Permission.** For the purposes of this code, the authority having jurisdiction for granting the special permission contemplated in a number of rules is the State Building Inspector. Special permission shall be requested in writing using the Request for Modification of the State Building Code form available from local building departments or from the Office of the State Building Inspector, 450 Columbus Boulevard, Hartford CT 06103. www.portal.ct.gov/DAS.

CHAPTER 2 – WIRING AND PROTECTION

(Del) **240.67 Arc Energy Reduction.** Delete in its entirety without substitution.

(Amd) **250.50 Grounding Electrode System.** If available on the premises at each building or structure served, each item in 250.52 (A)(1) to (A)(7), inclusive, shall be bonded together to form the grounding electrode system. Where none of these grounding electrodes are available, one or more of the grounding electrodes specified in 250.52 (A)(4) to (A)(8), inclusive, shall be installed and used.

CHAPTER 3 – WIRING METHODS AND MATERIALS

(Add) **300.4.1 Drilling and notching.**

(A) Structural floor, wall, ceiling and roof members.

(1) Solid sawn lumber. Notches in solid lumber joists, rafters and beams shall not exceed one-sixth of the depth of the member, shall not be longer than one-third of the depth of the member and shall not be located in the middle one-third of the span. Notches at the ends of the member shall not exceed one-fourth the depth of the member. The tension side of members 4 inches or greater in nominal thickness shall not be notched except at the ends of the members. The diameter of holes bored or cut into members shall not exceed one-third the depth of the member. Holes shall not be closer than 2 inches to the top or bottom of the member, or to any other hole located in the member. Where the member is also notched, the hole shall not be closer than 2 inches to the notch.

Exception: Notches on cantilevered portions of rafters are permitted provided the dimension of the remaining portion of the rafter is not less than 4-inch nominal and the length of the cantilever does not exceed 24 inches.

(2) Engineered wood products. Cuts, notches and holes bored in trusses, structural composite lumber, structural glue-laminated members or I-joists are prohibited except where permitted by the manufacturer's recommendations or where the effects of such alterations are specifically considered in the design of the member by a registered design professional.

(3) Studs. Any stud in an exterior wall or interior bearing partition may be cut or notched to a depth not exceeding 25 percent of its width. Studs in nonbearing interior partitions may be notched to a depth not to exceed 40 percent of a single stud width. Any stud may be bored or drilled, provided that the diameter of the resulting hole is no greater than 40 percent of the stud width, the edge of the hole is no closer than 5/8 inch to the edge of the stud and the hole is not located in the same section as a cut or notch.

Exceptions:

The grounded conductor shall be extended to any switch location as necessary that require line-to-neutral voltage to operate the electronics of the switch in the standby mode and shall meet the requirements of 404.22.

Informational Note: The provision for a (future) grounded conductor is to complete a circuit path for electronic lighting control devices.

(Amd) **404.22 Electronic Lighting Control Switches**. Electronic lighting control switches shall be listed.

(Amd) **406.4 General Installation Requirements**

(D) Replacements. Replacement of receptacles shall comply with 406.4(D)(1), 406.4(D)(2), 406.4(D)(3), 406.4(D)(5) and 406.4(D)(6).

(D)(4) Arc-Fault Circuit-Interrupter Protection. Replacement receptacles are not required to be provided with arc-fault circuit-interrupter protection

(Amd) 440.14 Location

(Add) Exception No. 3: Where the interior section of a factory packaged split system is fed solely from the exterior section of the system and the disconnecting means for the exterior section is capable of being locked in the open position, a separate disconnecting means for the interior section shall not be required within sight from that section. The provisions for locking or adding a lock to the disconnecting means shall remain in place with or without the lock installed.

CHAPTER 5 - SPECIAL OCCUPANCIES

(Amd) 525.5 Overhead Conductor Clearances

(B) Clearances to Portable Structures

(2) Over 600 Volts.

(Add) **Exception:** Tents erected and dismantled under the supervision of a licensed electrician or other person approved by the authority having jurisdiction may be placed within the 15 feet (4.5 m) space provided the finished height of the tent is a minimum of 10 feet (3.0 m) below the conductors.

Chapter 6 – SPECIAL EQUIPMENT

(Amd) **690.12 Rapid Shutdown of PV Systems on Buildings.** PV system circuits installed on or in buildings shall include a rapid shutdown function to reduce shock hazard for emergency responders in accordance with 690.12(A) through (D).

Exception: Ground mounted PV system circuits that enter buildings, of which the sole purpose is to house PV system equipment, shall not be required to comply with 690.12

(A) Controlled Conductors. Requirements for controlled conductors shall apply to PV circuits supplied by the PV system.

(Amd) **105.1 Required.** Any owner or owner's authorized agent who intends to construct, enlarge, alter, repair, move, demolish or change the occupancy of a building or structure, or to move a lot line that will affect any existing building or structure, or to erect, install, enlarge, alter, repair, remove, convert or replace any electrical, gas, mechanical or plumbing system, the installation of which is regulated by this code, or to cause any such work to be performed, shall first make application to the building official and obtain the required permit.

(Add) **105.1.3 Connecticut State Fire Safety Code abatement.** Where conflicts exist between the requirements of this code and the requirements of a Connecticut State Fire Safety Code abatement order issued in writing by the local fire marshal with respect to an existing building, the requirements of that portion of the Connecticut State Fire Safety Code that regulates existing buildings shall take precedence.

Exceptions:

1. New fire protection systems shall meet the requirements of Chapter 9 of this code.
2. Electrical work shall meet the requirements of the NFPA 70, National Electrical Code.
3. Structural, plumbing and mechanical work shall conform to the requirements of this code.

(Amd) **105.2 Work exempt from permit.** Exemption from the permit requirements of this code shall not be deemed to grant authorization for any work to be done in any manner in violation of the provisions of this code or any other laws, statutes, regulations or ordinances of the jurisdiction. Permits shall not be required for the following:

Building:

1. One-story detached accessory structures used as tool and storage sheds, playhouses and similar uses, provided the floor area is not greater than 200 square feet (18.58 m^2).
2. Fences, other than swimming pool barriers, not over 7 feet (2134 mm) high.
3. Oil derricks.
4. Retaining walls that are not higher than 3 feet (914 mm) measured from finished grade at the bottom of the wall to finished grade at the top of the wall, unless supporting a surcharge or impounding Class I, II or III-A liquids.
5. Water tanks supported directly upon grade if the capacity does not exceed 5,000 gallons (18 927 L) and the ratio of height to diameter or width does not exceed 2 to 1.
6. Sidewalks, driveways and on-grade concrete or masonry patios not more than 30 inches (762 mm) above adjacent grade and not over any basement or story below and which are not part of an accessible route.
7. Painting, papering, tiling, carpeting, cabinets, countertops and similar finish work not involving structural changes or alterations.
8. Temporary motion picture, television and theater stage sets and scenery.
9. Prefabricated swimming pools accessory to a Use Group R-3 occupancy, as applicable in Section 101.2, which are equal to or less than 24 inches (610 mm) deep, do not exceed 5,000 gallons (18 927 L) capacity and are installed entirely above ground.
10. Shade cloth structures constructed for nursery or agricultural purposes and not including service systems.
11. Swings and other playground equipment.
12. Window awnings in Group R-3 and U occupancies, supported by an exterior wall that do not project more than 54 inches (1372 mm) from the exterior wall and do not require additional support.

2022 Continuing Education for Electricians

WARNING: **The contents of the following curriculum outline shall not be copied in whole or in part for any purpose other than to be used in this program. The developer of this program takes no responsibility for any typographical, technical or power point errors should they exist.**

CURRICULUM OUTLINE

(FOR ALL UNLIMITED ELECTRICAL LICENSE HOLDERS)

PART I – Connecticut General Statutes and Safety
(1 Hour Instructional Time)

Connecticut General Statutes & Regulations:

Include the following Connecticut General Statutes and Regulations in all course handouts to attendees for their future reference. *(Classroom review not required.)*

- Sec 20-340 Exemptions from licensing requirements
- Sec 20-332b, Sec 20-332c Hiring ratios re apprentices, journeymen and contractors (See Exhibit A below)
- Sec 20-332-15a Employment of apprentices
- Sec 20-332-15-a(f) How to register an apprentice
- Sec 20-332-16 Prohibited acts. Records. Lettering
- Sec 20-335 License fee. Continuing education requirements. Expiration and renewal
- 20-338a Work required to be performed by licensed persons
- Sec 20-338b Building permits applications. Who may sign
- Sec 20-338c Work not to commence until permit is obtained
- Sec 20-340 Exemptions from licensing requirements
- Sec 20-341 Penalties for violations

NEW OR CHANGED REGULATIONS – (TO BE REVIEWED WITH EACH CLASS)

- PA 21-37 – IN PART – SEE BELOW
- PA 21-154 – SEE BELOW

STATE OF CONNECTICUT

Substitute House Bill No. 6100

Public Act No. 21-37

AN ACT CONCERNING DEPARTMENT OF CONSUMER PROTECTION LICENSING AND ENFORCEMENT, ANTITRUST ISSUES AND THE PALLIATIVE USE OF MARIJUANA AND REVISIONS TO THE LIQUOR CONTROL ACT.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Sec. 16. Section 21a-10 of the general statutes is repealed and the following is substituted in lieu thereof (*Effective October 1, 2021*):

(a) The Commissioner of Consumer Protection may establish, combine or abolish divisions, sections or other units within the Department of Consumer Protection and allocate powers, duties and functions among such units, but no function vested by statute in any officer, division, board, agency or other unit within the department shall be removed from the jurisdiction of such officer, division, board, agency or other unit under the provisions of this section.

(b) The Commissioner of Consumer Protection shall adopt regulations, in accordance with chapter 54, to designate a staggered schedule for the renewal of all licenses, certificates, registrations and permits issued by said department. If such designation of a staggered schedule results in the expiration of any license, certificate, registration or permit for a period of less than or more than one year, said commissioner may charge a prorated amount for such license, certificate, registration or permit. For any new license, certificate, registration or permit that is issued and for any guaranty fund fee that is imposed on or after January 1, 1995,

the commissioner may charge a one-time prorated amount for such newly issued license, certificate, registration, permit or guaranty fund fee.

(c) For any Department of Consumer Protection license, certificate, registration or permit that requires the holder to complete continuing education requirements, the continuing education requirements shall be completed within the annual or biannual period that begins and ends three months prior to the renewal date for the applicable license, certificate, registration or permit, except for licenses issued pursuant to chapter 400j.

Sec. 23. (NEW) (*Effective January 1, 2022*) (a) No contract to perform work on a private residence, as defined in section 20-419 of the general statutes, by a contractor licensed pursuant to chapter 393 of the general statutes or any person who owns or controls a business engaged to provide the work or services licensed under the provisions of said chapter by persons licensed for such work, shall be valid or enforceable against an owner, as defined in section 20-419 of the general statutes, unless it: (1) Is in writing; (2) is signed by the owner and the contractor or business; (3) contains the entire agreement between the owner and the contractor or business; (4) contains the date of the transaction; (5) contains the name and address of the contractor and the contractor's license number or, in the case of a business, the name of the business owner, partner or limited liability member and the phone number and address of the business, partnership or limited liability company; (6) contains the name and license number of any licensees performing the work, provided the name and the license number of a licensee may be amended in writing during the term of the contract; (7) contains a notice of the owner's cancellation rights in accordance with the provisions of chapter 740 of the general statutes; and (8) contains a starting date and completion date.

(b) Each change in the terms and conditions of a contract specified in subsection (a) of this section shall be in writing and shall be signed by the owner and contractor or business, except that the commissioner may, by regulations adopted pursuant to chapter 54 of the general statutes, dispense with the necessity for complying with such requirement.

STATE OF CONNECTICUT

House Bill No. 6378

Public Act No. 21-154

AN ACT CODIFYING PREVAILING WAGE CONTRACT RATES.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Section 1. Subsection (d) of section 31-53 of the general statutes is repealed and the following is substituted in lieu thereof (*Effective October 1, 2021*):

(d) For the purpose of predetermining the prevailing rate of wage on an hourly basis and the amount of payment, [or] contributions and member benefits paid or payable on behalf of each person to any employee welfare fund, as defined in subsection (i) of this section, in each town where such contract is to be performed, the Labor Commissioner shall [(1) hold a hearing at any required time to determine the prevailing rate of wages on an hourly basis and the amount of payment or contributions paid or payable on behalf of each person to any employee welfare fund, as defined in subsection (i) of this section, upon any public work within any specified area, and shall establish classifications of skilled, semiskilled and ordinary labor, or (2)] adopt the rate of wages on an hourly basis in accordance with the provisions of this section and section 31-76c and the amount of payment, contributions and member benefits, including health, pension, annuity and apprenticeship funds, as recognized by the United States Department of Labor and the Labor Commissioner paid or payable on behalf of each person to any employee welfare fund, as defined in subsection (i) of this section, as established in the collective bargaining agreements or understandings between employers or employer associations and bona fide labor organizations for the same work in the same trade or occupation in the town in which the applicable building, heavy or highway works project is being constructed. For each trade or occupation for which more than one

collective bargaining agreement is in effect for the town in which such project is being constructed, the collective bargaining agreement of historical jurisdiction shall prevail. For residential project rates and for each trade or occupation for which there is no collective bargaining agreement in effect for the town in which the building, heavy or highway works project is being constructed, the Labor Commissioner shall adopt and use such appropriate and applicable prevailing wage rate determinations as have been made by the Secretary of Labor of the United States under the provisions of the Davis-Bacon Act, as amended.

Sec. 2. Section 31-54 of the general statutes is repealed and the following is substituted in lieu thereof (*Effective October 1, 2021*):

The Labor Commissioner shall **[**hold a hearing at any required time to**]** determine the prevailing rate of wages upon any highway contract within any specified area on an hourly basis and the amount of payment or contributions paid or payable on behalf of each employee to any employee welfare fund, as defined in section 31-53, as amended by this act, upon any classifications of skilled, semiskilled and ordinary labor. Said commissioner shall determine the prevailing rate of wages on an hourly basis and the amount of payment or contributions paid or payable on behalf of each employee to any employee welfare fund, as defined in section 31-53, as amended by this act, in each locality where any highway or bridge is to be constructed, and the Commissioner of Transportation shall include such rate of wage on an hourly basis and the amount of payment or contributions paid or payable on behalf of each employee to any employee welfare fund, as defined in section 31- 53, as amended by this act, or in lieu thereof, in cash as part of wages each pay day, for each classification of labor in the proposal for the contract and in the contract. The rate and the amount so established shall, at all times, be considered as the minimum rate of wage on an hourly basis and the amount of payment or contributions to an employee welfare fund, or cash in lieu thereof, for the classification for which it was established. Any contractor who pays any person at a lower rate of wage on an hourly basis or the amount of payment or contributions paid or payable on behalf of each employee to any employee welfare fund, as defined in section 31-53, as amended by this act, or where he is not obligated by any agreement to make payment or contributions to the employee welfare funds, as defined in section 31- 53, as amended by this act, and fails to pay the amount of such payment or contributions directly to the employee as a part of his wages each pay day, than that so established

for the classifications of work specified in any such contract shall be fined not more than two hundred dollars for each offense. The provisions of this section shall apply only to state highways and bridges on state highways.

Approved July 12, 2021

EXHIBIT A

Sec. 20-332b. Hiring ratios re apprentices, journeymen and contractors. Electrical, plumbing, heating, piping and cooling, sprinkler fitter and sheet metal work. Regulations. The Commissioner of Consumer Protection shall amend existing regulations of Connecticut state agencies adopted pursuant to section 20-332 to specify the following allowable hiring ratios regarding apprentices, journeymen and contractors for the following trades:

TRADE

Electrical, Plumbing, Heating, Piping and Cooling,
Sprinkler Fitter and Sheet Metal Work

Apprentices	Licensees (Journeymen or Contractors)
1	1
2	2
3	3
4	6
5	9
6	12
7	15
8	18
9	21
10	24

Ratio continues at 3 Journeypersons
To 1 Apprentice

(P.A. 10-27, S. 1; P.A. 17-76, S. 2.)

History: P.A. 10-27 effective May 10, 2010; P.A. 17-76 amended licensee numbers corresponding to apprentice numbers 3 to 10, effective June 27, 2017.

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Sec. 20-332c. Apprentice, journeymen and contractor working group established. Membership. Report. (a) There is established a working group to discuss hiring ratios for apprentices, journeymen and contractors and study the hiring ratio relief process. The working group shall meet at least three times annually and shall study and make recommendations related to apprentices, journeymen and contractors.

(b) The working group shall consist of ten members, and shall be evenly divided between members of the following union and nonunion industry trade groups: The International Brotherhood of Electrical Workers, the Independent Electrical Contractors of New England, the Associated Builders and Contractors of Connecticut, Sheet Metal Local 40, Sprinkler Fitters Local 669, the Connecticut Chapter of American Fire Sprinkler Association, the United Association of Plumbers and Pipefitters Local 777, the Plumbing Heating and Cooling Contractors of Connecticut, the Connecticut Heating and Cooling Contractors and the Connecticut State Building and Construction Trades Council. Each union industry trade group member shall be either the business manager of such group or such business manager's designee from such group. Each nonunion industry trade group member shall be either the president of such group or such president's designee from such group.

(c) Such members shall be selected as follows:

(1) Two union members appointed by the speaker of the House of Representatives;

(2) Two union members appointed by the president pro tempore of the Senate;

(3) One nonunion member appointed by the majority leader of the House of Representatives;

(4) One union member appointed by the majority leader of the Senate;

(5) Two nonunion members appointed by the minority leader of the House of Representatives; and

(6) Two nonunion members appointed by the minority leader of the Senate.

(d) All appointing authorities shall consult with the chairpersons and ranking members of the joint standing committee of the General Assembly having cognizance of matters relating to the Department of Consumer Protection prior to making any appointments pursuant to this section.

(e) All appointments to the working group shall be made not later than thirty days after the effective date of this section. Any vacancy shall be filled by the appointing authority.

(f) The members of the working group shall select the chairpersons of the working group from among the members of the group. One chairperson shall be a union member and one chairperson shall be a nonunion member. Such chairpersons shall schedule the first meeting of the working group.

(g) The administrative staff of the joint standing committee of the General Assembly having cognizance of matters relating to the Department of Consumer Protection shall serve as administrative staff of the working group.

(h) Not later than December 1, 2017, and annually thereafter, the working group shall submit a report on its recommendations to the joint standing committee of the General Assembly having cognizance of matters relating to the Department of Consumer Protection, in accordance with the provisions of section 11-4a.

(P.A. 17-76, S. 1.)

History: P.A. 17-76 effective June 27, 2017.

2018 Connecticut State Building Code: *(Include in all course handouts to attendees for their future use. Classroom review not required)*

All of the following 2018 State Building Codes are applicable to all license holders relative to each particular project. The State Building Official's website address is:

https://portal.ct.gov/DAS/Office-of-State-Building-Inspector/Building-and-Fire-Code-Adoption-Process/Documents

2018 CONNECTICUT STATE BUILDING CODE

2015 International Building Code
2009 ICC/ANSI A117.1 Accessible and Usable Buildings and Facilities
2015 International Existing Building Code
2015 International Plumbing Code
2015 International Mechanical Code
2015 International Energy Conservation Code
2017 NFPA 70, National Electrical Code, of the National Fire Protection Association Inc.
2015 International Residential Code of the International Code Council, Inc.
2018 Amendments to the Connecticut State Building Code

NOTE: Always refer to the State Building Officials website indicated above for all of the most currently adopted codes and "AMENDMENTS" to the codes.

Safety:

Instructors are to utilize only the following Power Point Presentation: "2022 CT Electrical Construction Safety Presentation".

PART II - NEC Calculations - (3 Hours Instructional Time)

Instructors are to utilize only the following Power Point Presentation: "2022 CT NEC Calculation Presentation".

END

Construction Safety

OSHA®
Occupational Safety and Health Administration

Top 10 OSHA Violations of 2020

1. Fall Protection (1926.501)

- Most cited OSHA violation for the past 10 years
- Leading cause of death in construction
- Lack of fall protection and proper training
- Annual citations issued for:
  - Fall Protection for Residential Construction
  - Unprotected Sides and Edges
  - Roofing Work on Low-sloped Roofs
  - Protection From Falling Through Holes

2. Hazard Communications (1910.134)

- Required to effectively communicate the health and safety risks of chemicals that are used and stored to workers
- Chemicals shall be labeled with signage
- Access to Safety Data Sheets (SDS)
- Train workers to recognize and understand the labels and SDS
- Annual citations issued for:
  - Written Communication Program
  - Employee Training
  - Safety Data Sheets
  - Labeling of Containers

3. Respiratory Protection (1910.134)

- Rose to number 3 from 5 on the top 10 in 2020 as thousands of workers were now wearing respirators because of COVID
- Employer must establish and maintain a respiratory program
- Program includes
  - Administration
  - Worksite-specific procedures
  - Employee Training
  - Medical Evaluations
  - Fit Testing
  - Proper cleaning and maintenance

4. Scaffolding (1926.451)

- It's estimated that 65% of workers in construction work on scaffolds
- More than 4,500 injuries and 60 fatalities each year
- Annual citations issued for:
  - Fall Protection
  - Providing Access
  - Platform Construction
  - Fall Protection
  - Erection, Dismantling, Moving, and Altering

5. Ladders (1926.1053)

- Nearly 60% of the fatalities in construction involve the use of ladders
- More than 310 workers killed
- More than 10,350 seriously injured
- Factors that contribute to falls:
  - Worker Inexperience or Lack or Training
  - No Fall Protection Program
  - Lack or Improper Fall Protection
  - Incorrect Working Length of Lifelines
  - Incorrect Anchorage Method

6. Control of Hazardous Energy (1910.147)

- Know as Lockout / Tagout (LOTO)
- Electrocution is the top 4th hazard in construction
- About 9% of construction workers fatalities are caused by electrocutions
- Annual citations issued for:
  - Developing, Documenting, and Utilizing Control Methods
  - Periodic Inspections of Energy Control Procedures
  - Establishing and Energy Control Plan
  - Training on the Energy Control Plan
  - Complying With the LOTO Procedures

7. Powered Industrial Trucks (1910.178)

- Powered Industrial Trucks include forklifts, tractors, and platform lift trucks
- Only trained and competent operators shall be permitted to operate powered industrial trucks
- No operators under 18 years of age
- Annual citations issued for:
  - Operator Training and Refresher Training
  - Certification of Operator
  - Taking Powered Industrial Trucks Out of Service

8. Fall Protection – Training Requirements (1926.503)

- **Plan – Provide – Train** for Fall Protection
- Employers must ensure employees know when fall protection is required
- Employers must train employees on how to use and inspect equipment
- Employer is responsible to keep a log of all employees that received training, including their signature and the date of training.
- Annual citations issued for:
  - Training Program
  - Retraining
  - Competent Person

9. Eye and Face Protection (1926.503)

- Every year thousands of workers are blinded by preventable eye injuries
- Protection required for flying debris, chemical exposure, harmful gases, and hazardous particles
- Employers are required to provide the proper PPE for eye and face protection
- Annual citations issued for:
  - PPE for Eyes and Face Protection
  - Side Protection for Flying Objects
  - Noncomplying PPE

10. Machinery & Machine Guarding 1910.212

- Moving machine parts have the potential injuries, such as crushed hands and fingers, amputations, burns, or blindness.
- Employees should be trained to use hazardous machinery properly
- Annual citations issued for:
  - Machine Guarding
  - Guarding Devices
  - Anchoring Fixed Machinery

Lockout/Tagout Requirements

OSHA requirements in 1910.147, 1910.333 and 1926.417

Control of Hazardous Energy (Lockout/Tagout)

This standard covers the servicing and maintenance of machines and equipment in which the unexpected energization or start-up of the machines or equipment, or release of stored energy, could harm employees. This standard establishes minimum performance requirements for the control of such hazardous energy.

Lockout/Tagout Procedures

Before any maintenance, construction, demolition, tie-in, inspection or servicing of equipment (electrical, mechanical, steam or other) that requires entrance into or close contact with machinery, equipment, power sources or line breaking, the power shall be disconnected and locked out.

NFPA 70E

- ARTICLE 120 Establishing an Electrically Safe Work Condition
- Informative Annex G Sample Lockout/Tagout Program

Lockout/Tagout Program

Definitions

- Employee (Contractor)
- Energy Source
- Energized
- Energy Isolation Device
- LOTO Device

Lockout/Tagout Program

Responsibility

- Designee to implement the program
- Qualified (Authorize) employee
  - Person who locks or unlocks
- Nonqualified (Affected) employee
  - An employee whose job require them to use the equipment that is locked out

Lockout/Tagout Program

Responsibility

- All employees shall be instructed in the safety significance of the LOTO procedure.
- Make any new employees aware
- All persons installing a lockout/tagout device shall sign their names and the date on the tag

Authorized Employee Training

- The recognition of hazardous sources
- The type and magnitude of energy
- The procedures for energy isolation and control
- Purpose and use of LOTO devices
- Penalties for not following procedures

Affected Employee Training

- Instructed in the purpose and use of the energy control procedures

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- Understand the penalties for attempted restarts

LOTO Sequence

- Identify all energy sources
- Notify affected employees
- Shut down the equipment following specific procedures
- Lockout all energy sources
- Stored or residual energy must be relieved
- Attempt restart only after the all clear and test
- Clear and Plug – Not required under specific conditions

Lockout/Tagout Program

Preparation for LOTO

- Review current drawings tags, labels, and signs to identify and locate all disconnecting means
- Make a list of disconnecting means to be locked
- Determine if it will be possible to verify a visible open point
- Review other work activity to identify where and how other personnel might be exposed to electrical hazards.

Lockout/Tagout Program

Preparation for LOTO

- Establish energy control methods for control of other hazardous energy sources in the area.
- Provide an adequately rated test instrument to test each phase conductor or circuit part to verify that they are deenergized
- Provide a method to determine that the test instrument is operating satisfactorily.

NFPA 70E 120.4(B)(6) Testing

(1) Test instrument to be used, the required PPE, and the person who will use it to verify proper operation of the test instrument on a known voltage source before and after use

(2) Requirement to define the boundary of the electrically safe work condition

(3) Requirement to test before touching every exposed conductor or circuit part(s) within the defined boundary of the work area

(4) Requirement to retest for absence of voltage when circuit conditions change or when the job location has been left unattended

(5) Planning considerations that include methods of verification where there is no accessible exposed point to take voltage measurements

Test Instruments

FLUKE.

IEC 61010 Electrical measurement category ratings for test tools

Important note: CAT ratings on test tools are different than hazard/risk category ratings on PPE gear. CAT ratings are determined by the potential transient impulse in the workplace that a connected test tool might experience. PPE requirements are determined by the surface energy level a user might experience.

Measurement 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	• Appliances, 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 than 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. Measurement categories. IEC 1010 applies to low-voltage (< 1000 V) test equipment.

ARTICLE 110 General Requirements for Electrical Safety-Related Work Practices

110.4 Energized Work.

110.4(B) Infeasibility.

Informational Note: Examples of work that might be performed within the limited approach boundary of exposed energized electrical conductors or circuit parts because of infeasibility due to equipment design operational limitations include performing diagnostics and testing (for example, start-up or troubleshooting) of electric circuits that can only be performed with the circuit energized and work on circuits that form integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

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Table 130.5(C)

Estimate of Likelihood of Occurrence of an Arc Flash Incident

Table 130.5(C) Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems

Task	Equipment Condition	Likelihoo Occurre
Reading a panel meter while operating a meter switch	Any	No
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, maintenance on a single cell of a battery system or multi-cell units in an open rack		
For ac systems, work on energized electrical conductors and circuit parts, including electrical testing	Any	Yes
Operation of a CB or switch the first time after installation or completion of maintenance in the equipment		
For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including electrical 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		

Table 130.7(C)(15)(a) PPE Categories

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 0.33 sec (2 cycles) fault clearing time, minimum working distance 455 mm (18 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 0.33 sec (2 cycles) fault clearing time, minimum working distance 455 mm (18 in.)		
600-volt class motor control centers (MCCs)	2	3.1 m (10 ft)
Parameters: Maximum of 65 kA available fault current, maximum of 0.33 sec (20 cycles) fault clearing time, minimum working distance 455 mm (18 in.)		
600-volt class motor control centers (MCCs)	4	4.2 m (14 ft)
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.)		

Table 130.7(C)(15)(c) Personal Protective Equipment

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/cm² (16.75 J/cm²) Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield 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) Heavy duty leather gloves Leather footwear (AN)
2	Arc Rated Clothing, Minimum Arc Rating of 8 cal/cm² (33.5 J/cm²) Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield 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) Heavy duty leather gloves Leather footwear
3	Arc Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm² (104.7 J/cm²)

LOTO Sequence

Notify affected employees

- Nonqualified employees shall be notified
- The qualified employee implementing the LOTO shall know the disconnecting means location for all sources of electrical energy and the location of all sources of stored energy.
- The qualified person shall be knowledgeable of hazards associated with electrical energy.

LOTO Sequence

Shut down the equipment following specific procedures

If the electrical supply is energized, the qualified person shall de-energize and disconnect the electric supply and relieve all stored energy.

LOTO Sequence

Shut down the equipment following specific procedures

Wherever possible, the blades of disconnecting devices should be visually verified to be fully opened

LOTO Sequence

Lockout all energy sources

Lockout/tagout all disconnecting means with lockout/tagout devices.

LOTO Sequence

Attempt restart only after the all clear and test

- Attempt to operate the disconnecting means to determine that operation is prohibited
- Test for the absence of voltage with voltage rated test instrument

LIVE –DEAD-LIVE Test

- Verify test instrument on a known source of voltage
- Test for the absence of voltage
- Verify test instrument on know source of voltage

LOTO Sequence

Tags

- Tags to be used with locks
- Able to withstand the environment
- Firmly attached and able to withstand 50 lbs. of unlocking strength
- Repercussions for anyone removing a lock or tag without authorization

Complex LOTO or Group Procedure

Permitted where one or more of the following exists:

(1) Multiple energy source
(2) Multiple crews
(3) Multiple crafts
(4) Multiple locations
(5) Multiple employers
(6) Multiple disconnecting means
(7) Particular sequences
(8) Job or task that continues for more than one work period

Complex LOTO or Group Procedure

- Identify the single authorized employee with overall responsibility
- Implement energy control and communicate with authorized employees
- Authorized employees must have an understanding of the hazards
- Each authorized employee places/removes their own lock
- The authorized employee in control only removes their lock after everyone else's are

Steps for Restoration of Equipment and Removal of Locks and Tags

- Inspect the work area to ensure that all personnel and tools are clear, and guards are in place
- Notify all affected employees before removing lockout devices
- Inspect area before startup

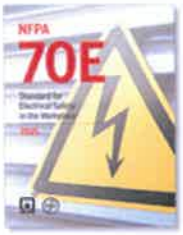
LOTO-SPECIFIC PROCEDURE

- Equipment Identification
- General Description
- Manufacturer
- Model Number
- Location of Equipment

LOTO-SPECIFIC PROCEDURE

- Types and Magnitude of Energy & Hazards
- Names of Qualified Persons authorized to LOTO
- Names of Affected Persons and how to notify them
- Types of Stored Energy

NFPA 70E Electrical Safety in the Workplace



ARTICLE 110 General Requirements for Electrical Safety-Related Work Practices

110.1 Priority.

Hazard elimination shall be the first priority in the implementation of safety-related work practices.

Informational Note No. 1: Elimination is the risk control method listed first in the hierarchy of risk control identified in 110.5(H)(3). See Annex F for examples of hazard elimination.

Informational Note No. 2: An electrically safe work condition is a state wherein all hazardous electrical conductors or circuit parts to which a worker might be exposed are placed and maintained in a de-energistate, for the purpose of temporarily eliminating electrical hazards. See Article 120 for requirements to establish an electrically safe work condition for the period of time for which the state is maintained. See Informative Annex F for information regarding the hierarchy of risk control and hazard elimination.

ARTICLE 110 General Requirements for Electrical Safety-Related Work Practices

110.2 General.

Electrical conductors and circuit parts shall not be considered to be in an electrically safe work condition until all of the requirements of Article 120 have been met.

Safe work practices applicable to the circuit voltage and energy level shall be used in accordance with Article 110 and Article 130 until such time that electrical conductors and circuit parts are in an electrically work condition.

Informational Note: See 120.5 for the steps to establish and verify an electrically safe work condition.

ARTICLE 110 General Requirements for Electrical Safety-Related Work Practices

110.3 Electrically Safe Work Condition.

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 follow conditions exist:

(1) The employee is within the limited approach boundary.

(2) 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.

ARTICLE 110 General Requirements for Electrical Safety-Related Work Practices

110.4 Energized Work.

110.4(A) Additional Hazards or Increased Risk.

Energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increased risk.

Informational Note: Examples of additional hazards or increased risk include, but are not limited to, interruption of life-support equipment, deactivation of emergency alarm systems, and shutdown of hazardous location ventilation equipment.

ARTICLE 110 General Requirements for Electrical Safety-Related Work Practices

110.4 Energized Work.

110.4(B) Infeasibility.

Energized work shall be permitted where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.

ARTICLE 110 General Requirements for Electrical Safety-Related Work Practices

110.4 Energized Work.

110.4(B) Infeasibility.

Informational Note: Examples of work that might be performed within the limited approach boundary of exposed energized electrical conductors or circuit parts because of infeasibility due to equipment design operational limitations include performing diagnostics and testing (for example, start-up or troubleshooting) of electric circuits that can only be performed with the circuit energized and work on circuits that form integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

ARTICLE 130
Work Involving Electrical Hazards

130.1 General.

Article 130 covers requirements for work involving electrical hazards such as the electrical safety-related work practices, assessments, precautions, and procedures when an electrically safe work condition cannot be established.

Safety-related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized.

ARTICLE 130
Work Involving Electrical Hazards

130.1 General.

When energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts are not put into an electrically safe work condition, and work is performed as permitted in accordance with 110.4, all of the following requirements shall apply:

(1) Only qualified persons shall be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition.

(2) An energized electrical work permit shall be completed as required by 130.2.

(3) A shock risk assessment shall be performed as required by 130.4.

(4) An arc flash risk assessment shall be performed as required by 130.5.

All requirements of Article 130 shall apply whether an incident energy analysis is completed or if Table 130.7(C)(15)(a), Table 130.7(C)(15)(b), and Table 130.7(C)(15)(c) are used in lieu of an incident energy analysis.

ARTICLE 130
Work Involving Electrical Hazards

130.5 Arc Flash Risk Assessment.

130.5(A) General.

An arc flash risk assessment shall be performed:

(1) To identify arc flash hazards

(2) To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health

(3) To determine if additional protective measures are required, including the use of PPE

ARTICLE 130
Work Involving Electrical Hazards

130.5 Arc Flash Risk Assessment.

130.5(F) Arc Flash PPE.

One of the following methods shall be used for the selection of arc flash PPE:

(1) The incident energy analysis method in accordance with 130.5(G)

(2) The arc flash PPE category method in accordance with 130.7(C)(15)

Either, but not both, methods shall be permitted to be used on the same piece of equipment. The results of an incident energy analysis to specify an arc flash PPE category in Table 130.7(C)(15)(c) shall not be permitted.

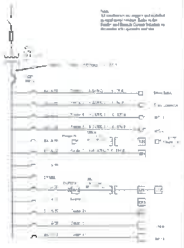
Electrical Task 1

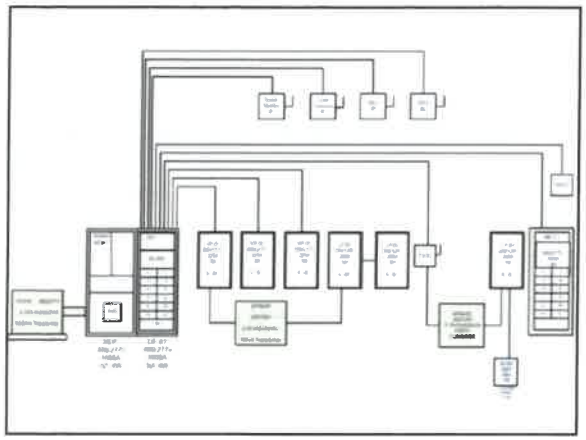
Referring to the one-line diagrams, panel schedules, feeder and transformer schedules, arc flash study, and arc flash labels select the required personal protective equipment for arc flash, arc blast, and electric shock protection. Select the required PPE.

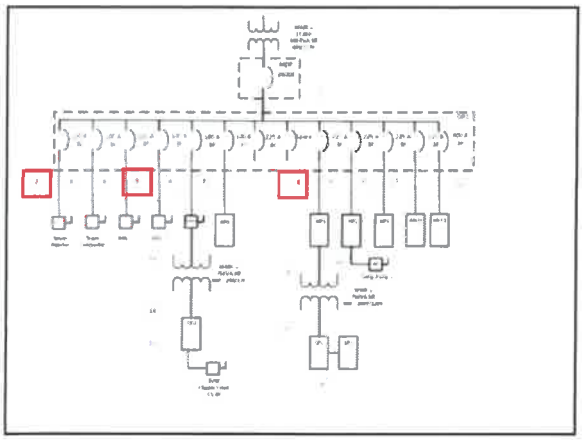
NFPA 70E 2021 Edition can be viewed with free access online at www.nfpa.org by selecting NPFA 70E under the List of NFPA Codes & Standards.

Refer to Appendix A

- One-line diagrams
- Panel Schedules
- Feeder & Branch Circuit Schedule
- Transformer Schedule
- Equipment Duty Report
- Arc Flash Hazard Report
- Arc Flash Labels for Equipment
- Conductors & Busways "C" Values







Panel Schedules

SWITCHBOARD DP1 SCHEDULE

PANELBOARD HP1 SCHEDULE

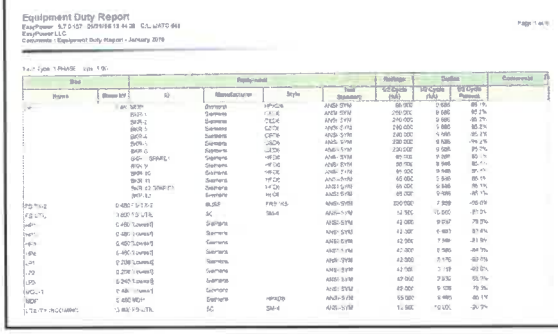
Feeder and Branch Circuit Schedule

Feeder Schedule				
Feeder Designation	Wire Quantity & Size	Ground Wire Quantity & Size	Conduit Size	Length (Feet)
1	4 Runs 4 – 600 kcmil	1 - 4/0 AWG	4"	100
2	3 - 3 AWG	1 - 6 AWG	1 ¼"	70
3	3 - 2 AWG	1 - 6 AWG	1 ¼"	80
4	3 - 2 AWG	1 - 6 AWG	1 ¼"	120
5	3 - 3 AWG	1 - 6 AWG	1 ¼"	150
6	3 - 2 AWG	1 - 6 AWG	1 ¼"	80
7	4 – 4/0 AWG	1 - 6 AWG	2"	240
8	4 – 4/0 AWG	1 - 4 AWG	2"	40
9	4 – 4/0 AWG	1 - 4 AWG	2"	200
10	4 – 4/0 AWG	1 - 4 AWG	2"	145
11	4 – 4/0 AWG	1 - 4 AWG	2"	180
12	3 Runs 4 – 350 kcmil	1 - 1 AWG	3"	80
13	3 - 3 AWG	1 - 6 AWG	1 ¼"	80
14	4 – 3/0 AWG	1 - 6 AWG	2"	80
15	2 – 8 AWG	1 - 10 AWG	1"	125
16	3 – 4 AWG	1 - 6 AWG	1 ¼"	82
17	4 – 3/0 AWG	1 - 6 AWG	2"	18
18	4 – 3/0 AWG	1 - 6 AWG	2"	70

Transformer Schedule

Transformer Schedule						
Transformer Designation	Location	kVA Rating	Primary Voltage	Secondary Voltage	Impedance	Remarks
XMFR - 1	Pad Mount	500	13,800	480/277	5.75%	TX-UTIL
XMFR - 2	Shop Area	75	480	240/120	5.1%	TX - 2
XMFR - 3	Electrical Rm.	75	480	208/120	5.%	TX - 3

Equipment Duty Report


Equipment Duty Report

EasyPower LLC

Arc Flash Hazard Report

Arc Flash Hazard Report

Arc Flash Labels for Equipment

WARNING

Arc Flash and Shock Risk Assessment
Appropriate PPE Required

0' - 5"	Arc Flash Boundary
6.2	cal/cm2 at 18 inches - Arc Flash Incident Energy
	Refer to NFPA 70E-2015 Table H.3(b)
0.48	kV Shock Hazard when cover is removed
3' - 6"	Limited Approach
1' - 0"	Restricted Approach - Class 00 Voltage Gloves

Equipment Name: HP1 (Fed by: BKR-9)
SNEET - January, 2016

Conductors and Busways "C" Values

Conductors and Busways "C" Values

AWG or kcmil	Copper						Copper					
	Three Single Conductors						Three Conductor Cable					
	Steel Conduit			Nonmagnetic Conduit			Steel Conduit			Nonmagnetic Conduit		
	600V	5kV	15kV	600V	5kV	15kV	600V	5kV	15kV	600V	5kV	15kV
14	389			389			389			389		
12	617	617		617			617			617		
10	981	981		982			982			982		
8	1557	1551		1559	1555		1559	1557		1560	1558	
6	2425	2406	2389	2430	2418	2407	2431	2425	2415	2433	2428	2421
3	3806	3751	3696	3826	3789	3753	3830	3812	3779	3838	3823	3798
4	4774	4674	4577	4811	4745	4679	4820	4785	4726	4833	4803	4762
2	5907	5736	5574	6044	5926	5809	5989	5930	5828	6087	6023	5958
1	7293	7029	6759	7493	7307	7109	7454	7365	7189	7579	7507	7364
1/0	8925	8544	7973	9317	9034	8590	9210	9086	8708	9473	9373	9053
2/0	10755	10062	9390	11424	10878	10319	11245	11045	10500	11703	11529	11053
3/0	12844	11804	11022	13923	13048	12360	13656	13333	12613	14410	14119	13462
4/0	15082	13606	12543	16673	15351	14347	16392	15890	14813	17483	17020	16013
250	16483	14925	13844	18594	17121	15968	18311	17851	16466	19779	19352	18001
300	18177	16293	14769	20868	18975	17409	20617	20052	18313	22525	21938	20163
350	19704	17385	15678	22737	20526	18672	22646	21914	19821	24904	24126	21982
400	20566	18235	16366	27297	21786	19731	24253	23372	21042	26918	26044	23518
500	22185	19172	17492	26706	23277	21330	26980	25449	23126	30096	28712	25916
600	22965	20567	17962	28033	25204	22097	28752	27975	24897	32154	31258	27766
750	24137	21387	18889	29735	26453	23408	31051	30024	26933	34605	33315	29735
1000	25278	22539	19923	31491	28083	24887	33864	32689	29320	37197	35749	31959

[1] These values are equal to one over the impedance per foot and based upon resistance and reactance values found in IEEE Std 241-1990.

Electrical Task 1

The training center added a new wiring lab requiring 120/208 panels installed in each of the wiring booths. The installation of panel LP1 requires adding a transformer to be supplied by panel HP1. Safety-related work practices shall be used to safeguard employees from injury while exposed to electrical hazards from electrical conductors or circuit parts that can become energized. Panel HP1 shall be placed into an Electrically Safe Work Condition prior to any task required for the new installation.

Electrical Task 1

- Scenario 1 select the proper arc flash PPE using the incident energy analysis method in accordance with 130.5(G)
- Scenario 2 select the proper arc flash PPE using the arc flash PPE category method in accordance with 130.7(C)(15)

Scenario 1

130.5 Arc Flash Risk Assessment.

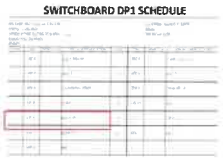
130.5(F) Arc Flash PPE.

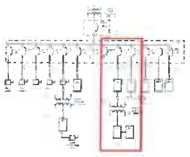
One of the following methods shall be used for the selection of arc flash PPE:

(1) The incident energy analysis method in accordance with 130.5(G)

Scenario 1

1. What breaker is requires LOTO for panel HP1 to be in an electrically safe work condition?
   - Panel DP1 Breaker 9
   - Found on Panel Schedule for DP1
   - Found on One-line diagram (Note the number in the box refers to the feeder).



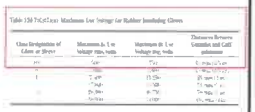


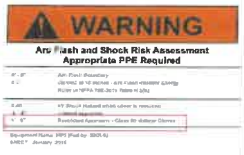
Scenario 1

2. Based on the results of the Arc Flash Study what is shock hazard at panel HP1 that an employee is exposed to?
   - Panel HP1 Panel Schedule, Arc Flash Label HP1
   - 480 Volts

Scenario 1

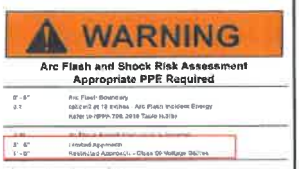
3. What is the minimum class of rubber insulating gloves required for shock protection while verifying for the absence of voltage at panel HP1 after with the appropriate category rated test instrument?
   - Table 130.7(C)(7)(a) Maximum Use Voltage for Rubber Insulating Gloves
   - Class 00 - 500 Volts





Scenario 1

4. What are the following Approach Boundaries?



a. Limited Approach

3' – 6"

b. Restricted Approach

1' – 0"

Scenario 1

5. What is the Arc Flash Boundary?

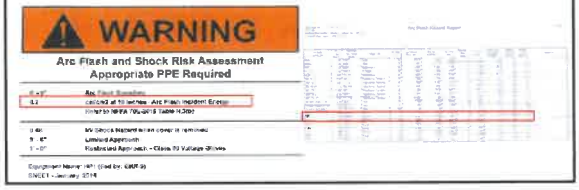
0' – 5"

Scenario 1

6. What is the Incident Energy at Panel HP1?

Panel HP1 Arc Flash Label, Arc Flash Hazard Report

0.2 cal/cm^2 at 18 Inches



Scenario 1

7. What is the minimum Arc-Rated for Arc Rated Clothing in cal/cm2 based on the results of the Arc Flash Study?

Table 130.5(G) Selection of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method Is Used

0.2 cal/cm² or greater

Scenario 1

Table 130.5(G)

Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Arc-rated long-sleeve shirt and pants or arc-rated 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, high-visibility apparel) (AN)[e]
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[d]

Electrical Task 1

The training center added a new wiring lab requiring 120/208 panels installed in each of the wiring booths. The installation of panel LP1 requires adding a transformer to be supplied by panel HP1. Safety-related work practices shall be used to safeguard employees from injury while exposed to electrical hazards from electrical conductors or circuit parts that can become energized. Panel HP1 shall be placed into an Electrically Safe Work Condition prior to any task required for the new installation.

Scenario 2

130.5 Arc Flash Risk Assessment.

130.5(F) Arc Flash PPE.

One of the following methods shall be used for the selection of arc flash PPE:

(2) The arc flash PPE category method in accordance with 130.7(C)(15)

Scenario 2

130.7(C)(15) Arc Flash PPE Category Method.
The requirements of 130.7(C)(15) shall apply when the arc flash PPE category method is used for the selection of arc flash PPE.

(a) *Alternating Current (ac) Equipment.* When the arc flash risk assessment performed in accordance with 130.5 indicates that arc flash PPE is required and the arc flash PPE category method is used for the selection of PPE for ac systems in lieu of the incident energy analysis of 130.5(G), Table 130.7(C) (15) (a) shall be used to determine the arc flash PPE category. The estimated maximum available fault current, maximum fault-clearing times, and minimum working distances for various ac equipment types or classifications are listed in Table 130.7(C)(15)(a). An incident energy analysis shall be required in accordance with 130.5(G) for the following:
(1) Power systems with greater than the estimated maximum available fault current
(2) Power systems with longer than the maximum fault clearing times
(3) Less than the minimum working distance

Scenario 2

(c) *Protective Clothing and Personal Protective Equipment (PPE).* Once the arc flash PPE category has been identified from Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b), Table 130.7(C)(15)(c) shall be used to determine the required PPE. Table 130.7(C)(15)(c) lists the requirements for PPE based on arc flash PPE categories 1 through 4. This clothing and equipment shall be used when working within the arc flash boundary. The use of PPE other than or in addition to that listed shall be permitted provided it meets 130.7(C)(7).

(Note there are three Informational Notes)

Scenario 2

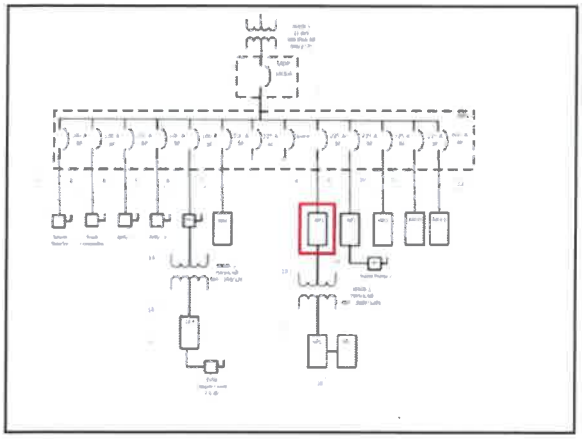
Table 130.7(C)(15)(a) Arc Flash PPE Categories for Alternating Current (ac) Systems

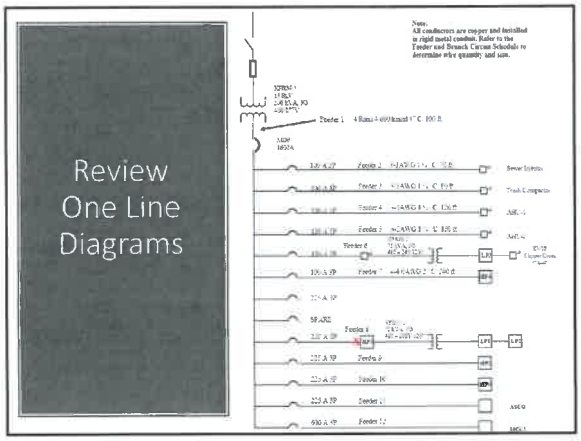
Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 volts and below	1	485 mm (19 in.)
Parameters: Maximum of 25 kA available fault current, maximum of 0.03 sec (2 cycles) fault clearing time, minimum working distance 455 mm (18 in.)		
Panelboards or other equipment rated greater than 240 volts and up to 600 volts	3	900 mm (3 ft)
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.)		
600-volt class motor control centers (MCCs)	2	1.5 m (5 ft)
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.)		
600-volt class motor control centers (MCCs)	4	4.2 m (14 ft)
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.)		

Table 130.7(C)(15)(c) Personal Protective Equipment

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/cm² (16.75 J/cm²) Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield or arc flash suit hood Arc-rated jacket, parka, raincoat, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heat-resistant leather gloves Leather footwear
2	Arc Rated Clothing, Minimum Arc Rating of 8 cal/cm² (33.5 J/cm²) Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield and arc-rated balaclava Arc-rated jacket, parka, raincoat, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heat-resistant leather gloves Leather footwear
3	Arc Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm² (104.7 J/cm²)





Scenario 2 - Fault XFRM-1

Calculate the available Fault Current on the Transformer Secondary with Infinite Primary Available.

Step 1: Determine the transformer full-load amperes (IFLA)

$$I_{FLA} = \frac{kVA \times 1{,}000}{E_{L\text{-}L} \times 1.732}$$

$$\frac{500 \times 1{,}000}{480 \times 1.732}$$

$$\frac{500{,}000}{831.36}$$

$I_{FLA} = 601$ A

Where:

$E_{L\text{-}L}$ = line-to-line volt

kVA = transformer kVA

Scenario 2 - Fault XFRM-1

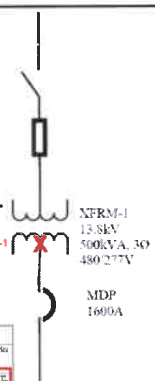
Calculate the available Fault Current on the Transformer Secondary with Infinite Primary Available.

Step 2: Determine the transformer multiplier.

$$\text{Multiplier} = \frac{100}{\%Z}$$

Transformer Schedule

Transformer Designation	Location	kVA Rating	Primary Voltage	Secondary Voltage	Impedance	Remarks
XMER - 1	Pad Mount	500	13,800	480/277	2.99%	TX-UTIL
XMER - 2	Shop Area	75	480	208/120	2.8%	TX - 2
XMER - 3	Electrical Rm	75	480	208/120	2.8%	TX - 3



Scenario 2 - Fault XFRM-1

Calculate the available Fault Current on the Transformer Secondary with Infinite Primary Available.

Step 2: Determine the transformer multiplier.

$$\text{Multiplier} = \frac{100}{\%Z} = \frac{100}{5.75} = 17.391$$

Note:

The nameplate transformer impedance (%Z) value may vary +/- 10% from the actual values determined by UL Standard 1561. For high-fault condition scenario, multiply the transformer %Z by 0.9, and for low-fault condition scenario, multiply the %Z by 1.1. Use 1.0 times %Z for no impedance tolerance effect.

Scenario 2 - Fault XFRM-1

Calculate the available Fault Current on the Transformer Secondary with Infinite Primary Available.

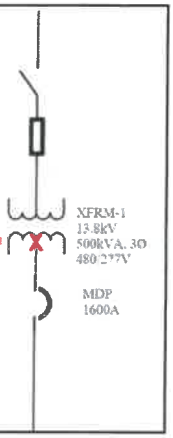
Step 3: Determine the available fault current (IFC) at the 3-phase utility transformer secondary.

IFC (L-L-L) = IFLA x Multiplier

IFC (L-L-L) = 601 x 17.391 = 10,452

Note:

The utility voltage may vary +/- 10% for power, and +/- 5.8% for 120-volt lighting services.



Scenario 2 - Fault MDP

Calculate the available Fault Current Main Distribution Panel (MDP).

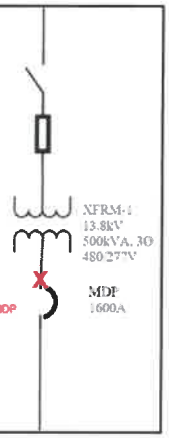
Step 4: Calculate the "f" factor.

$$f = \frac{1.732 \times L \times I_{FC\,(L\text{-}L\text{-}L)}}{C \times n \times E_{L\text{-}L}}$$

Where:

L = length (feet) of conduit to the fault
C = constant for conductors or busway
n = number of conductors per phase (adjusts the "C" value for parallel runs)
I_{FC} = available fault current in amperes at the beginning of the circuit.
$E_{L\text{-}L}$ = line-to-line voltage

Note the "C" value for the conductors is found on the "C" value table.



Feeder & Branch Circuit Schedule

Feeder Schedule				
Feeder Designation	Wire Quantity & Size	Ground Wire Quantity & Size	Conduit Size	Length (Feet)
1	4 Runs 4 – 600 kcmil	1 - 4/0 AWG	4"	100
2	3 - 3 AWG	1 – 6 AWG	1 ¼"	70
3	3 - 3 AWG	1 – 6 AWG	1 ¼"	80
4	3 - 3 AWG	1 – 6 AWG	1 ¼"	120
5	3 - 3 AWG	1 – 6 AWG	1 ¼"	150
6	3 - 2 AWG	1 – 6 AWG	1 ½"	60
7	4 – 4/0 AWG	1 – 6 AWG	2"	240
8	4 – 4/0 AWG	1 – 4 AWG	2"	40
9	4 – 4/0 AWG	1 – 4 AWG	2"	200
10	4 – 4/0 AWG	1 – 4 AWG	2"	145

Conductors and Busways "C" Values

Conductors and Busways "C" Values

AWG or kcmil	Copper – Three Single Conductors – Steel Conduit 600V	5kV	15kV	Nonmagnetic Conduit 600V	5kV	15kV	Copper – Three Conductor Cable – Steel Conduit 600V	5kV	15kV	Nonmagnetic Conduit 600V	5kV	15kV
14	389			389			389			389		
12	617	617		617			617			617		
10	981	981		982			982			982		
8	1557	1551		1559	1555		1559	1557		1560	1558	
6	2425	2406	2389	2430	2418	2407	2431	2425	2415	2433	2428	2421
4	3806	3751	3696	3826	3789	3753	3830	3812	3779	3838	3823	3798
3	4774	4674	4577	4811	4745	4679	4820	4785	4726	4833	4803	4762
2	5907	5736	5574	6044	5926	5809	5989	5930	5828	6087	6023	5958
1	7293	7029	6759	7493	7307	7109	7454	7365	7189	7579	7507	7364
1/0	8925	8544	7973	9317	9034	8590	9210	9086	8708	9473	9373	9053
2/0	10755	10062	9390	11424	10878	10319	11245	11045	10500	11703	11529	11053
3/0	12844	11804	11022	13923	13048	12360	13656	13333	12613	14410	14119	13462
4/0	15082	13606	12543	16673	15351	14347	16392	15890	14813	17483	17020	16013
250	16483	14925	13644	18594	17121	15866	18311	17851	16466	19779	19352	18001
300	18177	16293	14709	20868	18975	17409	20617	20052	18319	22525	21938	20163
350	19704	17385	15678	22737	20526	18672	22646	21914	19821	24904	24126	21982
400	20566	18235	16366	27297	21786	19731	24253	23372	21042	26916	26044	23518
500	22185	19172	17492	26706	23277	21330	26980	25449	23126	30096	28712	25916
600	22965	20567	17962	28033	25204	22097	28752	27975	24897	32154	31258	27766
750	24137	21387	18889	29735	26453	23408	31051	30024	26933	34605	33315	29735
1000	25278	22539	19923	31491	28083	24887	33864	32689	29320	37197	35749	31959

* These values are equal to one over the impedance per foot and based upon resistance and reactance values found in IEEE Std 241-1990.

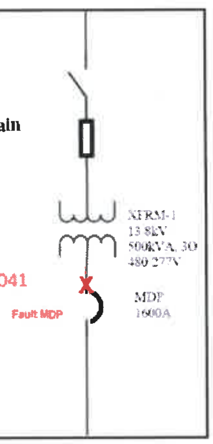
Scenario 2 - Fault MDP

Calculate the available Fault Current Main Distribution Panel (MDP).

Step 4: Calculate the "f" factor.

$$f = \frac{1.732 \times L \times I_{FC\,(L\text{-}L\text{-}L)}}{C \times n \times E_{L\text{-}L}}$$

$$f = \frac{1.732 \times 100 \times 10{,}452}{22{,}965 \times 4 \times 480} = 0.041$$



Scenario 2 - Fault MDP

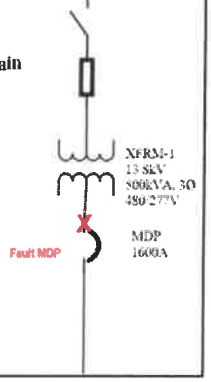
Calculate the available Fault Current Main Distribution Panel (MDP).

Step 5: Determine the "M" (multiplier).

$$M = \frac{1}{1 + f}$$

$$M = \frac{1}{1.041}$$

M = 0.961



Scenario 2 - Fault MDP

Calculate the available Fault Current Main Distribution Panel (MDP).

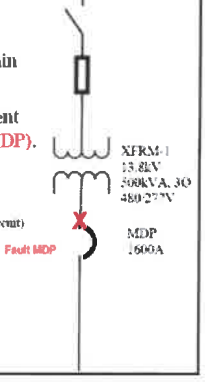
Step 6: Calculate the available fault current (IFC) at the end of the circuit (Fault at MDP).

IFC (L-L-L) = **IFC (L-L-L) x M**

(At the end of the circuit) (At the beginning of the circuit)

$IFC_{(L-L-L)} = 10{,}452 \times .961$

$IFC_{(L-L-L)} = 10{,}044\ A$

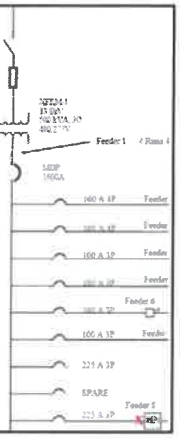


Scenario 2 - Fault HP1

Calculate the available Fault Current Panel HP1.

Step 7: Calculate the "f" factor.

$$f = \frac{1.732 \times L \times I_{FC\,(L-L)}}{C \times n \times E_{L-L}}$$



Feeder & Branch Circuit Schedule

Feeder Schedule				
Feeder Designation	Wire Quantity & Size	Ground Wire Quantity & Size	Conduit Size	Length (Feet)
1	4 Runs 4 – 600 kcmil	1 - 4/0 AWG	4"	100
2	3 - 3 AWG	1 – 6 AWG	1 ½"	70
3	3 - 3 AWG	1 – 6 AWG	1 ½"	80
4	3 - 3 AWG	1 – 6 AWG	1 ½"	120
5	3 - 3 AWG	1 – 6 AWG	1 ½"	150
6	3 - 2 AWG	1 – 6 AWG	1 ½"	60
7	4 – 4/0 AWG	1 – 6 AWG	2"	240
8	4 – 4/0 AWG	1 – 4 AWG	2"	40
9	4 – 4/0 AWG	1 – 4 AWG	2"	200
10	4 – 4/0 AWG	1 – 4 AWG	2"	145

Conductors and Busways "C" Values

Conductors and Busways "C" Values

AWG or kcmil	Copper						Copper					
	Three Single Conductors						Three Conductor Cable					
	Steel Conduit			Nonmagnetic Conduit			Steel Conduit			Nonmagnetic Conduit		
	600V	5kV	15kV	600V	5kV	15kV	600V	5kV	15kV	600V	5kV	15kV
14	389			389			389			389		
12	617	617		617			617			617		
10	981	981		982			982			982		
8	1557	1551		1559	1555		1559	1557		1560	1558	
6	2425	2406	2389	2430	2418	2407	2431	2425	2415	2433	2428	2421
4	3806	3751	3806	3826	3789	3753	3830	3812	3779	3838	3823	3798
3	4774	4674	4577	4811	4745	4678	4820	4785	4726	4833	4803	4762
2	5907	5736	5574	6044	5926	5809	5989	5930	5828	6087	6023	5958
1	7293	7029	6759	7493	7307	7109	7454	7365	7189	7579	7507	7364
1/0	8925	8544	7973	9317	9034	8590	9210	9086	8708	9473	9373	9053
2/0	10755	10062	9390	11424	10878	10319	11245	11045	10500	11703	11529	11053
3/0	12844	11804	11022	13923	13048	12360	13656	13333	12613	14410	14119	13462
4/0	15082	13606	12543	16673	15351	14347	16392	15890	14813	17483	17020	16013
250	16483	14925	13644	18594	17121	15866	18311	17851	16466	19779	19352	18001
300	18177	16293	14769	20868	18975	17409	20617	20052	18319	22525	21938	20163
350	19704	17385	15678	22737	20526	18672	22646	21914	19821	24904	24126	21982
400	20566	18235	15386	27297	21786	19731	24253	23372	21042	26916	26044	23518
500	22185	19172	17492	26706	23277	21330	26980	25449	23126	30096	28712	25916
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1000	25278	22539	19923	31491	28083	24887	33864	32689	29320	37197	35749	31959

* These values are equal to one over the impedance per foot and based upon resistance and reactance values found in IEEE Std 241-1990.

Scenario 2 - Fault HP1

Calculate the available Fault Current Panel HP1.

Step 7: Calculate the "f" factor.

$$f = \frac{1.732 \times 40 \times 10{,}044}{15{,}082 \times 4 \times 480} = 0.024$$

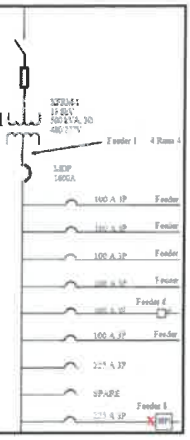
Scenario 2 - Fault HP1

Calculate the available Fault Current Panel HP1.

Step 8: Determine the "M" (multiplier).

$$M = \frac{1}{1 + f}$$

$$M = \frac{1}{1.041} = 0.961$$



Scenario 2 - Fault HP1

Calculate the available Fault Current Panel HP1.

Step 9: Calculate the available fault current (I_{FC}) at the end of the circuit (Fault at HP1).

IFC (L-L-L) = IFC (L-L-L) x M

(At the end of the circuit) (At the beginning of the circuit)

$I_{FC(L-L-L)}$ = 10,044 x .977

$I_{FC(L-L-L)}$ = 9,813 A

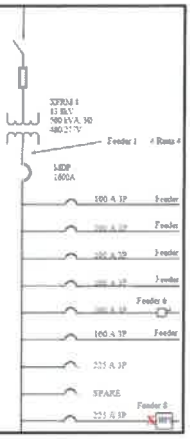


Table 130.7(C)(15)(a) Arc Flash PPE Categories for Alternating Current (ac) Systems

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 volts and below	1	485 mm (19 in.)
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.)		
Panelboards or other equipment rated greater than 240 volts and up to 600 volts	2	900 mm (36 in.)
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.)		
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.)		

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/cm² (16.75 J/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, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[e]
	Leather footwear[f] (AN)
2	**Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm² (33.5 J/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, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[e]
	Leather footwear[f]

Comparison of Methods in 130.5(F)

130.5(F)(1) and (2) Arc Flash PPE		
	(F)(1) Incident Energy	(F)(2) PPE Category Method
Shock Hazard	480 V	480 V
Limited Approach	3' 6"	3' 6"
Restricted Approach	1' 0"	1' 0"
Arc Flash Boundary	0' 5"	3' 0"
Incident Energy to Select Arc Flash PPE	0. 2 cal/cm²	8 cal/cm²
Short Circuit Current at Panel HP1	9,037 A	9,813 A

QUESTIONS?

2022 Calculation Questions

Chapter 1

110.14(C) Temperature Limitations

Question 1

A 2 AWG THHN aluminum conductor is connected to a circuit breaker with termination temperature limitation marked (not to exceed) 60°C and marked for CU AL conductors. What is the allowable ampacity of the 2 AWG THHN aluminum conductor now that it is connected to this circuit breaker?

110.14(C)(a)(2)

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

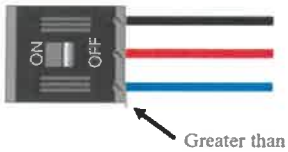
(1) **Equipment Provisions.** The determination of termination provisions of equipment shall be based on 110.14(C)(1)(a) or (C)(1)(b). Unless the equipment is listed and marked otherwise, conductor ampacities used in determining equipment termination provisions shall be based on Table 310.15(B)(16) as appropriately modified by 310.15(B)(7).

(a) Termination provisions of equipment for circuits rated 100 amperes or less, or marked for 14 AWG through 1 AWG conductors, shall be used only for one of the following:

(1) Conductors rated 60°C (140°F)

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

Question 2



Greater than 100 amps

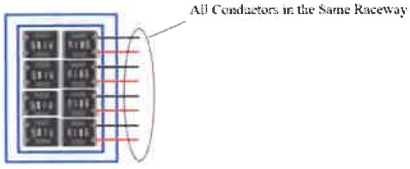
What is the allowable ampacity of the 4/0 AWG THWN copper conductor connected to a circuit breaker with wire connection temperature limitation marked (not to exceed) 75° C?

110.114(C)(1)(b)(2)

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

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

Question 3



Eight 6 AWG THHN copper current-carrying conductors are installed to replace existing wiring within an existing single rigid metal conduit. Type RMC.
The area of installation has an ambient temperature of 30°C. The new eight 6 AWG THHN conductors are connected to existing 50-ampere 2-pole circuit breakers with a marked terminal temperature rating of 60°C.

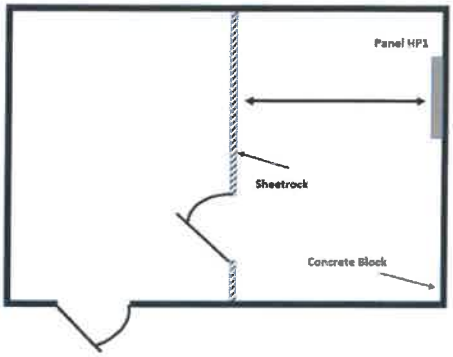
What is the ampacity of the conductors, and is this an acceptable installation?

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

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

[1]Number of conductors is the total number of conductors in the raceway or cable, including spare conductors. The count shall be adjusted in accordance with 310.15(B)(5) and (6). The count shall not include conductors that are connected to electrical components that cannot be simultaneously energized.

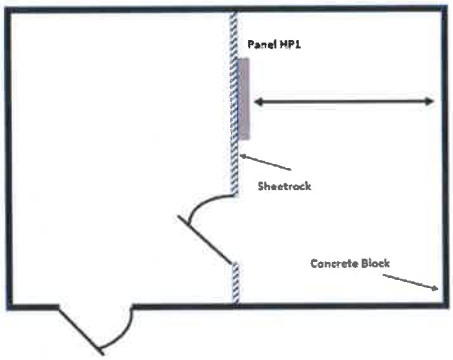
Question 1



Panelboard	Voltage
HP1	277/480 Volts 3 PH 4W
HP2	277/480 Volts 3 PH 4W
LP1	120/208 Volts 3 PH 4W
LP2	120/208 Volts 3 PH 4W
LP3	120/240 Volts 1PH 3W

The working clearance for panelboard HP1 falls under Condition Number _____ and the minimum working clearance is _____.

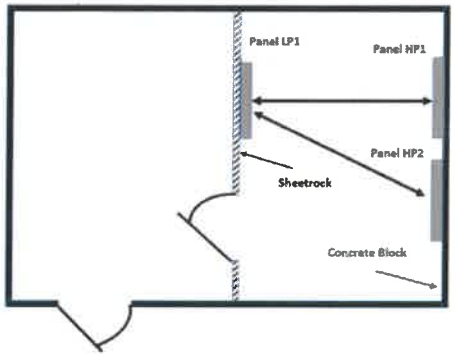
Question 2



Panelboard	Voltage
HP1	277/480 Volts 3 PH 4W
HP2	277/480 Volts 3 PH 4W
LP1	120/208 Volts 3 PH 4W
LP2	120/208 Volts 3 PH 4W
LP3	120/240 Volts 1PH 3W

The working clearance for panelboard HP1 falls under Condition Number _____ and the minimum working clearance is _____.

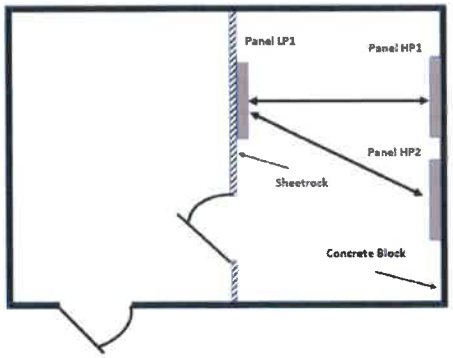
Question 3



Panelboard	Voltage
HP1	277/480 Volts 3 PH 4W
HP2	277/480 Volts 3 PH 4W
LP1	120/208 Volts 3 PH 4W
LP2	120/208 Volts 3 PH 4W
LP3	120/240 Volts 1PH 3W

The working clearance for panelboard HP1 falls under Condition Number _____ and the minimum working clearance is _____.

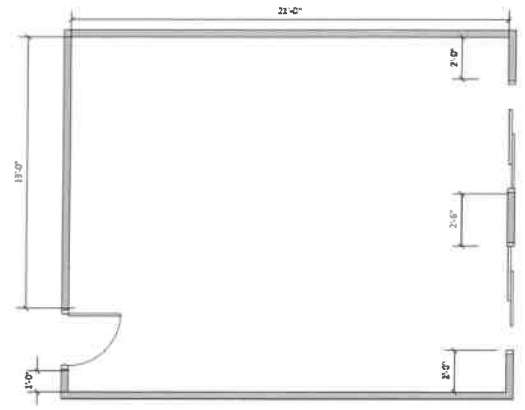
Question 4



Panelboard	Voltage
HP1	277/480 Volts 3 PH 4W
HP2	277/480 Volts 3 PH 4W
LP1	120/208 Volts 3 PH 4W
LP2	120/208 Volts 3 PH 4W
LP3	120/240 Volts 1PH 3W

The working clearance for panelboard HP2 falls under Condition Number _____ and the minimum working clearance is _____.

Chapter 2



Determine the minimum number of dwelling unit receptacles required for the room and draw their location on the figure above.

When a household wall-mounted oven is tapped from a 50-ampere branch circuit, the ampacity of the tap conductors shall not be less than ____.

What is the minimum ungrounded conductor(s) feeder demand for two 3 kW household electric ovens in a dwelling unit?

A fixed appliance in a dwelling unit has a nameplate marking of 50 amperes. What is the rating of the individual branch circuit required to supply this appliance? The load is noncontinuous.

What is the lighting load for a 625 square foot structural addition to an existing one-family dwelling?

Determine the general lighting load for a one-story office building that measures 125 feet by 150 feet.

Only the shell for an office building is to be built. It is 225 feet long, 90 feet wide, and 10 stories high. Calculate the lighting and receptacle feeder demand in volt-amperes for the building with the number of receptacles unknown.

A warehouse is 300 feet by 300 feet with a 120/208-volt, 3-phase, 4-wire service. Calculate the lighting feeder demand in volt-amperes. (The line and neutral lighting feeder demand are the same value.)

What is the minimum size grounding electrode conductor required for 3/O service conductors where the grounding electrode conductor will jump between building steel and two ground rods driven six feet apart in the earth?

a. 1/0
b. #4
c. #3
d. #6

For grounding raceways and equipment, what is the minimum size equipment grounding conductor required for a 60 amp overcurrent protection device?

a. #6
b. #12
c. #8
d. #10

Exposed interior structural steel that is not intentionally grounded and likely to become energized on a 480/277 volt system with three 500 kcmil copper ungrounded conductors per phase requires what size bonding jumper connection to the electrical service?

a. 1/0
b. 2/0
c. 3/0
d. 4/0

What size main bonding jumper is required for a 1200 amp electrical service fed from a parallel installation consisting of three 600 kcmil THWN conductors in parallel per phase?

a. 250 kcmil
b. 4/0
c. 2/0
d. 3/0

What is the size of the copper common grounding electrode conductor used for two or more separately derived alternating current systems?

a. #1
b. 1/0
c. 2/0
d. 3/0

What is the minimum size grounding electrode conductor required for a 500 kcmil service conductor?

a. 1/0
b. #2
c. #3
d. 2/0

What is the maximum number of 20-amp 120-volt duplex receptacles permitted on a 20-amp circuit in a commercial occupancy?

a. No maximum
b. 11
c. 10
d. 13

Chapter 3

What is the minimum burial depth of a direct buried cable or conductor to the top of the cable or conductor?

a. 18"
b. 24"
c. 6"
d. 12"

When a size 3 AWG copper conductor, with THW insulation, is installed in an area where the ambient temperature is 114 deg F, the wire has an allowable ampacity of _____.

A. 100 amperes
B. 75 amperes
C. 82 amperes
D. 58 amperes

When a size 1/0 AWG THWN aluminum conductor is installed in an ambient temperature of 45 deg c, the conductor has an allowable ampacity of _____.

A. 100 amperes
B. 90 amperes
C. 98 amperes
D. 104 amperes

Where a 100-ampere load is to be supplied with THWN copper conductors in an area where the ambient temperature Will reach 110 deg, F, size_____ THWN conductors are required to serve the load.

A. 1 AWG
B. 2 AWG
C. 3 AWG
D. 1/0 AWG

What size aluminum conductor is required for a 400-amp electrical service installed at a dwelling rated 120/240 volt?

a. 350 kcmil
b. 400 kcmil
c. 500 kcmil
d. 600 kcmil

The load on a size 6 AWG THHN copper conductor is limited to_____ where connected to a circuit breaker with a termination rated at 60° C.

A. 75 amperes
B. 65 amperes
C. 60 amperes
D. 55 amperes

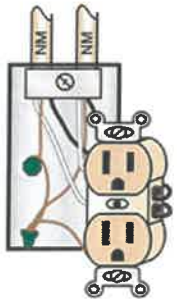
Two 12 AWG conductors pass unbroken through a lighting outlet box. Two 14 AWG conductors enter the box and splice to two 14 AWG conductors leaving the box and two 16 AWG fixture wires that supply a luminaire. Determine the minimum box volume required for this installation. Calculate the box volume to one decimal place.

a. 12.5 in.3
b. 14.0 in.3
c. 16.0 in.3
d. 18.0 in.3
e. 20.5 in.3

Two 12 AWG conductors pass through a switch box unbroken. Two 12 AWG conductors terminate on the switch (hot and switch leg) in the switch box. A bare 12 AWG equipment grounding conductor connects to the grounding screw in the box and continues through the box. Determine the minimum size metal device box suitable for this installation.

a. 3 x 2 x 2 in. device box
b. 3 x 2 x 2 1/4 in. device box
c. 3 x 2 x 2 1/2 in. device box
d. 3 x 2 x 2 3/4 in. device box
e. 3 x 2 x 3 1/2 in. device box

In accordance with Article 314, determine the volume allowance using the total number of conductors for the purposes of box fill in the device box as shown.



a. 5
b. 6
c. 7
d. 8
e. 9

What size copper type NM or NMS cable is required for a 60 amp circuit?

a. #8
b. #6
c. #4
d. #3

What is the minimum size wireway would you need for 6-#4 THHN, 4-350 kcmil THW, and one #6 bare cu conductor?

A) 2" x 2"
B) 3" x 3"
C) 4" x 4"
D) 6" x 6"

A 6" x 6" nonmetallic wireway has 12-#4 RHW copper conductors inside, how many 1/0 THW copper conductors can be added to the trough?

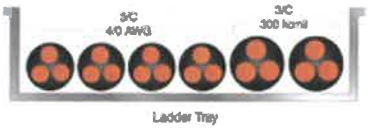
A) 21
B) 17
C) 19
D) 25

A 4" x 4" metallic wireway has 24-#10 THWN copper conductors, 12-#12 THWN, and 3-#3 THWN inside, how many #10 THWN copper conductors can be added to the trough?

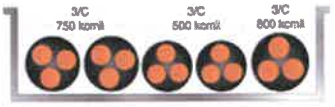
A) 110
B) 117
C) 119
D) 112

Using the illustration, calculate the minimum standard-size ladder cable tray needed for the installation, as shown, for the following multiple conductor cables: four 3-conductor 4/0 AWG and two 3-condcutor 300 kcmil. (OD 4/0 AWG = 1.92 inches; OD 300 kcmil = 2.12 inches.)

(Note: The abbreviation OD refers to the outside diameter of a cable measured in inches.)



Calculate the minimum standard-size ventilated trough cable tray needed for the installation of the following multiple conductor cables: two 3-conductor 750 kcmil; two 3-conductor 500 kcmil; and one 3-conductor 800 kcmil. (OD 750 kcmil = 3.05 inches, OD 500 kcmil = 2.68 inches, and OD 800 kcmil = 3.24 inches.)



Ventilated Trough-Type Cable Tray

Chapter 4

Determine the MINIMUM size THHN copper conductors required to supply a 3 hp, 240-volt, single-phase continuous-duty motor when all terminations have a rating of 75°C.

A. 14 AWG
B. 12 AWG
C. 10 AWG
D. 8 AWG

Conductors supplying a 40 hp, 480-volt, three-phase, 5-minute rated elevator motor with an ampere rating of 50 amperes marked on the nameplate, shall have an ampacity of at least_____.

A. 42.5 amperes
B. 45.9 amperes
C. 62.5 amperes
D. 67.5 amperes

Determine the MAXIMUM initial rating of non-time delay fuses to be used for branch-circuit, short-circuit and ground-fault protection for a 5 hp, 230-volt, three-phase, squirrel cage, continuous-duty motor.

A. 40 amperes
B. 45 amperes
C. 50 amperes
D. 60 amperes

Determine the absolute MAXIMUM standard size time-delay fuses permitted for short-circuit, branch-circuit and ground-fault protection for a 40 hp, 480-volt, three-phase, induction type, continuous-duty motor.

A. 100 amperes
B. 110 amperes
C. 115 amperes
D. 125 amperes

What standard size time-delay fuses are required for the feeder overcurrent protection of a feeder supplying four (4), 15 hp, 480-volt, three-phase, continuous-duty induction-type motors, each protected with 40 ampere rated time-delay fuses?

A. 100 amperes
B. 110 amperes
C. 125 amperes
D. 150 amperes

A single 30-horsepower, 460-volt, 3-phase, continuous-duty, induction type Design B motor is supplied by a motor branch circuit. Calculate the minimum ampacity for the motor branch-circuit conductors.

a) 50 A
b) 60 A
c) 70 A
d) 80 A

A single 3-horsepower, 240-volt, single-phase, continuous-duty, induction type Design B motor is supplied by a motor branch circuit. Calculate the minimum ampacity for the motor branch-circuit conductors.

a) 17 A
b) 21.25 A
c) 27 A
d) 38.25 A

One 3-horsepower, 240-volt, single-phase, continuous-duty, induction-type Design B motor; one 71/2-horsepower, 240-volt, single-phase, continuous-duty, induction-type Design B motor; and one 10-horsepower, 240-volt, single-phase, continuous-duty, induction-type Design B motor are supplied by a single motor branch circuit. Calculate the minimum ampacity for the single motor branch-circuit conductors supplying all three motors.

a) 119.5 A
b) 130.2 A
c) 125 A
d) 137.5 A

Determine the maximum overload protection, using overload relays, for a 25-horsepower, 240-volt, 3-phase continuous-duty motor with a motor nameplate full-load current rating of 65 amperes, a temperature rise of 40°C, and a service factor of 1.15.

a) 65 A
b) 66.25
c) 70 A
d) 81.25 A

What is the minimum current rating of the motor disconnecting means for a 40-horsepower, 208-volt, 3-phase squirrel-cage motor?

a) 114 A
b) 116.15 A
c) 131.1 A
d) 150 A

A single 75-horsepower, 208-volt, 3-phase, continuous-duty, induction type Design B motor is supplied by a motor branch circuit. Calculate the minimum ampacity for the motor branch-circuit conductors.

a) 263.75 A
b) 251 A
c) 211 A
d) 225 A

One branch circuit supplies a piece of fixed electric space heating equipment (motor-operated) with one 5-horsepower, 230-volt, single-phase motor and one unit of electric heat rated at 12,500 watts at 230 volts. Calculate the minimum branch-circuit ampacity to supply the combined load.

Hint: Fixed electric heat is required to be sized at 125% according to Section 424.3(B).

a) 100 A
b) 102.94 A
c) 103 A
d) 150 A

Determine the maximum overload protection, using overload relays, when starting current is a problem, for a 50-horsepower, 208-volt, continuous-duty motor with a motor nameplate full-load current rating of 148 amperes and a service factor of 1.15.

a) 207.2 A
b) 210.5 A
c) 120.2 A
d) 180.7 A

For an installation with a primary current of 1.75 amperes, determine the maximum standard size fuse permitted using Table 450.3(B), for primary-only protection, where the primary currents are less than two amperes.

a) 2 A fuse
b) 3 A fuse
c) 4 A fuse
d) 5 A fuse

For an installation with a 45-kVA, 3-phase transformer, a 460-volt primary, a 220-volt secondary, and secondary protection where the transformer secondary overcurrent protection does not exceed 125% of the secondary current, determine the maximum standard rating of the primary feeder OCPD, where primary and secondary overcurrent protection are provided for the transformer.

a) 100 A OCPD
b) 150 A OCPD
c) 125 A OCPD
d) 200 A OCPD

Chapter 6

What size conductor is required for the source circuit conductors from a photovoltaic module with a short circuit current rating sum of 22 amps when the lowest ambient temperature is expected to be 15 degrees Fahrenheit?

a. #12
b. #10
c. #6
d. #8

A 3-pair shielded 485 communication cable has an overall diameter of .360", how many can we pull through a 2" IMC conduit?

A) 12
B) 13
C) 14
D) 16

How many Cat 6 cables can you pull through a ¾" EMT Conduit?

A) 2
B) 3
C) 4
D) 6

A 6 fiber single mode optical fiber cable has an overall diameter of .1890", how many can be pulled through a 4" EMT conduit?

A) 120
B) 170
C) 210
D) 195

Chapter 9

Determine the maximum number of 6 AWG THW copper conductors permitted in a 1-1/4- inch RMC conduit nipple, 20 inches long, connecting a cabinet and an auxiliary gutter.

Determine the minimum size rigid metal conduit needed for an installation consisting of two 3-phase, 480-volt motor circuits installed in the same conduit. One motor circuit consists of 1 AWG THW copper conductors and the other is fed with 4 AWG THW copper conductors.

What is the minimum size rigid PVC conduit, Schedule 80, permitted for the installation of four 4/0 AWG THW copper conductors and one 1 AWG bare copper equipment grounding conductor?

a. 1-1/2 in. PVC, Schedule 80
b. 2 in. PVC, Schedule 80
c. 2-1/2 in. PVC, Schedule 80
d. 3 in. PVC, Schedule 80

Additional Calculations

Determine the current, in amperes, for a 120-volt, single-phase branch circuit that has only six (6) 100-watt incandescent luminaries (lighting fixtures) connected.

A. 5 amperes
B. 15 amperes
C. 20 amperes
D. 2 amperes

A 36,026 VA load connected to a 208Y/120-volt, three-phase circuit will draw _____ of current per phase.

A. 110 amperes
B. 173 amperes
C. 250 amperes
D. 100 amperes

The power factor of 5-kW load drawing 30 amperes of current when connected to a 208-volt, single-phase source is_____.

A. 92 percent
B. 46 percent
C. 80 percent
D. 83 percent

What is the voltage drop on a single-phase branch circuit supplying a 42-ampere load a distance of 125 feet with 6 AWG TW uncoated copper conductors? Calculate your answer to two decimal places.

a) 4.91 V
b) 5.25 V
c) 3.35 V
d) 2.86 V

What size copper conductors are needed to supply a 3-phase, 208-volt, 200-ampere load at a distance of 250 feet and not exceed a 3% voltage drop? (Use 12.9 for k)

a. 2/0 AWG
b. 3/0 AWG
c. 4/0 AWG
d. 250 kcmil

What is the voltage drop of a 240 volt 24 amp single phase load located 160 feet from the panelboard using #10 THHN conductors?

a. 4.25 volts
b. 9.5 volts
c. 3.2 volts
d. 5.9 volts

How much power is required to operate a series circuit with 80 ohms of resistance and 3 amps of current?

a. 240 watts
b. 720 watts
c. 580 watts
d. 820 watts

2022 Calculation Answers

Chapter 1

110.14(C) Temperature Limitations

Question 1

A 2 AWG THHN aluminum conductor is connected to a circuit breaker with termination temperature limitation marked (not to exceed) 60°C and marked for CU/AL conductors. What is the allowable ampacity of the 2 AWG THHN aluminum conductor now that it is connected to this circuit breaker?

Answer

110.14(C)(1)(a)(2) applies
CB terminations = 60°C
Table 310.15(B)(16) Allowable Ampacity
Limited by CB to 60°C
THHN ampacity @ 90°C not permitted
Use ampacity of 2 AWG Al @ 60°C
2 AWG THHN aluminum = 75 amps
Answer: 75 A

110.14(C)(a)(2)

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

(1) Equipment Provisions. The determination of termination provisions of equipment shall be based on 110.14(C)(1)(a) or (C)(1)(b). Unless the equipment is listed and marked otherwise, conductor ampacities used in determining equipment termination provisions shall be based on Table 310.15(B)(16) as appropriately modified by 310.15(B)(7).

(a) Termination provisions of equipment for circuits rated 100 amperes or less, or marked for 14 AWG through 1 AWG conductors, shall be used only for one of the following:

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

Question 2

What is the allowable ampacity of the 4/0 AWG THWN copper conductor connected to a circuit breaker with wire connection temperature limitation marked (not to exceed) 75° C?

Answer

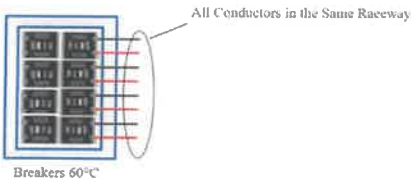
110.14(C)(1)(b)(2) applies
CB terminations = 75°C
Table 310.15(B)(16) Allowable Ampacity
Limited by CB to 75°C
THWN ampacity @ 75°C
Use ampacity of 2 AWG Al @ 60°C
4/0 AWG THWN copper = 230 amps
Answer: 230 A

110.114(C)(1)(b)(2)

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

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

Question 3



Eight 6 AWG THHN copper current-carrying conductors are installed to replace existing wiring within an existing single rigid metal conduit. Type RMC.
The area of installation has an ambient temperature of 30°C. The new eight 6 AWG THHN conductors are connected to existing 50-ampere 2-pole circuit breakers with a marked terminal temperature rating of 60°C.

What is the ampacity of the conductors, and is this an acceptable installation?

Answer

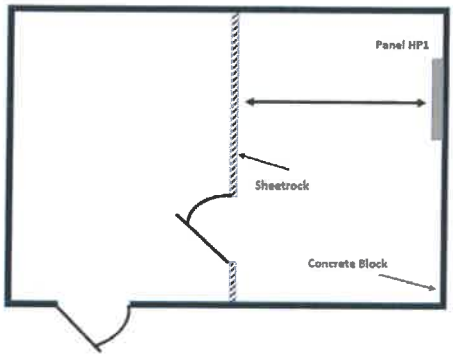
Table 310.15(B)(16) Allowable Ampacity
6 AWG THHN @ 90°C = 75 amps
Table 310.15(B)(3)(a) Adjustment Factors
8 current-carrying conductors = 70%
75 amps × 0.70 = 52.5 amps
6 AWG in 60°C column = 55 amps
55 amps is not permitted
Ampacity = 52.5 amps
Answer: 52.5 A

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

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

[1]Number of conductors is the total number of conductors in the raceway or cable, including spare conductors. The count shall be adjusted in accordance with 310.15(B)(5) and (6). The count shall not include conductors that are connected to electrical components that cannot be simultaneously energized.

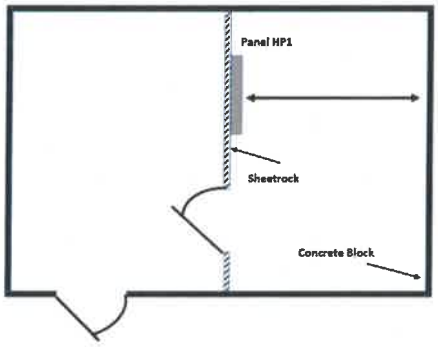
Question 1



Panelboard	Voltage
HP1	277/480 Volts 3 PH 4W
HP2	277/480 Volts 3 PH 4W
LP1	120/208 Volts 3 PH 4W
LP2	120/208 Volts 3 PH 4W
LP3	120/240 Volts 1PH 3W

The working clearance for panelboard HP1 falls under Condition Number ___1___ and the minimum working clearance is ___3 feet_____.

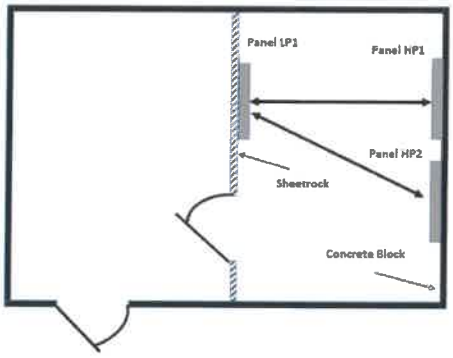
Question 2



Panelboard	Voltage
HP1	277/480 Volts 3 PH 4W
HP2	277/480 Volts 3 PH 4W
LP1	120/208 Volts 3 PH 4W
LP2	120/208 Volts 3 PH 4W
LP3	120/240 Volts 1PH 3W

The working clearance for panelboard HP1 falls under Condition Number ___2___ and the minimum working clearance is ___3 ft 6 in.___.

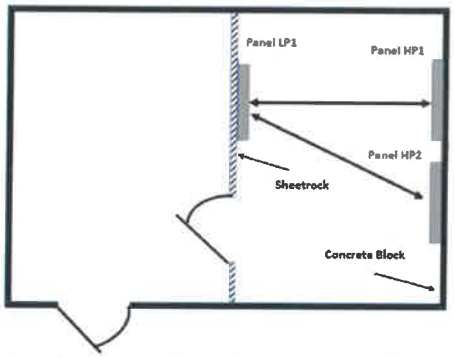
Question 3



Panelboard	Voltage
HP1	277/480 Volts 3 PH 4W
HP2	277/480 Volts 3 PH 4W
LP1	120/208 Volts 3 PH 4W
LP2	120/208 Volts 3 PH 4W
LP3	120/240 Volts 1PH 3W

The working clearance for panelboard HP1 falls under Condition Number ___3___ and the minimum working clearance is ___4 ft.___.

Question 4

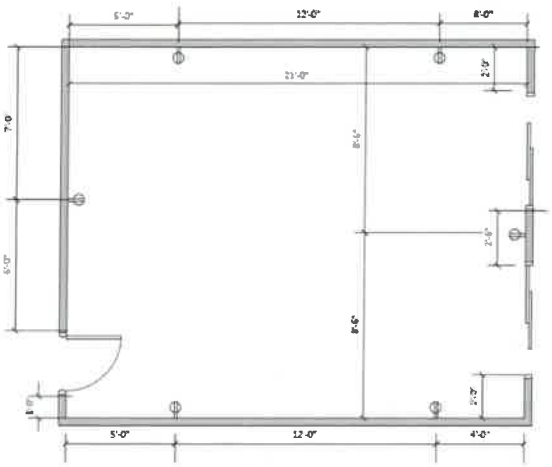


Panelboard	Voltage
HP1	277/480 Volts 3 PH 4W
HP2	277/480 Volts 3 PH 4W
LP1	120/208 Volts 3 PH 4W
LP2	120/208 Volts 3 PH 4W
LP3	120/240 Volts 1PH 3W

The working clearance for panelboard HP2 falls under Condition Number ___1___ and the minimum working clearance is ___3 ft.___.

Chapter 2

6 Receptacles
210.52 (A)(1) & (A)(2)



Determine the minimum number of dwelling unit receptacles required for the room and draw their location on the figure above.

When a household wall-mounted oven is tapped from a 50-ampere branch circuit, the ampacity of the tap conductors shall not be less than ____.

a. 20 A **
b. 25 A
c. 30 A
d. 35 A

210.19(A)(3) Exception No. 1

What is the minimum ungrounded conductor(s) feeder demand for two 3 kW household electric ovens in a dwelling unit?

Solution: Table 220.55, Note 3 permits two options.
Calculate both options and select the smaller.

Option 1
Table 220.55, Column A
Two units less than 31/2 kW
2 units = 75%
Line = 2 units × 3 kW × 0.75
= 4.5 kW

Option 2
Table 220.55, Column C
2 units = 11 kW

Selection: Option 1 gives smaller load
Answer: 4.5 kW

A fixed appliance in a dwelling unit has a nameplate marking of 50 amperes. What is the rating of the individual branch circuit required to supply this appliance? The load is noncontinuous.

a. 40 A
b. 50 A *
c. 60 A
d. 62.5 A

Note: Individual branch circuits are permitted to supply any load for which they are rated. See 210.23. If, in addition to the appliance, other loads are served from the same branch circuit, see 422.10(B).

What is the lighting load for a 625 square foot structural addition to an existing one-family dwelling?

Solution: 220.16(A)(1)

Over 500 sq ft use value in Table 220.12

Unit load for dwelling units = 3 VA per sq ft

Lighting load = Area x unit load
= 625 x 3
= 1,875 VA

Determine the general lighting load for a one-story office building that measures 125 feet by 150 feet.

Solution: 220.12 and Table 220.12

Unit load for offices = 3-1/2 VA per sq ft

Lighting load = Area x unit load
= (125 x 150) x 3.5
= 18,750 x 3.5
= 65,625 VA

Only the shell for an office building is to be built. It is 225 feet long, 90 feet wide, and 10 stories high. Calculate the lighting and receptacle feeder demand in volt-amperes for the building with the number of receptacles unknown.

Solution: Area = L x W
= 225 x 90
= 20,250 sq ft

220.12 and 220.14(K)
VA per sq ft = 3.5 + 1
= 4.5 VA

Demand = Area x VA per sq ft x No. floors
= 20,250 x 4.5 x 10
= 911,250 VA

A warehouse is 300 feet by 300 feet with a 120/208-volt, 3-phase, 4-wire service. Calculate the lighting feeder demand in volt-amperes. (The line and neutral lighting feeder demand are the same value.)

Table 220.12

Unit load for a warehouse = 1/4 VA per sq ft

Area = L x W
= 300 x 300
= 90,000 sq ft
Calc. load = Area x unit load
= 90,000 x 0.25
= 22,500 VA

Table 220.42, Demand factor
Calculated load 22,500 VA
First 12,500 at 100% –12,500 = 12,500 VA
Balance at 50% x 10,000 = + 5,000 VA

What is the minimum size grounding electrode conductor required for 3/0 service conductors where the grounding electrode conductor will jump between building steel and two ground rods driven six feet apart in the earth?

a. 1/0
b. #4 **
c. #3
d. #6

250.66 specifies the minim urn required GEC.

Always copper unless otherwise indicated in the question.

250.66 (A) the #6 maximum is not applicable here as the grounding electrode conductor extends to building steel which requires a larger size grounding electrode conductor so you can not take advantage of the maximum #6 permitted in 250.66A.

For grounding raceways and equipment, what is the minimum size equipment grounding conductor required for a 60 amp overcurrent protection device?

a. #6
b. #12
c. #8
d. #10 **

Table 250.122

Exposed interior structural steel that is not intentionally grounded and likely to become energized on a 480/277 volt system with three 500 kcmil copper ungrounded conductors per phase requires what size bonding jumper connection to the electrical service?

a. 1/0
b. 2/0
c. 3/0 **
d. 4/0

250. 104 (C) says to use Table 250.102 (C) (1)

Remember always use copper unless otherwise stated in the question

However, it also says it is not required to be larger than a 3/0 or 250 kcmil aluminum.

You do not have to do the 12.5% calculation in the note one below the table which would have been 187,500 kcmil round up to a 4/0. So the answer is capped at 3/0 copper.

What size main bonding jumper is required for a 1200 amp electrical service fed from a parallel installation consisting of three 600 kcmil THWN conductors in parallel per phase?

a. 250 kcmil **
b. 4/0
c. 2/0
d. 3/0

250.24 (B) sends to 250.28 (D) (1) which sends you to table 250.102 (C) (1)

250.102 (C) (2) Allows use of the table for parallel installations.

Note 1 below table 250.102 (C) (1) says to add up the Kcmils for the equivalent area in parallel installations.

Over 1100 kcmil its 12.5% of the phase conductors

1800 x .125 = 225 kCmil

225 Kcmil x 1000 = 225000 cmil

Chapter 9 Table 8 = 250 kcmil next size larger is 250,000 cmil

What is the size of the copper common grounding electrode conductor used for two or more separately derived alternating current systems?

a. #1
b. 1/0
c. 2/0
d. 3/0 **

250.30 A (6) (a) (1)

What is the minimum size grounding electrode conductor required for a 500 kcmil service conductor?

a. 1/0 **
b. #2
c. #3
d. 2/0

Table 250.66 specifies the minimum required size GEC

Always use copper unless otherwise indicated in the question.

What is the maximum number of 20-amp 120-volt duplex receptacles permitted on a 20-amp circuit in a commercial occupancy?

a. No maximum
b. 11
c. 10
d. 13 **

220.14 (I) 180 va per receptacle

Power = Voltage x current

A 20 amp circuit at 120v = 2,400 va available

2,400 va divided by by 180 va per receptacle = 13.3

The 80% rule has no on making this determine

Chapter 3

What is the minimum burial depth of a direct buried cable or conductor to the top of the cable or conductor?

a. 18"
b. 24" **
c. 6"
d. 12"

300.5 Column 1 all locations not specified and Note 1 below the table which states measuring is to the top of the cable or conductor.

When a size 3 AWG copper conductor, with THW insulation, is installed in an area where the ambient temperature is 114 deg F, the wire has an allowable ampacity of _____.

A. 100 amperes
B. 75 amperes **
C. 82 amperes
D. 58 amperes

ANSWER – (B) 75 amperes
100 amperes x .75 = 75 amperes

When a size 1/0 AWG THWN aluminum conductor is installed in an ambient temperature of 45 deg c, the conductor has an allowable ampacity of _____.

A. 100 amperes
B. 90 amperes
C. 98 amperes **
D. 104 amperes

ANSWER – (C) 98 amperes
1/0 THW aluminum ampacity before derating = 120 amperes, 120 amps x .82 (correction factor) = 98 amperes.

Where a 100-ampere load is to be supplied with THWN copper conductors in an area where the ambient temperature Will reach 110 deg, F, size_____ THWN conductors are required to serve the load.

A. 1 AWG **
B. 2 AWG
C. 3 AWG
D. 1/0 AWG

ANSWER - (A) 1 AWG
Required ampacity = 100 amps / .82 = 122 amperes

What size aluminum conductor is required for a 400-amp electrical service installed at a dwelling rated 120/240 volt?

a. 350 kcmil
b. 400 kcmil
c. 500 kcmil
d. 600 kcmil **

310.15 (B) (7)

There is an example in informational annex example D7 for reference.

The short answer is to use Table 310.15 (B) (16) = 600 kcmil.

Take the 400 amps and multiply it by 83% per 310.15 (B) (7) (1). This equals 332amps. Go to 310.15 (B) (16) on the aluminum side of the chart Use the 75 degree C column because you are over 100 amps per 110.14 (C) (1) (b) 600 kcmil is the required size

The load on a size 6 AWG THHN copper conductor is limited to_____ where connected to a circuit breaker with a termination rated at 60° C.

A. 75 amperes
B. 65 amperes
C. 60 amperes
D. 55 amperes **

ANSWER· (D) 55 amperes

Table 310,15(8)(16) lists the ampacity of size 6 AWG, copper, 60° C rated conductors to be 55 amperes.

Two 12 AWG conductors pass unbroken through a lighting outlet box. Two 14 AWG conductors enter the box and splice to two 14 AWG conductors leaving the box and two 16 AWG fixture wires that supply a luminaire. Determine the minimum box volume required for this installation. Calculate the box volume to one decimal place.

a. 12.5 in.3
b. 14.0 in.3
c. 16.0 in.3 **
d. 18.0 in.3
e. 20.5 in.3

Solution:
Using Table 314.16(B)
Two 12 AWG = 2 × 2.25 in.3 = 4.50 in.3
Four 14 AWG = 4 × 2.00 in.3 = 8.00 in.3
Two 16 AWG = 2 × 1.75 in.3 = 3.50 in.3
Minimum volume required = 4.50 + 8.00 + 3.50 = 16.0 in.3

Two 12 AWG conductors pass through a switch box unbroken. Two 12 AWG conductors terminate on the switch (hot and switch leg) in the switch box. A bare 12 AWG equipment grounding conductor connects to the grounding screw in the box and continues through the box. Determine the minimum size metal device box suitable for this installation.

a. 3 x 2 x 2 in. device box
b. 3 x 2 x 2 1/4 in. device box
c. 3 x 2 x 2 1/2 in. device box **
d. 3 x 2 x 2 3/4 in. device box
e. 3 x 2 x 3 1/2 in. device box

Solution: a. Calculate the number of conductors in the box for the purposes of determining box fill.

Switch	2
Two 12 AWG passing through	2
Two 12 AWG on switch	2
Equipment grounding conductor	1
Total Count	7

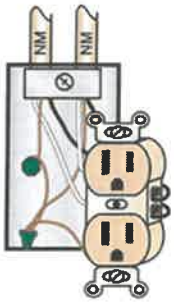
Volume allowance = Seven 12 AWG
Answer: Seven 12 AWG conductors

Determine the minimum size metal device box for this installation.

Table 314.16(B)	Seven 12 AWG
7 x 2.25 in.3 = 15.75 in.3	Minimum volume required = 15.75 in.3
Table 314.16(A), device box	3 x 2 x 3-1/2 in. = 18.0 in.3

Answer: 3 x 2 x 3-1/2 in. device box

In accordance with Article 314, determine the volume allowance using the total number of conductors for the purposes of box fill in the device box as shown.



a. 5
b. 6
c. 7
d. 8
e. 9

Solution:

Cable clamps	1
Circuit conductors	4
Equipment grounding conductors	1
Device	2
Total	8

Note: See *NEC* Reference: 314.16(B)(1) through (5)

What size copper type NM or NMS cable is required for a 60 amp circuit?

a. #8
b. #6
c. #4 **
d. #3

334.80 After any ampacity adjustment, in the end NM or NMS (RX) cable must be sized under the 60 degree "C" column of 310.16. This is largely due to the effects of heating caused by various insulation in the walls. A larger wire will help dissipate heat.

What is the minimum size wireway would you need for 6-#4 THHN, 4-350 kcmil THW, and one #6 bare cu conductor?

A) 2" x 2"
B) 3" x 3"
C) 4" x 4" **
D) 6" x 6"

Solution:
Chapter 9, Tables, Art. 376.22(A)
Table 5, Table 8

#4 -.0824 (6) = .4944
350'S- .5958(4) = 2.3832
#6 - .027

A=.4944 + 2.3832 + .027 =
A= 2.9 x 5
A=14.523 min in.^{2} A 4" x 4" trough would work, which is 16 in.^{2}

A 6" x 6" nonmetallic wireway has 12-#4 RHW copper conductors inside, how many 1/0 THW copper conductors can be added to the trough?

A) 21
B) 17
C) 19
D) 25 **

Solution:
Chapter 9, Tables, Art. 378.22
Table 5, Table 8

#4 -.1333 (12) = 1.596

6 x 6 = 36"sq x 20% fill = 7.2 in.^{2}
7.2 - 1.596 = 5.604 [remaining area]

1/0- .2223

A= 5.604/.2223 =
A= 25.21 or 25 - 1/0 conductors can be added

A 4" x 4" metallic wireway has 24-#10 THWN copper conductors, 12-#12 THWN, and 3-#3 THWN inside, how many #10 THWN copper conductors can be added to the trough?

A) 110
B) 117 **
C) 119
D) 112

Solution:

Chapter 9, Tables, Art. 376.22(A)
Table 5, Table 8

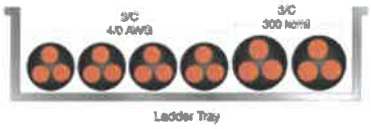
#10 -.0211 (24) = .5064
#12-.0133(12) = .1596
#3-.0973(3) = .0466

4 x 4 = 16"sq x 20% fill = 3.2 $in.^2$
3.2-(.5064+.1596+.0466) = 2.4874 [remaining area]
2.4874/.0211 = 117.89

A= 117-#10 THWN CU conductors can be added

Using the illustration, calculate the minimum standard-size ladder cable tray needed for the installation, as shown, for the following multiple conductor cables: four 3-conductor 4/0 AWG and two 3-condcutor 300 kcmil. (OD 4/0 AWG = 1.92 inches; OD 300 kcmil = 2.12 inches.)

(Note: The abbreviation OD refers to the outside diameter of a cable measured in inches.)



Solution:

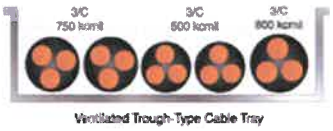
392.22(A)(1)(a), single layer
Sum of OD (Sd) not to exceed width of tray

4/0 AWG width = 1.92 × 4 = 7.68 in.
300 kcmil width = 2.12 × 2 = 4.24 in.

Min. width = 7.68 + 4.24 = 11.92 in.

Table 392.22(A)
Next larger std. size = 12 in. wide ladder cable tray

Calculate the minimum standard-size ventilated trough cable tray needed for the installation of the following multiple conductor cables: two 3-conductor 750 kcmil; two 3-conductor 500 kcmil; and one 3-conductor 800 kcmil. (OD 750 kcmil = 3.05 inches, OD 500 kcmil = 2.68 inches, and OD 800 kcmil = 3.24 inches.)



Ventilated Trough-Type Cable Tray

Solution:

392.22(A)(1)(a), single layer
Sd not to exceed width of tray

750 kcmil width = 3.05 × 2 = 6.10 in.
500 kcmil width = 2.68 × 2 = 5.36 in.
800 kcmil width = 3.24 × 1 = 3.24in.

Min. width = 6.10 + 5.36 + 3.24 = 14.70 in.
Table 392.22(A)

Next larger std. size = 16 in. wide ventilated trough tray

Chapter 4

What is the minimum burial depth of a direct buried cable or conductor to the top of the cable or conductor?

a. 18"
b. 24" **
c. 6"
d. 12"

300.5 Column 1 all locations not specified and Note 1 below the table which states measuring is to the top of the cable or conductor.

When a size 3 AWG copper conductor, with THW insulation, is installed in an area where the ambient temperature is 114 deg F, the wire has an allowable ampacity of _____.

A. 100 amperes
B. 75 amperes **
C. 82 amperes
D. 58 amperes

ANSWER – (B) 75 amperes
100 amperes x .75 = 75 amperes

When a size 1/0 AWG THWN aluminum conductor is installed in an ambient temperature of 45 deg c, the conductor has an allowable ampacity of _____.

A. 100 amperes
B. 90 amperes
C. 98 amperes **
D. 104 amperes

ANSWER – (C) 98 amperes
1/0 THW aluminum ampacity before derating = 120 amperes, 120 amps x .82 (correction factor) = 98 amperes.

Where a 100-ampere load is to be supplied with THWN copper conductors in an area where the ambient temperature Will reach 110 deg, F, size_____ THWN conductors are required to serve the load.

A. 1 AWG **
B. 2 AWG
C. 3 AWG
D. 1/0 AWG

ANSWER - (A) 1 AWG
Required ampacity = 100 amps / .82 = 122 amperes

What size aluminum conductor is required for a 400-amp electrical service installed at a dwelling rated 120/240 volt?

a. 350 kcmil
b. 400 kcmil
c. 500 kcmil
d. 600 kcmil **

310.15 (B) (7)

There is an example in informational annex example D7 for reference.

The short answer is to use Table 310.15 (B) (16) = 600 kcmil.

Take the 400 amps and multiply it by 83% per 310.15 (B) (7) (1). This equals 332amps. Go to 310.15 (B) (16) on the aluminum side of the chart Use the 75 degree C column because you are over 100 amps per 110.14 (C) (1) (b) 600 kcmil is the required size

The load on a size 6 AWG THHN copper conductor is limited to_____ where connected to a circuit breaker with a termination rated at 60° C.

A. 75 amperes
B. 65 amperes
C. 60 amperes
D. 55 amperes **

ANSWER· (D) 55 amperes

Table 310,15(8)(16) lists the ampacity of size 6 AWG, copper, 60° C rated conductors to be 55 amperes.

Two 12 AWG conductors pass unbroken through a lighting outlet box. Two 14 AWG conductors enter the box and splice to two 14 AWG conductors leaving the box and two 16 AWG fixture wires that supply a luminaire. Determine the minimum box volume required for this installation. Calculate the box volume to one decimal place.

a. 12.5 in.3
b. 14.0 in.3
c. 16.0 in.3 **
d. 18.0 in.3
e. 20.5 in.3

Solution:
Using Table 314.16(B)
Two 12 AWG = 2 × 2.25 in.3 = 4.50 in.3
Four 14 AWG = 4 × 2.00 in.3 = 8.00 in.3
Two 16 AWG = 2 × 1.75 in.3 = 3.50 in.3
Minimum volume required = 4.50 + 8.00 + 3.50 = 16.0 in.3

Two 12 AWG conductors pass through a switch box unbroken. Two 12 AWG conductors terminate on the switch (hot and switch leg) in the switch box. A bare 12 AWG equipment grounding conductor connects to the grounding screw in the box and continues through the box. Determine the minimum size metal device box suitable for this installation.

a. 3 x 2 x 2 in. device box
b. 3 x 2 x 2 1/4 in. device box
c. 3 x 2 x 2 1/2 in. device box **
d. 3 x 2 x 2 3/4 in. device box
e. 3 x 2 x 3 1/2 in. device box

Solution: a. Calculate the number of conductors in the box for the purposes of determining box fill.

Switch	2
Two 12 AWG passing through	2
Two 12 AWG on switch	2
Equipment grounding conductor	1
Total Count	7

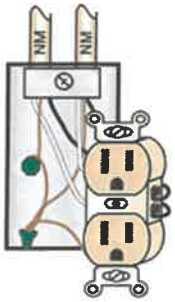
Volume allowance = Seven 12 AWG
Answer: Seven 12 AWG conductors

Determine the minimum size metal device box for this installation.

Table 314.16(B)	Seven 12 AWG
7 x 2.25 in.3 = 15.75 in.3	Minimum volume required = 15.75 in.3
Table 314.16(A), device box	3 x 2 x 3-1/2 in. = 18.0 in.3

Answer: 3 x 2 x 3-1/2 in. device box

In accordance with Article 314, determine the volume allowance using the total number of conductors for the purposes of box fill in the device box as shown.



a. 5
b. 6
c. 7
d. 8
e. 9

Solution:

Cable clamps	1
Circuit conductors	4
Equipment grounding conductors	1
Device	2
Total	8

Note: See *NEC* Reference: 314.16(B)(1) through (5)

What size copper type NM or NMS cable is required for a 60 amp circuit?

a. #8
b. #6
c. #4 **
d. #3

334.80 After any ampacity adjustment, in the end NM or NMS (RX) cable must be sized under the 60 degree "C" column of 310.16. This is largely due to the effects of heating caused by various insulation in the walls. A larger wire will help dissipate heat.

What is the minimum size wireway would you need for 6-#4 THHN, 4-350 kcmil THW, and one #6 bare cu conductor?

A) 2" x 2"
B) 3" x 3"
C) 4" x 4" **
D) 6" x 6"

Solution:
Chapter 9, Tables, Art. 376.22(A)
Table 5, Table 8

#4 -.0824 (6) = .4944
350'S- .5958(4) = 2.3832
#6 - .027

A=.4944 + 2.3832 + .027 =
A= 2.9 x 5
A=14.523 min in.^{2} A 4" x 4" trough would work, which is 16 in.^{2}

A 6" x 6" nonmetallic wireway has 12-#4 RHW copper conductors inside, how many 1/0 THW copper conductors can be added to the trough?

A) 21
B) 17
C) 19
D) 25 **

Solution:
Chapter 9, Tables, Art. 378.22
Table 5, Table 8

#4 -.1333 (12) = 1.596

6 x 6 = 36"sq x 20% fill = 7.2 in.^{2}
7.2 - 1.596 = 5.604 [remaining area]

1/0- .2223

A= 5.604/.2223 =
A= 25.21 or 25 - 1/0 conductors can be added

A 4" x 4" metallic wireway has 24-#10 THWN copper conductors, 12-#12 THWN, and 3-#3 THWN inside, how many #10 THWN copper conductors can be added to the trough?

A) 110
B) 117 **
C) 119
D) 112

Solution:

Chapter 9, Tables, Art. 376.22(A)
Table 5, Table 8

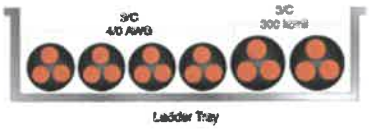
#10 -.0211 (24) = .5064
#12-.0133(12) = .1596
#3-.0973(3) = .0466

4 x 4 = 16"sq x 20% fill = 3.2 in.^{2}
3.2-(.5064+.1596+.0466) = 2.4874 [remaining area]
2.4874/.0211 = 117.89

A= 117-#10 THWN CU conductors can be added

Using the illustration, calculate the minimum standard-size ladder cable tray needed for the installation, as shown, for the following multiple conductor cables: four 3-conductor 4/0 AWG and two 3-condcutor 300 kcmil. (OD 4/0 AWG = 1.92 inches; OD 300 kcmil = 2.12 inches.)

(Note: The abbreviation OD refers to the outside diameter of a cable measured in inches.)



Solution:

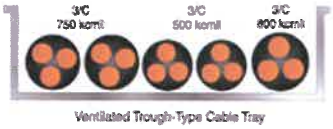
392.22(A)(1)(a), single layer
Sum of OD (Sd) not to exceed width of tray

4/0 AWG width = 1.92 × 4 = 7.68 in.
300 kcmil width = 2.12 × 2 = 4.24 in.

Min. width = 7.68 + 4.24 = 11.92 in.

Table 392.22(A)
Next larger std. size = 12 in. wide ladder cable tray

Calculate the minimum standard-size ventilated trough cable tray needed for the installation of the following multiple conductor cables: two 3-conductor 750 kcmil; two 3-conductor 500 kcmil; and one 3-conductor 800 kcmil. (OD 750 kcmil = 3.05 inches, OD 500 kcmil = 2.68 inches, and OD 800 kcmil = 3.24 inches.)



Ventilated Trough-Type Cable Tray

Solution:

392.22(A)(1)(a), single layer
Sd not to exceed width of tray

750 kcmil width = 3.05 × 2 = 6.10 in.
500 kcmil width = 2.68 × 2 = 5.36 in.
800 kcmil width = 3.24 × 1 = 3.24in.

Min. width = 6.10 + 5.36 + 3.24 = 14.70 in.
Table 392.22(A)

Next larger std. size = 16 in. wide ventilated trough tray

Chapter 4

Chapter 4

Determine the MINIMUM size THHN copper conductors required to supply a 3 hp, 240-volt, single-phase continuous-duty motor when all terminations have a rating of 75°C.

A. 14 AWG
B. 12 AWG **
C. 10 AWG
D. 8 AWG

ANSWER – (B) 12 AWG

Motor FLC = 17 amperes Table 430.248.
17 amperes x 125% (Table 430.22) = 21.25 amperes
Size 12 AWG THHN is rated at 25 amperes at 75°C (Table 310.15(B)(16))

Conductors supplying a 40 hp, 480-volt, three-phase, 5-minute rated elevator motor with an ampere rating of 50 amperes marked on the nameplate, shall have an ampacity of at least_____.

A. 42.5 amperes **
B. 45.9 amperes
C. 62.5 amperes
D. 67.5 amperes

ANSWER - (A) 42.5 amperes

Motor FLA = 50 amperes x 85% Table 430.22 (E) = 42.5 amps

Determine the MAXIMUM initial rating of non-time delay fuses to be used for branch-circuit, short-circuit and ground-fault protection for a 5 hp, 230-volt, three-phase, squirrel cage, continuous-duty motor.

A. 40 amperes
B. 45 amperes
C. 50 amperes **
D. 60 amperes

ANSWER = (C) 50 amperes
5 HP FLC = 15.2 amperes (Table 430.250) 15.2 amperes x 300% = 45.6 amperes (Table 430.52)
Since 45.6 amperes is not a standard rating for non-time delay fuses, as per 430.52 (C) (1) Ex 1, You are permitted to go up to the next standard size fuse (240.6 (A)) which is rated at 50 amperes.

Determine the absolute MAXIMUM standard size time-delay fuses permitted for short-circuit, branch-circuit and ground-fault protection for a 40 hp, 480-volt, three-phase, induction type, continuous-duty motor.

A. 100 amperes
B. 110 amperes **
C. 115 amperes
D. 125 amperes

ANSWER – (B) 110 amperes

40 HP FLC = 52 amperes (Table 430.250)
52 amperes x 225% = 117 amperes (430.52 (C) (1) Ex.2 (b))

Since you are NOT permitted to exceed 225% of the FLC of the motor, you must go down to the next smaller standard size fuse as listed in 240.6 (A).

What standard size time-delay fuses are required for the feeder overcurrent protection of a feeder supplying four (4), 15 hp, 480-volt, three-phase, continuous-duty induction-type motors, each protected with 40 ampere rated time-delay fuses?

A. 100 amperes **
B. 110 amperes
C. 125 amperes
D. 150 amperes

ANSWER – (A) 100 amperes

15 HP FLC = 21 amperes (Table 430.250)
40 Amp (largest OCP in group) + 21 Amp+ 21 Amp + 21 Amp = 103 amps
You are required to go down to 100 ampere rated fuses. (240.6(A))

See 430.62 (A)

A single 30-horsepower, 460-volt, 3-phase, continuous-duty, induction type Design B motor is supplied by a motor branch circuit. Calculate the minimum ampacity for the motor branch-circuit conductors.

a) 50 A **
b) 60 A
c) 70 A
d) 80 A

Solution: Minimum ampacity branch-circuit conductors

Table 430.250, 3-phase, 30 hp 460 V = 40 A FLC

430.22(A), branch circuit ampacity = FLC × 125%

40 × 1.25 = 50 A

A single 3-horsepower, 240-volt, single-phase, continuous-duty, induction type Design B motor is supplied by a motor branch circuit. Calculate the minimum ampacity for the motor branch-circuit conductors.

a) 17 A
b) 21.25 A **
c) 27 A
d) 38.25 A

Solution: Minimum ampacity BC conductors

Table 430.248, single-phase, 3 hp, 240 V = 17 A FLC

430.22(A) branch circuit ampacity = FLC × 125%

17 × 1.25 = 21.25 A

One 3-horsepower, 240-volt, single-phase, continuous-duty, induction-type Design B motor; one 71/2-horsepower, 240-volt, single-phase, continuous-duty, induction-type Design B motor; and one 10-horsepower, 240-volt, single-phase, continuous-duty, induction-type Design B motor are supplied by a single motor branch circuit. Calculate the minimum ampacity for the single motor branch-circuit conductors supplying all three motors.

a) 119.5 A **
b) 130.2 A
c) 125 A
d) 137.5 A

Solution:

Table 430.248, single-phase

3 hp, 240 V = 17 A FLC
7 1/2 hp, 240 V = 40 A FLC
10 hp, 240 V = 50 A FLC

430.24, branch circuit ampacity = (largest FLC × 125%) + other motor(s)

(50 × 1.25) + 40 + 17

62.5 + 40 + 17 = 119.5 A

Determine the maximum overload protection, using overload relays, for a 25-horsepower, 240-volt, 3-phase continuous-duty motor with a motor nameplate full-load current rating of 65 amperes, a temperature rise of 40°C, and a service factor of 1.15.

a) 65 A
b) 66.25
c) 70 A
d) 81.25 A **

430.32(A)(1), Separate Overload Device
40°C rise, 1.15 service factor
Max. overload rating = 125%

Max. overload = motor nameplate FLC rating × 125%

65 × 1.25 = 81.25 A

What is the minimum current rating of the motor disconnecting means for a 40-horsepower, 208-volt, 3-phase squirrel-cage motor?

a) 114 A
b) 116.15 A
c) 131.1 A **
d) 150 A

Solution:

430.6(A) use Table 430.250 value
40 hp, 208 V = 114 A FLC

430.110(A)
Min. current rating = FLC × 115%

114 × 1.15 = 131.1 A

A single 75-horsepower, 208-volt, 3-phase, continuous-duty, induction type Design B motor is supplied by a motor branch circuit. Calculate the minimum ampacity for the motor branch-circuit conductors.

a) 263.75 A **
b) 251 A
c) 211 A
d) 225 A

Solution:

Table 430.250, 3-phase, 75 hp, 208 V = 211 A FLC

430.22(A), branch circuit ampacity = FLC × 125%

211 × 1.25 = 263.75 A

One branch circuit supplies a piece of fixed electric space heating equipment (motor-operated) with one 5-horsepower, 230-volt, single-phase motor and one unit of electric heat rated at 12,500 watts at 230 volts. Calculate the minimum branch-circuit ampacity to supply the combined load.

Hint: Fixed electric heat is required to be sized at 125% according to Section 424.3(B).

a) 100 A
b) 102.94 A **
c) 103 A
d) 150 A

Solution:
Table 430.248, single-phase 5 hp 230 V = 28 A FLC

I = W ÷ E = 12,500 ÷ 230 = 54.35 A

430.24, Exception 2 and 424.3(B)

Branch circuit ampacity = (motor FLC + heat FLC) × 125%

(28 + 54.35) × 1.25 = 82.35 × 1.25 = 102.94 A

Note: Section 430.24, Exception No. 2 refers to 424.3(B) for fixed electric space heating. It requires that the conductors and the overcurrent protective device supplying fixed electric space-heating equipment be sized at 125%. Section 424.1 defines the scope of fixed electric space-heating equipment.

Determine the maximum overload protection, using overload relays, when starting current is a problem, for a 50-horsepower, 208-volt, continuous-duty motor with a motor nameplate full-load current rating of 148 amperes and a service factor of 1.15.

a) 207.2 A **
b) 210.5 A
c) 120.2 A
d) 180.7 A

Solution:

430.32(C), Starting current is a problem
Service factor = 1.15
Max. overload rating = 140%

Max. overload = motor nameplate FLC rating × 140%

148 × 1.40 = 207.20 A

For an installation with a primary current of 1.75 amperes, determine the maximum standard size fuse permitted using Table 450.3(B), for primary-only protection, where the primary currents are less than two amperes.

a) 2 A fuse
b) 3 A fuse *
c) 4 A fuse
d) 5 A fuse

Solution: Table 450.3(B), primary protection

Currents less than 2 A
OCPDpri = Ipri × 300% max.
= 1.75 × 3.00
= 5.25 A

Note 1 is not applicable
Next smaller size
240.6(A) standard sizes
5.25 A → 3 A

For an installation with a 45-kVA, 3-phase transformer, a 460-volt primary, a 220-volt secondary, and secondary protection where the transformer secondary overcurrent protection does not exceed 125% of the secondary current, determine the maximum standard rating of the primary feeder OCPD, where primary and secondary overcurrent protection are provided for the transformer.

a) 100 A OCPD
b) 150 A OCPD
c) 125 A OCPD *
d) 200 A OCPD

Table 450.3(B), Primary and Secondary Protection

Currents of 9 A or more

Max. rating of OCPD = 250%

$OCPD_{pri} = I_{pri} \times 250\%$

$= 56.54687107 \times 2.5$

$= 141.37$ A

Next smaller OCPD → 125 A OCPD

Chapter 6

What size conductor is required for the source circuit conductors from a photovoltaic module with a short circuit current rating sum of 22 amps when the lowest ambient temperature is expected to be 15 degrees Fahrenheit?

a. #12
b. #10
c. #6
d. #8 **

690.8 (B) (2) & Table 310.16

Take the sum of the short circuit current rating times 125%. Then multiply by the temperature correction factor of 1.14 for 15 degrees Fahrenheit.

22 x 1.25 x 1.14 = 31.35 amps Since terminal temperature is not stated, per 110.14 (C), under 100 amps is sized at 60 degrees Celsius in 310.15 (B) (16).

Chapter 8

A 3-pair shielded 485 communication cable has an overall diameter of .360", how many can we pull through a 2" IMC conduit? (Use 3.14 for π)

A) 12
B) 13
C) 14 **
D) 16

Solution:

Chapter 9, Tables, Notes 5 and 9
Table 4, 2" IMC at 40% (over 2) = 1.452 in.²

Diameter of communication cable= .360 inches
$A=3.14(r^2)$
A=3.14(.18)(.18)
A=.101736

Number of cables = 1.452/.101736 =14.27 or 14-commuication cables.

How many Cat 6 cables can you pull through a ¾" EMT Conduit?

A) 2
B) 3
C) 4
D) 6 **

Solution:

Chapter 9, Tables, Notes 5 and 9
Table 4, 3/4" EMT at 40% (over 2) = .213 in.²

Diameter of Cat 6 cable= .3 inches
$A=3.14(r^2)$
A=3.14(.15)(.15)
A=.0765

Number of cables = .213/.0765 =3.015 or 3-cat 6 cables.

A 6 fiber single mode optical fiber cable has an overall diameter of .1890", how many can be pulled through a 4" EMT conduit?

A) 120
B) 170
C) 210 **
D) 195

Solution:

Chapter 9, Tables, Notes 5 and 9
Table 4, 2" EMT at 40% (over 2) = 5.901 in.^{2}

Diameter of communication cable= .1890 inches
$A=3.14(r^2)$
$A=3.14(.0945)(.0945)$
$A=.028$

Number of cables = 5.901/.028 = 210.44 or 210 fiber optic cables

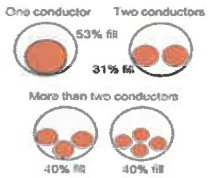
Chapter 9

Determine the maximum number of 6 AWG THW copper conductors permitted in a 1-1/4- inch RMC conduit nipple, 20 inches long, connecting a cabinet and an auxiliary gutter.

Solution:

Chapter 9, Table 1, Note 4
Permitted fill for nipple = 60%
Chapter 9, Table 4, Article 344
11/4 in. Rigid Metal Conduit (RMC)
60% Col. 11/4 in. = 0.916 in.2
Chapter 9, Table 5
6 AWG THW = 0.0726 in.2
Quantity = 0.916 ÷ 0.0726
= 12.6 → 12 conductors

Note. See NEC Reference: Chapter 9, Table 1, Note 4 and Tables 4 and 5



Determine the minimum size rigid metal conduit needed for an installation consisting of two 3-phase, 480-volt motor circuits installed in the same conduit. One motor circuit consists of 1 AWG THW copper conductors and the other is fed with 4 AWG THW copper conductors.

Solution: Chapter 9, Table 5

1 AWG THW = 0.1901 in.2
4 AWG THW = 0.0973 in.2
0.1901 × 3 = 0.5703 in.2
0.0973 × 3 = 0.2919 in.2
Total = 0.8622 in.2

Chapter 9, Table 4 (RMC)
40% fill column
0.8622 in.2 = 2 in. RMC

Note: See NEC Reference: Chapter 9, Tables 4 and 5

What is the minimum size rigid PVC conduit, Schedule 80, permitted for the installation of four 4/0 AWG THW copper conductors and one 1 AWG bare copper equipment grounding conductor?

a. 1-1/2 in. PVC, Schedule 80
b. 2 in. PVC, Schedule 80
c. 2-1/2 in. PVC, Schedule 80
d. 3 in. PVC, Schedule 80

Solution: Chapter 9, Table 5

4/0 AWG THW = 0.3718 in.2
Chapter 9, Table 1, Note 8
Chapter 9, Table 8

1 AWG bare = 0.087 in.2
4 × 0.3718 in.2 = 1.4872 in.2
1 × 0.087 in.2 = 0.087 in.2
Total = 1.5742 in.2

Chapter 9, Table 4
40% fill column
1.5742 in.2 = 2-1/2 in. PVC, Schedule 80

Note: See NEC Reference: Chapter 9, Tables 4, 5, and 8, and Note 8 of Table 1

Additional Calculations

Determine the current, in amperes, for a 120-volt, single-phase branch circuit that has only six (6) 100-watt incandescent luminaries (lighting fixtures) connected.

A. 5 amperes
B. 15 amperes
C. 20 amperes
D. 2 amperes

ANSWER – (A) 5 amperes

$I = \frac{\text{watts}}{\text{volts}}$ $I = \frac{600 \text{ watts}}{120 \text{ volts}} = 5 \text{ amperes}$

A 36,026 VA load connected to a 208Y/120-volt, three-phase circuit will draw _____ of current per phase.

A. 110 amperes
B. 173 amperes
C. 250 amperes
D. 100 amperes

ANSWER – (D) 100 amperes

$I = \frac{VA}{E \times 1.732}$ $I = \frac{36{,}026 \text{ VA}}{208 \text{ volts} \times 1.732}$ $I = \frac{36{,}026}{360} = 100 \text{ amperes}$

The power factor of 5-kW load drawing 30 amperes of current when connected to a 208-volt, single-phase source is_____.

A. 92 percent
B. 46 percent
C. 80 percent
D. 83 percent

ANSWER – (C) 80 percent

PF = $\frac{\text{kW X 1000}}{\text{Volts x amperes}}$ PF = $\frac{\text{5-kW X 1000}}{\text{208-volt x 30-amperes}}$ PF = $\frac{\text{5,000 Watts}}{\text{6,240 VA}}$ = .80 or 80%

What is the voltage drop on a single-phase branch circuit supplying a 42-ampere load a distance of 125 feet with 6 AWG TW uncoated copper conductors? Calculate your answer to two decimal places.

a) 4.91 V **
b) 5.25 V
c) 3.35 V
d) 2.86 V

Solution:
Note: Chapter 9, Table 8, DC resistance Table 310.104(A)
TW = 60°C
Temp. correction necessary
Divide by 1.05

6 AWG uncoated copper = 0.491 ohms/kFT

Vd = (DC Res. × I × 2L) ÷ (1,000 × 1.05)
= (0.491 × 42 × 2 × 125) ÷ (1,000 × 1.05)

5,155.5 ÷ 1,050 = 4.91 volts

What size copper conductors are needed to supply a 3-phase, 208-volt, 200-ampere load at a distance of 250 feet and not exceed a 3% voltage drop? (Use 12.9 for k)

a. 2/0 AWG
b. 3/0 AWG
c. 4/0 AWG **
d. 250 kcmil

Solution:

Vdmax = supply voltage × 3%

208 × 0.03 = 6.24 V

cmils = (k × L × I × 1.73) ÷ Vd
= (12.9 × 200 × 250 × 1.73) ÷ 6.24
= 1,115,850 ÷ 6.24
= 178,822 cmils

Chapter 9, Table 8, Area, cmils
Read (more than) 178,822 = 211,600 cmils

211,600 cmils = 4/0 AWG copper

What is the voltage drop of a 240 volt 24 amp single phase load located 160 feet from the panelboard using #10 THHN conductors?

a. 4.25 volts
b. 9.5 volts **
c. 3.2 volts
d. 5.9 volts

K = 12.9 for Copper or 21.2 for aluminum
VD single phase = (2 x K x I x D) / Cmil
VD = (2 x 12.9 x 24 x 160') / 10,380
VD = 9.5 volts

How much power is required to operate a series circuit with 80 ohms of resistance and 3 amps of current?

a. 240 watts
b. 720 watts **
c. 580 watts
d. 820 watts

This is called your I squared R losses

Current squared times the resistance formula is used (3 amps x 3 amps) x 80

9 amps x 80 = 720 watts

STATE OF CONNECTICUT

DEPARTMENT OF CONSUMER PROTECTION
OCCUPATIONAL & PROFESSIONAL LICENSING DIVISION

EVALUATION FORM FOR ELECTRICAL CONTINUING EDUCATION COURSE

TO BE FILLED OUT BY THE STUDENT AND MAILED TO THE ADDRESS BELOW
PROVIDERS ARE NOT PERMITTED TO COLLECT, PROCESS OR DELIVER THIS INFORMATION

Date: _____ Email Address: _____ Phone: _____

Student Name: _____

School Name: _____ Course Name: _____

Location of Class: _____ Time: _____ Course Date: _____

Each instructor shall be evaluated by the students at the end of the course. Please rate your instructor and course in the following categories. Circle your choices.

INSTRUCTOR / FACILITY		POOR	FAIR	GOOD	VERY GOOD
1.	Started and ended class on time	1	2	3	4
2.	Instructor's delivery of subject matter	1	2	3	4
3.	Level of preparation for the class	1	2	3	4
4.	Knowledge of the subject	1	2	3	4
5.	Ability to answer questions	1	2	3	4
6.	Rapport with the class	1	2	3	4
7.	Made learning enjoyable	1	2	3	4
8.	Enthusiasm	1	2	3	4
9.	Depth of coverage	1	2	3	4
10.	Taught the course as it was advertised	1	2	3	4
11.	Gave me information that will benefit	1	2	3	4
12.	Overall evaluation of the Instructor	1	2	3	4
13.	Registration process	1	2	3	4
14.	Staff handled in a professional manner	1	2	3	4
15.	Materials (handouts)	1	2	3	4
16.	Course content	1	2	3	4
17.	Overall evaluation of the course	1	2	3	4
18.	Accommodations of Facility	1	2	3	4

Comments: _____

_____

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